

Coastal halophilous Limonium communities from West Iberian Peninsula.

José Carlos COSTA¹, Carlos NETO², Tiago MONTEIRO-HENRIQUES¹, Pedro ARSÉNIO¹, Estevão PORTELA-PEREIRA², Ana CAPERTA¹ & Jesús IZCO³

Résumé

Dans le présent travail, nous avons étudié sept communautés présentes dans les marais salés de l'ouest de la Péninsule Ibérique, principalement rattachées à la classe *Sarcocornietea fruticosae*. Trois nouveaux syntaxa sont décrits dans ce travail : *Myriolimo diffusum-Limonietum algarvensis*, *Triglochin maritimae-Sarcocornietum maritimae* subass. *puccinellietosum alpini* et *Limonium lanceolati-algarvensis*. Le premier est une association chamaephytique des marais limoneux secs thermoméditerranéens, seulement inondés par l'eau salée pendant les grandes marées ; il occupe des places bien drainées de l'Algarve (Province Lusitanien-Andalouse Côtière, Région Méditerranée), et est caractérisé par les endémiques ibériques *Myriolimon diffusum* et *Limonium algarvense*. Le deuxième est une communauté halophytique formée par *Sarcocornia perennis* subsp. *alpini*, *Halimione portulacoides*, *Triglochin maritima*, *Puccinellia maritima* et *Plantago maritima* sur des sites périodiquement inondés par des eaux salées, riches en sable et limon, au nord de la Ria de Aveiro (District Miniense, Sous-province Cantabrique-Atlantique, Province Atlantique-Européenne, Région Eurosibérienne). La dernière est une alliance composée de communautés thermoméditerranéennes de *Limonium sp. pl.* noyées par les marées plus élevées dans la Province Lusitanien-Andalouse Côtière. Nous présentons également quelques relevés des associations *Limonium vulgare-Juncetum subulati* et *Limonietum lanceolati*, et nous amplifions la distribution du *Puccinellio tenuifoliae-Limonietum plurisquamati* jusqu'à l'estuaire du Tage et du *Limonietum lanceolati* à l'estuaire du Sado. Nous proposons aussi la ségrégation entre *Myriolimetum ferulacei*, sur les falaises maritimes de l'Algarve, et *Inulo crithmoidis-Myriolimetum ferulacei*, dans les marais.

Mot clés: marais, phytosociologie, biogéographie, Portugal, Galice

Summary

Coastal halophilous Limonium communities from West Iberian Peninsula.

In the present work, we studied seven communities occurring in salt marshes in the west of the Iberian Peninsula, mostly ascribable to *Sarcocornietea fruticosae* class. Three new syntaxa are described: *Myriolimo diffusum-Limonietum algarvensis*, *Triglochin maritimae-Sarcocornietum alpini* subass. *puccinellietosum maritimae* and *Limonium lanceolati-algarvensis*. The first one is a chamaephytic community existing on thermomediterranean dry salt marshes, only inundated during high tides; it occupies well-drained sands from the Algarve (Coastal Lusitanian-Andalusian Province, Mediterranean Region), which the director species are the Iberian endemisms *Myriolimon diffusum* and *Limonium algarvense*. The second one is a halophytic community formed by *Sarcocornia perennis* subsp. *alpini*, *Triglochin maritima*, *Halimione portulacoides*, *Puccinellia maritima*, and *Plantago maritima* on sites occasionally inundated by saltwater, rich in sand and silt, north of the Ria de Aveiro (Miniense District, Cantabrian-Atlantic Subprovince, Eurosiberian Region). The last one is the alliance *Limonium lanceolati-algarvensis*, formed by *Limonium sp. pl.* communities from the Coastal Lusitanian-Andalusian Province. We also extend the distribution area of *Puccinellio tenuifoliae-Limonietum plurisquamati* to the Tagus estuary. We propose the segregation between *Myriolimetum ferulacei*, from the Algarve sea cliffs, and *Inulo crithmoidis-Myriolimetum ferulacei*, from salt marshes.

Key words: salt marshes, phytosociology, biogeography, Portugal, Galicia

1 Centro de Botânica Aplicada à Agricultura (CBAA), Instituto Superior de Agronomia, University of Lisbon (ULisboa), Tapada da Ajuda, 1349-017 Lisboa, Portugal. jccosta@isa.ulisboa.pt tmh@isa.ulisboa.pt arseniop@isa.ulisboa.pt anadelaunay@isa.ulisboa.pt

2 Centro de Botânica Aplicada à Agricultura (CBAA), Institute of Geography and Spatial Planning (IGOT), University of Lisbon (ULisboa). Edifício da Faculdade de Letras. Alameda da Universidade. 1600-214 Lisboa. Portugal. cneto@campus.ul.pt estevao@campus.ul.pt

3 Department of Botany, University of Santiago de Compostela, Campus de Santiago E-15782 Santiago de Compostela, Spain. jesus.izco@usc.es

Introduction

Within the Iberian Peninsula context, the Portuguese salt marshes' vegetation is of great originality, as the boundary between the Eurosiberian and the Mediterranean Regions is found in Lusitanian territory (GÉHU & RIVAS-MARTÍNEZ 1983; COSTA *et al.* 2009). The separation may be related to the fact that salinization processes in the Mediterranean Sea shores are greatly influenced by the saline solution movements in the subsoil and by the presence of a saline phreatic sheet during summer time (CORRE, 1978), since tides are practically insignificant. On the Atlantic coast the main reason for the existence of halophytic areas is, on the contrary, soil submersion by seawater due to tides (SÁNCHEZ *et al.*, 1998). Regarding the southwestern Iberian

Peninsula, plant communities' distribution has been influenced by both the depth and salt content of the phreatic sheet and the seawater submersion period (COSTA *et al.*, 1996), which may explain the original combination of some Atlantic and Mediterranean plants and communities present on this area.

In this paper we deepen the study of recently described communities by COSTA *et al.* (2009), as well as, communities of *Limonium sp. pl.* which form a new alliance included in *Limonietalia* order. This order is characterized by littoral and inland temporary wet Mediterranean high saline *Limonium sp. pl.* and perennial grasses communities.

Material and methods

Phytosociological relevés and nomenclature were drawn up after the principles of the Zurich-Montpellier landscape and 'sigmatist' school (BRAUN-BLANQUET 1965, GÉHU & RIVAS-MARTÍNEZ 1980, WEBER *et al.* 2000 and RIVAS-MARTÍNEZ 2005). Bioclimatic and biogeographic nomenclature follows RIVAS-

MARTÍNEZ *et al.* (2002) and COSTA *et al.* (1999). The taxonomic nomenclature follows the work of CASTROVIEJO *et al.* (1986-2010), FRANCO (1971, 1984), FRANCO & ROCHA AFONSO (1994, 1998, 2003), except for *Myriolimon diffusum* and *Myriolimon ferulaceum* that follows LLEDÓ *et al.* (2005).

