

Geobotanical characterisation of the *Trifolion squamosi* nom. corr. alliance (class. *Juncetea maritimi*) in Catalonia and the Western Mediterranean

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Key words: Catalonia, Western Mediterranean, geobotanical characterisation, syntaxonomic validation, subsaline meadows, *Trifolion maritimi* nom. inept., *Trifolion squamosi* nom. corr.

Ključne besede: Katalonija, zahodno Sredozemlje, geobotanične značilnosti, sintaksonomsko ovrednotenje, subsalina travišča, *Trifolion maritimi* nom. inept., *Trifolion squamosi* nom. corr.

Abstract

We present a summary of part of the phytogeographic results described in the author's PhD thesis. In this case, we characterise and validate several syntaxa of subsaline meadows in the *Trifolion squamosi* nom. corr. alliance (class. *Juncetea maritimi*) in Catalonia (incl. NE Spain and SE France) and in other regions of the Western Mediterranean (N Algeria, Languedoc and Provence). In total, we study six syntaxa in geobotanical terms, based on synthetic tables and factor analyses of correspondence published previously in the thesis: one alliance (*Trifolion squamosi*), two associations and three subassociations (*Agropyro-Trifolietum* subass. *typicum*, subass. *festucetosum comb. nova*, subass. *brachypodietosum nova*; *Festucetum arundinaceae*).

Izvleček

V članku predstavljamo del rezultatov fitogeografske raziskave avtorjeve doktorske naloge. Nomenklaturno smo ovrednotili subsalina travišča zveze *Trifolion squamosi* nom. corr. alliance (class. *Juncetea maritimi*) v Kataloniji (vključno z SV Španijo in JV Francijo) in ostalih delih zahodnega Sredozemlja (severna Alžirija, Languedoc in Provansa). Šest sintaksonov smo preučili geobotanično na podlagi sintetskih tabel in faktorске korespondenčne analize, objavljene v doktorski nalogi: zvezo (*Trifolion squamosi*), dve asociaciji in tri subasociacije (*Agropyro-Trifolietum* subass. *typicum*, subass. *festucetosum comb. nova*, subass. *brachypodietosum nova*; *Festucetum arundinaceae*).

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Introduction

In 2019, at the University of Girona (Catalonia, Spain), the author of this article defended his PhD thesis on hay meadows in the Mediterranean region of Catalonia (Mercadal 2019a, 2019b, 2019c). However, as that document was a monograph, the new syntaxa described are invalid, in accordance with Article 1 of the International Code of Phytosociological Nomenclature (ICPN) (Weber et al. 2000, Theurillat et al. 2020). For that reason, herein we validate and geobotanically characterise several syntaxa that include regularly mown subsaline meadows of the *Trifolion squamosi* nom. corr. alliance (class. *Juncetea maritimi*) in the Western Mediterranean, as we have done previously for other syntaxonomical units (Mercadal 2018, 2020a, 2020b, 2020c, 2020d).

Materials and Methods

We geobotanically characterised six syntaxa (one alliance, two associations and four subassociations) in the *Trifolion squamosi* nom. corr. alliance (class. *Juncetea maritimi*), presented previously in the author's PhD thesis (Mercadal 2019c: Table 120).

The study area covers the Mediterranean Biogeographic Region of NE Catalonia (incl. NE Spain and SE France), more specifically the Ruscinic territory, which includes the regions of Roussillon, Alt Empordà and Baix Empordà (Figures 1a-1b). Detailed geobotanical information on the meadows mapped in each region can be consulted in Mercadal (2019a).

We followed the traditional syngmatist phytosociological method (Braun-Blanquet 1964, 1979), as well as a synthetic classification. We compared our relevés using synthetic tables and factor analyses of correspondence with those of various related plant communities in the Western Mediterranean (N Algeria, Catalonia, Languedoc and Provence, cf. Mercadal 2019c: Table 120). In this article, we reference these analytical data and other ecological and chorological information by directly citing the thesis. We reproduce only a few maps and one table that we consider essential for understanding the text (Figures 1 and 2 & Table 1).

The syntaxonomic abbreviations used are those proposed by Mucina et al. (2016) or, failing that, those proposed by Theurillat et al. (2020); all these are listed in Mercadal (2019c).

With regard to the nomenclature of the taxa, we follow the system used in Mercadal (2019b), which basically corresponds to that found in Bolòs et al. (2005) or, failing that, the nomenclature used by Tison & Foucault

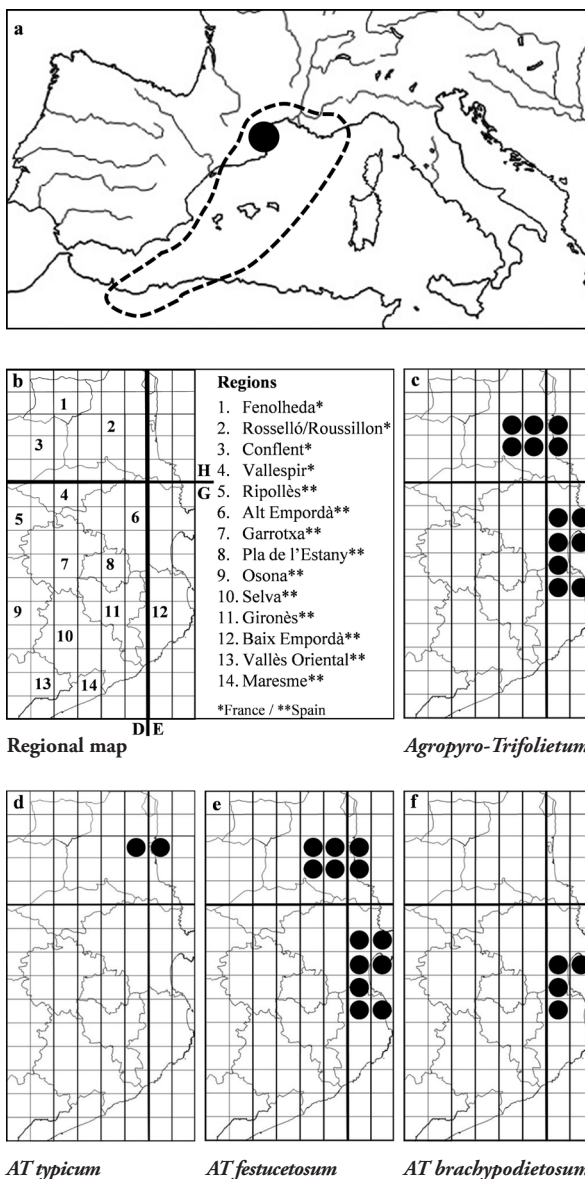


Figure 1: Location of the study area (● – incl. NE of Spain and SE of France) in the Western Mediterranean (a-b) and distribution of some syntaxa on the regional map of northeast Catalonia (c-f). Modified from Mercadal (2019c). Dashed line, relevé comparison area; map grid, UTM coordinate system (10 × 10 km) [UTM zone, 31T].

