Phytodiversity of the remnants of Canarian endemic juniper woodlands on El Hierro, Canary Islands

La phytodiversité dans les rémanents de la forêt endémique de genévrier d'El Hierro, îles Canaries

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Abstract

*Hot spots of endemicity such as the Canary Isles are of particular interest as far as conserving biodiversity is concerned. The most westerly of these oceanic islands preserve dry woodlands dominated by the Canarian juniper (*Juniperus turbinata *subsp.* canariensis*). The island of El Hierro has been studied because it conserves the biggest extension of this kind of dry forest in the Canary Islands. In this context, the arid zones are reputed as being zones that present a low biodiversity.*

A study of 24 plots of 200 m² has been carried out. All the vascular taxa present have been identified, and the degree of cover and gregarianism has been calculated using the Braun-Blanquet methodology. For each one of the taxa the biological type and the chorology have been assigned. Tables with relevés have been elaborated and an analysis of clusters and dendrograms to see the affinities between the studied plots has been drawn up.

Although less than a tenth part of the natural vegetation is composed of juniper woodlands dominated by Juniperus turbinata *subsp.* canariensis*, it contains more than a fifth of the total of wild vascular plants from the island. This flora associated with junipers contains 30,6% of the endemic taxa from the Macaronesian region. Between them it represents 22,1% of endemics from the Canary Islands, 4,6% of endemics from Canary islands and Madeira, 3,1% of endemics for El Hierro and 0,8% of endemics from the Canary, Madeira and Cape Verde islands.*

The analysis of phytodiversity of the different plots studied reflects a high affinity between the dry juniper woodlands from the lowlands and the others situated in more elevated places. From these we can differentiate those situated in moister conditions, which enter in contact with laurel forests on one hand, and those in close proximity with the Pinus canariensis *forest, on the other.*

Keywords: dendrogram, dry forest, endemicity, hot-spot, Macaronesian.

Resumé

Les points chauds d'endémicité, tels que le sont les îles Canaries, sont particulièrement intéressants pour la conservation de la biodiversité. Les îles les plus occidentales des Canaries préservent des forêts sèches dominées par le genévrier Juniperus turbinata *subsp.* canariensis. *Notre étude se concentre sur l'île d'El Hierro, parce qu'elle présente la plus grande extension de ce type de forêt sèche dans l'ensemble des îles Canaries. Dans ce contexte, les zones arides sont réputées pour avoir une faible biodiversité.*

Nous avons étudié 24 parcelles de 200 m², pour lesquelles toutes les plantes vasculaires ont été

Mots clés : dendrogramme, endémicité, forêt sèche, hot-spot, Macaronésie.

identifiées, leur couverture et leur sociabilité ont été calculées en employant la méthodologie établie par Braun-Blanquet. Pour chaque taxon, le type biologique et la chorologie ont été précisés. Nous avons élaboré des tableaux avec l'ensemble des relevés et, afin de connaître les affinités des parcelles étudiées, nous présentons également les résultats sous forme de clusters et de dendrogrammes.

Bien que la forêt de genévriers (dominée par Juniperus turbinata *subsp.* canariensis*) représente moins d'un dixième de la végétation naturelle, on y trouve un cinquième du total de la flore vasculaire de l'île d'El Hierro. La flore associée avec le genévrier comprend 30,6 % des taxons endémiques de la région macaronésique, parmi lesquels 22,1 % d'endémiques des îles Canaries, 4,6 % d'endémiques des îles Canaries et Madeira, 3,1 % d'endémiques d'El Hierro, et 0,8 % d'endémiques des îles Canaries, Madeira et Cap Vert.*

L'analyse de la phytodiversité des différentes parcelles étudiées reflète une très forte affinité entre les forêts sèches de genévriers des parcelles les plus basses et les forêts de genévriers des parcelles de plus haute altitude. Parmi les parcelles plus élevées, on peut différencier celles situées dans des conditions plus humides près de la forêt laurifoliée, de celles situées à proximité des forêts de Pinus canariensis *en ambiances plus sèches.*

Introduction

The Canary Islands are a centre for plant biodiversity (Médail & Quézel 1999). They are usually included in the Mediterranean hotspot, a biodiversity hotspot recognized at a world level (Blondel & Aronson 1999; Myers *et al.* 2000). Within this archipelago our study is focused on the juniper woodlands from the island of El Hierro. It is on this island and Gomera island that the greater surfaces of juniper woodlands in the Canary archipelago are to be found (Fernández Palacios *et al.* 2008). These Canarian juniper woodlands, dominated by *Juniperus turbinata* Guss. subsp. *canariensis* (Guyot) Rivas-Mart., Wildpret & P. Pérez, have been defined as thermophilous woodlands (Santos 1980). They are located in low and middle areas "*medianías*" of the most westerly Canary islands (Otto *et al.* 2006). They are dry forests with a low tree canopy and, in fact, they are formed by canopy and intercanopy patches where nanophanerophytes, chamaephytes and therophytes grow. These woodlands have suffered considerable regression due to anthropic activity, and now only small fragments of them remain (Otto *et al.* 2006). Only a few phytosociological studies have been made on El Hierro's juniper woodlands, and these rather general and included within standard vegetation works (del Arco *et al.* 1996; von Gaisberg 2005). In this scenario we would like to answer the following questions: what level of phytodiversity do these woodland environments at present manifest? and which environmental factors are conditioning this biodiversity?