Results

1. *Limonio vulgaris*-*Juncetum subulati* J.C. Costa, Neto, T. Almeida & Lousã in J.C. Costa, Arsénio, Monteiro-Henriques, Neto, E. Pereira, T. Almeida & Izco 2009

[*Arthrocnemo glauci*-*Juncetum subulati* sensu RIVAS-MARTÍNEZ *et al.* (1980), COSTA *et al.* (1996) non *Arthrocnemo glauci*-*Juncetum subulati* Brullo & Furnari 1976]

Phytocoenoses dominated by *Juncus subulatus*, on depression or abandoned salt pans, flooded for a more or less long period by brackish water derived from autumn and winter rainfall, completely dried out during summer. It is found in saline-clayey soils, with a high sandy fraction, being the Iberian *Arthrocnemion macrostachyi* community that bear the longest period of flood. In its floristic characteristic composition are included: *Juncus subulatus*, *Halimione portulacoides*, *Sarcocornia fruticosa*, *Limonium vulgare*, *Aster tripolium* subsp. *pannonicus*, *Arthrocnemum macrostachyum*, *Sarcocornia perennis* subsp. *alpini*, *Polygonum equisetiforme*, *Myriolimon*

ferulaceum, *Inula crithmoides*, *Elytrigia elongata*, *Triglochin barrelieri*, etc. (Table 1). It occurs in the thermomediterranean dry bioclimate, within the Tagus and the Guadalquivir rivers, in the Coastal Lusitanian-Andalusian Province, Mediterranean Region (Fig. 1). Of difficult syntaxonomic positioning, as it contains plant species both from *Sarcocornietea fruticosae* (*H. portulacoides*, *S. fruticosa*, *A. macrostachyum*, *S. alpini*, *P. equisetiforme*, *M. ferulaceum*, *I. crithmoides*, *T. barrelieri*, *Suaeda vera*, *Cistanche phelypaea*, *Artemisia gallica*, *Limoniastrum monopetalum*, *M. diffusum*) and from *Juncetea maritimi* (*J. subulatus*, *L. vulgare*, *J. maritimus*, *A. tripolium* subsp. *pannonicus*, *E. elongata*, *F. laevis*), we decided to assign it to the former, within *Sarcocornietalia fruticosae* order, *Arthrocnemion macrostachyi* alliance, *Arthrocnemion macrostachyi* suballiance, as the characteristic species of *Sarcocornietea* are more frequent and because these communities occupy the higher parts of the salt marshes resisting to high salinity contents during summer. It corresponds to Natura 2000 natural habitat 1410.

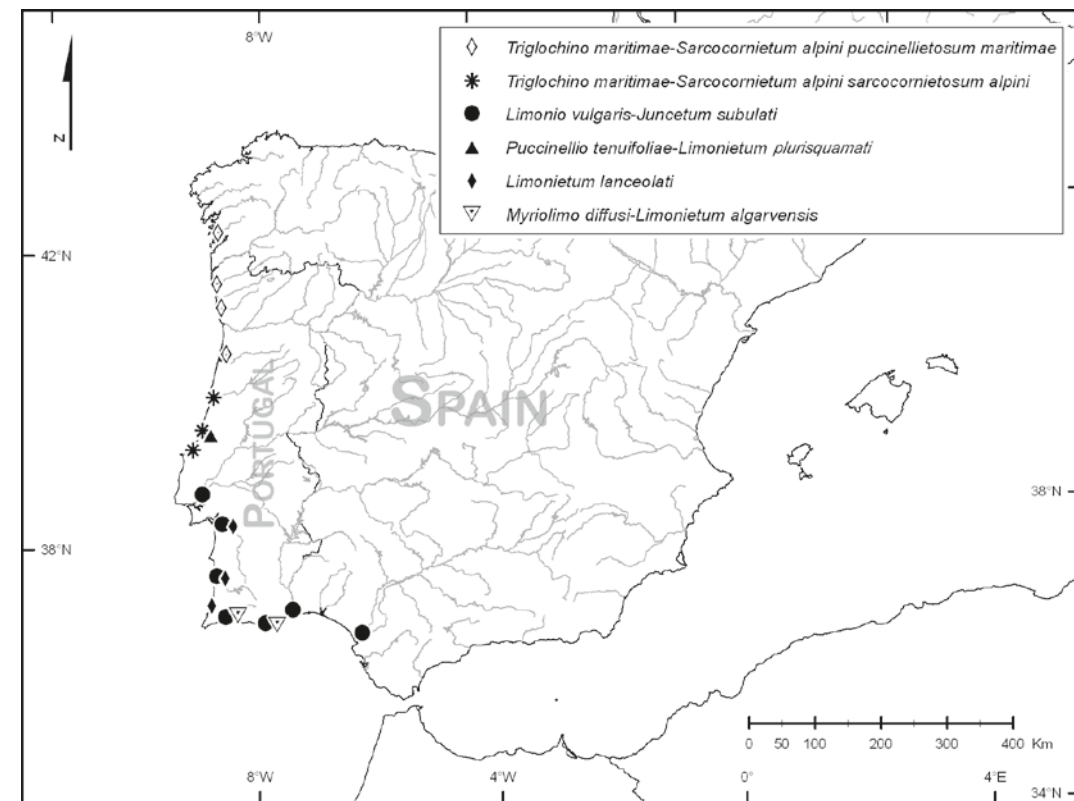


Figure 1
Distribution of *Limonio vulgaris*-*Juncetum subulati*, *Triglochino maritimae*-*Sarcocornietum alpini* *sarcocornietosum alpini*, *Triglochino maritimae*-*Sarcocornietum alpini* *sarcocornietosum alpini*, *Triglochino maritimae*-*Sarcocornietum alpini* *puccinellietosum maritimae*, *Limonietum lanceolati*, *Myriolimo diffusum*-*Limonietum algarvensis*, *Limonietum lanceolati*, *Myriolimo diffusum*-*Limonietum algarvensis*, *Puccinellio tenuifoliae*-*Limonietum plurisquamati*

