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Phytosociology and taxonomic notes on some endemic-rich associations of the Naples Gulf

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Key words: Chasmophyte, Endemic dolomite, Phytogeography, Phytosociology, Scrub, Southern Italy.

Ključne besede: hazmofit, endemiti na dolomitu, fitogeografija, fitosociologija, Scrub, južna Italija.

Abstract

The Gulf of Naples is an important centre of endemism, well known from the floristic point of view, but much less from the phytosociological one. In this paper we investigated the non-forest vegetation focusing on communities rich in endemics. We described two communities as new: *Eryngio amethystini-Santolinetum neapolitanae* for the garrigues on limestone, *Globulario neapolitanae-Loniceretum stabianae* for the vegetation on dolomitic rocks, both from the Lattari mountains, and we extend the area of *Crithmo maritimi-Limonietum cumani* for the vegetation on volcanic rocks and rarely on limestones along the coast, which was known for a few localities. The syntaxonomical position and the phytogeographical context of these communities are discussed. A few taxonomic notes are added on rare or interesting species retrieved in the course of the enquiry.

Izvleček

Neapeljski zaliv je pomembno središče endemizma, poznan zaradi flore, še bolj pa po rastlinskih združbah. V članku smo obravnavali negozdno vegetacijo, predvsem združbe, bogate z endemiti. Opisali smo dve novi asociaciji: *Eryngio amethystini-Santolinetum neapolitanae* za garigo na apnencu in *Globulario neapolitanae-Loniceretum stabianae* za vegetacijo na dolomitnem skalovju, ki uspevata na gorovju Lattari. Območje razširjenosti asociacije *Crithmo maritimi-Limonietum cumani* smo razširili na vegetacijo na vulkanskem skalovju in redko na apnencu ob obali, ki je bila do sedaj znana le z nekaj lokacijami. Obravnavali smo sintaksonomsko uvrstitev in fitogeografijo teh rastlinskih združb. Dodali smo nekaj taksonomskih opomb o redkih ali zanimivih vrstah, ki smo jih zabeležili v naši raziskavi.

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Introduction

The area of the Gulf of Naples and in particular its southern part, the Sorrento Peninsula, has since long attracted the attention of botanists for his rich and interesting flora. The explorations of several botanists including Tenore, Gussone, Lojacono and others (Del Guacchio et al., 2020) have recognized the strong floristic identity of this territory characterized by a high number of narrow range endemics. There are two main types of endemics, those related to the coast, both on volcanic rocks and on limestone, and the endemics of the garrigues and rocks of the mountain areas. Among the species thriving on the coast *Centaurea cineraria* subsp. *sirenum, Centaurea deusta* subsp. *leucolepis*, *Limonium cumanum, Limonium tenoreanum*, *Seseli polyphyllum*, can be mentioned. While in the Sorrento Peninsula and the small "Lattari" mountain range *Bromopsis caprina, Centaurea tenorei*, *Globularia neapolitana*, *Lonicera stabiana*, *Santolina neapolitana* can be found. Moreover, together with the high number of local endemics, several Italian endemics such as *Helichrysum litoreum* and *Centaurea cineraria* subsp. *cineraria* are occurring. These high levels of endemism led to the identification of distinct ecoregions (Blasi et al., 2018).

While the floristic knowledge of this area is quite good (SBI, 1952; De Natale et al., 2008; Blasi & Biondi, 2017), the vegetation has still to be thoroughly investigated. A map of the series of vegetation exists (Blasi, 2010) but detailed phytosociological and syntaxonomical studies of the area are almost completely lacking (but see Masucci & Simeone, 2006). A valuable paper on the forest vegetation recently appeared (Cancellieri et al., 2017) but they investigated only the area of Amalfi in Salerno administrative province. In order to fill this gap, we analysed the non-forest vegetation types rich in endemics of the Gulf of Naples. The material we collected is sometimes not very abundant, due to the rarity of the vegetation. Nonetheless we think that the survey of these communities is rather complete and deserve to be presented.

Moreover, during the study of these communities we collected rare and interesting species, on which we have made some taxonomic observations that we report below in the text in a separate paragraph.

Material and methods

Study area

The Gulf of Naples has an extension of 195km, between Mt. of Procida and "Punta Campanella". The area is mainly hilly with high cliffs along the coast. In the south a small mountain range occupy most of the Sorrento Peninsula which closes the gulf and reaches the highest altitude at Mt. Sant'Angelo a Tre Pizzi (1444m). Another peak above 1000m is Mt. Faito (1131m). The dolomitic landscape of this mountain range is characterized by steep slopes and cliffs and is renowned worldwide for its scenic sightings.

The complex geology results from the Apennine orogenesis and the subsequent extensional phase that leaded to formation of volcanoes along the Tyrrhenian coast. These phases can be recognizable in the Sorrento Peninsula (an anti-Apennine thrust) and the volcanic complex of Vesuvio and Campi Flegrei (Casciello et al., 2006).

