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A COMPARATIVE STUDY OF THE VEGETATION AT AIGUAMOLLS DE L'EMPORDÀ WETLANDS (N.E. IBERIAN PENINSULA)

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RESUM

S'ha estudiat el poblament vegetal de tres àrees del Parc Natural dels Aiguamolls de L'Empordà representatives de la seva diversitat. L'estudi i classificació posterior s'han realitzat mitjançant l'anàlisi de conglomerats (Clustering), els grups de TWINSPAN, l'anàlisi de correspondència i el mètode fitosociològic. Les diferències entre els grups obtinguts responen a factors ecològics, però també a l'activitat humana. Els resultats permeten fer un esquema de la dinàmica de successions de la vegetació a la zona del Parc i establir conclusions per a la seva gestió.

RESUMEN

Se ha estudiado la vegetación de tres áreas incluidas en el Parque Natural dels Aiguamolls de l'Empordà (Gerona), representativas de la diversidad paisajística de la zona. El estudio y posterior clasificación se han realizado mediante Clustering, los grupos de TWINSPAN, el análisis de correspondencias y el método fitosociológico. Las diferencias entre los grupos obtenidos responden a factores ecológicos y también a la actividad humana. Los resultados permiten confeccionar un esquema de la dinámica de sucesión de la vegetación del Parque y establecer conclusiones para su gestión.

ABSTRACT

Three areas within Aiguamolls de l'Empordà Natural Park (Gerona, Iberian Peninsula) representative of the habitat diversity within the wetlands have been described and classified with Cluster analysis, TWINSPAN groups, Correspondence analysis and Phytosociological methods. The differences between the groups produced are due to ecological factors and human activity. The results allow a dynamic scheme of succession to be formulated for the pasture vegetation of the closes, with conclusions for the management of this important protected area.

Keywords: Empordà wetlands, Catalonia, Iberian Peninsula, vegetation, multivariate analysis, phytosociology.

INTRODUCTION

Aiguamolls de l'Empordà Natural Park (AENP), situated in the Gulf of Roses, N.E. Catalonia (Figure 1) encompasses one of the last extensive wetlands surviving along the Mediterranean coastline. It has traditionally been valued for its ornithological importance (Sargatal & Fèlix, 1989) and was declared a Ramsar site in 1992.

The climate is typically Mediterranean with hot dry summers and maximum rainfall in spring and autumn, an annual precipitation of 600 l/m2, average temperature of 15ºC and maximums towards the end of July.

The coastal plain of the Empordà region was formed as a result of tectonic movements 25 million years ago. Sedimentation from the Fluvià and Muga Rivers throughout the Quaternary era over this delta plain, and the dynamic interaction of these sediments with the sea have shaped the marshes, lagoons and sand dune systems of the Empordà wetlands as they are today (Bach, 1990). Three distinct sediment environments can be identified: fluvial, marsh and marine, distinguished by soil texture, organic content and salinity. A general characteristic of the coastal plain are the abundant variations in microtopography and sedimentation patterns which occur over relatively small areas producing a complicated mosaic effect in the vegetation. This mosaic is further emphasised by human activity.

The floristic records from the beginning of the century by the botanists Bubani, Vayreda and Sennen are listed in the catalogue of higher plants of the Alt Empordà region compiled by Malagarriga (1976). More recently Farràs & Velasco (1994) described the principal plant communities of these wetlands, focusing particularly on the saltmarsh associations. This study aims to complement this knowledge and is a description of the vegetation and ecology of three sites (within the AENP) not previously treated.

SITE SELECTION AND DESCRIPTION

The three sites chosen for the study are representative of some of the principal habitats of the wetlands, and each contained vegetation units that had not previously been described. The sites, l'Estany de Palau, Closes de l'Ullal and La Rubina all lie in Polygon 1 of the AENP (Fig. 1) and have been the subject of a study on Lepidoptera (Stefanescu & Miralles 1994).

Two of the three study sites, l'Estany de Palau and Closes de l'Ullal, are formed on the bed of a once extensive lake, l'Estany de Castelló; Closes de l'Ullal is a typical water meadow while the site at Palau includes hemimarsh and part of the extensive reedbed occupying l'Estany de Palau.

L'Estany de Castelló, a lake of 8 km diameter lying between Castelló d'Empuries and Roses and described since Roman times, was in existence until the eighteenth century. The lake received fresh water and sediments from the River Muga and was connected to the sea through what are now the canals of the Santa Margarida urbanization. After the twelth century the natural silting up of the lake was accelerated by human intervention and nowadays only a few small areas (els Estanys de Mornau, l'Estany de Palau and Vilaüt) remain more or less permanently flooded. The reclaimed areas became flood or water meadows ('closes'), mowed for hay and grazed, and limited by drainage canals bordered with wide hedges of riverine vegetation. These meadows have a high agricultural and biological value and are a unique landscape element in the mediterranean region.

The soils originating from these lakes and marshes are silty clays or muds with abundant organic matter and are more or less saline from the historical connection

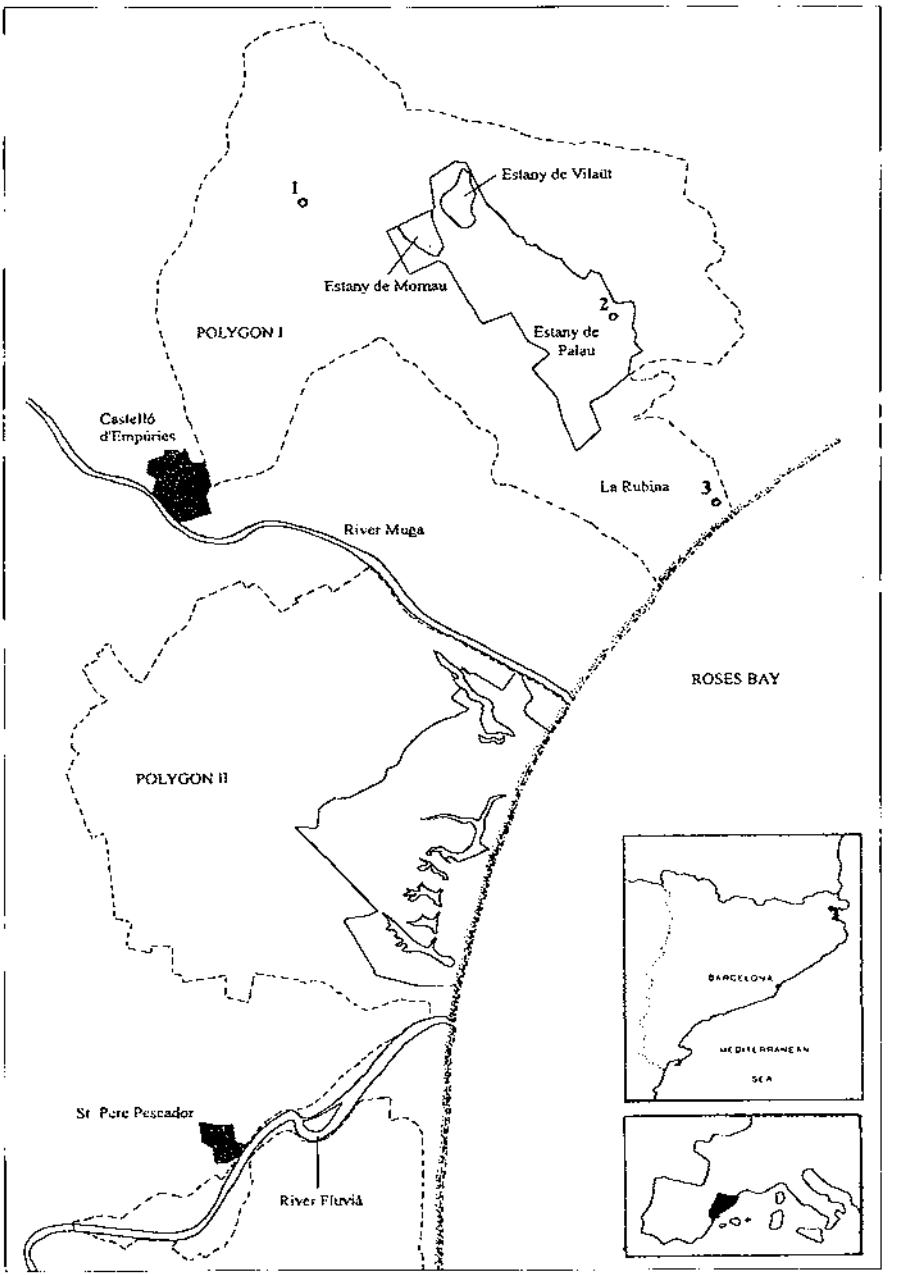


Fig.1 - Map of the study area, showing the three sampling sites. 1: Closes de l'Ullal 2: Estany de Palau 3: La Rubina. Discontinuous lines correspond to the limits of the Natural Park, and solid lines to the Integral Reserves.

with the sea. In places where water meadows have persisted the soil may become relatively deep and rich but the threat of salinity is ever present; historically the regular winter flooding of the 'closes' serves to wash the soils and keep salinity more or less at bay.

The third study site, at La Rubina, is on the site of an old beach ridge sequence; and includes ancient beach ridges (apparent from the sandy, coarse and well drained soil) and a saltmarsh formed in the depression between these.

The coastal saltmarshes are formed by the gradual silting up of coastal lagoons formed in depressions between old beach ridge sequences. The saltmarsh soils are also silty clay or muds with high levels of organic matter and salts as well as remains of bivalves. This is deposited over a base of coarser sandy material (the beach ridge sequences). As well as being regularly flooded by fresh water in the rainy season these areas are frequently flooded by sea water when strong winds blow from the sea inland during winter.

As already mentioned, the coastal plain is characterised by abrupt variations in microtopography and soil structure. At each of the three study sites subunits of vegetation are readily distinguished. These are described to aid identification of the groups produced by data analysis.

At La Rubina the area of saltmarsh, formed in a beach ridge depression and periodically flooded by fresh and sea water is denominated section A, and the site of an old beach ridge, with markedly coarser sandier soil, some organic matter and saline mud section B. Section C is a disused field strip with a dry gravel and sand substrate and little organic matter or salts.

The site at Palau includes the edge and part of the reedbed which occupies the deep marsh or l'Estany de Palau (section D). This area remains flooded (to 50 cm) for at least 10 months of the year and the soils are usually anaerobic. Sections E and F are at the top and middle of the hemimarsh on the slope down to the reedbed respectively, heavily grazed by cattle and shallowly flooded (to 15 cm) or waterlogged for most of year. Section E is slightly drier than sections D or F. The entire area was cultivated for rice until 1982.

At Closes de l'Ullal there are marked changes in the vegetation from one side of the field to the other. The following zones can be identified: an area of tall meadow vegetation flooded in winter and cut for hay (section G); an area where flooding is more persistent, characterised by the invasion of marsh species (section H) and a corner shallowly flooded for most of the year (section I). There is a large zone on the other side of the field which is quite a bit drier with a low vegetation (section J) and where this become more saline section K. The field is bordered by a tall hedge of riverine woodland section L.

METHODS

At each of the three main study sites a central point was located, which coincided with the position of the light trap set for the study on Lepidoptera (Stefanescu & Miralles 1994). All vegetation within a radius of approximately 50 m from this reference point was sampled (the approximate area of influence of the light trap). The

sites were divided into sections, based on the areas of vegetation already described, allowing a grid to be marked out for each section. The sampling points were located on this grid using random numbers as coordinates. It should be emphasised that all the vegetation at a site was included and not only apparently homogenous stands. For each section the curve of cumulative species richness with area gave an approximation of the minimum number of samples needed (Greig-Smith, 1957) , which was in all cases exceeded. Although this curve rarely becomes completely horizontal (a reflection of the continous variation in vegetation) the point of inflection does provide a guideline for sampling. The final data set was 411; 202 at Closes de l'Ullal, 107 at La Rubina and 102 at Palau.

A quadrat of 1m side (subdivided into 16) was placed at each point and abundance and cover recorded for all the vascular species present. The Domin Scale was chosen, this is a logarithmic scale with values from 0-10 combining abundance and cover and allowing a high precision with practice (Kershaw & Looney, 1985). Sampling was carried out from May to July 1993, the annual vegetation at La Rubina being sampled first.

Phytosociological study

As a complement to the main quadrat survey a phytosociological study based on the communities identified at each site was undertaken, concentrating on the most interesting associations. These have been studied in detail while the rest, already described by Farràs & Velasco (1994) for AENP, are briefly listed to enable comparison with the results of the main survey. Following phytosociological principles the association tables also include relevés from other areas within the Park, whose exact location is listed at the foot of each table. A numeric value of cover was recorded for each species in a relevé (discrete vegetation unit) according to the method of Braun-Blanquet (1979). The size of the homogenous unit studied (e.g. 100 m2) and height and total cover of the vegetation were also noted.

Data analysis

Mean cover and frequency of each species at the three study sites was calculated. The vegetation was classified using clustering based on complete linkage, using the programme SPSS for windows 6.0 and two-way indicator species analysis TWINSPAN (Hill *et. al.*, 1975). Detrended correspondence analysis DCA (Hill & Gauch, 1980) was also applied. To sinplify interpretation the mean of 5 to 7 stands was taken and the resulting stands are those used throughout the analysis. Although some information is inevitably lost it was felt the simplification obtained, particularly for correspondence analysis, compensated this. Stands were only grouped with others from the same sampling section. Thus the original data set of 202 stands at Closes de l'Ullal, 107 at La Rubina and 102 at Palau was simplified to 29, 15 and 15 stands, respectively. In a few places a reference is made to the original data set if this was felt necessary.

To detect habitat preferences the chi-squared statistic was applied to the frequency of occurrence of the different species in the vegetation groups produced by TWINSPAN (Basset, 1978; Kershaw & Looney, 1985). Diversity was calculated using the Shannon-Wiener index (Shannon & Weaver, 1949) H':

$$H' = \sum_{i=1}^{s} p_i \log_2 p_i$$

where H' = Information content of sample (bits/individual
s = Number of species
p = Proportion of total sample belonging to ith species

RESULTS

The three sites

A total of 163 taxa were recorded from the stand survey; and a further 39 from the phytosociological inventories or simply recorded from the three sites. Table 1A shows the results of the stand survey as frequencies of occurrence for the species at each site. A total of 79 species were recorded from Closes de l'Ullal of which 41 were exclusive to that site; 73 from La Rubina of which 61 were exclusive and 52 from Palau of which 21 were exclusive to that site. Table 1B is a further list of other species recorded from the sites either through the phytosociological inventories or noted as present. The total at l'Ullal becomes 115 of which 68 are exclusive; 85 from La Rubina of which 73 are exclusive and 54 from Palau of which 22 are exclusive.

Species	Closes de l'Ullal	La Rubina	Palau
Equisetum ramosissimum ssp. *ramosissimum*	0.01	-	-
Ephedra distachya ssp. *distachya*	-	0.09	-
Clematis flammula	0.01	-	-
Ranunculus sardous ssp. *sardous*	0.04	-	0.01
Ranunculus repens	0.04	-	-
Sedum sediforme	-	0.30	-
Rubus ulmifolius	0.08	-	0.05
Rosa canina ssp. *stylosa*	0.09	-	-
Potentilla reptans	0.01	-	-
Crataegus monogyna	0.02	-	-
Lathyrus hirsutus	0.01	0.02	-
Medicago littoralis	-	0.06	-
Trifolium campestre	-	0.04	-
Trifolium nigrescens	-	0.06	-
Trifolium repens	0.01	-	-
Trifolium fragiferum	0.15	-	0.01
Trifolium squamosum	0.04	-	-
Lotus corniculatus ssp. *tenuifolius*	0.30	-	-
Lotus corniculatus ssp. *corniculatus*	-	0.01	0.07
Tetragonolobus maritimus	0.05	-	-
Ornithopus pinnatus	-	0.12	-
Helianthemum guttatum ssp. *guttatum*	-	0.08	-

Species	Closes de l'Ullal	La Rubina	Palau
Helianthemum salicifolium	-	0.12	-
Helianthemum hirtum	-	0.19	-
Fumana thymifolia var. *vulgaris*	-	0.13	-
Tamarix anglica	0.01	-	0.04
Althaea officinalis	0.09	-	0.15
Linum usitatissimum ssp. *angustifolium*	-	0.06	-
Linum strictum ssp. *strictum*	-	0.07	-
Paliurus spina-christi	0.01	-	-
Rhamnus alaternus	0.03	-	-
Cornus sanguinea	0.01	-	-
Hedera helix	0.05	-	-
Oenanthe fistulosa	0.14	-	-
Oenanthe lachenalii	0.28	-	0.15
Apium graveolens	0.20	-	-
Apium nodiflorum ssp. *nodiflorum*	-	-	0.15
Daucus carota	-	0.22	-
Quercus humilis	0.11	-	-
Ulmus minor	0.20	-	-
Euphorbia terracina	-	0.07	-
Euphorbia hirsuta	-	-	0.06
Callitriche stagnalis	-	-	0.04
Rumex conglomeratus	0.02	-	0.06
Rumex crispus	0.01	-	-
Polygonum mite	-	-	0.20
Polygonum aviculare	0.01	-	-
Arenaria serpyllifolia ssp. *serpyllifolia*	-	0.11	-
Minuartia hybrida	-	0.01	-
Cerastium pumilum	-	0.08	-
Paronychia argentea	-	0.08	-
Spergularia maritima	0.02	0.01	-
Petrorhagia prolifera ssp. *prolifera*	-	0.09	-
Atriplex portucaloides	-	0.08	-
Atriplex prostrata	0.06	-	0.02
Suaeda maritima	0.02	-	-
Arthrocnemum macrostachyum	-	0.07	-
Arthrocnemum fructicosum	-	0.56	-
Asterolinon linum-stellatum	-	0.15	-
Samolus valerandi	-	0.04	0.06
Limonium vulgare	0.02	0.46	-
Limonium virgatum ssp. *virgatum*	-	0.28	-
Limonium girardianum ssp. *girardianum*	-	0.06	-
Fraxinus angustifolia ssp. *angustifolia*	0.14	-	-
Ligustrum vulgare	0.01	-	-
Blackstonia perfoliata ssp. *imperfoliata*	-	0.09	-
Centaurium pulchellum ssp. *pulchellum*	0.02	-	-
Centaurium pulchellum ssp. *tenuiflorum*	-	0.06	-
Centaurium erythraea ssp. *majus*	0.02	-	-

