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Effects of abandoning long-term goat grazing on species composition and species richness of pastures at La Gomera, Canary Islands

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Abstract

Goat grazing management is a powerful ecological force structuring plant communities which effects are highly different depending on factors such as climatic conditions, grazing intensity, type of plant community, etc. Pastures in the Canary Islands have important heritage, socioeconomic and landscape values because they are the remains of traditional livestock management and a key element of local economy. An experimental study of goat grazing exclusion has been carried out in an area of La Gomera Island to determine the main effects of grazing abandonment on species richness and species composition. The species composition of La Gomera pastures is more sensitive to grazing than to climatic variability, though effects in the species richness in relation to grazing were not detected. Because the pasture origin in this area involved artificial, removing of non useful plants in order to provide land for agriculture more than 300 years ago, and using it for pastures around 80 years ago, the sustainable use has maintained this rich plant community. Grazing abandonment can have a negative effect on the pastures' diversity, as grazing has been a strong force in the maintenance of certain species. Public promotion of this primary activity is suggested to allow the continuation with minimal effects on the vegetation composition. This will help to conserve the high diversity of this area and the promotion of natural values as well as traditional and sustainable human activities.

Additional key words: detrended correspondence analysis; plant community; rarefaction; sustainability.

Resumen

Efectos a largo plazo del abandono del pastoreo de cabras en la composición y riqueza de especies en los pastizales de La Gomera, Islas Canarias

El pastoreo caprino es una importante fuerza estructurante de las comunidades de plantas, con efectos altamente dependientes de factores como las condiciones climáticas, la intensidad de pastoreo y el tipo de comunidad entre otros. Los pastizales de las Islas Canarias tienen valores culturales, socioeconómicos y paisajísticos importantes, puesto que son remanentes de actividades tradicionales y elementos clave de la economía local. Se ha llevado a cabo un estudio de exclusión del ramoneo de cabras en la isla de La Gomera para determinar los efectos del abandono del pastoreo en la riqueza y composición de especies de sus pastizales. La composición de especies de los pastizales está más influenciada por el pastoreo que por la variabilidad climática, aunque no se detectaron efectos en la riqueza de especies entre áreas pastoreadas y no pastoreadas. La explotación sostenible de estos ecosistemas para fines agrícolas desde hace más de 300 años y como pasto desde hace aproximadamente 80 años, ha mantenido su alta riqueza de especies. El abandono del pastoreo puede afectar negativamente a la diversidad de los pastizales, al haber sido una importante fuerza para el mantenimiento de ciertas especies. Se sugiere la promoción pública de esta actividad para asegurar su continuación con mínimos efectos en la composición de la vegetación, así como para ayudar a conservar los altos valores de diversidad de estos ecosistemas y la promoción de sus valores naturales y de las actividades tradicionales sostenibles.

Palabras clave adicionales: análisis de correspondencia corregido; comunidad de plantas; rarefacción; sostenibilidad.

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Abbreviations used: DCA (detrended correspondence analysis); SCP (species relative frequency).

Introduction

Goat grazing management has been a traditional sustainable land use in many areas of the planet (Milchunas *et al*., 1988; Crawley, 1997) requiring correct grazing management to maintain the species composition and the high diversity values of the plant communities of grazing lands (Baldock *et al.,* 1994; Olff and Ritchie, 1998). In spite of this traditional and sustainable use, the effects cause remarkable and significant variation in species composition (Casado *et al.,* 2004; Arévalo *et al*., 2007).

Grazing effects on species richness and species composition are contradictory in many studies (Olff and Ritchie, 1998) and there are studies concluding that herbivores can enhance, have weak effects or even have a negative impact on plant diversity and richness (Osem *et al*., 2002; De-Bello *et al*., 2007) as well as different effects on soil nutrients (McIntosh *et al*., 1997; Bakker *et al*., 2004; Peco *et al*., 2006; Fernández-Lugo *et al*., 2009). The lack of consistent responses has been attributed to factors such as the evolutionary history of grazing, productivity gradients or grazing intensity (Milchunas and Lauenroth, 1993). The high context dependence of grazing effects on ecosystems highlights the need to carry out studies that allow us to identify the intrinsic dynamics of the pastures in each region (Perevolotsky and Seligman, 1998; De-Bello, 2006).

Pastures in the Canary Islands have an anthropogenic and recent origin, but they have important heritage, socioeconomic and landscape values because they are the remains of traditional livestock management and a key element of the local economy (Mata *et al*., 2000; Arévalo *et al*., 2007). Canarian pastures are fragmented and of modest size (González *et al.,* 1986). They are very rich plant communities, something that can be attributed to their history, management and dynamics (Arévalo *et al*., 2007). These ecosystems are grazed by goats, which are the most common grazer animal in the archipelago (Bermejo, 2003). These plant communities are an important traditional economic resource exploited by the local population. However, as experienced by industrialized countries, changes in the farming industry have led to these extensive livestock systems either being intensified or abandoned (García Dory and Martínez, 1988; Marrero and Capote, 2001). This process is not concluded yet (Bermejo, 2003) and the abandonment of this traditional activity becomes more evident every day.

