

RELATIONSHIPS BETWEEN SYNTAXONOMY OF *THERO-SALICORNIETEA* AND TAXONOMY OF THE GENERA *SALICORNIA* AND *SUAEDA* IN THE IBERIAN PENINSULA

Javier Loidi, Mercedes Herrera, Idoia Biurrun & Itziar García-Mijangos

Department of Plant Biology and Ecology (Botany), Faculty of Sciences, University of the Basque Country, Ap. 644, E-48080 Bilbao, Spain; tel. +34 4 4858 137, fax +34 4 4648 500, E-mail gvploarj@lg.ehu.es

Keywords: Phytosociology, Portugal, Salt marsh, Spain

Abstract: This paper deals with the syntaxonomy of the class *Thero-Salicornietea* in the Iberian Peninsula, falling particularly upon the significance that taxonomy of the genera *Salicornia* and *Suaeda* has on it. Three alliances were differentiated, two Atlantic and one Mediterranean. The Atlantic ones were *Salicornion dolichostachyo-fragilis*, with four associations grouping slikke communities with tetraploid glasswort (*Salicornia*) species, and *Salicornion europaeo-ramosissimae*, with three associations of schorre with generally diploid glasswort species. The Mediterranean alliance *Salicornion patulae* had six associations distributed both in coastal (southern and eastern coasts) and inland salt marshes. A complete syntaxonomy of the class, maps of the distribution of its associations and tables summarizing their floristic composition are also provided.

INTRODUCTION

Europe's Atlantic coasts are subject to a much more pronounced tidal regime than its Mediterranean ones. This means that the range of the Atlantic coastal salt-marshes is much larger, and that niches and biotopes are more abundant. In these salt-marshes we can basically distinguish two zones, that are usually named by most of the authors with the Flemish terms *slikke* and *schorre*. The former term indicates the area flooded daily during high tides, while *schorre* is used for the level, which is only occasionally flooded during spring tides (BUENO 1997). Of the plant communities that make up salt-marsh vegetation, this paper studies the ones included in the *Thero-Salicornietea* class, of holarctic distribution.

Thero-Salicornietea communities live in coastal marshes subject to tidal flooding as well as in inland marshes or playas, where flooding and salinity depend on the rainfall regime and on the geomorphologic and lithological conditions of the surroundings. Soils can be formed by more or less fine materials depending on sedimentation conditions, which vary from being sandy to loamy or clay. In any case, they always have a high salinity level and are essentially mineral, in spite of the fact that in some cases they may be slightly enriched with organic matter.

Such communities are clearly pioneers within the salt-marsh vegetation complex. They occupy positions in the first-line belt of the zonation determined by flooding intensity, i.e. in the nearest low tidal line, on the borders of marsh drainage system channels or in ponds left on marsh surfaces during low tide. They are also found as initial stages of the secondary succession after disturbances have led to the disappearance of other vegetation types, giving way to mosaic vegetation patterns in a blend that mixes these communities with patches of other types belonging to *Juncetea maritimi*, *Sarcocornietea fruticosae*, *Spartinetea maritimae*

or *Zosteretea*. The phenological optimum of these communities is late summer or autumn, when they flower and fruit; this occurs later in more southerly territories due to the early arrival of winter in territories further to the north.

Species richness is low, rarely reaching 6 or 7 species in one relevé; monospecificity is quite frequent. The height of the vegetation is variable, but it is generally lower than that of the surrounding perennial communities. Cover is also usually low, as is biomass, with a high proportion of the ground uncovered by vegetation. These communities are formed by therophytic succulent *Chenopodiaceae* (often with fleshy articulated stems), mostly belonging to the genera *Salicornia*, *Suaeda*, *Microcnemum*, and *Halopeplis*. The first two genera are rather complicated from the taxonomic point of view, presenting several microspecies, which are difficult to determinate, even more if we consider that only living material can be used for determination, as occurs with *Salicornia* taxa. The fact that there are two ploidy levels in the genus *Salicornia* has been abundantly documented (BALL 1964, BALL & TUTIN 1959, CASTROVIEJO & COELLO 1980, CONTANDRIOPOULOS 1968, VALDÉS & CASTROVIEJO 1990, HERRERA et al. 1989), and the morphological consequences and ecological-phytocoenotic implications of this fact have been dealt with on a number of occasions (GÉHU 1992, GÉHU et al. 1979, GÉHU & GÉHU-FRANCK 1992, LAHONDÈRE et al. 1992, RIVAS-MARTÍNEZ & HERRERA 1996). The correct determination of these species is essential for syntaxonomy of *Thero-Salicornietea* communities, and vice versa, phytosociology and distribution of communities give us information about their taxonomic relevance. VALDÉS & CASTROVIEJO (1990) accept only two tetraploid taxa (*Salicornia emerici*, *S. dolichostachya*) and one diploid taxon (*Salicornia ramosissima*) within the genus in the Iberian Peninsula. Therefore, we have followed the concept by RIVAS-MARTÍNEZ & HERRERA (1996), since in this work all the species, which, in our opinion, are present in the studied area, are recognized.

The present study provides a complete review of this vegetation type in the Iberian Peninsula, taking special care of taxonomy of *Salicornia* and *Suaeda* species. All the available data in the literature has been collected and used in the synthesis, except for those whose *Salicornia* taxa determination is not very reliable. A total of 330 relevés are represented in Tabs. 4, 5 and 6. Accepted typology is presented in the syntaxonomical scheme, which also gives nomenclatural types, synonyms, character species and short descriptions of associations and subassociations.

The nomenclature of plants follows CASTROVIEJO et al. (1986–1997) and TUTIN et al. (1964–1980, 1993). The only taxon for which we have not followed these floras is *Scirpus maritimus* var. *compactus* (HOFFM.) G. MEY., in addition to *Suaeda* and *Salicornia* taxa, whose nomenclature is explained in Tab. 2.

Trinomial names of subspecies have been abbreviated into binomial ones in tables. We list them here: *Armeria pubigera* subsp. *depilata* (BERNIS) FERN. PRIETO et LOIDI, *Puccinellia festuciformis* subsp. *tenuifolia* (BOISS. et REUT.) W.E. HUGHES, *Sarcocornia perennis* subsp. *alpini* (LAG.) CASTROV., *Suaeda vera* subsp. *braun-blanquetii* (CASTROV. et PEDROL) RIVAS MART. et al.

MORPHOLOGY, ECOLOGY AND DISTRIBUTION OF *SALICORNIA* AND *SUAEDA* TAXA

A clear tendency towards the segregation of tetraploid ($2n=36$) species from diploid ($2n=18$) ones can be observed in genus *Salicornia*. Tetraploid species possess cylindrical fertile segments in the lower part of the spikes and subequal flowers, while diploid ones develop

Table 1. Relationships between syntaxonomy of *Thero-Salicornietea* and taxonomy of *Salicornia*.

Alliances / Associations	<i>Salicornia</i> species
I. <i>Salicornion dolichostachyo-fragilis</i>	
<i>Salicornietum dolichostachyae</i>	<i>S. dolichostachya</i> , 2n=36 (<i>S. lutescens</i> , 2n=36)
<i>Salicornietum fragilis</i>	<i>S. lutescens</i> , 2n=36 (<i>S. dolichostachya</i> , 2n=36)
<i>Salicornietum obscurae</i>	<i>S. obscura</i> , 2n=18 (<i>S. lutescens</i> , 2n=36)
<i>Suaedetum maritimae</i>	<i>S. lutescens</i> , 2n=36
II. <i>Salicornion europaeo-ramosissimae</i>	
<i>Sarcocornio perennis-Salicornietum ramosissimae</i>	<i>S. ramosissima</i> , 2n=18
<i>Suaedetum vulgaris</i>	<i>S. ramosissima</i> , 2n=18
<i>Spergulario marinae-Salicornietum europaeae</i>	<i>S. europaea</i> , 2n=18
III. <i>Salicornion patulae</i>	
<i>Suaedo maritimae-Salicornietum patulae</i>	<i>S. patula</i> , 2n=18
<i>Salicornietum emerici</i>	<i>S. emerici</i> , 2n=36
<i>Suaedo braun-blanquetii-Salicornietum patulae</i>	<i>S. patula</i> , 2n=18
<i>Suaedo splendidis-Salicornietum patulae</i>	<i>S. patula</i> , 2n=18 (<i>S. ramosissima</i> , 2n=18)
<i>Microcnemetum coralloidis</i>	<i>S. patula</i> , 2n=18
<i>Haloplelidetum amplexicaulis</i>	<i>S. patula</i> , 2n=18

convex-sided fertile segments and lateral flowers usually distinctly smaller than the central ones. The group of tetraploids includes the Atlantic *Salicornia dolichostachya* and *S. lutescens*, that do not become reddish, and the Mediterranean *S. emerici* that becomes pink or red in fruit. The two Atlantic tetraploids differ from each other in the number of fertile segments in terminal spike, 10–30 for *S. dolichostachya* and 6–18 for *S. lutescens*, which becomes yellowish in fruit. The group of diploid species includes three of Atlantic distribution: *Salicornia obscura*, *S. ramosissima* and *S. europaea*, and one mostly Mediterranean, both coastal and continental, *Salicornia patula*, which also appears in the southern Atlantic coasts of Iberian Peninsula (Huelva and Algarve). *Salicornia ramosissima* and *S. patula* always become red in fruit, while *S. obscura* never does, and *S. europaea* shows a slight trend to it.

