ECOGEOGRAPHICAL CHARACTERIZATION OF GERMPLASM OF TAGASASTE AND ESCOBON *(CHAMAECYTISUS PROLIFERUS* (L. FIL.) LINK *SENSU LATO)* FROM THE CANARY ISLANDS: SOIL, CLIMATOLOGICAL AND GEOGRAPHICAL FEATURES

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SUMMARY

Results from texture, electrical conductivity and pH of soil samples as well as altitude and rainfall data from the habitats of 162 populations of wild and cultivated tagasaste and escobon *(Chamaecytisus proliferus* (L. fil.) Link *sensu lato)* from the Canary Islands are presented. Germplasm from these populations is conserved in the Centro de Conservación de Recursos Fitogenéticos, Alcalá de Henares, Madrid. Most of the samples were collected in sites with sandy soils with low salinity and pH values between 5 and 7. Escobon of El Hierro, tagasaste, white escobon of Gran Canaria and white escobon of Tenerife are found on northern slopes of the islands which are under the influence of the trade winds. Narrow-leaved escobon and escobon of southern Gran Canaria grow both on northern and southern slopes in areas which are not directly affected by these winds. Accessions are identified from areas where frost occurs as well as from arid zones. Utilisation of the plant genetic resources of this fodder species should he influenced by both ecological data and island provenance as ecogeographical variation within this complex increases from west to east.

KEY WORDS: *Chamaecytisus proliferus*
Ecogeography
Escobon
Fodder
Germplasm
Legumes
Tagasaste

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INTRODUCTION

Situated 100 km from the African continent, the Canary Islands possess a rich flora with more than 600 endemics (Hansen, Sunding, 1985). Among these endemics one legume shrub from the island of La Palma known as tagasaste *(Chamaecytisus proliferus* (L. fil.) Link ssp. *palmensis* (Christ Link) has achieved importance as a source of food for livestock not only in this archipelago but also in Australia and New Zealand (Francisco-Ortega *et al.*, 1991) where it is also utilised as a soil conservation species (Sheppard, Bulloch, 1986) and as a winter source of pollen for bees (Holmes, 1982). *C. Proliferus* forms a species complex with seven morphological forms (Acebes-Ginovés, 1990; Francisco-Ortega, 1992) endemic to the islands of El Hierro (escobon of El Hierro), La Palma (tagasaste and white tagasaste), La Gomera (narrow-leaved escobon), Tenerife (narrow-leaved escobon and white escobon of Tenerife) and Gran Canaria (escobon of southern Gran Canaria and white escobon of Gran Canaria). Tagasaste is the only morphological form which is cultivated: all the other forms although not cultivated, are heavily pruned by peasant farmers (Pérez de Paz *et al.*, 1986; Francisco-Ortega *et al.*, 1990).

Despite its high potential as a fodder crop for arid zones of subtropical regions (Oldham *et al.*, 1991) tagasaste could be regarded as an underexploited crop and is only recently that germplasm from the whole complex has been collected (Francisco-Ortega *et al.*, 1990). Reports based on cultivated tagasaste from Australia and New Zealand suggest that the species is not hardy (Reid, Wilson, 1985) and that it thrives better on sandy soils (Nicholas, 1984).

The use of ecogeographical data as a primary source of information for the collection, conservation and subsequent utilisation of plant genetic resources has become a major priority because they provide important information for selecting the most appropriated accessions in any plant breeding programme. In this paper analyses of ecogeographical data related to the germplasm collection sites of cultivated and wild populations of *C. proliferus* are presented. It is hoped that results shown here will lead to a better utilisation of germplasm of this species both in the Canary Islands and elsewhere.

MATERIALS AND METHODS

Germplasm, soil samples and climatological and geographical data were gathered for 162 wild and cultivated populations of *C. proliferus* in the Canary Islands during 1989 which are listed in Table 1. Germplasm is conserved at the Centro de Conservación de Recursos Fitogenéticos in Alcalá de Henares, Madrid. A complete ecological description of each of these localities has been previously given (Francisco-Ortega, Jackson, 1989). The analyses of some of the ecological data shown in this previous work have been the basis for the results presented here.

Selection of these localities was carry out after identification of collection sites for herbarium specimens held in BM, K, ORT and P. A literature survey was also accomplished and the distributions of the species were established for El Hierro (Santos-Guerra, 1977; Perez de Paz *et al.*, 1986), La Palma, La Gomera and Tenerife (Ceballos, Ortuño, 1976; Perez de Paz *et al.*, 1986) and Gran Canaria (Montelongo *et al.*, 1984). Within these distributions, collection sites were approximately 3 km apart and were selected following the climatic gradient which exists in each island.