The study of grazing abandonment effects has potential management implications (setting the maximum number of animals, suggesting promoting the traditional activity in the protected area...), environmental (plant and animal protection, exotic species...) and socioeconomic importance, and is necessary to achieve conservation of these ecosystems. The main hypothesis of this study is that grazing abandonment will significantly change species composition and species richness in these pastures, and the second hypothesis is that climatic variability will drive important changes in species composition from year to year. The results will provide useful information that will help managers to continue with this activity, which is of high cultural value at present.

Material and methods

Study site

Field work was carried out in two natural protected areas, *Valle Gran Rey* Rural Park and Natural Monument of *Lomo del Carretón*, located in the south western part of the island of La Gomera (28°02' N; 17° 12' W), Canary Islands (Spain). Total studied area comprises 2,193 ha; from 0 m a.s.l. to 900 m a.s.l., with deep ravines and few plains. The area is characterized by a Mediterranean climate, with a dry season in summer and a humid season in winter and spring. The long-term (1955-2005) mean annual precipitation is 138.8 ± 23.2 mm and mean annual temperature is 14.8 ± 0.7°C (Marzol, 2000). During the study period, 2003 was a drier year (103.4 mm), 2001-2002 and 2004 received close to the mean, and 2004 received the highest rainfall (377.1 mm). The mean rainfall in the studied period was higher (243.4 mm) that the long-term mean (237, 209, 103, 377, 289 mm respectively for each year).

Volcanic rock forms the majority of the area, included as recent basalts (Villalba and Santana, 2000) and the soil have been considered as brown soils and litosoils (Rodríguez and Mora, 2000).

Natural vegetation in the area varied from sweet spurge scrubland (*Euphorbia balsamifera*) covering the lowest parts of the slopes (0-400 m a.s.l.) and «cardonal» or *E. canariensis* shrubland growing above (400-600 m a.s.l.), to the upper parts which were dominated by thermophilous vegetation (600-900 m a.s.l.) mainly represented by the tree *Juniperus turbinata*. In the beds of ravines the palm tree *Phoenix canariensis* formed palm grooves (Del-Arco *et al*., 2006). Little of the natural vegetation remains today, mainly due to the deforestation of the thermophilous woodland to provide wood and open lands for agriculture and grazing that become an important activity around 80 years ago.

At present, main plant communities of both Natural Protected Areas are the coastal shrubland (0-600 m a.s.l.) extended in the previous distribution of natural shrubland and dominated by *E. berthelotii* and other shrubs; and pastures occupying abandoned terraces, which are abundant in both areas and cover the altitudinal gradient, composed of grasses (*Stipa capensis*, *Hyparrhenia hirta*, *Brachypodium distachyon*, *Bromus* spp., etc.), legumes (*Medicago* spp. and *Trifolium* spp.) and other forbs (*Notoceras bicorne*, *Cynara cardunculus*, *Plantago lagopus*, *Ajuga iva*, *Convolvulus althaeoides*, etc.). Fragments of palm grooves and *E. canariensis* scrublands persist in both areas, whereas small stands of *E. balsmifera* and *J. turbinata* forest are present in Valle Gran Rey and Lomo del Carretón respectively (Del-Arco *et al.,* 2006). However, these natural communities were not included in the study due to their inaccessible location or in the case of palm grooves, because they have been traditionally kept for agricultural uses different from grazing.

Grazing areas of this study cover up to 1,418 ha where 31 farmers practice mainly goat grazing with animals belonging to the Canarian breeds. Mean stocking rate is 0.21 ± 0.18 animals ha^{-1} day^{-1}, using mainly a continuous grazing system. There are no cultivated pastures in the Canary Islands, and all the study areas were spontaneous pastures that appeared after removing the shrubland. This area includes 775 ha on which grazing had been abandoned for more than 10 years. Boths grazed *vs.* ungrazed areas are similar in terms of vegetation composition, geology, soil and land use (except for grazing management).

Design of the study

A total of 41 permanent transects, each 30 m long, were located randomly in the study area, with point samples taken every 0.3 m; *i.e.* 100 points in every transect (Daget and Poissonet, 1971). Twenty-five transects were distributed in grazed areas and 16 in non-grazed areas following a stratified sampling (60% of the area was under grazing management; Fig. 1).

These abandoned areas were similar on soil characteristics (Rodríguez and Mora, 2000) and the abandonment was more related with the gradually movement of rural population to urban areas. Altitude of transects is not significantly different among transects in grazed areas and in abandoned areas (Student $t = -5.69$, for $n = 1$ and $p > 0.05$) for our study area. Five transects were lost in 2001 (4 in grazed *vs*. 1 in non-grazed), two in 2002 (1 in grazed *vs*. 1 in non-grazed) to 2004 and one in 2005 (grazed transect) due to some location problems and vandalism. Also, as it can be seen in Figure 1, the abandonment is patchily organized. Because of that, these areas are comparable in order to environmental conditions.

All transects were georeferenced, with fixed UTM coordinates and a fixed orientation for each, in order to make possible the recording of data from the same location, every year, with high precision and to reduce sampling error.