The differences between these two sides of the gulf lies on the lithology. In fact, the coastal line and the area of Posillipo are characterized by tuffaceous material and lapillus from the volcanic complex of "Campi Flegrei" forming the older deposit of Trentaremi tuff ring in the homonymous bay and the characteristic and younger stratigraphic unit of "Neapolitan Yellow Tuff" (Scarpati et al., 2013).

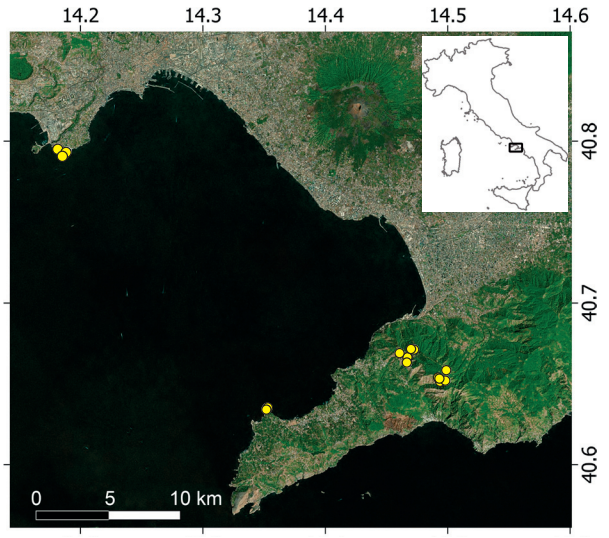

Figure 1: Map of the study site with localization of relevés.
Slika 1: Zemljevid obravnavanega območja z lokacijami vegetacijskih popisov.

On the other side the lithology is characterized by two main types. On the coastal line of Sorrento, the stratigraphic unit is represented by the "Campanian Ignimbrite" (Milia, 1998), that forms a characteristic crag and shows an influence of the super-syntheme "Flegreo-Ischitano" (ISPRA, 2014) formed by tuff and pyroclasts. Conversely in the inner area and on the heights, the lithology drastically changes, showing the carbonatic geological base that characterizes the peninsular Italy, with dolomites and micritic limestone formations dating back to the Cretaceous and Jurassic period (Iannace et al., 2008).

The whole area can be referred to the Mediterranean macrobioclimate, but at higher altitude, like Mt. Faito and Mt. San Michele, a temperate thermotype and an upper humid ombrotype can be found (Pesaresi et al., 2017). On the contrary, the area of Posillipo, shows a lower mesomediterranean thermotype and a lower subhumid ombrotypes.

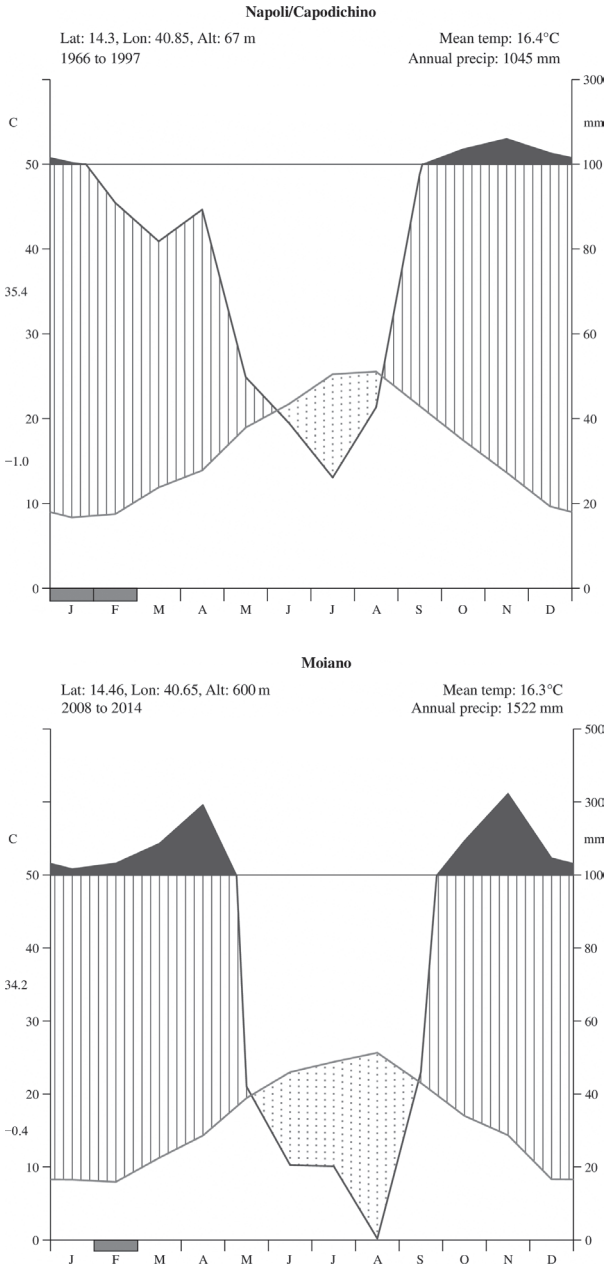

Figure 2: Climatic diagrams of two stations of the study site. We used bibliographic data (ISPRA, 2003) and data sets from the SCIA database (ISPRA, 2011) for a period of ~30 years (normal climatic) for Naples and 7 years for Moiano. The elaboration and creation of the Walter and Lieth diagram were made with R package "climatol".

