112° Congresso della Società Botanica Italiana onlus
IV INTERNATIONAL PLANT SCIENCE CONFERENCE (IPSC)
Parma, 20 - 23 September 2017

COMPARISON OF DUNE HABITATS OF NORTH MEDITERRANEAN COASTS - TUSCANY (IT) WITH THOSE OF BLACK SEA COASTS -DOBROGEA (RO, BG):

SIMILARITIES AND DIFFERENCES

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INTRODUCTION

The “habitats” directive 92/43/EEC of the European Union aims at creating a coherent network under the name of Natura 2000, to protect the unique natural European heritage. Coastal dune habitats, which cover relatively small areas and are charcterized by a narrow width, host a high level of biodiversity and an extremely specialized flora/vegetation. In fact, despite the narrow width and shape of the dune systems, 17 habitat types in annex I of the 92/43/EEC directive describe the important environmental heterogeneity of coastal sand dune habitats in Europe (European Commission 2003). In this context, It seemed to be of great interest to investigate and compare the floristic and phytocoenotic features of dune habitats of two European coastal areas very different by the biogeographical point of view: the coast of Tuscany (Italy, Mediterranean Region, Italo-Thyrrenian province), and the coast of Dobrogea, a cross-border coastal strip between Romania and Bulgaria on the Black Sea (Eurosiberian Region, Escitian province).

AREAS OF STUDY AND METHODS

The mainland coast of Tuscany is included between 44°03’ - 42°09’ N and 9°45’- 11°45’ E. The lenght is about 315 km of wich about 200 of sandy coasts. Sands: in major part quarzolitic (quarzolitic-feldspatic near Arno river; quarzolitic-caciclastic near Fine river); ph: 7-10; CaCo3 20- 50%; salinity (NaCl) : 0,01- 0,3 %. Sea salinity: about 33‰. Dune system (shoreline - fixed dune) max 350 m width, 10 m high.
The coast of Dobrogea includes all the Romanian coast and part of the north coast of Bulgaria (45°15’-43°21’ N, 28°30’-29°42’ E). The total lenght is about 290 km, of wich about 270 of sandy coasts. Sands: in major part biogenic origin (shells); ph: 8; CaCo3 10-25%; salinity (NaCl) : 0,1%. Sea salinity: about 17 ‰. Dune system (shoreline - fixed dune) max 500 m width, 3 m high.
From a bioclimatic point of view, according to the bioclimatic classification of Rivas-Martinez and Rivas-Saenz (2015) the two regions are both included in a Mediterranean macrobioclimate but quite different: Mediterranean pluviseasonal oceanic (Tuscany) and Mediterranean pluvisesonal continental steppic (Dobrogea) (Figg.1, 2, 3 a,b).
Floristic and vegetational data on dune enviroments reported in literature (Arrigoni, 1990; Bertacchi et al., 2016;, Vagge & Biondi, 1999 for Tuscany; Faragas, 2012; Tzonev et al., 2015 for Dobrogea), together new field surveys in summer 2017 are been compared. Habitas H2260, 2270, 9340 were not included in this report. The nomenclature is in accordance with Euro+Med PlantBase (http://www.emplantbase.org/home.html). Habitats and dignostic species are in accordance with Biondi (et al., 2012), Acosta & Ercole (2015) for Tuscany and Fagaras (2012) for Dobrogea.