Species	Closes de l'Ullal	La Rubina	Palau
Calystegia sepium ssp. *sepium*	-	-	0.10
Convolvulus arvensis	-	-	0.13
Teucrium polium ssp. *polium*	-	0.17	-
Sideritis hirsuta ssp. *emporitana*	-	0.02	-
Thymus vulgaris ssp. *vulgaris*	-	0.05	-
Lycopus europaeus	-	-	0.08
Mentha suaveolens	-	-	0.03
Salvia verbenaca ssp. *verbenaca*	-	0.03	-
Vitex agnus-castus	0.01	-	-
Bellardia trixago	-	0.01	-
Plantago coronopus	0.02	-	0.01
Plantago lagopus	-	0.19	-
Plantago crassifolia	0.02	0.28	-
Plantago lanceolata	-	0.04	-
Plantago major ssp. *major*	0.14	-	-
Galium palustre ssp. *elongatum*	-	-	0.29
Valantia muralis	-	0.08	-
Valerianella pumila	-	0.07	-
Scabiosa atropurpurea	-	0.22	-
Aster squamatus	0.39	0.08	0.04
Conyza sumatrensis	-	0.16	-
Helichrysum stoechas	-	0.06	-
Inula crithmoides	-	0.51	-
Inula viscosa	0.01	0.13	-
Pulicaria dysenterica	-	-	0.09
Artemisia gallica ssp. *gallica*	-	0.38	-
Hedypnois rhagadioloides	-	0.02	-
Cichorium intybus	0.01	-	-
Picris echioides	0.01	-	0.02
Sonchus maritimus ssp. *aquatilis*	0.01	-	0.07
Crepis sancta	-	0.05	-
Alisma plantago-aquatica	0.01	-	0.52
Triglochin maritimum	-	0.02	0.05
Triglochin bulbosum ssp. *barrelieri*	-	0.02	-
Muscari comosum	-	0.08	-
Asparagus acutifolius	0.01	-	-
Ruscus aculeatus	0.01	-	-
Romulea columnae ssp. *columnae*	-	0.30	-
Iris pseudacorus	0.16	-	0.27
Juncus bufonius ssp. *bufonius*	-	-	0.01
Juncus maritimus	-	0.35	-
Juncus acutus	0.04	0.08	0.17
Juncus effusus	-	-	0.03
Juncus inflexus	-	-	0.05
Juncus articulatus	0.03	-	0.25
Juncus subulatus	-	-	0.21
Juncus compressus ssp. *compressus*	0.12	-	0.12

Species	Closes de l'Ullal	La Rubina	Palau
Juncus compressus ssp. *gerardi*	0.20	-	-
Scirpus holoschoenus	0.03	-	-
Scirpus maritimus	0.03	0.09	0.52
Scirpus lacustris	-	-	0.37
Eleocharis palustris ssp. *palustris*	0.10	-	0.40
Cyperus longus	0.04	-	-
Schoenus nigricans	-	0.24	-
Carex vulpina ssp. *nemorosa*	0.10	-	0.35
Carex divisa ssp. *divisa*	0.50	-	-
Carex hirta	0.02	-	-
Carex distans	0.04	-	0.03
Carex extensa	-	0.14	-
Festuca arundinacea s.l.	0.29	0.01	0.01
Lolium rigidum	0.02	-	-
Lolium perenne	0.01	-	-
Desmazeria rigida ssp. *rigida*	-	0.02	-
Poa annua ssp. *annua*	0.01	-	-
Poa trivialis ssp. *trivialis*	0.36	-	0.01
Puccinellia festuciformis	0.06	0.30	-
Dactylis glomerata ssp. *glomerata*	-	0.06	-
Glyceria fluitans	0.03	-	-
Brachypodium phoenicoides	-	0.06	-
Elymus elongatum	-	0.42	-
Elymus repens	0.02	-	-
Elymus pungens	0.05	0.20	0.09
Agropyron cf. *acutum*	-	0.16	-
Hordeum marinum ssp. *marinum*	0.20	-	-
Hordeum secalinum	0.23	-	-
Gaudinia fragilis	-	-	-
Koeleria pubescens ssp. *pubescens*	-	0.02	-
Agrostis stolonifera	0.07	-	0.42
Polypogon monspeliensis	0.07	-	0.02
Alopecurus bulbosus	0.07	-	-
Parapholis filiformis	-	0.09	-
Parapholis incurva	-	0.02	-
Arundo donax	0.01	-	-
Phragmites australis ssp. *australis*	0.02	-	0.66
Aeluropus littoralis	-	0.02	-
Cynodon dactylon	0.36	-	0.01
Echinocloa crus-galli ssp. *crus-galli*	-	-	0.25
Paspalum distichum	0.32	-	0.75
Lemna minor	-	-	0.01
Sparganium erectum	-	-	0.01
Typha angustifolia ssp. *australis*	-	-	0.36
Typha latifolia	-	-	0.02
Ophyrs sphegodes ssp. *sphegodes*	-	0.06	
Total number of species	79	73	52
SITE DIVERSITY	5.09	5.28	4.00

Tab. 1A: Results of the stand survey; frequencies of ocurrence of species at the three study sites. Nomenclature follows Bolòs & Vigo (1984-1995) and Bolòs et.al., 1993.

Closes de l'Ullal	La Rubina	Palau
Ramunculus sceleratus	*Ononis natrix* ssp. *natrix*	*Rumex crispus*
Vicia sativa ssp. *nigra*	*Medicago truncatula*	*Juncus conglomeratus*
Vicia hirsuta	*Trifolium glomeratum*	
Melilotus sulcata	*Fumana ericoides* var. *spachii*	
Trifolium pratense	*Linaria arvensis* ssp. *arvensis*	
Dorycnium rectum	*Centranthus calcitrapeae*	
Lythrum hyssopifolia	*Centaurea aspera*	
Epilobium hirsutum	*Galactites tomentosa*	
Tamarix canariensis	*Vulpia* spp.	
Linum usitatissimum ssp. *angustifolium**	*Brachypodium retusum*	
*Apium nodiflorum**	*Lagurus ovatus*	
Euphorbia platyhyllos	*Ophyrs tenthredinifera*	
*Euphorbia hirsuta**		
Polygonum hydropiper		
*Polygonum mite**		
Spergularia marina		
*Atriplex portulacoides**		
Calystegia sepium ssp. *sepium**		
Heliotropium europaeum		
Parentucellia viscosa		
Orobanche minor		
Galium palustre ssp. *elongatum**		
Rubia peregrina ssp. *peregrina*		
Bellis perennis		
Cirsium arvense		
Leontodon taraxacoides ssp. *hispidus*		
Sonchus asper ssp. *asper*		
Allium vineale		
Bromus catharticus		
Bromus hordeaceus ssp. *hordeaceus*		
Arrhenatherum elatius ssp. *elatius*		
Gaudinia fragilis		
Phleum pratense		
Phalaris minor		
Echinochloa crus-galli ssp. *crus-galli**		
Orchis laxiflora		
Total number of species: 36	12	2

Tab. 1B: Other species found at the study sites: data from the phytosociological study or recorded from the site.
*(*indicates species already cited for other sites).*

An examination of the composition by families (Figure 2) showed the Gramineae to be the most important family at all three sites, reflecting the importance of pasture vegetation in these wetlands. This was in sharp contrast to the normal situation of saltmarshes where Chenopodiaceae is the most dominant family. The abundance of Juncaceae and Cyperaceae at Palau and the presence of Cyperaceae at Closes de l'Ullal indicate extremely humid conditions. Although the salt meadow area at La Rubina is humid the extreme salinity particularly favours Chenopodiaceae. The abundance of Cystaceae and Caryophyllaceae, typically Mediterranean families, at La Rubina reflect the dry stony habitat of the beach ridges and abandoned field strips.

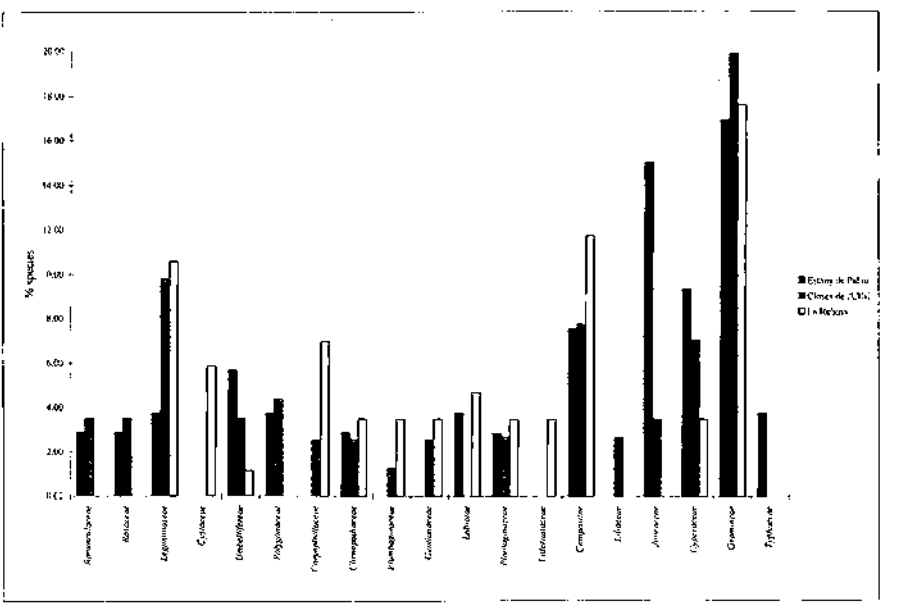


Fig.2 - Taxonomic composition of plant assemblages at the three study sites considering percentage contribution of each family to the species total.

Table 2 shows mean cover (a measure of abundance) and frequency of the 'top twenty' species at each site. *Paspalum distichum* is the most abundant species at both Palau and Closes de l'Ullal. Although this is in part due to the vital form of this introduced species which forms a dense carpet becoming completely dominant (at Closes de l'Ullal it is only the fifth most frequent species) it also reflects similarities between the vegetation at the two sites. Although 6 of the 20 most frequent species at Closes de l'Ullal are grasses; the most representative meadow species, *Poa trivialis*, *Festuca arundinacea* and *Hordeum secalinum* are neither most abundant or frequent. In contrast *Cynodon dactylon*, a low reptant species of dry grassland with a similar growth habit to *Paspalum distichum* is important. The predomi-

nance of *Carex divisa*, *Hordeum marinum* ssp. *marinum* and *Juncus compressus* ssp. *gerardi* at Closes de l'Ullal indicate a degree of salinity while *Aster squamatus*, an introduced opportunist highly competitive on bare ground produced by overgrazing or salinization, implies a degree of stress at the site.

At the marsh site, Palau, the second most frequent and abundant species is *Phragmites australis*. At La Rubina *Arthrocnemum fructicosum* is both most frequent and abundant; the dominance of this species in the salt meadows is almost complete.

	Closes de l'Ullal		La Rubina		Palau	
1	*Paspalum distichum*	59.8	*Arthrocnemum fructicosum*	52.4	*Paspalum distichum*	75.9
2	*Cynodon dactylon*	55.3	*Elymus elongatus*	26.5	*Phragmites australis*	49.0
3	*Carex divisa* ssp. *divisa*	51.8	*Inula crithmoides*	26.2	*Agrostis stolonifera*	18.2
4	*Poa trivialis* ssp. *trivialis*	49.5	*Juncus maritimus*	21.4	*Scirpus lacustris*	18.1
5	*Festuca arundinacea*	38.0	*Artemisia gallica*	20.5	*Scirpus maritimus*	18
6	*Aster squamatus*	33.1	*Plantago crassifolia*	17.9	*Carex vulpina* ssp. *nemorosa*	17.6
7	*Oenanthe lachenalii*	32.6	*Sedum sediforme*	17.9	*Eleocharis palustris* ssp. *palustris*	17.5
8	*Hordeum marinum* ssp. *marinum*	31.0	*Schoenus nigricans*	17.3	*Alisma plantago-aquatica*	17.4
9	*Iris pseudacorus*	30.9	*Elymus pungens*	16.1	*Typha angustifolia* ssp. *australis*	14.4
10	*Lotus corniculatus* ssp. *teniufolius*	30.1	*Limonium vulgare* ssp. *serotinum*	15.0	*Iris pseudacorus*	11.1
11	*Ulmus minor*	25.0	*Puccinellia festuciformis*	14.3	*Juncus acutus*	10.8
12	*Hordeum secalinum*	21.7	*Helianthemum hirtum*	12.7	*Echinocloa crus-galli* ssp. *crus-galli*	8.94
13	*Juncus compressus* ssp. *gerardi*	20.3	*Scabiosa atropurpurea* var. *maritima*	12.2	*Galium palustre* ssp. *elongatum*	7.54
14	*Apium graveolens*	20.2	*Plantago lagopus*	11.1	*Convolvulus arvensis*	7.14
15	*Fraxinus angustifolia* ssp. *angustifolia*	17.8	*Limonium virgatum* ssp. *virgatum*	11.0	*Juncus articulatus*	7.12
16	*Oenanthe fistulosa*	16.4	*Teucrium polium* ssp. *polium*	10.1	*Juncus subulatus*	5.71
17	*Quercus humilis*	15.2	*Agropyron* cf. *acutum*	7.95	*Juncus compressus* ssp. *compressus*	4.89
18	*Trifolium fragiferum*	13.5	*Fumana thymifolia* var. *vulgaris*	7.07	*Polygonum mite*	4.73
19	*Plantago major* ssp. *major*	12.0	*Ornithopus pinnatus*	7.05	*Althaea officinalis*	4.27
20	*Juncus compressus* ssp. *compressus*	11.0	*Ephedra distachya* ssp. *distachya*	6.86	*Apium nodiflorum*	3.88
a	*Carex divisa* ssp. *divisa*	0.50	*Arthrocnemum fructicosum*	0.56	*Paspalum distichum*	0.75
b	*Aster squamatus*	0.39	*Inula crithmoides*	0.51	*Phragmites australis*	0.66
c	*Cynodon dactylon*	0.36	*Limonium vulgare* ssp. *serotinum*	0.46	*Alisma plantago-aquatica*	0.52
d	*Poa trivialis* ssp. *trivialis*	0.36	*Elymus elongatus*	0.42	*Scirpus maritimus*	0.52
e	*Paspalum distichum*	0.32	*Artemisia gallica*	0.38	*Agrostis stolonifera* ssp. *stolonifera*	0.42
f	*Lotus corniculatus* ssp. *teniufolius*	0.30	*Juncus maritimus*	0.35	*Eleocharis palustris* ssp. *palustris*	0.40
g	*Festuca arundinacea*	0.29	*Sedum sediforme*	0.30	*Scirpus lacustris*	0.37
h	*Oenanthe lachenalii*	0.28	*Puccinellia festuciformis*	0.30	*Carex vulpina* ssp. *nemorosa*	0.35
i	*Hordeum secalinum*	0.23	*Romulea columnae*	0.30	*Typha angustifolia* ssp. *australis*	0.35
j	*Juncus compressus* ssp. *gerardi*	0.20	*Plantago crassifolia*	0.28	*Galium palustre* ssp. *elongatum*	0.29
k	*Hordeum marinum* ssp. *marinum*	0.20	*Limonium virgatum* ssp. *virgatum*	0.28	*Iris pseudacorus*	0.27
l	*Ulmus minor*	0.20	*Schoenus nigricans*	0.24	*Juncus articulatus*	0.25
m	*Apium graveolens*	0.20	*Scabiosa atropurpurea* ssp. *maritima*	0.22	*Echinocloa crus-galli* ssp. *crus-galli*	0.25
n	*Iris pseudacorus*	0.16	*Daucus carota*	0.22	*Juncus subulatus*	0.21
o	*Trifolium fragiferum*	0.15	*Elymus pungens*	0.20	*Polygonum mite*	0.20
p	*Fraxinus angustifolia* ssp. *angustifolia*	0.14	*Helianthemum hirtum*	0.19	*Juncus acutus*	0.17
q	*Oenanthe fistulosa*	0.14	*Plantago lagopus*	0.19	*Althaea officinalis*	0.15
r	*Plantago major* ssp. *major*	0.14	*Teucrium polium* ssp. *polium*	0.17	*Oenanthe lachenalii*	0.15
s	*Juncus compressus* ssp. *compressus*	0.12	*Agropyron* cf. *acutum*	0.16	*Apium nodiflorum*	0.15
t	*Quercus humilis*	0.11	*Conyza sumatrensis*	0.16	*Convolvulus arvensis*	0.13

***Tab.2** Most important species at each of the study sites considering their mean cover (1-20) and frequency (a-t).*

The Vegetation Groups:
Cluster Analysis

The Cluster Analysis produced 13 groups at an arbitrary level set at 85 percent similarity. (Figure 3.) The structure of the groups and abundance of each species can be seen in Table 3, where the diversity and number of stands (both grouped and original) in each group is also listed.

Attention has been focused on the most abundant species in each group; species with very low abundances may be a product of reducing the number of quadrats for analysis.

