

The coastal sandy therophytic communities (*Linarion pedunculatae*) in Iberian Peninsula and Northern Africa (Morocco and Algeria)

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Abstract

Therophytic plant communities that develop on western and southern coastal sands of the Iberian Peninsula and Northern Africa (Morocco and Algeria) have been studied. Asyntaxonomical revision and chorology of the *Linarion pedunculatae* was made using the Braun-Blanquet methodology and multivariate analysis (Correspondence Analysis). A new association (*Loto arenarii-Linarietum arenicolae*) is described for the Atlantic coast of Morocco.

Keywords: *Cutandietalia maritimae*, dunes, Northern Africa, Phytosociology.

Resumen

Se estudian las comunidades de terófitos efímeros de playas y dunas del sur y oeste de la Península Ibérica así como las correspondientes al Norte de África (Marruecos y Argelia). Se presentan los resultados de la revisión sintaxonómica y corológica de *Linarion pedunculatae* aplicando la metodología fitosociológica de Braun-Blanquet y análisis multivariable de componentes principales. Se describe una nueva asociación (*Loto arenarii-Linarietum arenicolae*) para las costas atlánticas de Marruecos.

Palabras clave: *Cutandietalia maritimae*, dunas, Fitosociología, Norte de África.

Introduction

The ephemeral terophytes developed on sandy coasts support the movement of the sand caused by the wind and an important degree of salinity due to their proximity to the sea. Under such conditions the vegetation is poor in taxa and has a degree of low covering (<30%). It occupies biotopes adjacent to the mobile dunes with *Ammophila ar enari* subsp. *australis* communities (*Ammophilion australis*) and to the semi-fixed dunes communities (*Crucianelletalia maritimae*).

This vegetation is distributed along the coast of the Iberian Peninsula, from Galicia to Almería (Díez-Garretas *et al.*, 1978; Rivas-Martínez *et al.*, 1980; Díez-Garretas, 1984; Izco *et al.*, 1988; J.C. Costa *et al.*, 1994), although some authors extend its chorology to the coasts of Valencia (Peinado *et al.*, 1985; Alcaraz *et al.*, 1998). The presence of this alliance on the coasts of Northern Africa (Morocco and Algeria) has been pointed out by Díez-Garretas *et al.* (*op. cit.*) and Rivas-Martínez *et al.* (*op. cit.*), however there are not many published data (Géhu & Sadki, 1995).

One of the characteristic taxa of these communities, *Linarion pedunculata*, is an Iberian-North African endemism that lives on the coastal sands in the west and south of the Iberian Peninsula, north Morocco and Algeria (Viano, 1978). Besides the var. *pedunculata*, the var. *lutea* Maire, with yellow corolla cited in Algeria, Morocco (Tingitana Peninsula) and Almería (Spain) has

been described. Moreover, it has not been recognized as such by some authors (Valdés, 1987).

The aim of this study is to establish a syntaxonomical revision of this vegetation type using all the available data with the help of multivariate analysis methods and in accordance with the regulations of the Code of Phytosociological Nomenclature (Weber *et al.*, 2000).

Material and methods

The plant communities have been studied according to the Braun-Blanquet method (1979). The concept of subassociation and variant follow Braun-Blanquet (*op. cit.*) and Géhu & Rivas-Martínez (1981). So, the division in subassociations reflect the geographic, bioclimatic and/or edaphic differences discriminated by differential species, whereas the successional contacts with other formations are considered as variants.

All the relevés supplied by the literature, together with the new ones reported by us, constitute the data set of 104 relevés that we will use to prepare a synthetic table according to phytosociological methodology (Tab. 1).

We have made statistical analyses of Tab. 1 in order to improve the manual classification: synthetic relevés were treated as OSUs (operational syntaxonomical units). A five-step scale of frequency was used even when the number of relevés of the original table was lower than five (Escudero & Pajaron, 1994). We have

carried out a unimodal approach based on CA following the suggestions of Ter Braak & Prentice (1988).