Material and methods

El Hierro island is located in the southwestern extreme of the Canary Isles, lying between 17º52'-18º09'W and 27º38'-27º51'N. It is a small island (278.5 km^2), the most oceanic island of the Archipelago (Nogales *et al.* 2009), and geologically the youngest, being 1 M yr of age (Fuster *et al.* 1993). In order to know the phytodiversity of these juniper woodlands 24 plots of 200 m^2 have been studied, each plot being situated at different levels, aspects and slopes (Figure 1). The plots are found between 206 m and 1.012 m above see level. As well as the habitat conditions, all the vascular plants were identified in each plot, and their cover and degree of gregariousness were calculated; for this purpose the Braun-Blanquet (1979) method was employed. The life form and chorology of each taxon were then assigned (Stierstorfer & von Gaisberg 2006). With this combined data two tables have been elaborated (Tables 1 and 2). One with the physical characteristics of the plots, and another with their phytodiversity. In order to establish the affinities between the studied plots, the results are presented in cluster and dendrogram form (Figure 5). Dendrograms were produced according to the unweighted pair-group mean arithmetic method (UPGMA), using B-Vegana software (De Cáceres *et al*. 2003).

Results

Although the total area of *Juniperus turbinata* subsp. *canariensis* woodland covers less than a tenth part of the natural vegetation of the island, within it is found more than a fifth of the total amount of the vascular flora of El Hierro. More than 131 (Table 2) out of the

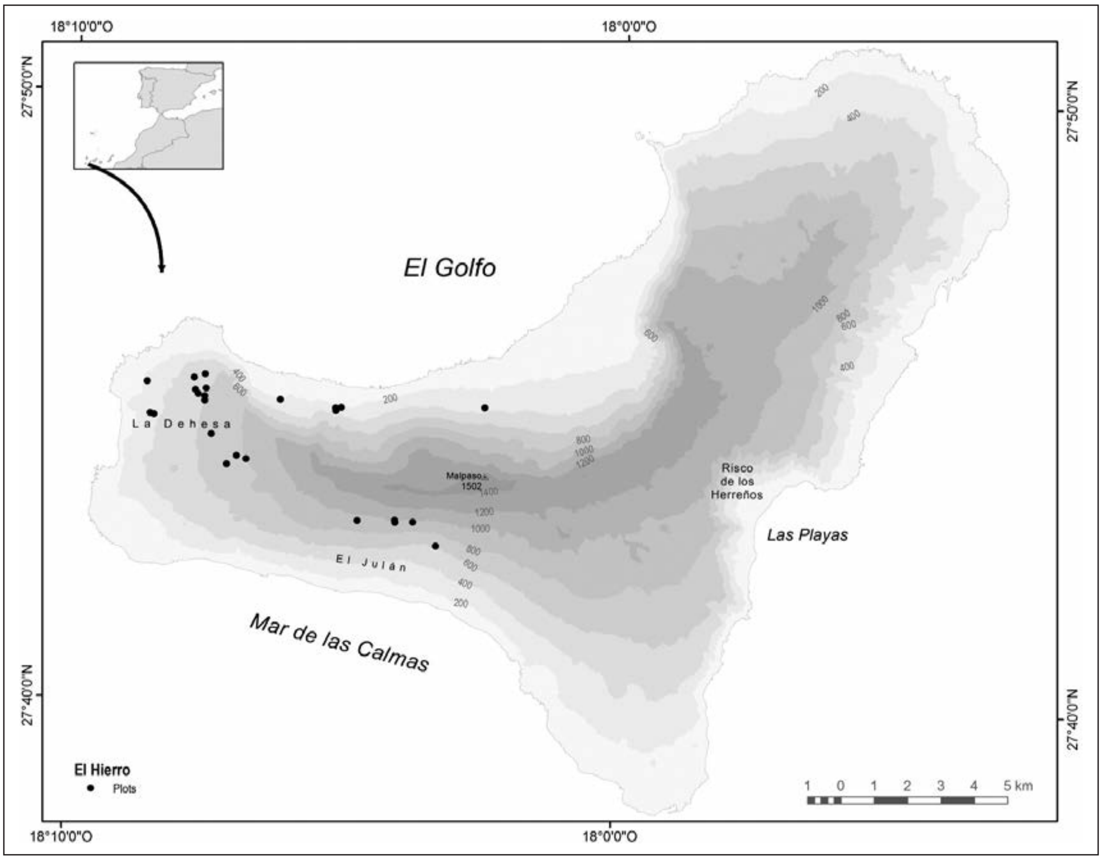

Figure 1 – Location of the studied plots on El Hierro island.

Table 1 – Characteristics of the plots studied.