RESULTS AND DISCUSSION

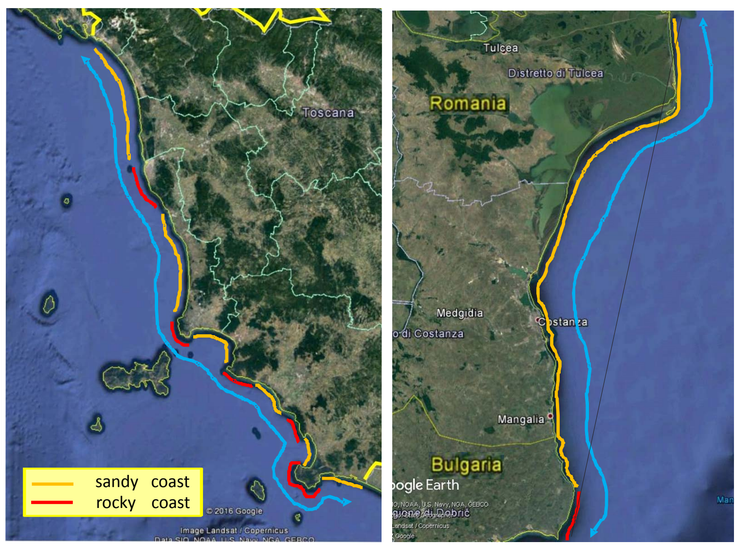
Foristic

The analysis of the floristic data shows that a limitated and specific flora is always detectable in the strip from shoreline to fixed dune, along the Tuscany coast as along the Dobrogea coast, albeit obviously different (Tab. 1). From the list are excluded the aliens, all occasionaly species and the species the can be found in other environments. The species reported (50 for Tuscany, 47 for Dobrogea) are strictly associated if not exclusive of the dune environments and humid dune slacks. From the comparison of the dune flora of the two investigated area, 16 species are in common, although three of these (*C. maritima, S. kali, E. farctus*) are different sub-species (Tab1). Apart from these species, a marked difference in chorological spectrum is evident (Fig.4 a, b). In accordance with the directive 92/43/EEC of the European Union, 12 of these are considered diagnostic species for the detection of the same dune habitats for both the investigated areas, 2 species diagnostic for different habitats, 2 not diagnostic (Tabb. 2, 3).

Fig. 1a Geographical localization of the two regions

Fig. 2 Bioclimatic detection of the two regions

Fig. 3 Satellite image of the wo regions and geomorphology



Tab 1. Species closely associated with dune habitats of the two geographical areas investigated (° common species)

