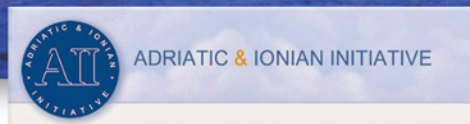


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## Notes on the vegetation diversity on the Adriatic and Ionian Italian coasts: the dunes and cliffs

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### Abstract

After a brief introduction of the environmental conditions and some phytogeographic, climate and geomorphological notes, the Italian Adriatic and Ionian coastal vegetation is described briefly, considering that of the dunes and cliffs.

Key words: biodiversity, cliffs, Italian Adriatic/ Ionian coasts, phytosociology, sand dunes, syntaxonomy.

### Introduction

Coasts represent one of the most complex of ecological systems. At the same time, they are one of the most fragile systems on our planet, in which the incessant actions of the wind and the sea reshape the morphology, and modify the ecosystem. Along with the undeniable beauty of the landscape, a significant level of coenological, species and biological diversity can be added to characterise this strip of land under tension between two very different environments, which makes the coast among the most interesting in terms of its natural and scientific profile.

The coastline represents a 'restricting environment' of great selectivity, in which there are very specialised forms of life. In the course of their evolutionary history, the plants that live among the dunes along the low and sandy coasts have adapted to the severe conditions through various morphological, anatomical and physiological strategies. These conditions are defined by the dryness and mobility of the sand, the lack of nutrients, the saline aerosol, the wind, and the strong irradiation. The coastal vegetation is highly specialised and azonal, and thus although consistent with the macroclimate, it is strictly correlated with the substrate.

In the context of these fragile coastal ecosystems, the plant species and communities have important roles as indicators of environmental quality, for which in the past they have often not been given their true value (Biondi, 1999; Biondi & Géhu, 1994).

Currently the beaches, dunes and interdunal and retrodunal wetlands, however, are among the most vulnerable and threatened of habitats on a global scale (Audisio, 2002). It is easy to understand, then, why in Italy the environments that have been shown to have the highest levels of extinct or endangered species

(21%) are indeed these coastal and lagoon areas (Conti *et al.*, 1992).

### The Italian Coastline

The Italian peninsula juts out into the Mediterranean Sea, which it separates into the western and eastern basins. Italy has a coastline of over 7,500 km, which makes up about 80% of the administrative boundaries. It can be seen, therefore, that while forming the most diverse of mosaics, the coastal environments represent a significant part of the Italian landscape.

The morphology of the Italian coast consists of two fundamental aspects: the high rocky coast and the low sandy coast. Although both are represented for the two basins, the rocky coast is dominant along the Tyrrhenian coast, and the sandy coast is dominant along the Adriatic and Ionian coasts. The geomorphological panorama of the coasts is completed by a series of wetland areas (i.e., lagoons, stagnant pools and salty marshes), of which the most important are the north Adriatic lagoons and brackish pools, the Gargano lakes, the southern Lazio lakes, Orbetello lagoon, and the stagnant pools and marshes of Sicily and Sardinia.

The lithology is very diverse, and it includes recent sediments of the Quaternary, detritus deposits of the Pliocene (clay, marl, sand, conglomerates), sandily and carbonaceous formations of the Miocene and the Cretaceous, and granites and basalts.

From the climate point of view, the Tyrrhenian, Ionian and low-Adriatic areas are dominated by the oceanic, pluviseasonal Mediterranean bioclimate. The mid-Adriatic is affected by the sub-Mediterranean, oceanic, temperate bioclimate. Then, the high-Adriatic is under the influence of the oceanic temperate bioclimate that along the Veneto section assumes a steppes-

like character (Rivas-Martinez *et al.*, 2004a).

On a biogeographic basis, the territory is divided between the two Mediterranean regions (with the western and eastern Mediterranean subregions, the Italo-Tyrrhenian and Adriatic Provinces, and the sectors of the Italian western coast and Puglia) and EuroSiberian (with the Alpine-Caucasus subregion, the Apennine-Balkan Province, and the Padano and Apennine sectors) (Rivas-Martinez *et al.*, 2004b).

### The vegetation of the Adriatic and Ionian coasts

In a context that is particularly wide and varied, the vegetative component of the Italian coasts is equally diverse and rich, even if the degradation processes of anthropogenic origin have drastically reduced the parts that are still truly natural. The scientific literature on the Italian coastal vegetation is very rich. Limiting ourselves to the phytosociological studies, for the forerunners we can note in particular the examples of: Frei (1937), Pignatti (1952) and Pirola (1959) for Sicily; Béguinot (1941) and Pignatti (1953, 1960, 1966) for Veneto; Lausi & Poldini (1962) for Friuli-Venezia Giulia; Corbetta (1968, 1976) and Lorenzoni (1978) for Emilia-Romagna; Biondi *et al.*, 1992 for Marche, Corbetta (1970) Chiesura Lorenzoni & Lorenzoni (1977) for Puglia.

In addition to numerous studies that have dealt with specific coastal segments, there are several contributions available that present the various scenarios, on a phytosociological basis, for the entire coastal perimeter, or at least for most of it. The first study in terms of a research campaign carried out along all of the Italian coastline was that of Géhu *et al.* (1984). Others followed, among which we can mention the overviews of Bartolo *et al.* (1989), Géhu & Biondi (1996a, 1996b), Biondi (1999, 2007), Corbetta *et al.* (1999), and Brullo *et al.* (1997, 2001).

