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EDICIONES COMPLUTENSE

Plant communities supported by the geological setting: the case history of the Isole dei Ciclopi (east Sicily)

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Abstract. This paper provides an update inventory of the vascular flora and a framework of the plant communities of the Isole dei Ciclopi (Acicastello, Catania) taking into account their geological setting. A total of 111 phytosociological relevés were performed in the period 2015-2016. The plant communities has been analyzed using WPGMA and Euclidean distance classification. The study area preserves interesting plant-communities, mainly represented by shrubs vegetation (*Oleo-Ceratonion siliquae* and *Pruno-Rubion ulmifolii*), rocky coast communities (*Crithmo-Staticion)*, cliff vegetation (*Anthyllidion barbae-jovis*), halo-nitrophilous vegetation (*Pegano-Salsoletea*), spring-flowering meadows (*Frankenion pulverulentae*) and nitrophilous communities (*Allion triquetri* and *Echio-Galactition tomentosae*). The vegetation analysis allow the identification of twelve vegetation types and also the reconstruction of three vegetation series. The collected data have been organized in a GIS and the following thematic maps have been produced: vegetation map, habitats map (according to the 92/43/EEC Directive). According to directive 92/43/EU, only three habitat types were delimited through the phytosociological assessment of the plant communities. The flora of the investigated area consists of 102 taxa. The majority of the taxa represented in the life form spectrum are therophytes and hemicryptophytes. From a chorological point of view, the Mediterranean element outweighs the rest, followed by the most diverse group of widespread taxa. Furthermore a detailed geological investigation was carried out and a geological sketch map was performed. The comparison between the vegetation and geological maps shows a good correlation, mostly regarding the distribution of the plant communities onto the different types of substrata.
Keywords: flora, habitats, conservation, vegetation and geological maps, Sicily, Mediterranean islets.

[es] La vegetación y su relación con el sustrato geológico: el caso de Isole dei Ciclopi (este de Sicilia, Italia)

Resumen. Se presenta un inventario actualizado de la flora vascular y de las comunidades vegetales de la Isole dei Ciclopi (Acicastello, Catania) teniendo en cuenta su situación geológica. Se realizaron un total de 111 inventarios fitosociológicos en el período 2015-2016. Las comunidades de plantas se han analizado mediante clasificaciones (WPGMA, distancia euclídea). El área de estudio conserva interesantes comunidades vegetales, representadas principalmente por vegetación arbórea (*Oleo-Ceratonion siliquae* y *Pruno-Rubion ulmifolii*), comunidades costeras rocosas (*Crithmo-Staticion*), vegetación de acantilados (*Anthyllidion barbae-jovis*), vegetación halo-nitrófila-(*Pegano-Salsoletea*), comunidades terofíticas de carácter halófilo (*Frankenion pulverulentae*) y comunidades nitrófilas (*Allion triquetri* y *Echio-Galactition tomentosae*). El análisis de la vegetación ha permitido la identificación de doce tipos de comunidades y la reconstrucción de tres series de vegetación. Los datos recogidos se han organizado en un SIG y se han elaborado los siguientes mapas temáticos: mapa de vegetación, mapa de hábitats (Directiva 92/43/CEE). De acuerdo con la Directiva 92/43/CEE, sólo tres tipos de hábitats fueron delimitados a través de la evaluación fitosociológica de las comunidades vegetales. La flora de la zona investigada se compone de 102 taxones, la mayoría terofitos y hemicriptofitos. Desde el punto de vista corológico, el elemento mediterráneo supera al resto, seguido por el grupo más diverso de taxones de amplia distribución. Además, se llevó a cabo una detallada investigación geológica y se realizó un mapa preliminar geológico. La comparación entre la vegetación y los mapas geológicos muestra una buena correlación, principalmente en lo que respecta a la distribución de las comunidades vegetales en los diferentes tipos de sustratos.
Palabras clave: Flora, hábitats, conservación, vegetación, mapas geológicos, Sicilia, islotes Mediterráneos.

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Introduction

The Mediterranean islands generally represent very important areas for the occurrence of several endemic or rare vascular plant species (Médail & Quézel, 1999; Kallimanis & *al*., 2010). Cyclops Islands ("Isole dei Ciclopi" in Italian), close to the Sicilian coast, in the Ionian Sea, are so small (about 2 Ha), but famous in the world because connected to one of the most known Greek myths: Odysseus and the Cyclops, narrated by Homer in his Odyssey. Moreover they represent the products of the oldest Etnean volcanic phase occurred about 500000 years ago (Branca & *al*., 2011; De Beni & *al.*, 2011). Anyway as islets, they have a biogeographical interest to be compared mainly with the numerous small islands around Sicily. In the past the circum-Sicilian islets, attracted the interest of several botanists, which have mainly investigated the vascular flora (Lojacono-Pojero, 1878; Sommier, 1906, 1907, 1922; Francini & Messeri, 1956; Albo, 1959; Di Martino, 1958, 1962, 1963; Di Martino & Trapani, 1964, 1967, 1968; Catanzaro, 1965, 1984, 1992; Ferro & Furnari, 1968; Di Martino & Perrone, 1970, 1974; Ferro & Furnari, 1970; Di Benedetto, 1973; Brullo & Di Martino, 1974; Brullo & *al*., 1977; Brullo & Marcenò, 1983; Longhitano, 1983; Bartolo & *al*., 1990; Brullo & Siracusa, 1995; Siracusa, 1995; Troìa, 1998; Gianguzzi, 1999; Mazzola & *al*., 2001; Pasta & Lo Cascio, 2002; Pasta, 2004; Minissale & *al*., 2005; Gianguzzi & *al*., 2006; Romano & *al*., 2006; Pasta, 2001; Lo Cascio & Pasta, 2012; Pasta & *al*., 2014; Minissale & Sciandrello, 2017).

Regarding the Isole dei Ciclopi the first floristic collections were carried out by Nicotra (1893) and Zodda (1911), but the first vascular flora check-list can be attributed to Musmarra (1941) and recently to Siracusa (1995), while for the vegetation there are no detailed studies for this area, except for an abstract on the ecology of the protected area of the Isola Lachea (De Santis & *al*., 1995).

The present study is part of a project of research and monitoring activities carried out in the Nature Reserve "Isola Lachea e Faraglioni dei Ciclopi" (nowadays managed by CUTGANA), in order to a correct management of the protected area.

The aim of this research is to provide an updated inventory of the vascular flora and a framework of the plant communities of the Isole dei Ciclopi taking into account their geological setting.

Study area

The Isole dei Ciclopi are located in the Etnean volcanic district (S.E Sicily), in front of the little village of Acitrezza (Figure 1). Mount Etna Volcano is the largest active volcano in Europe and consists of the products of several overlapping eruptive centers. Rittmann (1973) firstly recognized five different eruptive stages in the etnean volcanic activity. The first stage, named Pre-Etnean stage, corresponds to a long period of submarine and subaerial fissure-type eruptions, whose products are now exposed in the Acitrezza, Acicastello and Ficarazzi area, localized on the lower SE flank of the volcano (Figure 1). Recent classification (Branca & *al*., 2011) grouped this products in the Basal Tholeiitic Supersynthem and the literature data are agree to date the eruptive phenomena at about 500000 years ago.

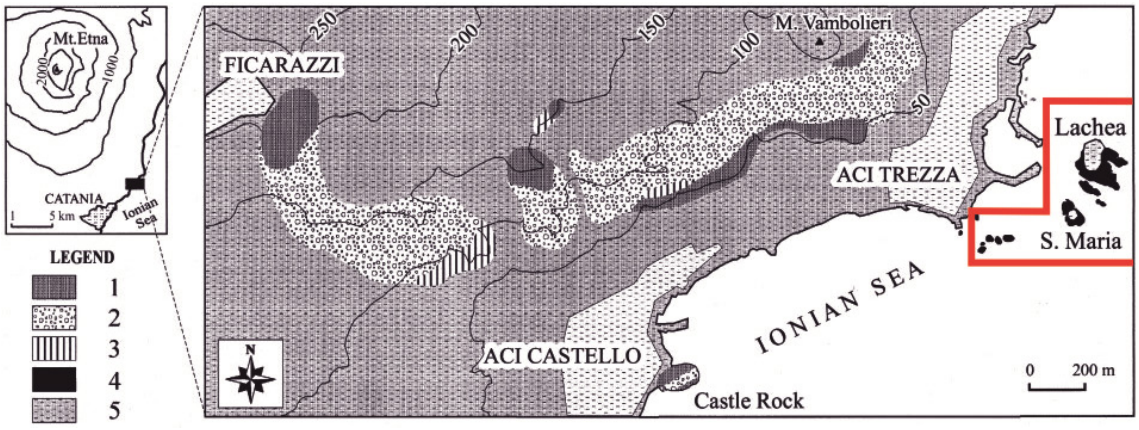

Figure 1. Geological sketch map of the Acicastello–Acitrezza–Ficarazzi area. 1. Pillow-lavas and pillow breccia. 2. Volcaniclastic deposits. 3. Subvolcanic rocks with closely spaced columnar joints. 4. Subvolcanic rocks with widely spaced columnar joints. 5. Younger alkaline volcanics and sedimentary rocks chiefly marly claystones; sands and gravels. Inside the red box are highlighted the Isole dei Ciclopi (after Corsaro & Cristofolini, 2000; modified).

In the Acitrezza area the volcanic products constitute an archipelago (Isole dei Ciclopi) made by two main islands (Lachea and S. Maria) and six islets. This setting was inherited by the occurrence of a tectonic uplift, causing the subaerial exposition of the volcanic products and associated sediments (see below) and their relative erosion.

Figure 2. Panoramic view of the study area from west (from CUTGANA).

The Ciclopi Archipelago, covering an area of about 2 ha, can be subdivided in two distinct sectors (Figure 2). The southern one is composed by four islets having a total dimension of few square metres; the biggest are named Faraglione di Mezzo (having 20 meters high and characterized by vertical slopes) and Faraglione Piccolo (high about 10 meters). Every islet is totally made by volcanic products.

The northern one is located in front of the small harbour of Acitrezza village and includes the Faraglione Grande and the Isola Lachea. The latter represents the biggest island of the Archipelago, having an altitude of about 25 m above sea level and a surfaces of about 1,5 ha, with a roughly circular shape. Finally the Faraglione Grande is almost conical in shape and reach about 30 meters in high and it is characterized by rather steep surfaces.