Soil samples (750 g) were collected from the upper 50 cm of the soil layer. Annual rainfall data were obtained from precipitation maps for El Hierro and La

TABLE 1

GERMPLASM COLLECTION SITES OF CHAMAECYTISUS PROLIFERUS

Lugares de recolección de germoplasma de Chamecytisus proliferus

Acc.	Mo.	Local.	Coordina.	I.	Acc.	Mo.	Local.	Coordina.	I.
	4	Anaga 1.......			65	7	Temisas.......		
2	4	Anaga 2.......			66	7	Taidía.........		
3	2	Malpaíses.....			67	7	Aguas Tunte ..		
4	2	Teneguía......			68	7	Tirajana 1.....		
5	2	Tomascoral ...			69	7	Cercados......		
6	2	El Paso 1......			70	7	Los Hornos ...		
7	2	Cumbrecita....			71	7	El Juncal......		
8	2	Bejenado......			72	7	Capellanía		
9	2	Hoya Sima			73	7	Santa Lucía ...		
10	2	El Paso 2......			74	7	Tirajana 2.....		
12	2	Las Nieves....			75	7	Fataga 1.......		
13	3	Tenerra			76	7	Fataga 2.......		
14	3	Bombas Agua.			77	7	Fataga 3.......		
15	2	Taburiente			78	7	La Charca.....		
16	3	Los Cantos....			79	7	Fataga 4.......		
17	3	Dos Aguas			80	7	Ayagaures		
18	3	Escuchaderos .			81	7	Arguineguín...		
19	2	San Antonio...			82	7	Soria 1		
20	2	La Mata.......			83	7	Soria 2		
21	2	Garafía........			84	7	Chira..........		
22	2	Puntallana.....			85	7	Guayadeque 1.		
23	2	Los Tilos......			86	7	Guayadeque 2.		
24	2	Los Sauces....			88	7	Los Marteles..		
25	2	Gallegos			89	2	Huertas		
26	2	Marcos........			90	7	Ventaiga		
27	2	Cabezadas			91	6	Firgas.........		
28	2	Roque Faro ...			92	6	Teror 1........		
31	5	Siete Ojos.....			93	7	Guardaya		
35	4	Tigaiga 1......			94	6	Teror 2........		
36	4	Tigaiga 2......			95	7	Perralillo......		
37	6	Utiaca.........			96	7	La Coruña.....		
38	6	Troya			97	2	La Montañeta .		
39	6	Lomo Picacho.			98	7	Tamadaba 2...		
40	6	Roque Grande.			99	5	Los Quemados		
41	6	Lagunetas.....			100	5	Vilaflor		
43	7	Tejeda			101	5	La Hondura ...		
44	2	Retamilla			102	5	Madre Agua...		
45	6	Cueva Grande.			103	5	Brnco. Río 1 ..		
45	6	Lanzarote			104	5	Boca Tauce 1 ..		
47	6	Carpinterías...			105	5	Boca Tauce 2 .		
48	6	Fontanales			106	5	Chío		
49	6	Llano Mesas ..			107	5	Roque Cedro..		
50	2	Fagajesto......			108	5	El Junquillo...		
51	6	Brnco. Pinar...			109	5	Gutiérrez 1.....		
52	6	Tres Cruces ...			110	5	Gutiérrez 2....		
53	6	Montaña Alta .			111	5	Erjos..........		
54	7	Tamadaba 2...			112	2	San José.......		
55	7	Los Brezos....			113	5	Vergara 1		
56	7	Artenara			115	5	Escobones		
57	7	Taurito........			116	5	El Estrecho.....		
58	7	Las Niñas.....			117	5	Los Tomillos..		
59	7	Pajonales......			119	2	La Vega.......		
60	7	Inagua 1.......			120	2	El Tanque......		
62	7	Inagua 2.......			121	2	Portelas		
63	7	Brnco. Meca ..			122	5	Masca.........		
64	7	Roque Nublo..			123	5	La Fortaleza....		

