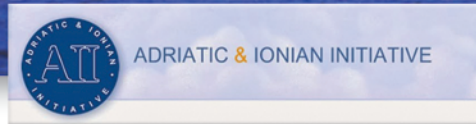


PLANT SOCIOLOGY

formerly **FITOSOCIOLOGIA**

Volume 51 (2) - Suppl. 1 - December 2014

RIVISTA SEMESTRALE - POSTE ITALIANE S.P.A. - SPED. ABB. POST. - D.L. 353/2003 - (CONV. IN L. 27/02/2004 N. 46) ART. 1, COMMA 2, DCB ANCONA - TASSA RISCOSSA-TAXE PERÇUE-CMPP AN
EDITO DALLA SOCIETÀ ITALIANA DI SCIENZA DELLA VEGETAZIONE ONLUS - PAVIA - DIRETTORE RESPONSABILE PROF. E. BIONDI - SUPPLEMENTO 1 - VOLUME 2 - II° SEMESTRE 2014



Journal of the Italian Society for Vegetation Science

Syntaxonomic considerations of the Mediterranean vegetation dominated by perennial psammophilous graminaceous plants

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Abstract

The vegetation dominated by perennial psammophilous grasses along the Mediterranean coasts is reviewed and updated according to the new concepts, with particular reference to the European grasses. First, the class of the dune psammophilous vegetation that is already indicated in the Vegetation Prodrôme of Italy with the name of *Ammophiletea* is updated to *Euphorbio paraliae-Ammophiletea australis*. Thus, the dune vegetation of the central and northern Atlantic is distinguished in syntaxonomic terms from that of the similar Mediterranean and south-Atlantic formations. This separation is carried out at the order level, by recognizing the order *Elymetalia arenarii* for the north-European Atlantic coasts and the order *Ammophiletalia australis* for the Mediterranean and thermo-Atlantic coasts. For the Mediterranean area is also recognized the order *Elymetalia gigantei*, for the Pontic zone and specifically for the Black Sea coasts and the Marmara Sea areas.

The main aim of this revision is therefore recognition of the syntaxa that make up the hierarchical scheme proposed for the Mediterranean Basin, with the definition of the alliance *Ammophilion australis* for the vegetation of the white dunes, the alliance *Agropyron juncei* for that of the embryonic dunes and the alliance *Elymion gigantei* for that of the Pontic dunes. In terms of the alliance *Ammophilion australis*, the suballiance *Ammophilion australis* is recognized for the European thermo-Atlantic and Mediterranean coastal areas except for the coasts of north Africa and the new suballiance *Sileno succulentae-Ammophilion australis* is described for the Mediterranean part of north Africa. For the alliance *Agropyron farcti* that defines the vegetation that shows the richest biodiversity of the whole system, four suballiances are recognized. Of these, two are 'structural system', even if they are well characterised in ecological and floristic terms, and two are biogeographic. The first two of the suballiances are *Sporobolion arenarii*, which includes the first perennial vegetation of the first parts of embryonic dunes directly reached by seawater, and *Elymo farcti-Otanthion maritimi* suball. nova, which includes the vegetation of the inner parts of the embryonic dunes characterised by reduced mobility of the sandy substrate. Defined in chorological terms, the two suballiances within the Mediterranean Basin are: the suballiance *Agropyrenion farcti*, which includes the European psammophilous communities from the Iberian Peninsula to the Balkan one up to the Pontic Region except for the Crete and Cyprus Islands; and the suballiance *Sileno succulentae-Elymion farcti* suball. nova, which includes the communities of the north African Mediterranean coast. Finally, within the order *Elymetalia gigantei*, the alliance *Elymion gigantei* is recognized for the psammophilous vegetation of the Pontic dunes.

Keywords: Atlantic coasts, coastal vegetation, embryonic dunes, Mediterranean coasts, mobile dunes, syntaxonomy.

Introduction

The sandy coasts are characterised by particular vegetation formations that are in chain succession along a gradient defined by ecological factors, such as the salinity, the winds, and the particular quality of the substrate, especially in terms of its mobility and extreme dryness (Biondi, 2007). Stabilisation of the sandy substrate occurs through the annual and, in particular, perennial psammophytes. These are characterised by their hypogean structure, which together with their above-ground structure can retain the sand, thus promoting the progressive growth of the dunes.