The naturalistic high value of the area allowed it to be included in the network of Sites of Community Importance (SCI) according to the Habitats Directive (code ITA070006 Isole dei Ciclopi, cod. ITA070028 Fondali di Acicastello, Isola Lachea - Ciclopi). Furthermore the Archipelago on 1998 was established as a Nature Reserve "Isola Lachea e Faraglioni dei Ciclopi", and on 1989 the arm of the sea between the Archipelago and the Acitrezza harbor began the Marine Protected Area "Isole Ciclopi".

According to a recent phytogeographic subdivision of Sicily (Sciandrello & *al*., 2015), this area belongs to the Etna district included in the north-east Sicilian subsector.

According to the bioclimatic classification proposed by Rivas-Martínez (1993, 2004), the investigated territory is referred to the Mediterranean pluviseasonal oceanic bioclimate, with thermotypes low thermomediterranean, and ombrotypes semiarid (or lower humid, Bazan & *al*., 2015).

Geological setting of the isole dei ciclopi

The northern sector of the Ciclopi Archipelago is characterized by the predominant outcrop of basaltic lava rocks (Figure 3b) and marly clays (Figure 3a), withish in color belonging to the "Argille grigio-azzurre" formation (Wezel, 1967). The entire stratigraphic succession is cropping out at the Isola Lachea when the marly clays generally overlie the volcanic products, except on the western sector where the two litotypes are interlayed.

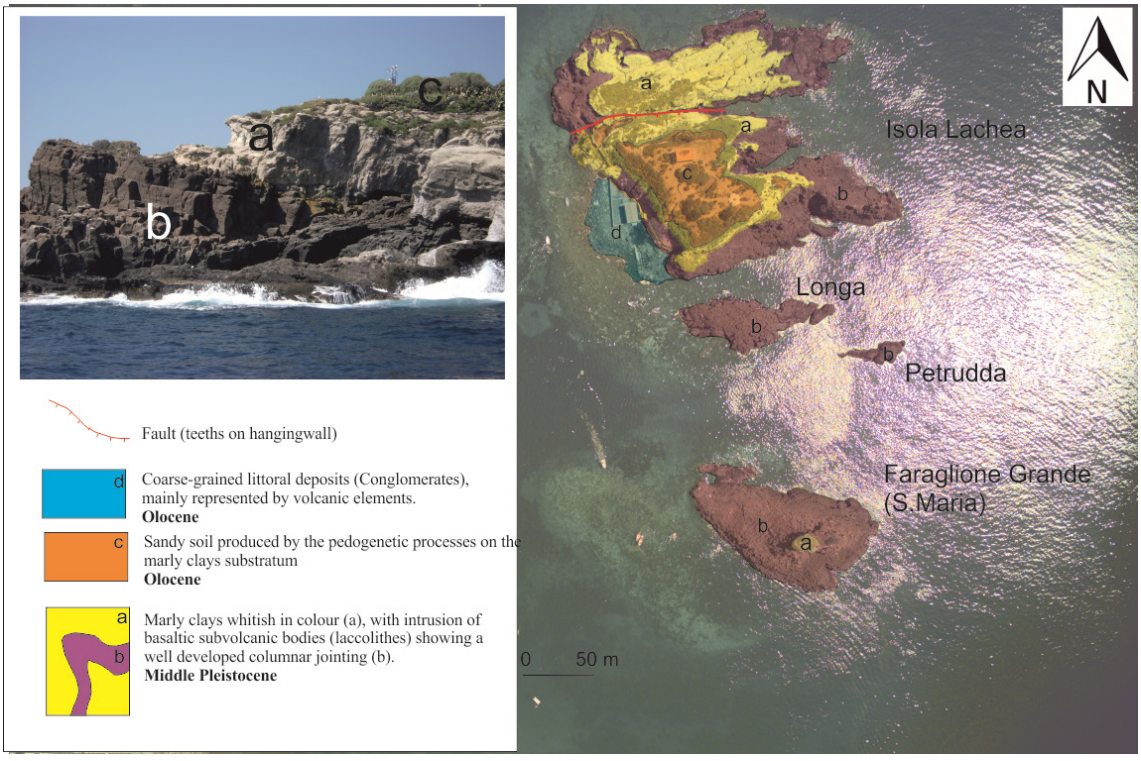

Figure 3. Geological sketch map of the northern sector of the Ciclopi Archipelago. In the picture on the left the overall stratigraphic setting of the Isola Lachea is showed. It is also notable the absence of vegetation characterizing the volcanic surfaces.

On the top of the Isola Lachea above the marly clays, a thin level of sandy soil is present (Figure 3c). The soil has been mapped only when the thickness exceed 40 cm., and it is typically absent on the volcanic surfaces. Finally, in the east sector of the island a coarse-grained littoral deposit is present (Figure 3d).

The volcanic rocks outcropping on the area are represented by dolerites-basalts (Analcime basalts, Tanguy, 1978), dark-grey in colour. Volcanic bodies are affected by the "columnar jointing "consisting on decimetric-metric scale fracturing of the rocks due to the occurrence of thermal contraction episodes during the slow transition from the molten to the solid states of the lavas. It is notable, on the lava outcrops, the total absence of scoriaceous surfaces and soils. This feature is probably linked with the eruptive style of the magmatic activity. Indeed, the volcanic activity occurred in the area did not consist on the classical eruptions producing lava flows and pyroclastic products, but in intrusions of magmas inside the soft package of the Pleistocene marly-clays. The intruded magmas chilled in slow way making planar and compact volcanic bodies (laccolites) without scoriaceus horizons whose alteration usually represents the first step of the volcanic soil formation. Furthermore the occurrence of strong winds, due to the exposition of the island, and the steep volcanic surfaces don't allow the accumulation of epiclastic deposits possibly produced by the erosional processes.

The marly clays are represented by fine-grained sediments, poorly cemented, except the areas affected by thermal metamorphism close to the volcanic intrusions. This sediments are affected by an intense fracturing centimetric in scale that decreases their hardness. This properties, linked with the occurrences of the outcrops at the top of the island, having a subplanar setting, helps the development and the preservation of the soil above the withish marly clays.

Materials and Methods

The vegetation analysis was carried out following the phytosociological method (Braun-Blanquet, 1964) taking into account the most recent acquisitions related to symphytosociology and geosymphytosociology (Biondi, 2011; Rivas Martínez, 2005). A total of 111 phytosociological relevés were performed in the period 2015-2016. Subsequently, data related to halo-nitrophilous scrub vegetation and halophilous plant communities were subjected to multivariate analysis using Syntax 2000 software (Podani, 2001). Original Braun-Blanquet sampling scales were transformed into the ordinal scale according to Van der Maarel (1979). A hierarchic classification method (WPGMA) was performed. Dissimilarity of the relevés was measured using the Euclidean distance coefficient. Syntaxa classification follows Mucina & *al*. (2016).

For the correlation between vegetation types and habitats we referred to the Italian Interpretation Manual for the Habitats of Directive 92/43/EEC (Biondi & *al*., 2009); while EUNIS coding and status assessment follows Janssen & *al*. (2016). The plant communities was mapped using ArcGis 10.3 (ESRI Inc., Redlands, CA, USA).

Plants were collected from all over the study area and also throughout the year to obtain a complete inventory of existing species, noting their local distribution and preferred habitat. The exsiccata (preserved in the Herbarium of University of Catania) were studied with the help of Flora Europaea (Tutin & *al*., 1964-80), the Italian floras (Fiori, 1923-29; Pignatti, 1982). Taxonomic nomenclature follows Giardina & *al*. (2007). In the list, species and families follow alphabetical order. For each taxon, life form, chorological element, frequency, and local distribution are reported. The life form of each taxon follows the Raunkiaer system as proposed by Pignatti (1982) while the chorological types are adapted from Brullo & *al*. (1998).

Moreover, each taxon's frequency in the study area is indicated using the following abbreviations: C (common, spread in several habitats), NC (not common, spread in some habitats), R (rare, localized on specific habitats).

Results and Discussion

Flora

The vascular flora of this area consists of 102 specific and infraspecific taxa (Appendix 1). The most represented families are Poaceae

(18 taxa), Asteraceae (16 taxa) and Fabaceae (7 taxa). The life form spectrum of the vascular flora indicates the predominance of therophytes (52%), with hemicryptophytes (15%) and phanerophytes (10%) (Figure 4). From a chorological viewpoint, most species show a Mediterranean distribution (46 taxa) (Figure 5).

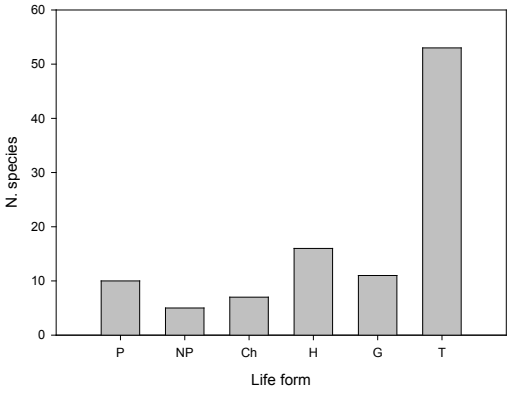

Figure 4. Life form spectrum (102 taxa); P: Phanerophytes; NP: Nanophanerophytes; Ch: Chamaephytes; H: Hemicryptophytes; G: Geophytes; T: Therophytes.

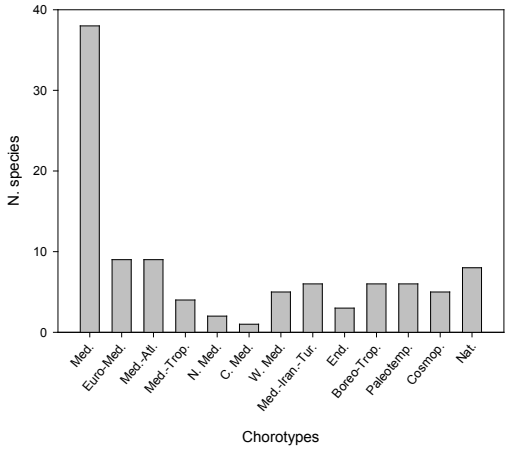

Figure 5. Chorological spectrum. Chorotypes: Med.: Circum-Mediterranean; Euro-Med.: Euro-Mediterranean; Med.-Atl.: Mediterranean Atlantic; Med.-Trop.: Mediterranean Tropical; N. Med.: North Mediterranean; C. Med.: Centre Mediterranean; W Med.: West Mediterranean; Med.-Iran.-Tur.: Mediterranean-Irano-Turanian; End.: Endemic; Boreo-Trop. Boreo-Tropical; Paleotemp.: Paleotemperate; Cosmop.: Cosmopolitan; Nat.: Naturalized (chorological types adapted from Brullo & *al*., 1998).

