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Review of communities of *Lygeum spartum* L. in the south-eastern Iberian Peninsula (western Mediterranean)

A. García-Fuentes*†, C. Salazar*, J. A. Torres*, E. Cano*, & F. Valle‡

**Dpto. de Biología Animal, Biología Vegetal y Ecología, Fac. CC. Experimentales, Universidad de Jaén, 23071-Jaén, Spain*
‡Dpto. de Biología Vegetal, Facultad de Ciencias, Universidad de Granada, 18001-Granada, Spain

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A study of south-eastern Iberian plant communities where *Lygeum spartum* L. appears has been carried out, considering the chorological units Castellano-Maestrazgo-Manchega province (Manchego sector), Baetic province and Murciano-Almeriense province. This kind of vegetation develops in areas where thermotypes range from thermomediterranean to mesomediterranean while ombrotypes oscillate from semi-arid to dry. In the south-eastern Iberian Peninsula, 12 phytosociological associations include *L. spartum* to a greater or lesser extent. The new association *Limonio quesadensis–Lygeetum sparti* García-Fuentes *nova* for the Hispalense sector (Baetic province) and the subassociation *Limonio delicatuli-Gypsophiletum tomentosae limonietosum maji* Salazar *nova* endemic to the Guadiciano-Bastetano district (Guadiciano-Bacense sector, Baetic province) are also proposed.

Keywords: Albardine communities; grass; phytosociology; semi-arid zone; SE Iberian Peninsula; Spain

Introduction

Albardine (*Lygeum spartum*) is a perennial tussock grass, similar to esparto-grass (*Stipa tenacissima* L.) but smaller in size, although the ecology of the two species may be similar. In the Iberian Peninsula albardine is found in environments that vary in xericity but are always rich in marls and clays and is even optimal in coastal areas exposed to sea breezes or on gypsum-rich soils (Rivas-Goday & Rivas-Martínez, 1963). It is a member of plant communities that may be used as perennial pasture or mixed with basophilic matorral scrub of *Rosmarinetea officinalis* Rivas-Martínez, T.E. Díaz, F. Prieto, Loidi & Penas 1991.

These phytocoenoses appear in areas of the south-eastern Iberian Peninsula under a semi-arid-to-dry ombrotype, occupying biotopes on which arboreal vegetation is

† Corresponding author. Fax: 34-953-012141. E-mail: agarcia@ujaen.es

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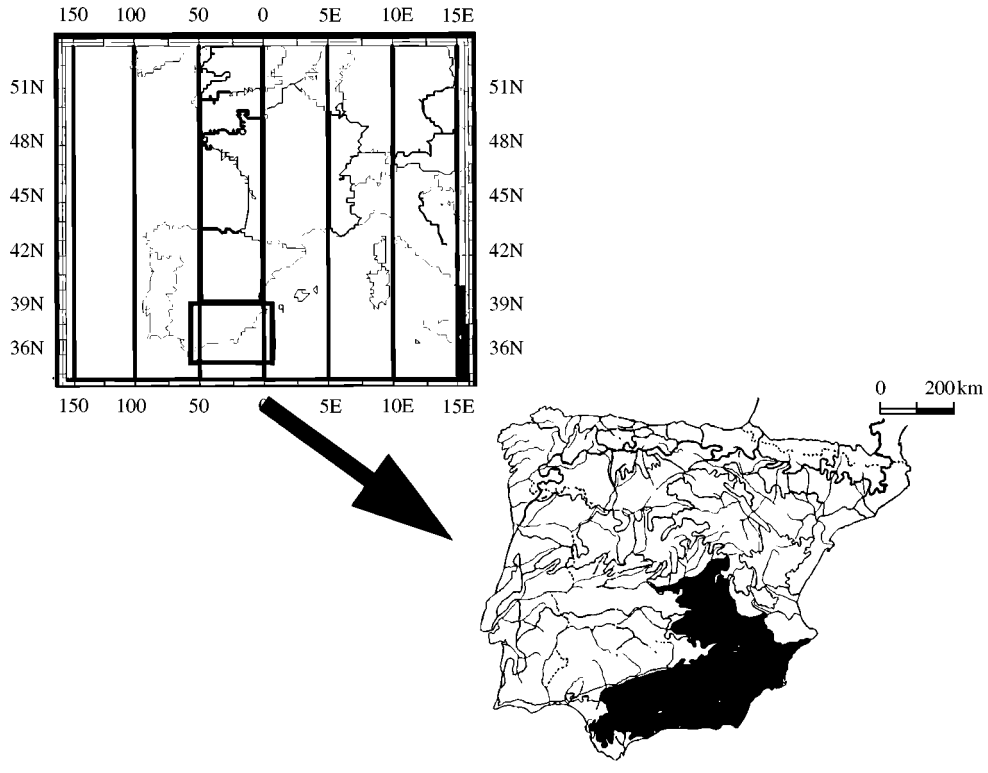

Figure 1. Location of the study area.

generally unable to develop, owing to the low rainfall and/or salinity of the soil. These communities then either become permanent or replace the arboreal vegetation in certain serial degradation stages.

The plants with which *L. spartum* is most frequently associated include many endemic taxa of the genus *Limonium*, as well as other halophyte species with a larger chorological area belonging to the genera *Plantago*, *Senecio*, *Inula*, etc.

In the south-eastern Iberian Peninsula these communities play a major role in countering negative phenomena such as erosion and desertification. Due to the poor nature of the marlaceous-clay (sometimes gypsum-rich) substrates on which they develop, combined with the heavy rains that may fall in a very brief period of time in Mediterranean areas (flash floods), these communities are now seen as being a key tool for fixing soil, because the root systems of albardine tussocks are particularly effective on steep slopes.

Chorologically speaking, the study area covers the Manchego sector (Castellano-Maestrazgo-Manchega province) and the Murciano-Almeriense and Baetic provinces (Fig. 1) of the Ibero-Levantine and Ibero-Atlantic superprovinces in the Iberian Peninsula.

The dominant geological materials in the area are mostly limestones, dolomites, marls, marlaceous limestones, clays and Triassic materials (sandstone), with materials rich in gypsum and sulphur salts in a large part of the territory studied.

Edaphologically, over the territory as a whole there is a predominance of regosols, cambisols, vertisols and lithosols, together with orthic solonchack in salt-rich areas.

The south-eastern of the Iberian Peninsula includes the thermo-, meso-, supra-, oro- and cryoro-Mediterranean thermotypes, whereas the ombrotypes range from arid to humid (according to the classification of Rivas-Martínez, 1996).

Methods

For the analysis of the vegetation described in this paper the phytosociological methods of the Zurich-Montpellier school (Braun Blanquet, 1951), subsequently modified by such authors as Géhu & Rivas-Martínez (1981) is used.

This methodology is based on obtaining field data by making relevés that include information on the physical environment (relevé area, exposure, slope, degree of cover, etc.), and the species present, with corresponding indexes of abundance. Subsequently, the characteristic species of the various phytosociological units are separated in these relevés from those that act as companions, in order for them to be arranged phytosociologically. Based on this information, tables have been devised, presenting a new association and subassociation (Tables 1 & 2).