Slika 1: Lokacija preučevanega območja (● – skupaj s SV Španijo in JV Francijo) v zahodnem Sredozemlju (a-b) in razširjenost nekaterih sintaksonov na regionalnem zemljevidu SV Katalonije (c-f). Spremenjeno po Mercadal (2019c). Prekinjena črta prikazuje območje primerjave popisov; mreža je UTM koordinatni sistem (10 × 10 km) [UTM zone, 31T].

(2014) or Castroviejo (1986-2019). Exceptionally, we followed other works, which are indicated in Mercadal (2019b: Table 3).

Results and Discussion

Class. *Juncetea maritimi* Br.-Bl. in Br.-Bl., Roussine et Nègre 1952 [cf. Mercadal 2019c: 485, 2020c]

Ord. *Juncetalia maritimi* Br.-Bl. ex Horvatić 1934 [cf. Mercadal 2019c: 488, 2020c]

1. All. *Trifolium squamosi* Br.-Bl. in Br.-Bl., Roussine et Nègre 1952 nom. corr. [cf. Mercadal 2019c: 567]

Synonyms: *Trifolium maritimi* Br.-Bl. 1931 nom. inval. (Art. 2b); *Trifolium maritimi* Br.-Bl. 1932 nom. inval. (Art. 2b); *Trifolium maritimi* Br.-Bl. 1950 nom. inval. (Art. 2b); *Trifolium maritimi* Br.-Bl. ex Molinier et Tallon 1950 nom. inval. (Art. 2b); *Trifolium maritimi* Br.-Bl. in Br.-Bl. et al. 1952 nom. inept. (Art. 44); *Trifolium squamosi* Br.-Bl. ex Julve 1993 p. p. nom. inval. (Art. 2b).

Homonym: *Trifolium maritimi* Br.-Bl. ex Simonneau 1952 nom. illeg. (Art. 31). **Corresponding name:** *Trifolium squamosi* (Br.-Bl. in Br.-Bl. et al. 1952) Rivas Goday et Rivas-Mart. 1963 nom. corr. (Art. 44)

Holotypus: *Agropyro pycnanthi-Trifolietum maritimi* Br.-Bl. in Br.-Bl. et al. 1952 nom. inept. (Art. 44).

Physiognomy and floristic composition: subhalophilic and mesohydrophilous meadows, 40 to 80 (150) cm in height, typically with 100% cover. The most abundant life form corresponds to the hemicryptophytes (43%); however, the alliance stands out due to the elevated presence of therophytes (39%). Most of the plants have a Pluriregional (57%) or Mediterranean distribution (28%) (Mercadal 2019c: Figs. 253-254). The dominant taxa are, basically, leguminous plants, most of which are annual (*Trifolium squamosum*, *T. pratense*, *T. resupinatum*, *Tetragonolobus maritimus*, *Melilotus siculus*, *M. indicus*, *M. segetalis*), and perennial grasses (*Elymus athericus*, *E. campestris*, *Hordeum secalinum*, *Festuca arundinacea*, *F. interrupta*) of forage value. These plants are usually accompanied by several different taxa in the class *Juncetea maritimi* (*Carex distans*, *C. divisa*, *Limonium narbonense*, *Alopecurus bulbosus*, *Juncus compressus* subsp. *gerardi*, *J. maritimus*) and meadow species with a wide ecological spectrum (*Poa pratensis*, *P. trivialis*, *Cynodon dactylon*, *Rumex crispus*, etc.) (Mercadal 2019c: Table 138).

Characteristic and differential species: *Trifolium squamosum*, *T. resupinatum* (diff.), *Tetragonolobus maritimus* (diff.), *Melilotus siculus*, *M. indicus*, *M. segetalis*, *Medicago scutellata* (terr. charact. Languedoc), *Hordeum secalinum*, *Vicia tetrasperma* subsp. *gracilis*, *V. lutea* subsp. *lutea* var. *hirta*, *Bellevalia romana* (terr. charact. Roussillon), *Bromus commutatus* (diff.), *Sonchus asper* (diff.), *Festuca interrupta* (diff.), *Tragopogon porrifolius* (diff. Languedoc), *T. lamottei* (diff. Catalonia).

Ecology: saline or brackish land near the sea, with an alkaline pH, clay or sandy-clay texture and seasonally flooded. The saline concentration varies over the course of the year: in the rainiest periods, the salinity of the first few centimetres of soil decreases thanks to the precipitation and irrigation. On the other hand, in the summer (and during certain dry periods), the saline concentration increases, but by that time the therophytes of forage value have already wilted or been mown (Adriani 1934, Braun-Blanquet et al. 1952). Generally, the meadows are mown regularly to obtain high quality forage, although sometimes they are mown a second time, grazed, irrigated, fertilised and sown again.

Geographical distribution: Provence, Languedoc, north-east of Catalonia and North Africa (Algeria) (Figure 2). Most likely, it must also be distributed in other regions of the Western Mediterranean coast.

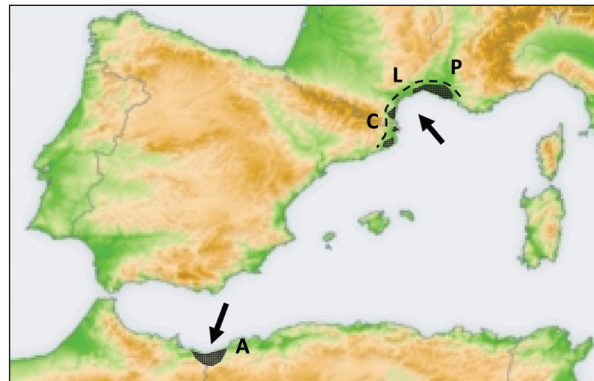


Figure 2: Distribution of the *Trifolium squamosi* alliance in the Western Mediterranean (Mercadal 2019c: Fig. 255). Dashed line, potential area of the alliance.