Acc.	Mo.	Local.	Coordina.	I.	Acc.	Mo.	Local.	Coordina.	I.
124	5	La Guancha	28RCS4033	T	149	5	Güimar	28RCS5633	T
125	5	Pinar Icod 1	28RCS3732	T	150	5	Izaña 1	28RCS5128	T
126	5	Pinar Icod 2	28RCS3432	T	151	5	Pinar Arico	28RCS4832	T
127	5	Pinar Icod 3	28RCS3232	T	152	5	Brnco. Río 2	28RCS4721	T
128	5	El Charquido	28RCS5938	T	153	5	Izaña 2	28RCS5023	T
129	5	Brco. Corcho	28RCS5940	T	154	5	El Contador	28RCS5117	T
130	5	Fuente Joco	28RCS5638	T	155	2	Ca. Forestal	28RCS3738	T
131	5	La Crucita	28RCS5536	T	156	5	El Hospital	28RCS3129	T
132	5	Las Arenas	28RCS5735	T	157	5	Boca Tauce 3	28RCS3519	T
133	2	Aguamansa	28RCS5138	T	158	5	La Colorada	28RCS3518	T
134	5	La Orotava 1	28RCS4933	T	159	5	Teresme	28RCS3307	T
135	5	El Portillo	28RCS4533	T	160	5	Pinar Tijoco	28RCS3322	T
136	5	La Orotava 2	28RCS4733	T	161	5	Llano Negro	28RCS3120	T
137	5	La Orotava 3	28RCS5136	C	163	5	Canal Fyffes	28RCS3218	T
138	5	Agando	28RBS8210	G	164	5	Los Pechos	28RDR4592	C
139	5	Chipude	28RBS7611	G	165	7	Encantadora	28RBS7817	G
140	5	Las Hayas 1	28RBS7513	G	177	2	La Peña	28RBR0679	H
141	5	Las Hayas 2	28RBS7413	G	178	2	Montañetas	28RBR0878	H
142	5	Igualero	28RBS7810	G	179	1	Jinamar	28RBR0674	H
143	2	La Palmita	28RBS8217	G	180	4	Monte Agua	28RCS2134	T
144	5	San Lorenzo	28RBS7908	G	181	6	Las Garzas	28RDS3809	C
145	5	Monte Toriño	28RCS6644	T	183	1	Tábano	28RBR0271	H
146	5	Brco. Cueva	28RCS5418	T	184	2	Tiñor	28RBR1171	H
147	5	Las Chozas	28RCS5730	T	198	7	Infiernillo	28RDR5192	C
148	5	Lomo Benito	28RCS5432	T	199	5	Los Llanos	28RCS2333	T

Acc. = accession number; **Mo.** = morphological type, coded as follows: **1** = escobon of El Hierro, **2** = typical tagasaste, **3** = white tagasaste, **4** = white escobon of Tenerife, **5** = narrow-leaved escobon, **6** = white escobon of Gran Canaria, **7** = escobon of southern Gran Canaria; **Local.** = collection site; **Coordina.** = geographical coordinates on the Universal Transverse Mercator projection (UTM); **I** = island, coded as follows; **H** = El Hierro, **P** = La Palma, **G** = La Gomera, **T** = Tenerife, **C** = Gran Canaria.
Acc. = número de muestra; Mo. = tipo morfológico codificado como: 1 = escobón de El Hierro, 2 = tagasaste típico, 3 = tagasaste blanco, 4 = escobón blanco de Tenerife, 5 = escobón de hoja angosta, 6 = escobón blanco de Gran Canaria, 7 = escobón del sur de Gran Canaria; Local. = lugar de recolección; Coordina. = coordenadas geográficas en la Proyección Universal Transversal de Mercator (UTM); I = isla, codificada como: H = El Hierro, P = La Palma, G = La Gomera, T = Tenerife, C = Gran Canaria.

Gomera (Anonymous, 1975), for Tenerife (Hernández-Abreu, 1977), for La Palma (Santos-Guerra, 1984) and for Gran Canaria (Anonymous, 1989). Temperature data were not included in this study as most of the Canarian meteorological stations with records of temperature do not cover the whole distribution of the collection sites. However, due to the climatic features of the Canary Islands there is a strong relationship between temperature and altitude (Rivas-Martínez, 1987). Thus, the altitude of each population was considered to be a guide to the temperature. Both altitude and geographical coordinates on the Universal Transverse Mercator grid projection were obtained from maps published by the Servicio Geográfico del Ejército, Madrid (Maps scale 1:25.000, series 5V and scale 1:50.000, series L).