Vegetation

Vegetation is described from 111 unpublished relevés collected during the study. A total of 12 plant communities were identified, belonging to 6 classes, as explained in the syntaxonomical scheme (Appendix 2). Cluster analysis of the halophilous (cluster A) and halo-nitrophilous (cluster B) scrubs vegetation allowed to distinguish four main plant communities with specific differential species (Figure 6). The description of each plant community is given below.

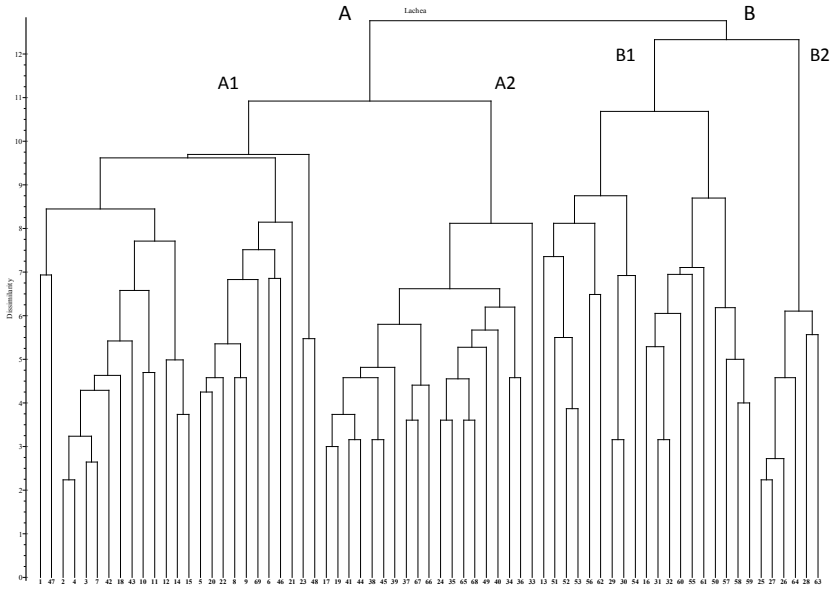

Figure 6. Cluster analysis. Plant communities: A1. *Suaedo verae-Atriplicetum halimi*, A2. *Crithmetum maritimi*, B1. *Atriplici halimi-Artemisietum arborescentis,* B2. *Matthiola incana* comm.

Rocky coast vegetation

(*Crithmo maritimi-Staticion* Molinier 1934)
Crithmetum maritimi Béguinot 1941

(Table 1, cluster A2, Figure 7A)

Characteristic species: *Crithmum maritimum*

Structure and ecology: Chamaephytic vegetation colonizing the cliffs or gently sloping volcanic outcrops along the sea, influenced by the sea-spray and by the organic waste accumulated during the sea-storms. This association is characterized by the dominance of *Crithmum maritimum*, mixed with sparse individuals of *Lotus cytisoides, Allium commutatum*, *Capparis orientalis* and *Matthiola incana.* It is linked to thermo-Mediterranean subhumid bioclimatic belt, in catenal contact, towards the inland, with the *Pegano-Salsoletea* vegetation. In fact as already noted by Biondi (2007) in similar contexts, the rocks closest to the sea, subjected to the actions of the marine aerosol, are colonized by halo-rupicolous pioneer vegetation, while on the less exposed cliffs halotolerant communities grow.

Local distribution: Isola Lachea and Faraglione Grande.

Habitat: EUNIS B3.1b Mediterranean and Black Sea rocky sea cliff and shore (LC); not considered in Habitat Directive.

Rocky cliff vegetation

(*Anthyllidion barbae-jovis* Brullo & De Marco 1989)
Matthiola incana* subsp. *incana comm.

(Table 1, cluster B2, Figure 7B)

Diagnostic species: *Matthiola incana*

Structure and ecology: On volcanic rocky cliff, in an almost total absence of soil, grows a sub-halophilous vegetation characterized by dominance of *Matthiola incana* subsp. *incana.* According Brullo & De Marco (1989) this chamaephitic species is characteristic of *Anthyllidion barbae-jovis* alliance. On the cliff of the Faraglione degli Uccelli the physiognomy of this rupicolous plant communities is given mainly by *Matthiola incana* subsp. *incana* and other few species belonging to the *Anthyllidion barbae-jovis* alliance, as *Allium commutatum*, *Lotus cytisoides* and *Silene vulgaris* subsp. *todaroana* (Brullo & De Marco, 1989).

Local distribution: Faraglione di Mezzo

Habitat: EUNIS B3.1b Mediterranean and Black Sea rocky sea cliff and shore (LC); not considered in Habitat Directive.

Perennial halo-nitrophilous vegetation

(*Salsolo vermiculatae-Peganetalia harmalae* Br.-Bl. & O.Bolòs 1958)

Table1. *Atriplici halimi-Suaedetum verae* Biondi 1988 (1-25)
(*Atriplici-Suaedion*, *Salsolo-Peganetalia*, *Pegano-Salsoletea*)
Crithmetum maritimi Béguinot 1941 (26-44)
(*Crithmo maritimi-Staticion*, *Crithmo-Staticetalia*, *Crithmo-Staticetea*)

Cluster	A1	A1	A1	A1	A1	A1	A1	A1	A1	A1	A1	A1	A1	A1	A1	A1	A1	A1	A1	A1	A1	A1	A1	A1	A1	A2	A2	A2	A2	A2	A2	A2	A2	A2	A2	A2	A2	A2	A2	A2	A2	A2	A2
Area (m^2)	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	16	16	16	16	16	16	16	16	20	20	20	40	16	16	16	16	16	16	16	16	16	16	16	16	16	20	20	20	20
Cover (%)	80	85	90	90	100	90	100	100	100	80	85	85	85	80	85	100	90	90	85	90	85	90	95	90	90	75	75	75	30	85	60	90	80	80	85	90	80	80	70	90	80	85	75	65
Slope (°)	20	15	60	65	5	25	45	5	20	5	5	40	50	65	60	.	45	.	.	5	65	25	5	5	5	55	65	80	30	65	75	60	.	.	.	60	50	35	25	60	70	15	60	65
Exposure	SE	W	W	W	E	W	E	E	E	E	E	W	W	W	W	.	W	.	.	NW	NW	NW	E	E	E	W	W	N	N	NW	W	W	.	.	.	N	W	N	N	W	E	E	W	NE
Reference N.	1	2	3	4	5	6	7	8	9	10	11	12	14	15	18	20	21	22	23	42	43	46	47	48	69	17	19	24	33	34	35	36	37	38	39	40	41	44	45	49	65	66	67	68
Relevé N.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
Characteristics																																											
Suaeda vera	3	4	4	4	4	3	5	4	3	4	4	4	3	3	4	4	1	2	3	5	3	3	4	3	2	1	2	+	1	2	1	+	.	.	+	1	2	2	1	.	+	.	.	.
Crithmum maritimum	+	2	1	2	.	1	1	.	.	.	.	2	1	+	+	+	+	.	1	2	3	2	2	2	.	3	3	2	3	3	3	4	4	4	4	4	4	4	4	3	4	4	4	4
Characteristics *Pegano-Salsoletea*																																											
Artemisia arborescens	.	.	.	.	3	3	.	2	3	.	.	+	1	1	+	2	3	3	2	.	.	3	.	+	3	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
Atriplex halimus	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Characteristics *Crithmo-Limonietea*																																											
Matthiola incana subsp. *incana*	1	+	1	1	.	1	1	+	+	+	.	+	1	1	1	+	+	+	.	+	2	2	1	.	1	+	1	3	.	3	2	3	1	1	+	3	+	1	+	4	2	1	1	2
Allium commutatum	1	1	+	1	+	1	1	+	+	.	.	.	.	.	+	1	+	+	.	.	1	1	2	+	1	+	+	1	.	+	1	1	+	.	+	+	+	+	.	1	1	+	1	+
Capparis orientalis	.	.	+	+	.	+	1	.	+	1	.	.	.	.	1	.	+	.	.	.	+	+	.	.	.	1	1	1	.	+	1	1	2	1	1	2	1	+	1	+	1	2	3	1
Lotus cytisoides	.	.	.	.	.	.	.	.	.	.	.	1	+	1	.	.	.	.	.	.	.	.	.	.	.	+	+	+	1	1	+	+	+	.	+	.	.	.	.	.	.	.	.	.
Silene vulgaris subsp. *tenoreana*	.	.	.	.	.	.	.	.	.	.	.	1	1	2	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	1	.	.	+	.	.	.	1	.	.
Limbarda chrithmoides	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	1	.	2	.	.	.	.	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Other species																																											
Asparagus acutifolius	+	.	.	.	+	+	.	+	.	.	.	+	+	+	+	+	+	+	.	.	.	1	1	.	+	.	+	.	.	+	.	+	.	.	.	.	.	.	.	.	.	+	.
Brassica fruticulosa	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	1	.	.	+	.	.	+	.	.	.	.	.	.	.	.	+	+	+	.	+
Opuntia ficus-indica	1	.	.	.	.	+	.	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1	.	1	.	.	.	.	.	.	.	1	.	.	.	.
Melilotus italicus	2	.	.	.	+	+	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Dittrichia viscosa	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Parapholis incurva	.	+	+	+	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Dactylis glomerata subsp. *hispanica*	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	1	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
Arisarum vulgare	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.
Ficus carica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.
Sonchus asper	+	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ferula communis	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Other species: *Trachynia distachya* and *Mesembryanthemum nodiflorum* + in 1; *Thapsia garganica* + in 23; *Piptatherum miliaceum* subsp. *miliaceum* + in 25; *Umbilicus horizontalis* + in 44.