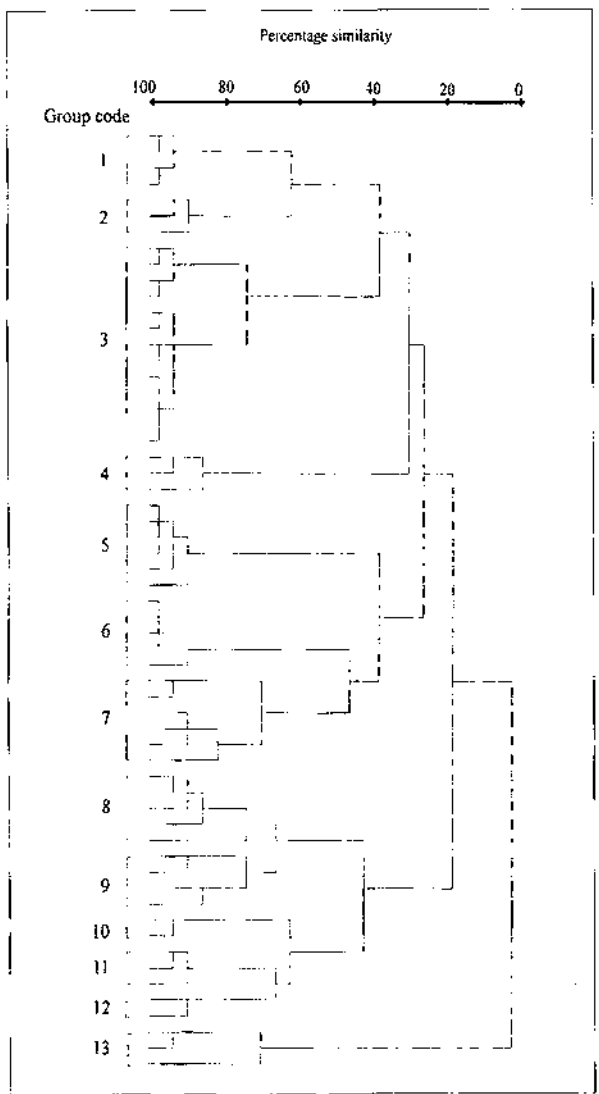


Fig.3 - Dendrogram of Complete linkage clustering for the stands surveyed from the three study sites. 1. Reedbed., 2. Memimosh corth Carex, *ssp., 3. Paspalum distichum* swards, *4. Mordeum marinum* swards, *5. Salt meadows, 6. Riverine woodland hedges, 7. Salt steppes, 8. Hay meadow, 9.* Cynodon dactylon *grassland, 10.* Carex divisa *flushes, 11 and 12. Damp meadow margins, 13. Dry therophytic pastures.*

	1	2	3	4	5	6	7	8	9	10	11	12	13
Phragmites australis	7 74	2 83	0.74	-	0.07	0.25	-	-	-	-	-	-	-
Scirpus maritimus	2 44	1 63	0 42	0 57	-	-	0.10	-	0 14	0.42	-	0.21	-
Alisma plantago-aquatica	2 24	0 57	0 57	-	-	-	-	-	-	-	-	-	-
Typha angustifolia* ssp. *australis	1 76	-	0 57	-	-	-	-	-	-	-	-	-	-
Eleocharis palustris* ssp. *palustris	1.36	0.93	1 29	-	-	-	-	-	-	-	-	0.21	-
Iris pseudacorus	1.22	1.13	1.83	-	-	-	-	0.09	0 11	-	2 72	0.43	-
Paspalum distichum	1 11	3 42	7.4	-	-	-	-	0 31	0 39	0 33	3 94	4.57	-
Convolvulus arvensis	0 80	1 26	0.01	-	-	-	-	-	-	-	-	-	-
Polygonum mite	0 51	0.63	0 06	-	-	-	-	-	-	-	-	-	-
Galium palustre* ssp. *elongatum	0 43	1.34	0 14	-	-	-	-	-	-	-	-	-	-
Scirpus lacustris	0.29	-	1 31	-	-	-	-	-	-	-	-	-	-
Mentha suaveolens	0 26	-	-	-	-	-	-	-	-	-	-	-	-
Agrostis stolonifera* ssp. *stolonifera	0 25	2.63	1 06	-	-	-	-	-	0 89	-	-	-	-
Apium nodiflorum	0.21	0.07	0 22	-	-	-	-	-	-	-	-	-	-
Typha latifolia	0.21	-	-	-	-	-	-	-	-	-	-	-	-
Juncus subulatus	0 18	1 10	0 13	-	-	-	-	-	-	-	-	-	-
Juncus articulatus	0.14	0.56	0 45	-	-	-	-	-	-	-	0 33	-	-
Sparganium erectum	0.14	-	-	-	-	-	-	-	-	-	-	-	-
Echinochloa crus-galli* ssp. *crus-galli	0.09	1.39	0.34	-	-	-	-	-	-	-	-	-	-
Lemna usitatissimum ssp. *angustifolium*	0.04	-	0.02	-	-	-	0.15	-	-	-	-	-	0.3
Pulicaria dysenterica	0.04	0.48	0.05	-	-	-	-	-	-	-	-	-	-
Carex vulpina* ssp. *nemorosa	0 04	3.68	0.5	-	-	-	-	0.77	-	0.25	1 56	0 21	-
Lemna minor	0.04	-	-	-	-	-	-	-	-	-	-	-	-
Rumex conglomeratus	0.02	-	-	-	-	-	-	-	-	-	-	-	-
Juncus acutus	-	2 97	0 14	0.19	0.1	-	0.59	0.46	-	-	-	-	-
Althaea officinalis	-	1.38	0 01	-	-	-	-	0 84	0.18	-	0.03	1 14	-
Juncus compressus* ssp. *compressus	-	1.20	0.16	-	-	-	-	1 00	0.02	-	0 44	1 86	-
Sonchus maritimus ssp. *aquatilis*	-	0.83	-	-	-	-	-	-	0 11	-	-	-	-
Elymus pungens	-	0.83	-	0.06	-	-	2.59	0.86	0.89	-	-	-	-
Juncus articulatus	-	0 56	-	-	-	-	-	-	-	-	-	-	-
Oenanthe lachenalii	-	0 48	0.15	0.41	-	-	-	2 51	1.43	1 19	0 64	3 79	-
Lotus corniculatus ssp. *corniculatus*	-	0 44	0.02	-	0.01	-	-	-	-	-	-	-	-
Tamarix anglica	-	0 38	0 09	-	-	0.18	-	-	-	-	-	-	-
Callitriche stagnalis	-	0 37	-	-	-	-	-	-	-	-	-	-	-
Rubus ulmifolius	-	0 34	0.05	-	-	1.31	-	-	-	-	-	-	-
Euphorbia hirsuta	-	0 30	-	-	-	-	-	-	-	-	-	-	-
Lycopus europaeus	-	0 26	0.08	-	-	-	-	-	-	-	-	-	-
Triglochin maritimum	-	0 21	0.04	-	0 04	-	0 05	-	-	-	-	-	-
Aster squamatus	-	0 19	0.06	0 66	0 24	-	-	2.33	1.45	1.4	1 64	2.64	-
Samolus valerandi	-	0 17	0.04	-	0.17	-	-	-	-	-	-	-	-
Carex distans	-	0 14	-	-	-	-	-	0 29	0 11	-	-	0.21	-
Poa trivialis	-	0 14	-	0 01	-	-	-	4.6	2.21	0 42	3.33	3.29	-
Juncus inflexus	-	0 11	0.15	-	-	-	-	-	-	-	-	-	-
Rumex conglomeratus	-	0 10	0.01	-	-	0.01	-	-	-	-	0 14	-	-
Juncus bufonius ssp. *bufonius*	-	0 10	-	-	-	-	-	-	-	-	-	-	-
Polypogon monspeliensis	-	0 10	0 04	0 05	-	-	-	0.17	0 04	2 54	-	0.21	-
Cynodon dactylon	-	0 10	-	-	-	-	-	-	-	-	-	0.50	-
Apium nodiflorum	-	0 07	-	-	-	-	-	-	-	-	-	-	-
Ranunculus sardous ssp. *sardous*	-	0 05	0.06	-	-	-	-	-	0 21	0 05	-	-	-
Picris echioides	-	0 04	-	-	-	-	-	-	-	-	-	-	-
Atriplex prostrata	-	0.02	0 01	1 03	-	-	-	0.23	0 18	-	0 17	-	-
Plantago coronopus	-	0 02	-	-	-	-	-	-	-	-	-	-	-
Festuca arundinacea	-	0 02	-	-	-	-	0.06	5.2	1.71	0 46	0 39	1.5	-
Glyceria fluitans	-	-	0.2	-	-	-	-	-	-	-	-	-	-
Juncus effusus	-	-	0 16	-	-	-	-	-	-	-	-	-	-
Oenanthe fistulosa	-	-	0 09	-	-	-	-	-	0.25	0.55	3 83	0.79	-
Trifolium squamosum	-	-	0 04	-	-	-	-	0.43	0.14	-	-	-	-
Alopecurus bulbosus	-	-	0 04	-	-	-	-	0.06	0.79	0.07	0 28	0.07	-
Carex divisa* ssp. *divisa	-	-	0 03	1 80	-	-	-	1.69	1 48	5 93	4.28	3.50	-
Lotus corniculatus* ssp. *tenuifolius	-	-	0.03	0 29	-	-	-	2.94	1.57	1.02	0.39	2.36	-
Trifolium fragiferum	-	-	0.03	-	-	-	-	0.54	0.74	-	1 00	2.36	-
Hordeum marinum* ssp. *marinum	-	-	-	6.38	-	-	-	1.00	0 73	1.10	-	0.86	-
Cynodon dactylon	-	-	-	5 91	-	-	-	3.69	4.07	0.93	-	-	-
Puccinellia festuciformis	-	-	-	1.43	1.65	-	0 73	0.06	0.11	0.23	-	0.29	-
Suaeda maritima	-	-	-	0.82	-	-	-	-	-	-	-	-	-
Juncus compressus* ssp. *gerardi	-	-	-	0.71	-	-	-	1.17	0.13	3.60	0 50	1.57	-

Plantago coronopus	-	-	-	0.48	-	-	-	-	0.04	-	-	-	-
Elymus repens	-	-	-	0.47	-	-	-	0.17	0.50	-	-	-	-
Lolium rigidum	-	-	-	0.40	-	-	-	-	0.14	-	-	-	-
Spergularia marítima	-	-	-	0.22	0.01	-	-	0.03	0.07	0.07	-	-	-
Limonium vulgare* ssp. *serotinum	-	-	-	0.22	1.07	-	1.42	-	-	-	-	-	-
Hordeum secalinum	-	-	-	0.21	-	-	-	2.43	1.82	-	0.11	0.64	-
Apium graveolens	-	-	-	0.14	-	-	-	1.09	0.23	0.50	2.56	2.36	-
Plantago crassifolia	-	-	-	0.14	0.17	-	2.82	0.14	0.14	-	-	-	-
Plantago major* ssp. *major	-	-	-	0.14	-	-	-	0.60	0.29	0.66	1.00	1.57	-
Rumex crispus	-	-	-	0.10	-	-	-	-	-	-	-	-	-
Poa trivialis ssp. *trivialis*	-	-	-	0.10	-	-	-	-	-	-	-	-	-
Arthrocnemum fruticosum	-	-	-		7.24	-	1.49	-	-	-	-	-	-
Elymus elongatus	-	-	-	-	3.27	-	1.14	-	-	-	-	-	-
Inula crithmoides	-	-	-	-	3.04	-	1.34	-	-	-	-	-	-
Juncus maritimus	-	-	-	-	2.05	-	1.52	-	-	-	-	-	-
Carex extensa	-	-	-	-	0.79	-	-	-	-	-	-	-	-
Artemisia gallica	-	-	-	-	0.65	-	2.11	-	-	-	-	-	1.33
Inula viscosa	-	-	-	-	0.39	-	0.01	0.09	-	-	-	-	-
Parapholis filiformis	-	-	-	-	0.38	-	0.63	-	-	-	-	-	-
Atriplex portucalensis	-	-	-	-	0.31	-	0.29	-	-	-	-	-	-
Agropyron* cf. *acutum	-	-	-	-	0.24	-	1.09	-	-	-	-	-	-
Limonium virgatum* ssp. *virgatum	-	-	-	-	0.22	-	1.61	-	-	-	-	-	-
Daucus carota	-	-	-	-	0.21	-	0.90	-	-	-	-	-	-
Schoenus nigricans	-	-	-	-	0.20	-	2.68	-	-	-	-	-	-
Parapholis incurva	-	-	-	-	0.19	-	-	-	-	-	-	-	-
Conyza sumatrensis	-	-	-	-	0.12	-	0.48	-	-	-	-	-	-
Limm strictum ssp. *strictum*	-	-	-	-	0.05	-	0.18	-	-	-	-	-	-
Arthrocnemum macrostachyum	-	-	-	-	0.05	-	0.29	-	-	-	-	-	-
Sedum sediforme	-	-	-	-	0.04	-	1.94	-	-	-	-	-	2.00
Triglochin bulbosum ssp. *barrelieri*	-	-	-	-	0.01	-	0.02	-	-	-	-	-	-
Romulea columnae ssp. *columnae*	-	-	-	-	0.01	-	0.02	-	-	-	-	-	1.69
Brachypodium phoenicoides	-	-	-	-	0.01	-	0.62	-	-	-	-	-	-
Ulmus minor	-	-	-	-	-	4.98	-	-	-	-	-	-	-
Fraxinus angustifolia* ssp. *angustifolia	-	-	-	-	-	3.27	-	0.29	-	-	0.03	-	-
Quercus humilis	-	-	-	-	-	3.05	-	-	-	-	-	-	-
Rosa canina* ssp. *styloso	-	-	-	-	-	1.32	-	-	-	-	-	-	-
Hedera helix	-	-	-	-	-	0.67	-	-	-	-	-	-	-
Rhamnus alaternus	-	-	-	-	-	0.37	-	-	-	-	-	-	-
Crataegus monogyna	-	-	-	-	-	0.21	-	-	-	-	-	-	-
Arundo donax	-	-	-	-	-	0.16	-	-	-	-	-	-	-
Vitex agnus-castus	-	-	-	-	-	0.12	-	-	-	-	-	-	-
Clematis flammula	-	-	-	-	-	0.11	-	-	-	-	-	-	-
Paliurus spina-christi	-	-	-	-	-	0.07	-	-	-	-	-	-	-
Ligustrum vulgare	-	-	-	-	-	0.07	-	-	-	-	-	-	-
Cornus sanguinea	-	-	-	-	-	0.04	-	-	-	-	-	-	-
Ruscus aculeatus	-	-	-	-	-	0.03	-	-	-	-	-	-	-
Asparagus acutifolius	-	-	-	-	-	0.02	-	-	-	-	-	-	-
Blackstonia perfoliata ssp. *imperfoliata*	-	-	-	-	-	-	0.42	-	-	-	-	-	-
Petrorhagia prolifera	-	-	-	-	-	-	0.35	-	-	-	-	-	-
Limonium girardianum ssp. *girardianum*	-	-	-	-	-	-	0.32	-	-	-	-	-	-
Dactylis glomerata	-	-	-	-	-	-	0.29	-	-	-	-	-	-
Centaurium pulchellum ssp. *tenuiflorum*	-	-	-	-	-	-	0.29	-	-	-	-	-	-
Koeleria pubescens ssp. *pubescens*	-	-	-	-	-	-	0.15	-	-	-	-	-	-
Plantago lanceolata	-	-	-	-	-	-	0.14	-	-	-	-	-	-
Scabiosa atropurpurea* ssp. *maritima	-	-	-	-	-	-	0.10	-	-	-	-	-	3.87
Aeleuropus littoralis	-	-	-	-	-	-	0.10	-	-	-	-	-	-
Lathyrus hirsutus	-	-	-	-	-	-	0.07	-	-	-	0.17	0.14	-
Helichrysum stoechas	-	-	-	-	-	-	0.06	-	-	-	-	-	1.05
Trifolium campestre	-	-	-	-	-	-	0.05	-	-	-	-	-	0.52
Teucrium polium* ssp. *polium	-	-	-	-	-	-	0.02	-	-	-	-	-	3.33
Euphorbia terracina	-	-	-	-	-	-	0.01	-	-	-	-	-	-
Bellardia trixago	-	-	-	-	-	-	0.01	-	-	-	-	-	-
Tetragonolobus maritimus	-	-	-	-	-	-	-	0.51	0.25	0.14	-	-	-
Picbris echioides	-	-	-	-	-	-	-	0.44	-	-	0.19	0.29	-
Scirpus holoschoenus	-	-	-	-	-	-	-	0.34	-	-	-	0.36	-
Centaurium erythraea	-	-	-	-	-	-	-	0.11	-	0.04	-	0.04	-
Centaurium pulchellum ssp. *pulchellum*	-	-	-	-	-	-	-	0.10	0.02	-	-	-	-
Equisetum ramosissimum ssp. *ramosissimum*	-	-	-	-	-	-	-	0.06	-	-	-	-	-
Trifolium repens	-	-	-	-	-	-	-	-	-	0.07	-	-	-
Cichorium intybus	-	-	-	-	-	-	-	-	-	0.04	-	-	-
Cyperus longus	-	-	-	-	-	-	-	-	-	-	2.72	-	-

Carex hirta	-	-	-	-	-	-	-	-	-	-	1.17	-	-
Potentilla reptans	-	-	-	-	-	-	-	-	-	-	0.22	-	-
Helianthemum hirtum	-	-	-	-	-	-	-	-	-	-	-	-	4.24
Plantago lagopus	-	-	-	-	-	-	-	-	-	-	-	-	3.70
Fumana thymifolia var.vulgaris	-	-	-	-	-	-	-	-	-	-	-	-	2.36
Ornithopus pinnatus	-	-	-	-	-	-	-	-	-	-	-	-	2.35
Ephedra distachya ssp. distachya	-	-	-	-	-	-	-	-	-	-	-	-	2.29
Helianthemum salicifolium	-	-	-	-	-	-	-	-	-	-	-	-	2.07
Asterolinon linum-stellatum	-	-	-	-	-	-	-	-	-	-	-	-	1.57
Helianthemum guttatum	-	-	-	-	-	-	-	-	-	-	-	-	1.24
Arenaria serpyllifolia ssp. serpyllifolia	-	-	-	-	-	-	-	-	-	-	-	-	1.17
Paronychia argentea	-	-	-	-	-	-	-	-	-	-	-	-	1.14
Cerastium pumilum	-	-	-	-	-	-	-	-	-	-	-	-	1.11
Thymus vulgaris ssp. vulgaris	-	-	-	-	-	-	-	-	-	-	-	-	1.10
Trifolium nigrescens	-	-	-	-	-	-	-	-	-	-	-	-	0.98
Medicago littoralis	-	-	-	-	-	-	-	-	-	-	-	-	0.94
Euphorbia terracina	-	-	-	-	-	-	-	-	-	-	-	-	0.9
Muscari comosum	-	-	-	-	-	-	-	-	-	-	-	-	0.72
Valantia muralis	-	-	-	-	-	-	-	-	-	-	-	-	0.71
Crepis sancta	-	-	-	-	-	-	-	-	-	-	-	-	0.71
Valerianella pumila	-	-	-	-	-	-	-	-	-	-	-	-	0.58
Ophrys sphegodes ssp. sphegodes	-	-	-	-	-	-	-	-	-	-	-	-	0.35
Hedypnois rhagadioloides	-	-	-	-	-	-	-	-	-	-	-	-	0.33
Desmazeria rigida ssp. rigida	-	-	-	-	-	-	-	-	-	-	-	-	0.24
Salvia verbenaca ssp. verbenaca	-	-	-	-	-	-	-	-	-	-	-	-	0.19
Minuartia hybrida	-	-	-	-	-	-	-	-	-	-	-	-	0.1
Sideritis hirsuta ssp. emporitana	-	-	-	-	-	-	-	-	-	-	-	-	0.1
Number of stands used in analysis	4	3	13	3	6	5	6	5	4	2	3	2	3
Original number of stands	26	22	86	18	43	43	44	42	28	13	19	13	20
Number of species	24	43	43	24	33	19	43	37	39	25	28	29	33
DIVERSITY	**3.00**	**4.59**	**2.57**	**3.28**	**3.48**	**2.88**	**4.49**	**4.23**	**4.13**	**3.64**	**3.91**	**4.16**	**4.60**

***Tab.3** Mean cover of species in each of the 13 quadrat groups derived by cluster analysis. Species achieving 1% cover or greater in any group are indicated in bold text.*

Group 1 are the species poor plots from the edge of the deep marsh reedbed at Palau. The dominant species is *Phragmites australis* accompanied by other helophytes such as *Scirpus maritimus, Typha angustifolia, Eleocharis palustris* ssp. *palustris* and *Alisma plantago-aquatica*. *Lemna minor* (the only hydrophyte found in the study) is occasionally present. The stands are from a wide band of grazed *Phragmites*, an area of transition between the shallowly flooded hemimarsh (dominated by swards of *Paspalum distichum*) and the deeply flooded, almost inpenetrable reedbed, which explains the presence of hemimarsh species such as *Polygonum mite* or *Juncus articulatus*. In structure too the partly grazed blocks of *Phragmites* with interspersed helophytes are intermediate between the low swards of the hemimarsh and the tall monospecific reed population. The abscence of hydrophytes can be attributed to the trampling effect of the cattle, density of the *Phragmites* stands and obvious eutrophication at the site. *Scirpus maritimus* is most abundant in this group

Group 2 stands are from the upper part of the grazed hemimarsh at Palau (section E). They are characterised by an abundance of *Carex vulpina* ssp. *nemorosa* (found on damp, heavy soils) with a rich accompanying flora eg. *Agrostis stolonifera* ssp. *stolonifera*, *Althaea officinalis* or *Euphorbia hirsuta*, and the presence of *Juncus acutus* clumps. The area is slightly drier than the middle reaches of the hemimarsh (indicated by the presence of *Poa trivialis*, *Carex distans* and *Festuca arundinacea*) and probably more saline, from species such as *Juncus acutus* and *Oenanthe lachenalii*. The conditions thus move away from those ideal for *Paspalum* dominance (see Group **3**) and encourage a more varied flora, some with a degree of salt tolerance.