In Atlantic salt-marshes there is also an ecological segregation of these two ploidy levels. Thus, the tetraploids are more abundant in slikke and the diploids in schorre. The concentration of the tetraploid species in the most highly stressed (flooded) habitats of the Atlantic salt-marshes suggests that the new taxa, originated by polyploidization, have colonized the new areas of the slikke from the schorre reservoirs where diploids live. Flooding conditions in the Mediterranean salt-marshes are similar to those of schorre and thus both bear mostly diploid *Salicornia* species.

The most abundant *Salicornia* species present in each of the associations of *Thero-Salicornietea* are shown in Tab. 1. Other less abundant or less frequent species are shown in brackets. The ploidy level is significantly correlated with alliances: alliance I. mainly groups tetraploid species, while diploid species mostly occur in II. and III. The chromosome number data were taken from TUTIN et al. (1993).

The annual species of *Suaeda* that take part in *Thero-Salicornietea* communities belong to the *Suaeda maritima* group, which differs from the nitrophilous *Suaeda splendens* in its leaves, that show neither a hyaline border nor a caducous apex. Three species can be distinguished within this group. *Suaeda maritima* appears only in the Atlantic coasts of northern Spain; *Suaeda spicata* has a Mediterranean coastal and continental distribution, and *S. albescens* appears in the Atlantic coasts of the Iberian Peninsula. *Suaeda maritima* and

Table 2. Nomenclatural synopsis for the *Suaeda* and *Salicornia* species cited in the text.

Correct name	Synonym
<i>Suaeda vera</i> subsp. <i>braun-blanquetii</i> (CASTROV. et PEDROL) RIVAS MART. et al., Itinera Geobot. 5: 407, 1991	<i>Suaeda fruticosa</i> subsp. <i>brevifolia</i> auct. non MOQ.; BRAUN-BLANQ. et O. BOLÒS 1958
<i>Suaeda splendens</i> (POURR.) GREN. et GODR., Fl. France 3: 30, 1855	
<i>Suaeda maritima</i> group	
<i>Suaeda maritima</i> (L.) DUMORT., Fl. Belg.: 22, 1840	<i>Suaeda prostrata</i> PALL., <i>Suaeda maritima</i> var. <i>macrocarpa</i> MOQ.
<i>Suaeda albescens</i> LÁZARO IBIZA, Asoc. Esp. Progr. Ci., Congr. Sevilla, Secc. 4, 3ª Parte: 74, 1920	<i>Suaeda maritima</i> var. <i>vulgaris</i> MOQ.
<i>Suaeda spicata</i> (WILLD.) MOQ., Ann. Sci. Nat. (Paris) 23: 317, 1831	<i>Suaeda maritima</i> auct. non (L.) DUMORT.: BRAUN-BLANQ. et O. BOLÒS 1958
<i>Salicornia dolichostachya</i> MOSS, New. Phytol. 11: 409, 1912	<i>Salicornia stricta</i> auct. non DUMORT.: G. MEY. 1824, p.p.
<i>Salicornia emerici</i> DUVAL-JOUVE, Bull. Soc. Bot. France 15: 176, 1868	
<i>Salicornia europaea</i> L., Sp. Pl.: 3, 1753	
<i>Salicornia lutescens</i> P.W. BALL et TUTIN, Watsonia 4: 203, 1959	<i>Salicornia fragilis</i> P.W. BALL et TUTIN, <i>Salicornia stricta</i> auct. non DUMORT.: G. MEY. 1824, p.p.
<i>Salicornia nitens</i> P.W. BALL et TUTIN, Watsonia 4: 204, 1959	
<i>Salicornia obscura</i> P.W. BALL et TUTIN, Watsonia 4: 204, 1959	
<i>Salicornia patula</i> DUVAL-JOUVE, Bull. Soc. Bot. France 15: 175, 1868	<i>Salicornia herbacea</i> auct. non (L.) L.: BRAUN-BLANQ. et O. BOLÒS 1958
<i>Salicornia pusilla</i> WOODS, Bot. Gaz. (London) 3: 30, 1851	<i>Salicornia disarticulata</i> MOSS
<i>Salicornia ramosissima</i> WOODS, Bot. Gaz. (London) 3: 29, 1851	

S. albescens both occur in the coasts of the Cantabrian fringe, where the former occupies organic matter-enriched biotopes in upper slikke, while the latter grows in upper schorre.

Tab. 2 summarizes the complexity in these two genera of the Iberian Peninsula, showing correct names and synonyms.

ECOLOGY AND DISTRIBUTION OF THE SYNTAXA

As a consequence of the greater diversity of biotopes in Atlantic salt-marshes we can distinguish two alliances in the French-Iberian Atlantic area: *Salicornion dolichostachyo-fragilis* (slikke communities) and *Salicornion europaeo-ramosissimae* (schorre communities), as opposed to only one in the Mediterranean: *Salicornion patulae*. These three alliances, and the thirteen associations they include in the Iberian Peninsula, are represented together in Tab. 3.

Table 3. Synoptic table of the *Thero-Salicornietea* class in the Iberian Peninsula. *Salicornion europaeo-ramosissimae* 1–3; *Salicornion dolichostachyo-fragilis* 4–7; *Salicornion patulae* 8–13. 1 – *Sarcocornio perennis-Salicornietum ramosissimae*; 2 – *Spergulario marinae-Salicornietum europaeae*; 3 – *Suaedetum vulgaris*; 4 – *Salicornietum dolichostachyae*; 5 – *Salicornietum fragilis*; 6 – *Salicornietum obscurae*; 7 – *Suaedetum maritimae*; 8 – *Haloepiletum amplexicaulis*; 9 – *Microcnemetum coralloidis*; 10 – *Suaedo braun-blanquetii-Salicornietum patulae*; 11 – *Suaedo maritimae-Salicornietum patulae*; 12 – *Suaedo splendidis-Salicornietum patulae*; 13 – *Salicornietum emeric*.

No. of column	1	2	3	4	5	6	7	8	9	10	11	12	13
No. of relevés	26	36	3	13	16	7	10	7	44	78	35	41	14
Character species of the associations, alliances and class													
<i>Salicornia ramosissima</i>	V	.	1	.	.	.	.	.	.	.	.	I	.
<i>Salicornia europaea</i>	+	V	.	.	.	.	.	.	.	.	.	.	.
<i>Suaeda albescens</i>	II	.	3	.	.	.	.	.	.	.	.	III	.
<i>Salicornia dolichostachya</i>	.	.	.	V	II	.	.	.	.	.	.	.	.
<i>Salicornia lutescens</i>	.	.	.	I	V	.	I	.	.	.	.	I	.
<i>Salicornia obscura</i>	.	.	.	II	I	V	.	.	.	.	.	.	.
<i>Suaeda maritima</i>	I	.	1	II	III	V	V	.	.	.	.	.	.
<i>Haloepelis amplexicaulis</i>	.	.	.	.	.	.	.	V	+	+	.	.	.
<i>Microcnemum coralloides</i>	.	.	.	.	.	.	.	II	V	+	.	.	.
<i>Salicornia patula</i>	.	.	.	.	.	.	.	V	II	V	V	V	.
<i>Salicornia emeric</i>	.	.	.	.	.	.	.	.	.	.	.	.	V
Differential species of <i>Salicornion dolichostachyo-fragilis</i>													
<i>Spartina maritima</i>	+	.	.	II	II	.	III	.	.	.	.	+	.
Differential species of <i>Salicornion europaeo-ramosissimae</i> and <i>Salicornion dolichostachyo-fragilis</i> against <i>Salicornion patulae</i>													
<i>Puccinellia maritima</i>	III	II	2	I	II	III	.	.	.	.	.	+	.
<i>Aster tripolium</i>	I	II	.	II	III	III	V	.	.	.	.	.	.
Differential species of <i>Salicornion patulae</i>													
<i>Arthrocnemum macrostachyum</i>	I	.	.	.	.	.	.	.	+	.	II	+	.
<i>Suaeda spicata</i>	.	.	.	.	.	.	.	.	I	II	III	.	II
<i>Suaeda splendens</i>	I	.	.	.	.	.	.	.	.	II	.	II	.
<i>Suaeda braunblanquetii</i>	.	.	.	.	.	.	I	+	I	.	.	.	.
<i>Aeluropus littoralis</i>	.	.	.	.	.	.	.	II	II	+	.	.	.
<i>Frankenia pulverulenta</i>	.	.	.	.	.	.	.	I	I	I	.	.	.
Other species													
<i>Juncus maritimus</i>	+	III	.	II	+	.	.	.	.	+	I	.	II
<i>Halimione portulacoides</i>	+	.	1	.	I	.	+	.	.	.	I	I	I
<i>Spergularia media</i>	.	I	.	III	II	II	.	.	.	I	+	.	.
<i>Plantago maritima</i>	+	+	.	+	.	.	.	.	II	+	.	.	.
<i>Frankenia laevis</i>	+	II	.	.	I	.	.	.	+	.	.	+	.
<i>Sarcocornia perennis</i>	II	.	.	+	I	.	III	.	.	.	.	I	.
<i>Sarcocornia fruticosa</i>	II	.	.	.	.	.	.	.	+	.	I	+	+
<i>Triglochin maritima</i>	I	III	.	II	+	.	.	.	.	.	.	.	.
<i>Atriplex prostrata</i>	I	I	.	.	.	.	.	.	.	+	I	.	.
<i>Limonium vulgare</i>	I	.	.	.	.	I	+	.	.	.	.	+	.
<i>Polygonum maritimum</i>	II	.	.	.	.	.	.	.	+	I	.	+	.
<i>Hordeum marinum</i>	I	.	.	.	.	.	.	.	+	I	.	+	.
<i>Salsola soda</i>	I	.	.	.	.	.	.	.	.	+	+	I	.
<i>Paspalum vaginatum</i>	.	I	.	+	.	I	.	.	.	.	+	.	.
<i>Spergularia marina</i>	I	II	.	.	.	.	.	.	.	I	.	.	.