A, Algeria; C, Catalonia; L, Languedoc, P, Provence.

Slika 2: Razširjenost zveze *Trifolium squamosi* v zahodnem Sredozemlju (Mercadal 2019c: Fig. 255).

Prekinjena črta prikazuje potencialno razširjenost zveze. A, Alžirija; C, Katalonija; L, Languedoc, P, Provansa.

Syntaxonomy: the alliance was validated simultaneously by Braun-Blanquet et al. (1952) and Simonneau (1952), resulting in two homonyms being erected with the same date (we do not know the months in which the two papers were published). Applying Article 33 of the ICPN, we choose the correct name as being *Trifolium maritimi* Br.-Bl. in Br.-Bl. et al. 1952 and reject *Trifolium maritimi* Br.-Bl. ex Simonneau 1952, which automatically becomes an illegitimate synonym (Art. 31). Later, we correct the name of the alliance according to Article 44, since the correct name of *Trifolium maritimum* Huds. (the name used by Braun-Blanquet to de-

scribe the alliance) currently corresponds, according to all western European floras, to *Trifolium squamosum* L. (Castroviejo 1986–2019, Bolòs & al. 2005, Lambinon & Verloove 2012, Stace 2014, Tison & Foucault 2014, Pignatti & al. 2017...).

We give priority to the authorship of Br.-Bl. in Br.-Bl. et al. 1952, since their type, *Agropyro-Trifolietum* (Art. 18a) corresponds to the traditional phytosociological concept of the alliance. On the other hand, the type of the rejected name, *Trifolium maritimi* Br.-Bl. ex Simonneau 1952, is the association *Festucetum arundinaceae*, a highly artificialised plant community with a floristic composition very far removed from the classic notion of *Trifolium maritimi* nom. inapt.

On the other hand, it should be noted that Julve (1993: 90) made significant amendments to the *Trifolium maritimi* nom. inapt. alliance [sub *Trifolium squamosi* Br.-Bl. 1931 em. Julve 1993] and included in it the hygrophilous Atlantic-Mediterranean associations that Foucault & Catteau (2012) would later use to describe the alliance *Ranunculo-Oenanthion*. Moreover, Julve excluded the alliance *Trifolium maritimi* nom. inapt. from the class *Juncetea maritimi* and attributed it to the order *Eleocharietalia palustris* and to the class *Agrostio-Arrhenatheretea*; however, surprisingly, he did not include *Agropyro-Trifolietum*. In our opinion, this union of associations and the change of order and class is not very coherent in phytosociological terms, as indicated by Foucault & Catteau (2012). In fact, the change is so great that Mucina et al. (2016) interpret *Trifolium squamosi* (Br.-Bl. 1931) em. Julve 1993 as an invalid alliance different from *Trifolium maritimi* nom. inapt. [sub *Trifolium squamosi* Julve 1993].

Later, Géhu (1999) attributed *Agropyro-Trifolietum* to the alliance *Alopecurion utriculati*, to which he also added the “Prairies humides thermophiles, d’optimum méditerranéo-(sub)atlantique, souvent à tendance oligohaline”, which Julve (1993) had previously included in *Trifolium squamosi*. Julve (eVeg 2020) currently follows Géhu’s criteria [sub *Alopecurion rendlei* Zeilder 1954].

Finally, it should be noted that Mucina et al. (2016) maintained *Trifolium maritimi* nom. inapt. as an independent syntaxonomic unit, but attributed it to the order *Potentillo-Polygonetalia* and the class *Molinio-Arrhenatheretea*. In our opinion, this syntaxonomic attribution is too synthetic, with the intention of grouping together all the regularly mown Atlantic-Mediterranean brackish meadows in the same order. Along these lines, Mucina et al. (2016) consider the nitrophilous alliance *Trifolio-Cynodontion* as a syntaxonomic synonym of *Trifolium maritimi* nom. inapt., something that we do not agree with either; this led to Guarino &

Pasta (2017) attributing *Kickxio-Trifolietum* to *Trifolium maritimi* nom. inapt., despite it being a nitrophilous community belonging to *Trifolio-Cynodontion*.

Variability: within the alliance, two associations can be differentiated: *Agropyro-Trifolietum* [#1.1] and *Festucetum arundinaceae* [#1.2]. However, we also analysed the *Lino-Gaudinietum* (class. *Stipo-Agrostietea*) relevés of Franquesa (1995) due to their floristic affinity (Mercadal 2019c: Table 138 & Figs. 256–257).

1.1 Ass. *Agropyro pycnanthi-Trifolietum maritimi*
Br.-Bl. in Br.-Bl., Roussine et Nègre 1952 nom. inapt. (Art. 44) [cf. Mercadal 2019c: 581]

Synonyms: Ass. à *Trifolium maritimum* et *Agropyrum pycnanthum* Br.-Bl. 1931 nom. inval. (Art. 2b) (orig. form); Association *Trifolium maritimum-Agropyrum pycnanthum* Br.-Bl. 1932 nom. inval. (Art. 2b) (orig. form); *Trifolietum maritimi* Adriani 1934 nom. inval. (Art. 2b); *Trifolietum maritimi* Soroceanu 1936 nom. inval. (Art. 2b); Asociación *Trifolium maritimum-Agropyrum pycnanthum* Br.-Bl. 1950 nom. inval. (Art. 2b) (orig. form); *Trifolietum maritimi* Molinier et Tallon 1950 nom. inval. (Art. 2b); *Trifolietum maritimi* Br.-Bl. 1951 nom. inval. (Art. 2b); *Agropyreto-Trifolietum maritimi* Br.-Bl. in Br.-Bl. in al. 1952 (orig. form) [sub *Agropyreto-Trifolietum maritimi* Br.-Bl. 1931; Ass. à *Trifolium maritimum* et *Agropyrum pycnanthum* (*acutum*) Br.-Bl. 1931].