The presented results are base on measurements taken between the years 2001 and 2005. Species composition and frequency was measured using the point-quadrat intersect method (Daget and Poissonet, 1971), recording 100 point samples in each transect. Species relative frequency was calculated as the number of points in which a species appears with regard to the sum of all points in which species are found in the transect (total of points touched by a species divided by the sum of total touches of all species; Bullock *et al*., 2001; Del-Pozo *et al*., 2006):

$$SCP_{ijk} = \frac{\Sigma P_{ijk}}{\Sigma P_{jk}}$$

where SCP_{ijk} = specific contribution by presence of a species i in the transect j in year k; P_{ijk} = points in which species i appears in transect j in year k; and P_{jk} = points in which any species appear in transect j in year k.

Statistical analysis

Rarefaction represents a powerful statistical method to calculate the expected number of species as a function of the sampling effort. In this study, effort is quantified in terms of the number of transects for which the species abundance was calculated using the SCP values. Species rarefaction curve was calculated (Hurlbert, 1971; Heck *et al*., 1975) for transects, separating grazed and non-grazed areas at the different years. Based on the rarefaction curves, the number of species were compared for grazed and non-grazed transects, using the highest possible sampling intensity for the five years (12 transects), with a non-parametric Wilcoxon test (for a $p < 0.05$, $n = 5$).

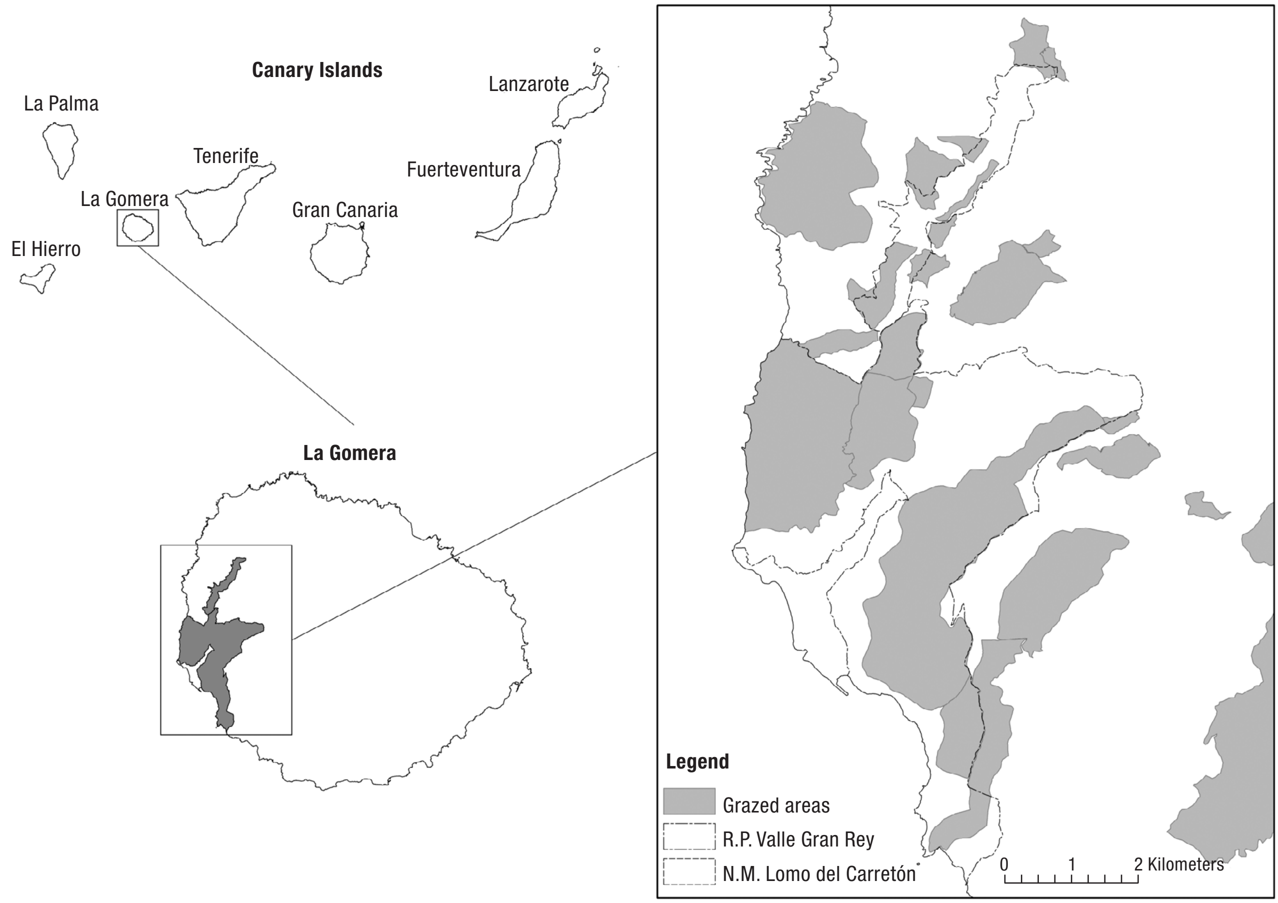

Figure 1. Canary Islands, showing the *Valle Gran Rey* Rural Park and Natural Monument of *Lomo del Carretón* and in grey indicating the grazed zones of the two protected areas.