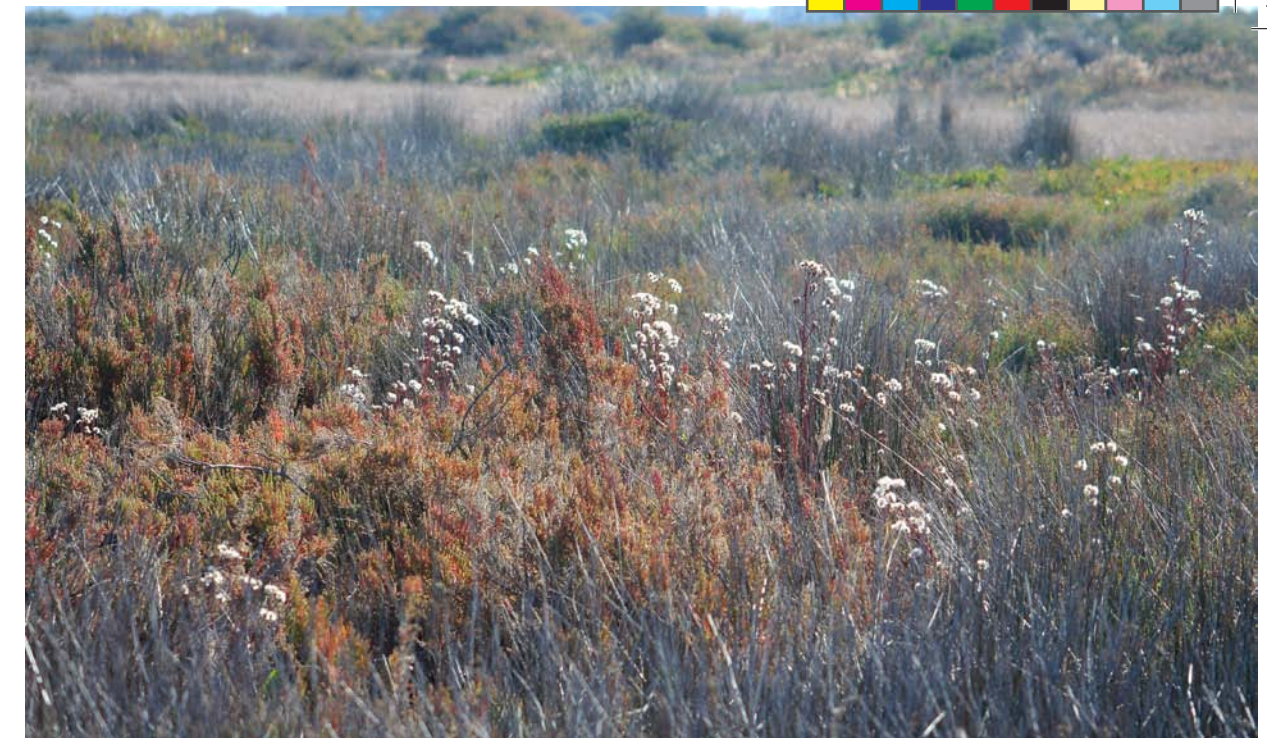


Photo 1
A depression in the Tagus Estuary with *Limonio vulgaris*-*Juncetum subulati*

Table 1
Limonio vulgaris-*Juncetum subulati*

No. of relevé	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Minimum surface (m ²)	2	2	2	2	2	2	4	4	20	4	4	2	20		
No. of species/ No. of relevés	3	5	5	6	4	6	7	11	14	8	9	7	12	9	13
Characteristics															
<i>Juncus subulatus</i>	5	4	3	4	4	5	3	4	5	4	4	3	4	V	V
<i>Halimione portulacoides</i>	.	.	.	+	+	1	2	3	1	2	2	2	+	.	II
<i>Sarcocornia fruticosa</i>	1	1	1	.	.	.	.	1	+	2	2	1	.	.	II
<i>Juncus maritimus</i>	.	.	.	.	.	1	1	+	2	+	3	+	1	.	III
<i>Limonium vulgare</i>	.	.	+	.	.	.	.	1	1	+	+	1	1	.	II
<i>Arthrocnemum macrostachyum</i>	.	+	.	1	2	.	.	+	+	.	1	.	1	V	V
<i>Aster pannonicus</i>	.	.	2	.	.	.	.	.	1	3	3	2	1	.	.
<i>Sarcocornia alpini</i>	1	.	.	2	+	.	.	.	.	.	.	.	.	.	III
<i>Polygonum equisetiforme</i>	.	.	.	.	.	.	2	1	+	.	.	.	+	.	II
<i>Inula crithmoides</i>	.	.	.	.	.	.	.	+	1	.	.	.	+	.	II
<i>Myriolimon ferulaceum</i>	.	.	.	.	.	.	.	+	2	.	.	.	.	.	II
<i>Elytrigia elongata</i>	.	+	.	.	.	.	.	.	.	+	+	.	.	.	.
<i>Triglochin barrelieri</i>	.	.	.	.	.	.	.	.	+	.	.	.	+	.	II
<i>Suaeda vera</i>	.	.	.	.	.	+	.	.	.	.	.	.	.	.	III
Companions															
<i>Atriplex hastata</i>	.	.	.	.	.	.	.	.	+	1	1	.	+	.	II
<i>Parapholis filiformis</i>	.	.	.	+	.	.	2	1	.	.	.	.	.	.	II
<i>Polypogon maritimus</i>	.	.	.	+	.	.	.	.	+	.	.	.	+	.	II
<i>Bolboschoenus compactus</i>	.	+	.	.	.	.	.	.	.	.	.	.	.	II	II
<i>Salicornia patula</i>	.	.	2	.	.	.	.	.	.	.	.	3	.	.	.
<i>Hordeum marinum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	II	+
<i>Phragmites australis</i>	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.
<i>Plantago coronopus</i>	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.

More: 2 *Spartina patens*, + *Artemisia gallica* in 13; *Scirpus littoralis* II, *Ruppia maritima* subsp. *drepanensis* I, *Cotula coronopifolia* I, *Salicornia ramosissima* I in 14; *Limoniastrum monopetalum* II, *Limonium algarvensis* II, *Juncus acutus* II, *Frankenia laevis* II, *Myriolimon diffusum* I, *Cistanche phelypaea* +, *Polypogon maritimus* III, *Salsola soda* I, *Spergularia media* I in 15

Places: 1, 4 Vau Salines, Tagus River (Alcochete); 2 S. Francisco, Tagus River (Alcochete); 3, 11 Museu do Sal, Tagus River (Alcochete); 6 Ponta da Erva, Tagus River; 6, 7, 8, 9, 13 Hortas, Tagus River (Alcochete); 10, 12 Samouco, Tagus River (Alcochete); 15 RIVAS-MARTÍNEZ *et al.* (1980) under the name *Arthrocnemo glauci*-*Juncetum subulati*; 16 COSTA *et al.* (1996) under the name *Arthrocnemo glauci*-*Juncetum subulati juncetosum subulati*

2. *Triglochino maritimae-Sarcocornietum alpini* J.C. Costa, Neto, Izco in J.C. Costa, Arsénio, Monteiro-Henriques, Neto, E. Pereira, T. Almeida & Izco 2009

Halophytic community dominated by *S. perennis* subsp. *alpini*, *Triglochin maritima* and *H. portulacoides* (Table 2) occurring in salt marshes in areas north of the Tagus River, in sandy-silty zones, occasionally flooded by brackish water, in the mesomediterranean bioclimate, also in some salt-marshes placed in general thermotemperate bioclimate, but with local mediterranean influence. It is a geovarious of *Halimione portulacoidis-Sarcocornietum alpini*, which belongs in the southwest of the Iberian Peninsula, south of the Tagus Estuary, in the thermomediterranean territories. It contacts at lower elevations with *Puccinellio maritimae-Sarcocornietum perennis* and with *Limonio-Juncetum maritimi* at higher quotas. We propose its inclusion in *Sarcocornienion alpini* suballiance because it occurs on salt marshes only exceptionally reached by tides. It corresponds to Natura 2000 natural habitat 1420.