Plots	Code	Latitude	Longitude	Altitude (m)	Aspect	Slope (°)	Richness
1 [P_05]: El Cres	CR1	27°44'22"N	18º07'26"W	740	WNW	17	29
2 [P_06]: El Cres	CR2	27°43'53"N	18º07'09"W	750	N	31	26
3 [P_07]: Barranco de la Charca	BC1	27°44'41"N	18º08'34"W	342	W	14	15
4 [P_08]: El Julán	JU2	27°42'59"N	18º03'43"W	990	SSW	32	16
5 [P_09]: Sabinosa	SA2	27°44'50"N	18º05'11"W	254	NNW	35	24
6 [P_10]: Sabinosa	SA1	27°44'51"N	18º05'04"W	265	NNE	42	31
7 [P_11]: Sabinosa	SA3	27°44'48"N	18º05'10"W	292	NE	40	16
8 [P_12]: El Sabinar	SR6	27°44'55"N	18º07'34"W	608	NW	18	24
9 [P_13]: El Sabinar	SR2	27°45'07"N	18º07'33"W	589	WNW	20	28
10 [P_14]: El Sabinar	SR5	27°44'59"N	18º07'35"W	595	W	10	21
11 [P_15]: El Julán	JU3	27°42'59"N	18º04'03"W	982	S	38	15
12 [P_16]: El Julán	JU1	27°43'01"N	18º04'04"W	1 012	S	40	22
13 [P_17]: El Sabinar	SR1	27°45'13"N	18º08'38"W	304	SE	12	18
14 [P_18]: Barranco de la Charca	BC2	27°44'41"N	18º08'30"W	363	NNW	21	26
15 [P_19]: El Sabinar	SR3	27°45'05"N	18º07'45"W	536	NW	17	16
16 [P_20]: El Sabinar	SR4	27°45'01"N	18º07'41"W	505	NNW	19	14
17 [P_21]: El Sabinar	SR7	27°45'17.6"N	18º07'46.4"W	515	NNE	19	17
18 [P_22]: El Sabinar	SR8	27°45'21.0"N	18º07'34.5"W	530	NW	10	21
19 [P_23]: El Julán	JU4	27°43'00.2"N	18º04'44.3"W	947	SSE	20	16
20 [P_24]: EL Julán	JU5	27°42'36.8"N	18º03'17.9"W	649	W	29	20
21 [P_25]: El Cres	CR3	27°44'01.5"N	18º06'58.1"W	776	WSW	12	31
22 [P_26]: El Cres	CR4	27°43'58.4"N	18º06'47.6"W	817	W	14	31
23 [P_27]: Sabinosa	SA4	27°44'57.6"N	18º06'11.5"W	206	N	37	31
24 [P_28]: Sabinosa	SA5	27°44'54.1"N	18º02'27.6"W	298	N	42	33

Table 2 – Vascular plants of the plots studied.