<i>Puccinellia fasciculata</i>	I	.	.	.	.	.	.	II	II	.	.	.
<i>Parapholis incurva</i>	I	.	.	.	.	.	.	I	+	.	.	.
<i>Juncus subulatus</i>	+	.	.	.	.	.	.	.	+	+	.	.
<i>Crypsis aculeata</i>	I	.	.	.	.	.	.	.	+	.	+	.
<i>Inula crithmoides</i>	.	+	.	.	I	.	.	.	.	+	.	.
<i>Scirpus compactus</i>	.	I	.	.	.	.	.	.	+	+	.	.
<i>Sphenopus divaricatus</i>	.	.	.	.	.	.	II	+	I	.	.	.
<i>Sarcocornia alpini</i>	.	.	.	.	.	.	.	.	.	+	+	II
<i>Armeria depilata</i>	I	I	.	.	.	.	.	.	.	.	.	.
<i>Cochlearia aestuaria</i>	.	+	.	+	.	.	.	.	.	.	.	.
<i>Elymus pycnanthus</i>	.	I	.	.	I	.	.	.	.	.	.	.
<i>Limonium binervosum</i>	.	I	.	.	+	.	.	.	.	.	.	.
<i>Juncus gerardi</i>	.	+	.	.	.	.	.	.	+	.	.	.
<i>Bupleurum semicompositum</i>	.	.	.	.	.	.	I	+	.	.	.	.
<i>Puccinellia tenuifolia</i>	.	.	.	.	.	.	.	+	I	.	.	.
<i>Puccinellia rupestris</i>	.	.	.	.	.	.	.	+	+	.	.	.
<i>Limonium costae</i>	.	.	.	.	.	.	.	+	+	.	.	.
<i>Centaureum spicatum</i>	.	.	.	.	.	.	.	+	.	+	.	.
<i>Phragmites australis</i>	.	.	.	.	.	.	.	.	I	+	.	.
<i>Cressa cretica</i>	.	.	.	.	.	.	.	.	+	.	+	.
<i>Plantago coronopus</i>	.	.	.	.	.	.	.	.	+	.	+	.
<i>Aster squamatus</i>	.	.	.	.	.	.	.	.	.	+	+	.

Table 4. Synoptic table of the *Salicornion dolichostachyo-fragilis* alliance. 1–2 – *Salicornietum dolichostachyae*; 3–4 – *Salicornietum fragilis*; 5 – *Salicornietum obscurae*; 6–7 – *Suaedetum maritimae*.

No. of column	1	2	3	4	5	6	7
No. of relevés	5	8	10	6	7	4	6
Character species of the associations and the alliance							
<i>Salicornia dolichostachya</i>	V	V	III	.	.	.	.
<i>Salicornia lutescens</i>	II	.	V	V	.	.	II
<i>Salicornia obscura</i>	III	.	I	.	V	.	.
<i>Suaeda maritima</i>	IV	.	II	IV	V	4	V
Character species of the class							
<i>Salicornia europaea</i>	.	II	.	.	.	.	.
Other species							
<i>Aster tripolium</i>	I	II	III	IV	III	.	V
<i>Puccinellia maritima</i>	I	I	II	.	III	.	.
<i>Spartina maritima</i>	V	.	.	IV	.	3	II
<i>Spergularia media</i>	.	IV	I	II	II	.	.
<i>Sarcocornia perennis</i>	.	I	I	I	.	.	V
<i>Triglochin maritima</i>	.	IV	.	I	.	.	.
<i>Juncus maritimus</i>	.	II	.	I	.	.	.
<i>Paspalum vaginatum</i>	.	I	.	.	I	.	.
<i>Halimione portulacoides</i>	.	.	II	.	.	.	I
<i>Limonium vulgare</i>	.	.	.	.	I	.	I

Salicornietum dolichostachyae: 1 – HERRERA (1995): tab. 29, 3 rels.; LOIDI et al. (1997): tab. 77, rels. 10–11; 2 – BUENO (1997): tab. 14, 8 rels. *Salicornietum fragilis*: 3 – HERRERA (1995): p. 223, 1 rel.; LOIDI et al. (1997): tab. 77, rels. 1–9; 4 – BUENO (1997): tab. 15, 6 rels. *Salicornietum obscurae*: 5 – HERRERA (1995): tab. 28, 7 rels. *Suaedetum maritimae*: 6 – ONAINDIA (1986): tab. 25, 4 rels.; 7 – BUENO (1997): tab. 25, 6 rels.



Fig. 1. Location of the relevés. *Salicornion dolichostachyo-fragilis*: ★ *Salicornietum dolichostachyae*; ● *Salicornietum fragilis*; ★ *Salicornietum obscurae*; ▲ *Suaedetum maritimae*.

Salicornion dolichostachyo-fragilis (Tab. 4)

This alliance groups Atlantic salt-marsh associations that live under daily flooding conditions in salt marshes, i.e. those which live in the first belt, or slikke. The slikke is flooded twice a day, even during neap tides, and soils are usually formed by fine materials, mostly loam, which accounts for their generally muddy texture. The drainage network is arborescent and in some salt-marshes the slikke covers a wide area. Four associations of this alliance can be identified in the Iberian Peninsula. *Salicornietum dolichostachyae* groups oligospecific glasswort communities in Atlantic coastal slikkes on loamy soils. *Salicornietum fragilis* is often found to be in contact with the latter but occupies areas where the soil is more compact at a slightly higher level where flooding is shallower and does not last as long. *Salicornietum obscurae* has been recorded at only one location on the eastern Cantabrian coast (HERRERA 1995), at a higher level, in the slikke-schorre contact area. The fourth association is *Suaedetum maritimae*, distributed on the Atlantic coast and of an earlier phenology than the ones previously mentioned. It occurs in the upper level of the slikke where a certain amount of organic detritus accumulates. The Iberian distribution of these associations is shown in Fig. 1.

Salicornion europaeo-ramosissimae (Tab. 5)

This alliance includes Atlantic associations that live in ponds, channels and areas cleared by man in the upper level of the salt marsh, or schorre, where flooding occurs only at spring high tides (RIVAS-MARTÍNEZ 1990, RIVAS-MARTÍNEZ & HERRERA 1996, BUENO 1997). The schorre is usually a flat surface with semiterrestrial saline soils formed by clay, loam or sand, which have reached a certain degree of maturity and are thus quite compact and covered mostly by perennial dense vegetation. Drainage is meandriform and most of the glasswort communities of this alliance occur in its channels. Inland salt-marshes of the Subatlantic area bear some *Salicornia* communities which are also included here.

There are three associations in the Iberian Peninsula; their locations are shown in Fig. 2. The most widely distributed association is *Sarcocornio perennis-Salicornietum ramosissimae*, recorded from the Cantabrian coasts to the Algarve (south Portugal), and easily distinguishable by *Salicornia ramosissima*, which turns reddish at the end of the summer when maturity is reached. It occupies clearances caused by disturbance of the perennial vegetation of the highly saline areas in the schorre, in contact with the *Sarcocornietea fruticosae* communities. Much less abundant is *Spergulario marinae-Salicornietum europaeae*, only reported in the salt-marshes of Asturias (BUENO 1997), where it occurs on loamy soils of moderate to low salinity. It is in contact with subhalophilic vegetation of *Juncetea maritimi*. The communities dominated by *Suaeda albescens* are included in *Suaedetum vulgaris*, a broad association

Table 5. Synoptic table of the *Salicornion europaeo-ramosissimae* alliance. 1–4 – *Sarcocornio perennis-Salicornietum ramosissimae* (1–3 – *salicornietosum ramosissimae*; 4 – *puccinellietosum fasciculatae*); 5 – *Spergulario marinae-Salicornietum europaeae*; 6 – *Suaedetum vulgaris*.

No. of column	1	2	3	4	5	6
No. of relevés	7	5	11	3	36	3
Character species of the associations and the alliance						
<i>Salicornia ramosissima</i>	V	V	V	3	.	1
<i>Salicornia europaea</i>	.	I	.	.	V	.
<i>Suaeda albescens</i>	.	V	II	.	.	3
Differential species of the subassociation <i>puccinellietosum</i>						
<i>Puccinellia fasciculata</i>	.	.	.	3	.	.
Other species						
<i>Puccinellia maritima</i>	V	V	+	.	II	2
<i>Sarcocornia perennis</i>	III	III	.	.	+	.
<i>Spergularia marina</i>	II	.	.	1	II	.
<i>Atriplex prostrata</i>	.	.	II	1	I	.
<i>Frankenia laevis</i>	.	.	+	1	II	.
<i>Aster tripolium</i>	IV	.	.	.	II	.
<i>Triglochin maritima</i>	III	.	.	.	III	.
<i>Armeria depilata</i>	III	.	.	.	I	.
<i>Plantago maritima</i>	II	.	.	.	+	.
<i>Suaeda maritima</i>	III	.	.	.	.	1
<i>Halimione portulacoides</i>	.	II	.	.	.	+
<i>Juncus maritimus</i>	.	.	.	1	III	.