Here, we provide a synthesis of the Adriatic–Ionian coastal vegetation in terms of its phytosociology that is limited to the cliff and dune phytocoenoses. Given the vastness of the subject, we report on the most representative aspects, drawn from the studies cited above and from those reported in the literature, with the exclusion of the Sicilian coast, which deserves specific treatment. For each category of vegetation, its habitat of origin is also given, according Annex I of the Habitats Directive 92/43 EEC.

### The low sandy and gravelly coasts

Along the sandy coastline, the alternation of the dune ridges and intradunal depressions has resulted in a vegetation sequence that establishes the xerophilous phytocoenoses on the tops of the dunes and the halo-

hygrophilous or hygrophilous phytocoenoses in the intradunal and retrodunal depressions.

Starting from the shoreline, the whole system is spread along the gradient of the intensity of the wind, from the unstructured and open communities that are more pioneering, continuing to the most structurally and floristically complex, such as the evergreen sclerophyllous shrubbery and woods.

This represents a particular topographic series that in the more typical and original forms can now be seen in only a few locations within the Mediterranean basin. The strong human disturbance and the coastal erosion have led to compression, mixing and loss of identity, and often also to the total disappearance of some or all of the plant communities. Even the submerged portion of the beach has an important role that reflects on the emerged environment and that therefore must be considered an integral part of the coastal system.

In this context, it is therefore possible to distinguish different habitats that follow on from each other, at times in the space of a few tens of metres, and that host complex units of the phytosociological landscape (Fig. 1). These units, which phytosociologists refer to with the term geoserries, can be schematically identified as the following ecological typologies: submerged, halonitrophilous of the beach; xerophilous of the dune ridges; and halo-hygrophilous and hygrophilous in the depressions (interdunal and retrodunal). Of these, the following illustrate the main representatives relating to the Adriatic–Ionian coasts, referring to the phytosociological rank of the alliance; the syntaxonomic scheme with the most significant associations is given in the Appendix.

### The submerged beach

Habitat 1120\* - *Posidonia* beds (*Posidonium oceanicae*)

This is the site of the phanerogamic seagrasses, which are mainly *Posidonia oceanica* (endemic to the Mediterranean), which has developed on the moving seabed between 1 m and 40 m in depth, and which determines the lower limit of the infralittoral zone (Bruno, 2001). These seagrasses constitute an effective barrier to wave motion, and thus effectively protect the shoreline from erosion and stabilise the sea bottom; moreover, for many species this represents their breeding site and it is one of the main sources of oxygenation of the environment. Other submerged phanerogamic seagrasses are *Cymodocea nodosa*, *Zostera noltii* and *Zostera marina*.

The phytosociology of these seagrasses includes alliances *Zosterion marinae* (*Posidonia oceanica*, *Zostera* spp. and *Cymodocea nodosa* seagrasses). The algal alliances are *Peyssonnelion squamariae*, *Cystoseirion crinitae* and *Caulerpion*.

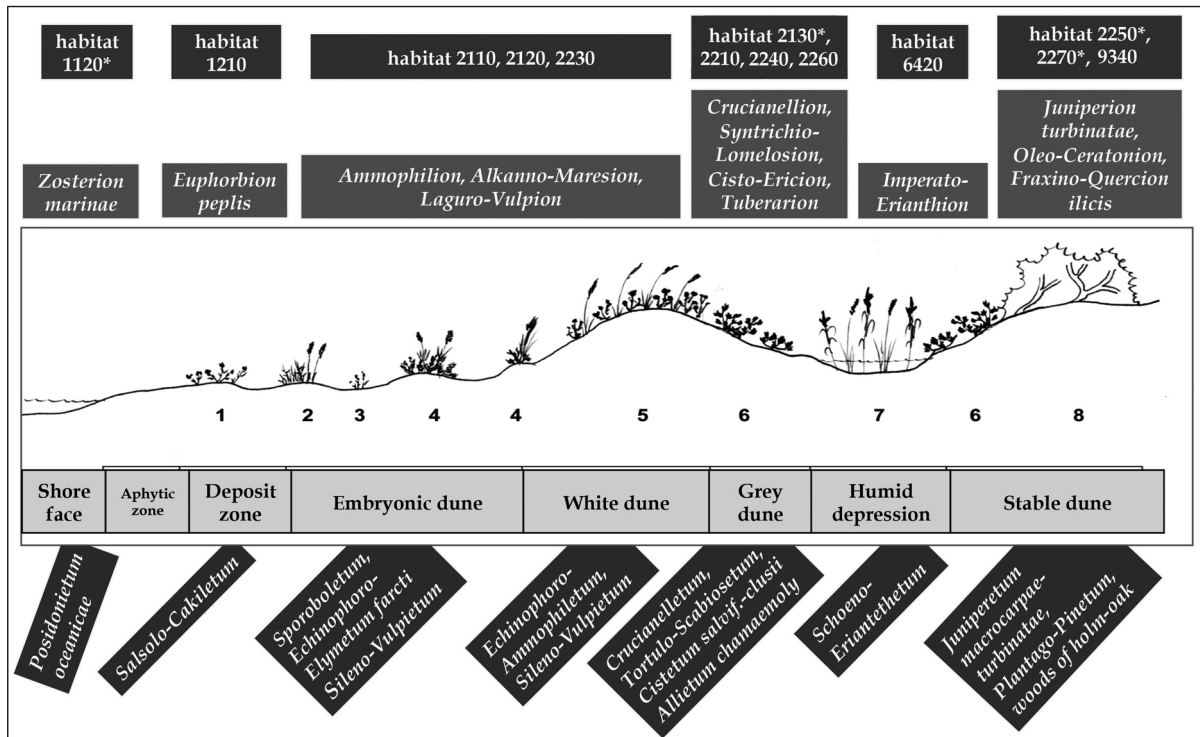


Fig. 1 - The dune system. It is characterized by the chain zonation of the plant communities arranged in strips parallel to the coast line, from the most pioneer to the most mature. (by E. Biondi, 2007, modified)

### The halo-nitrophilous strip

Habitat 1210 – Annual vegetation of the drift lines

This is represented by the therophytic halo-nitrophilous vegetation that has colonised the sandy pebbled beach between the strip devoid of vegetation next to the shoreline and the psammophytic perennial phytocoenoses.