A bibliographical review of the albardine communities in the south-eastern Iberian Peninsula has been also carried out. A diagnosis is made for each of the twelve associations reported, highlighting its physiognomic, structural, ecological, chorological, dynamic and floristic characteristics.

For all questions regarding the nomenclature of the plant communities the International Code of Phytosociological Nomenclature (Barkman *et al.*, 1988) has been followed.

With regard to the authorship of the plant species cited, the criteria used in *Flora Iberica* (Castroviejo *et al.*, 1986–1997) have been followed for taxa included in the volumes published to date, and *Flora Europaea* (Tutin *et al.*, 1964–1980) for the remaining taxa, except *Senecio auricula* var. *major* Willkomm (Willkomm & Lange, 1870).

For the analysis of the various associations, a synthesis table of the 12 albardine associations present in the south-eastern Iberian Peninsula was drawn up (Table 3), using 130 phytosociological relevés. When this process was complete, a binary data matrix of the remaining species according to their presence or absence was designed, to which various types of statistical analysis were applied. For this purpose, Syntax software version 5·0 (Podani, 1993) was used. The final method chosen as providing the most reliable results was non-metric ordination (Yule technique) in two dimensions.

Results

The plant formations presided over by *Lygeum spartum* in the south-eastern Iberian Peninsula are as follows:

Association Dactylo hispanicae-Lygeetum sparti *Rivas-Martı´nez (Alcaraz 1984)*

Dense pasture with high cover, dominated by albardine, accompanied by hemicryptophytes (e.g. *Dactylis glomerata* var. *hispanica* (Roth) Koch, *Stipa tenacissima*, *Brachypodium retusum* (Pers.) Beauv., *Hyparrhenia hirta* (L.) Stapf. and *Stipa parviflora* Desf.) with spring phenology, reaching its optimum in May during the fructification of *Lygeum* and *Dactylis*.

This association favours clayey and marly soils that may tend towards a slight temporary hydromorphy, caused by the difficulty of percolation of water in these clay-textured soils. It may also develop on somewhat halophilic soils. The optimum for this association is thermo- and meso-Mediterranean under a semi-arid or dry ombrotype. It is distributed (Fig. 4(a)) throughout the Castellano-Maestrazgo-Manchega and Murciano-Almeriense provinces, as well as in the Setabense (Catalano-Valenciano-Provenzal province) and Guadiciano-Bacense (Baetic province) sectors. During the

course of this study, this plant formation have also been detected in southern parts of the Hispalense district (Baetic province) that are rich in marlaceous-clay materials and with a slight gypsum content, under a dry or, in some cases, subhumid ombrotype.

Insofar as the variability of this association is concerned, apart from the typical subassociation, it presents the subassociation *limonietosum caesii* Alcaraz 1984 for areas with a certain salt content, representing a catenary contact with the halophilic association *Limonio caesii-Lygeetum sparti* Rivas-Martínez & Alcaraz (Alcaraz, 1984). Also, within this phytocoenosis the subassociation *salsoletosum genistoidis* Alcaraz 1984 can be discerned, with *Salsola genistoides* Juss. *ex* Poiret and *Convolvulus althaeoides* L. as

Table 1. Limonio delicatuli-Gypsophiletum tomentosae *subassociation* limonietosum maji *Salazar* nova

Relevé no.	1	2	3	4	5	6	7	8
Altitude (1 = 10m)	75	75	75	87	78	81	71	72
Area(m^2)	100	25	400	100	25	16	25	100
Coverage (%)	60	70	50	90	80	80	60	50
Number of species	8	14	10	12	6	14	13	10
Characteristics of association and higher units								
Gypsophila tomentosa	2	2	2	4	2	+	1	1
Limonium delicatulum	3	3	3	2	+	2	1	1
Suaeda vera Forsskal *ex* J.F.Gmelin	2	2	1	1	–	–	–	–
Limonium supinum	1	+	–	–	–	–	+	–
Limonium latebracteatum	–	+	–	1	–	+	–	+
Lygeum spartum	–	2	1	2	4	4	3	3
Differentials of the subassociation *limonietosum maji*								
Limonium majus	2	1	1	1	1	2	3	2
Limonium minus	–	–	1	–	–	+	2	1
Differentials of variant with *Gypsophila x castellana*								
Gypsophila x castellana	–	–	–	–	–	1	+	1
Inula crithmoides	–	–	–	–	–	1	1	–
Sarcocornia fruticosa	–	–	–	–	–	1	+	–
Accompanying species								
Plantago maritima	3	3	–	+	–	–	–	–
Elymus elongatus (Host.) Runemark	+	–	–	+	–	–	–	–
Brachypodium phoenicoides (L.) Roemer and Schultes	1	1	+	2	+	2	1	+
Suaeda spicata (Willd.) Mocq.	–	1	+	1	–	–	–	–
Bassia hyssopifolia (Pallas) O.Kuntze	–	+	+	–	–	–	–	–
Juncus maritimus Lam.	–	1	–	1	–	–	–	–
Artemisia barrelieri	–	–	+	1	–	–	–	–
Atriplex halimus L.	–	–	–	–	+	+	+	–
Stipa tenacissima	–	–	–	–	–	+	+	+
Atriplex glauca	–	–	–	–	–	1	+	–

Plus: 2: *Schoenus nigricans* L. (+); *Elymus pungens* (Pers.) Melderis (+). 6: *Sonchus crassifolius* Pourret *ex* Willd. (+). 8: *Helianthemum squamatum* (+).

Locations: 1, 2 & 3. River Baza salt-marsh (Granada), 30SWG2454; 4. Espartal 'rambla' (Baza) (Granada), 30SWG3054; 5. Mazarra 'rambla' (Granada), 30SWG2854; 6. El Margen salt-marsh (Granada), 30SWG3566; 7. River Baza (Granada), 30SWG2655; 8. River Cullar (Granada), 30SWG2859.

characteristic taxa of the subassociation. Both these subassociations develop in the thermo- and lower meso-Mediterranean belts of the Murciano-Almeriense province (Alcaraz, 1984). The presence of these subassociations in the Baetic province has not been detected, but it is likely that the subassociation *limonietosum caesii* Alcaraz 1984 is present in the Manchego sector, since halophilic albardine communities belonging to the association *Limonio caesii-Lygeetum sparti* (Valdes Franzi *et al.*, 1993) are present in this area.