Sarcocornio perennis-Salicornietum ramosissimae: salicornietosum ramosissimae: 1 – HERRERA (1995): tab. 27, rels. 1–7; 2 – BUENO (1997): tab. 17, 5 rels.; 3 – COSTA (1991): tab. 16, rels. 1, 3, 5–13, sub *Suaedo splendidis-Salicornietum ramosissimae, puccinellietosum fasciculatae*: 4 – HERRERA (1995): tab. 27, rels. 8–10. *Spergulario marinae-Salicornietum europaeae*: 5 – BUENO (1997): tab. 24, 36 rels. *Suaedetum vulgaris*: 6 – BUENO (1997): tab. 26, 3 rels.

occurring in schorres from the North Sea to the Cantabrian coast of the Bay of Biscay. Data are available from only one locality in Asturias (BUENO 1997), but it is in all probability quite frequent along the Atlantic Iberian coastline.

Salicornion patulae (Tab. 6)

Tidal oscillation is much less pronounced on Mediterranean coasts than it is on Atlantic coastlines, so the flooding gradient occupies a much narrower band and differentiation between slikke and schorre is irrelevant. In these circumstances, the halophilic annual communities of succulents usually occupy the first positions in zonation, in contact with the *Spartinetea* communities. The inland salt-marshes, abundant in some regions of the Iberian Peninsula where lithological, climatic and geomorphologic conditions are favourable, also bear this kind of vegetation in places where water remains longer in spring or early summer. These salty depressions are frequent in areas where rocks rich in easily soluble minerals, like gyp or marl, are dominant, as occurs in some of the largest basins of the biggest Iberian rivers, such as the Ebro, Tagus or Guadiana.

The distribution of the associations of this alliance is shown in Fig. 3. They can be separated into two groups, continental and coastal. The first group has three associations: *Suaedo braun-blanquetii-Salicornietum patulae* is the most frequent and extensive, occupying places



Fig. 2. Location of the relevés. *Salicornion europaeo-ramosissimae*: ● *Sarcocornio perennis*-*Salicornietum ramosissimae*; ▲ *Suaedetum vulgare*; * *Spergulario marinae*-*Salicornietum europaeae*. Biogeographic map of RIVAS-MARTÍNEZ et al. (1990).



Fig. 3. Location of the relevés. *Salicornion patulae*: ★ *Microcnemum coralloidis*; ✕ *Suaedo maritimae*-*Salicornietum patulae*; ▲ *Salicornietum emeric*; * *Suaedo braun-blanquetii*-*Salicornietum patulae*; ● *Suaedo splendidis*-*Salicornietum patulae*; ◆ *Halopeplidum amplexicaulis*. Biogeographic map of RIVAS-MARTÍNEZ et al. (1990).

where water remains longer than in biotopes covered by perennial vegetation; *Microcnemum coralloidis* is much less frequent (reported in the Ebro and Duero Valleys and La Mancha) and occurs in places where flooding is ephemeral; *Halopeplidum amplexicaulis*, however, occurs in locations where flooding lasts longer; relevés of this association are only recorded from the Ebro basin, although *Halopeplis amplexicaulis* is also found in coastal salt-marshes. The last two associations are defined by *Microcnemum coralloides* and *Halopeplis amplexicaulis* respectively, both absent from *Suaedo braun-blanquetii*-*Salicornietum patulae*. This group of associations is separated from the rest because they sustain some continental-optimum halophytes like *Puccinellia fasciculata* and *Suaeda vera* subsp. *braun-blanquetii*.

Table 6. Synoptic table of the *Salicornion patulae* alliance. 1 – *Halopeplidum amplexicaulis*; 2–8 – *Microcnemum coralloides*; 9–20 – *Suaeda braun-blanquetii*-*Salicornietum patulae*; 21–24 – *Suaeda maritima*-*Salicornietum patulae*; 25–30 – *Suaeda splendidis*-*Salicornietum patulae* (25–27 – *salicornietosum patulae*; 28 – *crispisetosum aculeatae*; 29 – *salicornietosum lutescentis*; 30 – *salicornietosum ramosissimae*); 31–33 – *Salicornietum emeric* (31–32 – *salicornietosum emeric*; 33 – *suaedetosum maritimae*).

No. of column	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33					
No. of relevés	7	8	3	15	6	7	3	2	6	3	5	6	7	9	6	3	18	3	2	10	20	2	9	4	7	12	2	5	9	6	4	5	5					
Character and differential species of the continental associations																																						
<i>Halopeplis amplexicaulis</i>	V	.	.	.	.	II	.	.	.	I	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Microcnemum coralloides</i>	II	V	3	V	V	V	3	2	.	I	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Suaeda braun-blanquetii</i>	I	.	.	.	I	I	.	2	IV	.	II	I	III	III	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Polygomon maritimum</i>	.	.	.	.	I	.	.	.	.	.	.	.	.	.	I	I	I	I	.	II	.	.	.	.	.	.	.	I	.	.	.	.	.	.	.
<i>Spergularia marina</i>	.	.	.	.	.	.	.	.	.	.	I	III	III	III	I	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Aeluropus litoralis</i>	.	.	1	II	II	.	2	.	I	.	II	.	I	III	III	.	II	1	1	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.
<i>Puccinellia fasciculata</i>	.	.	.	III	II	.	.	.	.	.	II	.	V	V	II	1	III	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Frankeniana pulverulenta</i>	I	I	.	.	.	III	.	.	III	1	.	.	.	.	II	.	.	.	.	.	3	1	I	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Sphenopus divaricatus</i>	II	.	.	.	.	III	.	.	I	.	.	.	I	I	.	2	+	2	.	I	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Character and differential species of the coastal associations																																						
<i>Suaeda spicata</i>	.	.	1	II	.	.	1	.	III	.	III	II	III	.	I	.	II	3	.	.	III	1	III	2	.	.	.	.	.	.	.	.	.	.	.	V
<i>Suaeda splendens</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III	3	II	.	2	II	.	.	.	.	IV	.	2	V	.	.	.	.	.	.	.	.
<i>Suaeda maritima</i> group (<i>albescens</i>)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	IV	.	.	IV	II	.	.	.	.	.	.	.
<i>Spartina maritima</i>	I	.	.	I	I	
<i>Sarcocornia perennis</i>	III	II	
<i>Cressa cretica</i>	I	.	.	II	IV	
<i>Crypsis aculeata</i>	III	
<i>Salicornia lutescens</i>	V	
<i>Salicornia ramosissima</i>	V	.	.	
<i>Salicornia emeric</i>	4	V	V	
<i>Halimione portulacoides</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II	.	I	.	.	I	.	.	II	I	.	I	.	I	.	.
Character species of the alliance																																						
<i>Salicornia patula</i>	V	II	1	1	.	IV	3	.	V	3	V	V	V	V	V	3	V	3	2	V	V	2	V	4	V	V	2	V	V	V	.	.	.	.	.	.
Other species																																						
<i>Hordeum marinum</i>	.	II	II	II	1	II	II	.	1	I	
<i>Atriplex prostrata</i>	I	.	.	.	I	.	I	I
<i>Sarcocornia fruticosa</i>	1	1	.	I	2	I	.	I	.	.	.
<i>Spergularia media</i>	I	.	II	.	III	.	.	.	I	3
<i>Plantago maritima</i>	.	.	.	II	II	.	1	1	I
<i>Arthrocnemum macrostachyum</i>	1	1	.	II	2
<i>Phragmites australis</i>	IV	1	.	.	III	I	1

No. of column	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33				
No. of relevés	7	8	3	15	6	7	3	2	6	3	5	6	7	9	6	3	18	3	2	10	20	2	9	4	7	12	2	5	9	6	4	5	5				
<i>Parapholis incurva</i>	.	.	.	+	III	II	.	.	.	.	.	.	I	.	.	.	.	.	.	.	IV	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Puccinellia tenuifolia</i>	2	.	.	.	.	II	.	.	.	.	I	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	.	.	.		
<i>Plantago coronopus</i>	III	.	I	.	.	.	.	.	.	.	.	III	.	.	.	.	I	.	I	.	.	.		
<i>Salsola soda</i>	I	.	.	.	.	.	.	.	I	.	I	.	.	.	.	.	.	.	.	.	.	III	.	
<i>Juncus maritimus</i>	I	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Sarcocornia alpini</i>	2	.	.	.	.	.	.	.	.	II	I	.	III	.	
<i>Bupleurum semicompositum</i>	I	.	.	.	II	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Limonium costae</i>	I	.	.	.	.	.	.	.	.	I	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Puccinellia rupestris</i>	I	.	.	.	.	.	.	.	.	I	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Frankenia laevis</i>	I	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	.	.	.	.	.	.	.	.
<i>Scirpus compactus</i>	I	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Spergularia nicaeensis</i>	I	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Atriplex rosea</i>	
<i>Limonium vulgare</i>	I	.	
<i>Puccinellia maritima</i>	II	I	.	.