Slika 2: Klimatski diagram dveh postaj v obravnavanem območju. Uporabili smo objavljene podatke (ISPRA, 2003) in podatkovni niz iz baze SCIA (ISPRA, 2011) za obdobje ~30 let (normalna klima) za Neapelj in 7 let za Moiano. Obdelavo in izdelavo diagram po Walter in Lieth smo naredili v R paketu "climatol".

According to Blasi et al. (2018) the Gulf of Naples belongs to the Southern Tyrrhenian Section, but to different subsections: the area near Naples (with volcanic substrates) fits the Western Campania Subsection, while the carbonatic area of the Sorrento Peninsula can be referred to the Cilento Subsection.

The vegetation in both areas is generally anthropogenically influenced, especially in the surroundings of Naples where the urbanization led to the disappearance of several habitats (De Natale & La Valva, 2000). The Mediterranean belt has almost disappeared and only small fragments of maquis with *Pistacia lentiscus* and other sclerophyllous species occurs. The supramediterranean belt in the Sorrento Peninsula is characterized mainly by secondary chestnut forest, but locally relics of the original oak and mixed forest dominated by *Quercus cerris* and *Ostrya carpinifolia* can still be found. Above 1000m the mountain belt hosts a thermophilic beech forest (Cancellieri et al., 2017).

Phytosociological survey

In the summer 2020 we carried out 25 phytosociological relevés in selected vegetation types rich in endemics. Relevés were carried out according to Braun-Blanquet method (Westhoff & van der Maarel, 1980) using the modified Braun-Blanquet scale of abundance (Barkman et al., 1964).

The phytosociological relevés have been carried out in the area of Mt. Faito and Mt. San Michele in the Sorrento Peninsula in an altitude range between 500–1100m a.s.l., and on the coast of Sorrento and Posillipo, in particular in the marine protected area "Parco Sommerso di Gaiola".

The table of relevés was arranged manually into three tables corresponding to well defined communities and the diagnostic species were chosen subjectively, by means of comparison with tables of similar vegetation in the literature. In the choice of diagnostic species, preference has been given to rare species of Sorrento Peninsula and neighbouring areas. Relevés will be deposited in the EVA database, the database of European vegetation (Chytrý et al., 2016).

The nomenclatural of the species and syntaxa, follow Bartolucci et al. (2018) checklist and Mucina et al. (2016) respectively.

Results and discussion

Community with *Santolina neapolitana*

Santolina is a genus of shrubby *Asteraceae* with seven closely related species identified for Italy (Pignatti et al., 2017). Several species have been brought in cultivation blurring the original distribution. Nonetheless in the hills and mountains of the western Mediterranean basin many endemics can be found. *Santolina neapolitana* is a species endemic to the Campania region. In the Lattari Mts. it occurs with an extensive population from 600m to 1100m in the peaks of Mt. Faito and Mt. San Michele (Figure 3).

The floristic composition of this community above 1000m in the mountain belt is dominated by chamaephytes and hemicryptophytes mainly on ridges. Below the community occurs in mosaic with therophytes such as *Gastridium ventricosum*, *Trifolium scabrum*, *Daucus broteroi*. At these altitudes, the chamaephytes are mainly restricted to rockier sites.

From the syntaxonomical point of view the community with *Santolina neapolitana* is characterized by two floristic pools. The first is represented by chamaephytes and small shrubs and can be referred to the alliance *Cytiso spinescenti-Saturejon montanae* (Pirone & Tammaro, 1997). The second pool is characterized by hemicryptophytes of *Festuco-Brometea* Br.-Bl. et Tx. ex Soó 1947 even though the physiognomy suggests that the community with *Santolina* is a garrigue and not a grassland. Moreover, this community is well characterized not only by the endemic *Santolina neapolitana* but also by other rare or endemic species, such as *Centaurea tenorei*, endemic of Sorrento Peninsula and *Galium lucidum* subsp. *bernardii* which is restricted to Southern Italy. Although these species are hemicryptophytes, they clearly belong to the floristic composition of our association.

For this reason, we describe this community as *Eryngio amethystini-Santolinetum neapolitanae* ass. nov. hoc loco (holotypus relevé 11, Table 1). *Eryngium amethystinum* is not a character-species but is physiognomically important.