This association has two subassociations: *sarcocornietosum alpini* (table 2, relevés 1 to 7) and *puccinellietosum maritimae* J.C. Costa, Neto & Izco subass. *nova hoc loco* (Table 2, relevés 8 to 15). The first one is typical and characteristic of the Portuguese Dividing Sector, Coastal Lusitanian-Andalusian Province, Mediterranean Region, between Óbidos Lagoon and Mondego River (Fig. 1). The second, *puccinellietosum maritimae*, occurs north of the Ria de Aveiro reaching Galicia in the Northern Galician-Portuguese Subsector, Cantabrian-Atlantic Subprovince, Atlantic European Province, Eurosiberian Region (Fig. 1), with *Puccinellia maritima* and *Plantago maritima* as differential species (Table 2). Holotypus: relevé no. 13 of table 2, held in Corrubedo (Coruña, Spain).

No. of relevé	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Minimum surface (m ²)	2	6	2	4	4	2	4	1	2	4	4	6	15	6	6
No. of species	4	6	3	7	5	4	4	10	6	7	8	8	7	7	9
Characteristics															
<i>Sarcocornia alpini</i>	2	3	3	2	3	3	3	2	4	4	2	2	5	2	2
<i>Halimione portulacoides</i>	5	3	4	4	3	3	2	2	1	2	4	+	+	.	.
<i>Triglochin maritima</i>	.	.	2	1	+	2	1	2	2	2	1	2	1	1	2
<i>Juncus maritimus</i>	2	.	.	1	.	.	.	1	2	.	2	1	+	1	+
<i>Aster pannonicus</i>	.	+	.	.	+	.	.	.	.	+	2	+	.	.	2
<i>Inula crithmoides</i>	.	+	.	+	.	1	.	1	.	.	+	.	.	.	.
<i>Limonium vulgare</i>	.	.	.	+	.	.	.	1	+	.	3	.	+	.	.
<i>Sarcocornia fruticosa</i>	.	.	.	.	.	.	.	1	.	1	.	.	.	.	.
<i>Sarcocornia perennis</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
Differential species of subassociation puccinellietosum maritimae															
<i>Puccinellia maritima</i>	.	.	.	.	.	.	.	3	1	+	2	2	+	1	2
<i>Plantago maritima</i>	.	.	.	.	.	.	.	.	.	.	.	2	1	1	+
Companions															
<i>Spergularia media</i>	.	+	.	+	.	.	+	+	.	.	.	1	.	1	2
<i>Spartina maritima</i>	1	.	.	.	.	.	.	.	.	+	.	.	.	.	.
<i>Salicornia ramosissima</i>	.	+	.	.	.	.	.	1	.	.	.	.	.	.	.
More: + <i>Puccinellia tenuifolia</i> in 4; 1 <i>Cotula coronopifolia</i> , + <i>Bolboschoenus compactus</i> in 15															
Places: 1, 3, 4, 5 Barrosa do Cal River, Óbidos Lagoon (Caldas da Rainha); 2 Mondego River (Figueira da Foz); 6, 7 Salir do Porto, Tornada River (Caldas da Rainha); 8 Vagueira, Ria de Aveiro (Vagos); 9 Torreira Ria de Aveiro (Murtosa); 10 Murtosa, Ria de Aveiro, 11 Costa Nova, Ria de Aveiro (Aveiro); 12 Ofir Cávado River (Esposende), 13 Corrubedo (Coruña, Spain); 14, 15 Viana do Castelo, Lima River															

Table 2
Triglochino maritimae-Sarcocornietum alpini

Table 3
Puccinellio tenuifoliae-Limonietum plurisquamati



Photo 2
Triglochino maritimae-Sarcocornietum alpini on Lagoa de Óbidos

3. *Puccinellio tenuifoliae-Limonietum plurisquamati* J.C. Costa, Neto & Portela-Pereira in J.C. Costa, Arsénio, Monteiro-Henriques, Neto, Portela-Pereira, T. Almeida & Izco 2009 corr. hoc loco

Chamaephytic association on sandy-brackish soils, only occasionally touched by brackish water during equinoctial tides, although occasionally flooded by fresh water during winter or springtime. *Limonium plurisquamatum*, *Puccinellia tenuifolia*, *H. portulacoides*, *F. laevis*, *J. maritimus*, *M. ferulaceum* are the most reliable species (Table 3). It occurs in the

Portuguese Dividing Sector, Dividing Portuguese-Sadensean Subprovince, Coastal Lusitanian-Andalusian Province, Mediterranean Region, between the Tagus River and S. Martinho do Porto (Tornada River) (Fig. 1), in the thermomediterranean subhumid to dry bioclimate.

No. of relevé	1	2	3	4	5	6	7	8	9	10	11	12	13
Minimum surface (m ²)	1	2	3	4	4	2	4	2	2	2	4	1	1
No. of species	6	5	5	8	9	11	10	7	10	6	9	4	5
Characteristics													
<i>Limonium plurisquamatum</i>	3	4	2	3	3	3	3	3	4	4	3	3	3
<i>Puccinellia tenuifolia</i>	1	3	2	1	1	+	1	+	+	+	.	.	.
<i>Halimione portulacoides</i>	.	3	2	1	+	2	1	3	.	.	+	1	1
<i>Frankenia laevis</i>	2	1	.	2	1	2	3	.	.	2	1	3	2
<i>Myriolimon ferulaceum</i>	2	2	4	1	3	+	.	.	.	1	.	.	.
<i>Juncus maritimus</i>	.	.	.	.	+	.	2	2	2	.	3	2	2
<i>Artemisia gallica</i>	.	.	.	.	.	+	1	+	1	1	1	.	.
<i>Juncus acutus</i>	.	.	.	.	1	.	1	1	+	.	2	.	.
<i>Inula crithmoides</i>	1	.	.	3	1	+	.	.	.	.	.	.	.
<i>Aster pannonicus</i>	.	.	.	.	.	+	.	.	+	.	.	.	.
Companions													
<i>Plantago coronopus</i>	.	.	+	+	.	+	+	.	.	+	.	.	+
<i>Carpobrotus edulis</i>	.	.	.	.	.	.	1	1	.	.	1	.	.
<i>Polypogon maritimus</i>	.	.	.	.	.	+	.	1	2	.	.	.	.
<i>Hordeum marinum</i>	.	.	.	.	.	+	.	+	1	.	.	.	.
<i>Gaudinia fragilis</i>	.	.	.	.	.	.	+	.	2	.	.	.	.
<i>Dittrichia viscosa</i>	.	.	.	.	.	.	+	.	.	.	1	.	.
More: 2 <i>Elytrigia juncea</i> subsp. <i>borealis-atlantica</i> in 1; 1 <i>Spergularia salina</i> , 1 <i>Paspalum distichum</i> in 4; 1 <i>Torilis arvensis</i> in 9; + <i>Aetheorhiza bulbosa</i> in 11													
Places: 1-5 Salir do Porto, Tornada River (Caldas da Rainha), 6 Hortas, Tagus River (Alcochete) 7-13 Coia, Tagus River (Seixal)													