We analyzed species richness of transects as a dependent variable with respect two factors: grazing *vs*. ungrazed and the sampled year, and added altitude as a covariable (as long as it an important variable affecting species richness) using an analysis of covariance (ANCOVA, $p < 0.05$). Normality of the data was checked with the Komogorov-Smirnov test, and homoscedasticity of the data was examined with a Levene contrast (for $p < 0.05$). The post-hoc Tukey tests was used to detect significant differences among groups found different overall ($p < 0.05$). Due to the large set of statistical contrasts a multiple test procedure of Holm for independent tests (Legendre and Legendre, 1998) was also applied.

Detrended correspondence analysis (DCA) (Hill and Gauch, 1980) was used to examine how species composition differed among transects and changed over time in the different sampling years using the ordination package CANOCO (Ter-Braak and Šmilauer, 1998). Analyses were based on species abundances calculated as SCP. Other ordination techniques are based on sample distances (multidimensional scaling) or similarities to composed groups (classification). However, the best way to analyze species composition is gradient analysis, as long as is the canonical answer of the species to environmental gradient (Gauch, 1982). In the case of the DCA, this technique improves other gradient analysis techniques, as long as correct the compression of scores of samples at the end of the axes and the quadratic relationship of firsts axis with the second (Jongman *et al*., 1987).

To determine if DCA axes are able to discriminate the species composition based on the treatments (grazed *vs*. ungrazed, the dependent variable), the coordinates of transects from the DCA for axes I and II were analyzed using logistic regression (using the statistical of Wald for a $p < 0.05$). The DCA coordinates of axes I and II for transects were correlated with the sampling year of that transect to determine if the axes' gradients are related to the annual variability, and also these axes coordinates were correlated with the annual precipitation of the year (using the Pearson correlation coefficient, for $p < 0.05$ and $n = 192$). In order to reveal the relationship of the DCA transects' scores (axes I and II) with altitude, the Pearson correlation coefficient was calculated among these variables. Altitude is the strongest environmental gradient in the occidental Canary Islands, which are characterized by strong altitudinal gradients as occur in La Gomera (Fernández-Palacios and De-Nicolás, 1995; Arévalo *et al*., 2005).

Basic statistical methods according to Zar (1984) were implemented using the SPSS computer package (SPSS, 1997).

Results

A total of 214 species (Appendix A) were found throughout the study, but the number of species changed from year to year (73, 119, 132, 115 and 147 from 2001 to 2005 respectively).

The generated rarefaction curves to discriminated between grazed *vs.* abandoned transects (Fig. 2), showed not significant differences in the number of species at a similar sampling effort ($Z = -1.483$, for $n = 5$ and $p > 0.05$), using the Wilcoxon test, for both the highest possible sampling effort (12 transects) and for sampling each year.

Once tested the normality and homocedasticity of the data, the ANCOVA revealed similar results as the rarefaction analysis. Grazing effect on species richness was revealed not significant ($F_{1,193} = 0.722$, $p > 0.05$) as well as the interaction grazing *vs*. year ($F_{4,193} = 0.722$, $p > 0.05$), while the year of sampling was a significant effect on species richness ($F_{4,193} = 0.722$, $p < 0.01$). The Tuckey test indicated two groups of years: 2001-2004 *vs*. 2002, 2003 and 2005 that differed significatively ($p < 0.05$).

The DCA analysis revealed an important variability based on the species relative frequency, with almost 7 SD (standard deviation units) for axis I and 5 SD between transects for axis II, indicating that there are no species in common between many transects. Discrimination based on the sampled years showed not significant differences in any of the axes (Fig. 3). The Pearson correlation coefficient of the years *vs*. transect scores for axes I and II did not reveal significant correlation (for axis I $r = 0.105$, $p > 0.05$ and for axis II $r = -0.071$, $p > 0.05$, in both cases $n = 193$), meaning that the species gradient in species composition revealed by both axes cannot be attributed to the differences in year. The same analyses but using annual precipitation of the year reported similar results (for axis I $r = -0.058$, $p > 0.05$ and for axis II $r = 0.079$, $p > 0.05$, in both cases $n = 193$).