Electrical conductivity (EC) and pH were determined in solution (soil and water at ratio 1:1). Soil texture was determined by the pipette method, particle sizes and soils being classified following the USDA scheme (Porta-Casanelles, 1986).

Numerical analyses were carried out on a data matrix in which each population was regarded as an OTU (Operational Taxonomic Unit). The following seven variables were included: altitude, annual rainfall, pH, EC, and sand, clay and silt content. Prior to the analyses, data were rescaled to a mean of zero and a standard deviation of one. Ordination of populations was accomplished using Principal

Component Analysis (PCA) (CLUSTAN 3,2 package: Wishart, 1987) on the matrix of standardised data. Multivariate analyses of data through PCA provides a reduced dimensional model in which it is not only possible to identify putative relationships between populations or individuals (OTUs) but also to select those variables which account for most of the variation which exists between these OTUs. It is expected that this multivariate technique will help to define the patterns of ecogeographical variation which occur within the distribution range of C. proliferus.

RESULTS

Table 2 shows that most of the collection sites had sandy soils. The majority fell within the «sand», «loamy sand», «sandy loam» or «loam» USDA classes. Only 38 soil samples had less than 40 p. 100 of sand. Furthermore just three accessions of typical tagasaste, three of escobon of southern Gran Canaria, one of white escobon of Gran Canaria and one of narrow-leaved escobon were collected on clay soils. All the accessions of white tagasaste were collected in localities which had less than 10 p. 100 of clay. Results from EC and pH characterization were also rather uniform as none of the samples came from saline soils and the pH of most of the collection sites fell between 5 and 7 (Table 2). The highest pH value was 8 and it was found in a population of white tagasaste from La Caldera de Taburiente national park. Accession 53 was of white escobon of Gran Canaria and was collected in Montaña Alta (Guía district) from a soil of pH 4 which was the lowest pH observed.

TABLE 2

MEAN VALUES AND VARIATION RANGES FOR ECOGEOGRAPHICAL VARIABLES OF GERMPLASM COLLECTION SITES OF *CHAMAECYTISUS PROLIFERUS*

Valores medios y ámbitos de variación para variables ecogeográficas de lugares de recolección de germoplasma de Chamaecytisus proliferus

Morphological form *Tipo morfológico*	*N*	*Ph*	*Elec con* (dSm)	Sand *Arena* (%)	Silt *Limo* (%)	Clay *Arcilla* (%)	Altitude *Altitud* (m)	Raifall *Precip.* (mm)	*Or*
Typical tagasaste (wild and cultivated)	34	4,2-7,4 (6,1)	0,6-1,12 (0,30)	13-95 (57)	2-50 (31)	2-49 (12)	350-1.800 (900)	300-1.200 (695)	N-S
White tagasaste	5	6,8-8,0 (7,3)	0,11-0,18 (0,15)	65-90 (82)	5-25 (13)	4-10 (6)	600-1.550 (1.080)	700-750 (725)	N-S
Narrow-leaved escobon	58	4,6-7,6 (6.3)	0,02-0,74 (0.17)	21-88 (57)	8-56 (29)	2-44 (13)	400-2.150 (1.500)	275-800 (525)	N-S
White escobon of Tenerife	5	5,5-6,6 (5,9)	0,17-0,51 (0,37)	45-70 (61)	23-47 (33)	4-9 (6)	650-1,200 (900)	800-900 (840)	N
Escobon of southern Gran Canaria	41	4,8-7,8 (6,6)	0,07-0,64 (0,17)	21-88 (48)	9-54 (31)	3-48 (22)	350-1.600 (900)	175-850 (400)	N-S
White escobon of Gran Canaria	17	4,0-7,0 (5,6)	0,10-0,90 (0,27)	9-75 (43)	19-68 (34)	6-64 (24)	500-1.200 (930)	475-900 (650)	N
Escobon of El Hierro ..	2	6,8-6,9 (6,8)	0.18-0,22 (0,20)	83-84 (83)	11-11 (11)	5-6 (5)	1.000-1.150 (1.075)	600-700 (650)	N

N = number of localities; **Elec. con.** = electrical conductivity; **Or.** = geographical orientation. Mean values are given in brackets.