4. *Myriolimetum ferulacei* Rothmaler 1943 nom. mut. prop.

[bas. *Limonietum ferulacei* Rothmaler 1943]

[sin. *Crithmo-Limonietum lanceolati* Rivas-Martínez, Lousã, T.E. Díaz, Fernández-González & J.C. Costa 1990); *Crithmo maritimae-Limonietum ovalifolii* Rivas-Martínez, Lousã, T.E. Díaz, Fernández-González & J.C. Costa 1990 nom. inval. (art. 30)]

Chamaephyte association on sea cliffs heavily sprinkled by the Atlantic Ocean waters during winter storms. *Myriolimon ferulaceum* (L.) Lledó, Erben & M. Crespo (= *Limonium ferulaceum* (L.) O. Kuntze),

Limonium ovalifolium, *Crithmum maritimum*, *F. laevis*, *Plantago coronopus* subsp. *occidentalis*, *Dactylis marina*, *Asteriscus maritimus*, *Daucus halophilus*, *Limonium virgatum*, *Spergularia australis*, *Calendula incana*, *Silene rothmaleri*, are the most reliable species (Table 4, relevés 1-3). It can be found in limestone cliffs between the Cape S. Vincent and Praia da Rocha in the Algarve (Fig. 2), in the thermomediterranean dry bioclimate. It is included in the *Crithmo-Daucion halophili* alliance, *Crithmo-Staticetalia* order and *Crithmo-Staticetea* class due to its ecology and floristic composition.

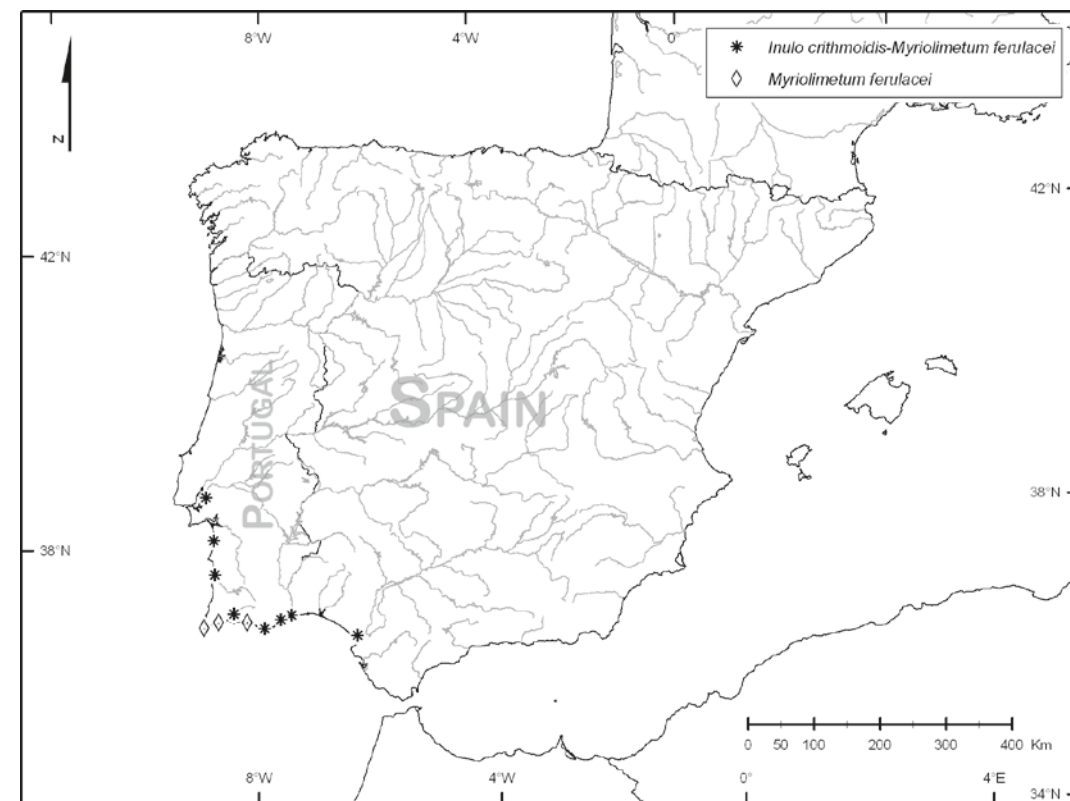


Figure 2
Distribution of *Inulo crithmoidis-Myriolimetum ferulacei* and *Myriolimetum ferulacei*

5. *Inulo crithmoidis-Myriolimetum ferulacei* Rivas-Martínez, Costa, Castroviejo & E. Valdés 1980 num. mut. prop.

[bas. *Inulo crithmoidis-Limonietum ferulacei* Rivas-Martínez, Costa, Castroviejo & E. Valdés 1980]

Chamaephytic association dominated by *M. ferulaceum* accompanied by *I. crithmoides*, *H. portulacoides*, *F. laevis*, *P. iberica*, *A. gallica*, *P. equisetiforme*, *L.*

monopetalum, etc. (table 4, relevés 4-12). It can be observed in clayey or silty soils from salt marshes only inundated by the equinoctial tides. It occurs in the thermomediterranean dry bioclimate, in the Coastal Lusitanian-Andalusian Province, between the Tagus and Guadalquivir rivers (Fig. 2).