Discrimination based on grazed *vs*. non-grazed (Fig. 4) using a logistic regression revealed no relationship between the scores of transects in axis I and the treatment (B = –0.347, Wald statistic = 4.207, $p > 0.05$), but the relationship between the transect scores of axis II and the treatment was revealed significant (B = –1.291, Wald statistic = 25.857, $p < 0.01$). When we correlated the axes' scores with the altitude of transects, axis I was highly related to altitude ($r = 0.777$, $p < 0.001$)

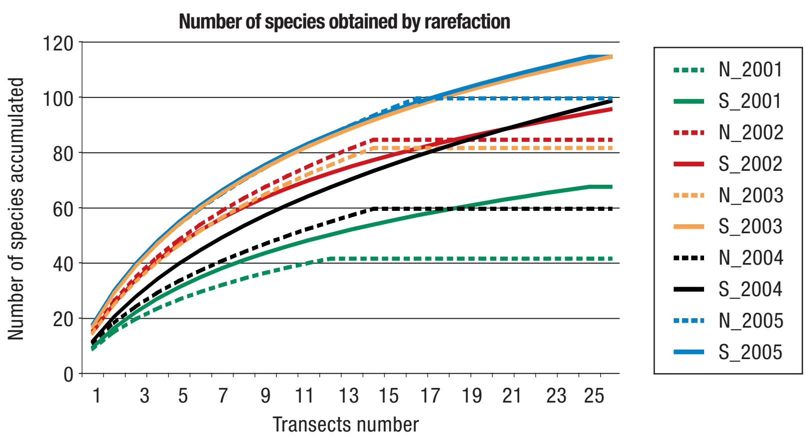

Figure 2. Mean values of species numbers obtained by rarefaction for each year and management treatment (grazed *vs*. ungrazed). The vertical line indicated the minimum sampling effort for which value differences in species richness were compared in grazed areas (S) *vs*. non-grazed (N).

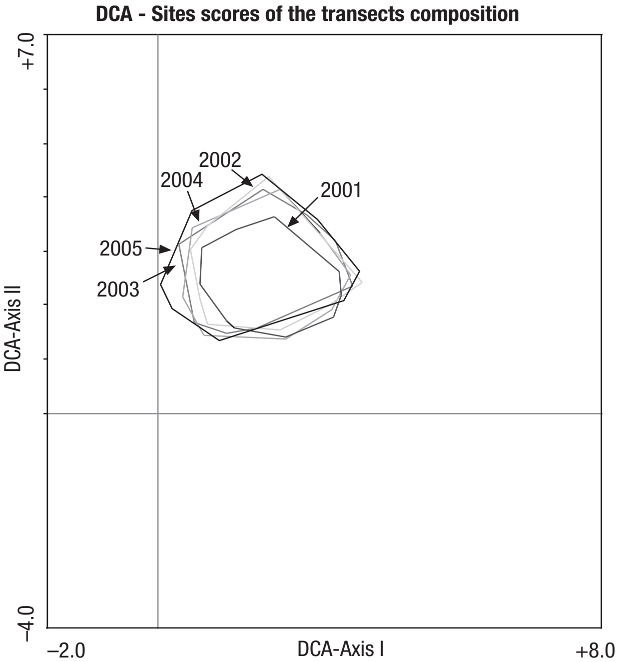

Figure 3. Detrended correspondence analysis (DCA) transect scores for species richness by year of sampling. Polygons enclosed 90% of the transects using the minimum possible area (each year polygon for each year indicated with an arrow). Eigenvalue of axis I: 0.295 and axis II: 0.202, with a 35% of total inertia explained by both axes.

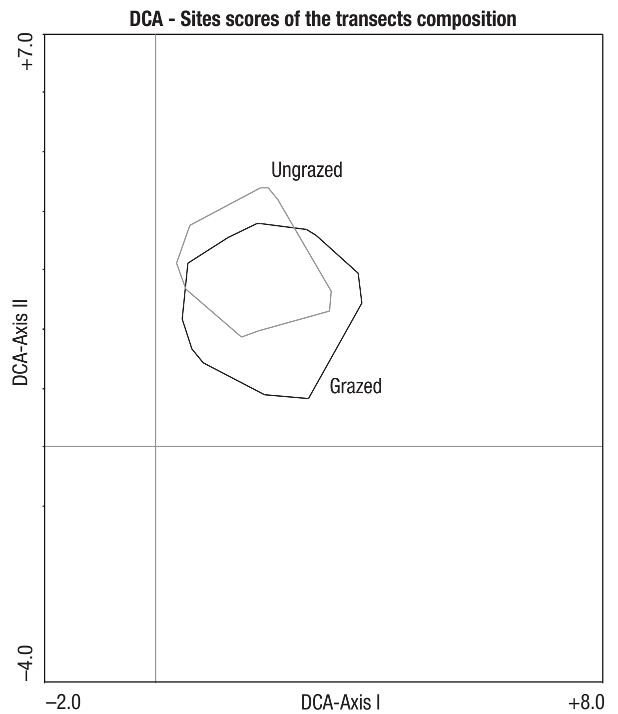

Figure 4. Detrended correspondence analysis (DCA) transect scores. Polygons enclosed 90% of the transects of each treatment.

while this relationship was not significant for axis II ($r = -0.136$, $p > 0.05$ and $n = 193$ in both cases).