***N** = número de localidades; **Elec. con.** = conductividad eléctrica; **Precip** = precipitación anual; **Or.** = orientación geográfica. Se dan entre paréntesis los valores medios.*

In contrast with these results, data from the other variables (also shown in Table 2) yielded a greater range of variation. Annual rainfall varied between 1,200 mm, for an accession of wild tagasaste from northern La Palma, and 175 mm for germplasm of escobon of southern Gran Canaria collected in Barranco de Fataga in the south of this island. Most of the accessions of wild tagasaste, white escobon of Gran Canaria, white escobon of Tenerife and escobon of El Hierro were collected in areas with rainfall values greater than 750 mm. These morphological forms were only found on the northern slopes of the islands in those areas clearly associated with the north-eastern trade winds (Font-Tullot, 1955). Only the collection sites situated a lower altitudes showed low rainfall values. None of the accessions of these morphological forms was collected in zones with precipitation values below 500 mm.

Most of the accessions from the other three morphological forms namely, narrow-leaved escobon, escobon of southern Gran Canaria and white tagasaste were collected in zones with rainfall values smaller than 750 mm. All these populations were found growing on northern and southern slopes of the islands but in areas which were not under the direct influence of the trade winds. Eleven accessions of escobon of southern Gran Canaria and two of narrow leaved escobon were collected in areas with rainfall values lower than 300 mm.

The first three factors from PCA accounted for 36, 23, and 16 p. 100 of total variation, respectively. The variables responsible for separation along the first principal component were related to soil texture. They included (with component loading in parentheses) sand content (0,93), silt content (–0,75) and clay content (–0,68). Variables affecting separation along the second principal component included annual rainfall (0,77), pH (–0,58) and EC (0,53). Along the third principal component, collection sites were separated according to altitude (0,77), EC (–0,53) and silt content (0,42). Eight values for the last four components were less than one and therefore they were not included in this study.

Scatter diagrams with scores along the first three factors are shown in Figures 1 and 2. These two plots show that although there was a tendency for sites from Gran Canaria (indicated by triangle symbols in both Figures) to have positive values along the first factor there were no sharp discontinuities between the different islands or morphological forms along this component. Sites of cultivated tagasaste had both negative (accessions 9 and 4) and positive values on the first component (accessions 27 and 25), and similar results were observed for germplasm of the other morphological types.

Variation along the second component provided a better discrimination between morphological forms. Accessions with large negative values on this factor were collected in arid zones from the south of Tenerife and Gran Canaria. One accession of cultivated tagasaste from "Los Quemados, Teneguía" in the south of La Palma also had a low score along this component. Most of the collection sites of tagasaste, white tagasaste, escobon of El Hierro and the two white escobons of Tenerife and Gran Canaria did not exhibit such low values on this component. Accession 46 of white escobon of Gran Canaria and 19 and 155 of cultivated tagasaste had large positive scores along this component (Fig. 1) which was due to the fact that their soil samples had low pH and large EC values.

Scores along the third component are illustrated in Figure 2. Most of the accessions collected at high altitude had large positive scores on this component. Few collection sites of white escobon of Tenerife, white escobon of Gran Canaria, escobon of El Hierro and tagasaste had scores larger than zero along the third factor. However one site of cultivated tagasaste from Gran Canaria (accession 89) was found at high altitude in a zone where it is possible that winter frosts occur. It is