However, one of the most important factors in explaining the floristic richness (43 species from 22 original stands) of the stands are undoubtably the *Juncus acutus* clumps; which, inpenetrable to cattle grazing, provide a safe haven for a wide variety of species eg. *Sonchus maritimus*, *Pulicaria dysenterica, Lycopus europaeus, Galium palustre* ssp. *elongatum* and *Juncus subulatus*.

The very large **Group 3** brings together plots from Closes de l'Ullal and Palau (sections I and F). The stands, from mid hemimarsh are species poor (with low diversity) and dominated by dense, monospecific swards of the grass *Paspalum distichum*. *Paspalum distichum,* of Central American origin, was probably introduced with crop, particularly rice seeds. Its competitiveness has been well documented from the Camargue where it develops abundantly on abandoned agricultural land that is temporarily flooded (Mesléard *et. al.*, 1993). A rapid growth when flooded throughout the growing season allows *Paspalum* to emerge quickly and rapidly exclude all competitors provided soil salinity does not exceed 0 g Cl/l. A similar situation is observed at AENP, particularly in disused ricefields such as these at Palau and Al Matà in Polygon II (see Phytosociology).

At Palau and Closes de l'Ullal the plots are shallowly flooded (to 15 cm) during spring and most of the summer; this is obviously sufficient to ensure soil salinity does not surpass 0g Cl/l. The area is grazed by cattle; this further coincides with observations from the Camargue where in the absence of grazing *Paspalum* is a poor competitor (Mesleard *et. al.*, 1991).

Although all the stands in this group are species poor, those from Closes de l'Ullal are especially so, and at lower levels form a separate subgroup. This floristic difference can be attributed to the abundance of *Iris pseudacorus* in this corner of the site, inferior grazing pressure and dissimilar origins (Closes de l'Ullal has always been a meadow).

The list of accompanying species may appear long for a group with such species poor stands but it should be remembered that the group is the largest of all and encompasses 86 original stands. There are species characteristic both of slightly drier or more humid habitats (*Carex vulpina* ssp. *nemorosa, Agrostis stolonifera* ssp. *stolonifera, Echinochloa crus-galli* ssp. *crus-galli* or *Scirpus lacustris, Phragmites australis, Typha angustifolia, Alisma plantago-aquatica* in addition to typical hemimarsh species such as *Juncus articulatus* or *Eleocharis palustris* ssp. *palustris).*

Group 4 is quite separate from the three anterior groups. The stands lie in section J at Closes de l'Ullal and are distinguished by pauperate swards of *Hordeum marinum* ssp. *marinum* with *Cynodon dactylon* also abundant. The first grass is found on salt marsh margins (Hubbard, 1984) while the second is a typical lawn species in temperate climates, found on dry sandy soil and withstanding considerable drought. In places the swards are interrupted by patches of bare ground covered with halophytes such as *Limonium vulgare*, *Puccinellia festuciformis* and *Suaeda maritima*. This is the driest area of the field, flooded only during the heaviest winter rains and quite dry in spring and summer, and the floristic composition shows it also to be the most saline.

Group 5 consists of the stands from section A at La Rubina. Easily characterised, these salt meadows are dominated by the halophytes *Arthrocnemum fructicosum*, *Inula crithmoides* and *Elymus elongatus* with *Limonium vulgare* and *Puccine-*

llia festuciformis also abundant. The hummocks of perennial *Arthrocnemum fruticosum* may reach 1m in places and the vegetation becomes dense and almost inpenetrable. Many of the other species found (eg. *Carex extensa* and *Triglochin bulbosum* ssp. *barrelieri*) grow on the bare silty soil of the depressions formed between the hummocks. The whole area is periodically flooded with sea water.

Group 6 are the boundary hedges of the hay meadow site l'Ullal (Sec. L) formed of riverine woodland and which line the circumnavigating drainage ditches. The most abundant species are *Ulmus minor* and *Fraxinus angustifolia* accompanied by the shrubs *Rosa canina* ssp. *stylosa*, *Rhamnus alaternus* or *Cornus sanguinea* and *Crataegus monogyna* along damper stretches where *Quercus humilis* dominates. As with the pasture vegetation within the field the hedges vary in floristic composition from the wetter to the drier side of the field where *Arundo donax* and *Vitex agnus-castus* are more common. Where *Ulmus* has died (from Dutch Elm disease) *Rubus ulmifolius* has become dominant.

Although the presence of the halophytes *Limonium vulgare*, *Juncus maritimus* and *Inula crithmoides* lend **Group 7** stands a degree of floristic similarity to those of Group **5** the difference in composition of the most abundant species (*Plantago crassifolia*, *Schoenus nigricans*, *Artemisia gallica*, *Parapholis filiformis*, *Sedum sediforme* and three *Limonium* species: *Limonium virgatum*, *L. vulgare* and *L. girardianum*) readily distinguish the two groups. These floristically rich salt steppes (43 species in 44 original samples) are from section B at La Rubina and are on sandier, coarser and better drained soils than those of Group 5. Samples 41 and 42 are separated into a subgroup at lower levels and are characterised by the dominance of *Elymus pungens* which forms dense hummocks along the raised banks of drainage ditches that criss-cross the area.

Groups 8-12 are the remaining stands from the Closes de l'Ullal (sections G, H, J and K). These are not so easily characterised.

Groups 8. These stands come principally from section G; a part of the field (flooded in winter and mowed for hay) that could best be said to represent the water meadow vegetation. They are characterised by a tall, luxurious growth of the grasses *Festuca arundinacea*, *Poa trivialis* ssp. *trivialis* and *Hordeum secalinum*; abundant legumes eg. *Lotus corniculatus* ssp. *tenuifolius*, *Trifolium fragiferum* and *Trifolium pratense* and a long list of accompanying species, many indicating a certain degree of salinity; e.g., *Apium graveolens*, *Juncus compressus* ssp. *gerardi*, *Oenanthe lachenalii* or *Alopecurus bulbosus*. 10 of the 37 species are grasses.

The stands from **Group 9** although having close affinities with those of Group **8** differs in the dominance of *Cynodon dactylon*, and the differing proportions of the other abundant species *Festuca arundinacea*, *Poa trivialis* ssp. *trivialis*, *Hordeum secalinum* and *Lotus corniculatus* ssp. *tenuifolius*, suggesting a slightly drier situation than that of Group **8**. Furthermore, *Carex vulpina* ssp. *nemorosa* has disappeared and other marsh species such as *Oenanthe lachenalii*, *Althaea officinalis* or *Juncus compressus* ssp. *compressus* have all decreased in abundance. This group is probably intermediate to the situation seen in Group **4**, with *Hordeum marinum* ssp. *marinum* dominant and *Cynodon dactylon* abundant. 14 of the 39 species are grasses.

Group 10. This small group of 2 stands (13 original stands) is characterised by almost monospecific flushes of *Carex divisa* accompanied by *Juncus compressus* ssp.

gerardi and in places *Polypogon monspeliensis*, species of brackish pastures or salt marshes suggesting slightly wetter and more saline conditions than groups **8** or **9**.

Carex divisa is again predominant in **Group 11**, although its abundance is less marked than in group 10 with *Paspalum distichum, Oenanthe fistulosa, Cyperus longus, Poa trivialis, Iris pseudacorus* and *Apium graveolens* also important. A number of these species cannot tolerate salinity, and all are found on wet marshy ground. This corresponds to wetter areas of the meadow which have been invaded by marsh species such as *Cyperus longus*. An inspection of the original data reveals *Carex divisa* and *Cyperus longus* not to be co-dominant.

The small **Group 12**, has minimal difference in composition to group **11**. *Paspalum distichum* is the predominant species with *Oenanthe lachenalii, Carex divisa, Poa trivialis, Aster squamatus, Trifolium fragiferum* and *Lotus corniculatus* ssp. *tenuifolius* also common. Clear distinction between these last two groups is difficult with such nominal variation in floristic composition.

The difficulty encountered in clearly defining these groups from the meadow at Closes de l'Ullal is a reflection of the complicated edaphic gradients existing over small areas which produce such marked variations within the same field.

Group 13 plots from the abandoned field strips at La Rubina (section C) and the most diverse of all, are completely separated from all the other stands by cluster analysis. They are characterised by a sparse, low coverage of therophytes (annuals) eg. *Helianthemum guttatum, H. salicifolium, Arenaria serpyllifolia* ssp. *serpyllifolia, Cerastium pumilum, Petrorhagia prolifera* and *Minuartia hybrida*, some scattered low bushes typical of mediterranean siliceous maquis eg. *Thymus vulgaris* ssp. *vulgaris, Fumana thymifolia* var. *vulgaris, Helianthemum hirtum* and abundant lichens, able to withstand the extreme conditions of summer. Communities of therophytes (see phytosociological study) are typical in the mediterranean region on the dry sands of river beds or rocky hillocks with maximum development from March to early May, becoming rapidly desiccated by early summer. Floristically distinct to all the other groups there are few grasses but abundant Caryophyllaceae, Cistaceae and Labiatae. Other noteworthy species found on this dry, sandy, non saline, oligotrophic terrain are *Sedum sediforme, Helichrysum stoechas, Plantago lagopus, Romulea columnae, Paronychia argentea, Teucrium polium* ssp. *polium, Sideritis hirsuta* ssp. *emporitana, Muscari comosum* while *Medicago littoralis* or *Scabiosa atropurpurea* var. *maritima* and *Ephedra distachya* ssp. *distachya* are the only components reflecting the proximity to the sea.

TWINSPAN analysis

The successive dichotomies of TWINSPAN produced a classification hierarchy culminating in 18 groups but analysis was restricted to 12. The final groups and indicator species at each level are shown in Figure 4. An immediately noticible feature of the hierarchy is the uneven level of classification at which the groups are produced. There are three reasons for this; the outlying groups **L**, **A** and **B** (floristically very distinct) could not be divided to greater than 4 or 8 group level; groups **J** and **K** were readily characterised at the 8-group level and further division was considered unnecessary for the present study and, finally, the 'pasture' groups, from the meadow at l'Ullal and the grazing marsh at Palau were not readily characterised at 4 or 8 group level and have been studied in more detail, giving groups C to I.

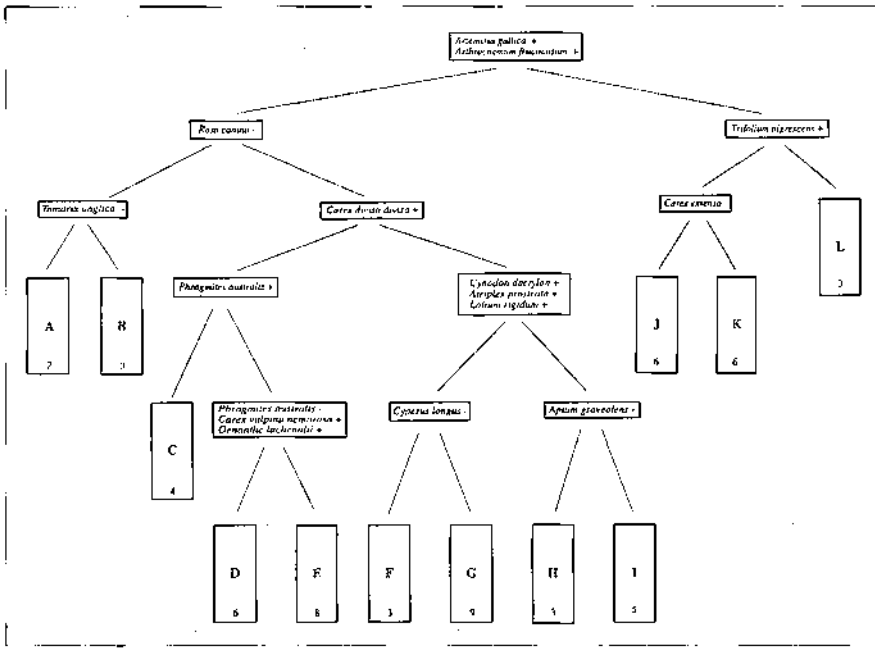


Fig.4. - Dendrogram produced by TWINSPAN analysis, showing the indicator species at each successive dichotomy and number of stands in each of the final 12 groups.

Table 4 gives mean cover of the most abundant species in each of the 12 groups produced by TWISPAN. The groups were further characterised by calculating the chi-squared statistic for species with each group and Table 5 shows those species showing significant positive association with a vegetation group. A comparison of the groups formed by cluster analysis and TWINSPAN is given in Table 6.

Groups **A** and **B** correspond to the boundary hedges at Closes de l'Ullal. Group **A** stands are from the drier side of the field and have abundant *Ulmus minor* with *Ligustrum vulgare, Paliurus spina-christi* (shrubs typical of margins or scrubland) and the climber *Clematis flammula.* In one area *Tamarix anglica* appears denoting salinity. Group **B** stands originate from the wetter areas of Closes de l'Ullal where *Quercus humilis* and *Fraxinus angustifolia* ssp. *angustifolia* co-dominate with *Ulmus minor* and are accompanied by shady wood shrubs such as *Cornus sanguinea* and *Crataegus monogyna,* limited in the mediterranean area to riverine woodland or deciduous forest found at higher altitudes. Groups **A** and **B** are together equivalent to Group **6.**

Group **C** plots are from the area within the meadow at Closes de l'Ullal (section I) which remains shallowly flooded for most or all of the year and are characterised by a dense sward of *Paspalum distichum* with *Glyceria fluitans,* abundant *Iris pseudacorus, Eleocharis palustris* ssp. *palustris, Agrostis stolonifera* ssp. *stolonifera,* and *Oenanthe fistulosa,* all requiring permanently damp to waterlogged conditions and not tolerating salinity. These stands have been separated from the very similar

	A	B	C	D	E	F	G	H	I	J	K	L
Ulmus minor	5.94	4.34	-	-	-	0.03	-	-	-	-	-	-
Quercus humilis	2.83	3.19	-	-	-	-	-	-	-	-	-	-
Fraxinus angustifolia ssp. *angustifolia*	2.72	3.63	-	-	-	-	0.16	-	-	-	-	-
Rosa canina ssp. *stylosa*	1.94	0.90	-	-	-	-	-	-	-	-	-	-
Rubus ulmifolius	1.61	1.10	-	-	0.19	-	-	-	-	-	-	-
Phragmites australis	0.06	0.38	-	5.48	1.79	-	-	-		0.07	-	-
Paspalum distichum	-	-	6.92	3.29	6.24	3.94	1.42	-	1.51	-	-	-
Iris pseudacorus	-	-	5.25	0.81	0.69	2.72	0.05	-	0.26	-	-	-
Eleocharis palustris ssp. *palustris*	-	-	1.38	1.29	1.08	-	0.22	-	0.09	-	-	-
Agrostis stolonifera ssp. *stolonifera*	-	-	0.75	0.27	1.85	-	0.17	-	0.71	-	-	-
Scirpus maritimus	-	-	0.54	1.73	0.85	-	0.09		0.20	0.57	0.10	0.12
Oenanthe lachenalii	-	-	0.25	-	0.24	0.64	2.02	1.76	1.25	-	-	-
Oenanthe fistulosa	-	-	0.23	-	-	3.83	0.27	-	0.31	-	-	-
Alisma plantago-aquatica	-	-	0.17	1.74	0.77	-	-	-	-	-	-	-
Aster squamatus	-	-	0.17	-	0.08	1.64	1.99	1.05	1.29	0.24	-	-
Lotus corniculatus ssp. *tenuifolius*	-	-	0.08	-	-	0.39	2.20	1.48	0.89	-	-	-
Typha angustifolia ssp. *australis*	-	-	-	1.51	0.60	-	-	-	-	-	-	-
Scirpus lacustris	-	-	-	1.06	1.30	-	-	-	-	-	-	-
Carex vulpina ssp. *nemorosa*	-	-	-	0.02	1.94	1.56	0.33	0.62	-	-	-	-
Juncus acutus	-	-	-	-	1.20	-	-	0.95	-	0.10	0.59	0.15
Elymus pungens	-	-	-	-	0.28	-	-	2.00	0.40	0.10	2.59	2.26
Poa trivialis ssp. *trivialis*	-	-	-	-	0.05	3.33	2.71	2.57	1.49	-	-	-
Trifolium fragiferum	-	-	-	-	0.05	1.00	0.74	0.12	0.69	-	-	-
Cynodon dactylon	-	-	-	-	0.03	-	2.37	5.33	3.60	-	-	-
Festuca arundinacea	-	-	-	-	0.01	0.39	2.28	2.33	1.86	-	0.06	0.06
Carex divisa ssp *divisa*	-	-	-	-	-	4.28	2.77	1.74	1.77	-	-	-
Cyperus longus	-	-	-	-	-	2.72	-	-	-	-	-	-
Apium graveolens	-	-	-	-	-	2.56	0.89	0.55	0.57	-	-	-
Carex hirta	-	-	-	-	-	1.17	-	-	-	-	-	-
Plantago major	-	-	-	-	-	1.00	0.72	0.14	0.43	-	-	-
Juncus compressus ssp. *gerardi*	-	-	-	-	-	0.50	1.31	1.10	0.74	-	-	-
Hordeum secalinum	-	-	-	-	-	0.11	1.35	1.86	0.73	-	-	-
Hordeum marinum ssp. *marinum*	-	-	-	-	-	-	0.82	2.33	3.31	-	-	-
Puccinellia festuciformis	-	-	-	-	-	-	0.13	0.57	0.63	1.65	0.73	0.18
Plantago crassifolia	-	-	-	-	-	-	-	0.57	-	0.17	2.82	0.81
Limonium vulgare ssp. *serotinum*	-	-	-	-	-	-	-	-	0.13	1.07	1.42	0.65
Arthrocnemum fruticosum	-	-	-	-	-	-	-	-	-	7.24	1.49	0.83
Elymus elongatus	-	-	-	-	-	-	-	-	-	3.27	1.14	0.71
Inula crithmoides	-	-	-	-	-	-	-	-	-	3.04	1.34	0.61
Juncus maritimus	-	-	-	-	-	-	-	-	-	2.05	1.52	0.43
Artemisia gallica	-	-	-	-	-	-	-	-	-	0.65	2.11	1.48
Agropyron cf. *acutum*	-	-	-	-	-	-	-	-	-	0.24	1.09	0.95
Limonium virgatum ssp. *virgatum*	-	-	-	-	-	-	-	-	-	0.22	1.61	0.50
Schoenus nigricans	-	-	-	-	-	-	-	-	-	0.20	2.68	0.86
Sedum sediforme	-	-	-	-	-	-	-	-	-	0.04	1.94	1.82
Scabiosa atropurpurea ssp. *maritima*	-	-	-	-	-	-	-	-	-	-	0.10	1.99
Teucrium polium ssp. *polium*	-	-	-	-	-	-	-	-	-	-	0.02	1.67
Helianthemum hirtum	-	-	-	-	-	-	-	-	-	-	-	2.12
Plantago lagopus	-	-	-	-	-	-	-	-	-	-	-	1.85
Fumana thymifolia var.*vulgaris*	-	-	-	-	-	-	-	-	-	-	-	1.18
Ornithopus pinnatus	-	-	-	-	-	-	-	-	-	-	-	1.17
Ephedra distachya ssp. *distachya*	-	-	-	-	-	-	-	-	-	-	-	1.14
Helianthemum salicifolium	-	-	-	-	-	-	-	-	-	-	-	1.04
Number of stands used in analysis	2	3	4	6	9	3	9	3	5	6	6	3
Original number of stands	18	25	24	40	63	19	63	21	31	43	44	20
Number of species	15	12	15	27	47	28	44	31	33	33	43	33

Tab.4. - Mean cover of the most abundant species in each of the 12 quadrat groups derived by TWINSPAN. Only those spp. achieving 1% cover or greater in any one group are shown.

stands at Palau by TWINSPAN (together in Group **3**) using *Phragmites australis* (absent at Closes de l'Ullal) as an indicator.