In more detail, along the Mediterranean and thermo-Atlantic coasts, the *Sporobolus pungens* (Schreb.) Kunth and *Elymus farctus* (Viv.) Runemark ex Melderis formations promote the building of the first sand accumulations, or drifts (the embryonic dunes) that then grow to increased heights (as the mobile dunes). This is due to the presence of the geophyte *Ammophila arenaria* (L.) Link subsp. *australis* (Mabille) Lainz [= *Ammophila arenaria* (L.) Link subsp. *arundinacea* H.

Lindb.] in the inner part of the dune system (Braun-Blanquet, 1933; Géhu, 1986, 1998; Géhu & Géhu-Franck, 1986, 1988; Géhu *et al.*, 1990; Rivas-Martínez *et al.*, 2002, 2011; Géhu & Biondi, 1994; Biondi, 1999; Biondi *et al.*, 2001; Brullo *et al.*, 2001; Biondi & Bagella, 2005). These communities are included in a single vegetation class and organised into the relevant subordinate syntaxonomic ranks according to the different criteria.

The aim of this article is to update the syntaxonomic scheme already published in the Vegetation Prodrôme of Italy according to the concepts which are presented here.

On the basis of this vision the class of vegetation that characterises the plant communities of the Atlantic and Mediterranean dunes that is currently proposed according to different definitions is here recognized, and the syntaxonomic scheme of this class, for each hierarchical level and in relation to the Mediterranean Basin is completed. The following proposed syntaxonomic scheme follows the interpretation of Géhu (1986), which is adapted according to the views of the

authors. Some syntaxa are repropoed here according to the rules of the International Code of Phytosociological Nomenclature (ICPN, Weber *et al.*, 2000).

Analysis of the syntaxonomical approaches

In the latest syntaxonomic schemes (Bardat *et al.*, 2004; Rivas-Martínez *et al.*, 2011; Schaminée *et al.*, 1995-1999; Rodwell, 1991-2000; Pott, 1995; Costa *et al.*, 2012; Bioret *et al.*, 2013; Biondi *et al.*, 2014), the class that includes the coastal dune vegetation of the northern Atlantic and the thermo-Atlantic and Mediterranean is proposed with different definitions. Moreover, the classification of the vegetation in biogeographical and ecological terms is defined at the level of alliance and suballiance, according to the views of the authors.

In particular, in their *Prodrome des végétations de France* ('Prodrome of the French Vegetation') Bardat *et al.* (2004) followed the interpretation of Géhu & Géhu-Franck (1988), according to the class *Euphorbio paraliae-Ammophiletea australis*. Within this, the order *Ammophiletalia australis* Br.-Bl. 1933 and two alliances were recognized: *Ammophilion arenariae* (Tüxen in Braun-Blanq. & Tüxen, 1952) Géhu 1986, for the Atlantic dune vegetation; and *Ammophilion australis* Br.-Bl. 1921 corr. Rivas-Martínez, Costa & Izco in Rivas-Martínez, Lousã, Díaz, Fernández-González & Costa 1990, for the Mediterranean and Mediterranean-Atlantic dune vegetation. The distinction at the alliance level between the specifically Atlantic and Mediterranean communities was introduced by Géhu (1986), and this showed how the Mediterranean communities form a group that is well distinguished from the pre-Pontic and Atlantic units, in that it is well characterised floristically (Géhu & Géhu-Franck, 1988). Within each alliance, the chain succession of the perennial formations that make up the dune system are defined at the suballiance level. This applies to both the Atlantic sector and the Mediterranean sector, where three suballiances are therefore defined: one that groups the halo-nitrophilous psammophilous vegetation of the parts of the embryonic dunes that are still influenced by the tides; one for the communities that make up the embryonic dunes; and one for the communities that colonise the mobile dunes. Bardat *et al.* (2004) followed the interpretation of Géhu (1986) and Géhu & Géhu-Franck (1988).