Alliance *Euphorbion peplis*. The most common associations are: *Salsolo kali-Cakiletum maritimae*, which is often found with the subassociation *xanthetosum italicum* of particularly eutrophic soils, differentiated by *Xanthium italicum*; *Xantho italicum-Cenchretum incerti* (favoured by the levelling of the dunes); *Raphano maritimi-Glaucietum flavi* (on gravel), with the last two especially along the central Adriatic. Another association known for gravel deposits rich in organic matter of the Adriatic coast of Puglia is *Atriplicetum hastato-tornabeni*.

### The dune ridges

The dunes are the result of a continuous dynamic process that depends on the interactions between three factors: the wind, the sand and the vegetation (Pignatti, 2002). The wind moves the sand, while the vegetation constitutes a barrier that allows its accumulation, and thus the formation of the ridges of the dune. This can be eroded by the wind if it is too strong. In this way, an equilibrium is established between deposition and erosion, which determines the height of the dune.

The dune ridges are characterised from the chain connections of the plant communities that are found in strips parallel to the coastline, from the more pioneering to the more mature. Along the Adriatic-Ionian coast, the topographic sequence includes the following typologies:

### HEMICRYPTOPHYTIC-GEOPHYTIC PERENNIAL VEGETATION

Habitat 2110 – Embryonic shifting dunes; habitat 2120 – Shifting dunes along the shoreline with *Ammophila arenaria*.

Alliance *Ammophilion australis*. This vegetation colonises the embryonic dunes and the higher more inland dunes (moving or white dunes), and it contributes to the stabilisation of the dunes through the plant rhizome. This is mainly represented by the associations *Sporobolium arenarii* (embryonic tufts, with *Sporobolus virginicus*, suballiance *Sporobolenion arenarii*), *Echinophoro spinosae-Elymetum farcti* (embryonic dunes and dune ridges with little nutrition from the sand, with *Elymus farctus*, suballiance *Sporobolo arenarii-Elymenion farcti*), *Echinophoro spinosae-Ammophiletum australis* (high dunes that are still mobile, with *Ammophila arenaria* subsp. *australis*, suballiance *Medicagini marinae-Ammophilenion australis*). The association *Inulo crithmoidis-Elytrigietum juncea* (embryonic dunes differentiated by *Inula crithmoides*) is found in the north-western Adriatic (Veneto, Emilia-

Romagna). Similar aspects have also been reported for Abruzzo.

#### EPHERMERAL THEROPHYTIC VEGETATION

Habitat 2230 – *Malcolmietalia* dune grasslands

Alliance *Alkanno-Maresion nanae*, with the associations *Maresio nanae-Ononidetum variegatae*, *Anthemido-Centaureetum conocephalae*, *Anchuso hybridae-Plantaginetum albicantis*, and *Onobrychido-Malcolmietum ramosissimae*.

Alliance *Laguro ovati-Vulpion fasciculatae*, with the associations *Sileno coloratae-Vulpietum membranaceae*, *Ambrosio coronopifoliae-Lophochloetum pubescentis*, *Sileno coloratae-Ononidetum variegatae*, and *Sileno nicaeensis-Cutandietum maritimae*.

These associations form mosaics with the perennial vegetation. In positions further back, there are therophytic-geophytic meadows of the alliance *Tuberarion guttatae* (association *Allietum chamaemoly*, with groupings of *Romulea rollii*).

#### SMALL-SIZED CHAMAEPHYTIC AND SUFFRUTICOSE VEGETATION

Habitat 2210 – *Crucianellion maritimae* fixed beach dunes

Alliance *Crucianellion maritimae*. This colonises the inner slopes of the dune systems that are stabilised and well developed, on compact sand (grey dunes). In Italy, this habitat is very localised and is under regression, due to fewer suitable sites. Along the Adriatic-Ionian coasts, this vegetation is known only for Puglia, Calabria and Sicily. The associations belonging to the alliance include: *Crucianelletum maritimae*, *Helichryso italici-Ephedretum distachyae* (retrodunal areas on consolidated sand), *Loto commutati-Thymetum capitati* (more or less deep calcareous sand on slabs of limestone), *Helichryso italici-Sarcopoterietum spinosi* (on stony substrates).

Habitat 2260 – *Cisto-Lavanduletalia* dune sclerophyllous shrubs

Sometimes the inner slopes of the dunes also include primary garrigues from the classes *Cisto-Micromerietea* (alliance *Cisto cretici-Ericion manipuliflorae*, with the association *Coridothymo capitati-Anthyllidetum hermannianae*) and *Rosmarinetea officinalis* (alliance *Cisto eriocephali-Ericion multiflorae*, with the associations *Cistetum salvifolio-clusii*, *Erico multiflorae-Halimietum halimifolii*, and *Helianthemo jonii-Fumagnetum thymifoliae*).