Biogeographic and bioclimatic typologies follow Rivas-Martínez (1987) and Rivas-Martínez *et al.* (2002).

The nomenclature of the taxa follow the Catalogue des plants de Maroc (Jahandiez & Maire, 1931-34), Flore de l'Afrique du Nord (Maire, 1953-87), Flora Europaea (Tutin *et al.*, 1964-93) and Flora Iberica (Castroviejo *et al.*, 1986-97).

Tab. 1. Synthetic Table of *Linarion pedunculatae* communities in the Iberian Peninsula and North Africa

Column number	1	2	3	4	5	6	7	8	9	10	11	12
Number of relevés	15	4	1	5	8	12	7	15	13	5	9	10
Differential taxa of ass. and subass.												
<i>Linaria pedunculata s.l.</i>	5	.	1	3	2	.	.	.	.	3	.	.
<i>Linaria mumbyana</i> var. <i>pygmaea</i>	.	4	.	.	.	.	.	.	.	.	.	.
<i>Silene ramosissima</i>	.	.	.	2	5	.	.	.	.	.	5	5
<i>Triplachne nitens</i>	.	.	.	3	4	.	.	.	.	.	.	.
<i>Linaria ficalhoana</i>	.	.	.	.	.	5	5	5	.	.	.	.
<i>Herniaria algarvica</i>	.	.	.	.	.	.	4	3	.	.	.	.
<i>Chaenorrhinum lusitanicum</i>	.	.	.	.	.	.	.	2	.	.	.	.
<i>Viola kitabeliana</i> var. <i>henriquesii</i>	.	.	.	.	.	.	.	.	5	.	.	.
<i>Omphalodes littoralis</i> subsp. <i>gallaecica</i>	.	.	.	.	.	.	.	.	2	.	.	.
<i>Linaria arenicola</i>	.	.	.	.	.	.	.	.	.	5	.	.
<i>Lotus arenarius</i>	.	.	.	.	.	.	.	.	.	4	.	.
Character taxa of alliance and order												
<i>Silene littorea</i>	1	.	.	3	5	5	4	5	5	.	.	.
<i>Pseudorlaya pumila s.l.</i>	4	4	1	.	.	.	2	3	4	4	5	5
<i>Erodium aethiopicum</i>	.	3	.	2	1	2	.	4	4	.	.	.
<i>Polycarpon alsinifolium</i>	+	4	.	.	1	5	.	5	.	3	.	.
<i>Cutandia maritima</i>	3	4	1	.	2	.	3	3	.	.	.	5
<i>Polycarpon diphyllum</i>	3	.	.	1	.	.	.	.	1	.	.	.
<i>Ononis variegata</i>	5	3	.	.	.	.	5	.	.	.	.	.
<i>Ononis broterana</i>	.	.	.	.	.	+	.	.	.	.	.	.
<i>Vulpia fasciculata</i>	.	.	.	.	.	+	.	.	.	.	3	5
<i>Malcolmia ramosissima</i>	.	.	.	.	.	.	.	.	1	.	.	.
<i>Ononis cossoniana</i>	.	.	.	.	.	.	.	.	.	3	.	.
<i>Erodium salzmannii</i>	.	.	.	.	.	.	.	.	.	4	.	.
<i>Erodium laciniatum</i>	.	.	.	.	.	.	.	.	.	.	4	5
<i>Desmazeria hemipoa</i>	.	.	.	.	.	.	.	.	.	.	3	3
<i>Maresia nana</i>	.	.	.	.	.	.	.	.	.	.	3	3
Character taxa of class												
<i>Medicago littoralis</i>	3	4	.	3	+	.	.	5	+	4	5	5
<i>Tuberaria guttata</i>	.	.	.	.	.	.	.	3	.	.	.	.
<i>Andryala arenaria</i>	.	.	.	.	.	.	.	2	.	.	.	.
<i>Corynephorus fasciculatus</i>	.	.	.	.	3	.	.	.	.	.	5	.
Companions												
<i>Senecio gallicus</i>	+	.	.	2	4	4	5	4	+	.	.	.
<i>Malcolmia littorea</i>	3	4	.	.	.	3	4	.	+	2	.	.
<i>Lotus creticus</i>	2	.	.	+	1	.	1	1	.	.	.	.
<i>Silene colorata</i>	.	4	1	.	.	+	4	2	.	.	.	.
<i>Rumex bucephalophorus s.l.</i>	1	.	.	.	.	3	.	2	+	.	.	.
<i>Hedypnois cretica</i>	2	1	.	2	.	.	.	.	.	.	.	.
<i>Corynephorus canescens</i> var. <i>maritimus</i>	.	.	.	.	.	2	2	1	.	.	.	.
<i>Centranthus calcitrapae</i>	.	4	.	.	.	+	.	3	.	.	.	.
<i>Euphorbia portlandica</i>	.	.	.	.	.	3	1	.	.	.	.	.
<i>Papaver setigerum</i>	.	.	.	.	.	2	.	3	.	.	.	.
<i>Paronychia argentea</i>	.	4	.	.	.	.	.	.	+	.	.	.
<i>Silene nicaensis</i>	5	.	.	.	.	.	1	.	.	.	.	.
<i>Elymus farctus</i>	+	.	1	.	.	.	.	.	.	.	.	.
<i>Cakile maritima</i>	+	.	.	3	.	.	.	.	.	.	.	.
<i>Lagurus ovatus</i>	.	.	.	.	.	.	.	.	.	.	5	5
<i>Lobularia maritima</i>	.	.	.	.	.	.	1	1	.	.	.	.
<i>Vulpia alopecuros</i>	.	.	.	.	.	.	.	2	+	.	.	.