The syntaxonomic schemes proposed by Rivas-Martínez *et al.* (2002, 2011) included the perennial dune vegetation initially in the class *Ammophiletea* Br.-Bl. & Tüxen ex Westhoff, Dijk & Passchier 1946. Later they were included in the newly proposed class *Euphorbio paraliae-Ammophiletea australis* Géhu & Rivas-Martínez in Rivas-Martínez *et al.* 2011, on the basis that the class published by Géhu & Géhu-Franck

(1988) was invalid according to Articles 5 and 8 of the ICPN. Within this class, Rivas-Martínez *et al.* (2011) defined the order *Ammophiletalia australis* Br.-Bl. 1933, with three alliances that include the psammophilous communities according to their ecological particularities. They recognized an alliance that includes the different communities of the embryonic dunes, *Honckenyo peploidis-Elytrigion boreoatlanticae* Tüxen in Br.-Bl. & Tüxen 1952 nom. inv. et nom. mut. in Rivas-Martínez *et al.* 2002. This alliance includes two suballiances, which are respectively characterised by the two geovicariant species of the genus *Elymus* (= *Elytrigia*): one of the Temperate and Mediterranean macrobioclimate with an Atlantic distribution, *Honckenyo peploidis-Elytrigienion boreoatlanticae* (Tüxen in Br.-Bl. & Tüxen 1952) Rivas-Martínez 2011; and the other of the Mediterranean macrobioclimate with eastern Mediterranean distribution that reaches west to the north African coasts, *Elytrigienion juncea* Rivas-Martínez, Costa, Castroviejo & Valdés 1980. The second alliance defined by Rivas-Martínez *et al.* (2011) includes the vegetation that colonises the mobile dunes, the alliance *Ammophilion australis* Br.-Bl. 1921 corr. Rivas-Martínez, Costa & Izco in Rivas-Martínez, Lousã, Díaz, Fernández-González & Costa 1990. For this alliance, Rivas-Martínez *et al.* (2002, 2011) also defined two suballiances: *Ammophilion australis* Rivas-Martínez & Géhu in Rivas-Martínez, Lousã, Díaz, Fernández-González & Costa 1990, for the communities dominated by *Ammophila australis* that develop along the Mediterranean coasts and reach up to the European Atlantic coasts as far as Galicia; and *Ammophilion arenariae* (Tüxen ex Br.-Bl. & Tüxen 1952) Rivas-Martínez, Costa, Castroviejo & Valdés 1980, for the vegetation of the mobile dunes found along the Cantabrian coasts, up to the southern Baltic (Rivas-Martínez *et al.*, 1980). Finally, there is the third alliance defined by Rivas-Martínez *et al.* (2011), *Sporobolion arenarii* (Géhu & Géhu-Franck ex Géhu & Biondi 1994) Rivas-Martínez & Cantó 2002, which includes the halo-nitrophilous communities of the Mediterranean salt-flat coastal dunes. On this basis, the ecological dimension, expressed as the alliance, has priority, while the biogeographical aspect is relegated to the subordinate level.

The classification proposed in the *Vegetation Prodrome of Italy* (Biondi *et al.*, 2014) is obviously defined only for the Mediterranean communities. Within the vegetation class *Ammophiletea* Br.-Bl. & Tüxen ex Westhoff, Dijk & Passchier 1946, the order *Ammophiletalia australis* Br.-Bl. 1933 is recognized with two alliances that differentiate the communities of the mobile dunes, *Ammophilion australis* Br.-Bl. 1921 corr. Rivas-Martínez, Costa & Izco in Rivas-Martínez, Lousã, Díaz, Fernández-González & Costa 1990, from those of the embryonic dunes, *Agropyro-Minuartion*

peploidis Tx. in Br.-Bl. & Tx. 1952. This latter alliance refers in effect to the formations of the embryonic dunes of the Atlantic coast, and in Biondi *et al.* (2014) it was used on a provisional basis.

Results

The classifications considered here highlight the different definitions in syntaxonomic terms, for which there is proposed a classification system of the plant communities that is consistent with what is stated in the presentation of the Vegetation Prodrome of Italy (Biondi *et al.*, 2014). For some aspects, this follows the update of the concept of the plant associations (Biondi, 2011).