	P_05 [1]	P_06 [2]	P_07 [3]	P_08 [4]	P_09 [5]	P_10 [6]	P_11 [7]	P_12 [8]	P_13 [9]	P_14 [10]	P_15 [11]	P_16 [12]	P_17 [13]
Aeonium canariense Webb ex Bertel var. *palmense* (Webb ex Christ) H.Y. Liu	1.1	.	.	.	+	2.3	1.2	.	.	.	.	.	.
Aira caryophyllea L. subsp. *caryophyllea*	.	.	.	.	.	.	+	.	.	.	.	.	.
Anagallis arvensis L.	+	+	.	.	+	.	.	+	+	+	.	.	+
Arabidopsis thaliana (L.) Heynh.	.	.	+	+	.	.	.	.	.	.	.	.	.
Arenaria leptoclados (Reichenb.) Guss.	.	.	.	.	.	.	.	.	.	.	.	.	.
Argyranthemum hierrense	+	+	.	.	.	+	.	1.2	1.1	1.1	.	.	.
Artemisia thuscula Cav.	+	.	.	.	2.3	1.2	1.2	.	.	.	.	.	.
Asphodelus ramosus L. subsp. *distalis* Z. Diaz & Valdes	.	.	1.1	.	+	+	.	.	.	.	.	.	+
Biserrula pelecinus L.	.	.	.	+	.	.	.	.	.	.	1.1	.	.
Brachypodium distachyon (L.) Beauv.	.	.	.	.	.	+	+	+	+	1.1	+	1.1	.
Bromus diandrus Roth	1.1	1.1	.	+	.	.	.	3.3	1.1	2.2	.	+	.
Carlina salicifolia Cav.	.	.	.	.	.	1.1	.	.	+	.	.	.	.
Cheilanthes catanensis (Cosent.) H.P. Fuchs	.	.	+	+	+	.	.	.	.	.	.	.	.
Chenopodium murale L.	.	.	.	.	.	.	.	+	.	.	.	.	.
Cistus monspeliensis L.	.	.	2.2	.	.	.	.	.	2.2	2.2	.	.	.
Cuscuta planiflora Ten.	.	.	.	.	.	+	.	.	.	.	.	.	+
Davallia canariensis (L.) Sm.	.	.	.	+	.	.	.	.	.	.	.	.	.
Drusa glandulosa (Poir.) H. Wolf ex Engl.	.	.	.	.	+	.	.	.	.	.	.	.	+
Echium hierrense Webb ex Bolle	.	.	.	+	.	.	.	.	.	.	.	.	.
Echium plantagineum L.	.	.	.	+	.	.	.	+	.	1.1	1.1	1.1	.
Erodium cicutarium (L.) L'her. subsp. *cicutarium*	+	+	.	.	.	.	.	1.1	.	.	.	.	.
Eruca vesicaria (L.) Cav. subsp. *vesicaria*	+	.	.	.	.	.	.	+	.	.	.	.	.
Euphorbia balsamifera Ait.	.	.	2.3	.	.	1.1	1.1	1.2	1.2	.	.	.	.
Euphorbia lamarckii Sweet subsp. *wildpretii* (Molero & Rovira) Rivas-Mart. & Gaisberg	.	.	.	.	.	.	.	.	.	.	.	2.2	2.2
Galium parisiense L.	.	+	.	.	.	.	.	.	.	.	.	+	.
Geranium rotundifolium L.	.	.	.	.	.	.	.	+	.	.	.	.	+
Hyparrhenia sinaica (Delile) Llaurado ex G. Lopez	.	.	.	1.1	.	.	.	.	.	.	2.2	3.3	.
Ifloga spicata (Forskal) Schultz Bip. subsp. *spicata*	.	.	.	.	.	+	.	.	+	.	+	.	.
Juniperus turbinata Guss.	2.3	2.3	2.2	3.4	2.2	2.2	2.3	3.3	3.3	1.2	1.2	2.2	2.3
Kleinia neriifolia Haw.	+	.	1.1	.	2.3	1.2	.	.	.	.	.	.	1.1
Lagurus ovatus L.	+	+	.	.	.	.	.	+	1.1	1.1	.	.	.
Lathyrus articulatus L.	.	+	.	.	+	.	.	.	.	.	.	.	.
Leontodon taraxacoides (Vill.) Merat subsp. *taraxacoides*	+	.	.	.	+	.	.	+	+	.	.	+	.
Lobularia canariensis (DC.) L. Borgen subsp. *intermedia* (Webb) L. Borgen	.	.	.	.	.	+	+	.	+	.	.	.	.
Matthiola incana (L.) R. Br. subsp. *incana*	+	1.1	.	.	.	+	+	.	.	1.1	.	.	.
Micromeria hyssopifolia Webb & Berthel.	2.3	1.2	1.1	2.3	+	1.1	.	+	+	3.3	2.2	3.3	+
Misopates orontium (L.) Rafin.	.	.	.	.	.	+	.	.	.	.	.	.	.
Ononis dentata Solander ex Lowe	.	+	.	.	.	+	.	.	.	.	.	.	.
Paronychia canariensis (L.f.) Juss	1.1	.	.	.	.	.	.	.	2.2	.	.	.	.
Pericallis murrayi (Bornm.) B. Nord.	.	.	.	.	.	+	.	.	.	.	.	.	.
Periploca laevigata Aiton subsp. *laevigata*	.	.	.	.	+	1.2	2.3	.	.	.	.	.	.
Petrorhagia nanteuilii (Burnat) P.W. Ball & Heywood	.	.	.	+	.	.	.	.	.	.	1.1	+	.
Phagnalon umbelliforme DC.	.	.	.	.	.	+	.	.	.	.	.	.	+
Plantago lagopus L.	+	1.1	+	.	.	+	.	1.2	.	+	.	.	.
Polycarpaea divaricata (Aiton) Poir.	1.1	.	+	.	.	.	.	.	+	+	+	.	+
Polycarpon tetraphyllum (L.) L.	.	.	.	.	+	+	.	.	.	.	.	.	.
Psoralea bituminosa L.	1.1	1.1	.	.	2.2	2.2	2.2	2.3	1.1	1.2	.	.	.
Rubia fruticosa Ait.	1.1	.	1.2	.	2.2	1.2	.	1.2	1.2	1.1	.	.	1.1
Rumex bucephalophorus L. subsp. *canariensis* (Steinh.) Rech. f.	.	.	.	.	+	+	.	.	+	.	.	.	.
Rumex lunaria L.	.	.	.	.	1.1	1.1	1.1	.	.	.	.	.	.
Sagina apetala Ard. subsp. *apetala*	.	.	.	.	+	+	.	.	.	.	.	.	.
Schizogyne sericea DC.	.	.	3.3	+	1.2	1.2	.	.	.	1.2	.	1.1	4.4
Senecio incrassatus Lowe	.	.	.	.	.	.	2.2	.	+	1.2	.	.	.
Silene gallica L.	1.1	1.1	.	.	.	+	.	1.1	.	.	.	+	.
Sisymbrium erysimoides Desf.	.	.	.	.	.	.	.	.	.	.	.	.	+
Sonchus hierrensis (Pit.) Boulos	.	2.2	1.1	.	+	1.1	.	.	+	.	.	.	.
Stachys arvensis (L.) L.	.	.	.	.	+	.	.	.	.	.	.	.	.
Stipa capensis Thunb.	.	.	+	+	.	.	.	.	.	.	1.2	1.2	.
Trifolium angustifolium L.	1.1	1.1	.	.	.	.	.	.	1.1	.	.	.	.
Trifolium arvense L.	1.1	1.1	.	1.1	+	.	.	.	+	2.2	1.1	1.1	.
Trifolium campestre Schreber	1.1	1.1	.	.	+	.	.	+	1.1	1.2	.	1.1	.
Trifolium scabrum L. subsp. *scabrum*	1.1	.	.	+	.	+	.	+	+	1.1	1.1	1.1	.
Tuberaria guttata (L.) Fourr.	1.1	1.1	.	.	.	.	.	.	1.1	1.1	.	1.1	.
Urtica urens L.	.	.	.	.	.	.	.	.	.	.	.	.	+
Vicia angustifolia L.	.	.	.	.	.	.	.	.	.	.	+	+	.
Vicia cirrhosa C. Sm. ex Webb & Berthel	.	.	.	.	.	.	.	.	.	.	.	.	.
Vicia lutea L. subsp. *lutea*	+	.	.	.	.	.	.	.	.	.	.	.	.
Vulpia myuros (L.) C.C. Gmelin	.	.	.	.	.	.	+	.	1.1	.	.	1.1	.
Wahlenbergia lobelioides (L. f.) Link subsp. *lobelioides*	.	.	.	.	.	.	.	.	.	.	.	.	+