Neotypus hoc loco designatus: Mercadal (2019c), unpublished PhD thesis, Table 147, rel. 6, p. 603 (France, Catalonia, Roussillon, Sant Nazari, 1 m, 31TDH9924, 31.04.2017). Plot size, 100 m²; height, 40 cm; total cover, 100%: *Hordeum secalinum* 1.1, *Trifolium squamosum* 3.3, *T. pratense* 1.1, *Festuca interrupta* 1.1, *Melilotus segetalis* 1.1, *M. siculus* 3.3, *M. indicus* 1.1, *Sonchus asper* +, *Tragopogon lamottei* +, *Vicia tetrasperma* subsp. *gracilis* +, *V. lutea* subsp. *lutea* var. *hirta* +, *V. segetalis* +, *Bellevalia romana* +, *Elymus athericus* 2.2, *E. campestris* 1.1, *Carex divisa* 2.2, *C. distans* 1.1, *C. flacca* +, *Narcissus tazetta* subsp. *tazetta* +, *Alopecurus bulbosus* 1.2, *Scorzonera laciniata* +, *Plantago crassifolia* +, *Orchis palustris* +, *Phragmites australis* 1.1, *Bromus hordeaceus* subsp. *hordeaceus* +, *Gaudinia fragilis* +, *Linum usitatissimum* subsp. *angustifolium* +, *Picris echioides* +, *Althaea officinalis* +, *Bellis perennis* +, *Galactites tomentosa* +, *Lathyrus aphaca* +, *Ophrys apifera* +, *Poa pratensis* subsp. *angustifolia* +, *Sherardia arvensis* +.

Physiognomy and floristic composition: subhalophilic and mesohygrophilous meadows, 40 to 80 (150) cm in height, dominated by *Festuca* gr. *arundinacea*, *Trifolium squamosum*, *Tetragonolobus maritimus*, *Hordeum secalinum*, *Bromus hordeaceus* subsp. *hordeaceus* or

Melilotus siculus. These plants are accompanied by several species characteristic of the class *Juncetea maritimi* (*Limonium narbonense*, *Carex divisa*, *C. distans*, *Juncus compressus* subsp. *gerardi*, *Alopecurus bulbosus*, *Festuca interrupta*, *Elymus athericus*, etc.), which are abundant to varying degrees depending on the level of soil moisture. Halophytes are more frequent in more natural and saline meadows; on the other hand, in meadows where there is greater human activity (well irrigated and fertilised), different taxa of *Molinio-Arrhenatheretea* are more frequent, such as *Poa trivialis*, *Holcus lanatus*, *Dactylis glomerata*, and so on (Mercadal 2019c: Tables 138, 144).

Floristically, the association is moderately rich (24 taxa/rel. on average) and has a high percentage of hemicryptophytes (42%) and therophytes (40%). The taxa are mainly Pluriregional (57%) or Mediterranean (28%) (Mercadal 2019c: Figs. 262, 264).

Characteristic and differential species: *Trifolium squamosum*, *Melilotus siculus*, *M. indicus*, *M. segetalis*, *Medicago scutellata* (terr. charact. Languedoc), *Hordeum secalinum*, *Vicia tetrasperma* subsp. *gracilis*, *V. lutea* subsp. *lutea* var. *hirta*, *Bellevalia romana* (terr. charact. Roussillon), *Tragopogon porrifolius* (diff. Languedoc), *T. lamottei* (diff. Catalonia), *Festuca interrupta* (diff.), *Bromus commutatus* (diff.), *Elymus athericus* (Link) Kerguelen [= *Agropyrum pycnanthus* (Godr.) Gren. et Godr. and probably *A. acutum* (DC.) Roem. et Schult.] (diff.).

Ecology: subsaline soils in the Mediterranean coastal region, with a clay or sandy-clay texture, alkaline and seasonally flooded. The meadows are mown and grazed regularly, although sometimes they are also irrigated, fertilised or resown.

Geographical distribution: well-known association of the western European Mediterranean: Provence (Camargue), Languedoc (around Montpellier) and Catalonia (plains of Roussillon and Empordà). Most likely, the association must also be developed by the wetlands of Narbonne and Sérignan (Languedoc). In Catalonia, it is quite widespread along the Ruscinic coast, between 0–16 (85) m of altitude (Figure 1c & Mercadal 2019c: Fig. 267).

Syntaxonomy: association validated in Braun-Blanquet et al. (1952: 121) through the publication of a synthetic relevé based on 29 unpublished association relevés from the Languedoc coastal region. For this reason, we designate as a neotype one of our own relevés from Roussillon, a little over 100 km from the association's *locus classicus*. Although the name of the association is a *nomen ineptum*, we did not correct it according to article 44 because we are not 100% sure what the cor-

rect name is for *Agropyrum pycnanthus* (Godr.) Gren. et Godr. nor from *A. acutum* (DC.) Roem. et Schult. (Tison & Foucault 2014: 232–234, E. Rico pers. commun.), the two names that Braun-Blanquet used to describe *Agropyro-Trifolietum* (cf. synonyms). In this case, the name must be submitted to the Committee for Change and Conservation of Names (CCCN) for a final decision. However, in our opinion, the taxon would correspond to *Elymus athericus* (cf. Mercadal 2019b: 763) and the correct name of the association would be *Elymo atherici-Trifolietum squamosi*.

Affinities: *Agropyro-Trifolietum* presents certain floristic affinities with several associations.

- With the *Oenantho-Gaudinion* alliance (*Geranio-Festucetum* subass. *caricetosum* and *Gaudinio-Arrhenatheretum* subass. *lotetosum*). *Agropyro-Trifolietum* constitutes a bridge association between the salt meadows of the order *Juncetalia maritimi* and the non-saline meadows of the order *Trifolio-Hordeetalia*, and for this reason shares several species with the *Oenantho-Gaudinion* associations that can withstand slightly saline soils (*Trifolium squamosum*, *Hordeum secalinum*, *Bromus commutatus*, *Gaudinia fragilis*, *Linum usitatissimum* subsp. *angustifolium*, etc.); however, these are generally easy to differentiate due to an elevated presence of halophytes.
- With *Lino-Gaudinietum*, an association endemic to Cap de Creus (Alt Empordà, NE Catalonia) dominated by *Gaudinia fragilis* and *Linum usitatissimum* subsp. *angustifolium*. This slightly brackish small meadow is characterised by several small clover species (*Trifolium nigrescens*, *T. dubium*, *T. micranthum*, *T. strictum*) and by *Agrostis capillaris* s.l. It grows in small depressions in siliceous soils that are seasonally flooded and periodically sprayed by droplets of wind-borne sea water. Its phytosociological attribution is complex, as indicated by Franquesa (1995). Franquesa gave priority to the annual calcifuge taxa and attributed the association to the class *Tuberarietea guttatae*, as a transitional community towards *Molinio-Arrhenatheretea*. However, she also saw affinities with *Agrostion salmanticae* (class. *Isoëto-Nanojuncetea*) from Extremadura (SW Spain). On the other hand, Rivas-Martínez et al. (2001, 2011) attributed *Lino-Gaudinietum* to the alliance *Agrostion castellanae* (ord. *Agrostietalia castellanae*, class. *Stipo-Agrostietea*).