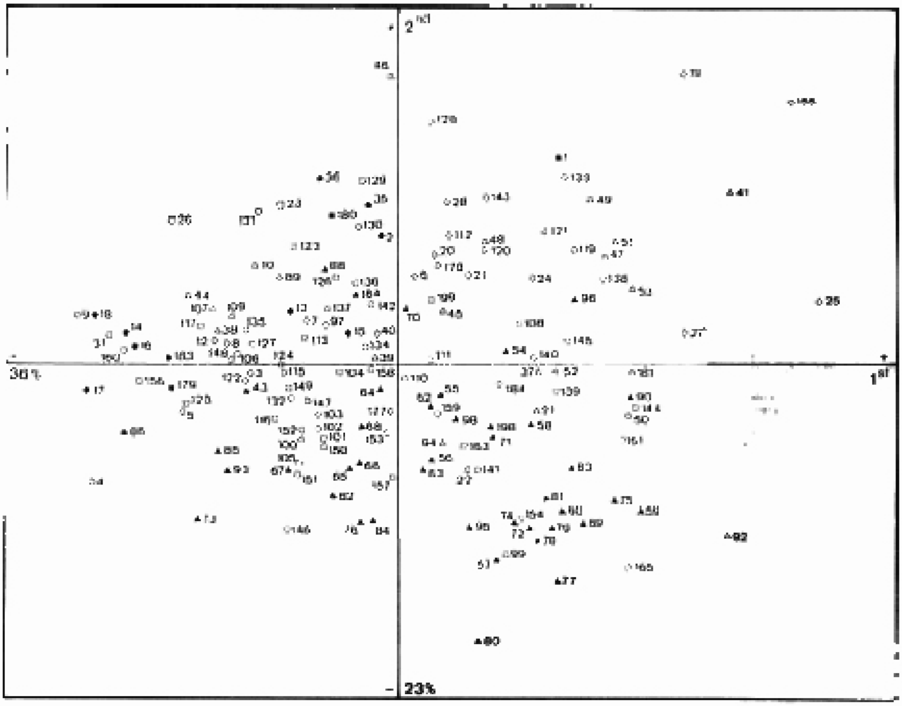

Fig. 1.—Scores along the first two factors of Principal Component Analysis for seven variables in 162 germplasm collections sites of *Chamaecytisus proliferus* in the Canary Islands. Cultivated tagasaste (◇), wild tagasaste (□), white tagasaste (◆), narrow-leaved escobon (○), white escobon of Tenerife (●), escobon of southern Gran Canaria (▲), white escobon of Gran Canaria (△), escobon of El Hierro (■).

Valores para los dos primeros factores del Análisis de Componentes Principales para siete variables en 162 lugares de recolección de germoplasma de Chamaecytisus proliferus *en las Islas Canarias. Tagasaste cultivado (◇), tagasaste silvestre (□), tagasaste blanco (◆), escobón de hoja angosta (○), escobón blanco de Tenerife (●), escobón del sur de Gran Canaria (▲), escobón blanco de Gran Canaria (△), escobón de El Hierro (■).*

worth mentioning that, during these field studies, populations of white tagasaste from high altitude areas of La Palma (e g. Pico de La Nieve, Barranco de Gallegos, Barranco de Los Tilos) were identified but it was not possible to collect germplasm from them. These populations are situated in areas where periodical frosts occur. The collection sites of white tagasaste which were at the highest altitudes were situated in «Los Escuchaderos» and «Barranco Bombas de Agua» at 1.550 and 1.500 metres respectively. It is believed that individuals from these populations might also have adaptation to low temperatures.

DISCUSSION

From these results there is good evidence that *C. proliferus* is a species adapted to non-saline, neutral, sandy soils, and which can grow under various climatological conditions. Its morphological forms display competitive ability in areas

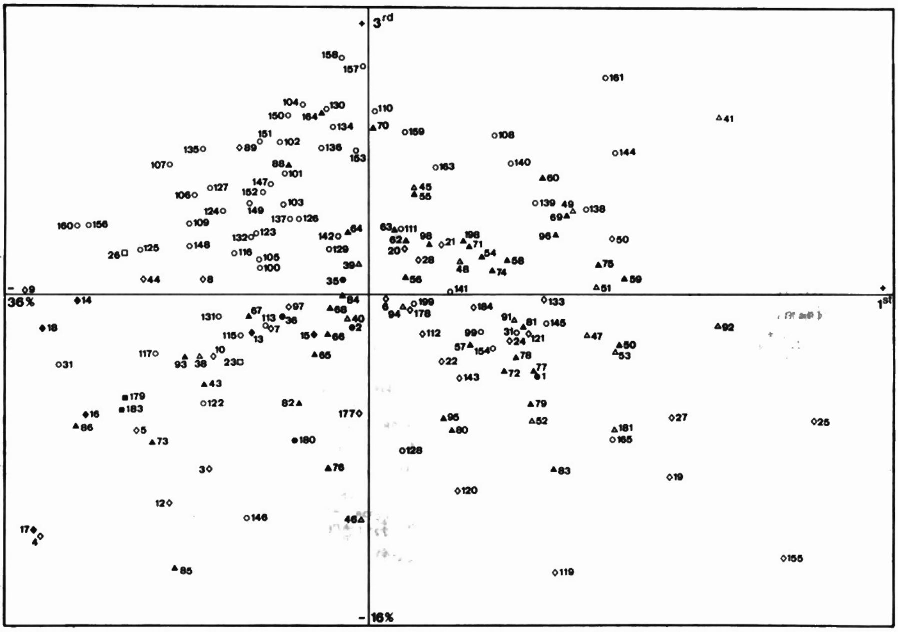

Fig. 2.—Scores along the first and third factors of Principal Component Analysis for seven variables in 162 germplasm collections sites of *Chamaecytisus proliferus* in the Canary Islands. Cultivated tagasaste (◇), wild tagasaste (□), white tagasaste (◆), narrow-leaved escobon (○), white escobon of Tenerife (●), escobon of southern Gran Canaria (▲), white escobon of Gran Canaria (△), escobon of El Hierro (■).