Localities: 1-11: Isola Lachea, 16.04.2015; 12-14: Faraglione Grande (Madonnina), 16.04.2015; 15-19,26-28: Isola Lachea, 22.06.2015; 20,21,36-39: Isola Lachea, 26.10.2015; 22-24: Isola Lachea, 28.01.2016; 25, 42-44: Isola Lachea, 24.05.2016; 29: Faraglione Grande (Madonnina), 22.06.2015; 30-35: Isola Lachea, 08.07.2015; 40: Isola Lachea (lower side of the house), 31.04.2016; 41: Isola Lachea, 24.05.2016.

Table 1 (cont.). *Atriplici halimi-Artemisietum arborescentis* Biondi 1988 (1-19)
(*Artemision arborescentis*, *Salsolo-Peganetalia*, *Pegano-Salsoletea*)
Matthiola incana subsp. *incana* community (20-25)
(*Anthyllidion barbae-jovis*, *Helichrysetalia italici*, *Crithmo-Staticetea*)

Cluster	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B2	B2	B2	B2	B2	B2
Area (m^2)	40	40	50	50	50	50	20	20	20	20	20	20	20	40	40	40	40	40	40	16	16	16	16	20	20
Cover (%)	90	80	90	95	85	80	85	80	85	80	100	90	85	70	80	80	75	75	85	85	85	85	50	80	85
Slope (°)	60	35	35	40	40	40	65	70	70	50	30	40	50	35	45	40	30	40	60	70	45	80	90	60	70
Exposure	W	W	NW	N	W	W	NW	NW	NW	NW	W	W	W	NW	NW	NW	SE	SW	SW	W	NW	W	W	N	N
Reference N.	13	16	29	30	31	32	50	51	52	53	54	55	56	57	58	59	60	61	62	25	26	27	28	63	64
Relevé N.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Characteristics																									
Artemisia arborescens	4	2	4	5	1	1	1	4	3	2	5	2	3	2	1	2	1	1	3	.	.	.	.	.	.
Matthiola incana subsp. incana	2	.	+	1	1	+	2	1	2	2	.	.	1	2	2	2	.	.	1	3	3	3	2	3	3
Characteristics *Pegano-Salsoletea*																									
Suaeda vera	1	2	.	.	2	1	1	.	1	+	.	1	1	2	1	2	1	3	1	.	.	.	.	.	.
Atriplex halimus	+	4	1	+	3	3	4	.	.	.	1	3	1	2	3	3	4	3	1	.	.	.	.	.	.
Characteristics *Crithmo-Limonietea*																									
Silene vulgaris subsp. tenoreana	2	+	1	1	+	1	1	1	1	1	+	.	+	1	1	2	1	1	1	3	2	3	1	1	2
Lotus cytisoides	1	+	+	+	1	+	+	+	+	+	.	+	2	1	+	+	1	2	3	1	2	2	2	3	2
Allium commutatum	.	+	.	.	+	1	1	+	1	1	+	2	1	+	.	.	.	1	+	+	+	1	.	.	1
Capparis orientalis	.	+	.	.	+	1	.	.	.	.	.	.	.	+	+	+	1	+	+	+	1	+	+	1	+
Crithmum maritimum	+	+	.	.	.	.	1	.	.	.	.	.	.	+	+	+	+	.	.	.	.	.	.	.	.
Other species																									
Dactylis glomerata subsp. *hispanica*	+	.	1	+	+	+	1	1	1	2	+	+	+	.	+	+	+	.	+	.	.	.	+	1	+
Asparagus acutifolius	1	+	+	+	+	+	1	2	1	+	+	+	+	1	+	+	1	+	1	.	.	.	.	.	.
Asparagus albus	.	+	1	1	+	1	.	1	1	+	2	1	1	.	.	.	+	+	+	.	.	.	.	.	.
Brassica fruticulosa	.	.	+	+	.	.	+	+	+	+	+	+	+	+	+	+	.	1	1	.	.	.	.	.	.
Sonchus asper	+	+	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	1	.	.
Sonchus oleraceus	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+	+	+	.	.	.	.	+	+
Melilotus italicus	.	.	1	+	+	+	.	.	.	.	1	+	+	.	.	.	.	.	.	.	.	.	.	.	.
Carlina hispanica subsp. *globosa*	.	.	+	1	.	.	.	.	.	.	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.
Lolium rigidum	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.
Daucus carota subsp. *carota*	.	.	+	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Chenopodium album	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.
Arisarum vulgare	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Trachynia distachya	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Ferula communis	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Other species: *Thapsia garganica* and *Galactites elegans* + in 11; *Reichardia picroides* + in 23; *Umbilicus horizontalis* + in 25.

Localities: 1,2: Faraglione Grande (Madonnina), 16.04.2015; 3-6: Faraglione Grande (Madonnina), 22.06.2015; 7-13: Faraglione Grande, 31.03.2016; 14-19: Faraglione Grande, 13.04.2016; 20-23: Faraglione di Mezzo (F. Uccelli), 22.06.2015; 24-25: Faraglione di Mezzo (F. Uccelli), 13.04.201

Figure 7. Perennial vegetation. A. Rocky coast vegetation with *Crithmum maritimum* (Isola Lachea); B. Rocky cliff vegetation with *Matthiola incana* (Faraglione di Mezzo); C-D. Halo-nitrophilous vegetation with *Suaeda vera* e *Atriplex halimus* (I. Lachea-Faraglione Grande); E-F. Nitrophilous vegetation with *Artemisia arborescens* (Faraglione Grande and Isola Lachea). The plant communities shown in A-B-D develop on cracks of the basaltic lavas. In C is visible the substrata represented by marly clays.

Atriplici halimi-Suaedetum verae Biondi 1988 *nom. inv. propos.*

(Table 1, cluster A1, Figure 7C-D)

Characteristic species: *Suaeda vera*, *Atriplex halimus*.

Structure and ecology: Halo-nitrophilous plant community colonizing coastal rocky habitats (marls, conglomerates, limestone and sandstone) directly influenced by the sea-spray and dunged by the seabirds (Brullo & *al*., 2013). The physiognomy is given mainly by *Atriplex halimus* and the bushes of *Suaeda vera,* this last species on the Isola Lachea achieving high cover values. In last years,

the excessive spread of Yellow-legged Gulls (*Larus michaellis*) on the Islands has favored the reduction of *Atriplex halimus* and a spread of *Suaeda vera*, the latter more tolerant nitrophilous species.

Local distribution: Isola Lachea and Faraglione Grande.

Habitat: EUNIS F6.8 Mediterranean halo-nitrophilous scrub (LC); 1430 Halo-nitrophilous scrubs (*Pegano-Salsoletea*).

Atriplici halimi-Artemisietum arborescentis Biondi 1988

(Table 1, cluster B1, Figure 7E-F)

Characteristic species: *Atriplex halimus*, *Artemisia arborescens*.

Structure and ecology: Synanthropic shrublands dominated mainly by *Artemisia arborescens*, sometimes growing together with *Atriplex halimus* and *Suaeda vera*. This very poor floristic settlement is often found in coastal sites, on marly and conglomeratic substrata, sometimes used as dumping places for urban waste and rubbles (Biondi & *al*., 1988). It can be considered as a permanent edaphic community whose evolution is contrasted by the human disturbance, combined to the action of coastal winds, seabirds, salt-spray (Brullo & *al*., 2013). It is found within the thermo-Mediterranean dry to subhumid bioclimatic belt, often in contact with the *Oleo-Ceratonion* vegetation.

Local distribution: Isola Lachea and Faraglione Grande.

Habitat: EUNIS F6.8 Mediterranean halo-nitrophilous scrub (LC); 1430 Halo-nitrophilous scrubs (*Pegano-Salsoletea*).

Halo-nitrophilous and sub-halophilous annual vegetation

(*Frankenion pulverulentae* Rivas-Martínez ex Castroviejo & Porta 1976)

Trifolio scabri-Catapodietum balearici Brullo et Giusto del Galdo 2003

(Table 2, rels. 1-13)

Characteristic species: *Trifolium scabrum, Catapodium balearicum*.

Structure and ecology: Halo-nitrophilous association colonizing the rocky coastal. This annual vegetation grows on in particular areas on flat surfaces with a few centimeters of soil, subject to marine-spray within the Thermo-mesomediterranean bioclimatic belt (Rivas Martínez & *al*., 2004). It is in catenal contact with the halo-nitrophilous plant communities of the *Atriplici halimi-Suaedetum verae*. The structure of *Trifolio scabri-Catapodietum balearici* is given mainly by *Catapodium balearicum* and several species belonging to the *Saginetea maritimae* class (Brullo & Giusso, 2003), as *Spergularia bocconi, Plantago coronopus, Parapholis incurva, Sagina maritima, Trifolium scabrum, Mesembryanthemum nodiflorum, Polycarpon tetraphyllum subsp. diphyllum* etc. The surfaces rich in nitrates, with little deeper soils and not very sunny, the *Trifolio scabri-Catapodietum balearici* is replaced by a vegetation dominated by *Mesembryanthemum nodiflorum* (Figure 8C).

Local distribution: Isola Lachea.

Habitat: EUNIS A2.6513 – *Salicornia* spp. pioneer saltmarshes; 1310 *Salicornia* and other annuals colonizing mud and sand.

Parapholido incurvae-Spergularietum bocconei Brullo, Scelsi & Spampinato 2001

(Table 2, rels. 14-23, Figure 8A-B)

Characteristic species: *Spergularia bocconei, Parapholis incurva*.

Structure and ecology: This vegetation prefers more or less the same ecological conditions of *Trifolio scabri-Catapodietum balearici* with some differences linked to an increased need to nitrates and very shallow soils. It is in catenal contact with the halo-nitrophilous plant communities of the *Crithmo maritimi-Staticetea*. The structure is given mainly by *Spergularia bocconi* and *Parapholis incurva* and other few species belonging to the *Saginetea maritimae* class (Brullo & Giusso, 2003), as *Spergularia salina, Parapholis incurva* and *Sagina maritima.*

Local distribution: Isola Lachea and Faraglione Grande.

Habitat: EUNIS A2.6513 – *Salicornia* spp. pioneer saltmarshes; 1310 *Salicornia* and other annuals colonizing mud and sand.