Table 2. Limonio quesadensis-Lygeetum sparti *García-Fuentes* nova

Relevé no.	1	2	3	4	5	6	7	8
Altitude (1 = 10m)	42	35	40	42	35	42	65	35
Area (m^2)	200	100	200	100	200	200	100	50
Slope (%)	–	–	6	–	–	15	4	–
Orientation	–	–	SE	–	–	S	N	–
Number of species	6	6	8	8	9	9	13	8
Characteristics of association and higher units:								
Lygeum spartum	3	2	4	2	2	3	3	5
Limonium quesadense	+	2	2	3	2	+	2	+
Sedum sediforme (Jacq.) Pau	.	.	.	.	.	1	.	.
Limonium lobatum (L. fil.) Chaz.	.	.	.	.	.	.	.	3
Accompanying species:								
Stipa tenacissima	+	+	.	.	.	+	1	.
Phragmites australis (Cav.) Trin. *ex* Steudel	2	.	.	+	.	.	.	
Artemisia barrelieri Besser	+	+	+	+	.	+	.	.
Juncus subulatus Forsskal	+	.	.	1	+	.	.	.
Elymus repens (L.) Gould	.	1	.	.	+	.	.	.
Dactylis glomerata L.	.	.	+	.	.	2	1	.
Aeluropus littoralis (Gouan) Parl.	.	.	2	1	+	.	.	.
Foeniculum vulgare Miller	.	.	+	.	.	.	. .	
Tamarix canariensis Willd.	.	.	+	+	+	.	.	.
Echinops strigosus L.	.	.	+	.	.	.	+	.
Frankenia pulverulenta	.	.	.	1	.	.	.	.
Limonium echioides (L.) Mill.	.	.	.	.	1	.	.	.
Atriplex glauca L.	.	.	.	.	+	.	.	.
Thapsia villosa L.	.	.	.	.	+	.	.	.
Chronanthus biflorus (Desf.) Frodin and Heywood	.	.	.	.	.	+	.	.
Capparis spinosa L.	.	.	.	.	.	+	.	+
Brachypodium retusum	.	.	.	.	.	+	+	.
Centaurea melitensis L.	.	.	.	.	.	.	1	1
Thymus zygis gracilis (Boiss.) R. Morales	.	.	.	.	.	.	1	.
Moricandia moricandioides (Boiss.) Heywood	.	.	.	.	.	.	1	.
Carlina corymbosa L.	.	.	.	.	.	.	+	.
Teucrium polium L.	.	.	.	.	.	.	+	.
Helianthemum squamatum (L.) Dum. Cours.	.	.	.	.	.	.	+	.
Lepidium subulatum L.	.	.	.	.	.	.	+	.
Plantago lagopus L.	.	.	.	.	.	.	.	1
Spergularia marina (L.) Besser	.	.	.	.	.	.	.	1
Asteriscus aquaticus (L.) Less.	.	.	.	.	.	.	.	+

Locations: 1, 4 & 6, Cuevezuela stream (Jaén); 2. Saltwater stream at Torrequebradilla (Jaén; 30SVG4194); 3. Laguna Honda (Alcaudete); 5. Saltwater stream at Torrequebradilla (Jaén; 30SVG4095); 7. Jaén-Torrequebradilla road, km 8 (Jaén); 8. Doña Aldonza reservoir (Jaén).

Finally, the subassociation *stipetosum tenacissimae* Cantó, Laorga & Belmonte 1986 is mentioned for drier areas of this albardine community (Cantó *et al.*, 1986). This fact should be considered to be another catenary contact with the Alicantino esparto associations located in areas of lower rainfall.

Association Limonio caesii-Lygeetum sparti *Rivas-Martı́nez & Alcaraz 1984*

A halophilic albardine association rich in species of the genus *Limonium*, such as *L. caesium* (Girard) Kuntze, *L. delicatulum* (Girard) Kuntze and *L. angustebracteatum* Erben. It occupies deep, gypsum-rich soils with temporary hydromorphy. Its optimal thermotype is thermo- and meso-Mediterranean under a dry and semi-arid ombrotype, with Murciano-Almeriense and Manchego distribution (Fig. 4(b)).

This phytocoenosis presents two recognized subassociations apart from the typical one. The first of these is the subassociation *limonietosum cossoniani* Alcaraz 1984, which develops on soils rich in coarse sand with Murciano and Alicantino distribution (Murciano-Almeriense province).

The subassociation *helianthemetosum polygonoidis* Valdés-Franzi *et al.* 1993 was given for the salt-marshes at Cordovilla (Albacete), enriching the association *Limonio caesii-Lygeetum sparti* with the taxa *Helianthemum polygonoides* Peinado, Martínez-Parras, Alcaraz & Espuelas (local endemic species), *Plantago maritima* L., *Elymus curvifolius* (Lange) Melderis and *Puccinellia fasciculata* (Torrey) E.P. Bick. This subassociation is a Manchego-Murciano variant and marks the limit of the distribution area of these halophilic Murciano-Almeriense albardine communities.

The association *Limonio caesii-Lygeetum sparti* was described as a permanent formation in these highly saline areas, contacting with other associations such as *Limonietum caesio-angustebracteati* Rigual 1968 *corr.* Rivas-Martínez & Costa 1984 and *Dactylo-Lygeetum sparti* in areas with less salt-rich soils.

Association Limonio delicatuli-Gypsophiletum tomentosae *Peinado & Martı́nez-Parras 1982*

An association dominated by rosette chamaephytes of the genus *Limonium* present near to salt-marshes and halophilic reed communities with a high presence of albardine. It develops on soils with a high salt content (orthic solonchacks) with a certain tendency towards hydromorphy in winter. Abundant species of the genus *Limonium* are present, e.g. *L. delicatulum*, *L. supinum* (Girard) Pignatti, *L. majus* (Boiss.) Erben, *L. minus* (Boiss.) Erben and *L. latebracteatum* Erben. Also present are *Gypsophila tomentosa* L., *Inula crithmoides* L. and *Plantago maritima*.

This phytocoenosis was separated from the *Gypsophiletum perfoliatae* Br.-Bl. & O. Bolòs 1958 because of the presence of the endemic elements *Limonium delicatulum* and *L. supinum* (Peinado & Martínez-Parras, 1982). Its distribution area is Baetic-Levantine (Fig. 4(c)), and it acts as a southern vicariance of the previously cited association in the Ebro valley. This phytocoenosis is very similar to the numerous associations of the order *Limonietalia* Br.-Bl. & O. Bolòs 1958 *em.* Rivas-Martínez & Costa 1984, which has similar ecological characteristics. They are differentiated by the high number of endemic halophilic taxa that characterise each location in the eastern and south-eastern Iberian Peninsula. Its authors originally included it in the suballiance *Gypsophilenion tomentosae*, which was devised to group the communities of *Limonium* and *Gypsophila tomentosa*, differentiating them from albardine communities with a certain degree of hydromorphy. However, this suballiance is not included in a review of the class (Rivas-Martínez, 1984) in which the phytosociological classes *Juncetea maritimi* Br.-Bl. *in* Br.-Bl. *et al.* 1952 and *Salicornietea fruticosae* were finally separated.

This association was reported for the Guadiana Menor valley in Granada, Spain (Salazar, 1996: 485). The authors of this paper consider the presence of species of the genus *Limonium* to be important, since they have not been clearly identified in previous studies of these halophic communities. Thus, such elements as *Limonium majus* and *L. minus* (both endemic to the Guadiciano-Bastetano district) may well have been confused; indeed, it is highly likely that what Esteve Chueca & Varo (1975) considered in all their relevés of the association to be *Limonium ovalifolium* (Poir.) Kuntze is actually *Limonium majus*. The differences between the Levantine albardine communities of this association has led us to propose a Guadiciano-Bastetana subassociation, *limonietosum maji* Salazar *nova* (Table 1, rel. 1–8, *typus* rel. 3), owing to the very limited distribution area of these endemic taxa.