#### PERENNIAL VEGETATION OF THE TEMPERATE CLIMATE

Habitat 2130\* - Fixed coastal dunes with herbaceous vegetation (grey dunes)

Alliance *Syntrichio ruraliformis-Lomelosion argen-*

*tae*. This alliance is endemic to the north Adriatic coast, and the structure of the phytocoenoses that belong to this alliance is determined by a thick carpet of bryochamaephytes, and at times of lichens, among which there are hemicryptophytes, therophytes and chamaephytes. This description corresponds to the association *Tortulo-Scabiosetum*, as described for the Veneto coast. An association that is similar, but described for the Ionian coast of Apulia, and therefore in a Mediterranean climate, is *Plantagini albicantis-Scabiosetum albae*.

#### SHRUB VEGETATION OF THE STABILISED DUNES, WITH A DOMINANCE OF JUNIPER (*Juniperus macrocarpa*, *J. phoenicea* subsp. *turbinata*)

Habitat 2250\* – Coastal dunes with *Juniperus* spp.

Alliance *Juniperion turbinatae*, with the associations *Asparago acutifolii-Juniperetum macrocarpae*, *Helianthemo sessilifolii-Juniperetum macrocarpae*, and *Juniperetum macrocarpae-turbinatae*.

In the temperate bioclimate (north Adriatic), this strip comprises the juniper of *Juniperus communis* (alliance *Pruno-Rubion ulmifolii*, with the association *Junipero communis-Hippophaetum fluviatilis*).

#### FOREST VEGETATION

Habitat 2270\* - Wooded dunes with *Pinus pinea* and/or *Pinus pinaster*; 9340 – *Quercus ilex* and *Quercus rotundifolia* forests

This occurs when the dune systems are highly developed more inland. This category includes the mixed woods of evergreen sclerophyllous and deciduous woods belonging to the alliance *Fraxino orni-Quercion ilicis*, with the associations of the holm oak woods (e.g., *Fraxino orni-Quercetum ilicis* and *Cyclamino hederifolii-Quercetum ilicis*), and to the alliance *Pistacio lentisci-Pinion halepensis*, with the associations of the pine woods of the Aleppo pine (on the sand: *Plantago albicantis-Pinetum halepensis*).

#### VEGETATION OF THE DEPRESSIONS BETWEEN THE DUNES

Habitat 6420 – Mediterranean tall humid grasslands of *Molinio-Holoschoenion*

This develops in the depressions that are more or less moist and are enriched in organic matter. It is represented by the association *Schoeno nigricantis-Erianthetum ravennae*. Its syntaxonomic collocation is within the alliance *Imperato cylindricae-Saccharion ravennae*. The same classification includes the associations *Calamagrostio epigejotis-Erianthetum ravennae* of Molise and Abruzzo, and *Imperato cylindricae-Schoenetum nigricantis* in Sardinia and Abruzzo.

The depressions sometimes also contain phytocoenoses belonging to the alliance *Scirpion compac-*

*to-littoralis*, with the associations *Scirpetum compacto-littoralis* (the coastal Scirpeto), *Puccinellio palustris-Scirpetum compacti* (at the edges of lagoons), *Scirpo compacti-Juncetum subulati* (thermophilous), and *Junco maritimi-Cladietum marisci*.

### The cliffs

The rocky shores are home to many plant communities that are differentiated primarily on the basis of the more or less marked actions of the salt winds. The rocks closest to the sea, and therefore those more subjected to the actions of the marine aerosol, are colonised by halo-rupicolous pioneer vegetation, while the less exposed cliffs have been colonised by halotolerant communities (Fig. 2).

In the first case, the vegetation belongs to the alliance *Crithmo-Staticion* (order *Crithmo-Staticetalia*, class *Crithmo-Staticetea*, with a wide Mediterranean distribution), which includes several associations that are characterised not only by *Crithmum maritimum*, but also by several species of *Limonium*, many of which are endemic and sometimes punctiform (Habitat 1240 - vegetated sea cliffs of the Mediterranean coasts with endemic *Limonium* spp.).

The known associations of the Adriatic and Ionian coasts include the following:

- *Crithmetum maritimi* (on cliffs and rock walls re-

ched by sea spray), Veneto;

- *Reichardio maritimae-Brassicetum robertianae* (on limestone cliffs), Monte Conero;

- *Crithmo maritimi-Limonietum virgati* (on conglomerate cliffs and gravel deposits), southern Abruzzo;

- *Crithmo-Limonietum diomedeeae* (on low limestone rocky coasts), endemic to Gargano and the Tremiti Islands;

- *Limonietum japgigi* (on limestone rocky coasts), endemic to Salento;

- *Frankenio-Limonietum cancellati* (on rocky coasts of Torre Guaceto-Brindisi);

- *Limonio virgati-Plantaginetum grovesii* (on marly coastal cliffs), Alimini Lakes;

- *Limonietum calabri* (on granite and gneiss), endemic to Calabria;

- *Crithmo-Limonietum lacinii* (on calcarenitic substrates), endemic to Capo Colonna (Calabria).