Other taxa: *Euphorbia paralias* 1: +, *Hypochaeris glabra* 1: +, *Silene cerastoides* 1: +, *Medicago marina* 1: 2, *Cyperus mucronatus* 5: 1, *Reichardia tingitana* 5: 2, *Anchusa calcarea* 7: 1, *Calystegia soldanella* 7: 3, *Hedypnois arenaria* 8: 5, *Ornithopus pinnatus* 8: +, *Reichardia gaditana* 8: 3, *Senecio leucanthemifolius* 10: 3, *Cerastium pentandrum* 10: 2, *Herniaria hirsuta* 10: 2, *Crucianella maritima* 10: +, *Brassica barrelieri* 10: 4, *Linum strictum* 11: 1, *Scorpiurus sulcatus* 11: 1, *Hippocrepis ciliata* 11: 1

References of the relevés of Table 1

1. Relevés of the authors. *Ononidi-Linarietum pedunculatae*.
2. Díez Garretas (1984: Table 4, rels. 8-11). *Ononidi-Linarietum pedunculatae linarietosum pygmaeae*.
3. Géhu and Sadki (1995: 346, Table 3, rel. 10). *Sub. Loto cretici-Elymetum farcti*.
4. Relevés of the authors. *Triplachno nitentis-Silenetum ramosissimae*.
5. Peinado et al. (1992: 317, Table 72, rels. 1-8). *Triplachno-Silenetum ramosissimae*.
6. Neto and Capelo (1999: 110, Table 18). *Herniario algarvicarum-Linarietum ficalhoanae*.
7. Díez Garretas (1984: table 5). *Herniario algarvicarum-Linarietum ficalhoanae*.
8. Costa J. C. et al. (1994: 60, Table 4). *Herniario algarvicarum-Linarietum ficalhoanae*.
9. Izco et al. (1988: Table 1). *Violo henriquesii-Silenetum littoreae*.
10. Relevés of the authors. *Loto arenarii-Linarietum arenicolae ass. nova*.
- 11, 12. Rivas Goday and Rigual (1959: Table 34, rels. 1-9, 10-19). *Sileno-Laguretum ovatae corynephoretosum et cutandietosum*.