Figure 3: Garigue with *Santolina neapolitana* in Monte Sant'Angelo a Tre Pizzi.
Slika 3: Gariga z vrsto *Santolina neapolitana* na Monte Sant'Angelo a Tre Pizzi.

Table 1: Phytosociological table of *Eryngio amethystini-Santolinetum neapolitanae* ass. nova.
Tabela 1: Fitocenološka tabela asociacije *Eryngio amethystini-Santolinetum neapolitanae* ass. nova.

Relevé N.	1	2	3	4	5	6	7	8	9	10	11*	
Altitude (m a.s.l.)	727	1032	1029	618	657	1038	1241	1156	1133	1130	1209	
Slope (°)	5	5	30	90	90	15	10	70	5	10	20	
Exposure	S-SW	SW	N	SW	NW	N	S-SW	SE	S	SE	S-SW	
Plot size (m^2)	3	30	20	25	40	30	40	20	10	10	25	
Total cover (%)	100	60	60	70	60	98	80	85	50	70	75	
Plot height (cm)	40	40	40			30	50	40	30	40	30	
Char *Eryngio amethystini.-Santolinetum neapolitanae*												Freq.
Santolina neapolitana	2a	2b	2b	2b	+	5	4	4	2b	2a	4	100
Differentials of the association												
Galium lucidum subsp. *bernardii*	+		+	2a				+				36
Centaurea tenorei									3	+		18
Char *Cityso-Saturejon montane, Ononido-Rosmarinetea*												
Helianthemum nummularium subsp. *obscurum*		+	+	+		+	+	+		+	+	73
Thapsia asclepium	2a			+								18
Euphorbia spinosa									2a	2b		18
Satureja montana		+	+									18
Asperula aristata subsp. *scabra*					+			1				18
Achillea ligustica						+		+				18
Dianthus longicaulis			+	+								18
Cerastium lacaitae				+								9
Cytisus spinescens											+	9
Char *Festuco-Brometea*												
Petrorhagia saxifraga subsp. *saxifraga*		+	+			+	+	+	+		+	64
Bromopsis erecta			+				+	+	1	+	2a	55
*Eryngium amethystinu*m	r	1	1			+	+				+	55
Allium sphaerocephalon			+	+		+				1		36
Koeleria macrantha		+	1			+					1	36
Festuca jeanpertii subsp. *campana*		+				+		1	1			36
Teucrium montanum							+	1			1	27
Allium pallens		+	1									18
Bupleurum baldense		+	+									18
Sanguisorba minor subsp. *minor*				+			+					18
Orobanche lutea				+							+	18
Carlina corymbosa						+				+		18
Crepis lacera										+	+	18
Stachys recta				+								9
Leontodon crispus				+								9
Galium corrudifolium					+							9
Teucrium chamaedrys						+						9
Onobrychis viciifolia											+	9
Knautia calycina								+				9
Char *Sedo-Scleranthetea*												
Petrosedum ochroleucum		+		+			+	+	+			45
Sedum album		+	+									18
Ziziphora acinos		+								1		18

Relevé N.	1	2	3	4	5	6	7	8	9	10	11*	
Companions												
Avena barbata	+	+		+		1		+				45
Briza maxima	+	+				1		+				36
Orlaya platycarpos			+			+		+	+			36
Trifolium scabrum		+	+							+		27
Triticum neglectum		+	+			+						27
Hypericum perforatum	1	+				+						27
Crupina vulgaris		+	+			+						27
Medicago minima			+						+	+		27
Campanula fragilis subsp. *fragilis*				+	+							18
Trifolium campestre	+					+						18
Trifolium stellatum		+	+									18
Bromus hordeaceus subsp. *molliformis*			+			+						18
Lomelosia crenata					3						+	18
Centranthus ruber					+							9
Anisantha rubens			+									9
Coronilla valentina				+								9
Daucus broteroi	+											9
Sixalix atropurpurea	+											9
Echium vulgare	1											9
Brachypodium retusum	3											9
Festuca danthonii	r											9
Aira cupaniana	+											9
Spartium junceum					+							9
Poa bulbosa		+										9
Fraxinus ornus						1						9
Acer obtusatum						1						9
Trifolium arvense						+						9
Asphodelus macrocarpus							r					9
Brachypodium distachyon										+		9

Community with *Lonicera stabiana* and *Globularia neapolitana*

On the rocky areas of Mt. Sant'Angelo, a chasmophytic community characterized by a high number of restricted endemics such as *Lonicera stabiana*, *Globularia neapolitana*, *Bromopsis caprina* can be found. Another very interesting species that occurs close to our relevés is *Erica terminalis*; this species is common in the eastern Mediterranean, where it builds extensive garrigues but is instead very rare in Italy where it occurs on shaded rocks (Pignatti et al., 2017).