Similarly (Esteve Chueca & Varo, 1975) the existence of a subassociation with *Gypsophila x castellana* Pau (a hybrid of *G. tomentosa* and *G. struthium* L.) is mentioned. As the authors explain, this should be considered as a transitional community towards the rosemary-scrub communities of *Gypsophila struthium* into which this hybrid is introduced. In any event, it merits the driest variant included in Table 1 (rel. 6–8). This variant presents an increase in the elements of *Salicornietalia fruticosae* and *Stipion tenacissimae* (*Sarcocornia fruticosa* (L.) A. J. Scott, *Inula crithmoides*, *Stipa tenacissima*), which indicate greater dryness and salinity.

The association is in contact and sometimes arranged in a mosaic pattern with the salt-marsh communities of the *Cistancho-Sarcocornietum fruticosi* Géhu & Géhu-Franck 1977 *nom. mut.* Rivas-Martínez, Fernández-González & Loidi 1997, where the water table is somewhat higher. Towards drier areas, they contact with albardine, esparto-grass and rosemary-scrub communities on gypsum-rich substrates (*Dactylo-Lygeetum sparti*, *Helianthemo squamati-Stipetum tenacissimae* (Pérez Raya 1987) García-Fuentes *in* Cano *et al.*, 1996 and *Jurineo pinnatae-Gypsophiletum struthii* (Rivas-Goday *et* Esteve 1965) Peinado, Alcaraz *et* Martínez-Parras 1992.

The *Limonio-Gypsophiletum* communities suffer, as do others in their class, from fairly damaging overgrazing, since this vegetation remains green even during the driest periods of the year. This circumstance endangers some of the endemic species cited, such as *Limonium majus* (Blanca & Cueto, 1987: 170).

Association Limonio quesadensis-Lygeetum sparti *García-Fuentes* nova *Table 2,* typus *rel. 2*

This association develops on soils with a good proportion of salts and temporary hydromorphy in southern areas of the upper Guadalquivir basin (García-Fuentes, 1996: 159). The formation is dominated by *Lygeum spartum*, enriched by the taxon *Limonium quesadense* Erben, which is endemic to the province of Jaén (Spain) and develops on saline sandy substrates in Quesada (Erben, 1993: 50), reaching areas of marlaceous gypsum and sulphur-rich areas near Mancha Real, Jaén and even the Guadiana Menor valley. This taxon can be regarded as a good differential element to separate it from the Manchego halophilic albardine communities of *Limonio caesii-Lygeetum sparti* and the albardine communities of *Dactylo hispanicae-Lygeetum sparti*, with which it contacts in less halophilic areas with greater xericity.

The new syntaxon is located in the lower meso-Mediterranean belt with a dry ombrotype, with at least Hispalense (Baetic province) distribution (Fig. 4(i)). These types of halophilic albardine communities develop on marlaceous-clay soils, with temporary hydromorphy, preferably close to trickling streams that dry up completely in summer to leave a crust composed of gypsum and sulphur salts. The biotopes are similar to those found in parts of the Guadiciano-Bacense and Manchego sectors; this is due to the entry of halophyte elements from the Guadiana Menor valley influence that is accentuated by the climatological conditions (dry ombrotype) and geological

characteristics of the terrain (poor marls with Keuper Triassic gypsum, as a result of allochthonous movements of the Sub-Baetic mountains to the south of the Hispalense district).

Since the relevés present high indexes for *Limonium quesadense*, together with other *Limonium* species, this albardine community should be included within the class *Salicornietea fruticosae* (Order *Limonietalia*).

Association Senecioni majoris-Limonietum furfuracei *Rigual 1972*

With an Alicantino-Murciano distribution area (Fig. 4(d)), this association develops on gypsum-rich substrates or molasse conglomerates splashed by sea spray. It is treated here as an albardine-community formation, since this association occupies biotopes in which albardine is optimal, accompanied by such taxa as *Senecio auricula* var. *major* Willk. *in* Willk. & Lange, *Limonium furfuraceum* (Lag.) Kuntze and *L. caesium*, with high abundancy indexes (Rigual, 1972: 130).

This association includes a subassociation, *crithmetosum maritimi* Rigual 1958, for environments that are directly influenced by sea breezes.

Association Limonietum caesio-delicatuli *Rigual 1972*

Another Alicantino-Murciano association (Fig. 4(d)) presenting in its tables (Rigual, 1972) as in the previous phytocoenosis high indexes for *Lygeum spartum*, which is in its ecological optimum. Other *Limonium* species present include *L. tournefortii* (Boiss.) Erben, *L. caesium* and *L. furfuraceum*.

This association is located on moderately lime-rich Triassic marls, and develops in small gulleys. It presents two subassociations apart from the typical one: the subassociation *lycietosum intricati* Rigual 1968 with *Lycium intricatum* Boiss., *Helichrysum stoechas* (L.) Moench and *Asparagus stipularis* Forsskal. for chlorine- and nitrate-rich areas; and the subassociation *salsoletosum genistoidis* Rigual 1968 in more highly nitrified areas.

Association Limonietum angustebracteato-delicatuli *Rivas-Martı´nez & Alcaraz in Alcaraz 1984*

The original table for this association, defined by its authors as a perennial grass developing on salt-rich soils, included as characteristic species *Limonium delicatulum*, *L. angustebracteatum*, *L.x eugeniae* Sennen, *L. supinum*, *Frankenia corymbosa* Desf. etc.

These communities present a spring-summer phenology with a high degree of coverage, where the species *Lygeum spartum* is scarce, although it may appear in isolation. This association develops on non-waterlogged salt-rich substrates, with low soil-moisture levels and on sandy soils. It was originally described as endemic to Murciano-Almeriense areas (Fig. 4(e)).

As Limonietum caesio-supini *Alcaraz, Sa´nchez-Gómez & De la Torre 1988*

This association has an Alicantino and Setabense distribution (Alcaraz *et al.*, 1988) (Fig. 4(f)). Optimal in the thermo- and meso-Mediterranean belts under a semi-arid-to-dry ombrotype, this grass community is presided over by *Limonium angustebracteatum*, *L. supinum* and *L. caesium*, developing on highly salt-rich soils with little or no moisture. Here, as with the previous association, the presence of albardine is scant, with mostly halophyte and succulent species typical of highly saline environments dominating.

Association Limonio insignis-Lygeetum sparti *Alcaraz, Sánchez-Gómez & De la Torre 1988*

A pasture association presided over by *Lygeum spartum* and *Limonium insigne* (Coss.) Kuntze developing on soils that are low in moisture and have a lower salt content than the previous two associations. Its optimum is in the semi-arid-to-dry thermo-Mediterranean belt of the Murciano-Almeriense province (Fig. 4(g)).