Results and discussion

The alliance *Linarion pedunculatae* is included by Rivas-Martínez *et al.* (2002) in the order *Cutandietalia maritimae* which groups the ephemeral terophytic communities of spring flowering, developing on coastal dunes and Mediterranean distribution.

Foucault (1999) include this alliance within a new order and class (*Ononido variegatae-Cutandietalia maritimae*, *Ononido variegatae-Cutandietea maritimae*). The chosen nomenclatural type based in Díez-Garretas *et al.* (1978) is invalid (Izco *et al.*, 1988), consequently the proposal order and class are invalid (Art. 17).

In the biotopes of these communities, sandy coasts, the ecological factors are very homogeneous and do not directly influence in their separation. The chorology of the taxa and the floristic combination being the main factors to be taken into account.

Ordination results show a congruence with our syntaxonomical classification (Fig. 1). The variation explained by the first two extracted axes is 37.6%, the total variation being 3.428 (sum of all extracted eigenvalues). Horizontal axis might be interpreted as a lati-

tudinal gradient from southern communities located in the positive edge, whereas vertical axis shows a chorological gradient. Syntaxa from the eastern of Iberian Peninsula (11 and 12) appear clearly isolated in the positive half of vertical axis (*Sileno-Laguretum ovatae corynephoretosum et cutandietosum*). These syntaxa must be excluded from *Linarion pedunculatae* and integrate in the Mediterranean alliance *Alkanno-Maresion nanae*, that shares taxa such as: *Erodium laciniatum* and *Maresia nana*. The community *Triplachno-Silenetum ramosissimae* (4 and 5) is found in an intermediate area and represents the eastern limit of *Linarion pedunculatae* in transition to the *Alkanno-Maresion nanae*.

Descriptions of syntaxa

LINARION PEDUNCULATAE Díez-Garretas, Asensi & Esteve in Díez-Garretas 1984

Communities of ephemeral plants developed on sandy coasts near the sea. It has a western Mediterranean distribution (Iberian Peninsula, Morocco and Algeria) with optimum in the thermomediterranean belt (thermotemperate in the Galician-Portuguese sector). The potential area of distribution and location of these communities is expressed in Fig. 2.

Character taxa: *Herniaria ficalhoana*, *Linaria arenicola*, *L. ficalhoana*, *L. pedunculata* (var. *pedunculata* et var. *lutea*), *Lotus arenarius*, *Omphalodes littoralis* subsp. *gallaecica*, *Silene littorea*.

VIOLo HENRIQUESII-SILENETUM LITTOREAE Izco, P. & J. Guitián 1988

Association of Dividing Portuguese and Galician-Portuguese sectors which represent the northern limit of the alliance. It can be found in mobile sands close to the semi-fixed dunes community (*Iberidetum procumbentis*).

HERNIARIO ALGARVICARUM-LINARIETUM FICALHOANAE Díez-Garretas 1984

Endemic community of Portugal from coastal areas between Cape S. Vicente and the mouth of river Tajo (Ribatagan-Sadensean and Algarvian sectors). It is located between the mobile dunes colonized by *Loto cretici-Ammophiletum australis* and the semi-fixed dunes with *Artemisia crithmifoliae-Armerietum pugentis*.

A subassociation has been described (*chaenorrhinetosum lusitanici*) on lithified calcareous