The community is very distinct due to the presence of these rare endemics, and we described it as a new association *Globulario neapolitanae-Loniceretum stabianae* ass. nov. hoc loco (holotypus relevé 13, Table 2). We only have few relevés, but it was impossible to collect more material given the very restricted range of the association. Although the character-species of the association belong to different life form according to Raunkiær, they are very close. For instance, *Globularia neapolitana* has a shrubby habit quite different from that of the closely related *Globularia cordifolia* and *Globularia meridionalis*. Even *Bromopsis caprina* is quite different from a typical hemicryptophytes such as the closely related *Bromopsis erecta* and it is quite shrubby.

Santolina neapolitana, a shrubby species like the others of the association, seems to find its primary habitat in the *Loniceretum stabianae* where it presents also a slightly different more mesophytic phenotype. From *Loniceretum stabianae* this species invades successfully the garigues of the *Santolinetum neapolitanae* discussed previously.

In summary it is a community of endemic shrubby species. Species of other life forms occur in the relevés as transgressive from other communities as is frequent in rock communities. Inspecting the table, the idea is that the phanerophytic *Lonicera stabiana* invades different communities. It is quite the opposite since *Lonicera stabiana* has a very low competitive and dispersal power and could be "invaded" by species of other communities.

Figure 4: Rocky communities of *Globularia neapolitana.*

Slika 4: Naskalne rastlinske združbe z vrsto *Globularia neapolitana.*

Concerning higher syntaxonomical units, the association clearly belong to the order *Potentilletalia caulescentis* Br.-Bl. in Br.-Bl. et Jenny 1926 of *Asplenietea trichomanis* (Br.-Bl. in Meier et Br.-Bl. 1934) Oberd. 1977, an order that encompasses the rocky vegetation on carbonates of the central and western Europe. Mucina et al. (2016) emphasized that *Potentilletalia caulescentis* is structurally heterogeneous since it includes associations dominated by hemicriptophytes and associations dominated by small shrubs. The possible separation of syntaxa dominated by chamaephytes and syntaxa dominated by shrubs requires further work (but see the nomenclatural revision in Terzi et al. (2017)). For the moment, based on the revision of Biondi et al. (1997), the closest alliance is *Saxifragion australis* Biondi et Ballelli ex S. Brullo 1984, described for the central and southern Apennines. However only one characteristic species of this alliance is present, *Edraianthus graminifolius*, while many Apennines endemics such as *Campanula tanfanii* and *Saxifraga porophylla* subsp. *porophylla* are absent. Moreover, the floristic pool of the Sorrento Peninsula is quite distinct from that of the rest of the Apennines and represents a distinct biogeographical province. Another difference is in the substrate. The associations of *Saxifragion australis* generally occur on limestone whereas our association is related to dolomites, which probably drive a completely different ecology from the vegetation growing on calcareous rocks. *Saxifragion australis* is an alliance of hemicriptophytes, whereas one of the most striking characters of the *Loniceretum stabianae* is that it is dominated by small shrubs such as *Lonicera stabiana*.

Relevé N.	12	13*	14	
Altitude (m a.s.l.)	1168	1160	1157	
Slope (°)	90	90	90	
Exposure	S	SW	SW	
Plot size (m²)	30	20	15	
Total cover (%)	15	35	10	
Char *Globulario neapolitanae-Loniceretum stabianae* nova				Freq.
Lonicera stabiana	+	2a	1	100
Globularia neapolitana	1	+	+	100
Santolina neapolitana	+		1	67
Campanula fragilis subsp. *fragilis*	+	1		67
Sesleria juncifolia subsp. *juncifolia*	+		+	67
Bromopsis caprina	2m	1		67
Char *Saxifragion australis*				
Edraianthus graminifolius			+	33
Companions				
Asperula aristata subsp. *scabra*		+		33
Galium lucidum subsp. *bernardii*	+			33
Leontodon crispus	+			33
Lomelosia crenata		+		33

Community with *Limonium cumanum*

Limonium cumanum is endemic to the Gulf of Naples. It is locally abundant but lacks from many areas. Differently from many other species of *Limonium*, this grows usually at some distance from the sea, and therefore it comes in close contact with the vegetation dominated by *Helichrysum litoreum* which is very important in the study area. This situation maybe is due to landslides which are very frequent in the volcanic rocks where this species usually occurs or maybe to certain intolerance to sea waves.

The composition of the community with *Limonium cumanum* is very similar to those of *Crithmo-Staticion* Molinier 1934 (e.g. *Crithmo-Limonietum remotispiculi,* see Corbetta et al. 2000) with *Crithmum maritimum*, *Helichrysum litoreum*, etc. and is distinct only in the identity of the *Limonium* species. Bartolo et al. (1989) described a *Crithmo maritimi-Limonietum cumani* Bartolo, Brullo & Signorello 1989 from limestones in Capri and Sorrento. However, *Limonium cumanum* grows also frequently on volcanic tuffs and actually this species was described from this type of rock (Vallariello et al., 2016). Our relevés extend considerably the range of the association. We observe a slight differentiation of our relevés from those of Bartolo et al. (1989) especially for the presence of *Jacobaea maritima* subsp. *bicolor* in our relevés. Maybe the populations on tuffs represent a distinct subassociation, but we refrain for the moment from a formal description.