As far as the class is concerned, the proposal of Rivas-Martínez *et al.* (2011) is adopted, with the class *Euphorbio paraliae-Ammophiletea australis* Géhu & Rivas-Martínez in Rivas-Martínez *et al.* 2011 (including the *Honckenyo-Elymetea arenarii* Tüxen 1966) accepted here to include the vegetation of both the north Atlantic dune systems and those of the Mediterranean and thermo-Atlantic. On this basis, therefore, the subordinate syntaxa are recognized and defined according to specific assumptions.

In more detail, the order is assigned the role of the fundamental rank that includes the phytocoenoses according to the biogeographical macro-units of Region and Subregion (Rivas-Martínez, 2007). Indeed, this view allows the better definition and clustering of the plant communities into the lower hierarchical levels. In this way, the alliance can represent the hierarchical level on the basis of the ecological characteristics of the community, while the suballiance can represent the rank for which both the biogeographical and ecological features are more detailed.

On the basis of this, with reference to the Mediterranean dune vegetation, the order *Ammophiletalia australis* Br.-Bl. 1933, as it has been interpreted to date (Bardat *et al.* 2004; Rivas-Martínez *et al.*, 2011), should be considered as *nomen ambiguum* because of the use of the subspecies epithet “*australis*”, which must follow the interpretation of Braun-Blanquet (1933) that defines a Mediterranean order with thermo-Atlantic penetration. Instead, in the different classifications analysed, this order includes both Mediterranean and Atlantic communities, and also the north European ones.

Therefore, three distinct orders are proposed: the order *Elymetalia arenarii* Br.-Bl. & Tüxen 1943, for the perennial psammophilous vegetation of the Atlantic and north European dunes and two orders for the Mediterranean area, the order *Ammophiletalia australis* Br.-Bl. 1933, which includes the perennial dune communities of the Mediterranean and south Atlantic coasts and the order *Elymetalia gigantei* Vicherek

1971 for the Black Sea coasts and the Marmara Sea areas. Within the order *Ammophiletalia australis*, two alliances are recognized: *Ammophilion australis*, for the mobile dune and *Agropyrion juncei*, for the embryonic dune. The classification here defined at the level of alliance has already been recognized for a long time in the literature and is therefore kept unchanged. However, it is considered more suitable to cluster mainly the vegetation of the alliance *Agropyrion juncei* at the lower hierarchical level, as it is characterised by higher specific and phytocoenotic biodiversity. In contrast, these aspects are not found in the mobile dune communities, where in their more stable parts *Ammophila arenaria* gives origin to dense structures where the other psammophilous species of a smaller size cannot survive, which is also linked to the accumulation of the sand.

The vegetation of the Mediterranean mobile dunes has been included in the alliance *Ammophilion australis* Br.-Bl. 1933 em. Géhu & Géhu-Franck 1988, which was reported by Géhu & Géhu-Franck (1988), and not in the alliance *Ammophilion australis* Br.-B. 1921 corr. Rivas-Martínez, Costa & Izco in Rivas-Martínez *et al.* 1990, which is instead currently used in the recent classifications analysed. Indeed, as was defined in Rivas-Martínez *et al.* (1990), this latter syntaxon includes both the Mediterranean vegetation (*Ammophilenion arundinaceae*) and the Atlantic vegetation (*Ammophilenion arenariae*). The syntaxon reported by Géhu & Géhu-Franck (1988) included only the thermo-Atlantic and Mediterranean communities and for this reason it is the most suitable for the classification proposed here. Within this alliance two suballiances are recognized: the suballiance *Ammophilenion australis*, for the European thermo-Atlantic and Mediterranean coastal areas, except for the north African coasts, and the new suballiance *Sileno succulentae-Ammophilenion australis*, for the north African Mediterranean coast.