Valores para el primero y el tercero de los factores del Análisis de Componentes Principales para siete variables en 162 lugares de recolección de germoplasma de Chamaecytisus proliferus *en las Islas Canarias. Tagasaste cultivado (◇), tagasaste silvestre (□), tagasaste blanco (◆), escobón de hoja angosta (○), escobón blanco de Tenerife (●), escobón del sur de Gran Canaria (▲), escobón blanco de Gran Canaria (△), escobón de El Hierro (■).*

where strong summer drought or cold stress exist. However, the capacity of *C. proliferus* to grow under different ecological habitats is not equally shown in all the islands. Plants of the two morphological forms of Gran Canaria appear to be adapted to a wider range of rainfall and altitude conditions. This ecological performance was only partially shown by narrow-leaved escobon in Tenerife. All the other morphological forms had more restricted habitat preferences. White escobon of Tenerife, typical tagasaste and escobon of El Hierro were only found in a narrow belt which was under the direct influence of the north-eastern trade winds. The other morphological form from La Palma, white tagasaste, had ecological similarities with narrow-leaved escobon and escobon of southern Gran Canaria. However it was confined to the Canary pine *(Pinus canariensis)* forest, on northern slopes, and to La Caldera de Taburiente, and it was never found at low altitudes or in the rest of the pine forest of this island.

These ecological features of the *C. Proliferus* complex suggest that ecological variation increases in the archipelago from west (El Hierro) to east (Gran Canaria) and that each of the morphological variants has particular ecological requirements. Consequently results described here indicate that previous reports (Esteve-Chueca, 1969; Sunding, 1972; Rivas Martínez, 1987) which gave all the morphological forms of *C. Proliferus* as characteristic and indicators of the Canary pine plant communities were not correct.

These ecological data agree with the proposal of Acebes-Ginovés (1990) and Francisco-Ortega (1992) that typical tagasaste, white escobon of Tenerife, escobon of El Hierro and white escobon of Gran Canaria are linked with those plant communities associated with the trade winds namely, the laurel *(Laurus azorica)* wood and heath *(Erica arborea)* belt, whereas narrow-leaved escobon, white tagasaste and escobon of southern Gran Canaria are associated with Canary pine formations. However, they also show that within this ecological framework, escobon of southern Gran Canaria is adapted to the most arid conditions, whereas narrow-leaved escobon has many of its populations at high altitude in areas where periodical frosts occur. However, within each of the morphological forms there is considerable adaptive ability. This was particularly true with germplasm of cultivated tagasaste. Both Pérez de Paz *et al.* (1986) and Acebes-Ginovés (1990) claimed that wild tagasaste is associated with sunny areas of the borders of the laurel wood and heath belt in La Palma. Nevertheless, germplasm of cultivated tagasaste was collected in zones outside this kind of habitat. Collection sites of cultivated tagasaste were identified in arid zones of southern La Palma and in high altitude areas of Gran Canaria.

Texture and chemical characterisation of soils indicate that these have not played an important role in the morphological differentiation of the *C. proliferus* complex. This species could be regarded as an heliophyle species which has a tendency to grow in those areas where the forest is not so dense (Pérez de Paz *et al.*, 1986). Due to the rough topography of the islands and the high levels of erosion existing, the landscape of the Canary Islands is strongly marked by small ravines and cliffs where the forest is not so dense. It is in these areas where the forest is more open, and the habitat is sunnier where *C. proliferus* reaches its optimal development. These ravines and cliffs have been subjected to an intense process of erosion and somehow have soils which are more sandy and acid than those of the neighbouring plant communities. Having a high adaptation to sandy and acid soils *C. proliferus* can exploit those habitats where *Pinus canariensis* and other trees (e.g. *Erica arborea, Laurus azorica*) appear not to find their optimum ecological conditions. This ecological feature of *C. proliferus* could explain the homogeneity of the soils where the species exists. A closer examination of the results from texture analyses reveals that all the sites whose samples had more than 80 p. 100 sand were situated in the bottom of gorges (e.g. «Barranco de Guayadeque» in Gran Canaria, «Barranco de Bombas de Agua» in La Palma). Floristic studies also indicated that all these sites had *C. proliferus* and other shrubs as dominant species as P. canariensis did not colonise these niches (Francisco-Ortega, 1992).