The community is common but is threatened by the anthropogenic influence and the invasion of the allochtonous *Carpobrotus acinaciformis*.

Table 3: Phytosociological table of *Chritmo maritimi-Limonietum cumani* Bartolo, Brullo & Signorello 1989.
Tabela 3: Fitocenološka tabela asociacije *Chritmo maritimi-Limonietum cumani* Bartolo, Brullo & Signorello 1989.

Relevé N.	15	16	17	18	19	20	21	22	23	24	25	
Altitude (m a.s.l.)	20	16	25	3	8	7	7	6	6	7		
Slope (°)	90	20	90	90	80	80	90	80	90	90	90	
Exposure	S-SE	E	NE	E	E	E	W	SE	SE	NE	NW	
Plot size (m²)	5	5	3	3	5	4	8	10	10	4	6	
Total cover (%)	70	100	80	70	40	60	80	60	100	10	20	
Plot height (cm)		60			40	40	20	30	20	20	40	
Char *Chritmo-Limonietum cumani* Bartolo, Brullo & Signorello 1989												Freq.
Limonium cumanum	5	+	1	1	1	+	1	2a	1	1	1	100
Char *Chritmo-Staticeon, Chritmo-Staticetea*												
Helichrysum litoreum		5	4	3	+		+	2b			2b	64
Crithmum maritimum	+			+	1		2b		+	+	2a	64
Jacobaea maritima subsp. *bicolor*								+		+		18
Medicago arborea					+							9
Allium commutatum							+					9
Companions												
Carpobrotus acinaciformis						2a	4	2b	4	+		45
Dactylis glomerata subsp. *hispanica*			+	+							+	27
Artemisia campestris subsp. *variabilis*					2b	3					+	27
Asparagus acutifolius		+	+									18
Dittrichia viscosa			+									9
Sixalix atropurpurea			+									9
Daucus carota			+									9
Pistacia lentiscus			1									9

Taxonomical notes

Aim of these notes is to present some observations on the variability of a few rare species that has been overlooked or taken marginally into account in the literature. In recent years several nomenclatural papers have appeared giving useful information about these species, but the descriptions that can be found in the reference texts often do not represent the full variability. We refrain from formal proposal because there is dramatic need of molecular studies on the flora of Southern Italy.

Santolina neapolitana: We observed a modest variation in the sizes of the capitula. In many cases the capitula were smaller (6 mm) than the range sizes mentioned in

Pignatti et al. (2017), especially in individuals growing on rocks. This character can be included in the variability of the species and maybe can change during the development of the flowers. We observed moreover individuals with glaucous and green leaves as often reported in literature (Del Guacchio et al., 2020) but these two types of leaves could occur on the same individual and are therefore unimportant taxonomically.

Lonicera stabiana: is a species of the group of *Lonicera etrusca* from which it is distinct from the colour of the berry and the different habitat. Nonetheless it must be stressed that in central Campania there are a few divergent populations of *Lonicera etrusca*. For instance, both in the Picentini Mts. and in the Sorrento Peninsula at lower altitudes populations of *Lonicera etrusca* are present with shrubby habit and atypical inflorescence which are perhaps intermediate between typical *Lonicera etrusca* and *Lonicera stabiana* (Herbarium Fanelli in RO). Also, near Naples populations of *Lonicera etrusca* with atypical features are frequent. Central Campania is possibly an area of intensive speciation of the group of *Lonicera etrusca*.

Globularia neapolitana: belongs to a difficult group that has been variously interpreted. Del Guacchio et al. (2020) and Innangi et al. (2020) consider *Globularia neapolitana* as a xeromorphic aspect of *Globularia cordifolia* in the Mediterranean climate, whereas Pignatti et al. (2017) consider the species perfectly distinct. In our opinion the morphology of the leaves suggests a close relationship of *Globularia neapolitana* with *Globularia cordifolia* than with *Globularia meridionalis*. The shrubby habit is quite peculiar and is probably not an adaptation to the Mediterranean climate but to the dolomite substrate. We think that the three species are distinct enough to deserve recognition at the species level. The problem could be solved only with the support of molecular analyses.

Sesleria juncifolia subsp. *juncifolia:* The group of *Sesleria juncifolia* is very difficult (Di Pietro et al., 2013; Đenader et al., 2020). According to Di Pietro (2007) our material on the *Sesleria* found in *Loniceretum stabianae* keys out clearly in *Sesleria juncifolia* subsp. *juncifolia* (Figure 5). Nonetheless the material is different from the populations in central

Apennine, because the inflorescences are smaller, and the leaves are more robust. Ubaldi (2006) described a *Sesleria apennina* subsp. *cylindrifolia* var. *circeana* (Bég.) Ubaldi which inhabits similar habitats and can be related to the material observed by us. The problem deserves more study.