The top parts of the cliffs are colonised by chasmophytic vegetation included in the class *Asplenietea trichomanis*, orders *Centaureo-Campanuletalia* and *Onosmetalia frutescentis* (Habitat 8210 - Calcareous rocky slopes with chasmophytic vegetation). The phytocoenoses of the Friuli coast belong to the alliance *Centaureo-Campanulion*, seen for both sides of the Adriatic Sea with a predominant spread to the east, with the associations *Campanulo-Centaureetum kartschiana* (cliffs exposed to the sea spray) and

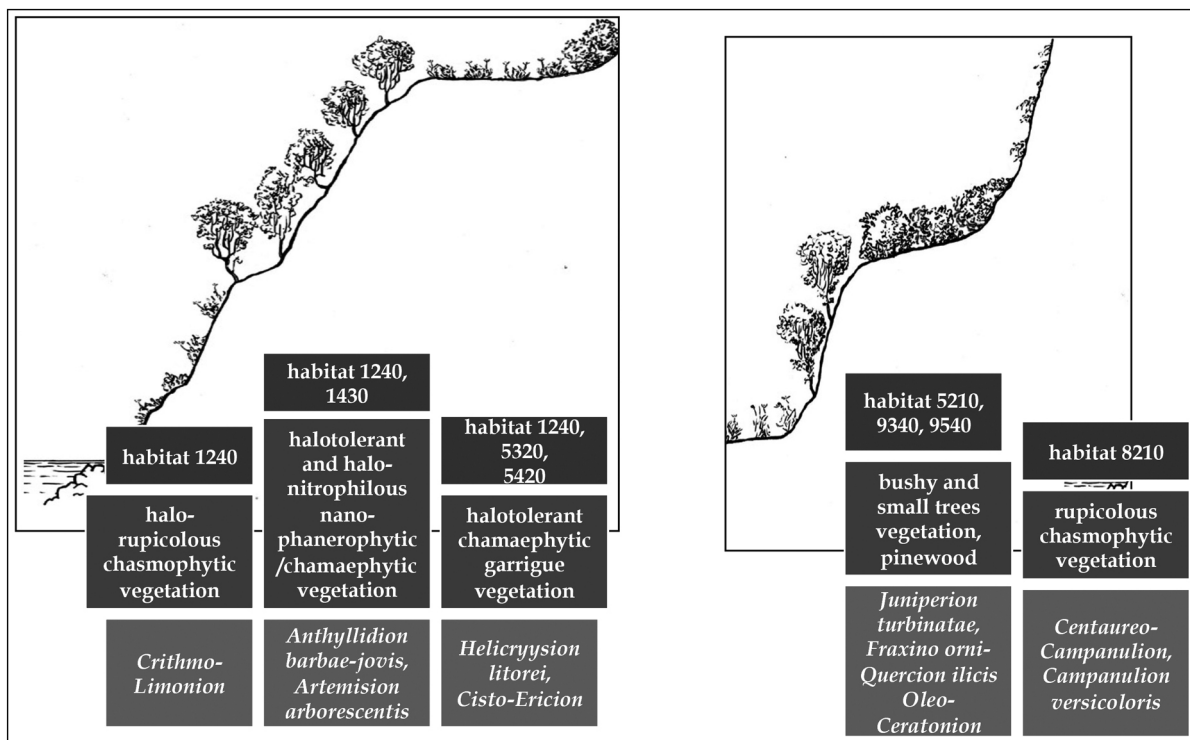


Fig. 2 - The cliffs. The rocks closest to the sea and most exposed to the sea aerosol are colonized by a pioneer halo-rocky vegetation, while in the less exposed cliffs halo-tolerant communities can be found. (by E. Biondi, 2007, modified)

*Micromerio-Euphorbietum wulfenii* (cliffs that have no direct marine influence). The Puglia phytocoenoses belong to the alliance *Campanulion versicoloris*, of the southern Balkan area, with the association *Campanulo-Aurinetum leucadeae* (the coast between Gallipoli and Otranto).

On the conglomerate-arenaceous cliffs of Punta Aderci in Abruzzo that are affected by dripping fresh water, there is a phytocoenosis of the alliance *Adiantion capilli-veneris* (order *Adiantetalia capilli-veneris*, class *Adiantetea*), within the association *Crithmo maritimi-Adiantetum capilli-veneris*.

Within the class *Crithmo-Staticetea* on the cliffs with less marine influence, there has developed chamaephytic and nanophanerophytic halotolerant vegetation of the alliance *Anthyllidion barbae-jovis* (order *Senegetalia cinerariae*), with the association *Anthyllido-Centaureetum diomedeeae* (the high limestone cliffs of the Tremiti Islands) (Habitat 1240 - vegetated sea cliffs of the Mediterranean coasts with endemic *Limonium* spp.; 5320 - Low formations of *Euphorbia* close to cliffs).

The cliffs are also home to the halotolerant and nitro-

philous shrub vegetation of the alliance *Artemision arborescentis* (order *Salsolo vermiculatae-Peganelalia harmalae*, class *Pegano harmalae-Salsoletea vermiculatae*), with the association *Suaedo verae-Atriplicetum halimi* (Gargano and the Tremiti Islands; the Santa Gilla stagnant pool, Sardinia; Ortona, Abruzzo) and the grouping of *Atriplex halimus* (Abruzzo) [Habitat 1430 - Halo-nitrophilous shrubs (Pegano-Salsoletea)].

The coastal cliff garrigues belong to the alliance *Cisto cretici-Ericion manipuliflorae* (associations *Saturejo cuneifoliae-Sarcopoterietum spinosi*, *Cisto monspeliensis-Sarcopoterietum spinosi*, and *Saturejo cuneifoliae-Ericetum manipuliflorae*) and *Cisto eriocephali-Ericion multiflorae* (associations *Asperulo aristatae-Fumanetum thymifoliae*, and *Cisto eriocephali-Rosmarinetum officinalis*). The alliance *Oleo-Ceratonion* is represented by the shrubbery of *Oleo-Euphorbietum dendroidis* (Monte Conero, Gargano, Tremiti Islands) and the alliance *Pistacio lentisci-Pinion halepensis* of the pine woods of *Pistacio-Pinetum halepensis* (Puglia, Tremiti Islands) and of *Erico arbores-Pinetum halepensis* (north-eastern Calabria).