Tuscany	Dobrogea
Achillea maritima (L.) Ehrend & Y.P. Guo **M_A (E)**	*Asperula setulosa* Boiss. **L_BS**
Aelouropus littoralis (Gouan) Parl. subsp littoralis **M °**	*Aelouropus littoralis* (Gouan) Parl. **M °**
Ammophila arenaria (L.) Link subsp. *arundinacea* H.Lindb. **E_M °**	*Ammophila arenaria* (L.) Link subsp. *arundinacea* H.Lindb. **E_M °**
Anthemis maritima L. **W_M**	*Agrostis gigantea* Roth subsp. *pontica* (Grecescu) Dihoru **E**
Asparagus acutifolius L. **E_M**	*Alyssum borzaeanum* Nyár. **E_sM**
Atriplex latifolia Wahlenb **C_B**	*Alyssum hirsutum* M.Bieb. **sM_C**
Cakile maritima Scop. subsp. *maritima* **M_A (E) °**	*Argusia sibirica* (L.) Dandy **L_BC**
Calystegia soldanella (L.) Roem & Schult. **C**	*Artemisia tschernieviana* Besser **E_S**
Chamaesyce peplis (L.) Prokh **E_M °**	*Astragalus varius* S.G. Gmel. **C_EA**
Centaurea paniculata L. subsp. *subciliata* (DC.) Arrigoni **E (Tuscany)**	*Astrodaucus littoralis* (Bieb.) Drude **L_BC**
Centaurea sphaerocephala L. **S_M**	*Cakile maritima* Scop. subsp. *euxina* (Pobed.) Nyár. ° **L_BD**
Crithmum maritimum L. **E_M**	*Centaurea arenaria* ssp. *borysthenica* (Gruner) Dostál **Po_Pa_Ba**
Crucianella maritima L. **S_M**	*Chamaesyce peplis (L.) Prokh* ° **E_M**
Cutandia maritima (L.) Benth. ex Barbey **S_M**	*Convolvulus persicus* L. **L_BC**
Cyperus capitatus Vand. **S_M**	*Corispermum nitidum* Kit. **Po_Pa_Ba**
Echinophora spinosa L. **E_M**	*Crambe maritima* L. **L_E**
Elymus farctus (Viv.) Runemark ex Melderis subsp. *farctus* **E_M °**	*Daucus guttatus* Sibth. et Sm. subsp. *zahariadi* Heywood **B**
Elytrigia atherica (Link) Kerguélen **E_M °**	*Dianthus bessarabicus* (Kleopov) Klokov **G_D**
Erianthus ravennae (L.) P. Beauv. **E_M**	*Elymus farctus* (Viv.) Runemark ex Melderis subsp. *bessarabicus* (Săvul et Rayss) Melderis ° **L_BS**
Eryngium maritimum L. **M_A (E) °**	*Elytrigia atherica* (Link) Kerguélen **E_M °**
Euphorbia paralias L. **E_M °**	*Ephedra distachya* L. **EA_C**
Glaucium flavum L. **E_M °**	*Eryngium maritimum* L. **M_A (E) °**
Helichrysum stoechas (L.) Moench **S_M**	*Euphorbia paralias* L. **E_M °**
Jacobaea maritima (L.) Pelser & Meijden subsp. *maritima* **S_M**	*Festuca beckeri* (Hackel) Trautv. subsp. *arenicola* (Prodan) Soó **sE_RB**
Juniperus oxycedrus L. subsp. *macrocarpa* (S.et S.) Ball **E_M**	*Glaucium flavum Crantz* subsp. *flavum* **E_M °**
Juniperus phoenicea L. subsp. *turbinata* (Guss.) Nyman **E_M**	
Lagurus ovatus L. **E_M**	*Gypsophyla perfoliata* L. **L-BC**
Malcolmia ramosissima (Desf.) Thell. **W_M**	*Lactuca tatarica* (L.) C.A. Mey **C_EA**
Matthiola sinuata (L.) R.Br. **M_A (E)**	*Leymus racemosus* (Lam.) Tzvelev subsp. *sabulosus* (Bieb.) Tzvelev. **sE_P**
Matthiola tricuspidata (L.) R.Br. **S_M**	*Medicago marina* L. **E_M °**
Medicago littoralis Loisel **E_M**	*Merendera sobolifera* C.A. Mey **eM**
Medicago marina L. **E_M °**	*Orchis laxiflora* subsp. *elegans* (Lam.) R.M.Bateman **Po_Pa**
Ononis variegata L. **S_M**	*Peucedanum arenarium* Waldst et Kit. **Po_Pa_Ba**
Pancratium maritimum L. **S_M**	*Plantago cornuti* Gouan **Po_M**
Phleum arenarium L. **M_A**	*Polygonum maritimum* L. **S_C °**
Pycnocomon rutifolium (Vahl) Hoffmanns. & Link **S_M (W)**	*Polygonum mesembricum* Chrtek. **L_M**
Plantago arenaria Poiret **SE_E**	*Salix rosmarinifolia* L. **EA**
Polygonum maritimum L. **S_C °**	*Salsola kali* L. subsp. *ruthenica* (Iljin) Soó **° EA**
Salsola kali L. subsp. *kali* **P_T °**	*Scirpoides holoschoenus* (L.) Soják **E_M °**
Scirpoides holoschoenus (L.) Soják **E_M °**	*Schoenus nigricans* L. **S_C °**
Schoenus nigricans L. **S_C °**	*Scolymus hispanicus* L. **M**
Silene colorata Poir. **S_M**	*Secale sylvestre* Host **EA_C**
Silene nicaeensis All. **S_M**	*Silene borysthenica* (Gruner) Walters **CE_E**
Solidago litoralis Savi **E (Tuscany)**	*Silene exaltata* Friv. **E_B**
Spartina versicolor Fabre **A**	*Silene thymifolia* Sm **L_BS**
Sporobolus virginicus Kuntz **S_T**	*Stachys maritima* Gouan **S_M °**
Stachys maritima Gouan **S_M °**	*Syrenia montana* (Pall.) Klokov **T_P_D_C**
Trachynia distachya (L.) Link **M_T**	*Xanthium italicum* Moretti **S_E °**
Vulpia fasciculata (Forssk.) Fritsch **M_A (E)**	
Xanthium italicum Moretti **S_E °**	