The vegetation that forms the embryonic dunes is included in the alliance *Agropyrion juncei* (R.Tüxen 1945 in Br.-Bl. & R.Tüxen 1952) Géhu, Rivas-Martínez & R. Tüxen 1972 in Géhu, Costa, Scoppola, Biondi, Marchiori, Peris, Franck, Caniglia & Veri 1984, within which four suballiances are recognized that include and subdivide the communities in ecological and biogeographical terms. The suballiance *typicum* is *Sporobolion arenarii* Géhu ex Biondi & Galdenzi suball. nova *hoc loco*. This syntaxon was not published in a valid form (according to Articles 5 and 8) by Géhu (1986), although it is proposed again here, in accordance with the ICPN rules, through the definition of the holotypus: the association *Sporobolo arenarii-Agropyretum juncei* (Br.-Bl. 1933, Géhu, Rivas-Martínez & R. Tüxen 1972) Géhu in Géhu, Costa, Scoppola, Biondi, Marchiori, Peris, Franck, Caniglia & Veri 1984, which was also the holotypus of the alliance

Agropyron juncei. The communities with *Sporobolus arenarius* included in this suballiance define the structure of the embryonic dunes, making up the vegetation of the first parts of the sand dune systems that are still influenced by the waves, for all of the sandy coasts of the Mediterranean.

The suballiance *Elymo farcti-Otanthenion maritimi* suball. nova *hoc loco* also covers a structural role, as it is found in the Mediterranean sand dune systems where it develops on the highest parts of the embryonic dunes, which for the larger systems tend to be more stable. This is due to the high levels of *Otanthus maritimus*, which characterises this new syntaxon. The other two suballiances included in the alliance *Agropyron juncei* define instead the synchronology of the embryonic dunes and are among their geosynvicariants: the suballiance *Agropyrenion juncei* Rivas-Martínez, Costa, Castroviejo & Valdés 1980, which includes the European psammophilous communities from the Iberian Peninsula to the Balkan one up to the Pontic Region except for the Crete and Cyprus Islands; and the suballiance *Sileno succulentae-Elymenion farcti* suball. nova *hoc loco*, of the embryonic dune vegetation along the north African coast. The former suballiance includes the association *Echinophoro spinosae-Elymetum farcti*, which was described and reported by Géhu (1986) in an invalid way (Article 3f; Géhu, 1986). According to the ICPN rules, this syntaxon is here validated through the indication of the holotypus (holotypus: relevé 14 in Table 2 for Géhu *et al.*, 1987).

Finally, the order *Elymetalia gigantei* with the alliance *Elymion gigantei* Morariu 1957 are recognized for the sandy coasts of the Pontic sector and specifically for the Black Sea coasts and the Marmara Sea areas (Géhu & Uslu, 1989; Sýkora *et al.*, 2003; Tzonev *et al.*, 2005, 2009; Kavgaci, 2007; Făgaras, 2013). The order *Elymetalia gigantei* is placed by some authors (Sýkora *et al.*, 2003; Tzonev *et al.*, 2009) in the class *Honckenyo-Elymetea arenarii* Tüxen 1966 but it is believed to belong to the class *Euphorbio paraliae-Ammophiletea australis* with which it shares many species.

Syntaxonomical scheme

For the syntaxonomic scheme, for each syntaxon and succession, the information and the rules are followed as already applied in the Vegetation Prodrôme of Italy (Biondi *et al.*, 2014).

Cl.: **EUPHORBIO PARALIAE-AMMOPHILETEA AUSTRALIS** Géhu & Rivas-Martínez in Rivas-Martínez, Asensi, Díaz-Garretas, Molero, Valle, Cano, Costa & Díaz 2011

[*Euphorbio-Ammophiletea arundinaceae* Géhu & Géhu-Franck 1988 (art. 5, 8), *Ammophiletea arenariae*

sensu. auct. non Br.-Bl. & Tüxen ex Westhoff, Dijk, Passchier & Sissingh 1946, quod est: *Honckenyo-Elymetea arenariae* Tüxen 1966].

Holotypus: *Ammophiletea australis* Br.-Bl. 1933

Diagnostic species: *Ammophila arenaria* (L.) Link subsp. *australis* (Mabille) Lainz [= *A. arenaria* (L.) Link subsp. *arundinacea* H. Lindb., *A. littoralis* (Beauv.) Rothm., *Arundo arenaria* L.], *Anthemis maritima* L., *Cyperus capitatus* Vand. [= *C. kalli* (Forssk.) Murb., *C. kallii* (Forssk.) Murb., *C. mucronatus* (L.) Mabille, non Steud. 1854, nom. illeg.], *Euphorbia paralias* L., *Lotus creticus* L., *Medicago marina* L., *Pancratium maritimum* L. and *Polygonum maritimum* L..