### Syntaxonomic scheme

ZOSTERETEA MARINAE Pignatti 1953

*ZOSTERETALIA* Bèguinot 1941

*Zosterion marinae* Christiansen 1934

*Zosteretum marinae* (Van Goor 1921) Harmsen 1936

*Zosteretum noltii* Harmsen 1936

*Cymonoceetum nodosae* Giaccone & Pignatti 1967

POSIDONIETEA OCEANICAE Hartog 1976 ex Ge'hu in Bardat, Bioret, Botineau, Boulet, Delpech, Ge'hu, Haury, Lacoste, Rameau, Royer, Roux & Touffet 2004

POSIDONIETALIA OCEANICAE Hartog 1976

*Posidonion oceanicae* Br.-Bl., Roussine & Negre 1952

*Posidonietum oceanicae* (Funk 1927) Molinier 1958

Alliances of seaweeds:

*Peyssonnelion squamariae* Augier & Boudouresque 1975 emend. Giaccone 1994,

*Cystoseirion crinitae* Molinier 1958,

*Caulerpion* Giaccone & Di Martino 1997.

CAKILETEA MARITIMAE Tüxen & Preising ex Br.-Bl. & Tüxen 1952

*EUPHORBIETALIA PEPLIS* Tüxen 1950

*Euphorbion peplis* Tüxen 1950

*Salsolo kali-Cakiletum maritimae* Costa & Manzanet 1981 corr. Rivas-Martínez *et al.* 1992, con subass. *xanthietum italicum*;

*Xantho italicum-Cenchretum incerti* Biondi, Brugiapaglia, Allegrezza & Ballelli 1992

*Raphano maritimi-Glaucietum flavum* Biondi, Brugiapaglia, Allegrezza & Ballelli 1992

*Thero-Atriplicion* Pignatti 1953

*Atriplicetum hastato-tornabeni* O.Bolòs 1962

AMMOPHILETEA AUSTRALIS Br.-Bl. & Tüxen ex Westhoff, Dijk & Passchier 1946

AMMOPHILETALIA AUSTRALIS Br.-Bl. 1933

*Ammophilion australis* Br.-Bl. 1921 corr. Rivas-Martínez, Costa & Izco in Rivas-Martínez, Lousã, T.E. Díaz, Fernández-González & J.C. Costa 1990

***Sporobolion arenarii*** Géhu 1988

*Sporoboletum arenarii* (Arénes 1924) Géhu & Biondi 1994

*Limonio virgati-Sporoboletum arenarii* Biondi, Casavecchia & Guerra 2006 (Salento)

***Sporobolo arenarii-Elymenion farcti*** Géhu 1987

*Echinophoro spinosai-Elymetum farcti* Géhu 1987

***Medicagini marinae-Ammophilenion australis*** (Br.-Bl. 1921) Riv.-Mart. & Géhu 1980 em. Géhu & Biondi 1994

*Echinophoro spinosae-Ammophiletum australis* (Br.-Bl. 1933) Géhu, Rivas-Martinez & R. Tx. 1972 in Géhu *et al.* 1984

TUBERARIETEA GUTTATAE (Br.-Bl. in Br.-Bl., Roussine & Nègre 1952) Rivas Goday & Rivas-Martínez 1963  
nom. mut. propos. in Rivas-Martínez *et al.* 2002

CUTANDIETALIA MARITIMAE Rivas-Martínez, Díez Garretas & Asensi 2002

***Alkanno-Maresion nanae*** Rivas Goday ex Rivas Goday & Rivas-Martinez 1963 corr. Díez-Garretas Asensi & Rivas-Martínez 2001

*Maresio nanae-Ononidetum variegatae* Géhu, Biondi, Géhu-Franck & Arnold-Apostolides 1986

*Anchuso hybridae-Plantaginetum albicantis* Corbetta & Pirone in Corbetta *et al.* 1992

*Anthemido-Centaureetum conocephalae* Brullo & Grillo 1985

*Onobrychido-Malcolmietum ramosissimae* Brullo, Scelsi & Spampinato 2000

***Laguro ovati-Vulpion membranaceae*** Géhu & Biondi 1994

*Sileno coloratae-Vulpietum membranaceae* (Pignatti 1953) Géhu & Scoppola 1984

*Ambrosio coronopifoliae-Lophochoetum pubescentis* Biondi, Brugiapaglia, Allegrezza & Ballelli 1992

*Sileno coloratae-Ononidetum variegatae* Géhu 1986

*Sileno nicaeensis-Cutandietum maritimae* Géhu & Biondi 1994

*Sileno conicae-Avellinietum michelii* Sburlino, Buffa, Filesi, Gamper & Ghirelli 2013

TUBERARIETALIA GUTTATAE Br.-Bl. in Br.-Bl., Molinier & Wagner 1940 nom. mut. propos. Rivas-Martínez *et al.* 2002

*Tuberarion guttatae* Br.-Bl. in Br.-Bl., Molinier & Wagner 1940 nom. mut. propos. Rivas-Martínez, *et al.* 2002