This observation on the ecological competition between the Canary pine and the escobon seems to confirm previous reports from Ceballos, Ortuño (1951, 1976) and Pérez de Paz *et al.* (1986) and suggests that many populations of narrow-leaved escobon might have vanished from those areas of Tenerife which were subjected to dense pine forest reforestation during the period 1946-1950.

An ecogeographical interpretation (IBPGR, 1985) can be placed upon the results shown in this paper, which can be summarised as follows:

1. Distribution of the seven morphological types which form the *C. proliferus* complex in the Canary Islands are clearly associated with particular regions and ecosystems. White escobon of Gran Canaria, typical tagasaste in La Palma, white escobon of Tenerife and escobon of El Hierro broadly share similar habitats in what is a clear case of vicariance. Both escobon of southern Canaria and narrow-leaved escobon in Tenerife, La Gomera and Gran Canaria are associated with zones

which are not under the influence of the trade winds and constitute the other example of vicariance in this complex.

2. There is a relationship between survival and frequency of each one of these morphological variants and associated ecological conditions. Populations of narrow-leaved escobon and white tagasaste were found in areas which are subjected to frost during part of the year whereas escobon of southern Gran Canaria reached zones with low rainfall which suggests that it might be a drought resistant form. Furthermore, analyses of morphological variants indicated that traits such as seed colour in Gran Canaria and leaf hairiness in La Palma and Tenerife followed a north-south ecogeographical cline in these islands (Francisco-Ortega, 1992).

3. Despite the fact that final decisions on germplasm utilisation should be supported by proper evaluation trials, and not solely on provenance data, preliminary sample selections for such trials can only be based on information from the collection sites. However these decisions should consider not only the ecological data from each of these sites but also the broad geographical boundaries which occur between each island. In this respect it is worth mentioning that Peeters *et al.* (1990) found that simple geographical data related to geopolitical boundaries gave good results in the selection of barley samples for salt tolerance. As each island can be considered as an isolated geographical unit it is likely that some characters have arisen and are found within such limits. Therefore it is recommended that strategies for germplasm evaluation should firstly consider samples according to island origin, and secondly define subsamples from each of these islands according to climatic and geographical variables.

The collection sites of *C. proliferus* analysed in this paper were not ecologically uniform. Germplasm from clay soils and from zones with low temperature and a strong drought season was identified. This suggests that the species is variable in its ability to survive under various environmental conditions. Therefore there is a good prospect for the further exploitation and utilisation of the plant genetic resources of this species.

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RESUMEN

Caracterización ecogeográfica de germoplasma de tagasaste y escobón (*Chamaecytisus proliferus* (L. fil.) Link *sensu lato*) en las Islas Canarias caracteres edafológicos, climatológicos y geográficos

Se dan los resultados del análisis edafológico de la textura, la conductividad y el pH, así como de la altitud y la precipitación de 162 hábitats de poblaciones cultivadas y silvestres de tagasaste y escobón

(Chamaecytisus proliferus (L. fil.) Link *sensu lato)*, cuyo germoplasma se encuentra en el Centro de Conservación de Recursos Fitogenéticos, en Alcalá de Henares, Madrid. La especie tiene su óptimo en suelos franco arenosos con bajo contenido salino y con valores de pH entre 5 y 7. Escobón de El Hierro, tagasaste, escobón blanco de Tenerife y escobón blanco de Gran Canaria se distribuyen en áreas del norte de las islas bajo la influencia de los vientos alisios. El escobón de hoja angosta y el escobón del sur de Gran Canaria se encuentran en zonas tanto del norte como del sur que no reciben la acción de estos vientos. Se identifica germoplasma recolectado en zonas que no están libres de heladas y en zonas áridas. La variabilidad ecogeográfica de esta leguminosa forrajera aumenta de oeste a este. Se recomienda que futuras estrategias para la utilización de sus recursos fitogenéticos deben considerar tanto los datos ecogeográficos como el origen insular del germoplasma.

PALABRAS CLAVE: *Chamaecytisus proliferus*
Ecogeografía
Escobón
Forraje
Germoplasma
Leguminosas
Tagasaste

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