Short description: Psammophilous perennial vegetation from the coastal sandy and fine-pebbly dunes, with a Mediterranean, thermo-Atlantic and Macaronesian coastal distribution, which is important in the dune construction and stabilisation processes.

Ord.: **AMMOPHILETALIA AUSTRALIS** Br.-Bl. 1933 [*Ammophiletea* Br.-Bl. 1931 (Article 2b), *Elymetalia arenarii* Br.-Bl. & Tüxen 1943 (art. 8), *Elymo-Ammophiletea arenariae* Géhu-Franck 1969, *Euphorbio-Ammophiletea* Géhu & Géhu-Franck 1969 (syntax. syn.)].

Holotypus: *Ammophilon australis* Braun-Blanquet 1933 em. Géhu & Géhu-Franck 1988.

Diagnostic species: *Ammophila arenaria* subsp. *australis*, *Echinophora spinosa* L. and *Sporobolus arenarius* (Gouan) Duval-Jouve [= *S. pungens* (Schreber) Kunth, no *S. virginicus* Kunth].

Short description: Perennial herbaceous vegetation typical of the forward beach areas and the embryonic and mobile dunes, distributed in the Mediterranean coastal areas, with extensions into the European thermo-Atlantic areas.

All.: **Ammophilon australis** Braun-Blanquet 1933 em. Géhu & Géhu-Franck 1988

[*Ammophilon littori-arenariae* Br.-Bl. 1921 (art. 43), *Ammophilon* Br.-Bl. 1931 nom. nud. (art. 2b, 8), *Ammophilon* Br.-Bl. 1933 nom. ambig. (art. 36) p.p., *Ammophilon borealis* Tüxen in Br.-Bl. & Tüxen 1952 (syntax. syn.), *Euphorbio-Ammophilon arenariae* Géhu & Géhu-Franck 1969 (syntax. syn.), *Ammophilon arundinaceae* Br.-Bl. 1921 corr. Rivas-Martínez, Costa, Castroviejo & Valdés Berm. 1980 (art. 43) p.p., *Ammophilon arundinaceae* Braun-Blanquet 1933 em. Géhu & Géhu-Franck 1988 (art. 43), *Ammophilon australis* Braun-Blanquet 1921 corr. Rivas Mart., M.J. Costa & Izco in Rivas Mart., Lousã, T.E. Díaz, Fern.-Gonz. & J.C. Costa 1990 p.p. (syntax. syn.)].

Holotypus: *Medicagini marinae-Ammophiletum australis* Br.-Bl. 1933

Diagnostic species: *Ammophila arenaria* subsp. *australis*, *Echinophora spinosa*, *Euphorbia paralias*,

Pancretium maritimum and *Launaea resedifolia* (L.) Kuntze [= *Podospermum laciniatum* (L.) DC. subsp. *decumbens* (Guss.) Gemeinholzer & Greuter].

Short description: Psammophilous perennial herbaceous communities that colonise the mobile dunes in the Mediterranean and European thermo-Atlantic coastal areas.

Suball.: *Ammophilenion australis* (Br.-Bl. 1921) Rivas-Martínez & Géhu in Rivas-Martínez, Lousã, Díaz, Fernández-González & Costa 1990

[*Ammophilenion arundinaceae* Rivas-Martínez, Costa, Castroviejo & E. Valdés 1980 (art. 27a, 28), *Medicagini-Ammophilenion arundinaceae* (Braun-Blanquet) Géhu & Biondi 1994 nom. illeg. (art. 29, 43)]

Holotypus: The same as the alliance.

Diagnostic species: The same as the alliance.

Short description: Psammophilous perennial herbaceous communities that colonise the mobile dunes in the European thermo-Atlantic and Mediterranean coastal areas except for the north African coast.

Suball.: *Sileno succulentae-Ammophilenion australis* suball. nova *hoc loco*

Holotypus: *Sileno succulentae-Ammophiletum arundinaceae* (Burolet 1927) Géhu & Géhu-Franck 1986 [Syn. *Ammophiletum arundinaceae* Br.-Bl. (1921) 1933 race géographique sud orientale à *Silene succulent* Vander Berghn 1977] in Géhu & Géhu-Franck (1986)

Diagnostic species: *Ammophila arenaria* subsp. *australis*, *Silene succulent* Forssk., *Ipomoea stolonifera* (Cyr.) Gmelin, *Lotus polyphyllus* Clarke, *L. creticus* and *Zygophyllum album* L..