- Haloepidetum amplexicaulis*: 1 – BLANCHÉ & MOLERO (1988): tab. 1, 6 rels., sub *Haloepidetum amplexicaulis-Salicornietosum ramosissimae*; BADIA et al. (1992): tab. 1, rel. 14
- Microcnemetum coralloidis*: 2 – RIVAS-MARTÍNEZ & COSTA (1976): tab. 6, 8 rels.; 3 – LAORGA (1986): tab. 57, 3 rels.; 4 – CIRUJANO (1981): tab. 2, 15 rels.; 5 – LADERO et al. (1984): tab. 1, 6 rels.; 6 – BLANCHÉ & MOLERO (1988): tab. 2, 6 rels.; BADIA et al. (1992): tab. 1, rel. 13; 7 – URSA (1986): tab. 15, 3 rels.; 8 – SALAZAR (1996): tab. 59, 2 rels.
- Suaedo braun-blanquetii-Salicornietum patulae*: 9 – BRAUN-BLANQUET & BOLÒS (1958): tab. 22, rels. 1–5, 8, sub *Ass. Salicornia herbacea* et *Suaeda brevifolia*; 10 – BADIA et al. (1992): tab. 1, rels. 10–12, sub *Asoc. Salicornia ramosissima*; 11 – BELMONTE & LAORGA (1987): tab. 7, 4 rels., sub *Suaedo splendidis-Salicornietum patulae*; SANTO & RODRÍGUEZ-OCHOA (1991): tab. 7, rel. 2, sub *Suaedo-Salicornietum europaeae*; 12 – URSA (1986): tab. 14, 6 rels., sub *Suaedo splendidis-Salicornietum ramosissimae*; 13 – BIURRUN (1995): tab. 52, rels. 7–13; 14 – LADERO et al. (1984): tab. 2, 9 rels., sub Comunidad de *Salicornia ramosissima*; 15 – LAORGA (1986): tab. 56, 6 rels., sub *Suaedo splendidis-Salicornietum patulae*; 16 – VELAYOS et al. (1989): tab. 14, rels. 1, 3, 4, sub *Suaedo splendidis-Salicornietum ramosissimae*; 17 – CIRUJANO (1981): tab. 1, 18 rels., sub *Suaedo splendidis-Salicornietum ramosissimae typicum* and *crispetosum aculeatae*; 18 – VALDÉS-FRANZI et al. (1993): tab. 8, 3 rels., sub *Suaedo splendidis-Salicornietum patulae*; 19 – GARCÍA FUENTES (1996): p. 153, 2 rels., sub *Suaedo splendidis-Salicornietum patulae*; 20 – MARTÍNEZ-PARRAS (1984): tab. 6, 10 rels., sub *Suaedo splendidis-Salicornietum ramosissimae typicum* and *crispetosum aculeatae*
- Suaedo maritimae-Salicornietum patulae*: 21 – CURCÓ (1996): tab. 5, rels. 1–13, 16–18, 20–23; 22 – RIGUAL (1968): tab. 1, rels. 1–2, sub *Arthrocnemo-Salicornietum europaeae*; 23 – PÉREZ (1995): tab. 135, rels. 1–9; 24 – PEINADO et al. (1985): tab. 12, rels. 1–3, 8, sub *Arthrocnemo glauci-Salicornietum ramosissimae*
- Suaedo splendidis-Salicornietum patulae salicornietosum patulae*: 25 – RIVAS-MARTÍNEZ et al. (1980): tab. 23, rels. 1–7, sub *Suaedo splendidis-Salicornietum ramosissimae typicum*; 26 – COSTA (1991): tab. 15, rels. 1–12, sub *Suaedo maritimae-Salicornietum patulae typicum*; 27 – GALÁN DE MERA et al. (1997): tab. 5, rels. 37–38
- crispetosum aculeatae*: 28 – RIVAS-MARTÍNEZ et al. (1980): tab. 23, rels. 8–9, sub *Suaedo splendidis-Salicornietum ramosissimae crispetosum aculeatae*; GALÁN DE MERA et al. (1997): tab. 5, rels. 36, 39–40, sub *Suaedo splendidis-Salicornietum patulae typicum*
- salicornietosum lutescentis*: 29 – COSTA (1991): tab. 15, rels. 13–21, sub *Suaedo maritimae-Salicornietum patulae salicornietosum lutescentis*
- salicornietosum ramosissimae*: 30 – COSTA (1991): tab. 15, rels. 22–25, sub *Suaedo maritimae-Salicornietum patulae salicornietosum ramosissimae*; tab. 16, rels. 2, 4, sub *Suaedo splendidis-Salicornietum ramosissimae typicum*
- Salicornietum emerici salicornietosum emerici*: 31 – BOLÒS (1962): tab. 57, rels. 3–4; BOLÒS (1967): p. 30, 2 rels.; 32 – CURCÓ (1996): tab. 4, 5 rels.
- suaedetosum maritimae*: 33 – BOLÒS (1962): tab. 57, rels. 1–2; BOLÒS (1967): p. 30, 3 rels.

The coastal group is also formed by three associations. *Suaeda maritima*-*Salicornietum patulae* is distributed in the western Mediterranean and is frequent on the Mediterranean coastline of the Iberian Peninsula. Some plants specific to the coastal Mediterranean salt-marshes, like *Arthrocnemum macrostachyum*, distinguish this association from the rest. *Suaeda spicata* is another species frequent in this association which also occurs in the inland group of communities. *Suaeda splendidis*-*Salicornietum patulae* is distributed in the south-western coast of the Iberian Peninsula, from Cádiz to the Algarve. The distinctive feature of this association is that it bears some species like *Suaeda albescens* (*S. maritima* group), *Sarcocornia perennis* and *Spartina maritima*, showing a clear Atlantic influence. The last association is *Salicornietum emerici*, which was described by the author to be in the area around Barcelona and is distributed in southern France and in the Tyrrhenian islands. Its indicator species is the tetraploid *Salicornia emerici* and it occurs in long-lasting water ponds.

Acknowledgements: We are grateful for support from project PI 96/52, financed by the Dirección General de Política Científica (Basque Government). The indications and suggestions of some anonymous reviewers helped us to improve this paper significantly.

REFERENCES

- BADIA D., SANZ J.A. & ALCAÑIZ J.M. (1992): Contribución al estudio de la vegetación halomorfa del Ebro medio. In: CONESA J.A. & RECASENS J. (eds.), *Actes del simposi internacional de botànica "Pius Font i Quer", Vol. II. Fanerogàmia*, Institut d'Estudis Ilerdencs, Lleida, pp. 227–232.
- BALL P.W. (1964): A taxonomic review of *Salicornia* in Europe. *Feddes Repert. Spec. Nov. Regni Veg.* 69: 1–8.
- BALL P.W. & TUTIN T.G. (1959): Notes on annual species of *Salicornia* in Britain. *Watsonia* 4: 193–205.
- BELMONTE D. & LAORGA S. (1987): Estudio de la flora y vegetación de los ecosistemas halófilos de la Rioja logroesa (Logroño, España). *Zubia* 5: 63–125.
- BIURRUN I. (1995): *Flora y vegetación acuática, higrófila y halófila de las cuencas de los ríos Arga y Bidasoa en Navarra*. PhD. Thesis, Universidad del País Vasco, Leioa.
- BLANCHÉ C. & MOLERO J. (1988): Las cubetas arréicas al sur de Bujaraloz (Valle del Ebro). Contribución a su estudio fitocenológico. *Lazaroa* 9: 277–299.
- BOLÒS O. DE (1962): *El paisaje vegetal barcelonés*. Universidad de Barcelona, Barcelona.
- BOLÒS O. DE (1967): Comunidades vegetales de las comarcas próximas al litoral situadas entre los ríos Llobregat y Segura. *Mem. Real Acad. Ci. Barcelona* 38: 3–280.
- BOLÒS O. DE (1996): La vegetació de les Illes Balears, Comunitats de plantes (Vegetation of the Balearic Islands, Plant communities). *Inst. Estudis Catalans Secc. Ci. Biol.* 114: 1–267.
- BRAUN-BLANQUET J. (1933): *Prodrome des groupements végétaux. Fasc. I (Ammophiletalia et Salicornietalia médit.)*. Montpellier.
- BRAUN-BLANQUET J. & BOLÒS O. (1958): Les groupements végétaux du bassin moyen de l'Ebre et leur dynamisme. *Anales Estac. Exp. Aula Dei* 5: 1–266.
- BRAUN-BLANQUET J. & TÜXEN R. (1943): Übersicht der höheren Vegetationseinheiten Mitteleuropas. *Commun. Stat. Int. Géobot. Médit. Montpellier* 84.
- BUENO A. (1997): *Flora y vegetación de los estuarios asturianos*. Cuad. Medio Ambiente, Naturaleza 3, Consej. Agricultura, Serv. Publ. Principado de Asturias, Oviedo.
- BUROLLET P.A. (1927): *Le Sahel de Sousse*. Tunis.
- CASTROVIEJO S. & COELLO P. (1980): Datos cariológicos y taxonómicos sobre las *Salicorniinae* A.J. SCOTT ibéricas. *Anales Jard. Bot. Madrid* 37: 41–73.
- CASTROVIEJO S., LAÍNZ M., LÓPEZ G., MONTSERRAT P., MUÑOZ GARMENDIA F., PAIVA J. & VILLAR L. (eds.) (1986–1997): *Flora iberica* 1–5, 8. Real Jardín Botánico, C.S.I.C., Madrid.
- CIRUJANO S. (1981): Las lagunas manchegas y su vegetación. II. *Anales Jard. Bot. Madrid* 38: 187–232.
- CONTANDRIOPOULOS J. (1968): À propos des nombres chromosomiques des *Salicornia* de la région méditerranéenne. *Bull. Mus. Hist. Nat. Marseille* 28: 45–52.