P_18 [14]	P_19 [15]	P_20 [16]	P_21 [17]	P_22 [18]	P_23 [19]	P_24 [20]	P_25 [21]	P_26 [22]	P_27 [23]	P_28 [24]	[Syn]
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.	.	.	.	.	1.2	1.1	.	.	.	.	I
.	.	+	.	.	+	.	+	+	.	.	III
.	.	+	.	.	.	.	1.1	+	.	.	III
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1.1	1.1	3.3	3.3	2.3	.	.	.	.	.	1.2	II
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2.2	2.2	1.1	1.1	1.1	.	.	+	.	II		
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4.4	4.4	4.4	4.4	3.4	2.3	2.3	2.2	2.3	1.2	2.3	V
1.1	2.2	+	2.2	2.2	.	.	.	.	1.1	+	III
.	.	.	.	.	.	.	1.1	1.1	.	.	II
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+	1.1	+	.	+	.	+	.	.	1.1	.	II
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.	+	.	.	+	3.4	.	3.3	2.2	1.2	+	IV
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+	.	+	.	.	.	.	+	+	.	.	III
.	.	.	.	.	.	.	.	.	1.2	.	II
+	.	.	.	.	.	.	.	.	+	.	I
.	.	.	.	.	.	.	1.1	1.1	1.1	1.1	III
1.1	3.3	2.2	1.2	1.1	.	.	1.1	.	1.1	2.2	IV
.	.	.	.	.	.	.	.	.	1.1	.	I
.	+	1.1	.	.	.	.	.	.	1.1	1.1	II
.	.	+	.	.	.	.	.	.	.	.	I
2.2	.	.	+	.	.	.	.	.	+	.	III
.	.	.	+	+	.	.	.	.	.	.	II
+	.	.	.	.	+	+	+	1.1	1.1	.	III
+	.	.	+	.	.	.	.	.	.	.	I
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Taxons with constancy lower than 3:

Aeonium hierrense (RP Murray) Pit & Proust in 23(+) 24(+)
Allium subvillosum Salzm. ex Schultes & Schultes fil. in 24(+)
Androcymbium hierrense A. Santos in 9(+)
Andryala pinnatifida Ait. in 1(+) 9(+)
Anthoxanthum aristatum Boiss. subsp. *aristatum* in 2(1.1) 24(+)
Asparagus umbellatus Link in 24(+)
Asterolinon linum-stellatum (L.) Duby in 2(+)
Bidens pilosa L. in 22(+)
Briza maxima L. in 1(+) 2(1.1)
Calendula arvensis L. in 21(+)
Carduus baeocephalus Webb subsp. *microstigma* Gaisberg & Wagenitz in 17(+) 18(+)
Ceballosia fruticosa (L. f.) G. Kunkel in 13(1.1)
Centaurium tenuiflorum (Hoffmanns. & Link) Fritsch subsp. *tenuiflorum* in 10(+) 20(+)
Cerastium glomeratum Thuill. in 24(+)
Convolvulus althaeoides L. subsp. *althaeoides* in 21(+)
Cosentinia vellea (Aiton) Tod. in 11(+) 12(+)
Crassula tillaea Lester-Garland in 17(+) 22(+)
Crepis foetida L. subsp. *foetida* in 2(+) 7(+)
Ebingeria elegans (Lowe) Chrtek. & Krisa in 2(1.1) 24(1.1)
Echium aculeatum Poir. in 21(+) 22(+)
Erica arborea L. in 24(+)
Erodium botrys (Cav.) Bertol. in 14(+) 21(+)
Erodium chium (L.) Willd. subsp. *chium* in 22(+)
Erysimum bicolor (Hornem.) DC. in 23(+)
Foeniculum vulgare Mill. subsp. *vulgare* in 24(+)
Galium aparine L. in 24(+)
Geranium purpureum Vill. in 24(+)
Gnaphalium luteo-album L. in 4(+) 5(+)
Habenaria tridactylites Lindl. in 24(+)
Hippocrepis multisiliquosa L. in 11(+) 21(+)
Hirschfeldia incana (L.) Lagreze-Fossat in 1(+) 21(+)
Hypericum canariense L. in 23(2.2) 24(2.3)
Hypochoeris glabra L. in 20(+) 22(+)
Lamarckia aurea (L.) Moench in 23(+)
Lathyrus tingitanus L. in 7(+)
Limonium pectinatum var. *solandri* (Webb & Bertel.) Kuntze in 13(+)
Lolium canariense Steud. in 8(1.1) 22(+)
Lotus sessilifolius DC. in 7(1.1)
Marrubium vulgare L. in 22(+)
Mercurialis canariensis Obbard & S.A. Harris in 21(+)
Nicotiana glauca R.C. Graham in 18(+)
Orobanche minor Sm. in 2(+)
Parietaria debilis Forster fil. in 17(+) 18(+)
Pinus canariensis Sweet ex Sprengel in 12(1.2) 20(+)
Plantago afra L. in 3(+) 14(+)
Pteridium aquilinum (L.) Kuhn in 23(1.2)
Reichardia ligulata (Vent.) G.Kunkel & Sunding in 6(+) 23(+)
Rumex angiocarpus Murb. in 23(+)
Scandix pecten-veneris L. subsp. *pecten-veneris* in 22(+)
Selaginella denticulata (L.) Link in 24(2.3)
Senecio teneriffae Sch. Bip. ex Bolle in 21(+)
Sherardia arvensis L. in 2(+)
Silene vulgaris (Moench) Garcke in 22(+) 24(+)
Solanum nigrum L. subsp. *nigrum* in 8(+)
Sonchus oleraceus L. in 15(1.1)
Sonchus tenerrimus L. in 8(+) 21(+)
Stellaria media (L.) Vill. subsp. *media* in 22(+)
Tolpis umbellata Bertol. in 12(+)
Trifolium glomeratum L. in 21(+) 22(+)
Trifolium pratense L. in 1(1.1)
Trifolium subterraneum L. in 8(+)
Umbilicus horizontalis (Guss.) DC. in 14(+) 18(+)