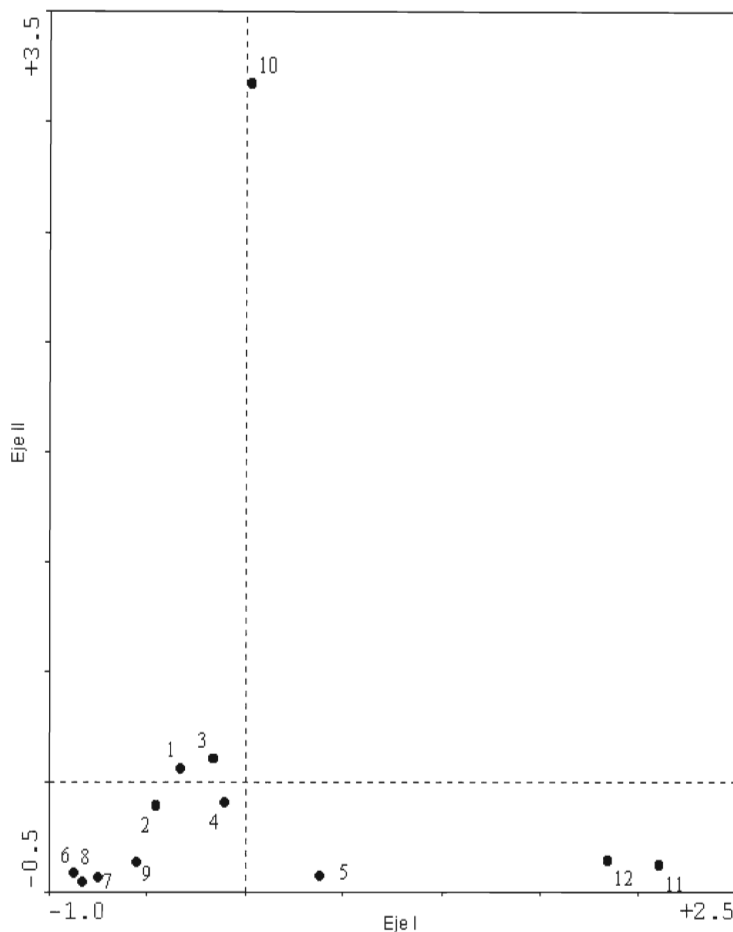


Fig. 1- Scatterplot of the OSU scores on the first two axes from correspondence analysis. 1-3 *Ononidi variegatae-Linarietum pedunculatae*. 4-5 *Triplachno nitentis-Silenetum ramosissimae*. 6-8 *Herniario algarvicae-Linarietum ficalhoanae*. 9 *Viola henriquesii-Silenetum littoreae*. 10 *Loto arenarii-Linarietum arenicolae*. 11-12 *Sileno-Laguretum ovatae corynephoretosum et cutandietosum*

dunes with *Chaenorrhinum serpyllifolium* subsp. *lusitanicum* as a differential taxon (J.C. Costa *et al.*, 1994).

ONONIDO VARIEGATAE-LINARIETUM PEDUNCULATAE Díez-Garretas *ex* Izco, P. & J. Guitián 1988

An extensive association that extends along the south littoral coast of the Iberian Peninsula, from the southern Algarvian sector to Almeria. (Tab. 2). It is also present in the north-western coasts of Morocco (Tingitanian sector) and in western Algeria (Coastal Algerian sector). It settles in mobile sand in contact with the *Ammophilion australis* communities (*Loto cretici-Ammophiletum australis*, *Medicagini marinae-Ammophiletum australis*) and the *Crucianelletalia maritimae* syntaxa (*Artemisio crithmifoliae-Armerietum pungentis*, *Loto cretici-Crucianelletum maritimae*).

In the variability of this community the typical subassociation *linarietosum pedunculatae* has been described, together with another distinguished by *Linaria mumbyana* var. *pygmaea*, developed on more consolidated sands in Gaditan-Coastal Onubensean and Algarvian sectors (Díez-Garretas, 1984).