Scrub vegetation

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

Asparago acutifolii-Oleetum sylvestris Bacchetta et al. 2003

(Table 3, rels. 1-7)

Diagnostic species: *Olea europaea* var. *sylvestris*.

Table 2. *Trifolio scabri-Catapodietum balearici* Brullo et Giusso del Galdo 2003 (1-13)
Parapholido incurvae-Spergularietum bocconei Brullo, Scelsi & Spampinato 2001 (14-23)
(*Frankenion pulverulentae*, *Frankenietalia pulverulentae*, *Saginetea maritimae*)

Area (m^2)	0.5	0.5	0.3	0.3	0.5	0.2	0.3	0.4	0.5	0.5	0.5	0.5	0.5	0.3	0.3	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.8
Cover (%)	90	90	90	90	90	90	6	85	80	65	70	80	90	80	85	90	90	85	90	90	85	70	90
Slope (°)	-	-	-	-	-	SE	N	N	N	-	-	-	-	-	-	NW	NW	NE	-	-	-	-	-
Exposure	-	-	-	-	-	5	5	5	5	-	-	-	-	-	-	3	3	2	-	-	-	-	-
Altitude (m)	8	8	9	9	9	9	8	8	8	9	9	10	10	8	8	6	6	6	7	7	7	7	7
Soil type	Ma	Ma	Ma	Ma	Ma	Ma	Ma	Ma	Ma	Ma	Ma	Ma	Ma	Ma	Ma	Vu	Vu	Vu	Vu	Vu	Vu	Vu	Vu
Relevé N.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Characteristics																							
Catapodium balearicum	4	4	4	4	3	4	1	4	4	2	3	4	3	.	.	.	.	.	.	.	.	.	1
Spergularia bocconi	.	.	.	.	+	.	1	+	+	.	.	.	.	4	4	.	+	.	5	1	+	3	4
Plantago coronopus	1	+	.	+	3	1	1	2	1	1	2	2	1	+	1	4	4	4	1	4	3	+	1
Parapholis incurva	3	1	2	1	2	+	.	.	.	.	.	.	.	+	+	3	2	1	1	3	3	1	+
Sagina maritima	.	.	.	.	.	.	3	1	1	+	1	+	.	+	+	1	1	+	1	.	1	.	1
Trifolium scabrum	.	.	+	.	1	+	+	+	+	1	1	+	2	.	.	.	.	.	.	.	.	.	.
Mesembryanthemum nodiflorum	.	.	.	+	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Medicago truncatula	.	.	.	+	+	.	.	.	.	+	.	+	1	.	.	.	.	.	.	.	.	.	.
Polycarpon tetraphyllum subsp. *diphyllum*	.	.	.	.	.	.	.	+	+	.	.	1	.	.	.	.	.	.	.	.	.	.	.
Other species																							
Suaeda vera	+	+	+	+	+	+	.	+	+	+	+	+	+	.	.	.	.	.	+	+	.	.	+
Sonchus asper	.	.	.	+	.	.	.	+	+	.	.	+	+	.	.	.	.	.	.	.	.	.	.
Crithmum maritimum	+	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
Allium commutatum	.	.	.	.	.	.	+	.	.	+	.	+	+	.	.	.	.	.	.	.	.	.	.
Anagallis arvensis	.	.	.	.	.	.	.	1	2	+	+	.	+	.	.	.	.	.	.	.	.	.	.
Melilotus italicus	.	.	.	.	.	.	.	+	.	+	+	+	+	.	.	.	.	.	.	.	.	.	.
Trachynia distachya	.	.	.	.	.	.	.	.	+	.	+	1	1	.	.	.	.	.	.	.	.	.	.
Anagallis foemina	.	.	.	.	.	.	.	.	.	.	.	+	1	.	.	.	.	.	.	.	.	.	.

Other species: *Silene vulgaris* subsp. *tenoreana* + in 19.

Localities: 1-5: Isola Lachea, 16.04.2015; 6: Isola Lachea, 08.07.2015; 7-15: Isola Lachea (white rock with *Suaeda*), 31.04.2016; 16-19: Faraglione Grande, 31.03.2016; 20-23: Faraglione Grande, 13.04.2016.

Table 3. *Rubus ulmifolius* community
(*Pruno spinosae-Rubion ulmifolii*, *Pyro spinosae-Rubetalia ulmifolii*, *Crataego-Prunetea*)

Altitude (m)	25	25	25	25	25	25	26	24	24	24	23	24	24
Area (m^2)	20	20	20	20	20	20	20	20	20	20	20	20	20
Cover (%)	90	90	90	90	90	100	100	95	95	95	100	90	100
Slope (°)	45	35	55	45	40	-	5	30	30	30	-	35	40
Exposure	W	W	W	W	W	-	E	N	N	N	-	N	W
Soil	Ma	Ma	Ma	Ma	Ma	Ma	Ma	Ma	Ma	Ma	Ma	Ma	Ma
Relev. No.	1	2	3	4	5	6	7	8	9	10	11	12	13
Characteristics													
Asparagus acutifolius	1	1	+	1	+	2	+	+	+	.	1	1	.
Rubus ulmifolius	2	1	2	1	1	+	.	4	2	4	3	1	4
Characteristics *Oleo-Ceratonion*													
Olea europaea var. sylvestris	4	3	4	4	3	4	5	.	1	.	1	+	.
Arisarum vulgare	1	1	1	1	1	1	4	.	.	.	.	.	.
Other species													
Opuntia ficus-indica	3	2	3	2	4	1	1	1	2	2	2	+	.
Ailanthus altissima	2	1	2	3	1	.	.	4	3	3	2	.	.
Brassica fruticulosa	1	2	1	2	1	+	.	2	1	1	1	+	.
Spartium junceum	2	1	3	1	2	.	.	2	1	.	2	4	1
Matthiola incana subsp. incana	2	1	1	1	1	+	+	.	+	+	+	+	+
Capparis orientalis	1	+	+	+	+	+	+	+	+	.	+	+	.
Dittrichia viscosa	.	+	.	+	+	.	.	+	+	+	+	+	.
Dactylis glomerata subsp. hispanica	+	+	.	+	+	.	.	.	+	+	+	+	.
Acanthus mollis	+	+	+	+	+	+	+	.	.	+	.	.	.
Thapsia garganica	+	+	+	1	.	.	.	+	+	.	+	+	.
Mercurialis annua	+	+	+	+	+	+	+	+	+	+	+	+	.
Piptatherum miliaceum subsp. miliaceum	.	.	.	+	.	.	.	+	+	.	+	+	.
Ficus carica	1	1	+	.	.	.	.	1	.	.	1	+	2
Carlina hispanica subsp. globosa	.	.	.	+	.	.	.	.	+	.	.	1	.
Galactites elegans	.	.	.	.	+	.	.	+	.	.	.	+	.
Allium commutatum	.	.	.	.	.	.	.	.	.	.	.	+	+
Daucus carota subsp. carota	.	.	.	.	.	.	.	.	.	.	+	+	.
Arundo donax	.	.	.	.	.	.	.	2	1	.	.	.	.

Other species: *Capparis spinosa* + in 4, *Robinia pseudacacia* 1 in 10.

Localities: 1-6: Isola Lachea, 08.07.2015; 7: Isola Lachea, 26.10.2015; 8-13: Isola Lachea, 08.07.2015.

Structure and ecology: On top of Lachea island and Faraglione Grande grows a evergreen vegetation dominated by *Olea europaea* var. *sylvestris*. Small plant species of the *Oleo-Ceratonion* alliance are presence, such as *Arisarum vulgare, Prasium majus* and *Asparagus acutifolius*. For its ecological characteristics this plant community can be referred to *Asparago acutifolii-Oleetum sylvestris*, association described by Bacchetta (2003) for Sardinia. In some parts of the island Lachea the *Olea europaea* communities are mixed with *Spartium junceum*, *Opuntia ficus-indica*, *Ailanthus altissima*, in particular the latter two species often tend to alter the typical structure of the shrub community and especially to steal the habitat of indigenous communities.

Local distribution: Isola Lachea and Faraglione Grande.

Habitat: F5.51 Thermo-Mediterranean brushes, thickets and heath-garrigues (VU); 9320 Foreste di *Olea* e *Ceratonia*.

Figure 8. Annual vegetation. A-B. Sub-halophilous vegetation with *Spergularia bocconei* and *Parapholis incurva* (Faraglione Grande); C. Halo-nitrophilous vegetationwith *Mesembryanthemum nodiflorum* (Isola Lachea); D. Nitrophilous vegetation with *Vulpia geniculata* (Isola Lachea).

Synanthropic vegetation

(*Pruno-Rubion ulmifolii* O. Bolòs 1954, *Allion triquetri* O. Bolòs 1967, *Echioplantaginei-Galactition tomentosae* O. Bolòs & Molinier 1969)

Rubus ulmifolius comm.

(Table 3, rels. 8-13)

Diagnostic species: *Rubus ulmifolius*.

Structure and ecology: As a result of the degradation of maquis, a secondary shrub develops on moist, nitrate rich soils. This vegetation occupying in particular the north-facing slopes, in proximity of geological fractures of the Isola Lachea. From a structural viewpoint, this vegetation is characterized by intricate, almost impenetrable bushes, such as *Rubus ulmifolius, Ficus carica* and *Spartium junceum*. Moreover, this community hold several synanthropic and alien species, as *Opuntia ficus-indica, Ailanthus altissima, Arundo donax, Robinia pseudoacacia, Brassica fruticulosa, Dittrichia viscosa, Mercurialis annua, Piptatherum miliaceum* subsp. *miliaceum, Daucus carota,* etc.

Local distribution: Isola Lachea.

Habitat: EUNIS F3.23 Tyrrhenian sub-mediterranean deciduous thickets; not considered in Habitat Directive.

Acanthus mollis comm.