Table 4
Myriolimetum ferulacei
Inulo crithmoidis-Myriolimetum ferulacei

Nº of relevé	1	2	3	4	5	6	7	8	9	10	11	12
Minimum surface (m ²)				4	2	8	1	2	4	6		
Nº of species / nº of relevés	13	10	8	6	4	11	5	6	8	10	9	12
Characteristics												
<i>Limonium ovalifolium</i>	V	V	V	.	.	.	.	.	.	.	.	.
<i>Crithmum maritimum</i>	I	V	V	.	.	.	.	.	.	.	.	.
<i>Plantago occidentalis</i>	IV	III	III	.	.	.	.	.	.	.	.	.
<i>Dactylis marina</i>	II	I	IV	.	.	.	.	.	.	.	.	.
<i>Asteriscus maritimus</i>	II	III	IV	.	.	.	.	.	.	.	.	.
<i>Daucus halophilus</i>	I	III	IV	.	.	.	.	.	.	.	.	.
<i>Limonium virgatum</i>	I	III	IV	.	.	.	.	.	.	.	.	.
<i>Spergularia australis</i>	+	II	II	.	.	.	.	.	.	.	.	.
<i>Calendula incana</i>	I	I	II	.	.	.	.	.	.	.	.	.
<i>Silene rothmaleri</i>	I	.	I	.	.	.	.	.	.	.	.	.
<i>Helichrysum decumbens</i>	+	.	II	.	.	.	.	.	.	.	.	.
<i>Frankenia laevis</i>	V	IV	III	.	.	.	1	.	+	.	.	IV
<i>Suaeda vera</i>	I	.	II	.	.	.	.	.	+	+	.	+
<i>Inula crithmoides</i>	I	.	.	.	.	.	.	1	2	1	V	III
<i>Myriolimon ferulaceum</i>	IV	II	IV	3	4	3	3	3	3	3	V	V
<i>Halimione portulacoides</i>	.	.	.	3	2	1	4	4	1	2	V	IV
<i>Puccinellia iberica</i>	.	.	.	.	1	.	2	+	.	.	.	I
<i>Artemisia gallica</i>	.	.	.	3	+	.	.	.	+	.	I	.
<i>Limoniastrum monopetalum</i>	.	.	.	.	.	.	.	.	.	1	III	III
<i>Triglochin barrelieri</i>	.	.	.	.	.	.	.	.	+	.	III	+
<i>Juncus subulatus</i>	.	.	.	.	.	.	.	.	.	.	II	.
<i>Limonium algarvense</i>	.	.	.	.	.	.	.	.	.	1	.	III
Companions												
<i>Armeria pungens</i>	III	I	I	.	.	.	.	.	.	.	.	.
<i>Salsola vermiculata</i>	II	II	II	.	.	.	.	.	.	.	.	.
<i>Lotus creticus</i>	I	IV	III	.	.	.	.	.	.	.	.	.
<i>Lobularia maritima</i>	I	.	II	.	.	.	.	.	.	.	.	.
<i>Beta maritima</i>	I	I	III	.	.	.	.	.	.	.	.	I
<i>Parapholis incurva</i>	II	I	II	.	.	.	.	.	.	.	.	II
<i>Polygonum equisetiforme</i>	I	.	.	.	.	3	.	.	+	+	I	+
<i>Parapholis filiformis</i>	II	.	I	.	.	.	1	.	.	+	.	IV
<i>Hordeum marinum</i>	I	.	.	.	.	.	+	.	.	+	.	II
<i>Juncus maritimus</i>	+	.	.	.	.	.	.	.	.	.	I	I
<i>Cynodon dactylon</i>	II	.	.	.	.	.	1	.	.	.	.	.
<i>Plantago coronopus</i>	.	.	.	.	.	.	1	.	.	1	.	.
<i>Aster pannonicus</i>	.	.	.	.	.	.	+	.	1	.	.	.
<i>Polypogon maritimus</i>	.	.	.	.	.	.	+	.	.	.	.	III
More: <i>Limonium echioides</i> III, <i>Mesembryanthemum nodiflorum</i> II, <i>Astragalus vicentinus</i> + in 1; <i>Bellis annua</i> , + <i>Senecio vulgaris</i> in 4; <i>Gaudinia fragilis</i> , + <i>Anacyclus radiatus</i> , + <i>Aster squamatus</i> in 6; + <i>Limonium lanceolatum</i> in 9; <i>Spartina densiflora</i> II, <i>Agrostis stolonifera</i> II in 11; <i>Spergularia media</i> III, <i>Spergularia bocconeii</i> II, <i>Beta macrocarpa</i> I, <i>Juncus acutus</i> I, <i>Salsola soda</i> + in 12												
Places: 1 ROTHMALER (1943); 2 RIVAS-MARTÍNEZ <i>et al.</i> (1990) under the name <i>Crithmo maritimi-Limonietum lanceolati</i> ; 3 COSTA <i>et al.</i> (1997); 4, 5, 7 Coia, Tagus River (Seixal); 6 Hortas, Tagus River (Alcochete), 8 Samouco, Tagus River (Seixal); 9 Praias do Sado, Sado River (Setúbal); 10 Ria de Alvor (Portimão); 11 RIVAS-MARTÍNEZ <i>et al.</i> (1980); 12 COSTA (1991)												



Photo 3
Limonietum lanceolati in Mira Estuary

7. *Myriolimo diffusum-Limonietum algarvensis* J.C. Costa, Lousã, Caperta & Neto *ass. nova hoc loco*

[holotypus relevé n° 3, Table 6]

The communities dominated by the chamaephytes *Myriolimon diffusum* (Pourr.) Lledó, Erben & Crespo (= *Limonium diffusum* (Pourr.) O. Kunze) and *Limonium algarvense* found in the Algarve are here designated as *Myriolimo diffusum-Limonietum algarvensis* (Table 6). This phytocoenosis occurs in sandy well-drained soils, inundated only during the highest tides, under the thermomediterranean dry bioclimate. It occupies places relatively lower than the occupied by the *Polygonum equisetiformis-Limonietum monopetalum* association, usually between this and *Cistancho phelypaeae-Suaedetum verae*. Therefore, the presence of *L. monopetalum* and *S. vera* is understandable. Its area of distribution, so far, is restricted to the salt marshes of the Algarve, in the Algarvian District, Coastal Lusitanian-Andalusian Province (Fig. 1).

To join these associations of *Limonium sp. pl.* from the west and southwest of the Iberian Peninsula, the alliance *Limonion lanceolati-algarvensis All. nova* [Holotypus: *Limonietum lanceolati* Arsénio, J.C. Costa, Neto & Monteiro-Henriques in Neto, Arsénio & J.C. Costa 2009 in Quercetea 9: 96-97 tb. XXII, 2009] is proposed, based on ecological and floristical criteria included in *Limonietalia* order. This alliance is formed by halophilous thermomediterranean Coastal Lusitan-Andalusian communities, with rosette and prostrate chamaephytes that colonize the upper tideland of salt marshes reached by the sea water only during the highest tides. *L. algarvense*, *L. daveaui*, *L. lanceolati* and *M. diffusum* are their characteristics species. *Inula crithmoides-Myriolimon ferulaceum*, *Puccinellia tenuifoliae-Limonietum plurisquamati*, *Limonietum lanceolati* and *Myriolimo diffusum-Limonietum algarvensis* are the associations that form this new alliance (corresponding to Natura 2000 natural habitat 1510*).