In our opinion, *Lino-Gaudinietum* is a transitional community between *Agrostion castellanae* and *Trifolium squamosi*, as shown by Mercadal (2019c: Table 138). However, due to its particular ecology (small calcifuge meadows), the low presence of taxa in the

class *Juncetea maritima*, and its unique floristic composition (with several acidophilic taxa), we will keep it within *Agrostion castellanæ*.

- With the association *Trifolietum nigrescenti-resupinati* described in the Camargue (Provence) and dominated and characterised by *Trifolium resupinatum*, *T. nigrescens*, *T. ornithopodioides* and *T. campestris* (Molinier & Tallon 1949, 1950, 1968). These slightly brackish small meadows contain several taxa in the class *Juncetea maritimi* (*Limonium narbonense*, *Atriplex portulacoides*, *Trifolium squamosum*, *Elymus athericus*), meaning that they are similar in floristic terms to the alliance *Trifolion squamosi* (Molinier & Tallon 1950), constituting a transitional association between *Trifolion squamosi* and *Trifolio-Cynodontion*. However, the lack of halophytes typical of *Trifolion squamosi* leads us to attribute it to *Trifolio-Cynodontion*, as proposed by Foucault & Catteau (2012).

Variability: within the association we distinguish three associations according to the edaphic characteristics and the agricultural practices (Mercadal 2019c: Tables 138, 144 & Fig. 268): subass. *typicum* [#1.1.1], subass. *festucetosum comb. nova* [#1.1.2] and subass. *brachypodietosum subass. nova* [#1.1.3].

1.1.1 Ass. *Agropyro-Trifolietum* subass. *typicum* [cf. Mercadal 2019c: 598]

Physiognomy and floristic composition: subhalophilic meadow, ranging from mesohydrophilous to hydrophilous, 40 to 80 (150) cm in height, dominated by leguminous plants (*Trifolium squamosum*, *T. resupinatum*, *Melilotus siculus*, *M. indicus*, *Melilotus segetalis*) and grasses of forage value (*Elymus athericus*, *E. campestris*, *Festuca interrupta*, *F. arundinacea*). These plants are generally accompanied by different taxa of the class *Juncetea maritima*: *Limonium narbonense*, *Scorzonera laciniata*, *Alopecurus bulbosus*, *Carex divisa*, *Tetragonolobus maritimus*, *Juncus compressus* subsp. *gerardi*, *J. maritimus*, etc. (Mercadal 2019c: Table 147).

Differential species: *Melilotus siculus*, *M. indicus*, *Medicago scutellata* (terr. diff. Languedoc), *Festuca interrupta*, *Elymus athericus*, *Orchis palustris*, *O. ×lloydiana*.

Ecology: land next to the sea, often surrounded by marshes. This is the most salinised subassociation (ranging from slightly to moderately saline), which occurs on alkaline soils, with a clay loam texture, high humidity and a variable carbonate content (low in the Roussillon region and high in the Languedoc region). The meadows are mown and grazed regularly, and they flood naturally each year (Table 1).

Table 1: Differential floristic, ecological and chorological characteristics of the *Agropyro-Trifolietum* (AT) subassociations. The soil data correspond to the study area.

Tabela 1: Razlikovalne floristične, ekološke in horološke značilnosti subasociacij asociacije *Agropyro-Trifolietum* (AT). Podatki o tleh veljajo za preučevano območje.

Characteristics	<i>AT typicum</i>	<i>AT festucetosum</i>	<i>AT brachypodietosum</i>
Differential species	<i>Melilotus siculus</i> , <i>M. indicus</i> , <i>Medicago scutellata</i> , <i>Festuca interrupta</i> , <i>Elymus athericus</i> , <i>Orchis palustris</i> , <i>O. ×lloydiana</i>	<i>Poa trivialis</i> subsp. <i>trivialis</i> , <i>Lotus corniculatus</i> subsp. <i>corniculatus</i> , <i>Agrostis stolonifera</i> , <i>Holcus lanatus</i> , <i>Oenanthe fistulosa</i> , <i>Polypogon monspeliensis</i> , <i>Ranunculus sardous</i> , <i>Leontodon taraxacoides</i> subsp. <i>taraxacoides</i>	<i>Brachypodium phoenicoides</i> , <i>Avena barbata</i> , <i>Inula viscosa</i> , <i>Hypochoeris radicata</i> , <i>Rubus ulmifolius</i> , <i>Cirsium vulgare</i> , <i>Ophrys apifera</i> subsp. <i>apifera</i> , s.l., <i>Lychnis flos-cuculi</i> , <i>Leontodon orobanche</i> <i>crenata</i> , <i>Anacamptis pyramidalis</i> , <i>Barlia robertiana</i>
pH 1 : 2.5 H₂O	7.8-9.9 [8.8]	7.6-9.0 [8.0]	7.7-9.5 [8.4]
Ground conductivity 1 : 5 25 °C (µS/cm)	No data (> <i>ATf</i>)	249.2-1842.7 [741.2]	165.1-668.6 [345.8]
Total carbonate content (%)	Slightly saline-moderate saline soils 0.0-3.0 [1.3] (Languedoc: 17.0-40.0%)	Slightly saline soils 0.0-2.7 [0.6]	Non saline-slightly saline soils 15.1-32.0 [23.6]
Organic matter (%)	1.3-3.6 [2.5]	1.6-5.2 [3.6]	1.3-5.8 [3.2]
Soil texture (ISSS)	Sandy clay loam	Clay	Sandy clay
Soil moisture (%)	No data (≥ <i>ATf</i>) (hydrophilous to mesohydrophilous meadows)	14.0-35.4 [26.6] (mesohydrophilous meadows)	13.7-25.1 [20.9] (mesohydrophilous to mesophilic meadows)
Agricultural activities	Mowing and grazing	Mowing, grazing, fertiliser, sowing and irrigation	Mowing and grazing
Geographical distribution	Languedoc-Roussillon coast	Provençal-Catalan coast	Empordà plain (Catalonia)

ISSS, International Society of Soil Science; in square brackets, the mean.

Geographical distribution: we only know this sub-association around Montpellier (Languedoc) and the Roussillon plain; however, it must be distributed along the coast of the Gulf of Leon, from Provence to Roussillon. In the study area, we only observed it in the lake of Sant Nazari (Roussillon), between 0-1 m of altitude, but it is necessary to prospect more the plain of the Empordà (Figure 1d; Mercadal 2019c: Fig. 272).