- COSTA J.C. (1991): *Flora e vegetação do parque natural da Ria Formosa (Flora and vegetation from Ria Formosa natural park)*. PhD. Thesis, Univ. Tecnica de Lisboa, Lisboa.
- CURCÓ A. (1996): La vegetació del delta de l'Ebre (II): les comunitats halòfiles i halo-nitròfiles (classes *Puccinellio-Salicornietea* i *Cakiletea maritima*) (Vegetation from the Ebro Delta (II): halophilic and halonitrophilous communities (*Puccinellio-Salicornietea* and *Cakiletea maritima* classes)). *Folia Bot. Misc.* 10: 113–139.
- GALÁN DE MERA A., SÁNCHEZ GARCÍA I. & VICENTE ORELLANA J.A. (1997): Coastal plant communities of the southwestern Iberian Peninsula, Spain and Portugal. *Phytocoenologia* 27: 313–352.
- GARCÍA FUENTES A. (1996): *Vegetación y flórua del alto valle del Guadalquivir: modelos de regeneración*. PhD. Thesis, Universidad de Jaén, Jaén.
- GÉHU J.M. (1992): Les salicornes annuelles d'Europe: système taxonomique et essai de clé de détermination. *Colloq. Phytosoc.* 18: 227–241.
- GÉHU J.M., CARON B. & GÉHU-FRANCK J. (1979): Essai de clé pour les Salicornes annuelles présentes sur les côtes du projet de carte floristique IFFB. *Doc. Florist.* 2: 17–24.
- GÉHU J.M. & GÉHU-FRANCK J. (1979): Les *Salicornietum emerici* et *ramosissimae* du littoral atlantique français. *Doc. Phytosoc. N.S.* 4: 349–358.
- GÉHU J.M. & GÉHU-FRANCK J. (1982): *La végétation du littoral Nord-Pas-de-Calais*. Centre Régional de Phytosociologie de Bailleul, Bailleul.
- GÉHU J.M. & GÉHU-FRANCK J. (1984): Schéma synsystématique et synchronologique des végétations phanérogamiques halophiles françaises. *Doc. Phytosoc. N.S.* 8: 51–70.
- GÉHU J.M. & GÉHU-FRANCK J. (1992): Les salicornes annuelles du Nord-Ouest de la France et leur phytoécologie. *Colloq. Phytosoc.* 18: 25–40.
- GÉHU J.M. & GÉHU-FRANCK J. & CARON B. (1978): Les *Salicornietum emerici* et *ramosissimae* du littoral méditerranéen français. *Acta Bot. Malac.* 4: 79–88.
- HERRERA M. (1995): Estudio de la vegetación y flora vascular de la cuenca del río Asón (Cantabria). *Guineana* 1: 1–429.
- HERRERA M., FERNÁNDEZ CASADO M.A. & FERNÁNDEZ PRIETO J.A. (1989): El género *Salicornia* L. en el estuario del río Asón (Cantabria). *Anales Jard. Bot. Madrid* 45: 551–552.
- LADERO M., NAVARRO F., VALLE C.J., MARCOS B., RUIZ TÉLLEZ T. & SANTOS M.T. (1984): Vegetación de los saladares castellano-leoneses. *Stud. Bot.* 3: 17–62.
- LAHONDÈRE C., BOTINEAU M. & BOUZILLE J.-B. (1992): Les salicornes annuelles du centre-ouest (Vendée, Charente-Maritime): taxonomie, morphologie, écologie, phytosociologie, phytogéographie. *Colloq. Phytosoc.* 18: 1–24.
- LAORGA S. (1986): *Estudio de la flora y vegetación de las comarcas toledanas del tramo central de la cuenca del Tajo*. PhD. Thesis, Universidad Complutense de Madrid, Madrid.
- LOIDI J. & BIURRUN I. (1998): Notas nomenclaturales sobre la vegetación del norte de la Península Ibérica, VII. *Lazaroa* 19: 161–165.
- LOIDI J., BIURRUN I. & HERRERA M. (1997): La vegetación del centro-septentrional de España. *Itinera Geobot.* 9: 161–618.
- MARTÍNEZ-PARRAS J.M. (1984): La vegetación lacustre de la depresión de Antequera (Andalucía). *Collect. Bot. (Barcelona)* 15: 289–306.
- ONAINDIA M. (1986): *Ecología vegetal de las Encartaciones y macizo del Gorbea*. Serv. Ed. Universidad del País Vasco, Leioa.
- PEINADO M., MARTÍNEZ-PARRAS J.M., ALCARAZ F., GARRE M. & DELA CRUZ M. (1985): Sobre los ecosistemas de dunas y playas murciano-almerienses: punta del Sabinar (Almería, España). *Doc. Phytosoc. N.S.* 9: 329–335.
- PÉREZ M.R. (1995): *Flora y vegetación de la comarca de La Marina Alta (Alicante)*. PhD. Thesis, Universitat de València, Valencia.
- PIGNATTI S. (1953): Introduzione allo studio fitosociologico della pianura veneta orientale con particolare riguardo alla vegetazione litoreana (continuazione) (Introduction to the phytosociological study of the eastern Veneto plane, with special remarks on coastal vegetation (continuation)). *Arch. Bot., Ser.* 3: 1–25.
- RIGUAL A. (1968): Algunas asociaciones de la clase *Salicornietea fruticosae* BR.-BL. et TX. 1943 en la provincia de Alicante. *Collect. Bot. (Barcelona)* 7: 975–995.
- RIVAS-MARTÍNEZ S. (1984): Vegetatio hispaniae. Notula IV. *Stud. Bot.* 3: 7–16.

- RIVAS-MARTÍNEZ S. (1990): Sintaxonomía de la clase *Thero-Salicornietea* en Europa occidental. *Ecol. Medit.* 16: 359–364.
- RIVAS-MARTÍNEZ S., CANTÓ P., FERNÁNDEZ-GONZÁLEZ F., NAVARRO C., PIZARRO J.M. & SÁNCHEZ-MATA D. (1990): *Biogeografía de la Península Ibérica, Islas Baleares y Canarias*. Copy distributed in X Jornadas de Fitosociología, Granada.
- RIVAS-MARTÍNEZ S. & COSTA M. (1976): Datos sobre la vegetación halófila de la Mancha (España). *Colloq. Phytosoc.* 4: 81–97.
- RIVAS-MARTÍNEZ S., COSTA M., CASTROVIEJO S. & VALDÉS E. (1980): La vegetación de Doñana. *Lazaroa* 2: 5–190.
- RIVAS-MARTÍNEZ S. & HERRERA M. (1996): Datos sobre *Salicornia* L. (*Chenopodiaceae*) en España. *Anales Jard. Bot. Madrid* 54: 149–154.
- SALAZAR C. (1996): *Estudio fitosociológico de la vegetación riparia andaluza (provincia Bética): cuenca del Guadiana Menor*. PhD. Thesis, Universidad de Jaén, Jaén.
- SANTO E. DEL & RODRÍGUEZ-OCHOA R. (1991): Suelos, vegetación y sus relaciones en zonas afectadas por salinidad en la Rioja media. *Zubia* 3: 107–141.
- TUTIN T.G., BURGESS N.A., CHATER A.O., EDMONDSON J.R., HEYWOOD V.H., MOORE D.M., VALENTINE D.H., WALTERS S.M. & WEBB D.A. (1993): *Flora europaea* 1. Ed. 2. Cambridge University Press, Cambridge.
- TUTIN T.G., HEYWOOD V.H., BURGESS N.A., MOORE D.M., VALENTINE D.H., WALTERS S.M. & WEBB D.A. (1964–1980): *Flora europaea* 1–5. Ed. 1. Cambridge University Press, Cambridge.
- TUXEN R. & OBERDORFER E. (1958): Die Pflanzenwelt Spaniens. II Teil. Eurosibirische Phanerogamen-Gesellschaften Spaniens. *Veröff. Geobot. Inst. Rübel Zürich* 32: 1–328.
- URSA C. (1986): *Flora y vegetación de la Ribera Tudelana*. PhD. Thesis, Universidad de Navarra, Pamplona.
- VALDÉS B. & CASTROVIEJO S. (1990): *Salicornia* L. In: CASTROVIEJO S. et al. (eds.), *Flora iberica* 2, Real Jardín Botánico, C.S.I.C., Madrid, pp. 531–547.
- VALDÉS-FRANZI A., GONZÁLEZ BESERAN J.L. & MOLINA R. (1993): *Flora y vegetación de los saladares de Cordovilla y Agramón (SE de Albacete)*. Inst. Est. Albacetenses, Exma. Diputación de Albacete, Albacete.
- VELAYOS M., CARRASCO M.A. & CIRUJANO S. (1989): Las lagunas del Campo de Calatrava (Ciudad Real). *Bot. Complut.* 14: 9–50.

Encl. Appendix pp. 111–114

APPENDIX

SYNTAXONOMY OF THE THERO-SALICORNIEA CLASS (Tab. 1)

Originally, all salt-marsh vegetation was included in one order, *Salicornietalia* (BRAUN-BLANQUET 1933), and, later, in one class, *Salicornietea* (BRAUN-BLANQUET & TÜXEN 1943). Within these high-ranking units, an alliance was created to group together all annual succulent *Chenopodiaceae* communities: *Therosalicornion* BR.-BL. 1933. As originally conceived, this alliance included other clearly halonitrophilous associations such as "*Ass. Suaeda maritima et Kochia hirsuta*" BR.-BL. 1933 or the "*Ass. Suaeda splendens et Salsola soda*" BR.-BL. 1933, together with non-nitrophilous communities. Today, these halonitrophilous associations are included in *Saginetea maritimae* (RIVAS-MARTÍNEZ et al. 1980, RIVAS-MARTÍNEZ 1990) and so most of *Therosalicornion* belongs to this class.

The idea of separating halophilic vegetation formed by annuals from similar vegetation formed by perennials was put forward by PIGNATTI (1953), who proposed for the former a subclass (*Therosalicornietea*) and an order (*Therosalicornietalia*), based on *Therosalicornion* BR.-BL. 1933, inside a broad halophilic class *Cakileto-Therosalicornietea*. The proposal of this class was not accepted, but the idea of separating a high rank unit to group all succulent annual *Chenopodiaceae* communities of non-nitrified halophilic habitats of salt marshes was taken up by TÜXEN (in TÜXEN & OBERDORFER 1958), who established the modern concept of the *Thero-Salicornietea* class, with halonitrophilous vegetation excluded.