Legend (according to Pignatti S.(1982) Flora d'Italia, Edagricole (BO) for Tuscany flora and to Sărbu et al. (2013) Vascular plants of Romania. Illustrated field determinator. Edit. Victor B Victor, Bu and Dihoru & Negrean (2009) . The Red Book of the Vacular plants of Romania. Edit. Rom. Acad., Bu for Dobrogea flora)

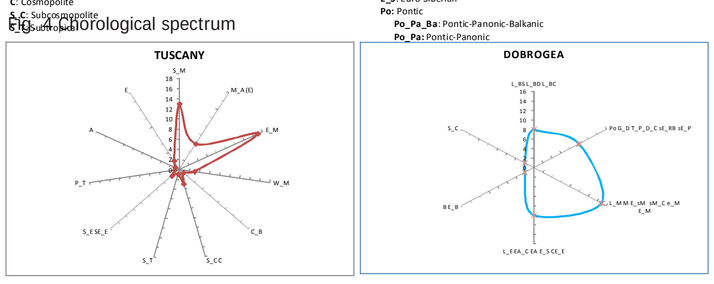
M : Mediterranean
- **M_A (E)**: Mediterranean-Atlantic (Eurimediterranean)
- **E_M** : Eurimediterranean
- **S_M**: Stenomediterranean
- **W_M**: Ovest Mediterranean
- **M_T**: Mediterranean Turanic

C_B: Circumboreal
P_T: Paleotemperate
S_E: Sud European
A: Anfiatlantic
SE_E: SE_European
E: Endemism
C: Cosmopolite
S_C: Subcosmopolite
E_S: Subboreal

L: Littoralic
- **L_BS**: Littoralic- Black Sea
- **L_BD**: Littoralic-Black Sea and Dagestan
- **L_BC:** Littoralic (Black Sea and Caspian Sea)
- **L_E:** Littoralic-European
- **L_M:** Littoralic-Mediterranean

M: Mediterranean
E_sM: East Sub-Mediterranean
sM_C: Sub-Mediterranean-Continental
EA_C: Continental Eurasian
EA: Eurasian
E_S: Euro-Siberian
Po: Pontic
- **Po_Pa_Ba**: Pontic-Panonic-Balkanic
- **Po_Pa:** Pontic-Panonic

Fig. 4 Chorological spectrum



Tab 2. Diagnostic species (*) (sensu directive 92/43/EEC) of dune habitats, in the two geographical areas investigated.
(*) (diagnostic italian species in accordance with http://www.isprambiente.gov.it/files/pubblicazioni/rapporti/R_215_15.pdf