(Table 4, rels. 1-3)

Diagnostic species: *Acanthus mollis*

Structure and ecology: Anthropogenic vegetation of sciaphilous and nitrophilous, perennial or annual herbs that grows on deep and nutrient-rich soils (Biondi & *al*., 2014). This plant community, with a winter-spring cycle, is localized in the shade of olive trees (*Olea europaea* var. *sylvestris*) of the Lachea Island. It is prefer ruderal environments with deep soils, rich in organic matter. The physiognomy of this community is given by the dominance of *Acanthus mollis* normally achieving

Table 4. *Galactites elegans* community
(*Echio-Galactition tomentosae*, *Brometalia rubenti-tectorum*, *Chenopodietea*)

Area (m^2)	20	20	20	20	40	20	20	10	10
Cover (%)	90	95	100	100	100	100	90	90	90
Slope (°)	-	-	-	-	-	5	5	5	5
Exposure	-	-	-	-	-	N	NW	W	W
Altitude (m)	10	10	10	10	10	11	8	10	10
Relev. No.	1	2	3	4	5	6	7	8	9
Characteristics									
Acanthus mollis	4	3	3	1	1	1	.	+	+
Galactites elegans	1	+	2	4	4	4	3	1	1
Characteristics *Epilobietea & Allion triquetri*									
Arisarum vulgare	2	3	1	1	1	.	+	.	+
Urtica membranacea	+	1	+	.	+	1	.	.	.
Parietaria lusitanica	+	+	+	.	.	1	.	.	.
Galium aparine subsp. *aparine*	+	.	+	.	.	+	.	.	.
Characteristics *Papaveretea* & *Brometalia*									
Mercurialis annua	1	2	1	3	1	2	.	+	2
Erodium malacoides	.	.	+	+	+	+	.	+	1
Brassica fruticulosa	+	.	+	1	1	1	2	+	.
Sonchus oleraceus	.	.	.	.	.	1	1	+	+
Anisantha madritensis	.	.	.	.	.	+	.	3	2
Glebionis coronaria	.	.	.	.	.	3	.	1	1
Solanum nigrum	.	.	+	+	.	.	.	.	.
Vulpia geniculata	.	.	.	.	.	.	.	3	3
Melilotus italicus	.	.	.	.	.	.	.	+	+
Catapodium rigidum	.	.	.	.	.	.	.	+	+
Anagallis arvensis	.	.	.	.	.	.	.	1	+
Vulpia ciliata	.	.	.	.	.	.	.	2	1
Other species									
Thapsia garganica	+	+	.	+	.	+	1	+	+
Asparagus acutifolius	+	+	+	+	+	.	+	.	.
Carlina hispanica subsp. *globosa*	.	+	.	+	+	+	.	1	.
Ferula communis	+	.	+	1	1	1	.	.	.
Trachynia distachya	.	.	.	.	.	+	1	1	1
Allium commutatum	+	.	.	+	.	.	1	.	.
Dittrichia viscosa	.	.	1	.	1	2	.	.	.
Valantia muralis	.	.	.	.	.	.	.	+	+
Polycarpon tetraphyllum subsp. *diphyllum*	.	.	.	.	.	.	.	+	1
Cerastium pumilum	.	.	.	.	.	.	.	+	+
Ailanthus altissima	.	.	.	+	+	.	.	.	.

Characteristics *Papaveretea* & *Brometalia*: *Hordeum murinum* subsp. *leporinum*, *Lolium rigidum*, *Plantago lagopus* and *Sonchus asper* 2 in 7; *Urospermum picroides* + in 8. Other species: *Erigeron bonariensis* + in 6; *Dactylis glomerata* subsp. *hispanica* 2, *Silene vulgaris* subsp. *tenoreana* 1, *Trifolium scabrum*, *Sedum rubens* and *Asparagus albus* + in 7.

Localities: 1-5: Isola Lachea, 28.01.2016; 6: Isola Lachea, 31.04.2016; 7: Faraglione Grande (under Madonnina), 31.04.2016; 8-9: Isola Lachea, 31.04.2016.

high cover values, mixed with several other nitrophilous species, as *Urtica membranacea, Parietaria lusitanica, Galium aparine* subsp. *aparine, Mercurialis annua, Galactites elegans, Erodium malacoides,* ect.. In Sicily, this vegetation is widespread in the thermo-mesomediterranean bioclimatic belt (Brullo & Marcenò, 1985).

Local distribution: Isola Lachea.

Habitat: not considered in EUNIS and Habitat Directive.

Galactites elegans comm.

(Table 4, rels. 4-9)

Diagnostic species: *Vulpia geniculata* and *Galactites elegans*.

Structure and ecology: Annual, subnitrophilous, thermoxerophilous, herbaceous communities that grow in abandoned and fallow fields, along roadsides and in disturbed areas in the Mediterranean region (Biondi & *al*., 2014). On the Lachea Island is widespread an annual weeds, a consequence of abandoning crops that have affected the island in the past. This vegetation is characterized by a rich contingent of nitrophilous species, including *Anisantha madritensis, Anagallis arvensis, Brassica fruticulosa, Catapodium rigidum, Cerastium pumilum, Dittrichia viscosa, Erodium malacoides, Glebionis coronaria, Galactites elegans, Hordeum leporinum, Lolium rigidum, Melilotus italicus, Mercuriales annua, Plantago lagopus, Polycarpon dyphyllum, Sonchus oleraceus, Trachynia distachya, Trifolium scabrum, Urospermum picroides, Valantia muralis*, *Vulpia geniculata, V. ciliata,* etc. mixed with some perennial species of *Lygeo-Stipetea*, as *Carlina corymbosa, Ferula communis, Dactylis hispanica* and *Thapsia garganica.* On the whole this community is referred to *Echio plantaginei-Galactition tomentosae*, alliance which groups the subnitrophilous vegetation of abandoned fields. In some well-sunny areas in less nitrophilous conditions, of the island Lachea, *Vulpia geniculata* assumes a significant structural role (Figure 8), forming monophitic community in contact with evergreen shrubs of *Olea europaea.*

Local distribution: Isola Lachea and Faraglione Grande.

Habitat: EUNIS E1.6 Mediterranean subnitrophilous grass communities; not considered in Habitat Directive.

Vegetation map

The processing of the vegetation map allowed to define 9 different vegetation types (Figure 9). For each one the phytosociological sintaxon (association or higher-order syntaxa), habitats and coverage in square meters (sqm) is indicated. The different types have been adapted to better respond to the mapping scale (1: 1.000). Some vegetation types, occupying very limited areas (as *Saginetea maritimae* communities), have not been mapped.

On the investigated territory, a total of about 2.5 ha, the 62% is characterized by the presence of the basaltic rocks without vegetation (15668 m^2).

The plant communities, most represented on the Island, are the halo-nitrophilous vegetation of *Pegano-Salsoletea* with an area of about 4,458 m^2 (18%), within which micro-communities of *Saginetea maritimae* are growing, but not mappable due to the small cover of this vegetation. These associations cover mainly the marly-clays outcrops.

Poorly represented are the evergreen shrub communities dominated by *Olea europaea* (900 m^2, 4%), as well as the salt-tolerant plant communities of the rocky coast with *Crithmum maritimum* (955 m^2, 4%) and uncultivated vegetation of the *Echio-Galactition* (632 m^2, 2%) and the bushes of *Rubus ulmifolius* (219 m^2, 1%). Moreover a strong threat is represented by alien species that occupy considerable surfaces, especially *Opuntia ficus-indica* (1534 m^2, 6%) and *Ailanthus altissima* (590 m^2, 2%). All these associations are widespread on the top of the island, where the soil is present.

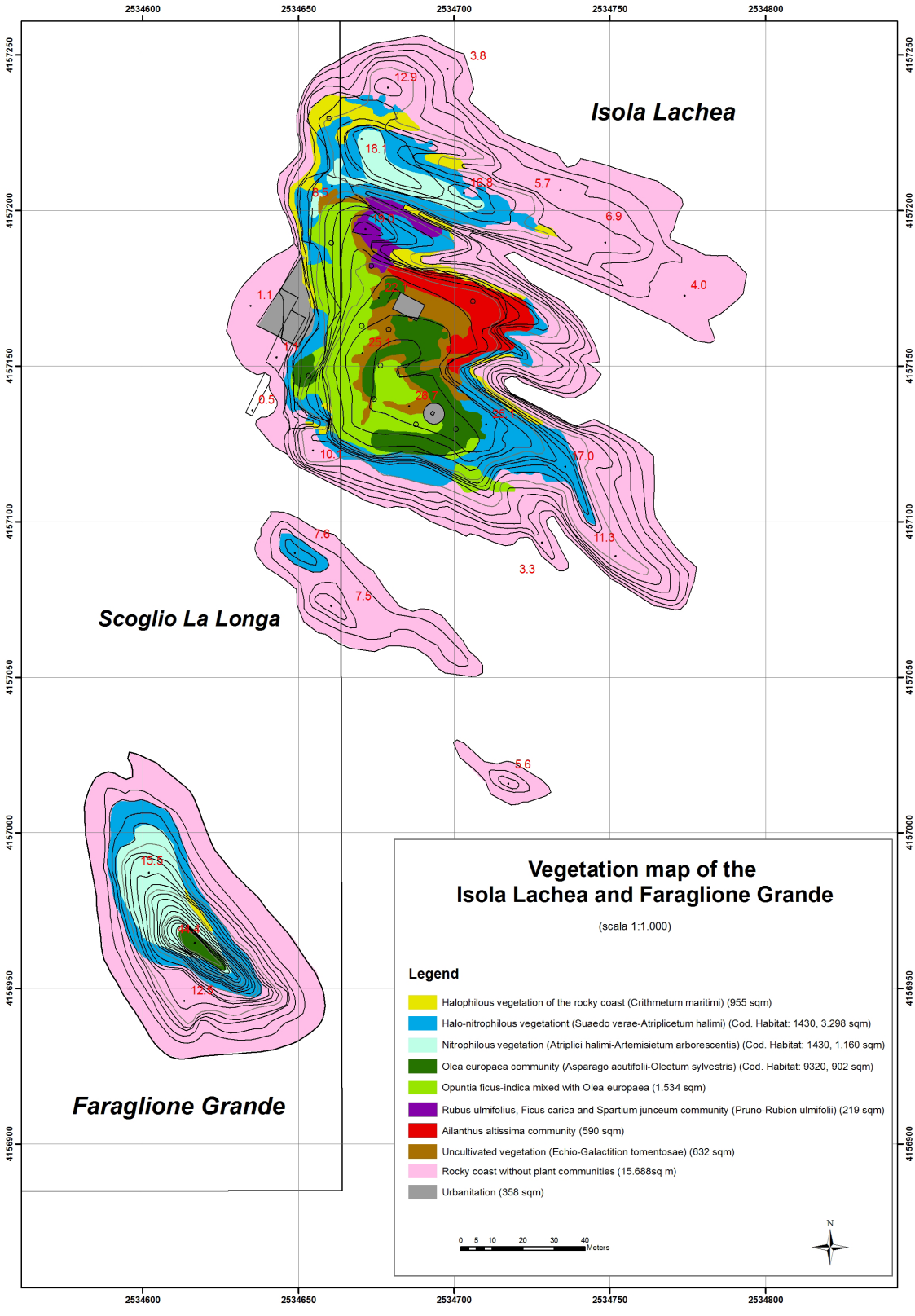

Figure 9. Vegetation map of the northern sector of the Ciclopi Archipelago

Conclusion

The results of the current flora (102 entities) of the Isole Ciclopi show a moderate floristic richness taking into account the small size of the islets. Previously Siracusa (1995) reports a total of 180 species, considering also those cited by other authors (Nicotra, 1893; Zodda, 1911; Musmarra, 1941), but by the same author only 91 taxa were counted in 1995.