A great variability is shown in the species scores determined by both DCA axes. A long gradient related to altitude revealed in axis I implicates the dominance of species such as *Aizoon canariense*, *Lycium intricatum*, *Eragrostis barrelieri*, *Sinapis alba*, *Lotus glinoides, Euphorbia balsamifera, Mesembryanthemum nodiflorum* and *Neochamaelea pulverulenta* at low altitude and *Ornithopus compressus*, *Trifolium arvense*, *Andryala pinnatifida*, or *Vulpia sp*. at higher altitude. With regard to axis II, some species are dominant in non-grazed transects, such as *Atalanthus pinnatus*, *Pimpinela* sp., *Daucus carota*, *Brachypodium arbuscula*, *Dactylis smithii*, *Ceropegia dichotoma*, *Retama rhodorhizoides*, *Piptatherum coerulescens*, *Phoenix canariensis* or *Cistus monspelienseis*, while some species are more common at the transects located in the grazed areas, such as *Scandix pecten-veneris*, *Sisymbrium irio*, *Lamarckia aurea*, *Raphanus raphanistrum*, *Carduus tenuiflorus*, *Sagina apetala*, *Notoceras bicorne* or *Calamintha sylvatica* (Fig. 5).

Discussion

Previous studies of grazing effects on plant species composition and species richness have traditionally been inconsistent and conflicting in their results, lacking a general model that predicts the response of grazing intensity or abandonment (Olff and Ritchie, 1998; Peco *et al*., 2006). Although fluctuations in total annual rainfall in Mediterranean areas has been considered as one of the most important parameters determining changes in pastures species composition (Figueroa and Davy, 1991; Espigares and Peco, 1995), this effect was not found important. Over the last 5 years of the study, precipitation ranged from 103 mm to 377 mm yr^{-1}, but it did not have a significant effect on species composition in function of the year (Fig. 3).

In contrast, it was found that goat grazing had a significant effect on species composition (Fig. 4) but not on species richness (Fig. 2), analyzing these with rarefaction and with statistical contrast. Many studies have demonstrated that grazing has an impact on species richness (Olff and Ritchie, 1998), although it is dependent on spatial-scale and highly related to climate variability (Huston, 1994; Cingolani *et al*., 2005) and resources availability (Milchunas *et al*., 1988; Osem *et al*., 2002). In arid environments such