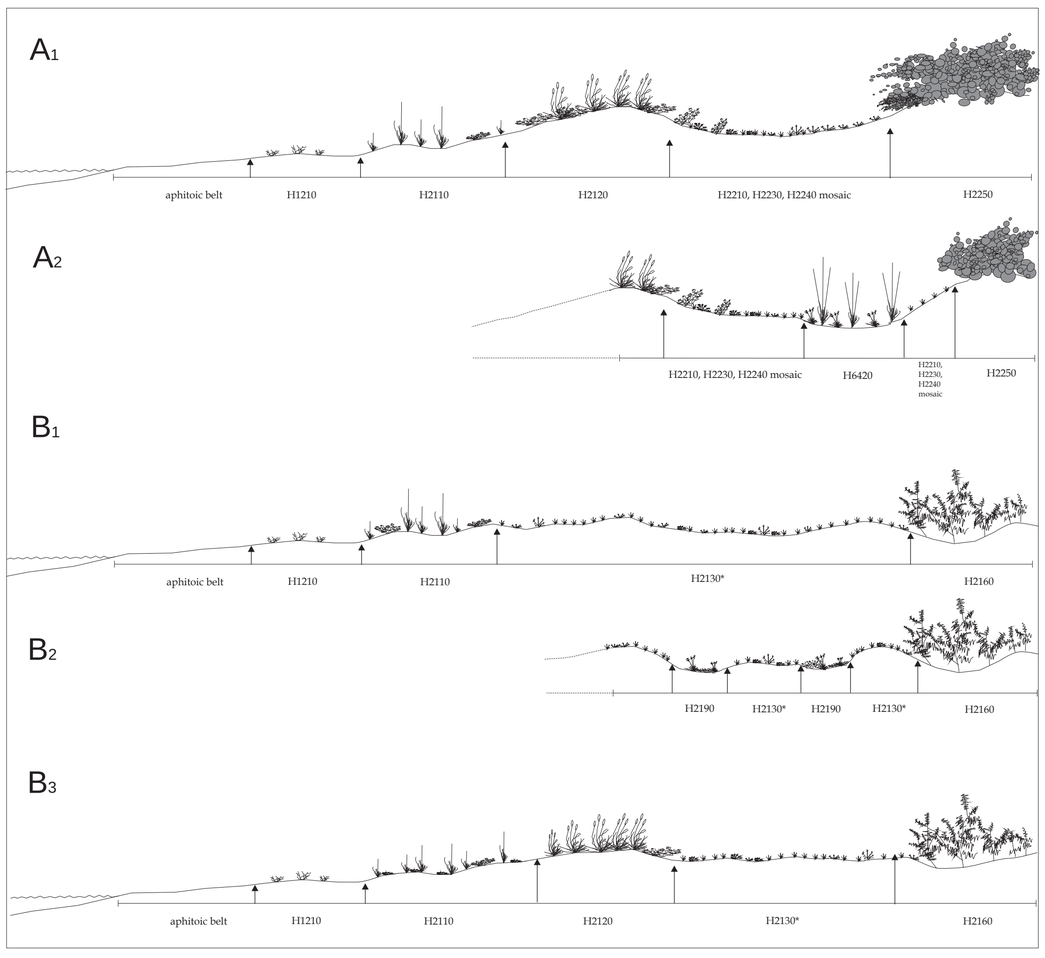
	common species		different subspecies		common species but in different habitats
	only Tuscany		only Dobrogea		(**) only in bulgarian Dobrogea