The flora richness in the last 100 years has clearly suffered a sharp drop, especially on the Lachea island. Musmarra (1941) signaled some pteridophytes now totally absent, as *Adiantum capillus-veneris* L., *Asplenium obovatum* Viv., *Asplenium trichomanes* L., *Ceterach officinarum* Willd., *Polypodium cambricum* L., *Dryopteris pallida* (Bory) C. Chr. ex Maire & Petitm., probably due to a lower edaphic humidity compared to that of the past.

Furthermore some of the species reported recently from Siracusa (1995) were not found, as *Euphorbia dendroides*, *Halimione portulacoides*, *Heliotropium bocconei*, *Reichardia picroides* var. *maritima*, *Senecio cineraria* subsp. *bicolor*. Probably the disappearance of these species is linked to the spread of some invasive alien species (*Ailanthus altissima*, *Opuntia ficus-indica*, *Arundo donax*) that in some cases cover large areas (Figure 10), replacing the natural habitats and characteristic species. The invasion of alien species in Isole Ciclopi is a further confirmation of a widespread phenomenon in the coastal areas of Sicily (Sciandrello & *al*., 2013, 2014, 2016) and surrounding islets (Minissale & *al*., 2005; Pretto & *al*., 2012; Minissale & Sciandrello 2017). Another important cause of the disappearance of some plant species or natural habitat is the excessive spread of Yellow-legged Gulls (*Larus michahellis*) in the spring and summer colonize the entire island for nesting, thus affecting the delicate ecological balance between plants, animals and soil, for the supply, with their droppings, of significant quantities of nitrates as already noted by Gristina & Marcenò (2008) for a coastal area of north-west Sicily.

In addition there are various exotic introduced as ornamental species such as *Casuarina equisetifolia*, *Thuja orientalis, Pittosporum tobira, Robinia pseudoacacia*, which have greatly changed the physiognomy of the Isola Lachea plant landscape's, especially on the summit plateau.

So overall, the various forms of disturbance on habitats and flora over time have resulted in a significant depletion of the floristic and phytocenotic diversity of the islets.

On the other hand, despite these disturbances a good correlation between the plant communities distribution and the stratigraphic succession is still clearly recognizable and appears of a sure interest. In particular the basal areas of the islands, characterized by presence of basalts, are dominated by halophilous communities of *Crithmo-Limonietea* present mostly on the cracks affecting the volcanic bodies (columnar joint) that are sometimes filled by thin thikness of soil. In the medium slopes, characterized by marly-clays exposures, we find mainly a nitrophilous and halo-nitrophilous vegetation of *Pegano-Salsoletea* that prefers a soft substrata (here represented by the marly clays) having a thin layer of soil. Finally on the top of the island, characterized by the presence of sandy soil exceeding 40 cm in thickness, grows evergreen vegetation of the *Oleo-Ceratonion* alliance.

The vegetation results helped define objectively habitats, according to Directive 43/92/EEC, which are present on the Isole Ciclopi. In particular, except for the habitat of marine type Reefs 1170 here not investigated, on the islands were surveyed the following habitats: 1310 *Salicornia* and other annuals colonizing mud and sand, 1430 Halo-nitrophilous scrubs (*Pegano-Salsoletea*), 9320 Foreste di *Olea* e *Ceratonia*. In addition the habitat 5330 Thermo-Mediterranean and pre-desert scrub and 6220 * Pseudo-steppe with grasses and annuals of the *Thero-Brachypodietea* shown in the Standard Data Form, are excluded for the absence of typical species of this habitat (Biondi & *al*., 2009).

Finally, for the purposes of proper management of the area, it would be desirable to adopt some specific conservation measures, in accordance with the Habitats Directive, aimed at re-naturalise or restore degraded or damaged habitats, especially the habitat of evergreen bush with *Olea europaea* and habitat of thermophilous shrubs with *Euphorbia dendroides,* as well as program of concrete measures for the eradication of invasive alien species, in particular *Ailanthus altissima* and *Opuntia ficus-indica* and as ultimate goal the control and containment of the Yellow-legged Gulls populations (*Larus michahellis*). It should however be emphasized that the solution of

these problems is not easy to solve, not only from the technical viewpoint, but also taking into account that some of these plants, such as the indian-fig prickly pear, are perceived, by most stakeholders, as forming part of the Sicilian identity (Barbera & *al*., 1992).

Figure10. Problematic species on Cyclops Islands. A. *Ailanthus altissima*; B-C. *Opuntia ficus-indica; D.* Yellow-legged Gulls (*Larus michahellis*).

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Appendix 1

Floristic list. Abbreviations are: Fr.: Frequency; Is. Lac.: Isola Lachea; Al.: S. Alonga; Gr.: Faraglione Grande; F. Mez.: Faraglione Di Mezzo; Pic.: Faraglione Piccolo; ***** Introduced plant species; p: presence in each islet; T.: total number of taxa for each islet.

N.	Family	Species	Chorology	Life form	Fr.	Lac.	Al.	Gr.	Mez.	Pic.
1	Acanthaceae	*Acanthus mollis* L.	O Med.	H scap	C	p				
2	Aizoaceae	*Mesembryanthemum nodiflorum* L.	Med.-Trop.	T scap	R	p				
3	Alliaceae	*Allium commutatum* Guss.	Med.	G bulb	NC	p		p	p	p
4	Alliaceae	*Allium ampeloprasum* L.	Med.	G bulb	C	p		p		
5	Amaryllidaceae	**Amaryllis belladonna* L.	Sud-Africa	G bulb		p				
6	Apiaceae	*Crithmum maritimum* L.	Med.-Atl.	Ch suffr	NC	p		p		p
7	Apiaceae	*Daucus carota* L. subsp. *carota*	Euro-Med.	H bien	NC	p		p		
8	Apiaceae	*Daucus gingidium* L.	C Med.	H bien	R	p				
9	Apiaceae	*Ferula communis* L.	Med.	H scap	NC	p		p		
10	Apiaceae	*Thapsia garganica* L.	Med.	H scap	NC	p		p		
11	Apocynaceae	**Nerium oleander* L.	Med.	P caesp	NC	p				
12	Araceae	*Arisarum vulgare* Targ.-Tozz.	Med.	G rhiz	NC	p		p		
13	Asparagaceae	*Asparagus acutifolius* L.	Med.	NP	NC	p		p	p	
14	Asparagaceae	*Asparagus albus* L.	O Med.	NP	NC	p		p		
15	Asteraceae	*Artemisia arborescens* (Vaill.) L.	Med.	NP	C	p		p		
16	Asteraceae	*Carlina hispanica Lam.* subsp. *globosa* (Arcang.) Meusel & Kästner	End. It.-sic.	H scap	NC	p		p		
17	Asteraceae	*Dittrichia viscosa* (L.) Greuter	O Med.	H scap	C	p				
18	Asteraceae	*Erigeron bonariensis* hort. ex Link	Avv.	T scap	C	p				
19	Asteraceae	*Erigeron canadensis* L.	Cosmop.	T scap	C	p				
20	Asteraceae	*Galactites elegans* (All.) Soldano	Med.	H bien	C	p		p		
21	Asteraceae	*Glebionis coronaria* (L.) Spach	Med.	T scap	C	p				
22	Asteraceae	*Limbarda chrithmoides* (L.) Dumort.	Med.-Atl.	Ch suffr	R	p				
23	Asteraceae	*Reichardia picroides* (L.) Roth	Med.	H scap	NC	p		p	p	
24	Asteraceae	*Sonchus asper* (L.) Hill	Cosmop.	T scap	C	p		p		
25	Asteraceae	*Sonchus bulbosus* (L.) Kilian & Greuter	Med.	G bulb	NC	p				
26	Asteraceae	*Sonchus oleraceus* L.	Cosmop.	T scap	C	p		p	p	
27	Asteraceae	*Urospermum picroides* (L.) F. W. Schmidt	Med.	T scap	C	p		p		
28	Asteraceae	*Symphyotrichum squamatum* (Spreng.) G. L. Nesom	Nat.	H scap.	C	p				
29	Asteraceae	*Pulicaria dysenterica* (L.) Bernh.	Euro-Med.	H scap	R	p				
30	Asteraceae	*Helminthotheca echioides* (L.) Holub	Med.	T scap	R	p				
31	Boraginaceae	*Heliotropium europaeum* L.	Euro-Med.-Iran.-Tur	T scap	NC	p		p		
32	Brassicaceae	*Brassica fruticulosa* Cirillo	O Med.	H scap	C	p		p		
33	Brassicaceae	*Matthiola incana* (L.) R. Br. subsp. *incana*	NO-Med.	Ch suffr	NC	p		p	p	p
34	Brassicaceae	*Sisymbrium polyceratium* L.	Med.	T scap	R	p				
35	Cactaceae	**Opuntia ficus-indica* (L.) Mill.	Nat.	P succ	C	p				
36	Capparidaceae	*Capparis orientalis* Veill.	Med.	Ch suffr	NC	p		p	p	
37	Capparidaceae	*Capparis spinosa* L.	Med.-Iran.-Tur.	Ch suffr	R	p				
38	Caryophyllaceae	*Cerastium pumilum* Curtis	Euro-Med.	Tscap	NC	p				
39	Caryophyllaceae	*Polycarpon tetraphyllum* subsp. *diphyllum* (Cav.) O. Bolòs & Font Quer	Med.	T scap	NC	p				
40	Caryophyllaceae	*Sagina maritima* G. Don	Med.-Atl.	T scap	NC	p		p		
41	Caryophyllaceae	*Silene vulgaris* (Moench) Garcke subsp. *tenoreana* (Colla) Soldano & F. Conti	End. sic.	H scap	C	p		p	p	
42	Caryophyllaceae	*Spergularia bocconi* (Scheele) Graebn.	Paleotemp.	T scap	NC	p		p		
43	Caryophyllaceae	*Spergularia salina* J. & C. Presl	Paleotemp.	T scap	NC			p		
44	Casuarinaceae	**Casuarina equisetifolia* L.	Australia	P scap	NC	p				
45	Chenopodiaceae	*Atriplex halimus* L.	Med.	P caesp	R	p		p		
46	Chenopodiaceae	*Chenopodium album* L.	Cosmop.	T scap	C	p		p	p	
47	Chenopodiaceae	*Suaeda vera* J. F. Gmelin	Med.-Atl.	NP casp	C	p	p	p	p	p
48	Convolvulaceae	*Cuscuta epithymum* L. subsp. *epithymum*	Paleotemp.	T par	NC	p				
49	Crassulaceae	*Sedum rubens* L.	Euro-Med.	T scap	NC			p		
50	Crassulaceae	*Umbilicus rupestris* (Salisb.) Dandy	Med.-Trop.	G bulb	NC	p				
51	Crassulaceae	*Umbilicus horizontalis* (Guss.) DC.	Med.-Trop.	G bulb	NC			p		
52	Cyperaceae	*Cyperus rotundus* L.	Med.-Trop.	G rhiz	C	p				
53	Euphorbiaceae	*Mercurialis annua* L.	Paleotemp.	T scap	C	p				