***Thero-Salicornietea* R.TX. ex GÉHU et GÉHU-FRANCK 1984**

Syn.: *Salicornietea* BR.-BL. et R. TX. 1943 p. p. (art. 8); *Salicornietea* BR.-BL. et al. 1952 p. p. min; *Therosalicornietea* PIGNATTI 1953 [as subclass. (art. 51) nom. inval. (art. 8); *Cakileto-Therosalicornietea* PIGNATTI 1953 p. p. min.; *Thero-Salicornietea strictae* R. TX. in R. TX. et OBERD. 1958 nom. inval. (art. 3f)].

Holotypus: *Thero-Salicornietalia* R. TX. ex GÉHU et GÉHU-FRANCK 1984.

Characteristic taxa: *Salicornia obscura*, *Suaeda maritima*.

***Thero-Salicornietalia* R. TX. ex GÉHU et GÉHU-FRANCK 1984**

Syn.: *Therosalicornietalia* PIGNATTI 1953 nom. inval. (art. 8); *Thero-Salicornietalia strictae* R. TX. in R. TX. et OBERD. 1958 nom. inval. (art. 3f); *Coeno-Salicornietalia* CHAPMAN 1959 nom. illeg. (art. 34).

Holotypus: *Salicornion dolichostachyo-fragilis* GÉHU et GÉHU-FRANCK ex GÉHU 1992 nom. illeg. (= *Salicornion dolichostachyo-fragilis* GÉHU et RIVAS-MARTÍNEZ ex GÉHU et GÉHU-FRANCK 1984; = *Salicornion dolichostachyae* BR.-BL. ex R. TX. 1974).

***Salicornion dolichostachyo-fragilis* GÉHU et RIVAS-MARTÍNEZ ex GÉHU et GÉHU-FRANCK 1984**

Syn.: *Thero-Salicornion strictae* R. TX. in R. TX. et OBERD. 1958 nom. inval. (art. 3f, 8); *Salicornion strictae* (*dolichostachyae*) R. TX. 1974 nom. dub. (art. 38); *Salicornion dolichostachyo-fragilis* GÉHU et GÉHU-FRANCK 1982 nom. inval. (art. 5); *Salicornion dolichostachyo-fragilis* GÉHU et RIVAS-MARTÍNEZ 1982 nom. inval. (art. 5); *Salicornion dolichostachyo-fragilis* GÉHU et GÉHU-FRANCK ex GÉHU 1992 nom. illeg. (art. 31).

Holotypus: *Salicornietum fragilis* GÉHU et GÉHU-FRANCK 1984.

Characteristic taxa: *Salicornia dolichostachya*, *S. lutescens* (= *S. fragilis*).

***Salicornietum dolichostachyae* GÉHU et GÉHU-FRANCK 1984**

Syn.: *Salicornietum dolichostachyae* GÉHU et GÉHU-FRANCK 1982 nom. inval. (art. 5); *Salicornietum strictae* KNAUER in R. TX. 1974 nom. dub. (art. 37); *Salicornietum strictae* CHRISTIANSEN 1955 nom. nud. (art. 2b, 7); *Salicornietum dolichostachyae* CORILLION et GÉHU 1959 nom. nud. (art. 2b, 7).

Holotypus: GÉHU & GÉHU-FRANCK (1982: tab. 43, rel. 11).

European Atlantic (from the North Sea to the south-western Iberian Peninsula) glasswort communities formed by *Salicornia dolichostachya* which live in unstable clay soils in the slikke lower level, emerging only at low tide and in contact with *Spartina* communities.

***Salicornietum fragilis* GÉHU et GÉHU-FRANCK 1984**

Syn.: *Salicornietum fragilis* GÉHU et GÉHU-FRANCK 1982 nom. inval. (art. 5); *Salicornietum lutescentis* pro nom. mut. in RIVAS-MARTÍNEZ 1990.

Holotypus: GÉHU & GÉHU-FRANCK (1982: tab. 44, rel. 22).

European Atlantic glasswort communities formed by tall, dense populations of *Salicornia lutescens*, and often by *Suaeda maritima*, which live in more stable sandy or sand-loamy soils in the upper slikke level.

***Salicornietum obscurae* GÉHU et GÉHU-FRANCK 1984**

Syn.: *Salicornietum obscurae* GÉHU et GÉHU-FRANCK 1982 nom. inval. (art. 5).

Holotypus: GÉHU & GÉHU-FRANCK (1982: tab. 45, rel. 4).

European Atlantic glasswort communities formed by the diploid *Salicornia obscura* which live on the transitional fringe between slikke and schorre levels.

***Suaedetum maritimae* (DE LITARDIÈRE et MALCUIT 1927) GÉHU et al. in R. TX. 1974 corr. BUENO 1997**

Syn.: *Salicornietum europaeae* DE LITARDIÈRE et MALCUIT 1927 nom. illeg. (art. 29); *Suaedetum macrocarpa* (DE LITARDIÈRE et MALCUIT 1927) GÉHU et al. in R. TX. 1974 (art. 43); *Suaedetum macrocarpa* GÉHU et GÉHU-FRANCK 1969 nom. nud. (art. 2b, 7); *Astero-Suaedetum macrocarpa* GÉHU 1976 nom. inval. (art. 3a); *Astero tripolii-Suaedetum maritimae* GÉHU 1976 corr. GÉHU et GÉHU-FRANCK 1984 nom. inval. (art. 3a).

Lectotypus: GÉHU & GÉHU-FRANCK (1982: tab. 44, rel. 22); Lectum: BUENO (1997: 245).

Relatively dense, tall communities of earlier phenology, dominated by *Suaeda maritima* which occupy organic matter-enriched biotopes located in the upper slikke. They are distributed all over the temperate Atlantic coasts of Europe.

***Salicornion europaeo-ramosissimae* GÉHU et GÉHU-FRANCK 1984**

Syn.: *Salicornion ramosissimae* R. TX. 1974 prov. nom. inval. (art. 3b); *Salicornion emerici* GÉHU et GÉHU-FRANCK 1984 p. p. min.

Holotypus: *Salicornietum pusillo-ramosissimae* GÉHU 1976 (= *Salicornietum disarticulato-ramosissimae* GÉHU 1976 corr. GÉHU et GÉHU-FRANCK 1984); Lectum: GÉHU & GÉHU-FRANCK (1984: 61).

Characteristic taxa: *Salicornia nitens*, *S. ramosissima*, *Suaeda albescens*.

***Sarcocornio perennis-Salicornietum ramosissimae* (GÉHU et GÉHU-FRANCK 1979) RIVAS-MARTÍNEZ 1990**

Syn.: *Puccinellio maritimae-Salicornietum ramosissimae* GÉHU et GÉHU-FRANCK 1979 nom. illeg. (art. 31), non R. TX. 1974; *Suaedo splendidis-Salicornietum ramosissimae* RIVAS-MARTÍNEZ et al. 1980 p. p.

Holotypus: GÉHU & GÉHU-FRANCK (1979: 355, tab. 2, rel. 48).

European Atlantic (Cantabrian-Atlantic and Mediterranean Iberian-Atlantic) glasswort communities formed by *Salicornia ramosissima* (reddish at maturity), which live on the upper schorre level on sandy or sand-loamy soils. Other halophytes like *Puccinellia maritima* or *Sarcocornia perennis*, transgressive from the surrounding perennial communities, often participate. They are present from the Cantabrian coast to the Algarve and Cádiz area coastal salt-marshes.

Variability

salicornietum ramosissimae subass. nova hoc loco, is the typical subassociation.

Holotypus: GÉHU & GÉHU-FRANCK (1979: 355, tab. 2, rel. 48)

puccinellietosum fasciculatae GÉHU et PROVOST 1974.

Puccinellia fasciculata is linked to clay-rich soils which are severely dried-out in summer and autumn, with a considerable increase in salt concentration during that period.

***Suaedetum vulgaris* GÉHU 1976 corr. GÉHU et al. 1983**

Syn.: *Suaedetum vulgaris* GÉHU et GÉHU-FRANCK 1969 nom. nud. (art. 2b, 7); *Suaedetum prostratae* GÉHU 1976 (art. 43).

Lectotypus: GÉHU & GÉHU-FRANCK (1982: tab. 48, rel. 16); Lectum: GÉHU & GÉHU-FRANCK (1984: 62).

Open communities dominated by *Suaeda albescens* (= *Suaeda maritima* var. *vulgaris*) which occur in the higher schorre level on well-drained sandy or sandy-loamy soils. They have Atlantic distribution.

***Spergulario marinae-Salicornietum europaeae* BUENO et F. PRIETO in BUENO 1997**

Holotypus: BUENO (1997: 241, tab. 24, rel. 26).

Glasswort communities formed by the diploid *Salicornia europaea*, slightly reddish at maturity. They occur in the upper schorre on frequently flooded biotopes with moderate or low salinity.

***Salicornion patulae* GÉHU et GÉHU-FRANCK 1984**

Syn.: *Microcnemum coralloidis* RIVAS-MARTÍNEZ et GÉHU in RIVAS-MARTÍNEZ 1984 (syntax. syn.); *Thero-Salicornion* auct. non BR.-BL. 1933; *Salicornion emerici* GÉHU et GÉHU-FRANCK 1984 p. p. (art. 25); *Salicornion ramosissimae* RIVAS-MARTÍNEZ et al. 1980 prov. nom. inval. (art. 3b), non R. TX. 1974.