	Tuscany presence	Dobrogea presence	diagnostic/ characteristic species (*)
habitat 1210	y	y	*Cakile maritima ssp.maritima*
			Cakile maritima ssp.euxina
			Salsola kali ssp. maritima
			Salsola kali ssp. ruthenica
			Xanthium italicum
			Euphorbia peplis
			Glaucium flavum
			Crambe maritima
			Argusia sibirica
habitat 2110	y	y	*Elymus farctus ssp.farctus*
			Elymus farctus ssp. bessarabicus
			Echinophora spinosa
			Achillea maritima (Otanthus maritimus)
			Cyperus capitatus
			Eryngium maritimum
			Sporobolus virginicus
			Spartina versicolor
			Calystegia soldanella
			Polygonum maritimum
			Leymus racemosus ssp. sabulosus
			Artemisia tschernieviana
			Convolvulus persicus
			Lactuca tatarica
habitat 2120	y	n/y(**)	*Ammophila arenaria ssp. arundinacea**
			Echinophora spinosa
			Anthemis maritima
			*Euphorbia paralias**
			*Medicago marina **
			Pancratium maritimum
			Solidago litoralis
			Eryngium maritimum
			Leymus racemosus ssp. sabulosus
			Medicago falcata L. subsp. tenderiensis (Operm.) Vas
habitat 2130	n	y	*Ephedra distachya*
			Alyssum borzaeanum
			Centaurea arenaria ssp. borysthenica
			Festuca beckeri
			Secale sylvestre
			Scabiosa argentea
			Carex colchica
habitat 2160	n	y	*Hippophae rhamnoides*
			Calamagrostis epigejos
Habitat 2190	n	y	*Salix rosmarinifolia*
			Scirpoides holoschoenus
			Schoenus nigricans
			Orchis laxiflora ssp. elegans
			Plantago cornuti
habitat 2210	y	n	*Crucianella maritima*
			Pancratium maritimum
			Helichrysum stoechas
			Pycnocomon rutifolium
habitat 2230	y	n	*Malcolmia ramosissima*
			Matthiola tricuspidata
			Medicago littoralis
			Cutandia maritima
			Phleum arenarium
			Vulpia fasciculata
			Lagurus ovatus
habitat 2240	y	n	*Trachynia distachya*
habitat 2250	y	n	*Juniperus oxycedrus*
			Juniperus phoenicea
			Asparagus acutifolius
habitat 6420	y	n	*Erianthus ravennae*
			Scirpoides holoschoenus
			Schoenus nigricans

Vegetation and Habitats

Although habitats identification is mainly related to the presence of specific associations or alliances (Biondi et al., Gigante et al., EEU), this is also due to the presence or absence of diagnostic species. Based on this, it was possible to identify three common habitats in the two regions (Tab. 3).
This, while, from a vegetational point of view, referring to the specific papers already mentioned, only alliance-level similarities with regard to plant populations that characterize habitat H1210 (*Euphorbion peplis* R. Tx. 1950) and order-level with regard the H2110 and H2120 habitats (*Ammophiletalia arudinaceae* Br.-Bl. 1933) were been found. As for the other phytocenoses of the other habitats , no similarities are been found.
In any case, from the data obtained, it can be seen that the same species diagnostics for habitats or characteristics for phytocenosis can only be found in the foredune environments (Table 2). In this context , overall in Habitat 1210, numerous species in common are present; proceeding inward, the number of common species quickly decreases . Inwardly, the floristic-vegetational diversity becomes much more intense and the habitats are very different and / or vicariant.
In this context some difference in floristic traits are anyway detectable even within the same areas of study: im Tuscany coast the diagnostic *Crucianella maritima* of Habitat 2210 is present only in the in the south-central sector, while, in Dobrogea, diagnostic *Ammophila arenaria* for H2120, is totally absent in Romanian sector.
In the first case the absence appears due to the thermomediterranean characteristics of *C.maritima*, which are found to a certain latitude along the coast of Tuscany (Cecina); in the case of *A.arenaria*, for Dobrogea, this seems to be due to the anthropic impact of the last decades (Fagaras, cit.).