Short description: Psammophilous perennial herbaceous communities that colonise the mobile dunes in the north African coast.

All.: *Agropyron juncei* (R.Tüxen 1945 in Br.-Bl. & R.Tüxen 1952) Géhu, Rivas-Martínez & R. Tüxen 1972 in Géhu, Costa, Scoppola, Biondi, Marchiori, Peris, Franck, Caniglia & Veri 1984

[*Sporobolion arenarii* (Géhu & Géhu-Franck ex Géhu & Biondi 1994) Rivas-Martínez & Cantó in Rivas-Martínez *et al.* 2002 (syntax. syn.)].

Holotypus: *Sporobolion arenarii-Agropyretum juncei* (Br.-Bl. 1933, Géhu, Rivas-Martínez & R. Tüxen 1972) Géhu in Géhu, Costa, Scoppola, Biondi, Marchiori, Peris, Franck, Caniglia & Veri 1984.

Diagnostic species: *Elymus farctus* (Viv.) Runemark ex Melderis subsp. *farctus* [= *Agropyron junceum* (L.) Beauv, *Agropyron junceum* (L.) Beauv. subsp. *mediterraneum* Simonet & Guinochet *sensu* Pignatti, *Elytrigia juncea* (L.) Nevski, *E. mediterranea* (Simonet) Prokudin], *Sporobolus arenarius*, *Echinophora spinosa*, *Otanthus maritimus* (L.) Hoffmanns. & Link

[= *Diotis candidissima* Desf., nom. illeg., *Diotis maritima* (L.) Cass., *Filago maritima* L.], *Calystegia soldanella* (L.) R.Br., *Medicago marina*, *Anthemis maritima*, *Cyperus capitatus* and *Silene succulenta* subsp. *corsica* (DC.) Nyman.

Short description: Psammophilous perennial herbaceous communities that colonise the embryonic dunes in the Mediterranean and European thermo-Atlantic coastal areas.

Suball.: *Sporobolenion arenarii* Géhu ex Biondi & Galdenzi suball. nova *hoc loco*

[*Sporobolenion arenarii* Géhu 1986 *nom. inval.* (art. 5, 8), *Sporobolenion arenarii* Géhu & Géhu-Franck ex Géhu & Biondi 1994 non Rothmaler 1943 (art. 27a), Incl.: *Sporobolion arenarii* (Géhu & Géhu-Franck ex Géhu & Biondi 1994) Rivas-Martínez & Cantó 2002].

Holotypus: The same as the alliance.

Diagnostic species: *Sporobolus arenarius*, *Polygonum maritimum*, *Ipomoea stolonifera*.

Short description: Halo-nitrophilous perennial herbaceous communities that occur in the first parts of the meso- and thermo-Mediterranean sand dune systems that are characterised by *Sporobolus arenarius*, which colonises the lower parts of the embryonic dunes that are regularly reached by the sea.

Suball.: *Elymo farcti-Otanthenion maritimi* suball. nova *hoc loco*.

Holotypus: *Elymo farcti-Otanthenion maritimi* Géhu ex Biondi & Galdenzi *ass. nova*

Diagnostic species: *Otanthus maritimus*, *Pancretium maritimum*, *Medicago marina*, *Euphorbia paralias*, *Ipomoea stolonifera* and *Silene succulenta* subsp. *corsica*.

Short description: Psammophilous plant communities that are physiognomically dominated by *Otanthus maritimus*, which occur on the inner parts of the embryonic dunes that are characterised by reduced mobility of the sandy substrate.

Ass.: *Elymo farcti-Otanthenion maritimi* Géhu ex Biondi & Galdenzi *ass. nova hoc loco*

[*Echinophoro spinosae-Elymetum farcti* Géhu ex Biondi & Galdenzi 2014 subass. *otanthenosum* Géhu ex Biondi 1994 (corresp. name)].