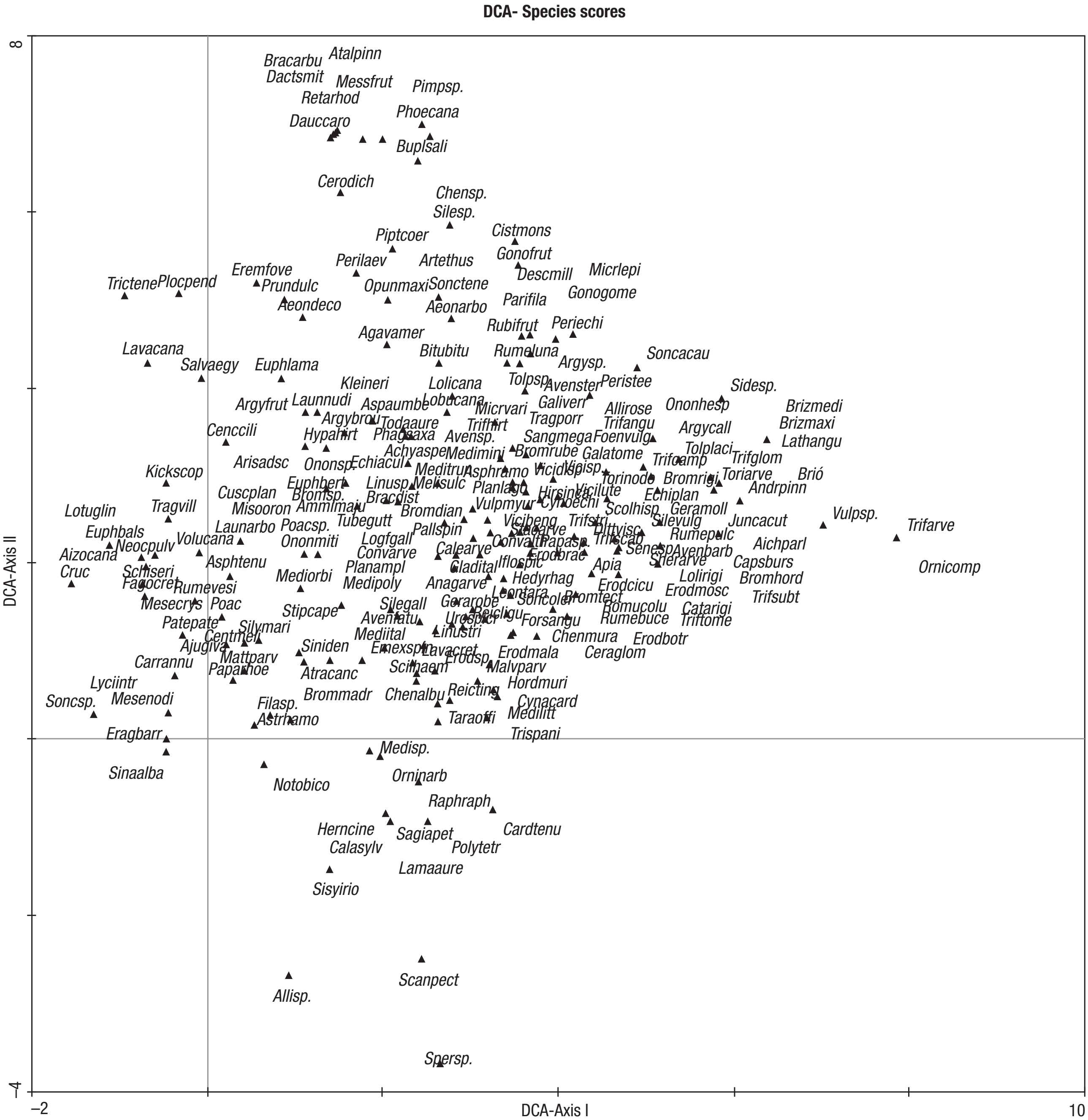

Figure 5. Detrended correspondence analysis (DCA) coordinates of the species composition per transect. Species are labelled with the first four letters of the genus followed by the first four letters of the specific epithet (as appears in appendix A).

as the study area, it is unlikely that species richness increase in grazed areas because plant growth and diversity would be limited rather by soil resources than aboveground competition, therefore grazing did not reveal any effect on species richness (Olff and Ritchie, 1998).

Altitudinal gradients are very important in the distribution of species (Hubbard and Wilson, 1988; Ullman *et al.*, 1995), particularly in islands with a strong altitudinal gradient like Tenerife or Gran Canaria (Arévalo *et al.*, 2005). A strong and significant effect of altitude on species distribution was found over the 750 altitudinal gradient of transects. In spite of this gradient, it did not obscure the variation produced by grazing management in species composition.

The species composition of pastures on La Gomera was more sensitive to grazing than climatic variability, but this study did not detect effects in species richness in relation with grazing. The climatic variability, as expected, was an important variable also determining species composition. The pastures origin in this area is related to artificial removing of non useful plants more than 300 years ago (González *et al*., 1986). Consequently, grazing abandonment can have a significant effect in the pastures' diversity, since grazing is a strong force in the maintenance of some species. Although is true that the dominant group of species are ruderal, some endemic species of La Gomera (*Euphorbia bertelotii*) and endemic species of the archipelago (*Micromeria varia*, *Echium aculeatum* or *Kikcia scoparia*) appeared in the inventories. Because of that, we suggest promotion of this traditional activity to conserve natural values as well as traditional sustainable human activities.

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Appendix A. Species list of the 214 species found in the survey sorted by their importance value (calculated as the percentage of presence in all the transects at different years). Nomenclature follows Izquierdo *et al.* (2004)

a) Species name	Importance value
Trifolium tomentosum	67.4
Trifolium subterraneum	63.7
Plantago amplexicaulis	45.1
Sonchus acaulis	40.9
Sonchus tenerrimus	36.8
Sanguisorba megacarpa	35.8
Lycium intricatum	34.2
Rumex lunaria	33.2
Bituminaria bituminosa	30.1
Convolvulus althaeoides	30.1
Kleinia neriifolia	28.5
Lavandula canariensis	23.3
Ononis sp.	21.8
Gladiolus italicus	21.8
Ononis mitissima	21.8
Raphanus raphanistrum	21.2
Briza media	18.7
Carduus tenuiflorus	17.4
Emex spinosa	17.1
Achyranthes aspera	16.6
Mesembryanthemum nodiflorum	16.1
Anagallis arvensis	16.1
Silybum marianum	15.0
Aeonium arboreum	15.0
Sherardia arvensis	15.0
Bupleurum salicifolium	14.2
Ammi majus	14.0
Mesembryanthemum crystallinum	14.0
Avena barbata	13.5
Micromeria varia	13.0
Notoceras bicorne	12.4
Phagnalon saxatile	11.4
Ifloga spicata	11.4
Calendula arvensis	11.2
Lobularia canariensis	9.8
Filago sp.	9.8
Piptatherum coerulescens	9.3
Dactylis smithii	9.3
Bromus rigidus	8.9
Stipa capensis	8.3
Centaurea melitensis	7.8
Hyparrhenia hirta	7.8
Kickxia scoparia	7.8
Prunus dulcis	7.8
Cynara cardunculus	7.3
Phoenix canariensis	7.3
Argyranthemum sp.	7.3
Vulpia myuros	6.2
Trifolium campestre	6.2
Hedypnois rhagadioloides	6.2
Vicia sp.	6.2
Capsella bursa-pastoris	5.7
Avena sterilis	5.7