Groups **D** & **E** are separated from **C** by the presence of *Phragmites australis*. Group **D** corresponds to the stands from the edge of the deep marsh at Palau, dominated by *Phragmites australis* and has been described in detail as Group 1.

Group **E** includes all the remaining stands from the hemimarsh at Palau. In contrast to cluster analysis TWINSPAN has grouped together the stands from the top and middle hemimarsh and separated the latter (*Paspalum* swards) from the similar stands at Closes de l'Ullal. Group **E** includes therefore, the *Paspalum distichum* swards (described in detail for Group **3**) and the plots with dominant *Carex vulpina* ssp. *nemorosa* and *Juncus acutus* hummocks which have been described in detail as Group **2**.

A number of species are significantly associated with both the hemi- and deep marsh; in some cases this may reflect true ecological plasticity as for *Phragmites australis* or *Typha angustifolia* or in others eg. *Eleocharis palustris* ssp. *palustris*, *Scirpus maritimus* or *Galium palustre* ssp. *elongatum* that the sampled area (the edge of the deep marsh) is a zone of transition.

The pasture groups F to I. The indicator species separating the 'marsh' groups **C**, **D** and **E** from the 'pasture' groups **F**, **G**, **H** and **I** is *Carex divisa*. This species is typically found in damp brackish pastures near the sea, suggesting that the factor separating the two categories is hydrology; **F**, **G**, **H** and **I** being dryer than **C**, **D**, and **E** and probably slightly more saline. On these potentially saline marsh soils desiccation is often concomitant with salinization.

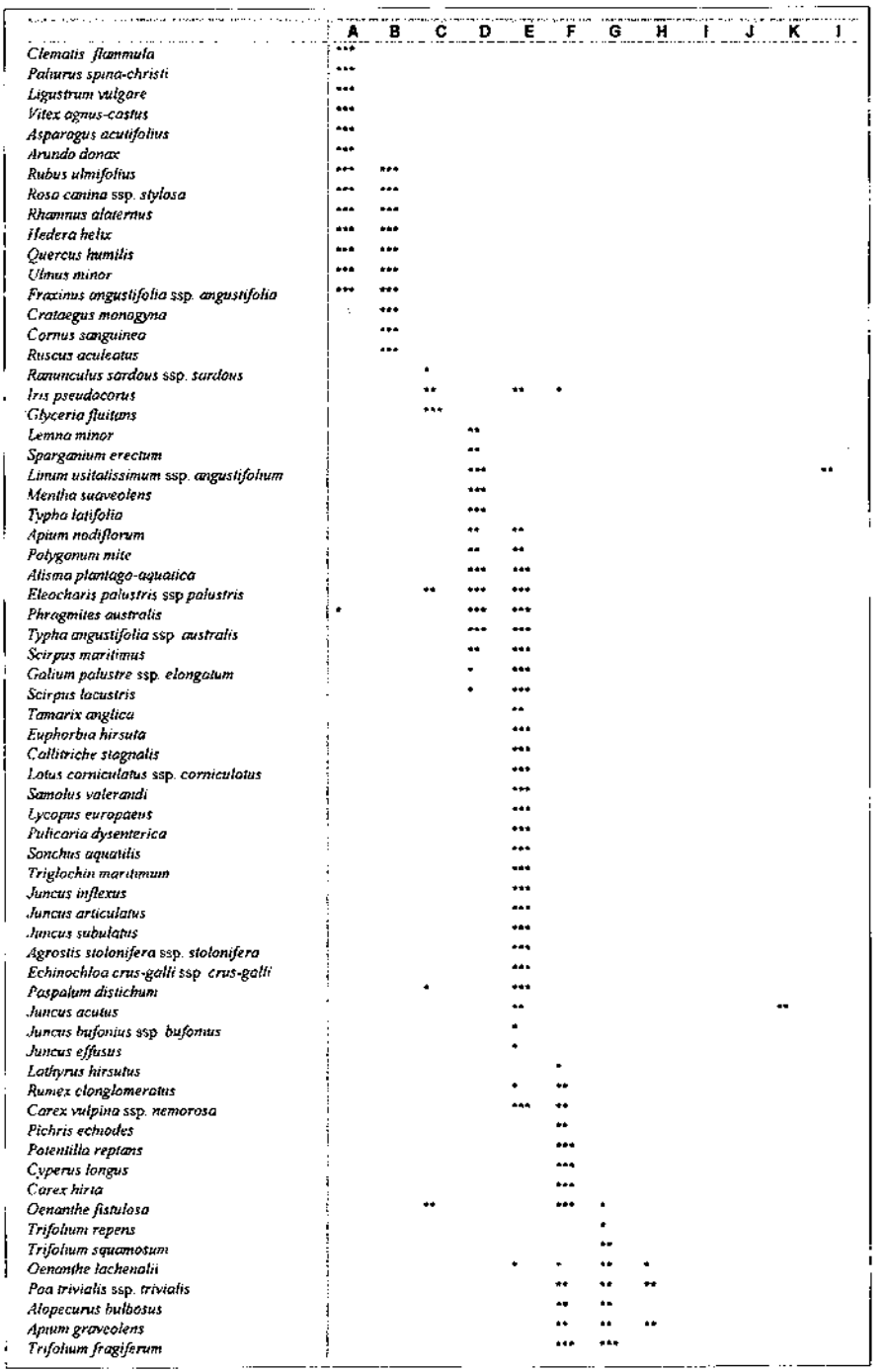
Group **F** are the stands from Closes de l'Ullal dominated by *Carex divisa* flushes, described in detail for Group **11**.

The indicator species separating groups **F** and **G** is *Cyperus longus*. Group **G** would be expected to be slightly dryer and perhaps more saline. The stands can be considered typical meadow with abundant grasses *Festuca arundinacea*, *Poa trivialis*, *Cynodon dactylon*, *Hordeum secalinum* and legumes eg. *Lotus corniculatus* ssp. *tenuifolius* and *Trifolium fragiferum*. *Aster squamatus* is common, an opportunistic species of Central American origin typical of disturbed and trampled ground. In overgrazed 'closes' it can become a serious weed.

The stands forming Group **H** (comparable to Group **9**) are dominanted by *Cynodon dactylon* which forms a low carpet on dry, sandy soil. This floristic composition probably represents a stage in the transition of the meadow vegetation towards dryer grassland. In the field these pauperate swards are readily distinguished from the tall species rich meadow.

Group **I** are the stands from the driest area of Closes de l'Ullal, dominated by swards of *Hordeum marinum* ssp. *marinum* with *Cynodon dactylon* also abundant. The dominance of *Hordeum marinum* ssp. *marinum* indicates salinization, where this is most pronounced bare ground and halophytes such as *Limonium vulgare*, *Suaeda maritima*, *Spergularia maritima* and *Puccinellia festuciformis* appear. This group has close affinities with the previous one and is almost certainly represents a further transition towards more halophytic vegetation. The 'overlap' observed in groups **F** to **I**, with species showing positive association with multiple groups is a reflection of the continuous variation of the vegetation in the pasture groups.

Groups **J**, **K** and **L** are the salt meadows, salt steppes and therophytic pastures of La Rubina, dominated by *Arthrocnemum fructicosum*, *Plantago crassifolia* and several species of *Helianthemum*. These three groups, clearly differentiated from the rest have previously been described as Groups **5**, **7** and **13** respectively.


A B C D E F G H I J K L
Clematis flammula
Paliurus spina-christi
Ligustrum vulgare
Vitex agnus-castus
Asparagus acutifolius
Arundo donax
Rubus ulmifolius
Rosa canina ssp. stylosa
Rhamnus alaternus
Hedera helix
Quercus humilis
Ulmus minor
Fraxinus angustifolia ssp. angustifolia
Crataegus monogyna
Cornus sanguinea
Ruscus aculeatus
Ranunculus sardous ssp. sardous
Iris pseudacorus
Glyceria fluitans
Lemna minor
Sparganium erectum
Linum usitatissimum ssp. angustifolium
Mentha suaveolens
Typha latifolia
Apium nodiflorum
Polygonum mite
Alisma plantago-aquatica
Eleocharis palustris ssp palustris
Phragmites australis
Typha angustifolia ssp. australis
Scirpus maritimus
Galium palustre ssp. elongatum
Scirpus lacustris
Tamarix anglica
Euphorbia hirsuta
Callitriche stagnalis
Lotus corniculatus ssp. corniculatus
Samolus valerandi
Lycopus europaeus
Pulicaria dysenterica
Sonchus aquatilis
Triglochin maritimum
Juncus inflexus
Juncus articulatus
Juncus subulatus
Agrostis stolonifera ssp. stolonifera
Echinochloa crus-galli ssp crus-galli
Paspalum distichum
Juncus acutus
Juncus bufonius ssp bufonius
Juncus effusus
Lathyrus hirsutus
Rumex clonglomeratus
Carex vulpina ssp. nemorosa
Pichris echioides
Potentilla reptans
Cyperus longus
Carex hirta
Oenanthe fistulosa
Trifolium repens
Trifolium squamosum
Oenanthe lachenalii
Poa trivialis ssp. trivialis
Alopecurus bulbosus
Apium graveolens
Trifolium fragiferum

Plantago major ssp. *major*	**	***						
Juncus compressus ssp. *gerardi*	**	***		**				
Centaurium pulchellum ssp. *pulchellum*		***						
Scirpus holoschoenus		***						
Festuca arundinacea		***						
Lolium perenne		***						
Polypogon monspeliensis		***						
Lotus corniculatus ssp. *tenuifolius*		***	**					
Tetragonolobus maritimus		***	**					
Carex divisa ssp. *divisa*	*	***	*	**				
Carex distans		**						
Aster squamatus		**		*				
Cichorium intybus		*						
Poa annua ssp. *annua*		*						
Elymus repens		*						
Centaurium erythraea		*		**				
Hordeum secalinum		***		***				
Plantago coronopus			*					
Equisetum ramosissimum ssp. *ramosissimum*			***					
Rumex crispus			***					
Polygonum aviculare			***					
Cynodon dactylon		***	**	***				
Hordeum marinum ssp. *marinum*		**	**	***				
Atriplex prostrata			**	**				
Lolium rigidum			***	**				
Suaeda maritima				***				
Spergularia marginata				*				
Parapholis incurva					**			
Carex extensa					***			
Inula viscosa					***			
Plantago crassifolia			***			***		
Daucus carota					***	***		
Atriplex portucaloides					***	***		
Juncus maritimus					***	***		
Inula crithmoides					***	***		
Limonium vulgare ssp. *serotinum*					***	***		
Limonium virgatum ssp. *virgatum*					***	***		
Puccinellia festuciformis					***	**		
Elymus elongatus					***	***		
Agropyron cf. *acutum*					**	***		
Parapholis filiformis					*	***		
Conyza sumatrensis					*	***		
Linum strictum ssp. *strictum*						***		
Petrorhagia prolifera						***		
Arthrocnemum maculatum						***		
Arthrocnemum fruticosum						***		
Limonium girardianum ssp. *girardianum*						***		
Blackstonia perfoliata ssp. *imperfoliata*						***		
Centaurium pulchellum ssp. *tenuifolium*						***		
Bellardia trixago						**		
Plantago lanceolata						***		
Schoenus nigricans						***		
Brachypodium phoenicoides						***		
Elymus pungens						***		
Koeleria pubescens ssp. *pubescens*						***		
Aeleuropus littoralis						***		
Artemisia gallica					**	***	***	
Sedum sediforme						***	**	
Ephedra distachya ssp. *distachya*							***	
Medicago littoralis							***	
Trifolium campestre							***	
Trifolium nigrescens							***	
Ornithopus pinnatus							***	
Helianthemum guttatum ssp. *guttatum*							***	
Helianthemum salicifolium							***	
Fumana thymifolia							***	
Euphorbia terracina							***	
Arenaria serpyllifolia ssp. *serpyllifolia*							***	
Minuartia hybrida							***	
Cerastium pumilum							***	
Paronychia argentea							***	

Asterolinon linum-stellatum	***
Sideritis hirsuta ssp. *emporitana*	***
Thymus vulgaris ssp. *vulgaris*	***
Salvia verbenaca ssp. *verbenaca*	***
Plantago lagopus	***
Valantia muralis	***
Valerianella pumila	***
Scabiosa atropurpurea var. *maritima*	***
Helichrysum stoechas	***
Hedypnois rhagadioloides	***
Crepis sancta	***
Muscari comosum	***
Romulea columnae	***
Desmazeria rigida ssp. *rigida*	***
Ophrys sphegodes ssp. *sphegodes*	***

Tab.5. *- Species showing significant positive association with the vegetation groups (A to I) recognized by TWINSPAN (***p≤0.001, ** p≤0.01, * p≤0.05). The remaining nine species showed no significant associations with any one group.*

Site AENP	Sec.	Habitat: vegetation / soil type	Description	Vegetation group by Cluster	TWINSPAN groups	Phytosociological associations	Phytosociological Alliance and Order
La Rubina	A	Ridge depression flooded by fresh and salt water	Salt meadows, dominated *Arthrocnemum fruticosum*	5	J	*Arthrocnemum fruticosum* and subas. *Agropyreto-Inuletum crithmoides*	*Arthrocnemion fruticosi* - *Arthrocnemetalia*
	B	Sandy soil; saline	Salt steppes: dominated *Plantago crassifolia*, *Limonium* spp.	7	K	*Schoeno-Plantaginetum crassifoliae* *Artemisio-Limonietum*	*Plantaginion crassifoliae* - *Juncetalia maritimi* *Limonion Galloprovincialis* - *Limonietalia*
	C	Gravelly dry abandoned field strips. No salinity	Therophytic pastures, *Helianthemum* spp., *Ornithopus pinnatus*, *Ephedra distachya*...	13	L	*Helianthemetum guttati*	*Helianthemion guttati* - *Helianthemetalia guttati*
Palau	D	Deepmarsh edge and part of medbed	Dominant *Phragmites australis*	1	D	*Scirpo-Phragmitetum Mediterraneum*	*Phragmition australis*-*Phragmitetalia*
	E	High heavemarsh, shallowly flooded and grazed	Dominant *Carex vulpina*, *oenanthe*, *Juncus acutus*	2	E	*Cypero-caricetum otrubae*	*Magnocaricion elatae* - *Phragmitetalia*
	F	Mid heminarsh, shallowly flooded and grazed	*Paspalum distichum* swards	3	B	*Paspalo-Agrostidetum*	*Paspalo-polypogonion semiverticillati* *Plantaginetalia*
Closes de l'Ullal	G	Flood meadow stands, flooded in winter, mowed and grazed	Dominant *Festuca arundinacea*, *Poa trivialis*..	8	C	*Gaudinio-Arrhenatheretum* ?	*Arrhenatherion elatioris* - *Arrhenatheretalia* *Juncion maritimi* *Juncetalia*
	H	Flood meadow swards with more persistant flooding characterised by an invasion of hygrophiles, mowed and grazed	Meadow vegetation + *Carex divisa*, *Oenanthe fistulosa*, *Cyperus longus*.,	11	F	*Gaudinio-Arrhenatheretum* ?	*Arrhenatherion elatioris* *Arrhenatheretalia* *Juncion maritimi* - *Juncetalia*
	(H)		*Paspalum distichum* dominant	12	-	*Gaudinio-Arrhenatheretum* ?	*Arrhenatherion elatioris* *Arrhenatheretalia* *Juncion maritimi* - *Juncetalia*
Closes de l'Ullal	(H)		*Carex divisa* swards	10	-	*Caricetum divisae*	*Juncion maritimi* *Juncetalia*
	I	Waterlogged pasture, grazed	Dominant *Paspalum distichum*, *Iris pseudacorus*..	3	C	*Paspalo-Agrostidetum*	*Paspalo-polypogonion semiverticillati* - *Plantaginetalia*
	J	Low dry grassland, grazed	dominant *Cynodon dactylon* with halophytes	9	H	?	*Juncion maritimi* - *Juncetalia*
	K	Dry grassland with halophytes..	Dominant *Hordeum marinum* with *Limonium vulgare*...	4	I	?	*Juncion maritimi* *Juncetalia*
	L	Riverine woodland boundary hedges	Dominant *Ulmus minor*, *Fraxinus angustifolia*	6	A + B	*Hedero-Ulmetum*	*Populion albae* - *Populetalia*

Tab.6. *- Comparison between vegetation groups obtained by the different methods applied in the study.*

Diversities

La Rubina was the most diverse site (5.28), closely followed by Closes de l'Ullal (5.09), while Palau was the most pauperate (4.00) (Table 1). Diversities were also calculated for individual cluster analysis groups (Table 3). The high value at La Rubina is due almost entirely to the *Heliánthemum-guttati* community (4.6) alt-

hough the salt steppe vegetation, particularly *Artemesio-Limonietum,* also has an elevated species number. In contrast the salt meadow communities are particularly pauperate. At Closes de l'Ullal the meadow vegetation (*Festuca* dominated) is the most diverse (4.23), with progressively decreasing values as the groups become more saline (Groups **12**, **11**, **10**, and **4**). The *Hordeum marinum marinum* assemblage has a lower value than the *Arthrocnemum* meadows at La Rubina, due to the almost complete dominance by just two species. The reedbed at Palau has the lowest of all values, attributable to the absolute dominance of *Phragmites australis*, a role played by *Paspalum distichum* on the grazed mid-hemimarsh swards.