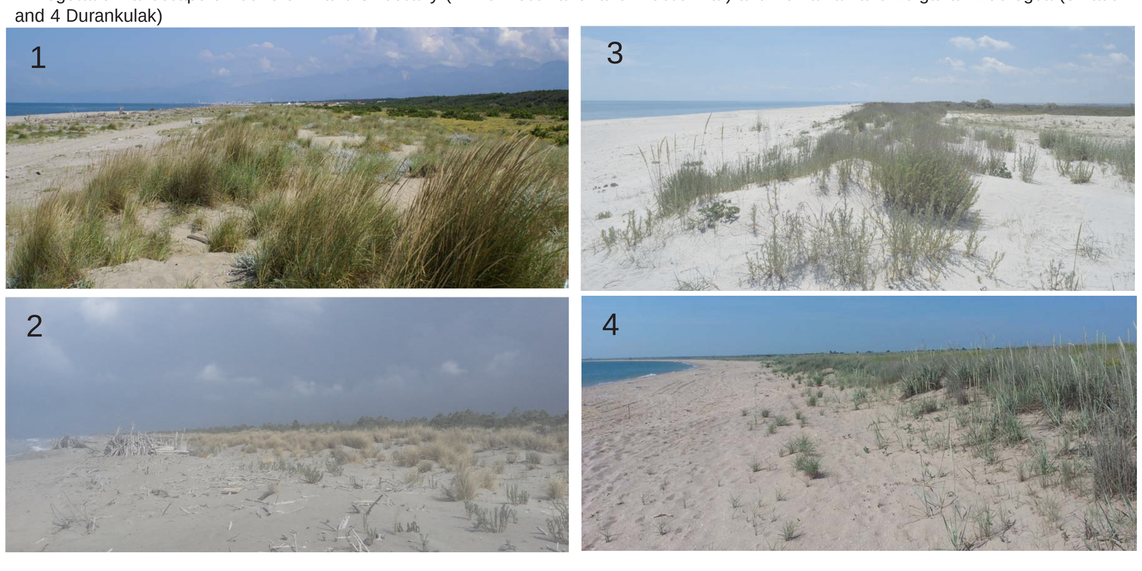
Fig. 5 Transect of most commonly zonation found in the dune systems of Tuscany (A 1,2) and Dobrogea (B 1,2,3) (see expl. in the text).



Tab 3. Dune habitats (sensu directive 92/43/EEC) in the two geographical areas investigated (T: Tuscany; D: Dobrogea)

N°	Habitats Directive 92/43/EEC	Natura 2000 code	
1	Annual vegetation of drift lines	1210	T, D
2	Embryonic shifting dunes	2110	T, D
3	Shifting dunes along the shoreline with *Ammophila arenaria* (white dunes)	2120	T, D
4	Fixed coastal dunes with herbaceous vegetation (grey dunes)	2130*	D
5	Dunes with *Hippophaë rhamnoides*	2160	D
6	*Crucianellion maritimae* fixed beach dunes	2210	T
7	*Malcolmietalia* dune grasslands	2230	T
8	*Brachypodietalia* dune grasslands with annuals	2240	T
9	Coastal dunes with *Juniperus* sp. pl.	2250*	T
10	Mediterranean tall humid herb grasslands of the *Molinio-Holoschoenion*	6420	T
11	Humid dune slacks	2190*	D

1 Vegetation landscape of dune of N and S Tuscany (1 M.di Vecchiano and 2 Uccellina) and Romanian and Bulgarian Dobrogea (3 Vadu and 4 Durankulak)



DISCUSSION AND CONCLUSIONS

From the comparison of the most common morphology od dune system and zonation of dune habitats in the two regions, the following similarities and differences appear (Fig. 5): 1- morphology of dune system is quite different, normally less high in all Dobrogean coast compared whith Tuscany; 2- foredune habitats (H1210; H2110;H2120) are always present in both cases , although in romanian part of Dobrogea H2120 is absent/missing overall for the absence of *A.arenaria* and the uncertain presence of *E.paralias* and *M.marina*; 3- the zonation of habitats is always “canonical” for the foredune while, inwards, often, can be observed a mosaic of 3 habitats of erbaceous fixed dune in Tuscany, and, in Dobrogea, a mosaic the H2130 and H2160 and H2190; ; 4- humid herb grasslandor humid dune slacks are geomorfologically the same in both dune systems and with two diagnostic species in common but are considered two totally different habitats (Tabb.2,3).
In conclusion, based on these first observations, it is interesting to note that habitats of the foredune of regions with very different geographic and climatic contexts are largerly characterized by the same diagnostic species or extremely close taxonomic species. As far as the strictly littoral environment is loss, the phytogeographic differences of the species on the vegetation landascape and relative habitats, become predominant .

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