b) Species name	Importance value
Sonchus sp.	5.7
Apiaceae	5.7
Bromus diandrus	5.2
Medicago minima	5.2
Erodium cicutarium	5.2
Aristida adscensionis	5.2
Astragalus hamosus	5.2
Lathyrus angulatus	5.2
Echium plantagineum	5.2
Ajuga iva	5.2
Argyranthemum broussonetii	5.2
Misopates orontium	5.2
Carrichtera annua	4.7
Retama rhodorhizoides	4.7
Malva parviflora	4.7
Trifolium angustifolium	4.7
Torilis nodosa	4.7
Tolpis laciniata	4.7
Schizogyne sericea	4.7
Scilla haemorrhoidalis	4.1
Medicago orbicularis	4.1
Argyranthemum callichrysum	4.1
Senecio sp.	4.1
Periploca laevigata	4.1
Gonospermum fruticosum	4.1
Briza maxima	4.1
Bromus rubens	3.8
Bromus tectorum	3.7
Calamintha sylvatica	3.7
Torilis arvensis	3.6
Galium verrucosum	3.6
Micromeria lepida	3.6
Allium roseum	3.6
Trifolium hirtum	3.6
Lolium rigidum	3.6
Chenopodium album	3.1
Parietaria filamentosa	3.1
Tragopogon porrifolius	3.1
Chenopodium murale	3.1
Rumex pulcher	3.1
Erodium brachycarpum	3.1
Medicago polymorpha	3.1
Aeonium decorum	3.1
Launaea nudicaulis	3.1
Avena sp.	3.1
Brachypodium distachyon	2.6
Medicago sp.	2.6
Silene vulgaris	2.6
Cistus monspeliensis	2.6
Cenchrus ciliaris	2.6
Daucus carota	2.6
Vicia lutea	2.6
Reichardia tingitana	2.1

Appendix A (cont.). Species list of the 214 species found in the survey sorted by their importance value (calculated as the percentage of presence in all the transects at different years). Nomenclature follows Izquierdo *et al.* (2004)

c) Species name	Importance value
Cuscuta planiflora	2.1
Ceropegia dichotoma	2.1
Taraxacum officinale	2.1
Trifolium striatum	2.1
Sideritis sp.	2.1
Andryala pinnatifida	2.1
Salvia aegyptiaca	2.1
Patellifolia patellaris	2.1
Dittrichia viscosa	2.1
Argyranthemum frutescens	2.1
Bromus hordeaceus	2.1
Sagina apetala	1.6
Echium aculeatum	1.6
Scolymus hispanicus	1.6
Pericallis echinata	1.6
Ornithopus compressus	1.6
Silene sp.	1.6
Euphorbia berthelotii	1.6
Eragrostis barrelieri	1.6
Trifolium scabrum	1.6
Reichardia ligulata	1.6
Cynosurus echinatus	1.6
Medicago truncatula	1.6
Eremopogon foveolatus	1.6
Messerchmidia fruticosa	1.6
Brachypodium arbuscula	1.6
Rubia fruticosa	1.6
Herniaria cinerea	1.6
Polycarpon tetraphyllum	1.6
Matthiola parviflora	1.0
Lolium canariense	1.0
Lavatera cretica	1.0
Medicago littoralis	1.0
Todaroa aurea	1.0
Ononis hesperia	1.0
Geranium molle	1.0
Pimpinella sp.	1.0
Hirschfeldia incana	1.0
Launaea arborescens	1.0
Medicago italica	1.0
Linum sp.	1.0
Descurainia millefolia	1.0
Juncus acutus	1.0
Volutaria canariensis	1.0
Asparagus umbellatus	1.0
Sisymbrium irio	1.0
Gonospermum gomerae	1.0
Leontodon taraxacoides	1.0
Neochamaelea pulverulenta	1.0
Allium sp.	1.0
Opuntia maxima	1.0
Plantago lagopus	1.0
Tolpis sp.	1.0
Lamarckia aurea	0.5

d) Species name	Importance value
Convolvulus arvensis	0.5
Hordeum murinum	0.5
Catapodium rigidum	0.5
Erodium moschatum	0.5
Trifolium arvense	0.5
Plocama pendula	0.5
Rumex vesicarius	0.5
Lotus glinoides	0.5
Scandix pecten-veneris	0.5
Erodium malacoides	0.5
Melilotus sulcatus	0.5
Bromus madritensis	0.5
Logfia gallica	0.5
Tuberaria guttata	0.5
Ornithogalum narbonense	0.5
Sinapis alba	0.5
Urospermum picroides	0.5
Romulea columnae	0.5
Linum strictum	0.5
Aizoon canariense	0.5
Erodium botrys	0.5
Fagonia cretica	0.5
Artemisia thuscula	0.5
Trisetum paniceum	0.5
Asphodelus tenuifolius	0.5
Sonchus oleraceus	0.5
Stachys arvensis	0.5
Silene gallica	0.5
Geranium robertianum	0.5
Agave americana	0.5
Papaver rhoeas	0.5
Avena fatua	0.5
Cerastium glomeratum	0.5
Erodium sp.	0.5
Pallenis spinosa	0.5
Trifolium glomeratum	0.5
Galactites tomentosa	0.5
Vulpia sp.	0.5
Euphorbia lamarckii	0.5
Aichryson parlatorei	0.5
Spergularia sp.	0.5
Pericallis steetzii	0.5
Euphorbia balsamifera	0.5
Foeniculum vulgare	0.5
Forsskaolea angustifolia	0.5
Vicia benghalensis	0.5
Tricholaena teneriffae	0.5
Asphodelus ramosus	0.5
Atalanthus pinnatus	0.5
Vicia disperma	0.5
Atractylis cancellata	0.5
Tragopogon villosum	0.5
Chenopodium sp.	0.5
Rumex bucephalophorus	0.5