It was given by its authors as a southern vicariance of the association *Limonio caesii-Lygeetum sparti* for Alicantino and Murciano areas. On less salt-rich ground it contacts with the albardine communities of *Dactylo hispanicae-Lygeetum sparti*, whereas in areas with soils richer in salt it contacts with the association *Limonietum angustebracteato-delicatuli*. On sandy soils it presents the subassociation *limonietosum cossoniani* Alcaraz, Sanchez Gomez & De la Torre 1988.

Association Senecioni auriculae-Lygeetum sparti *Rivas-Goday & Rivas-Martínez in Rivas-Martínez & Costa 1976*

Grasslands on subsaline soils with a clear predominance of albardine. The distribution area is exclusively Manchego (Fig. 4(h)). This association includes the albic saline albardine communities developing on gypsum-rich marls on the Castellano-Manchego high plain. These albardine communities develop on subsaline soils capable of withstanding the hard winters of the high plain. Consequently, their floristic composition differs from that of more thermal halophilic albardine communities both inland and on the coast.

The characteristic species of this phytocoenosis are *Senecio auricula* Bourgeau *ex* Cosson subsp. *auricula*, *Lepidium cardamines* L. *Lygeum spartum* and *Limonium dichotomum* (Cav.) Kuntze. Its optimum is in the meso-Mediterranean belt under a dry ombrotype.

Insofar as the variability of this association is concerned, it presents a subassociation, *elymetosum curvifolii* Cirujano 1981, characterized by the presence of *Elymus curvifolius* and the almost total absence of *Senecio auricula* and *Lepidium cardamines* (Cirujano, 1981: 223). This subassociation marks the transition towards the communities of *Juncion maritimi* Br.-Bl. (1931) 1952.

The difference between these high-plain albardine-community formations and the Alicantino formations of *Senecioni-Limonietum furfuracei* is the presence in the latter of *Senecio auricula* var. *major*, together with the fact that *Senecioni-Limonietum furfuracei* is influenced by sea breezes (Rigual, 1972: 130).

The association *Senecioni-Lygeetum sparti* marks the transition towards the association *Gypsophilo tomentosae-Limonietum dichotomi* Rivas-Martínez *et* Costa 1976 when there are higher levels of moisture in the soil during the summer and, therefore, lower salinity.

Association Gypsophilo tomentosae-Limonietum dichotomi *Rivas-Martínez & Costa 1976*

This Manchego association (Fig. 4(h)) differs from the previous one in that *Senecio auricula* is absent, with high indexes of the species *Gypsophila tomentosa*; the abundance of *Lygeum spartum* is also lower (Izco, 1984: 165). The taxon *Limonium dichotomum* is common to both associations and may even develop well in halophilic phytocoenoses.

This plant formation develops on salt-rich soils with some moisture content, on the shores of lakes, depressions in hills with moist and salt-rich gypsum and sandy soils, and even along roadsides if the moisture is high enough. It occupies somewhat

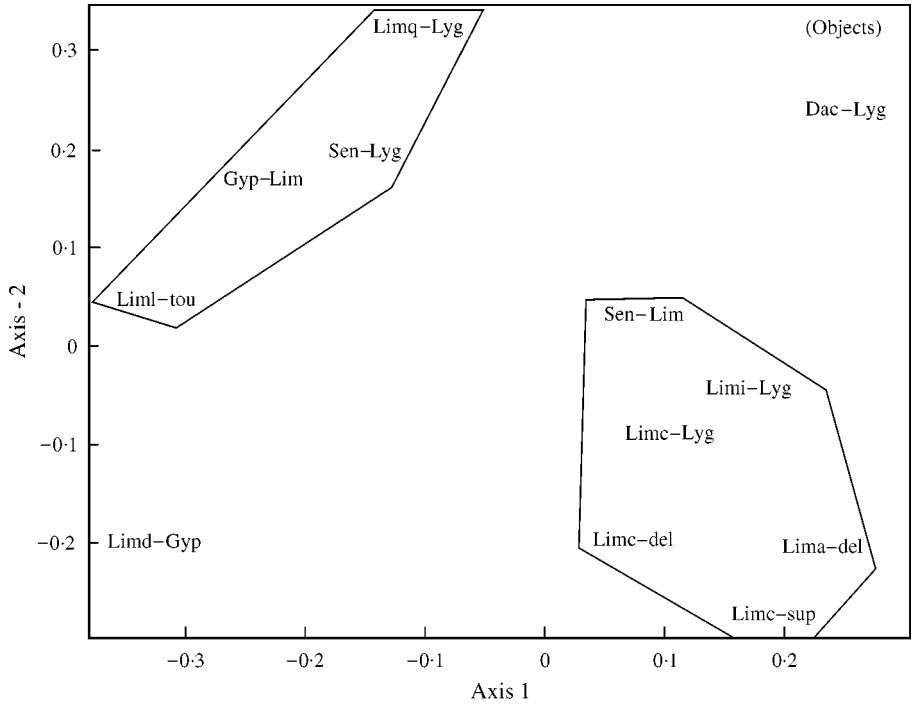

Figure 2. Non-metric multivariant (Yule) analysis of the associations described. Legend: Dac-Lyg (*Dactylo hispanicae-Lygeetum sparti*), Limc-Lyg (*Limonio caesii-Lygeetum sparti*), Limd-Gyp (*Limonio delicatuli-Gypsophiletum tomentosae*), Limq-Lyg (*Limonio quesadensis-Lygeetum sparti*), Sen-Lim (*Senecioni majoris-Limonietum furfuracei*), Limc-del (*Limonietum caesio-delicatuli*), Lima-del (*Limonietum angustebracteato-delicatuli*), Limc-sup (*Limonietum caesio-supini*), Limi-Lyg (*Limonio insignis-Lygeetum sparti*), Sen-Lyg (*Senecioni auriculae-Lygeetum sparti*), Gyp-Lim (*Gypsophilo tomentosae-Limonietum dichotomi*), Lima-tou (*Limonietum angustebracteato-tounefortii*).

wetter ground than the association *Senecioni auriculae-Lygeetum sparti* (Izc, 1984), giving rise to the presence of *Brachypodium phoenicoides* and *Scirpus holoschoenus* L.

As for its variability, besides the typical subassociation, a subassociation *holoschoenetosum* Rivas-Martínez & Izco *in* Rivas-Martínez & Costa 1976 can be distinguished, which prefers damp ground during the summer, with the taxa *Scirpus holoschoenus*, *Brachypodium phoenicoides* and *Thalictrum speciosissimum* L. It may be enriched with nitrophilous and subnitrophilous taxa such as *Artemisia herba-alba* Asso, *Frankenia pulverulenta* L., *Parapholis incurva* (L.) C.E. Hubbard and *Sphenopus divaricatus* (Gouan) Reichemb., etc. when settling on grazed land or along roadsides.