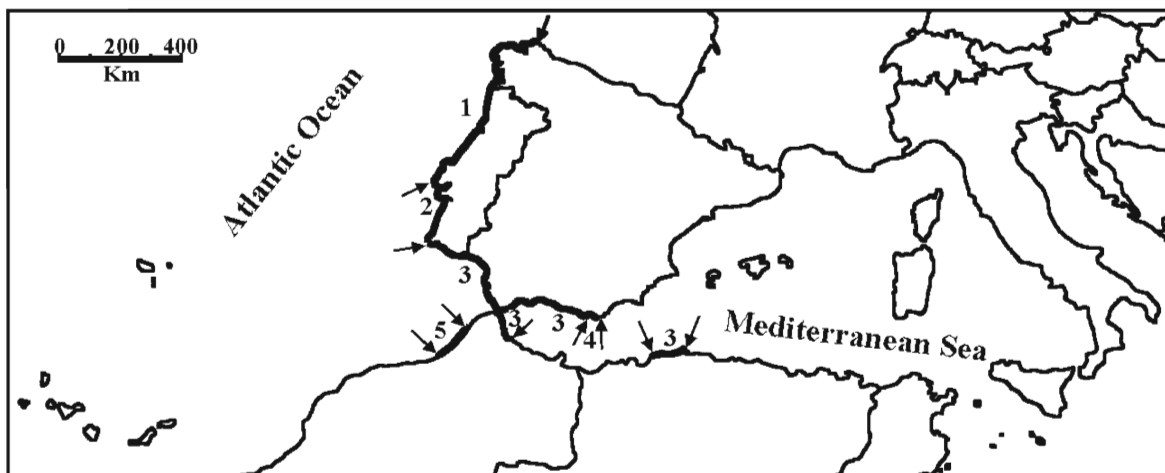


Fig. 2 - Potential area of distribution of the *Linarion pedunculatae* syntaxa: 1. *Viola henriquesii-Silenetum littoreae*, 2. *Herniario algarvicae-Linarietum ficalhoanae*, 3. *Ononido variegatae-Linarietum pedunculatae*, 4. *Triplachno nitentis-Silenetum ramosissimae*, 5. *Loto arenarii-Linarietum arenicolae*

Tab. 2. *Ononido variegatae-Linarietum pedunculatae*

Area m ²	1	4	2	1	2	2	1	1	2	1	1	2	2	2	2	
Number of species	4	7	9	8	10	6	6	5	8	5	6	6	6	4	7	
Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Character species of ass., alliance, order and class																
<i>Linaria pedunculata s. l.</i>	1	1	1	1	2	1	2	1	1	1	+	1	2	2	2	
<i>Ononis variegata</i>	.	1	+	2	+	.	1	+	1	3	1	+	1	.	2	
<i>Pseudorlaya pumila</i>	.	+	+	+	+	1	.	1	1	.	3	1	2	.	1	
<i>Medicago littoralis</i>	+	+	+	1	.	2	2	+	+	.	.	.	.	.	.
<i>Cutandia maritima</i>	.	.	1	.	+	.	.	.	+	.	.	1	1	2	2	
<i>Silene littorea</i>	.	+	.	.	.	2	1	.	.	.	.	.	.	.	.
<i>Polycarpon alsinifolium</i>	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.
Companions																
<i>Silene nicaensis</i>	+	+	1	+	1	+	+	.	1	1	1	+	+	+	1	
<i>Malcolmia littorea</i>	.	+	+	1	+	.	.	+	1	.	.	.	.	.	.
<i>Lotus creticus</i>	.	.	.	+	.	.	.	.	.	.	.	+	1	+	+
<i>Medicago marina</i>	+	.	+	.	1	.	+	.	.	.	.	.	.	.	.
<i>Hedypnois cretica</i>	.	.	.	+	1	.	.	.	+	.	.	.	.	.	.
<i>Rumex bucephalophorus s. l.</i>	.	.	.	.	+	2	.	.	.	1	.	.	.	.	.

Other taxa: *Silene cerastoides* 3: +, *Cakile maritima* 5: +, *Euphorbia paralias* 9: +, *Elymus farctus* 10: 1, *Hypochaeris glabra* 13: +.