Syntaxonomy: autonym that we create automatically in order to attribute new subassociations to *Agropyro-Trifolietum*. The authorship, year of publication and nomenclature type coincide with the data relating to the association.

Variability: in the study area, we can distinguish two variants and different facies in a similar manner to Braun-Blanquet et al. (1952) in Languedoc. The var. *Trifolium squamosum*, the type, (Mercadal 2019c: Table 147, rel. 1-9), which can represent several facies in accordance with the dominant plant (f. *Trifolium squamosum*, f. *Hordeum secalinum*, f. *Bromus hordeaceus* s. str., f. *Tetragonolobus maritimus*); and the var. *Melilotus siculus*, a grouping that is more salinised and floristically more impoverished (Mercadal 2019c: Table 147, rel. 10-11).

1.1.2 Ass. *Agropyro-Trifolietum* subass. *festucetosum arundinaceae* (Molinier et Tallon 1968) Mercadal comb. nova hoc loco [cf. Mercadal 2019c: 608]

Basionym: *Arrhenatheretum elatioris* Braun 1915 subass. *festucetosum arundinaceae* Molinier et Tallon 1968 [sub Arrhénathéraie sous-association à *Festuca arundinacea* = *Arrhenatheretum* Molinier & Tallon 1968 nom. illeg. (Art. 31) subass. *festucetosum* Molinier et Tallon 1968]. **Synonyms:** *Gaudinio-Arrhenatheretum* Br.-Bl. in Br.-Bl. et al. 1952 subass. *festucetosum* (Molinier et Tallon 1968) Gesti 2000 p. max. p. comb. ined. (Art. 1) [sub *Gaudinio-Arrhenatheretum* Br.-Bl. 1931 subass. *festucetosum* Molinier et Tallon 1970]; *Gaudinio-Arrhenatheretum* Br.-Bl. in Br.-Bl. et al. 1952 subass. *festucetosum* (Molinier et Tallon 1968) Gesti 2006 p. max. p. comb. inval. (Art. 3i) [sub *Gaudinio-Arrhenatheretum* Br.-Bl. 1931 subass. *festucetosum* Molinier et Tallon 1970]; *Agropyro-Trifolietum* Br.-Bl. in Br.-Bl. et al. 1952 subass. *festucetosum arundinaceae* (Molinier et Tallon 1968) Mercadal 2019 comb. ined. (Art. 1) [sub *Agropyro-Trifolietum* Br.-Bl. ex Br.-Bl. et al. 1952 subass. *festucetosum arundinaceae* (Molinier et Tallon 1970) Mercadal 2019]. **Corresponding names:** *Lino biennis-Festucetum arundinaceae* Dubuis et Simonneau ex Julve 1993 prov. nom. inval. (Art. 3b); *Lino biennis-Festucetum arundinaceae* Dubuis et Simonneau ex de Foucault in de Foucault et Catteau 2012; *Dorycnio*

gracilis-Festucetum arundinaceae (Molinier et Tallon 1968) de Foucault in de Foucault et Catteau 2012 [sub *Dorycnio gracilis-Festucetum arundinaceae* (Molin. et Devaux 1978) de Foucault in de Foucault et Catteau 2012 nom. illeg. (Art. 31)]. **Other denominations:** “Prairies à *Festuca arundinacea*” (Molinier & Tallon 1968); “Groupement à *Festuca arundinacea* Schreb.” (Dubuis & Simonneau 1968).

Lectotypus: Molinier & Tallon (1968), Table VI, rel. 2 (p. unnumbered) [sub Arrhénathéraie sous-association à *Festuca arundinacea*]; designated in Foucault et Catteau (2012: 67) [sub *Dorycnio-Festucetum* (Molin. et Devaux 1978) de Foucault in de Foucault et Catteau 2012].

Physiognomy and floristic composition: subhalophilic and mesohygrophilous meadow, 40 to 120 cm in height, dominated by *Festuca arundinacea* and with an elevated presence of the association's characteristic and differential species (*Trifolium squamosum*, *Hordeum secalinum*, *Bromus commutatus*, *Vicia tetrasperma*, *V. lutea*, *Tragopogon lamottei*, *Sonchus asper*, *Oenanthe lachenalii*, *Bellevalia romana*). The only taxa generally absent are the more exclusive ones, typical of more saline soils: *Melilotus siculus*, *Medicago scutellata*, *Elymus athericus*, *Festuca interrupta*, *O. palustris*, *O. ×lloydiana*. The differential taxa of the subass. *festucetosum* (cf. diff. species) are, after our amendment, common plants in the order *Trifolio-Hordeetalia* that withstand brackish soils.

Differential species: *Poa trivialis* subsp. *trivialis*, *Lotus corniculatus* subsp. *corniculatus*, *Agrostis stolonifera*, *Holcus lanatus*, *Oenanthe fistulosa*, *Polygomon monspeliensis*, *Ranunculus sardous* s.l., *Lychnis flos-cuculi*, *Leontodon taraxacoides* subsp. *taraxacoides*.

Ecology: soils that are slightly saline, clay and alkaline with a low carbonate content and often seasonally flooded (spring and autumn). During dry periods, the concentration of salt increases, which selects the plant population. For this reason, in the past, most meadows were intensively irrigated and fertilised (Dubuis & Simonneau 1968, Voelckel 1977). At present, the meadows are mown, grazed and sometimes remown, irrigated, fertilised and resown (Table 1).

Geographical distribution: Camargue (Provence) and the plains of Roussillon and Empordà (Catalonia). Probably also it distributed in the wetlands of Montpellier and Narbonne. In the study area, it is quite widespread along the Ruscinic coast, from the sea level to an altitude of 16(85) m (Figure 1e & Mercadal 2019c: Fig. 282).