The proposed *nom. mut.* in this work will be sent to the commission of the international code of phytosociological nomenclature in accordance with article 45.

6. *Limonietum lanceolati* Arsénio, J.C. Costa, Neto & Monteiro-Henriques in Neto, Arsénio & J.C. Costa 2009

Hemicryptophytic association, dominated by *Limonium lanceolatum* and *M. ferulaceum* accompanied by several plants of *Sarcocornietea fruticosae* (Table 5). It occurs in clayey or silty soils rich in schistose debris, only inundated during the highest tides. It occupies places relatively higher than the *Inula crithmoides-Arthrocnemum glauci* and lower than the *Cistancho phelypaeae-Suaedetum verae*, in salt marshes from the Mira (Odemira) and Cerca rivers (Aljezur) (Fig. 1), which belong in the Coastal Vincentine District in the Coastal Lusitanian-Andalusian Province. Also noted in the Sado estuary (relevés 7 and 8, Table 5), in sandy areas in clearings of *Cistancho phelypaeae-Suaedetum verae*; this territory is included in the Sadensean District of the same Province. It is in the thermomediterranean dry belt.

N° of relevé	1	2	3	4	5	6	7	8	9
Minimum surface (m ²)	4	6	2	6	4	4	2	2	
N° of species / n° of relevés	8	10	7	10	7	4	5	5	6
Characteristics									
<i>Limonium lanceolatum</i>	3	2	4	2	3	3	3	4	V
<i>Halimione portulacoides</i>	1	1	+	1	2	2	+		V
<i>Myriolimon ferulaceum</i>	1	2	1	2	+				V
<i>Suaeda vera</i>		+	+	+			1	+	I
<i>Arthrocnemum macrostachyum</i>			+	1	1	1			V
<i>Artemisia gallica</i>		1	+	1	+				III
<i>Inula crithmoides</i>	+	+		+	1				II
<i>Frankenia laevis</i>	+	+					2	1	I
<i>Puccinellia iberica</i>	1			+					III
Companions									
<i>Suaeda albescens</i>	+	+				1	3	+	II
<i>Spergularia media</i>		+		+					II
<i>Plantago coronopus</i>	+		+						I
<i>Juncus maritimus</i>				1	1				I
<i>Salsola vermiculata</i>		+						1	I

More characteristics: *Limonium vulgare* II, *Cistanche phelypaea* II in 9
Places: 1, 2 Vale D. Sancho, Cerca River (Aljezur); 3 Vila Nova de Milfontes near the bridge (Odemira); 4, 5 South of Monte do Zambujeiro, left bank Mira River (Odemira); 6 Monte do Carrical, right bank Mira River (Odemira); 7, 8 Tróia, Sado Estuary (Alcácer do Sal); 9 NETO *et al.* (2009)

Table 5
Limonietum lanceolati

N° relevé	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Minimum surface (m ²)	4	2	4	2	4	4	6	2	2	4	4	8	4	4	6	6	8	2	6	6
N° of species	6	5	4	4	5	4	5	6	7	6	8	8	6	5	6	5	6	7	4	7
Characteristics																				
<i>Myriolimon diffusum</i>	3	1	2	1	2	2	2	3	3	1	1	2	3	3	3	1	1	+	+	
<i>Limonium algarvense</i>		2	2	2	3	3	1	3	1	1	2	2	2	3	+	2	3	2	2	2
<i>Limonietum monopetalum</i>									+	+	+	+	1	+	+	+	+			
<i>Suaeda vera</i>				+	+	+	+	+	+	+	+							+		
<i>Frankenia laevis</i>	+				1		+	+		+						+		+		+
<i>Puccinellia iberica</i>		+									+	1	+	+						
<i>Arthrocnemum macrostachyum</i>		+									+		+			+				
<i>Limonium ovalifolium</i>						+			+											+
<i>Myriolimon ferulaceum</i>									+			+								
<i>Polygonum equisetiforme</i>																				+
<i>Inula crithmoides</i>											+									
Companions																				
<i>Salsola vermiculata</i>	+		+		+		+		+	+								+	+	
<i>Suaeda albescens</i>	+	1	+						1			1							1	
<i>Sporobolus pungens</i>	1							1			1		+			2		2		
<i>Parapholis filiformis</i>														+	+					

More: +*Spergularia salina* in 12, +*Elymus elongatus* in 15, +*Polygonum maritimum* in 20
Places: 1, 3, 5, 6, 9, 17, 19 Forte do Rato (Tavira); 2, 4, 11, 13, 16 Torre de Bias (Olhão); 7 Cocos Islet (Olhão); 8 Torre de Aires (Tavira); 10, 18, 20 between Manta Rota and Cacula (Vila Real de Stº António); 12 near Faro bridge; 14 Tavira Island; 15 Armona Island (Olhão).

Table 6
Myriolimo diffusum-Limonietum algarvensis

Association	Characteristic / Differential species	Distribution
<i>Limonio vulgaris-Juncetum subulati</i>	<i>Juncus subulatus</i> <i>Limonium vulgare</i> <i>Arthrocnemum macrostachyum</i> <i>Sarcocornia fruticosa</i> <i>Juncus maritimus</i> <i>Halimione portulacoides</i>	Coastal Lusitanian-Andalusian Province between Tagus and Guadalquivir rivers
<i>Triglochino maritimae-Sarcocornietum alpini sarcocornietosum alpini</i>	<i>Sarcocornia alpini</i> <i>Triglochin maritima</i> <i>Halimione portulacoides</i> <i>Juncus maritimus</i> <i>Limonium vulgare</i>	Portuguese Dividing Sector Coastal Lusitanian-Andalusian Province
<i>Triglochino maritimae-Sarcocornietum alpini puccinellietosum maritimae</i>	<i>Sarcocornia alpini</i> <i>Triglochin maritima</i> <i>Halimione portulacoides</i> <i>Juncus maritimus</i> <i>Limonium vulgare</i> <i>Puccinellia maritima</i> <i>Plantago maritima</i>	Galician-Portuguese Subsector Cantabrian-Atlantic Subprovince Atlantic European Province
<i>Puccinellio tenuifoliae-Limonietum plurisquamati</i>	<i>Limonium plurisquamatum</i> <i>Puccinellia tenuifolia</i> <i>Myriolimon ferulaceum</i> <i>Halimione portulacoides</i>	Portuguese Dividing Sector Coastal Lusitanian-Andalusian Province
<i>Limonietum lanceolati</i>	<i>Limonium lanceolatum</i> <i>Myriolimon ferulaceum</i> <i>Halimione portulacoides</i> <i>Suaeda vera</i> <i>Artemisia gallica</i>	Coastal Vincentine and Sadensean Districts Coastal Lusitanian-Andalusian Province
<i>Myriolimo diffusi-Limonietum algarvensis</i>	<i>Limonium algarvense</i> <i>Myriolimon diffusum</i> <i>Limoniasstrum monopetalum</i> <i>Suaeda vera</i>	Algarvian District Coastal Lusitanian-Andalusian Province
<i>Inulo crithmoidis-Myriolimetum ferulacei</i>	<i>Myriolimon ferulaceum</i> <i>Inula crithmoides</i> <i>Halimione portulacoides</i> <i>Limoniasstrum monopetalum</i> <i>Triglochin barrelieri</i>	Coastal Lusitanian-Andalusian Province between the Tagus and Guadalquivir rivers
<i>Myriolimetum ferulacei</i>	<i>Myriolimon ferulaceum</i> <i>Limonium ovalifolium</i> <i>Crithmum maritimum</i> <i>Dactylis marina</i> <i>Daucus halophilus</i> <i>Limonium virgatum</i> <i>Spergularia australis</i>	Vincentine Promontorium and Algarvian Districts Coastal Lusitanian-Andalusian Province