Ordination

Four axes were produced for the ordination by correspondence analysis but only the first two gave clear results and are discussed below. Figure 5a shows the distribution of stands from the three sites on axes I and II and Figure 5b the species responsible for this distribution. The stands from the three sites are clearly separated along these axes, although the separation is not linear along either axes. The observed star figure is a deformation of Guttman's theoretical parabola which appears where the environmental parameters conditioning species distribution are gradual in nature (Lleonart, 1979). The low variance accumulated by the first two axes (AI = 11.01, AII = 10.46) is a further indication of a complex situation with many environmental factors influencing the distribution ordination of species.

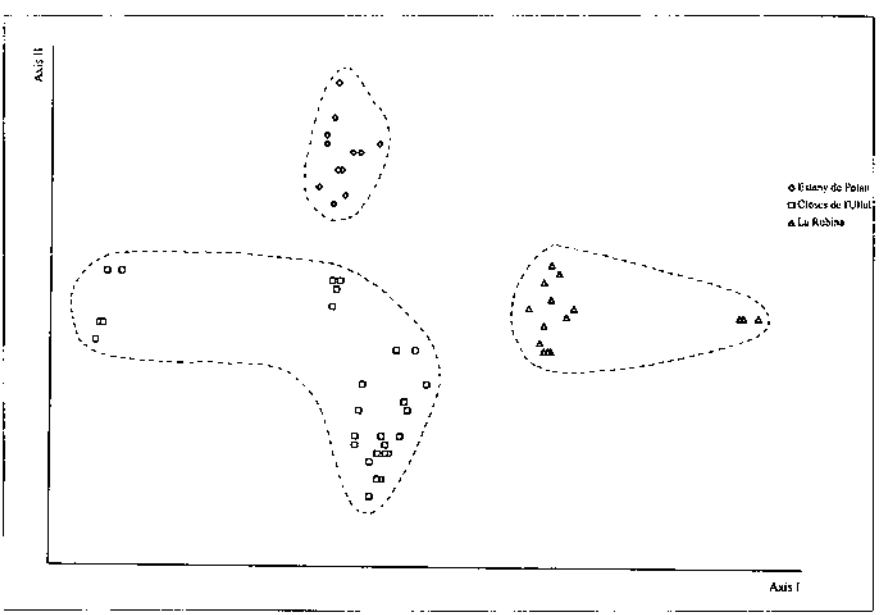


Fig. 5 a.

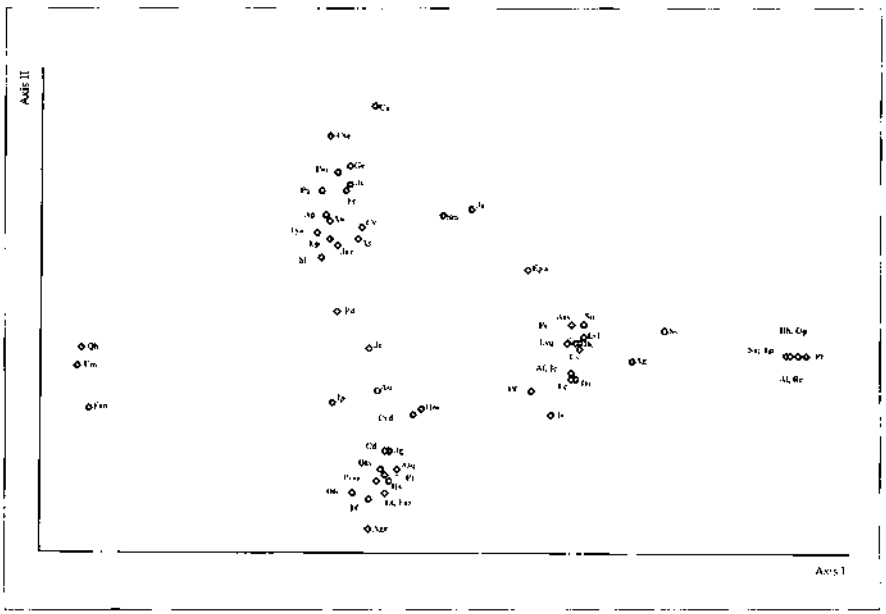


Fig. 5b. - Distribution of a) stands and b) species from the three study sites on the ordination produced by correspondence analysis.
Abbreviations: Aac- Agropyron cf. acutum, Af- Arthrocnemum fructucosum, Ag- Artemisia gallica, Agr- Apium graveolens, Al- Asterolinon linum-stellatum, An- Apium nodiflorum, Ao- Althaea officinalis, Ap- Alisma plantago-aquatica, As- Agrostis stolonifera, Asq- Aster squamatus, Ca- Convolvulus arvensis, Cd- Carex divisa divisa, Cs- Conyza sumatrensis, Cse- Calystegia sepium, Cv- Carex vulpina nemorosa, Cyd- Cynodon dactylon, Dc- Daucus carota, Ec- Echinochloa crus-galli crus-galli, Ee- Elymus elongatus, Ep- Eleocharis palustris palustris, Epu- Elymus pungens Fan- Fraxinus angustifolia, Far- Festuca arundinacea, Ge- Galium palustre elongatum, Hh- Helianthemum hirtum, Hm- Hordeum marinum marinum, Hs- Hordeum secalinum, Ic- Inula crithmoides, Ip- Iris pseudacorus, Iv- Inula viscosa, Ja- Juncus acutus, Jar- Juncus articulatus, Jc- Juncus compressus compressus, Jg- Juncus compressus gerardi, Jm- Juncus maritimus, Js- Juncus subulatus, Lt- Lotus corniculatus tenuifolius, Lvi- Limonium virgatum, Lvu- Limonium vulgare, Ofi- Oenanthe fistulosa, Ola- Oenanthe lachenalii, Op- Ornithopus pinnatus, Pa- Phragmites australis, Pc- Plantago crassifolia, Pd - Paspalum distichum, Pf - Puccinellia festuciformis, Pl- Plantago lagopus, Pma- Plantago major, Pm- Polygonum mite, Pt- Poa trivialis, Qh- Quercus humilis, Rc- Romulea columnae, Sa- Scabiosa atropurpurea, Sl- Scirpus lacustris, Sm- Scirpus maritimus, Sn- Schoenus nigricans, Ss- Sedum sediforme, Tf- Trifolium fragiferum, Tp- Teucrium polium polium, Tya- Typha angustifolia, Um- Ulmus minor.

Despite this complex situation the Cluster and TWINSPAN groups distributed on axes I and II (Figure 6a and 6b respectively) are readily distinguished. On the left of the ordination are the stands from the hedgerows at Closes de l'Ullal (Groups **A** and **B** and Group **6**) dominated by *Ulmus minor* with *Quercus humilis* and *Fraxinus angustifolia* ssp. *angustifolia*. Lying at the other extreme, to the far right are the stands from the dry gravel field strips at La Rubina. A multitude of species are important in determining the separation of the latter group from all the others; *Ephedra distachya* ssp. *distachya*, *Helianthemum hirtum*, *H. salicifolium*, *H. guttatum*, *Teucrium polium* ssp. *polium*, *Ornithopus pinnatus*, *Plantago lagopus*... and a long list of Caryophyllaceae; *Cerastium pumilum*, *Arenaria serpyllifolia* ssp. *serpyllifolia*, *Minuartia hybrida*.. (see Group **13** or **L**). To the left of the therophytic pastures, also clearly defined, are the salt meadow and steppe groups from La Rubina with dominant *Arthrocnemum fructicosum* and *Plantago crassifolia* respectively (Groups **5**, **7** or **J** and **K**). Other important species determining this cluster of stands are *Limonium vulgare*, *L. virgatum*, *Elymus elongatus* and *Juncus maritimus*.

The stands from Palau lie at the centre top of the diagram, well defined as three main groups by cluster analysis, and two more intermixed groups by TWINSPAN. The stands at the top are from the edge of the deep marsh, dominated by *Phragmites australis* (with *Calystegia sepium*, *Polygonum mite* and *Galium palustre* ssp. *elongatum*.. see Group **1**) Beneath this lie the plots from the middle hemimarsh dominated by *Paspalum distichum*. The upper hemimarsh stands lie slightly to the right; the species responsible for the tendency towards the right are *Juncus acutus*, *Scirpus maritimus*, *Triglochin maritimum* and *Samolus valerandi*. Other notable hemimarsh species are *Apium nodiflorum*, *Eleocharis palustris* ssp. *palustris*, *Juncus articulatus*, *J. subulatus*, *J. inflexus* and *Agrostis stolonifera* ssp. *stolonifera*.

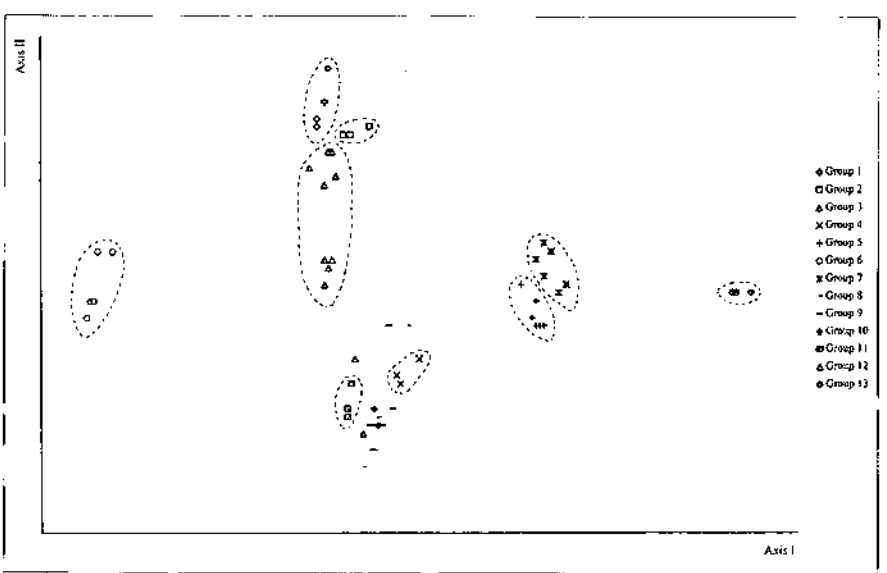


Fig. 6a.

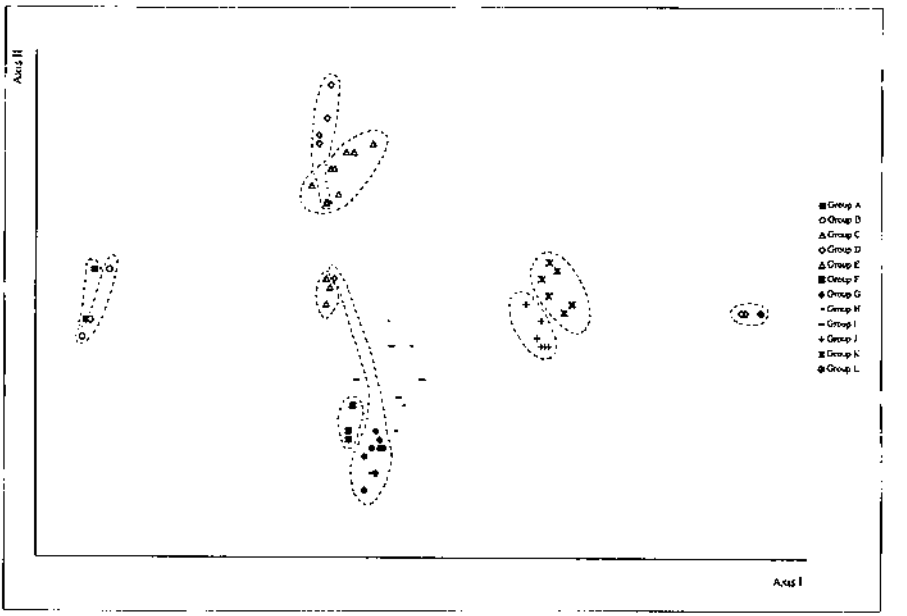


Fig. 6b. - Distribution of the groups produced by a) Cluster analysis and b) TWINSPAN analysis on the ordination produced by correspondence analysis. Readily identifiable groups have been indicated.

The stands in the centre of the ordination are from most humid area of Closes de l'Ullal continuously shallowly flooded or humid and dominated by *Paspalum distichum*. *Juncus compressus* ssp. *compressus* is also important in determining the position of this group. At the centre bottom of the diagram there is a tight cluster of groups; the 'pasture' groups (**4**, **8**, **9**, **10**, **11**, **12**, **C**, **F**, **G**, **H** and **I**) from the meadow vegetation at Closes de l'Ullal. These groups are not so clearly distinguished. Towards the left *Cyperus longus* and *Oenanthe fistulosa* appear to be influencing the positon of Groups **11** and **12**. The main nucleus of the cluster includes the grasses *Poa trivialis* ssp. *trivialis*, *Festuca arundinacea*, *Hordeum secalinum*, *Elymus repens*, *Alopecurus bulbosus*; other significant species are *Oenanthe lachenalii*, *Aster squamatus*, *Plantago major* ssp. *major*, *Apium graveolens*, *Lotus corniculatus* ssp. *tenuifolius*, all important components of the meadow vegetation. *Carex divisa* ssp. *divisa* and *Juncus compressus* ssp. *gerardi* lie close together. Species from the more humid area of the field, *Glyceria fluitans*, *Iris pseudacorus*, *Juncus compressus* ssp. *compressus* and *Althaea officinalis* are situated above this cluster of pasture species. To the right, towards the halophytes from La Rubina are Groups **4** and **9** with *Cynodon dactylon* and *Hordeum marinum* ssp. *marinum* significant factors in this situation. The relative position of these species further evidence to suggest that the assemblages dominated by them indicate are phases in the transition to more saline grassland.

It should be noted that environmental factors commonly vary in a complex-gradient (Whittaker 1982); the spatial distribution along axes I and II has no easy eco-

logical explanation. The driest of all groups, the therophytic pastures from La Rubina, lie at one extreme of the axes. The most humid stands, however (from the deep marsh at Palau) are not found at the opposite extreme of the ordination. Although in the central area of the diagram there appears to be an hydrological gradient from bottom to top (from the meadow vegetation at Closes de l'Ullal, through the grazed hemimarsh to the deep marsh at Palau at the top), this does not explain the position of species such as *Oenanthe fistulosa* or *Apium graveolens* at the foot of the diagram. Similarly no straightforward relationship appears to exist between either axes I or II and salinity, rather the most halophytic groups occupy an area of the diagram, and proximity to this area appears to represent increasing halophytic tendencies. Little new information is brought by examining axes III or IV. A multitude of environmental factors such as soil structure, salinity and chemical composition, period and depth of flooding, management (cutting or grazing) are undoubtably influencing the form of stand distribution.

Phytosociological Study

Four of the most interesting communities occurring at the sites have been studied in detail: *Helianthemetum guttati* includes relevés from the abandoned old field at La Rubina (section C), *Gaudinio-Arrhenetheretum* relevés from Closes de l'Ullal, *Paspalo-Agrostidetum* relevés from section F (mid hemimarsh) at Palau and the waterlogged corner (section I) of the meadow at Closes de l'Ullal and *Schoeno-Plantaginetum crassifoliae* includes relevés from the beach ridge (section B) at La Rubina. Where possible the affinities of the phytosociological units with the groups produced by cluster analysis and TWINSPAN are given. Although in many cases there are important similarities it should be remembered that correspondence will never be complete due to the different sampling methodologies involved; sampling all the vegetation at a site will usually produce too mixed a result for phytosociological purposes with too many accidentals and non constant species (cf. Moore, 1962). Where relating a group to an association is not possible it has instead been fitted into a higher level of the hierarchical phytosociological classification, eg. alliance or order where the fit will be more general (see Table 6). Below the four communities are studied in detail.

Helianthemetum guttati Br.-Bl. 1940 (Appendix A)

This community of therophytes (annual plants) is found on loose sandy-gravelly soil with little organic matter (oligotrophic), originally in dry river beds and on rocky outcrops and, more recently where the Mediterranean siliceous scrub vegetation called brolla *Cistion* has been destroyed by man. Typically occupying small areas, and with a reduced coverage, the association reaches a climax in late spring, dying back and setting seed in early summer with the onset of the intense heat leaving a few perennial species.

The *Helianthemum guttati* in the studied area presents two basic forms: the first three relevés, from the granitic outcrops of Polygon 1, are rich in characteristic species of the association: *Helianthemum guttatum, Trifolium cherleri, T. arvense, Galium pariense* ssp. *divaricatum, Hypochoeris glabra, Ornithopus compressus, Crassulea tillaea, Biserrula pelecinus, Tolpis barbata,* etc. The granitic outcrops, of

Paleozoic origin lie between Castelló d'Empúries and Roses and once formed islands in the ancient Estany de Castelló which until the eighteenth century covered the area (today they form geological islands in a sea of clay and silt sediments). The sparse vegetation on these dry sandy soils is at a maximum in late May after which the annual plants become rapidly desiccated and die.

The last three relevés occupy a similar environment (inland dune) at La Rubina but represent impoverished variants of the association. They have been included owing to the presence of *Helianthemum guttatum, Ornithopus pinnatus* and *Cerastium glomeratum.* Accompanying these are an array of species from the order *Thero-Brachypodietalia,* eg. *Petrorhagia prolifera, Helianthemum salicifolium, Sedum sediforme, Cerastium pumilum, Valantia muralis, Asterolinum linum-stellatum* or *Thymus vulgaris* ssp. *vulgaris. Helianthemion* has affinities with the therophytic grassland *Thero-Brachypodion* found on thin but more eutrophic soils; the presence of *Thero-Brachypodietalia* species probably indicates a soil-building process and transition towards this more eutrophic alliance (Aubert & Loisel, 197X).