Association Limonietum latebracteato-tournefortii *Castroviejo & Cirujano 1980*

This association was described for Manchego areas (Castroviejo & Cirujano, 1980) (Fig. 4(h)) where there is a clear predominance of rosette chamaephytes of the genus *Limonium* (*L. tournefortii, L. latebracteatum*, *L. supinum, L. costae* (Willk.) Pignatti, etc.); the original table also indicates a clear presence of *Lygeum spartum*, which is optimum in these albic Manchego albardine communities with salt efflorescences.

This community is unable to withstand waterlogging, and requires a fairly low water table. The distribution area of this association is Manchego.

A subassociation, *limonietosum supini* Castroviejo & Cirujano 1980, has been described in which there is a clear predominance of *Limonium supinum* and *L. costae*, to the detriment of the various subspecies of *Limonium delicatulum*, located in wetter areas than the typical subassociation. When temporary flooding occurs marking the transition towards the association *Puccinellio fasciculatae-Sarcocornietum alpini* Castroviejo & Cirujano 1980, the subassociation *sarcocornietosum alpini* Castroviejo & Cirujano 1980 appears.

This association is situated catenarily between the *Puccinellio-Sarcocornietum* or the *Suaedetum brevifoliae* Br.-Bl. & O. Bolòs 1958, for areas with higher soil moisture, and the *Senecio-Lygeetum* for drier land where no waterlogging occurs.

Discussion

Based on the review of the literature on the existing albardine communities in the south-eastern Iberian Peninsula, together with the proposal for a new phytosociological association with a Hispalense distribution area and a new subassociation for the Guadiciano-Bastetano district, we may conclude that there are 12 associations in which, to a varying extent, the taxon *Lygeum spartum* appears (Table 3). These plant communities also have numerous biogeographical subassociations and ecological variants, which have been included in the syntaxonomic scheme proposed.

Nevertheless, with regard to the large number of subassociations found (most of which have been validated correctly in accordance with the Code of Phytosociological Nomenclature), we should add that we disagree with many of them, since they are subassociations that have been described for ecotone areas, with widely distributed taxa and with no major ecological restrictions. Some of these subassociations should in most cases be treated as variants or faciations.

From the multivariant analysis of data on the synthesis table (Table 3) the results presented in Fig. 2 were obtained. The high quality of the method used is demonstrated by a stress value of 0·1364 (i.e. valid, as it falls between 0·1 and 0·2). The association with a Shepard diagram (Fig. 3) shows the evolution of the data analysed of the new distances against the original distances.

The graph in Fig. 2 shows how there are two groups corresponding to the different associations that belong to the alliances *Lygeo sparti-Limonion angustibracteati* and *Lygeo sparti-Lepidion cardaminis*. It can also be pointed out that the association *Dactylo hispanicae-Lygeetum sparti* which, in terms of its ecology and floristic composition, has little to do with the other associations is markedly separate. However, certain problems arise with the associations of Baetic distribution. In the first place, the association *Limonio delicatuli-Gypsophiletum tomentosae*, of Guadiciano-Bacense and Setabense distribution, is disconnected from the groups cited above, perhaps owing to the existence in the table of the taxon endemic to the Guadiciano-Bastetano district, *Limonium majus*. Given the striking floristic and ecological peculiarities of the Guadiciano-Bacense sector, it might be wise to modify the syntaxonomic status of the subassociation *limonietosum maji* Salazar *nova* by raising it to the association level.

Something similar occurs with the second association of Baetic (Hispalense) distribution, *Limonio quesadensis-Lygeetum sparti* García-Fuentes *nova*. Examining the results graph, this association appears to be closer to the biocoenoses of Manchego distribution than to those with Murciano-Almeriense or Setabense distribution areas. This conclusion is not untenable, because as the biogeographical maps in Fig. 4(i) show the Hispalense district also has a major influence on Manchego areas via the province of Albacete (to the east).

This syntaxon is provisionally included within the alliance *Lygeo sparti-Lepidion cardaminis*, which, although by definition it includes only Manchego *Limonietalia* communities, seems to us to be a more logical site for these inland salt-marsh biocoenoses

Table 3. Summary table of the studied associations

Order no.	1	2	3	4	5	6	7	8	9	10	11	12
Number of relevés	12	6	8	8	12	11	11	8	6	12	7	29
Lygeum spartum	V	V	IV	V	IV	V	.	.	V	V	II	I
Salsola genistoides	II	.	.	.	.	II	.	.	.	.	.	.
Frankenia corymbosa	I	+	.	.	.	II	II	II	I	.	.	.
Limonium caesium	II	V	.	.	+	IV	II	II	.	.	.	.
Limonium delicatulum	.	I	V	.	.	.	IV	.	.	.	.	III
Limonium cossonianum	.	I	.	.	I	.	II	III	I	.	.	.
Limonium angustebracteatum	.	+	.	.	.	IV	III	V	.	.	.	.
Limonium x eugeniae	.	+	.	.	.	.	II	III	.	.	.	.
Limonium supinum	.	.	I	.	.	.	.	III	.	.	.	IV
Inula crithmoides	.	.	I	.	.	II	.	+	.	.	.	.
Sarcocornia fruticosa	.	.	I	.	.	.	.	+	I	.	.	.
Gypsophila tomentosa	.	.	V	.	.	.	.	.	.	.	V	.
Limonium furfuraceum	.	.	.	.	V	IV	.	.	.	.	.	.
Plantago crassifolia Forsskal	.	.	.	.	III	II	.	.	.	+	.	.
Suaeda vera	.	.	III	.	.	IV	.	.	.	.	.	III
Juncus maritimus	.	.	.	.	.	I	.	.	.	.	+	.
Halimione portulacoides (L.) Aellen	.	.	.	.	.	II	.	+	.	.	.	.
Spergularia media (L.) C. Presl.	.	.	.	.	.	.	.	+	.	II	.	.
Arthrocnemum macrostachyum (Moric) Moris	.	.	.	.	.	.	.	II	+	.	.	.
Limonium dichotomum	.	.	.	.	.	.	.	.	.	IV	V	I
Lepidium cardamines	.	.	.	.	.	.	.	.	.	III	II	.
Sonchus crassifolius	.	.	.	.	.	.	.	.	.	I	III	.
Elymus curvifolius	.	.	.	.	.	.	.	.	.	I	II	.
Dactylis glomerata	IV	.	.	.	.	.	.	.	.	.	.	.
Brachypodium retusum	II	.	.	.	.	.	.	.	.	.	.	.
Piptatherum miliaceum (L.) Cosson	+	.	.	.	.	.	.	.	.	.	.	.
Lobularia maritima (L.) Desv.	+	.	.	.	.	.	.	.	.	.	.	.
Phagnalon saxatile (L.) Cass.	+	.	.	.	.	.	.	.	.	.	.	.
Stipa parviflora	+	.	.	.	.	.	.	.	.	.	.	.
Convolvulus althaeoides	+	.	.	.	.	.	.	.	.	.	.	.
Limonium latebracteatum	.	.	II	.	.	.	.	.	.	.	.	.