Table 7
Diagnostic species and chorology of the study associations

Discussion

In Table 7 we present the characteristic, differential species and the chorology of the associations study in this work. *Limonio vulgaris-Juncetum subulati* is distinguished from *Arthrocnemo glauci-Juncetum subulati* and *Elymo elongati-Juncetum subulati* by the differential species *L. vulgare* and *M. ferulaceum*.

Triglochino maritimae-Sarcocornietum alpini have as differential species *T. maritima* and *A. tripolium* subsp. *pannonicus*, on the other hand, the Mediterranean species *Puccinellia iberica*, *C. phelypaeae* and *A. gallica* are absent from the floristic composition, but these two are present in *Halimiono portulacoidis-Sarcocornietum alpini*.

We accepted the segregation of *Inulo crithmoidis-Myriolimetum ferulacei* from *Myriolimetum ferulacei* because the ecology of the communities is quite different (the first one occurs on salt marshes and the second on sea cliffs), as well as the floristic composition, with many differential species (*H. portulacoides*, *P. iberica*, *A. gallica*, *L. monopetalum*, *T. barrelieri*, *L. vulgare*, *L. algarvense*, *J. subulatus* in the first one and *L. ovalifolium*, *C. maritimum*, *F. laevis*, *P. coronopus* subsp. *occidentalis*, *D. marina*, *A. maritimus*, *D. halophilus*, *L. virgatum*, *S. australis*, etc. in the second).

The new alliance *Limonio lanceolati-algarvensis* corresponds to the coastal chamaephytic communities reached by the sea waters only during the highest tides. The atlantic species *F. laevis*, *L. ovalifolium* are the differential species to the other alliances of the order *Limonietalia*, on the other hand *M. ferulaceum*, *T. barrelieri*, *A. gallica*, *P. equisetiforme*, *P. iberica*, *L. monopetalum* and *S. vera* are the differential species to Cantabrian-Atlantic alliance *Limonio ovalifolii-Frankenion laevis* (*Glauco-Puccinellieta*, *Juncetea maritimae*).

Puccinellio tenuifoliae-Limonietum plurisquamati stands between *Limonio vulgaris-Juncetum subulati*, *Juncetea maritimi* and *Sarcocornietea fruticosae*; however, we propose its inclusion in the latter due to the presence of *M. ferulaceum*, *A. gallica*. Although *Myriolimo diffusi-Limonietum algarvensis* resembles the *Inulo crithmoidis-Myriolimetum ferulacei* association, its ecology is quite distinct as the latter occurs on clayey or silty soils and the first one on sandy soils. These two associations, *Inulo crithmoidis-Myriolimetum ferulacei* and *Limonietum lanceolati* are included *Limonio lanceolati-algarvensis* alliance due to their ecology, short time inundated, and floristic composition where *Sarcocornietea fruticosae* species dominate.

Syntaxonomic scheme

SARCOCORNIETEA FRUTICOSAE Br.-Bl. & Tüxen ex A. & O. Bolòs 1950 *nom. mut. prop.*

Sarcocornietalia fruticosae Br.-Bl. 1933 *nom. mut. prop.*

Arthrocnemion macrostachyi Rivas-Martínez & Costa 1984 *nom. mut. prop.*

Arthrocnemion macrostachyi

Limonio vulgaris-Juncetum subulati J.C. Costa, Neto, T. Almeida & Lousã in J.C.

Costa, Arsénio, Monteiro-Henriques, Neto, E. Pereira, T. Almeida & Izco 2009

Sarcocornienion alpini Rivas-Martínez, Lousã, T.E. Díaz, Fernández-González & J.C.

Costa 1990

Triglochino maritimae-Sarcocornietum alpini J.C. Costa, Neto, Izco in J.C. Costa,

Arsénio, Monteiro-Henriques, Neto, E. Pereira, T. Almeida & Izco 2009

sarcocornietosum alpini

puccinellietosum maritimae J.C. Costa, Neto, Izco *subass. nova hoc loco*

Limonietalia Br.-Bl. & O. Bolòs 1958

Limonion lanceolati-algarvensis J.C. Costa, Neto, Monteiro-Henriques, Arsénio, Portela-Pe-

reira, Caperta & Izco *All. nova hoc loco*

[*Holotypus alliancia: Limonietum lanceolati* Arsénio, J.C. Costa, Neto & Monteiro Henriques in Neto,

Arsénio & J.C. Costa 2009 in *Quercetea* 9: 96-97 tb. XXII, 2009]

Inulo crithmoidis-Myriolimetum ferulacei Rivas-Martínez, Costa, Castroviejo & E. Valdés 1980

num. mut. prop.

Puccinellio tenuifoliae-Limonietum plurisquamati J.C. Costa, Neto & E. Pereira in J.C. Costa, Ar-

sénio, Monteiro-Henriques, Neto, E. Pereira, T. Almeida & Izco 2009 *corr. hoc loco*

Limonietum lanceolati Arsénio, J.C. Costa, Neto & Monteiro-Henriques in Neto, Arsénio & J.C.

Costa 2009

Myriolimo diffusi-Limonietum algarvensis J.C. Costa, Neto & Caperta *ass. nova hoc loco*

CRITHMO-STATICETEA Br.-Bl. in Br.-Bl., Roussine & Négre 1952

Crithmo-Staticetalia Molinier 1934

Crithmo-Daucion halophili Rivas-Martínez, Lousã, T.E. Díaz, Fernández-González & J.C. Costa

1990

Myriolimetum ferulacei Rothmaler 1943 *nom. mut. prop.*

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