In the last three forms of the pastures it is interesting to note the presence of *Ephedra distachya* ssp. *distachya, Sedum sediforme, Lagurus ovatus* and *Medicago littoralis. Ephedra distachya* ssp. *distachya* is dominant in two of the relevés. Furthermore it is accompanied by *Paronychia argentea, Lagurus ovatus, Medicago littoralis* and *Helichrysum stoechas* together with a number of accompanying species such as *Asterolinon linum-stellatum* or *Trifolium campestre* described for *Diantho catalaunici-Ephedretum distachyae.* This association and *Diantho catalaunici-Corynephoretum canescentis* were first described from the Roussillon coastline by Baudière & Simonneau (1974) and more recently from the Languedoc region by Gehu & Bournique (1989). Both fall within the alliance *Diantho-Scrophularion-humifusae. Diantho catalaunici-Corynephoretum canescentis* is characteristic of looser sand (principally 0.5-2 mm diam.) on older (consolidated) sand dunes and is dominated by the grass *Coreynephorous canescens. Diantho catalaunici-Ephedretum distachyae,* dominated by *Ephedra distachya,* is found exclusively on finer sands (0.2-0.5 mm diam) and plays a fundadamental role in stabilising sand dunes against the strong winds typical of the Roussillon and Empordà coastline known locally as the 'Tramuntana' (Baudière & Simonneau, 1974).

Comparisons of communities from AENP wetlands with those described from the Roussillon region are perfectly logical given the proximity of the two areas. Likewise, a number of communities described by Farràs & Velasco (1994) have greater affinities with those described for the Llenguadoc region than southern Catalonia. However, the reduced area occupied by these communities at the study site (not exceeding 300 m2) prohibits any comparison with associations described from extensive areas; the relevés have not therefore been included within the association *Diantho catalaunici-Ephedretum distachyae.* The association *Corynephoretum catalaunicum* with the biennal grass *Corynephorous canescens* has been described at La Selva and El Maresme (Bolòs, 1959) and included in the alliance *Helianthemion guttati* (Folch i Guillèn 1981).

Although common within the mediterranean region *Helianthemum guttati* is a rarity in a coastal floodplain composed principally of marsh or alluvial sediments. Some of the stands from Group **13** or **L** can be classified under this association.

Gaudinio-Arrhenetheretum Br.-Bl. 1931 (Appendix B)
These meadows, optimally a Central European alliance, found on rich, humid soils are naturally rare within the Mediterranean owing to the scarcity of this type of habitat. In Catalonia the alliance *Arrhenatherion elatioris* is generally limited to the Pyrenees although the association *Gaudinio-Arrhenatheretum* has been recorded from La Selva, Les Guilleries and Montseny, which constitute its southern limit (Bolòs, 1959). Structurally tall (50-70 cm) and dense and highly productive they are mowed for hay and grazed to give first class meat and milk, the latter a precious resource in the Mediterranean. Floristically they are most similar to the structure seen in the associations from Languedoc, although species from the *narcissetosum* subassociation eg. *Narcissus poeticus*, *Leontodon hispidus* and *Anthriscurs silvestris* are absent.

Although spontaneous in origin the meadows are maintained by human intervention (mowing for hay) or 'improved' by sowing additional grass species and fertilizing, either naturally or artificially. Their distribution at these southern limits can be artificially increased by irrigation, but alternatively they are found on the beds of old lakes, as at Sils (Bolòs, 1959) or the water meadows ('Les closes') of the Empordà marshlands. The 'closes' are flooded in winter and maintained damp (but not waterlogged) in summer by an intricate system of drainage canals on the site of ancient lake beds (see 'site selection and description'). Four of the relevés (from the Mornau and Montmajor closes) are from the area in Polygon I covered to the eighteenth century by the Estany de Castelló. Relevé II is taken from the margins of a small lake, St Pere Pau, which dries, although still leaving the soil damp, in summer. Relevé V is from a similar area of Polygon II, (Closes de la Gallinera) formed where another large lake, l'Estany de St. Pere, once existed.

The association at AENP is characterised by *Geranium dissectum*, *Bellis perennis*, *Gaudinia fragilis*, *Lathyrus hirsutus*, *Tragopogon dubius* and *Lychnis flos-cuculi* and is generally abundant in grasses and legumes; *Poa trivialis* ssp. *trivialis*, *Holcus lanatus*, *Festuca arundinacea s.l.*, *Hordeum secalinum*, *Bromus hordeaceus* ssp. *hordeaceus*, *Alopecurus bulbosus*, *Trifolium pratense*, *Trifolium squamosum*, *Lotus corniculatus*, etc. Lax-flowered orchid, *Orchis laxiflora*, is also common. *Arrhenatherum elatius*, although found at AENP, was not frequent in the meadows. *Festuca arundinacea* is a remarkably constant component of the vegetation and where it becomes especially abundant appears to indicate a transition towards more saline stands, with *Alopecurus bulbosus*, *Oenanthe lachenalii* and *Carex divisa* more predominant. *Hordeum secalinum* and *Trifolium fragiferum* would be further indicative of this transitive group (Molinier & Tallon, 1968). These authors describe a *Festuca* pasture from the Camargue with numerous characteristics of *Arrhenetheretea*, differentials of the *Festuca* pasture (as above), abundant hygrophiles (*Carex vulpina* ssp. *nemorosa*, *Carex distans*, *Althaea officinalis*...) and some halophytes (*Limonium vulgare*, *Juncus gerardi*, *Tetragonolobus maritimus*). The pasture, closely related to the *Arrhenatheretum* 'prairic', develops where humidity and salinity are slightly higher (see '*Juncion maritimi* at Closes de l'Ullal' and 'pasture dynamics').

In the AENP the meadows are maintained by controlled natural flooding and mowing for hay and grazing. Abandoning these traditional extensive agricultural

practices leads to the establishment of non-productive salt pastures of little agricultural value. *Gaudinio-Arrhenatheretum* occupies reduced extensions at AENP where it has been banished to a few field margins. Where uncontrolled flooding results in elevated humidity, hygrophiles such as *Cyperus longus* or *Althaea officinalis* and *Fraxinus angustifolia* seedlings invade. In the absence of mowing the pasture progresses towards the dominant woodland community in this area *Populion albae*.

The relevés at Closes de l'Ullal are from section G. Some elements of Groups **8** (the *Festuca* dominated pasture), **11** and **12** (**F** & **G**) are described by the community but no single Cluster or TWINSPAN group shows a close correspondence, an indication of the reduced extension of the unit at the meadow.

Paspalo-Agrostidetum Br.-Bl. 1936. (Appendix C)
This mediterranean grassland association is formed on very wet, often waterlogged, eutrophic soils usually subject to grazing and trampling. It is characterised by dense swards of the grass *Paspalum distichum* which is accompanied by *Aster squamatus* and *Polygonum mite* or *Polygonum hydropiper, Echinochloa crus-galli* ssp. *crus-galli*... The community is common in suitable habitats along the Catalonian coast and is particularly associated with ricefields, where it forms dense carpets on soil not ploughed for some years as on the banks separating ricefields (Bolòs & Masclans, 1955). All the relevés except the last correspond to disused ricefields. Relevés I, II and III are from the middle reaches of the hemimarsh at Palau (section F), which is on the site of the ancient Estany de Castelló and was cultivated until 1982. Relevé IV is a shallowly flooded area of the Closes de l'Ullal meadow (which has never been cultivated for rice). Relevé V is from Al Matà ricefields, abandoned in 1990. The association is species poor, which appears to be normal for inventories from the Mediterranean (Bolòs & Masclans, 1955). The fact that all the accompanying species are characteristic of the order *Phragmitetalia* may reflect that the inventories come from abandoned ricefields, where previous work has described communities from river margins or ricefield banks. The studied sites, grazed by cattle (at Al Matà by Camargue horses) and flooded almost permanently, would undoubtably progress towards a reedswamp in the absence of grazing.

The relevés from Palau and Closes de l'Ullal correspond to Group **3** (see also Groups **E** & **C**)

Schoeno-Plantaginetum crassifoliae Br.-Bl. 1931. (Appendix D)
This typically Mediterranean community, found all along the Catalonian coastline, occupies the transition area between the sand dune systems and the more halophytic interior communities (Molinier & Tallon, 1965). It is found on sandy, more or less compact and slightly saline soils; damp in winter and never completely drying out. In the AENP the association is characterised by the presence of widely dispersed clumps of the rushes *Juncus maritimus* and *Juncus acutus* (never dominant), surrounded by a 'mat' of *Plantago crassifolia* which can cover up to 60% of the ground and accompanied by *Blackstonia perfoliata* ssp. *imperfoliata* (FONT *et al.*, 1996) and *Centaurium pulchellum* ssp. *tenuiflorum*. Some stands from Group **7** (or **K**) correspond to this association.

Other communities at the three study sites.

La Rubina

- *Arthrocnemetum fruticosi* Br.-Bl. 1931

This species poor association of perennial plants, predominately *Chenopodiaceae* with a few grasses, rushes or *Plumbaginaceae*, is dominated by a compact population of succulent *Arthrocnemum fructicosum* bushes often with 100% coverage and difficult to pass through. The community is found on highly saline, impermeable mud or clay soils, waterlogged usually until late spring. The soil surface is covered in summer by a layer of cianophids and salt from evaporation, beneath which lies a deep horizon of black sulphydrous mud which *Arthrocnemum* avoids using a superficial rooting aparatus. *Arthrocnemum fructicosum*, *Puccinellia festuciformis* and *Elymus elongatus* are constant and characteristic species of the community which is extensive at AENP, found in depressions and fringing the coastal lagoons (Farràs & Velasco, 1994).

The subassociation *Agropyreto-Inuletum crithmoidis* Br.-Bl. 1952 occurs on slightly higher microtopographical protuberances where the soil is less saline and the freatic level deeper. *Inula crithmoides*, *Elymus elongatus* and *Atriplex portulacoides* are abundant, often with some species of the *Schoeno-Plantaginetum* association or the *Limonion* alliance eg. *Plantago crassifolia*, *Limonium vulgare* ssp. *serotinum or Artemisia gallica* communities with which it forms a mosaic.

These salt meadows correspond to the stands from the saltmarsh area (section A - Groups **5** and **J** from the classification).

- *Artemisio-limonietum virgati* (Kühnh) Br.-Bl. 1931

This association occurs on small elevations (the remains of beach ridges), only damp a few months of the year, on compact sandy, slightly gravelly soils containing the remains of shells and highly salty. The freatic level is deeper than in the depressions occupied by *Arthrocnemum*. This association forms a mosaic with *Arthrocnemum* and *Schoeno-Plantaginetum* and occupies an intermediate position both in terms of humidity and salinity. Characteristic species are *Artemisia gallica*, *Limonium virgatum* ssp. *virgatum*, *L. girardianum* ssp. *girardianum* and *Triglochin bulbosum* ssp. *barrelieri*.

These salt steppes occur on the old beach ridge (section B) and correspond in part to Groups **7** and **K**.

Estany de Palau

-*Scirpo-Phragmitetum mediterraneum* Tx. et Preisg. 1942

Much impoverished compared to the associations at Languedoc or *Phragmition eurosibiricum*, this prototype helophytic community has *Phragmites australis* as the dominant species with *Typha latifolia*, *T. angustifolia* and species characteristic of the order *Phragmitetalia; Sparganium erectum*, *Iris pseudacorus*, *Eleocharis palustris* ssp. *palustris*, *Galium palustre* ssp. *elongatum*, *Alisma plantago-aquatica* accompanying. It needs permanently wet soils (fresh or slightly brackish water) and corresponds to the stands taken from the edge of the deepmarsh (Groups **I** and **D** from the classification).

Estany de Palau/Closes de l'Ullal

-*Cypero-Caricetum otrubae* Tx. in Tx. et Oberdorfer 1958

This is another example of an optimally Central European association which penetrates impoverished in the Mediterranean region (Bolòs, O, 1959) It is characteristically rich in sedges eg. *Carex vulpina* ssp. *nemorosa* accompanied by species of the *Magnocaricion elatae* alliance; *Althaea officinalis, Iris pseudacorus, Galium palustre* ssp. *elongatum, Rumex conglomeratus* and *Cyperus longus.* The helophytes and hemicryptophytes grow rapidly in spring giving the typical aspect of tall, luxurious growth in June and July. Although common at AENP it is usually fragmentary, occupying a narrow band on the land side of reedbeds or ditches where the soils remain humid all year. Of difficult agricultural use.

The stands taken from the top part of the hemimarsh at Palau (section E) (Group **2**) and the margins and the area where invade, appearing between the drainage canals and the pasture (section H) can be broadly assigned to this association.

Closes de l'Ullal

- *Hedero-Ulmetum.* This constitutes the bordering woodland hedges of the water meadows. Although the principal tree species of the association are *Ulmus minor* and *Fraxinus angustifolia* ssp. *angustifolia* the prescence of numerous examples of *Quercus humilis* indicates a more elevated humidity. The shrub layer is composed of *Ligustrum vulgare, Rubus ulmifolius, Crataegus monogyna, Cornus sanguinea, Rosa canina* and abundant *Hedera helix. Arum italicum, Brachypodium sylvaticum* and *Orobanche minor* are common components of the groundflora. Separating the bordering woodland and the meadow vegetation is a thin line of mediterranean shrubland *Pruno-Rubion ulmifolii,* dominated by *Rubus ulmifolius, Rosa sempervirens* etc, although distinction between this and the woodland is often confused.

- *Trifolio-Cydondontetum* Br.-Bl. et O. de Bolòs 1954.

Widely distributed in Catalonia along the coast this nitrophilous vegetation represents a transition between exclusively nitrophilous and exclusively marsh communities. *Trifolium fragiferum, Lotus corniculatus* ssp. *tenuifolius* and *Cichorium intybus* are characteristic species concurrent with the dense swards of *Cynodon dactylon. Trifolio-Cydondontetum* replaces *Paspalo-Agrostidetum* in trampled, but less humid areas.

The extension occupied by this alliance is small at Closes de l'Ullal, and most of the swards dominated by *Cynodon dactylon* belong to the *Juncion maritimi* alliance.

- *Caricetum divisae* Br.-Bl. 1931 and *Juncion maritimi* Br.-Bl. 1931

Caricetum divisae is found in brackish pastures, slightly salty and very damp for most of the year and usually occupies reduced extensions in a mosaic with other pastures of the alliance *Juncion maritimi.* The association has a dense coverage (100%) and the dominant species is *Carex divisa.* At Closes de l'Ullal the monospecific flushes dominated by *Carex divisa* are accompanied principally by *Juncus compressus* ssp. *gerardi, Aster squamatus* and *Polypogon monspeliensis.* Groups **11** and **F** from the classification can be broadly assigned to this association.

The *Caricetum divisae* described by Farràs & Velasco (1994) from flooded pastures near the Rec Madral additionally lists *Alopecurus bulbosus, Festuca arundi-*

nacea, *Atriplex prostrata* and *Hordeum marinum* as accompanying species. Bolòs *et. al* (1970) describe from Minorca a 'Groupement à *Hordeum marinum*' occupying a valley bottom, 100 m from the sea, with slightly salty clay soil and dominant *Hordeum marinum*, *Artemisia gallica* and *Polypogon maritimus* and many pasture species such as *Dactylis glomerata*, *Bromus hordeaceus* ssp. *hordeaceus* and *Gaudinia fragilis* also present. Bolòs *et. al.* (1970), Braun-Blanquet & Ramm (1957) and Rivas Martinez (1975) classify *Juncus compressus* ssp. *gerardi*, *Limonium vulgare*, *Oenanthe lachenalii*, *Juncus acutus*, *Alopecurus bulbosus*, *Tetragonolobus maritimus*, *Sonchus aquatilis* ssp. *maritimus* and *Plantago crassifolia* as characteristic of the higher orders *Juncion maritimi* and *Juncetalia*.

Most of the above species are common at Closes de l'Ullal and undoubtably much of the pasture vegetation from sections G, J and K falls within the alliance *Juncion maritimi*. It remains unclear however, whether the *Festuca* dominated stands with *Poa trivialis*, *Hordeum secalinum*, *Apium graveolens*, *Alopecurus bulbosus*, *Oenanthe lachenalii*, etc would fall within this alliance or the *Arrhenatheretea* class. This may depend on the accompanying species; where *Aster squamatus*, *Juncus compressus* ssp. *gerardi*, *Carex divisa* ssp. *divisa*, *Tetragonolobus maritimus* are more common and occasional *Juncus acutus* appears, the *Festuca* stands would perhaps be classified as *Juncion maritimi*. The 'fàcies' with dominant *Cynodon dactylon* accompanied by *Hordeum marinum* ssp. *marinum*, *Carex divisa* ssp. *divisa*, *Aster squamatus*, *Atriplex prostrata* and occasional *Alopecurus bulbosus*, *Spergularia maritima*, *Plantago crassifolia and Puccinellia festuciformis*, and the *Hordeum marinum* ssp. *marinum* dominant swards with halophytes such as *Suaeda maritima* and *Limonium vulgare* ssp. *serotinum* (indicating areas of maximum salinization at the meadow) can comfortably be assigned to *Juncion maritimi*. Thus stands from Groups **4**, **9** and **10** (**I** and **H**) generally fall within this alliance together with some from Groups **8**, **11** and **12** (**G** and **F**).

DISCUSSION

Comparison of groups produced by the different methods.

Cluster analysis, TWINSPAN, correspondence analysis and phytosociological methods have coincided in defining a series of readily characterised groups; ie the hedgerows from Closes de l'Ullal, the deep marsh at Palau and the salt steppes, meadows and therophytic pastures from La Rubina. Their treatment differed, however, of the meadow and marsh vegetation from Closes de l'Ullal and Palau (see Table 6). The series of plant assemblages dominated by *Festuca arundinacea*, *Cynodon dactylon* and *Hordeum marinum* ssp. *marinum* grouped generally as *Juncion maritimi* are clearly identified by TWINSPAN and cluster analysis. Through the use of indicator species TWINSPAN has given further insight as to the nature of the meadow vegetation at Closes de l'Ullal.