*Allietum chamaemoly* Molinier 1954

Aggruppam. a *Romulea rollii*

HELICHRYSO-CRUCIANELLETEA MARITIMAE (Sissingh 1974) Géhu, Rivas-Martinez & Tüxen in Géhu 1975  
em. Géhu & Biondi 1994

HELICHRYSO-CRUCIANELLEALIAMARITIMAE Géhu, Rivas-Martínez & Tüxen 1973 em. Sissingh 1974

***Crucianellion maritimae*** Rivas.Goday & Rivas-Martinez 1958

*Loto commutati-Thymetum capitati* Géhu, Biondi, Géhu-Franck & Marchiori 1984 (Salento)

*Helichryso italici-Sarcopoterietum spinosi* Géhu & Costa in Géhu, Costa, Scoppola, Biondi, Marchiori, Peris, Franck, Caniglia & Veri 1984

*Helichryso italici-Ephedretum distachyae* Géhu, Biondi, Géhu-Franck & Taffetani 1987

*Artemisio variabilis-Ephedretum distachyae* Brullo, Giusso Del Galdo, Siracusa & Spampinato 2001

*Plantagini albicantis-Scabiosetum albae* Brullo, Giusso Del Galdo, Siracusa & Spampinato 2001

HELICHYSETALIA ITALICI Biondi & Géhu in Géhu & Biondi 1994

***Helichryson litorei*** Biondi 2007

*Agropyro-Helichrysetum italici* Bartolo, Brullo & Signorello 1983

Aggruppam. a *Helichrysum italicum* and *Reichardia picroides* var. *maritima*

KOELERIO-CORYNEPHORETEA Klika in Klika & Novák 1941

ARTEMISIO-KOELERIETALIA ALBESCENTIS Sissingh 1974

***Syntrichio ruraliformis-Lomelosion argenteae*** Biondi, Sburlino & Theurillat in Sburlino, Buffa, Filesi, Gamper & Ghirelli 2013

*Tortulo-Scabiosetum* Pignatti 1952

FESTUCO-BROMETEA ERECTI Br.-Bl. & Tüxen ex Klika & Hadač 1944

SCORZONERO-CHRYSOPOGONETALIA Horvatić & Horvat in Horvatić 1958

***Saturejion subspicatae*** (Horvat 1962) Horvatic 1973

***Centaurenion dicroanthae*** (Pignatti 1962) Poldini & Feoli Chiapella in Feoli Chiapella & Poldini 1994

*Teucrio capitati-Chrysopogonetum grylli* Sburlino, Buffa, Filesi & Gamper 2008



CISTO CRETICI-MICROMERIETEA JULIANAE Oberdorfer 1954

*CISTO CRETICI-ERICETALIA MANIPULIFLORAE* Horvatić 1958

***Cisto cretici-Ericion manipuliflorae*** Horvatić 1958

*Coridothymo capitati-Anthyllidetum hermannianae* Brullo, Minissale & Spampinato 1987

Aggruppam. a *Cistus creticus* ssp. *creticus* and *Fumana thymifolia*

ROSMARINETEA OFFICINALIS Rivas-Martinez, T.E. Diaz, F. Prieto, Loidi & Penas 2002

*ROSMARINETALIA OFFICINALIS* Br.-Bl. ex Molinier 1934

***Cisto eriocephali-Ericion multiflorae*** Biondi 2000

***Cistetum salvifolio-clusii*** Bartolo, Giardina, Minissale & Spampinato 1987

*Erico multiflorae-Halimietum halimifolii* Taffetani & Biondi 1992

*Helianthemo jonii-Fumanetum thymifoliae* Taffetani & Biondi 1992

QUERCETEA ILICIS Br.-Bl.

*QUERCETALIA ILICIS* Br.-Bl. ex Molinier 1934 in Br.-Bl., Roussine & Nègre 1952

***Fraxino orni-Quercion ilicis*** Biondi, Casavecchia & Gigante ex Biondi, Casavecchia & Gigante in

Biondi, Allegrezza, Casavecchia, Galdenzi, Gigante & Pesaresi 2013

***Fraxino orni-Quercetum ilicis*** Horvati (1956) 1958

*Cyclamino hederifolii-Quercetum ilicis* Biondi *et al.* ex Biondi, Casavecchia & Gigante in Biondi, Allegrezza, Casavecchia, Galdenzi, Gigante & Pesaresi 2013

*PISTACIO LENTISCI-RHAMNETALIA ALATERNI* Rivas-Martinez 1975

***Oleo-Ceratonion siliquae*** Br.-Bl. ex Guinochet & Drouineau 1944 em. Rivas-Martinez 1975

*Oleo-Euphorbietum dendroidis* Trinajsti 1974

*Myrto-Pistacietum lentisci* (Molinier 1954 em. O.Bolòs 1962) Rivas-Martinez 1975

***Juniperion turbinatae*** Rivas-Martinez 1975 corr. 1987

*Asparago acutifolii-Juniperetum macrocarpae* O. Bolòs 1964

*Helianthemo sessilifolii-Juniperetum macrocarpae* Brullo, Giusso Del Galdo, Siracusa & Spampinato 2001

*Juniperetum macrocarpae-turbinatae* Pedrotti & Cortini-Pedrotti ex Pedrotti *et al.* 1982

*PINETALIA HALEPENSIS* Biondi, Blasi, Galdenzi, Pesaresi & Vagge Biondi, Blasi, Galdenzi, Pesaresi & Vagge in Biondi *et al.* 2014