Syntaxonomy: we attribute to this new combination the regularly mown subhalophilic and mesohygrophili-

lous meadows dominated by *Festuca arundinacea* from the Catalan-Provençal coast (Molinier & Tallon 1968, 1970, Dubuis & Simonneau 1968, Molinier & Deveaux 1978, Voelckel 1977, Watt & Vilar 1997, Gesti 2006, Mercadal 2019c). The syntaxon was validly described by Molinier & Tallon (1968: Table VI) as "Arrénathéraie sous-association à *Festuca arundinacea*", since on page 445 it is clear that the French name "Arrénathéraie" corresponds explicitly to the association *Arrhenatheretum* Molinier & Tallon 1968; an illegitimate homonym (Art. 31) of the *Arrhenatheretum* Braun 1915, but which also allows to validate the subassociation *festucetosum* Molinier & Tallon 1968 (Art. 30b). Molinier & Tallon (1968) published in Table VI 10 relevés, but in that case the type was not indicated. Later, after receiving other names (cf. synonyms), Foucault & Catteau (2012) characterized two associations: one to include the Camargue relevés by Molinier & Tallon (1968) [*Dorycnio-Festucetum*], and another for the Roussillon relevés published by Dubuis & Simonneau (1968) [*Lino-Festucetum*]. Moreover, for each syntaxon, they chose a type. However, Foucault & Catteau (2012: 67) qualified *Dorycnio-Festucetum* as a new association, despite the fact that it corresponds to a change in rank (*stat. novus*).

However, according to our results (Mercadal 2019c: Table 144 & Fig. 268), both syntaxa correspond to the subassociation *festucetosum* Molinier & Tallon 1968, which we transfer from *Arrhenatheretum* to *Agropyro-Trifolietum*, and we define several new differential species.

Finally, it should be noted that Delbosc et al. (2015) cited the association *Lino-Festucetum* Dubuis et Simonneau ex de Foucault in de Foucault et Catteau 2012 [= *Agropyro-Trifolietum* subass. *festucetosum*] from the Asco Valley, in northern Corsica. However, the Asco Valley is located at altitudes of between 200–2076 m, and the *Agropyro-Trifolietum* subass. *festucetosum* grows near the coast, at altitudes of between 0–85 m. Therefore, it is probably another different syntaxon of *Agropyro-Trifolietum* subass. *festucetosum*, and might correspond to a community in the *Oenantho-Gaudinion* alliance. Nevertheless, *Agropyro-Trifolietum* could grow on the coasts of Corsica.

Variability: in Catalonia, we can distinguish different facies in accordance with the dominant plant that accompanies *Festuca arundinacea*, such as: f. *Bromus commutatus* (brackish and very wet areas), f. *Bromus hordeaceus* (areas that are disturbed, nitrophilous, often grazed or fertilised) or f. *Hordeum secalinum* (more saline areas, which are often flooded naturally; this is the form closest to the subass. *typicum*).

1.1.3 Ass. *Agropyro-Trifolietum* subass. *brachypodietosum phoenicoidis* subass. *nova hoc loco* [cf. Mercadal 2019c: 627]

Synonyms: *Gaudinio-Arrhenatheretum* Br.-Bl. in Br.-Bl. et al. 1952 subass. *festucetosum* (Molinier et Tallon 1968) Gesti 2000 p. min. p. comb. ined. (Art. 1); *Gaudinio-Arrhenatheretum* Br.-Bl. in Br.-Bl. et al. 1952 subass. *festucetosum* (Molinier et Tallon 1968) Gesti 2006 p. min. p. comb. inval. (Art. 3i); *Agropyro-Trifolietum* Br.-Bl. in Br.-Bl. et al. 1952 subass. *brachypodietosum phoenicoidis* Mercadal 2019 nom. ined. (Art. 1).

Holotypus hoc loco designatus: Mercadal (2019c), unpublished PhD thesis, Table 145, rel. 1, p. 629 (Spain, Catalonia, Alt Empordà, Sant Pere Pescador, 2 m, 31TEG0871, 28.04.2004). Plot size, 100 m²; height, 45 cm; total cover, 100%: *Tetragonolobus matirimus* +, *Tragopogon lamottei* +, *Vicia tetrasperma* subsp. *gracilis* +, *Brachypodium phoenicoides* 2.2, *Avena barbata* +, *Inula viscosa* 1.1, *Ophrys apifera* subsp. *apifera* +, *O. scolopax* subsp. *scolopax* +, *Anacamptis pyramidalis* +, *Barlia robertiana* +, *Elymus campestre* 2.2, *Centaureum pulchellum* subsp. *tenuiflorum* +, *Festuca arundinacea* subsp. *arundinacea* 3.4, *Dactylis glomerata* subsp. *glomerata* +, *D. glomerata* subsp. *hispanica* +, *Lathyrus hirsutus* +, *Linum usitatissimum* subsp. *angustifolium* 1.2, *Trifolium pratense* 2.2, *T. dubium* +, *T. campestre* +, *Daucus carota* subsp. *carota* 1.2, *Equisetum ramosissimum* subsp. *ramosissimum* 1.1, *Hypochaeris radicata* +, *Plantago lanceolata* +, *Geranium dissectum* +, *Bromus hordeaceus* subsp. *hordeaceus* +, *Medicago sativa* subsp. *sativa* 1.2, *M. polymorpha* subsp. *polymorpha* +, *Poa pratensis* subsp. *pratensis* 1.1, *P. bulbosa* +, *Phragmites australis* +, *Aster pilosus* +, *Sherardia arvensis* +, *Bellis perennis* 1.1, *Gaudinia fragilis* +, *Galium verum* subsp. *verum* 1.1, *Crepis vesicaria* subsp. *taraxacifolia* +, *Myosotis ramosissima* subsp. *ramosissima* +, *Orobanche minor* +, *Ranunculus bulbosus* +, *Aristolochia rotunda* +, *Bellardia trixago* +, *Reichardia picroides* +, *Serapias lingua* +, *Valerianella microcarpa* +, *Schoenus nigricans* +, *Carex flacca* 1.2, *Cerastium glomeratum* +, *Scabiosa atropurpurea* 1.1, *Urospermum delachampii* +.

Physiognomy and floristic composition: subhalophilic meadow, mesohydrophilous to mesophilic, 45 to 120 cm in height, characterised floristically by the low presence of plants related to the association and the upper units. The only species belonging to the association that appear regularly are: *Tragopogon lamottei* (diff.), *Vicia tetrasperma* subsp. *gracilis*, *Trifolium squamosum* and *Hordeum secalinum*. The differentials of the subassociation are herbaceous plants from mesophilic meadows or relatively disturbed areas and some calcicolous orchids (cf. diff. species).

Plants typical of *Brachypodium phoenicoidis* are typical there, since the subass. *brachypodietosum* comprises a transition towards *Brachypodietalia phoenicoidis*. Thus, apart from *Brachypodium phoenicoides*, the following plants are more or less common: *Elymus campestris*, *Urospermum delachampii*, *Picris hieracioides* subsp. *hieracioides*, *Foeniculum vulgare* subsp. *piperitum* and *Scabiosa atropurpurea* (Mercadal 2019c: Table 155).