Holotypus: *Suaedo maritimae-Salicornietum patulae* BRULLO et FURNARI ex GÉHU et GÉHU-FRANCK 1984 corr. RIVAS-MARTÍNEZ 1990; Lectum: GÉHU & GÉHU-FRANCK (1984: 61).

Characteristic taxa: *Microcnemum coralloides*, *Salicornia emerici*, *S. patula*.

***Microcnemetum coralloidis* RIVAS-MARTÍNEZ in RIVAS-MARTÍNEZ et COSTA 1976**

Lectotypus: RIVAS-MARTÍNEZ & COSTA (1976: 82, tab. 6, rel. 4); Lectum: LOIDI & BIURRÚN (1998: 164).

Western Mediterranean association distributed in continental salt-marshes, in biotopes where flooding is ephemeral and the soil is covered by a thick saline crust. Dominated by *Microcnemum coralloides*, it occupies the second position in the haloserries after mono-specific *Haloplepis* communities (BADIA et al. 1992).

***Suaedo maritimae-Salicornietum patulae* BRULLO et FURNARI ex GÉHU et GÉHU-FRANCK 1984 corr. RIVAS-MARTÍNEZ 1990**

Syn.: *Salicornietum patulae* sensu BRULLO et FURNARI 1976 non (SCHULTZ 1939) CHRISTIANSEN 1955; *Arthrocnemo glauci-Salicornietum ramosissimae* BRULLO et FURNARI ex GÉHU et al. 1978 nom. inval. (art. 3f); *Suaedo vulgaris-Salicornietum patulae* BRULLO et FURNARI ex GÉHU et GÉHU-FRANCK 1984 (art. 43).

Lectotypus: GÉHU et al. (1978: 88, rel. 12, tab. 2); Lectum: GÉHU & GÉHU-FRANCK (1984: 62).

Coastal Mediterranean glasswort communities dominated by the reddish diploid *Salicornia patula*, which live in winter-flooded and summer-dry soils. Distributed in the western part of the Mediterranean basin, it has been recorded in the Valenciano-Tarraconense and Setabense sectors and in the Murciano-Almeriense province.

***Salicornietum emerici* O. DE BOLÒS ex BRULLO et FURNARI 1976**

Syn.: *Salicornietum emerici* O. DE BOLÒS 1962 prov. (art. 3b); *Arthrocnemo glauci-Salicornietum emerici* O. DE BOLÒS ex GÉHU et al. 1978 nom. inval. (art. 3a).

Lectotypus: BOLÒS (1962: tab. 57, rel. 3); Lectum: BOLÒS (1996: 46).

Western Mediterranean coastal (Sicily, Sardinia, Corsica, Languedoc, Camargue, Catalonia) glasswort communities dominated by the reddish tetraploid *Salicornia emerici* which live on sandy-loamy soils. They occupy ephemeral ponds with impermeable beds that dry out in summer or at the end of the spring, which leads to high saline concentration.

Variability

salicornietosum emerici O. DE BOLÒS 1962 is the typical subassociation.

Lectotypus: BOLÒS (1962: tab. 57, rel. 3); Lectum hoc loco.

suaedetosum maritimae O. DE BOLÒS 1962

Lectotypus: BOLÒS (1962: tab. 57, rel. 1); Lectum hoc loco.

Suaeda spicata (*S. maritima* group) occurs when nitrification increases.

***Suaedo braun-blauquetii-Salicornietum patulae* BR.-BL. et O. DE BOLÒS 1958 corr. RIVAS-MARTÍNEZ 1990**

Syn.: Ass. *Salicornia herbacea* et *Suaeda brevifolia* BR.-BL. et O. DE BOLÒS 1958 (art. 43); *Suaedo splendidis-Salicornietum ramosissimae* sensu CIRUJANO 1981, non RIVAS-MARTÍNEZ et al. 1980; *Suaedo splendidis-Salicornietum patulae* RIVAS-MARTÍNEZ 1984 nom. inval. (art. 3a), non RIVAS-MARTÍNEZ et al. 1980 corr. RIVAS-MARTÍNEZ 1990.

Lectotypus: BRAUN-BLANQUET & BOLÒS (1958: 99, tab. 22, rel. 1); Lectum: RIVAS-MARTÍNEZ (1990: 363).

Iberian inland salt-marsh glasswort communities living in habitats flooded for long periods and with low nitrogenate substance content. Its phenological optimum is in early autumn and is distributed mainly in the Ebro basin (Riojano and Bardenas-Monegros sectors) and in La Mancha (Manchego sector). In the Guadalquivir Valley (Hispalense sector) there have been reported glasswort communities by MARTÍNEZ PARRAS et al. (1984) and GARCÍA FUENTES (1996) which have been included in this association.

Dominated by *Salicornia patula*, this continental association differs from the two coastal ones also dominated by it in the presence of some continental species, as *Suaeda vera* subsp. *braun-blauquetii*, *Puccinellia fasciculata* and *Aeluropus litoralis*.

Note: The name *Suaedo splendidis-Salicornietum patulae* (RIVAS-MARTÍNEZ 1984) was created to group the communities from La Mancha (central Spain) based on the relevés published by CIRUJANO (1981: 188, tab. 1, typus rel. 13); however, this author used the name *Suaedo splendidis-Salicornietum ramosissimae* RIVAS-MARTÍNEZ et al. 1980 as he did not determine the glasswort species correctly. If we consider that all the inland Iberian communities of *Salicornia patula* belong to a single association, the oldest valid name, *Suaedo braun-blanquetii-Salicornietum patulae*, has priority (art. 25).

***Suaedo splendidis-Salicornietum patulae* RIVAS-MARTÍNEZ et al. 1980 corr. RIVAS-MARTÍNEZ 1990**

Syn: *Suaedo splendidis-Salicornietum ramosissimae* RIVAS-MARTÍNEZ et al. 1980 (art. 43).

Holotypus: RIVAS-MARTÍNEZ et al. (1980: 44, tab. 23, rel. 3, sub *Suaedo splendidis-Salicornietum ramosissimae* RIVAS-MARTÍNEZ et al. 1980).

Littoral diploid glasswort communities on the south-western coast of the Iberian Peninsula (Gaditano-Onubense and Algarviense sectors), located in saline clay soils flooded in the winter-spring period. They differ from the other two associations dominated by *Salicornia patula* in the presence of some Atlantic species such as *Suaeda albescens*, *Spartina maritima* and *Sarcocornia perennis*.

Variability

salicornietosum patulae subass. nova hoc loco, is the typical subassociation widespread in the Gaditano-Onubense and Algarviense coasts.

Holotypus: RIVAS-MARTÍNEZ et al. (1980: 44, tab. 23, rel. 3).

***crispisetosum aculeatae* RIVAS-MARTÍNEZ subass. nova hoc loco**

Holotypus: RIVAS-MARTÍNEZ et al. (1980: 45, tab. 23, rel. 9); Syn.: *Suaedo splendidis-Salicornietum ramosissimae crispisetosum aculeatae* RIVAS-MARTÍNEZ et al. 1980 nom. inval. (art. 2b, 7).

Crypsis aculeata and *Cressa cretica* occur in places where dessication happens later and organic matter accumulates.

***salicornietosum lutescentis* J.C. COSTA subass. nova hoc loco**

Holotypus: a sul do Aeroporto Faro (Algarve, Portugal), 2 m²: *Salicornia patula* 3.3, *Suaeda maritima* group 1.1, *Salicornia lutescens* 3.3, *Sarcocornia perennis* 2.2 (COSTA 1991: 66, tab. 15, rel. 17). In the coastal salt-marshes of southern Portugal (Algarve) *Salicornia lutescens* occurs, which mingles with *S. patula* in the most advanced positions of the fringe occupied by the latter (COSTA 1991); situations in which *S. lutescens* is found alone are very rare, which enables us to identify this subassociation.

***salicornietosum ramosissimae* J.C. COSTA subass. nova hoc loco**

Holotypus: Pedras d'El Rei (Algarve, Portugal), 1 m²: *Salicornia patula* 3.3, *Suaeda maritima* group 2.2, *Salicornia ramosissima* 2.2, *Sarcocornia perennis* 1.1 (COSTA 1991: 66, tab. 15, rel. 22). *Salicornia ramosissima* also mixes with *S. patula* in the Algarve, but in the highest fringe of the *S. patula* band, in the transition to *Sarcocornia perennis-Salicornietum ramosissimae*.

***Halopeplidetum amplexicaulis* BURLLET 1927**

Lectotypus: BURLLET (1927); Lectum: BLANCHÉ & MOLERO (1988: 286).

Western Mediterranean hyperhalophilic association of coastal and continental salt-marshes, dominated by *Halopeplis amplexicaulis*. It occurs in ponds where flooding persists for long time and salinity is very high, especially in terms of concentration of Na⁺ and K⁺ (BADIA et al. 1992); it occupies the first position in the haloserries of the Mediterranean salt-marshes. In the Iberian Peninsula, it has been reported in the Gaditano-Onubense sector (RIVAS-MARTÍNEZ 1990) but most of the data have been collected from the Bardenas-Monegros sector, in the Ebro basin (BADIA et al. 1992, BLANCHÉ & MOLERO 1988).

Variability

The subassociation *salicornietosum patulae* Blanché et MOLERO 1988 corr.; [Holotypus: BLANCHÉ & MOLERO 1988: 284, tab. 1, rel. 1 (Syn: *Halopeplidetum amplexicaulis salicornietosum ramosissimae* BLANCHÉ et MOLERO 1988)] has been described in some of the ponds of the Ebro basin salt-marshes, based on the presence of *Salicornia patula*. No ecological or biogeographical data support this subassociation.