Holotypus: Relevé 44 in Table 4 of Géhu & Biondi 1994.

Diagnostic species: *Otanthus maritimus*.

Short description: Communities that occur on the inner parts of the embryonic dunes where the plants have reduced the mobility of the dunes. Under these conditions, *Otanthus maritimus* dominates over other psammophilous species, which are consequently less numerous.

Suball.: *Agropyrenion farcti* Rivas-Martínez, Costa, Castroviejo & Valdés 1980

[Incl: *Echinophoro spinosae-Elymetum farcti* Géhu 1986 *nom. inval.* (art. 3f)]

Holotypus: *Cypero mucronati-Elytrigietum junceae* Br.-Bl. 1933.

Diagnostic species: *Elymus farctus*, *Lotus creticus*, *L. cytisoides*, *Cyperus mucronatus*, *Echinophora spinosa*, *Calystegia soldanella*.

Short description: Psammophilous embryonic dune communities that occur in European Mediterranean area from the Iberian Peninsula to the Balkan Peninsula up to the Pontic Region except for the Crete and Cyprus Islands.

Ass.: *Echinophoro spinosae-Elymetum farcti* Géhu ex Biondi & Galdenzi *ass. nova hoc loco*.

Validated name: *Echinophoro spinosae-Elymetum farcti* Géhu 1986 *nom. inval.* (art. 3f).

Holotypus: Relevé 14 in Table 2 of Géhu *et al.*, 1987.

Diagnostic species: *Echinophora spinosa* and *Elymus farctus*.

Short description: Association of central Mediterranean embryonic dunes communities that are distributed over a wide area of the European Mediterranean Basin, from the central to the eastern area up to the Pontic Region.

Suball.: *Sileno succulentae-Elymenion farcti* suball. *nova hoc loco*.

Holotypus: *Sileno succulentae-Elymetum farcti* (Burllet 1927) Géhu & Géhu-Franck 1986.

Diagnostic species: *Silene succulenta* Forssk. subsp. *succulenta*, *Lotus polyphyllus* E.D.Clarke, *Zygophyllum album* and *Alhagi graecorum* Boiss.

Short description: Psammophilous communities that occur on embryonic dunes along the coasts of central and eastern Mediterranean south region, from the Crete and Cyprus Islands up to the coasts of Tunisia, Egypt and Sinai (Géhu *et al.* 1984; Géhu, Costa & Uslu, 1992; Géhu & Géhu-Franck, 1986, 1992; Géhu *et al.*, 1992).

Order: **ELYMETALIA GIGANTEI** Vicherek 1971

Short description: Psammophilous perennial grass of the Pontic sectors and specifically of the Black Sea coast and the Marmara Sea areas.

All.: **Elymion gigantei** Morariu 1957

Holotypus: *Elymetum gigantei* Morariu 1957

Diagnostic species: *Leymus racemosus* subsp. *sabulosus* (M. Bieb.) Tzvelev, *Convolvulus persicus* L., *Argusia sibirica* (L.) Dandy Show, *Lagedium tataricum* (L.) Soják, *Centaurea arenaria* Bieb., *Elymus farctus* subsp. *bessarabicus* (Savul. & Rayss) Melderis, *Silene thymifolia* Sm., *Medicago marina*, *Stachys maritime*

Gouan, *Cynanchum acutum* L., *Artemisia arenaria* DC., *Leymus racemosus* subsp. *sabulosus*, *Ammophila arenaria* subsp. *australis* and *Eryngium maritimum*.

Short description: Psammophilous communities of the Pontic dunes.

Order: **ELYMETALIA ARENARII** Br.-Bl. & Tüxen 1943

[*Elymetalia arenarii* Fröde 1958 (art. 31), *Elymo-Ammophiletalia arenariae* Géhu-Franck 1969 (syntax. syn.)].

Holotypus: *Honckenyo latifoliae-Elymion arenarii* (Christiansen 1927) Géhu & Géhu-Franck 1988.

Diagnostic species: *Ammophila arenaria* (L.) Link subsp. *arenaria*.

Short description: Perennial herbaceous vegetation that is typical of the forward beach areas and of embryonic and mobile dunes, and is distributed in the north-European Atlantic coastal areas.

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