Differential species: *Brachypodium phoenicoides*, *Avena barbata*, *Inula viscosa*, *Hypochaeris radicata*, *Rubus ulmifolius*, *Cirsium vulgare*, *Ophrys apifera* subsp. *apifera*, *Orobanchae crenata*, *Anacamptis pyramidalis*, *Barlia robertiana*.

Ecology: land only slightly saline during dry periods, with a sandy-clay texture, alkaline, with a high carbonate content and rarely flooded. The meadows are essentially only mowed and/or grazed, whilst other agricultural activities are rare (Table 1).

Geographical distribution: Empordà plain, between 0–4 (16 m) of altitude (Figure 1f & Mercadal 2019c: Fig. 289).

1.2 Ass. *Festucetum arundinaceae* Simonneau 1952 [cf. Mercadal 2019c: 578]

Synonym: Ass. à *Festuca arundinaceae* Simonneau 1952 (orig. form) [sub Ass. à *Festuca arundinacea* Simonneau 1950].

Lectotypus hoc loco designatus: Simonneau (1952), Table 23, rel. VI (p. unnumbered).

Physiognomy and floristic composition: mesohygrophilous meadow 100 cm in height clearly dominated by *Festuca arundinacea*, which is usually accompanied by *Juncus maritimus*, *Trifolium resupinatum*, *T. squamosum*, *Melilotus* gr. *sulcatus* (probably *M. segetalis*), *Hordeum maritimum*, *Polypogon monspeliensis* and *Bolboschoenus maritimus*). Floristically, the association is poor (11 taxa/rel. on average) and contains a high percentage of therophytes (71%). All the taxa are Pluriregional (71%) or Mediterranean (29%) (Mercadal 2019c: Table 138 & Fig. 238).

Characteristic and differential species: *Trifolium resupinatum*, *Medicago intertexta* subsp. *ciliaris*, *Centaureum spicatum*, *Leontodon maroccanus* (diff.).

Ecology: subsaline soils (sodium-calcareous solonchaks containing 2 to 4 g/kg of salts in the surface horizon) with a silty-clay texture, intensely irrigated, sown, fertilised, mowed and grazed (Simonneau 1952, Dubuis & Simonneau 1957).

Geographical distribution: in 1950, it occupied several thousand hectares on the Maca plain, near Oran, in northern Algeria (Simonneau 1952). It is probably distributed in other regions of North Africa.

Syntaxonomy: Simonneau (1952) published 10 relevés of the association, but he did not indicate the nomenclature type. Therefore, we specify it in this article. Moreover, the intense agricultural activity makes its phytosociological attribution difficult. The presence of *Trifolium squamosum*, *Melilotus siculus* and several halophytes, as well as the ecology of the association, leads us to attribute *Festucetum* to *Trifolium squamosi*. In any case, new relevés need to be made, particularly in less heavily worked meadows, to find out how variable these are and to enable us to attribute this syntaxon accurately.

Syntaxonomic schema

Class. *Juncetea maritimi* Br.-Bl. in Br.-Bl., Roussine et Nègre 1952

Ord. *Juncetalia maritimi* Br.-Bl. ex Horvatić 1934

All. *Trifolium squamosi* Br.-Bl. in Br.-Bl., Roussine et Nègre 1952 nom. corr. [#1]

Ass. *Agropyro pycnanthi-Trifolietum maritimi* Br.-Bl. in Br.-Bl., Roussine et Nègre 1952 nom. inept. [#1.1]

subass. *typicum* [#1.1.1]

subass. *festucetosum arundinaceae* (Molinier et Tallon 1968) Mercadal *comb. nova hoc loco* [#1.1.2]

subass. *brachypodietosum phoenicoidis subass. nova hoc loco* [#1.1.3]

Ass. *Festucetum arundinaceae* Simonneau 1952 [#1.2]


Other syntaxa quoted in the text

Agrostietalia castellanæ Rivas Goday in Rivas-Mart., Costa, Castroviejo et E. Valdés 1980; *Agrostio stoloniferae-Arrhenatheretea elatioris* (Tüxen 1937 em. 1970) de Foucault 1984 nom. ined. (Art. 1) [= *Molinio-Arrhenatheretea*]; *Agrostion castellanæ* Rivas Goday 1958 corr. Rivas Goday et Rivas-Mart. 1963; *Agrostion salmanticae* Rivas Goday 1958; *Alopecurion utriculati* Zeidler 1954 [= *Molinio-Hordeion secalini* Horvatić 1934]; *Brachypodietalia phoenicoidis* Br.-Bl. ex Molinier 1934; *Brachypodium phoenicoidis* Br.-Bl. ex Molinier 1934; *Eleocharietalia palustris* de Foucault 1984 nom. ined. (Art. 1) [= *Deschampsietalia cespitosae* Horvatić 1958]; *Gaudinio fragilis-Arrhenatheretum elatioris* Br.-Bl. in Br.-Bl. et al. 1952 subass. *lotetosum preslii* Donker et Stevelink ex Mercadal 2020; *Geranio dissecti-Festucetum arundinaceae* (O. Bolòs 1959) Mercadal 2020 subass. *caricetosum distantis* Mercadal 2020; *Isoëto-Nanojuncetea* Br.-Bl. et Tx. in Br.-Bl. et al. 1952; *Kickxio commutatae-Trifolietum bocconei* Brullo

et Marcenò 1985; *Lino biennis-Gaudinietum fragilis* Franquesa 1995; *Molinio-Arrhenatheretea* Tx. 1937; *Oenanthe pimpinelloidis-Gaudinietum fragilis* Mercadal 2020; *Potentillo-Polygonetalia avicularis* Tx. 1947; *Ranunculo ophioglossifolii-Oenanthion fistulosae* de Foucault in de Foucault et Catteau 2012; *Stipo giganteae-Agrostietea castellanae* Rivas-Mart., Fernández-González et Loidi 1999; *Trifolietum nigrescenti-resupinati* Molinier et Tallon 1968; *Trifolio fragiferi-Hordeetalia secalini* Horvatić 1963; *Trifolio fragiferi-Cynodontion dactylonis* Br.-Bl. et O. Bolòs 1958; *Tuberarietea guttatae* Rivas Goday et Rivas-Mart. 1963.

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