Inferences on pasture dynamics

From the results of the cluster analysis, TWINSPAN, correspondence analysis and phytosociological study we would propose the following dynamic scheme for the

pasture vegetation of the 'closes'. (see Figure 7). The 'typical' water meadow vegetation, as described for the association *Gaudinio-Arrhenatheretum*, will be taken as the central point, even though, due to its reduced extension at Closes de l'Ullal no one cluster or TWINSPAN group accurately corresponds to this. It indicates a deep, humid soil with little salinity. The results appear to indicate that slightly dryer and more saline conditions lead to the establishment of a *Festuca* pasture, where *Festuca arundinacea* is dominant with abundant grasses and legumes. This is not necessarily a contradiction of the situation described from the Camargue (Molinier & Tallon, 1968) where the *Festuca* pasture develops from *Arrhenatheretum* with an increase in humidity and salinity. *Festuca* is not demanding and may be classified under *Arrhenatheretea* or *Juncion maritimi* according to other characteristic species present. At Closes de l'Ullal the tendency was towards *Juncion maritimi* and the accompanying species indicated the increased salinity to almost certainly be caused by dryer conditions. This plant assemblage is undoubtably one of the most common at Closes de l'Ullal (Groups **8**, **G**). Further drying of the *Festuca* pasture would give rise to swards dominated by *Cynodon dactylon*, accompanied by increasingly more salt tolerant species such as *Alopecurus bulbosus* and *Atriplex prostrata*. This assemblage, also very frequent at the study site, corresponds to Groups **9** & **H**. Succesively drier (and more saline) soils lead to a *Hordeum marinum* ssp. *marinum* dominated grassland with more demanding halophytes such as *Suaeda maritima* or *Limonium vulgare* ssp. *serotinum* representing the maximum phase of salinization seen at the site.

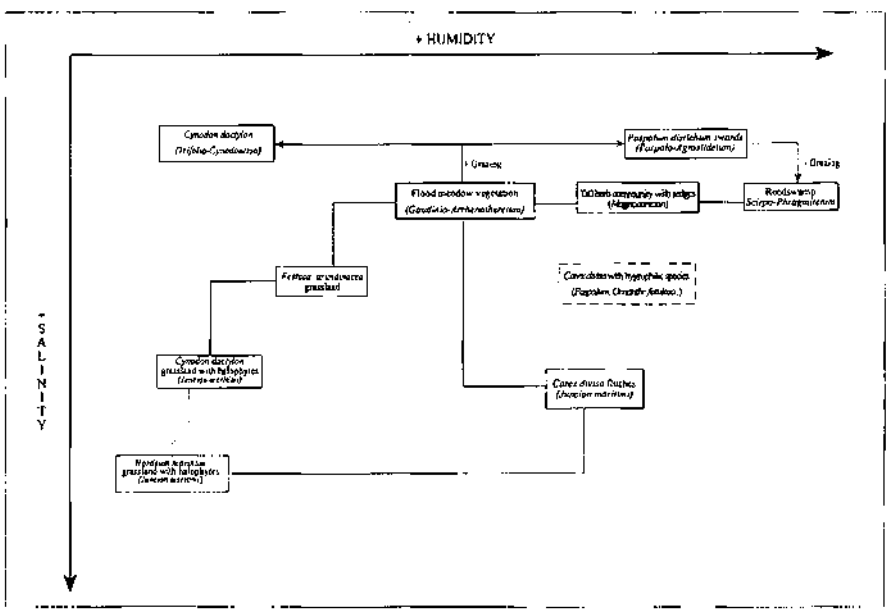


Fig. 7. - Dynamic relationship between plant assemblages of the pasture vegetation at AENP.

Braun-Blanquet & Ramm (1957) sketched a similar transition from *Molienietum Mediterraneum* pastures to *Juncion maritimi* alliance according to salinization. With wetter and slightly more brackish soil, *Gaudinio-Arrhenatherethum* tends towards *Carex divisa* ssp. *divisa* flushes, with no concomitant increase in salinity to the tall herb communities with sedges (Groups **2**, **E** and *Magnocaricion*) or to reed-bed *Phragmition* (Groups **1** & **D**) with maximum humidity. An increase in humidity accompananied by grazing favours the dense swards of Paspalo-Agrostidetum (Groups 3&C/E) whose equivalent under dryer conditions is Trifolio-Cynodontion. Finally, in the absence of mowing, the water meadow would progress towards riverine woodland of the order Populietalia albae (Groups 6, A&B).

Conservation

The most notable communites are those described in detail in the photosociological study, especially *Helianthemetum guttati*; and *Schoeno-Plantaginetum crassifoliae. Helianthemetum guttati* is unusual within a wetland site; the granitic outcrops in Polygon 1 are a curious testament to what were islands in l'Estany de Castelló. The disused field strips at La Rubina where this community and *Schoeno-Plantaginetum crassifoliae* occurs are an important refuge for many species of orchid; *Barlia robertiana*, *Serapias lingua*, *Ophyrs sphegodes* ssp. *sphegodes, Ophyrs tenthredinifera* and *Aceras anthropophorum.* While the granitic outcrops are at present grazed and do not appear to be under threat, the disused field strips at La Rubina could be cultivated at any time and are subject to human pressure from nearby tourist installations.

Maintenance of the water meadow vegetation (*Gaudinio-Arrhenatheretum)* depends on constant human attention and discontinuing traditional farming practices has disastrous effects on this ecologically and agriculturally valuable pasture. A similar situation exists at the Camargue where the importance of maintaining irrigation of the saline soils in preserving the *Arrhenatheretum* or *Festuca* grassland was emphasised by Molinier & Tallon (1968). Our results show the system to be remarkably sensitive to small variations in hydrological management on these potentially saline marsh soils. Likewise, an excess humidity leads to an invasion of marsh species with little agricultural value or to the eventual establishment of woodland. The water meadows harbour many rare species at a regional level, eg. *Lychnis flos-cuculi, Alopecurus bulbosus* and *Oenanthe fistulosa* and the orchid *Orchis laxiflora.*

CONCLUSIONS

The stand survey shows *Paspalum distichum*, *Carex divisa* ssp. *divisa*, *Cynodon dactylon*, *Phragmites australis* and *Arthrocnemum fructicosum* to be the most abundant and frequent species at the three sites; the first is important both at Closes de l'Ullal and Palau, in part a reflection of its growth habit but also of the continuous nature of the variation in the vegetation between the sites. This complex situation where many environmental factors are influencing distribution of the stands is highlighted by correspondence analysis.

Each site consists of a number of vegetation units reflecting the importance of the microtopographical and sedimentation variations over small areas which characterise these wetlands. Cluster analysis, TWINSPAN, correspondence analysis and phytosociological methods coincide in separating a series of readily characterised groups according to the different environmental conditions or human action (management). These are the saltmeadows, salt steppes and theropytic pastures from La Rubina, the reedbed, *Paspalum* hemimarsh swards, and *Carex*- dominated tall herb fringes at Palau and the riverine hedgerows bordering the meadow at Closes de l'Ullal.

The pasture vegetation at Closes de l'Ullal presents a more complex picture. TWINSPAN in particular, through the use of indicator species (eg *Carex divisa*, *Cyperus longus)* allows important insights into the dynamic relationship existing between the groups defined. Slight drying (which often represents salinization on these soils) of the flood meadow stands *Gaudinio-Arrhenatheretum* leads to a *Festuca* dominated pasture, readily identified by cluster analysis and TWINSPAN and probably one of the most common plant assemblages of the closes. Further drying gives rise to progressively more saline grassland with intermediate assemblages dominated by *Cynodon dactylon* and *Hordeum marinum* ssp. *marinum* with halophytes. With an increase in humidity tall herb communities with sedges appear or, with grazing *Paspalum* dominated swards. A similar hydrological regime in the absence of mowing encourages invasion by riverine woodland. This succesive scheme allows a management plan for the pastures to be formulated according to the desired end product. We hope these conclusions can be taken into consideration by AENP.

The flood meadow vegetation is important both ecologically and agriculturally and requires a correct irrigation and mowing to survive. In contrast the *Helianthemum guttati* and *Schoeno-plantaginetum* communities at La Rubina are under threat from human intervention.

The most diverse site was La Rubina, due to the *Helianthemum guttati* community and the salt steppes (including *Schoeno-plantaginetum*). Closes de l'Ullal had the highest number of species.

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Appendix A
Helianthemetum guttati Br.-Bl. 1940

	I	II	III	IV	V	VI
Char. of Association and Alliance						
Helianthemum guttatum ssp. *guttatum*	1	+		1		
Trifolium cherleri	+	+				
Trifolium arvense	+	+				
Tolpis barbata	+					
Galium pariense ssp. *divaricatum*	+	1				
Hypochoeris glabra	+		3			
Biserrula pelecinus	1	+	+			
Herniaria glabra	+					
Silene gallica		1	1			
Ornithopus compressus		+	+			
Crassulea tillaea			+			
Briza maxima	+	+				
Trifolium glomeratum	1	+			+	
Filago gallica	+	+				
Ornithopus pinnatus				+	2	+
Char. of Order *Helianthemetalia guttati* and Class *Helianthemetea guttati*						
Aira caryophylla ssp. *caryophyllea*	3	1	1			
Cistus monspeliensis		2	2			
Erica arborea		+				
Jasione montana	+	+				
Trifolium campestre	1	+			+	
Trifolium nigrescens	+		1	+	+	
Romulea columnae			+	+	+	
Cerastium pumilum				+	1	
Accompanying species:						
Cerastium glomeratum		+				
Petrorhagia prolifera	+	+			+	+
Paronychia argentea	+	+	1		+	1
Dactylis glomerata ssp. *hispanica*	+	2				
Rumex bucephalopherous	+	+	+			
Plantago lagopus	1		2	1	2	1
Plantago afra	+	+	3			
Filago pyramidata ssp. *canescens*	+	+	+			
Helichrysum stoechas	+			1	+	1
Erodium cicutorium ssp. *cicutorium*	+	+	+			
Bellardia trixago	+			+	+	+
Gaudinia fragilis	+	+	+			
Alyssum maritimum	+	+	1			
Galium maritimum	+	+				
Sanguisorba minor ssp. *spachiaria*		+	1			
Thymus vulgaris ssp. *vulgaris*		1	+		1	
Sherardia arvensis		+	1			
Brachypodium retusum	+	2	3			
Salvia verbenaca ssp. *verbenaca*		+	+		+	
Polycarpon tetraphyllum		+	+			

Lavandula stoechas		+	3			
Calicotome spinosa		1				
Urospermum dalechampii		+	1			
Medicago truncatula	+	+			+	+
Medicago polymorpha	+		1			
Euphorbia serrata	+		+			
Crepis sancta	+				+	
Sideritis hirsuta ssp. *emporitana*			+	+		
Sedum sediforme				2	2	1
Helianthemum salicifolium				1	1	1
Arenaria serpyllifolia ssp. *serpyllifoila*				+	+	
Valantia muralis				+	+	
Asterolinon linum-stellatum				+	+	
Hedypnois rhagadiolus				+		+
Ophyrs sphegodes ssp. *sphegodes*				+	+	
Fumana thymifolia var. vulgaris					1	2
Koeleria pubescens ssp. *pubescens*					1	+
Valerianella pumila				+	+	
Helianthemum hirtum				1	2	
Teucrium polium ssp. *polium*				1	2	2
Ephedra distachya ssp. *distachya*					2	2
Scabiosa atropurpurea ssp. *maritima*				2	2	1
Medicago littoralis				+	1	
Euphorbia terracina				+	+	
Artemesia gallica				1		
Species found in one inventary:						
Trifolium angustifolium	2					
Centranthus calcitrapae		+				
Brassica fructiculosa		+				
Allium sphaerocephalon		+				
Leontodon taraxacoides ssp. *hispidus*		+				
Crepis capillaris		2				
Phagnalon saxatile		+				
Antirrhinum orontium ssp. *orontium*			+			
Reichardia picroides			+			
Medicago orbicularis			1			
Bellis annua			+			
Carex divisa ssp. *chaetophylla*			+			
Vicia hirsuta			+			
Ophyrs tenthredinifera					+	
Minuartia hybrida					+	
Linaria arvensis ssp. *arvensis*					+	
Muscari comosum					1	
Desmazeria rigida ssp. *rigida*					+	
Lagurus ovatus						+
Linum strictum ssp. *strictum*						1

	Location	Date	Area m2	Cover %	
I	El Penardell, dry grassland.	EG 0883	14-6-96	50	80
II	La Torre del Vent	EG 1082	17-5-96	75	75
III	Els Communs, dry hillocks.	EG 0882	23-4-96	100	70
IV	La Rubina, study plot (RO8)	EG 1178	14-6-96	100	75
V	La Rubina, study plot (RO9)	EG 1178	1-5-96	100	90
VI	La Rubina, study plot (RO10)	EG 1178	14-6-96	100	75

Appendix B

Gaudino-Arrhenatheretum Br.-Bl. 1931	I	II	III	IV	V	VI
Char Association, Alliance and Order						
Geranium dissectum	2					
Bellis perennis	+					+
Gaudinia fragilis	1	+	+	2		+
Lathyrus hirsutus		+	+	1		
Lychnis flos-cuculi		1	+			
Tragopogon dubius				+		
Char. of Class Molinio-Arrhenatheretea						
Carex distans		1		1	2	+
Trifolium pratense		1		1	+	+
Trifolium squamosum		1	+			+
Galium verum		+		1		
Centaurium erythraea	+	+	+	+		+
Hypochoeris radicata		+				
Holcus lanatus			+			
Poa trivialis	+			1	1	3
Vicia tetrasperma ssp. *tetrasperma*	+					
Orchis laxiflora	+			+	+	+
Differentials Festuca arundinacea group						
Festuca arundinacea s.l.	2	2	3	3	3	2
Hordeum secalinum		3		2	1	+
Trifolium fragiferum						+
Accompanying species:						
Bromus hordeaceus ssp. *hordeaceus*		+				+
Lotus corniculatus		1	2	2		+
Galium palustre ssp. *elongatum*		1			1	
Agrostis stolonifera ssp. *stolonifera*		2	2	2	2	
Oenanthe fistulosa			+		1	
Juncus compressus ssp. *compressus*		+	+			+
Galium palustre ssp. *debile*	3			+		
Sonchus maritimus ssp. *aquatilis*				1	+	+
Ranunculus sardous ssp. *sardous*	1			+	+	
Carex vulpina ssp. *nemorosa*	1				+	+
Althaea officinalis					+	+
More or less halophytes						
Alopecurus bulbosus	4		1		1	
Carex divisa ssp. *divisa*	1				1	
Oenanthe lachenalii		2		+		1
Species found in one inventary:						
Oenanthe pimpenilloides	+					
Plantago lanceolata		+				
Medicago polymorpha		+				
Rumex conglomeratus		+				
Linum trigyum			+			
Convolvulus arvensis				+		
Calystegia sepium ssp. *sepium*				+		
Apium graveolens						1
Ranunculus repens						+

	Location		Date	Area m2	Cover %
I	Closa de la Gallinera	EG 0675	20-5-96	100	100
II	Closes de Mornau A	EG0782	14-6-96	75	100
III	Estany d'en Pere Pau	EG0883	14-6-96	100	100
IV	Closa dels Comuns	EG0781	05-6-96	150	100
V	Closes de Mornau B	EG0782	05-6-96	100	100
VI	Closes de l'Ullal (Study site)	EG0782	20-5-96	100	100

Apendix C
Paspalo-Agrostidetum Br.-Bl.1936

	I	II	III	IV	V
Char. of Association and Alliance					
Paspalum distichum	4	4	3	4	4
Polygonum hydropiper					1
Polygonum mite		+	+		
Aster squamatus		+	+		1
Char. of Order Plantaginetalia majoris					
Juncus compressus ssp *compressus*		+			
Trifolium fragiferum					+
Rumex crispus		+			+
Char. of Class Rudero-Secalinetea					
Echinochloa crus-galli ssp. *crus-galli*	+	+			
Accompanying species:					
Agrostis stolonifera ssp. *stolonifera*	+	+	1	1	1
Typha angustifolia ssp. *australis*	+		+		+
Phragmites australis	+	+	1		
Scirpus maritimus		+	+	+	+
Eleocharis palustris ssp *palustris*	+	+		+	+
Iris pseudacorus	+	+		2	
Juncus articulatus	+	+	+		+
Alisma plantago-aquatica	+	+	+	+	+
Scirpus lacustris s.l.	+	1			
Species found in one inventory:					
Juncus effusus	+				
Apium nodiflorum	+				
Pulicaria dysenterica			+		
Juncus inflexus			1		
Oenanthe fistulosa				+	
Ranunculus sardous ssp. *sardous*				+	
Scirpus mucronatus					1

Location		Date	Area m2	Cover %	
I	Els Fangassos, Palau: Study plot stands 50-54	EG 1080	10-7-93	100	100
II	Els Fangassos, Palau: Study plot stands 55-59	EG 1080	22-7-93	100	100
III	Els Fangassos, Palau: Study plot stand 33	EG 1080	22-7-93	100	100
IV	Closa de l'Ullal: waterlogged corner	EG 0782	25-5-93	100	100
V	Disused ricefields at Al Matà	EG 0873	15-7-94	100	100

Appendix D

Schoeno-Plantaginetum crassifoliae Br.-Bl. 1931

	I	II	III	IV	V
Char. of Association and Alliance					
Plantago crassifolia	2	1	4	3	4
Blackstonia perfoliata ssp. *imperfoliata*	+	+	1		
Centaurium pulchellum ssp. *ternuiflorum*	+	+			
Juncus acutus		2			1
Char of Order Juncetalia maritimi					
Juncus maritimus		1			
Limonium vulgare	2	1			
Triglochin maritimum	+				
Char. of Class Puccinellio-Salicornietea					
Artemisis gallica ssp. *gallica*	1	+			
Inula crithmoides		+			
Aeleuropus littoralis	+				
Parapholis filiformis		2			
Limonium girardianum ssp. girardianum		+			
Accompanying species:					
Schoemus nigricans	2	2	2	2	1
Limum strichtum ssp. *strictum*	+			+	
Limonium virgatum ssp. *virgatum*	1	1		1	+
Euphorbia terracina	+				+
Scabiosa atropurpurea ssp. *maritima*	+		2	+	1
Elymus pungens	+	1			
Petrorhagia prolifera	+	+			
Daucus carota	1	+			
Helichrysum stoechas			2	1	2
Medicago littoralis			1	+	2
Sideritis hirsuta ssp. *emporitana*			+	+	+
Teucrium polium ssp. *polium*	1		+		1
Linum usitatissimum ssp. *angustifolium*	+		+	+	
Cerastium pumilum			+	+	
Ophyrs sphegodes ssp. *sphegodes*				+	+
Sedum sediforme		+			1
Species found in one inventary:					
Ephedra distachya ssp. *distachya*	2				
Koeleria pubescens	1				
Centaurium pulchellum ssp. *pulchellum*	+				
Brachypodium phoenocoides				2	
Arenaria serpyllifolia ssp. *serpyllifolia*			+		
Ophyrs tenthredenifera					+
Pinus halepensis					+

	Location		Date	Area m2	Cover %
I	La Rubina:Study plot stands 45-46	1178	14-5-93	50	80
II	La Rubina:Study plot stands 53-56	1178	22-5-93	75	75
III	La Rubina: Abandoned field A	1178	1-5-96	100	70
IV	La Rubina: Abandoned field B	1178	1-5-96	100	75
V	La Rubina: Abandoned field C	1178	1-5-96	100	90

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