Limonium majus	.	.	V	.	.	.	.	.	.	.	.	.
Limonium minus	.	.	III	.	.	.	.	.	.	.	.	.
Gypsophila x castellana	.	.	II	.	.	.	.	.	.	.	.	.
Limonium quesadense	.	.	.	V	.	.	.	.	.	.	.	.
Sedum sediforme	.	.	.	+	.	.	.	.	.	.	.	.
Limonium lobatum	.	.	.	+	.	.	.	.	.	.	.	.
Senecio auricula major	.	.	.	.	V	.	.	.	.	.	.	.
Parapholis incurva	.	.	.	.	II	.	.	.	.	.	.	.
Plantago coronopus L.	.	.	.	.	.	III	.	.	.	.	.	.
Elymus repens	.	.	.	.	.	I	.	.	.	.	.	.
Lycium intricatum	.	.	.	.	.	I	.	.	.	.	.	.
Helichrysum stoechas	.	.	.	.	.	I	.	.	.	.	.	.
Asparagus stipularis	.	.	.	.	.	I	.	.	.	.	.	.
Artemisia barrelieri	.	.	.	.	.	II	.	.	.	.	.	.
Salsola vermiculata L.	.	.	.	.	.	+	.	.	.	.	.	.
Limonium insigne	.	.	.	.	.	.	.	.	V	.	.	.
Puccinellia fasciculata	.	.	.	.	.	.	.	.	.	III	.	.
Frankenia thymifolia Desf.	.	.	.	.	.	.	.	.	.	.	.	II
Limonium costae	.	.	.	.	.	.	.	.	.	.	.	II
Sarcocornia alpini (Lag.) Castroviejo	.	.	.	.	.	.	.	.	.	.	.	II

1.- *Dactylo hispanicae-Lygeetum sparti* (Alcaraz, 1984:270). 2.- *Limonio caesii-Lygeetum sparti* (Alcaraz, 1984:189). 3.- *Limonio delicatuli-Gypsophiletum tomentosae limonietosum maji* (Table 1). 4.- *Limonio quesadensis-Lygeetum sparti* (Table 2). 5.- *Senecioni majoris-Limonietum furfuracei* (Rigual, 1972:130). 6.- *Limonietum caesio-delicatuli* (Rigual, 1972:133). 7.- *Limonietum angustebracteato-delicatuli* (Alcaraz, 1984:187). 8.- *Limonietum caesio-supini* (Alcaraz *et al.*, 1988:260). 9.- *Limonio insignis-Lygeetum sparti* (Alcaraz *et al.*, 1988:261). 10.- *Senecioni auriculae-Lygeetum sparti* (Rivas-Martínez & Costa, 1976:90). 11.- *Gypsophilo tomentosae-Limonietum dichotomi* (Rivas-Martínez & Costa, 1976:91). 12.- *Limonietum angustebracteato-tounefortii* (Castroviejo & Cirujano, 1980:152).

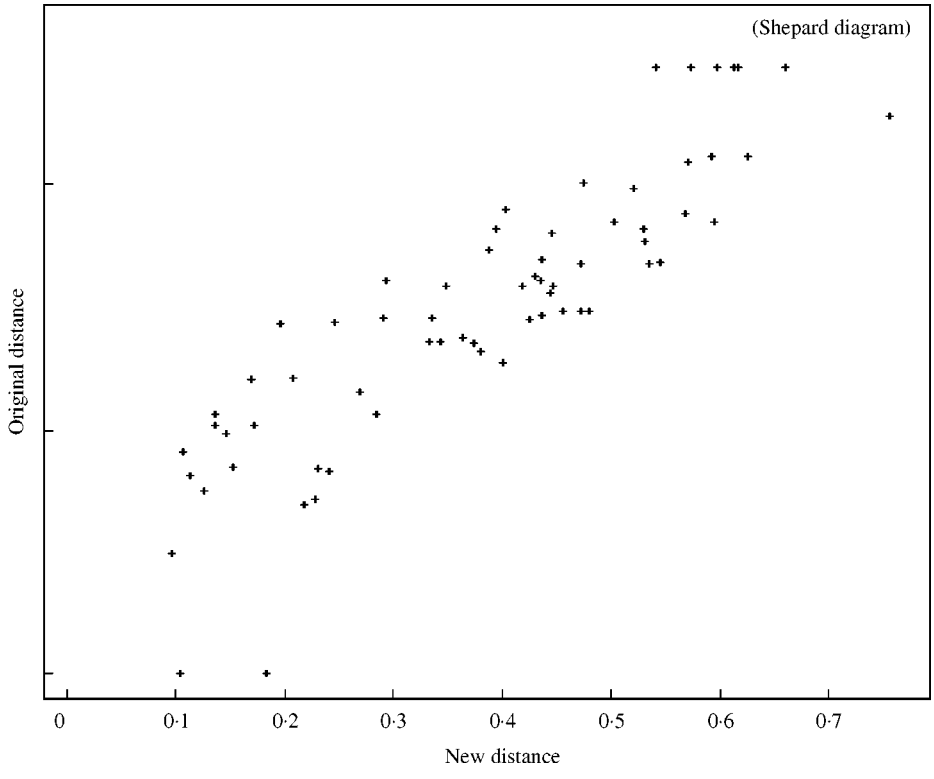

Figure 3. Shepard diagram of the analysis applied.

than those housing the coastally influenced Murciano-Almeriense and Setabense salt-marsh communities. However, the possibility of creating a new syntaxon to cover the albardine-community associations with Baetic distribution should not be discounted.

It is worthy of note that the biogeographical distribution area of the association *Limonio delicatuli-Gypsophiletum tomentosae*, which is present in Guadiciano-Bacense and Setabense areas (Fig. 4(c)), presents a disjunction with the biogeographical location of the associations *Senecioni-Lygeetum sparti*, *Gypsophilo tomentosae-Limonietum dichotomi* and *Limonietum latebracteato-tournefortii*, all of which are of Manchego distribution (Fig. 4(h)), but each of which has different ecological characteristics and a different floristic composition. This is clearly shown in the results of the multivariant analysis presented in Fig. 2, where these Manchego associations are grouped together, with the association *Limonietum latebracteato-tournefortii* at a greater distance from the other two. It should be noted that since it develops in more humid and more saline environments than the others, its floristic composition is different, hence its positioning in the diagram.

Something similar occurs with the other group in Fig. 2, where *Limonietum caesio-supini* develops in much more saline, drier environments than the other associations in the group, and consequently occupies a lower position in the table. At the opposite end of the group the association *Senecio-Limonietum* is found, which is coastally influenced and favours much more humid environments than the others.

In conclusion, a syntaxonomic scheme is presented to include the phytosociological characteristics of all these formations, indicating the distribution areas currently known for the syntaxa described.