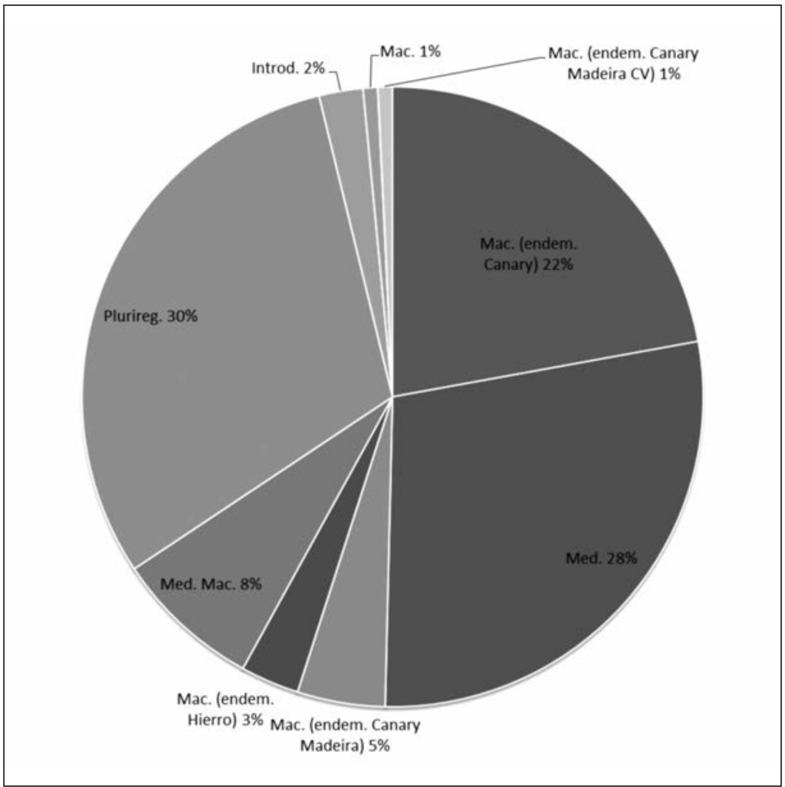

Figure 2 – Chorology of the taxa living in the juniper woodlands.
Mac.: endemic from Macaronesia floristic biogeographic region as defined by Tahtajan (1986); endem.: endemic from Canary Isles, Madeira Islands; CV: Cape Verd Isles; Med.: Mediterranean floristic biogeographic region as defined by Tahtajan (1986); Introd.: introduced; Plurireg.: pluriregional.

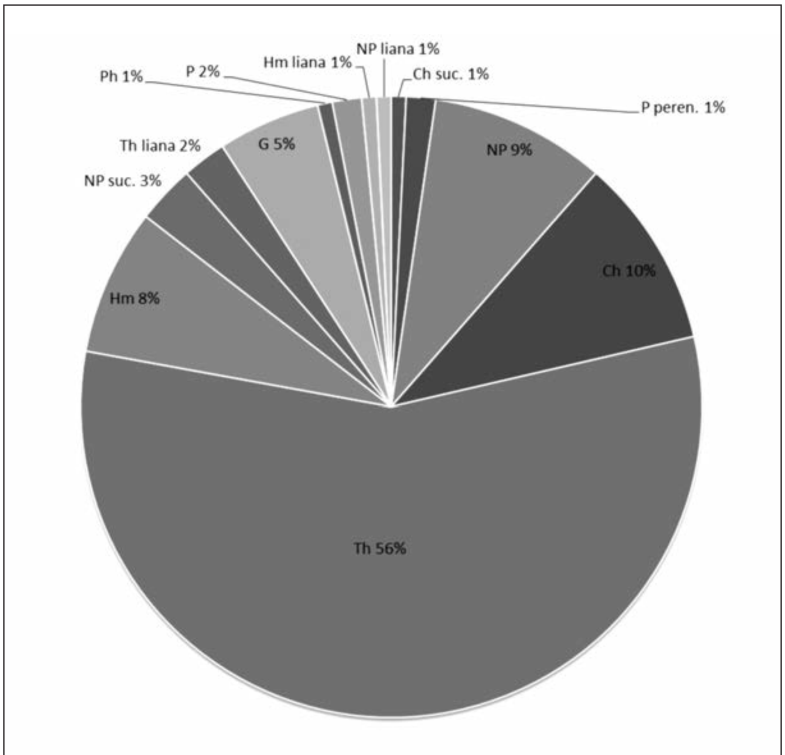

Figure 3 – Life forms of the taxa living in the juniper woodlands.
(Ch: chamaephytes; G: geophytes; Hm: Hemicryptophytes; liana: lianas; NP: nanophanerophytes; peren.: perennifolious; Ph and P: Phanerophytes; suc.: succulent; Th: Therophytes).

total 550 taxa found on the island (Stierstorfer & von Gaisberg 2006) have been detected in these juniper woodlands.