N.	Family	Species	Chorology	Life form	Fr.	Lac.	Al.	Gr.	Mez.	Pic.
54	Fabaceae	*Lotus cytisoides* L.	Med.	Ch suffr	NC	p		p	p	p
55	Fabaceae	*Medicago truncatula* Gaertn.	Med.-Atl.	T scap	NC	p				
56	Fabaceae	*Melilotus italicus* (L.) Lam.	Med.	T scap	NC	p		p		
57	Fabaceae	*Melilotus sulcatus* Desf.	Med.	T scap	C	p				
58	Fabaceae	**Robinia pseudacacia* L.	Nat.	P caesp	NC	p				
59	Fabaceae	**Spartium junceum* L.	Med.	P caesp	NC	p				
60	Fabaceae	*Trifolium scabrum* L.	Med.	T rept	NC	p		p		
61	Frankeniaceae	*Frankenia pulverulenta* L.	Med.-Iran.-Tur.	T scap	R	p				
62	Geraniaceae	*Erodium malacoides* (L.) L'Hér.	Med.	T scap	C	p				
63	Lamiaceae	*Prasium majus* L.	Med.	Ch frut	R	p				
64	Lauraceae	**Laurus nobilis* L.	Med.-Atl.	P caesp	NC	p				
65	Malvaceae	*Malva sylvestris* L.	Euro-Med.	H scap	C	p				
66	Moraceae	*Ficus carica* L.	N Med.	P scap	NC	p		p		
67	Oleaceae	*Olea europaea* var. sylvestris (Mill.) Lehr	Med.	P caesp	NC	p		p		
68	Oxalidaceae	*Oxalis pes-caprae* L.	Nat.	G bulb	C	p				
69	Papaveraceae	*Fumaria capreolata* L.	Euro-Med.	T scap	C	p				
70	Papaveraceae	*Fumaria flabellata* Gasparr.	Med.	T scap	NC	p				
71	Pittosporaceae	**Pittosporum tobira* (Thunb.) W. T. Aiton	Med.	T rept	NC	p				
72	Plantaginaceae	*Plantago coronopus* L.	Paleotemp.	T scap	NC	p		p		
73	Plantaginaceae	*Plantago lagopus* L.	Med.	T scap	C			p		
74	Poaceae	*Anisantha madritensis* (L.) Nevski	Med.-Atl.	T scap	C	p		p		
75	Poaceae	**Arundo donax* L.	Med.	G rhiz	NC	p				
76	Poaceae	*Catapodium balearicum* (Willk.) H. Scholz	Med.	T scap	NC	p		p		
77	Poaceae	*Catapodium rigidum* (L.) C. E. Hubb.	Euro-Med.-Iran.-Tur	T scap	C	p				
78	Poaceae	*Dactylis glomerata* subsp. *hispanica* (Roth) Nyman	Med.	H caesp	NC	p		p	p	
79	Poaceae	*Hordeum murinum* L. subsp. *leporinum* (Link) Arcang.	Euro-Med	T scap	C			p		
80	Poaceae	*Lagurus ovatus* L. subsp. *ovatus*	Med.	T scap	C	p		p		
81	Poaceae	*Lolium rigidum* Gaudin	Med.-Iran.-Tur.	T scap	C	p		p		
82	Poaceae	*Parapholis incurva* (L.) C. E. Hubb.	Med.-Atl.	T scap	NC	p		p		
83	Poaceae	*Piptatherum miliaceum* (L.) Coss. subsp. *miliaceum*	Med.-Atl.	H caesp	NC	p				
84	Poaceae	*Rostraria cristata* (L.) Tzvelev	Med.-Iran.-Tur.	T scap	C	p				
85	Poaceae	*Trachynia distachya* (L.) Link	Med.-Iran.-Tur.	T scap	C	p		p		
86	Poaceae	*Vulpia ciliata* Dumort.	Med.	T caesp	C	p				
87	Poaceae	*Vulpia geniculata* (L.) Link	O Med.	T caesp	C	p				
88	Poaceae	*Digitaria sanguinalis* (L.) Scop. subsp. *sanguinalis*	Boreo-Trop.	T scap	R			p		
89	Poaceae	*Avena barbata* Pott ex Link	Cosmop.	T scap	C	p		p		
90	Poaceae	*Cynodon dactylon* (L.) Pers.	Boreo-Trop.	G rhiz	NC	p				
91	Poaceae	*Gastridium ventricosum* (Gouan) Schinz & Thell.	Med.	T scap	NC	p				
92	Portulacaceae	*Portulaca oleracea* L. subsp. *oleracea*	Boreo-Trop.	T scap	C	p		p		
93	Primulaceae	*Anagallis arvensis* L.	Boreo-Trop.	T rept	C	p				
94	Primulaceae	*Anagallis foemina* Mill.	Boreo-Trop.	T rept	C	p				
95	Rosaceae	*Rubus ulmifolius* Schott	Euro-Med.	NP	NC	p				
96	Rubiaceae	*Galium aparine* L. subsp. *aparine*	Paleotemp.	T scap	NC	p				
97	Rubiaceae	*Valantia muralis* L.	End. sic.	T scap	C	p				
98	Simaroubaceae	**Ailanthus altissima* (Mill.) Swingle	Nat.	P scap	C	p				
99	Solanaceae	*Hyoscyamus albus* L.	Med.	T scap	C	p		p	p	p
100	Solanaceae	*Solanum nigrum* L.	Boreo-Trop.	T scap	C	p				
101	Urticaceae	*Parietaria lusitanica* L.	Med.	T rept	C	p				
102	Urticaceae	*Urtica membranacea* Poir.	Med.	T scap	C	p				
						T. 96	T. 1	T. 48	T. 12	T. 6

Appendix 2

Syntaxonomic scheme

Crithmo-Staticetea Br.-Bl. in Br.-Bl. et al. 1952
Crithmo maritimi-Staticetalia Molinier 1934
Crithmo maritimi-Staticion Molinier 1934
Crithmetum maritimi Béguinot 1941
Helichrysetalia italici Biondi et Géhu in Géhu et Biondi 1994
Anthyllidion barbae-jovis Brullo & De Marco 1989
Matthiola incana subsp. *incana* comm.

Pegano harmalae-Salsoletea vermiculatae Br-Bl & O.Bolòs 1958
Salsolo vermiculatae-Peganetalia harmalae Br.-Bl. & O. Bolòs 1954
Atriplici halimi-Suaedion verae Gehu et al. ex Bergmeier et Dimopoulos 2003
Atriplici halimi-Suaedetum verae Biondi 1988 *nom. inv. propos. (Suaedo verae-Atriplicetum halimi* Biondi 1988)
Artemision arborescentis Géhu et al. 1986
Atriplici halimi-Artemisietum arborescentis Biondi 1988

Saginetea maritimae Westhoff, Van Leeuwen & Adriani 1962
Frankenietalia pulverulentae Rivas-Martínez ex Castroviejo & Porta 1976
Frankenion pulverulentae Rivas-Martínez ex Castroviejo & Porta 1976
Trifolio scabri-Catapodietum balearici Brullo et Giusso del Galdo 2003
Parapholido incurvae-Spergularietum bocconei Brullo, Scelsi & Spampinato 2001
Mesembryanthemum nodiflorum comm.

Quercetea ilicis Br.-Bl. ex A. Bolòs et O. de Bolòs in A. Bolòs y Vayreda 1950
Pistacio lentisci-Rhamnetalia alaterni Rivas-Mart. 1975
Oleo-Ceratonion siliquae Br.-Bl. ex Guinochet et Drouineau 1944
Asparago acutifolii-Oleetum sylvestris Bacchetta et al. 2003

Crataego-Prunetea Tx. 1962
Pyro spinosae-Rubetalia ulmifolii Biondi, Blasi et Casavecchia in Biondi et al. 2014
Pruno spinosae-Rubion ulmifolii O. de Bolòs 1954
Rubus ulmifolius comm.

Chenopodietea Br.-Bl. in Br.-Bl. et al. 1952
Chenopodietalia Br.-Bl. in Br.-Bl. et al. 1936
Allion triquetri O. Bolòs 1967
Acanthus mollis comm.
Brometalia rubenti-tectorum (Rivas Goday et Rivas-Mart. 1973) Rivas-Mart. et Izco 1977
Echio-Galactition tomentosae O. Bolòs & Molinier 1969
Galactites elegans comm.
Vulpia geniculata comm.