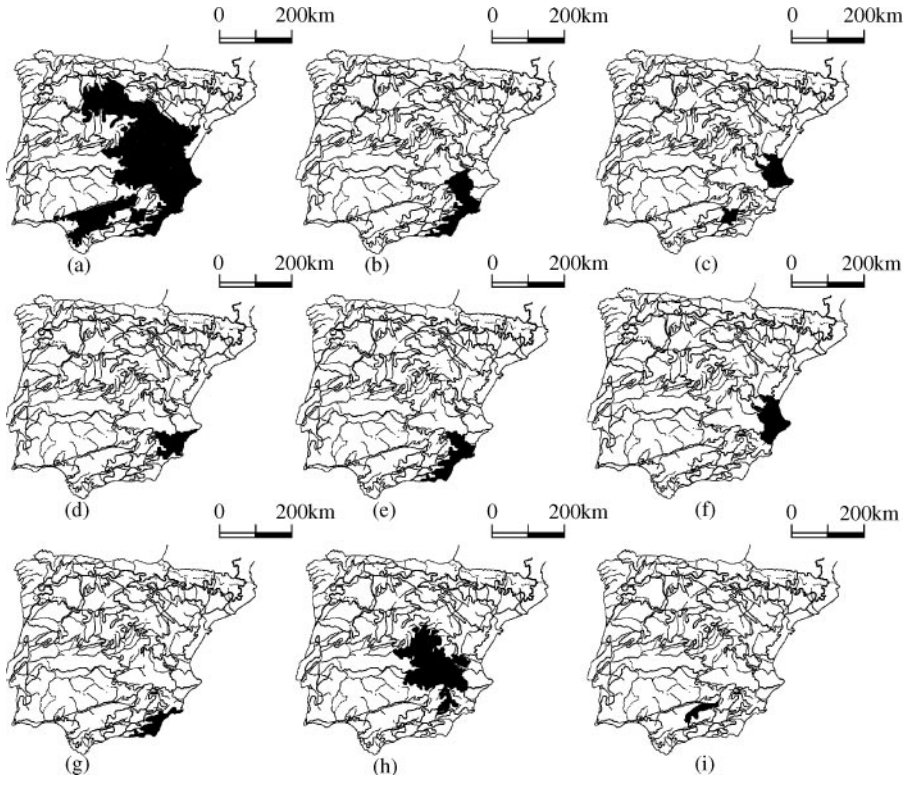

Figure 4. Biogeographical distribution of the described associations: (a) *Dactylo-Lygeetum sparti*, (b) *Limonio caesii-Lygeetum sparti*, (c) *Limonio delicatuli-Gypsophiletum tomentosae*, (d) *Senecioni majoris-Limonietum furfuracei* and *Limonietum caesio-delicatuli*, (e) *Limonietum angustibracteato-delicatuli*, (f) *Limonietum caesio-supini*, (g) *Limonio insignis-Lygeetum sparti*, (h) *Senecioni auriculae-Lygeetum sparti*, *Gypsophilo tomentosae-Limonietum dichotomi* and *Limonietum latebracteato-tournefortii*, (i) *Limonio quesadensis-Lygeetum sparti*.

Syntaxonomic scheme

Class *Thero-Brachypodietea ramosi* Br.-Bl. *ex* A. & O. Bolòs 1950
Order *Thero-Brachypodietalia ramosi* Br.-Bl. *ex* Molinier 1934
Alliance *Agropyro pectinati-Lygeion sparti* Br.-Bl. & O. Bolòs 1958 *corr.* Rivas-Martínez *et al.* 1998
*Association *Dactylo hispanicae-Lygeetum sparti* Rivas-Martínez *ex* Alcaraz 1984 (Setabense, Murciano-Almeriense, Guadiciano-Bacense, Castellano-Maestrazgo-Manchega & Hispalense)
subassociation *limonietosum caesii* Alcaraz 1984 (Murciano-Almeriense)
subassociation *salsoletosum genistoidis* Alcaraz 1984 (Murciano-Almeriense)
subassociation *stipetosum tenacissimae* Cantó, Laorga & Belmonte 1986 (Alicantina)

Class *Salicornietea fruticosae* Br.-Bl. & Tüxen *ex* A. & O. Bolòs 1950
Order *Limonietalia* Br.-Bl. *et* O. Bolòs 1958 *em.* Rivas-Martínez & Costa 1984
Alliance *Lygeo sparti-Limonion angustibracteati* Alcaraz, P. Sánchez and De la Torre 1988

*Association *Limonio caesii-Lygeetum sparti* Rivas-Martínez & Alcaraz *in* Alcaraz 1984 (Murciano-Almeriense and Manchego-Murciano)
subassociation *limonietosum cossoniani* Alcaraz 1984 (Murciano, Alicantino)
subassociation *helianthemetosum polygonoidis* Valdés-Franzi *et al.* 1993 (Manchego-Murciano)
*Association *Limonio delicatuli-Gypsophiletum tomentosae* Peinado & Martínez-Parras 1982 (Guadiciano-Bacense, Setabense)
subassociation *limonietosum maji* Salazar *nova* (Endemic to Guadiciano-Bastetano)
*Association *Senecioni majoris-Limonietum furfuracei* Rigual 1972 (Alicantino-Murciano)
subassociation *crithmetosum* Rigual 1958 (Alicantina)
*Association *Limonietum caesio-delicatuli* Rigual 1972 (Alicantino-Murciano)
subassociation *lycietosum intricatae* Rigual 1968 (Alicantina)
subassociation *salsoletosum genistoidis* Rigual 1968 (Alicantina)
*Association *limonietum angustebracteato-delicatuli* Rivas-Martínez & Alcaraz *in* Alcaraz 1984 (Murciano-Almeriense)
*As *Limonietum caesio-supini* Alcaraz, Sánchez-Gómez & De la Torre 1989 (Alicantino, Setabense)
subassociation *limonietosum cossoniani* Alcaraz, Sánchez-Gómez & De la Torre 1988 (Alicantino, Setabense)
*Association *Limonio insignis-Lygeetum sparti* Alcaraz, Sánchez-Gómez & De la Torre 1988 (Almeriense)
subassociation *limonietosum cossoniani* Alcaraz, Sánchez-Gómez & De la Torre 1988 (Almeriense).

Alliance *Lygeo sparti-Lepidion cardaminis* Rivas-Goday & Rivas-Martínez 1963
*Association *Senecioni auriculae-Lygeetum sparti* Rivas-Goday & Rivas-Martínez *in* Rivas-Martínez & Costa 1976 (Manchego)
subassociation *elymetosum curvifolii* Cirujano 1981 (Manchego)
*Association *Gypsophilo tomentosae-Limonietum dichotomi* Rivas-Martínez & Izco *in* Rivas-Martínez & Costa 1976 (Manchego)
subassociation *holoschoenetosum* Rivas-Martínez & Izco *in* Rivas-Martínez & Costa 1976 (Manchego)
*Association *Limonietum latebracteato-tournefortii* Castroviejo and Cirujano 1980 (Manchego)
subassociation *Limonietosum supinae* Castroviejo & Cirujano 1980 (Manchego)
subassociation *sarcocornietosum alpini* Castroviejo & Cirujano 1980 (Manchego)
*Association *Limonio quesadensis-Lygeetum sparti* García-Fuentes *nova* (Endemic to Hispalense)

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