The associated flora of these juniper woodlands makes up 30.6% of the endemic taxa from the Macaronesian floristic region, such as defined by Tahktajan (1986), of which 22.1% are Canary island endemics, 4.6% are endemics from the Canary and Madeira archipelagos, 3.1% are endemics from El Hierro, and 0.8% endemics from the Canary Isles, Madeira and Cape Verde (Figure 2). A second group of taxa is formed by species of a pluriregional distribution, with a 30.5% representation. The Mediterranean taxa are represented by a further 28.2%. Another portion, 7.6%, is made up of plants living in the Mediterranean and Macaronesia. In final place, the allochtonous taxa growing in the juniper woodlands are reduced to a mere 2.3%.

The biodiversity analysis, using cluster analyses UPGMA method and Chord coefficient for the different studied plots, reflects a great affinity between the plots located in the low areas, on the one hand, and those located in the more elevated areas on the other. From these latter ones we can distinguish the plots located in wetter environmental conditions, near the laurel forest (plots P_05, P_13; P_14), from those located near the Canary pine *Pinus canariensis* (plots P_08, P_15; P_16), zone, in drier environmental conditions. There also exist differences between the plots located on northern exposed slopes ("*barlovento"* in Spanish), which receive the influence of the wet winds (air masses a of a very humid nature) and the plots located on southern sheltered slopes "*sotavento*", where the descending air is drier.

The number of species on the studied plots oscillates between 14 and 33 taxa. We have observed two maximums in the decreasing number as the altitude descends; one between 200 and 400 m above sea level, and another between 500 and 800 m. The slope does not seem to greatly affect the number of species, but orientation, however, has a great influence. The highest biodiversity is observed on the plots with a N and NNE aspect, which have a correlation with the northern winds "*alisos*" ("alisios" in Spanish). These winds model the aerodynamic forms of the adult individuals sampled (Salvà-Catarineu & Romo 2008). A second block, with remarkable but slightly less biodiversity, is observed in the plots with a south-facing aspect. No stands of juniper woodland have been observed on the E or SW aspects (Figure 4).

The dendrogram reflects the affinity between the dry juniper woodlands from the lowlands and the others situated in more elevated stations (Figure 5). From these we can differentiate those situated in moister conditions, which enter in contact with laurel forests on one hand, and those in close proximity with the *Pinus canariensis* forest, on the other.

Discussion

The obtained results are comparable to the results provided by Fernández Palacios *et al*. (2008) for Tenerife and La Gomera islands. But their approach was somewhat different, and therefore their results, in particular for the island of Tenerife, because the therophytes were not taken into account.

Bearing this in mind, when it comes to introduced plants, Fernández Palacios *et al.* (loc. cit.) give an amount of 14%, as opposed to our 2.3%. This lower value can be explained by the much reduced anthropic impact on the natural vegetation of El Hierro and by the presence of a lower number of habitats opened to invasive plants on this island.

The globally widespread species, that is, the pluriregional ones, make up 29% in Fernández Palacios *et al*.'s survey, and we have found a similar value 30.5%, for El Hierro.

These authors detected 48% of macaronesian endemics, whereas we found only 31%. Finally Fernández Palacios *et al.* gave an amount superior to 20% for the Canary endemics, as opposed to the 25.2% detected by us. All these values could be explained by the reduced surface of El Hierro, as compared with Tenerife (2.034 km^2).

In relation to the life forms, the elevated number of therophytes here is remarkable (Figure 3). These make up more than a half of the species (56%). There is a lack of comparable data from other Canary islands, since the annuals were not studied by these authors. Nevertheless, this elevated number of annuals can be explained by the structure of this plant community, which is formed by woodland patches that contain gaps, with a very shallow soil, in which only therophytes can grow.

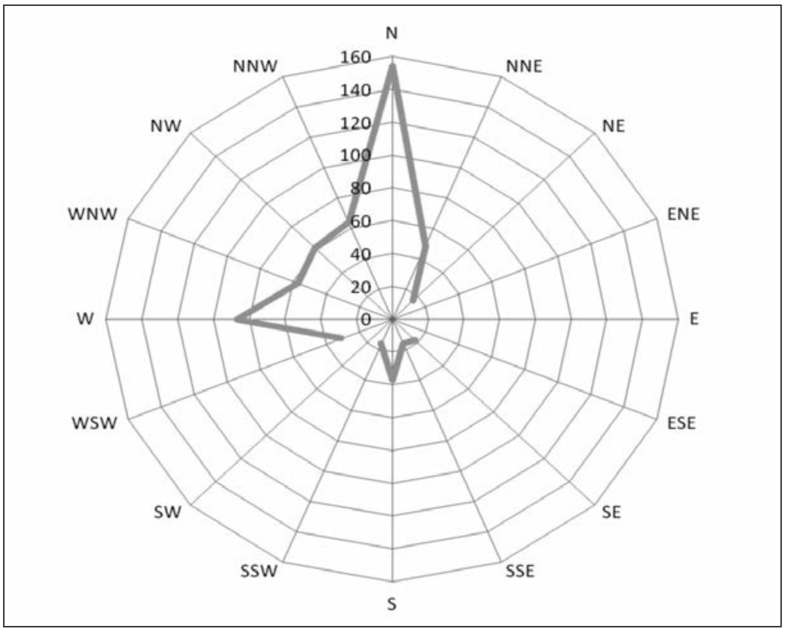

Figure 4 – Relation between number of taxa and aspect.