Bromopsis caprina: is circumscribed in two very different ways in the two editions of the Flora d'Italia of Pignatti (1982, 2017). In the edition of 1982, *Bromopsis caprina* is mainly distinct for the indumentum of the stem

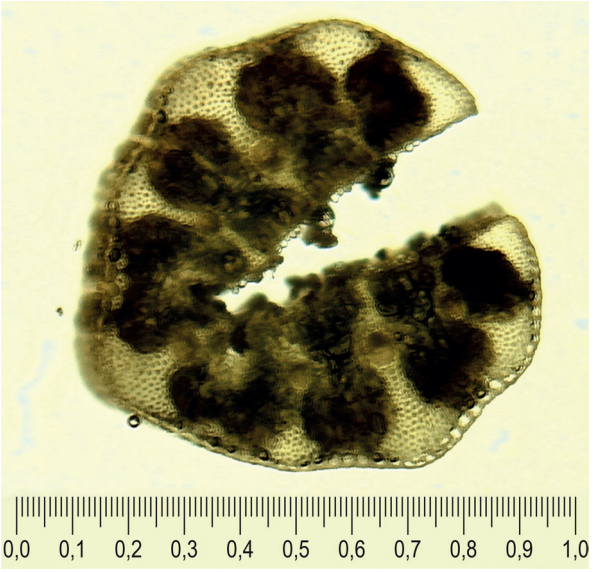

Figure 5: Leaf section of *Sesleria juncifolia* subsp. *juncifolia* at 5x magnification.
Slika 5: Prerez lista vrste vrste *Sesleria juncifolia* subsp. *juncifolia* pri 5x povečavi.

and is a widespread species weakly differentiated from *Bromopsis erecta* widespread in dry grasslands in Southern Italy, hence the alliance *Cytiso spinescentis-Bromion caprini* Bonin in Barbero et Bonin 1969. In the edition of 2017 *Bromopsis caprina* is a rare species of rocks, probably endemic to the Gulf of Naples, mainly distinct for the shape of the spike and the spikelets. After examination of the type there is no doubt that the correct definition is the latter (JSTOR Global Plants, 2020). In our study we found both forms of *Bromopsis*: *Bromopsis caprina* sensu Pignatti (1982) is widespread in the *Santolinetum neapolitanae*, whereas typical *Bromopsis caprina* sensu Pignatti et al. (2017) occurs rarely on the rocks of *Loniceretum stabianae*.

Limonium cumanum: is very variable but can easily be distinguished by the pubescent leaves. It is usually indicated on volcanic rocks, but it can grow equally on limestone. For instance, one of our relevés from Sorrento was carried out on limestone (relevé 18, Table 3).

Conclusions

The three associations described in this paper are striking since they present an astounding level of endemism not different from that of some insular ecosystems. They add to the already gathered information in emphasizing the distinctiveness of the phytogeographical sector of the Gulf of Naples. In the recent literature (Blasi et al., 2018) the

Gulf of Naples is assigned to different ecoregions mainly on the base of the distinct history and geology of tuffs near the coast and the limestones of the Sorrento Peninsula. Here we discard the obvious differences between the different substrates and concentrate on the high rate of (neo)endemism in the whole Gulf of Naples.

Mountains near the sea are often sites of high endemism (Sierra Nevada in Spain, Durmitor in Montenegro, Çika in Albania, Apuan Alps in Italy). The reason of this high level of endemism is the peculiar climate of mountains near the sea, with their clouds belt originating from the winds blowing from the sea, allowing the persistence of tertiary relics confined to warm and moist climate (Mahmutaj et al., 2014). The origin of endemics in the Gulf of Naples seems quite different from that of Durmitor or Apuane Alps. In the latter paleoendemics dominate, whereas the endemics of Sorrento Peninsula and Gulf of Naples are of a different kind, being closely related to more common species often widespread in the Apennines: *Globularia neapolitana* is related to *Globularia cordifolia*, *Lonicera stabiana* to *Lonicera etrusca* and *Centaurea tenorei* to *Centaurea ambigua*. In other terms it seems that the Gulf of Naples is not an area of conservation of relict species. but rather a center of differentiation and speciation of neoendemics. For instance, *Limonium* which is notoriously fragmented into several narrowly range species presents here an exceptional diversity at least for Italy, with three species in a small area. Also, *Centaurea cineraria* has been shown to be highly diverse in the area from a molecular point of view (Hilpold et al., 2011).