***Pistacio lentisci-Pinion halepensis*** Biondi, Blasi, Galdenzi, Pesaresi & Vagge Biondi, Blasi, Galdenzi, Pesaresi & Vagge in Biondi *et al.* 2014

*Plantago albicantis-Pinetum halepensis* Bartolo, Brullo, Minissale & Spampinato 1985

*Pistacio-Pinetum halepensis* De Marco, Veri & Caneva 1984

RHAMNO-PRUNETEA Rivas-Goday & Borja ex Tüxen 1962

*PYRO SPINOSAE-RUBETALIA ULMIFOLII* Biondi, Blasi & Casavecchia in Biondi *et al.* 2014

***Pruno-Rubion ulmifolii*** O. Bolòs 1954

*Junipero communis-Hippophaetum fluviatilis* Géhu & Scoppola in Géhu *et al.* 1984

MOLINIO-ARRHENATHERETEA Tüxen 1937

*SACCHARETALIA RAVENNAE* Biondi, Blasi & Casavecchia in Biondi *et al.* 2014

***Imperato cylindricae-Saccharion ravennae*** Br.-Bl. & O.Bolòs 1958

*Schoeno nigricantis-Erianthetum ravennae* Pignatti 1953

*Calamagrostio epigejotis-Erianthetum ravennae* Taffetani & Biondi 1992

*Imperato cylindricae-Schoenetum nigricantis* Arrigoni 1996

PHRAGMITI-MAGNOCARICETEA Klika 1941

*SCIRPETALIA COMPACTI* Hejny in Holub, Hejny, Morav. & Neuh. 1967 em. Rivas-Martinez 1980

***Scirpion compacti*** Dahl & Hadač 1941 corr. Rivas-Martinez, Costa, Castroviejo & E. Valdés 1980

*Scirpetum compacto-littoralis* (Br.-Bl. (1931) 1952 em. Riv.Mart. *et al.* 1980

*Puccinellio palustris-Scirpetum compacti* (Pignatti 1953) Géhu & Scoppola 1984

*Scirpo compacti-Juncetum subulati* Géhu *et al.* 1992

*Junco maritimi-Cladietum marisci* Géhu & Biondi 1988

CRITHMO-STATICETEA Br.-Bl. in Br.-Bl., Roussine & Nègre 1952

**CRITHMO-STATICETALIA** Molinier 1934 em. Biondi 2007  
**Crithmo-Staticion** Molinier 1934  
*Crithmetum maritimi* Béguinot 1941  
*Reichardio maritimae-Brassicetum robertianae* Biondi 1982  
*Crithmo maritimi-Limonietum virgati* Pirone 1995  
*Crithmo-Limonietum diomedeeae* Bartolo, Brullo & Signorello 1989  
*Limonietum japigici* Curti & Lorenzoni 1968  
*Frankenio-Limonietum cancellati* Mariotti 1992  
*Limonio virgati-Plantaginetum grovesii* Bartolo, Brullo & Signorello 1989  
*Limonietum calabri* Bartolo, Brullo & Signorello 1989  
*Crithmo-Limonietum lacinii* Bartolo, Brullo & Signorello 1989  
*Crithmo maritimi-Inuletum crithmoidis* Biondi, Casavecchia & Guerra 2006  
**SENECIONETALIA CINERARIAE** Biondi 2007  
**Anthyllidion barbae-jovis** Brullo & De Marco 1989  
*Anthyllido-Centaureetum diomedeeae* Brullo & De Marco 1989

**PEGANO HARMALAE-SALSOLETEA VERMICULATAE** Br.-Bl. & O. Bolòs 1958  
**SALSOLO VERMICULATAE-PEGANETALIA HARMALAE** Br.-Bl. & O. Bolòs 1954  
**Artemision arborescentis** Géhu & Biondi 1986  
*Suaedo verae-Atriplicetum halimi* Biondi 1988  
 Aggruppam. a *Atriplex halimus*  
**STELLARIETEA MEDIAE** Tüxen, Lohmeyer & Preising ex Von Rochow 1951  
**STELLARIENEA MEDIAE**  
**THERO-BROMETALIA** (Rivas Goday & Rivas-Martínez ex Esteve 1973) O. Bolòs 1975  
*Echio plantaginei-Galactition tomentosae* O. Bolòs & Molinier 1969  
*Verbasco garganici-Euphorbietum terracinae* Biondi, Casavecchia & Biscotti 2007

**STELLARIETEA MEDIAE** Tüxen, Lohmeyer & Preising ex Von Rochow 1951  
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*Echio plantaginei-Galactition tomentosae* O. Bolòs & Molinier 1969  
*Verbasco garganici-Euphorbietum terracinae* Biondi, Casavecchia & Biscotti 2007

**ASPLENIETEA TRICHOMANIS** (Br.-Bl. in Meier & Br.-Bl. 1934) Oberd. 1977  
**CENTAUREO KARTSCHIANAE-CAMPANULETALIA PYRAMIDALIS** Trinajstić ex Di Pietro & Wagensommer 2008  
**Centaureo-Campanulion** Horvatić 1934  
*Campanulo-Centaureetum kartschianae* Lausi & Poldini 1962  
*Campanulo-Aurinetum leucadeae* Bioanco, Brullo, Pignatti & Pignatti 1988  
*Campanulo versicoloris-Dianthion japigici* Di Pietro & Wagensommer 2008

**ADIANTEA** Br.-Bl. in Br.-Bl., Roussine & Nègre 1952  
**ADIANTEA CAPILLI-VENERIS** Br.-Bl. ex Horvatić 1934  
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