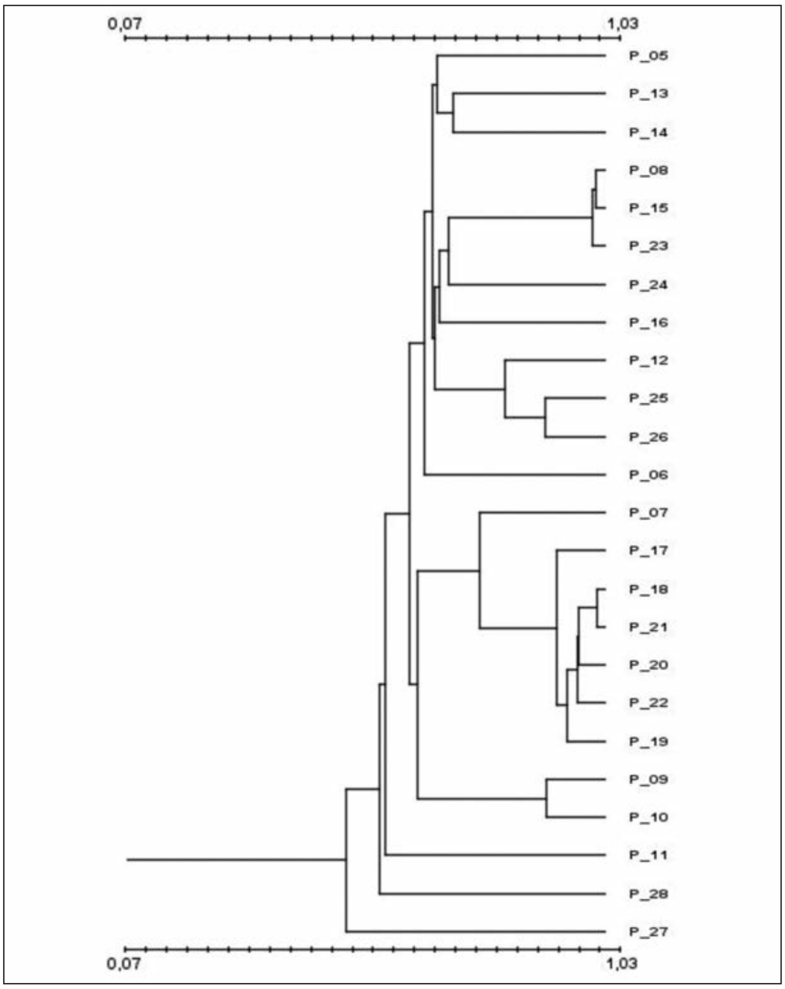

Figure 5 – Dendrogram that reflects the floristic affinities between the plots studied. Cluster analyses using UPGMA method and Chord coefficient. P_05 to P_14 are wet Canarian juniper woodlands from el Golfo area; P_08 to P_06 are dry Canarian juniper woodlands from el Julán area; P_07 to P_10 are dry Canarian juniper woodlands from the Sabinosa area; P_11 to P_27 are dry Canarian juniper woodlands from the El Sabinar area. To see the correspondence between code plots and relevées see Table 1.

The phanerophytes, including the different nanophanerophytes, constitute a 52.34%, and the chamaephytes a 20.9% (the therophytes have been eliminated in order to compare our data with that of Fernández Palacios *et al.* [loc. cit.]). In other words, woody plants represent 73.24% of the total and perennial non-woody species make up 26.76% of the total. Together, greater values are obtained for the studied plots on El Hierro. This can be explained by the better state of conservation of the natural vegetation on this small island.

Concerning the number of species (Table 1), and taking into account the fact that in Fernández Palacios *et al.* the plots were of 314 m^2 and our plots are of 200 m^2, the number of taxa oscillates between 14 and 33 obtained by us and 9-41 by Fernández Palacios *et al.* This difference is considered to be of little significance. Prior to this, Gaisberg (2005) obtained between 9 and 49 taxa for plots whose surface oscillated between 10-20 m^2, del Arco *et al.* (1996) recorded a range of 4-21 taxa for plots of 100 m^2, and Hernández (1987) obtained between 4 and 8 species for plots that had between 25 and 100 m^2 of surface area.

Conclusion

The juniper woodlands from El Hierro island exhibit a high degree of biodiversity. This phytodiversity richness seems more related to the physical properties of the sampled localities than to general environmental conditions (Salvà-Catarineu *et al.* 2012). These results are congruent with the ones obtained by Box & Fujiwara (2011) working on North American vegetation.

These open woodlands should be considered as hotspots within the greater hotspot of the Canary islands. Within them, Salvà-Catarineu & Romo (2008) observed practically no regeneration, and therefore we conclude that measures to preserve and manage them should be urgently drawn up.

The protection of areas within El Hierro such as the "Parque Rural de Frontera and La Reserva Integral de Mencafate", that are SCI (Sites of Community Importance, as defined by the European Commission Habitat Directive, 92/43/EEC) which contain Canarian juniper formations, is a welcome measure that reinforces the need for new studies on this type of open woodland dynamics.

Moreover, in our opinion, these dry woodlands – located in an Oceanic archipelago – are especially sensitive to climatic change, which in itself justifies the establishment of study programmes based on changes in their biodiversity over an extended period of time.

Acknowledgements

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