Localities: 1. Lagos beach, Vélez-Málaga, Málaga. 2. Golf course beach, Málaga. 3. Motril, Granada. 4. Calahonda beach, Marbella, Málaga. 5. Cancelada beach, Estepona, Málaga. 6. Chullera beach, Manilva, Málaga. 7. Punta Paloma dunes, Cádiz. 8. Torregorda beach, Cádiz. 9. Antilla beach, Lepe, Huelva. 10-12. River Martil beach, Tetuán. 13-15. M'Diq beach, Tetuán.

Tab. 3. *Loto arenarii-Linarietum arenicolae ass. nova*

Area m ²	2	2	2	1	1
Number of species	12	13	8	7	9
Relevé number	1	2	3	4	5

Character species of ass., alliance, order and class

<i>Linaria arenicola</i>	1	2	2	2	2
<i>Pseudorlaya pumila</i>	2	2	1	.	1
<i>Medicago littoralis</i>	.	1	1	+	+
<i>Lotus arenarius</i>	1	.	+	1	+
<i>Erodium salzmannii</i>	+	+	+	1	.
<i>Linaria pedunculata</i>	2	2	2	.	.
<i>Polycarpon alsinifolium</i>	1	2	.	.	1
<i>Senecio leucanthemifolius</i>	1	2	1	.	.
<i>Ononis cossoniana</i>	1	+	.	.	1
Companions					
<i>Brassica barrelieri</i>	1	+	1	1	.
<i>Herniaria hirsuta</i>	+	+	.	.	.
<i>Cerastium pentandrum</i>	1	1	.	.	.
<i>Malcolmia littorea</i>	.	.	.	+	+
<i>Crucianella maritima</i>	.	.	.	.	+

Localities: Morocco: 1-3. Ras R'Mel beach, Larache. 4-5. Moulay Bouselham dunes.

TRIPLACHNO NITENTIS-SILENETUM RAMOSISSI-MAE Peinado *et al.* 1985

An infra- and thermomediterranean association described from arid to semi-arid places in the Almeriense sector. Differential taxa: *Triplachne nitens* and *Silene ramosissima*.

LOTO ARENARII-LINARIETUM ARENICOLAE *ass. nova hoc loco*

Endemic association of the Atlantic coasts of Morocco (Tab. 3) that colonizes mobile sands in contact with *Ammophilion australis* communities (*Loto cretici-Ammophiletum australis*). Differential taxon: *Linaria arenicola*.

Holotypus: Tab. 3, rel. 3.

Conclusions

Linarion pedunculatae is the most western alliance of the order *Cutandietalia maritimae*. It extends on the coastal sands of the Iberian Peninsula and north Africa from Larache (Morocco) to near Algiers (Algeria).

The communities from the eastern Iberian Peninsula must be included in another Mediterranean alliance, *Alkanno-Maresion nanae*.

Syntaxonomy and nomenclature of the *Linarion pedunculatae* syntaxa is the follow:

HELIANTHEMETEA GUTTATI (Br.-Bl. in Br.-Bl., Roussine & Nègre 1952) Rivas Goday & Rivas-Martínez 1963 em. Rivas-Martínez 1978
Cutandietalia maritimae Rivas-Martínez, Díez-Garretas & Asensi in Rivas-Martínez *et al.* 2002
Linarion pedunculatae Díez-Garretas, Asensi & Esteve in Díez-Garretas 1984

Herniario algarvicarum-Linarietum ficalhoanae
Díez-Garretas 1984

chaenorrhinetosum lusitanici J.C.Costa,
Espirito-Santo & Lousa 1994

Violo henriquesii-Silenetum littoreae Izco, P. &
J. Guitián 1988

Ononido variegatae-Linarietum pedunculatae
Díez-Garretas ex Izco, P. & J. Guitián 1988

linarietosum pedunculatae Díez-Garretas ex
Izco, P. & J. Guitián 1988

linarietosum pygmaeae Díez-Garretas ex
Izco, P. & J. Guitián 1988

Triplachno nitentis-Silenetum ramosissimae
Peinado, Martínez Parras, Alcaraz, Garre & Cruz
1985

Loto arenarii-Linarietum arenicolae ass. nova
hoc loco

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