The reason why the Gulf of Naples seems to represent a centre of differentiation is open to speculations, but a role is probably played by the diversity of substrata. Along the coast, volcanic rocks are presents with chemistry typical to the Neapolitan magmatic province. Probably this chemistry played a role in the differentiation of the *Limonium* species and of other seacoast species. On the Lattari Mts., in the areas richest in endemics, the rapid speciation that seems to occur is possibly driven by the necessity to adapt to the peculiar chemistry of the dolomitic rocks. Differently from serpentines rocks, the role of dolomitic substrata in the evolution and ecology of plants is poorly known (Mota et al., 2008) but is well established for instance in *Pinus* spp. (Barbéro et al., 1998) and in a few phytosociological syntaxa which are related to dolomites (Mucina et al., 2016). In particular, in the Baetic province of the Southern Iberian Peninsula, scrubby vegetation exists with an extraordinarily high number of endemics (Mota et al. 2017). The Sorrento Peninsula, with its unusual concentration of narrow endemics, maybe represents on a smaller scale an analogous case. The new association (*Globulario neapolitanae-Loniceretum stabianae*) recognises the singularity of the dolomitic habitat of this area. Ecophysiological and phylogenetic research in this topic could be very rewarding - a few studies have highlighted that dolomitic soil alter the water balance of tree seedlings (Pröll et al., 2016), but little is known about the effects of dolomite on plant life.

Another explanation of the high number of endemic species for the Gulf of Naples, is the possible isolation during periods of marine transgression (Santangelo et al., 2017; Caiazzo et al., 2006). Southern Italy was repeatedly fragmented into small islands during the Tertiary and Quaternary. Fragmentation has been demonstrated to play a role in the genetic differentiation of many species of vertebrates (Canestrelli et al., 2010). The hypothesis of isolation is not mutually exclusive with the selective role of substratum since both could have played a role at the same time. Nonetheless edaphic hypothesis is more consistent with the presence of a few endemics of the Sorrento Peninsula in the Picentini Mountains which probably were not isolated from the mainland (*Santolina neapolitana*, *Globularia neapolitana*).

From the point of view of conservation, the three communities here described occupy a very small area, in particular *Loniceretum stabianae*; nonetheless they do not seem to be threatened since they occupy marginal unexploited habitats. Only the status of *Limonietum cumani* raises some concerns due to the high human impact and biological invasions. For instance, a small station of *Limonium cumanum* on the beach of Gaiola, which was recorded in 2019 has already disappeared due to touristic exploitation. *Limonietum cumani* represents Habitats 1240 and *Lonicereteum stabianae* Habitat 8210 sensu EU (European Commission 2013) and thus they deserve particular attention and protection.

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Appendix 1 Syntaxonomical scheme

Asplenietea trichomanis (Br.-Bl. inMeier et Br.-Bl. 1934) Oberd. 1977
Potentilletalia caulescentis Br.-Bl. in Br.-Bl. et Jenny 1926
Saxifragion australis Biondi & Ballelli ex Brullo 1984
Globulario neapolitanae-Loniceretum stabianae ass. nova

Festuco hystricis-Ononidetea striatae Rivas-Mart. *et al.* 2002
Erysimo-Jurineetalia bocconei S. Brullo 1984
Cytiso spinescentis-Saturejion montanae Pirone et Tammaro 1997
Eryngio amethystini-Santolinetum neapolitanae ass. nova

Crithmo-Staticetea Br.-Bl. in Br.-Bl. *et al.* 1952
Crithmo-Staticion Molinier 1934
Chritmo maritimi-Limonietum cumani Bartolo, Brullo & Signorello 1989

Appendix 2
Locality and date of the relevés in Tables

Stationary data are written in order: number of relevés, reference municipality, locality, WGS84 coordinates, altitude, date, and possible notes.

Rel. 1: Vico Equense, road to Mt. Faito, 40°40.08' N; 14°27.58' E, 730m a.s.l., 08/07/2020.
Rel. 2–3: Vico Equense, Mt. Faito, 40°40.21' N; 14°28.16' E, 1030m a.s.l., 08/07/2020.
Rel. 4: Vico Equense, road to Mt. Faito, 40°39.71' N; 14°27.95' E, 620m a.s.l., 08/07/2020.
Rel. 5: Vico Equense, road to Mt. Faito, 40°39.91' N; 14°27.95' E, 660m a.s.l., 09/07/2020, cliff along the road.
Rel. 6: Vico Equense, Mt. Faito, 40°40.21' N; 14°28.30' E, 1030m a.s.l., 09/07/2020, glade among pine trees.
Rel. 7: Vico Equense, road to S. Michele sanctuary, 40°39.43' N; 14°29.86' E, 1240m a.s.l., 09/07/2020.
Rel. 8: Vico Equense, towards Mt. S. Michele on 308 path, 40°39.15' N; 14°29.50' E, 1160m a.s.l., 09/07/2020.
Rel. 9–10: Vico Equense, towards Mt. S. Michele on 308 path, 40°39.06' N; 14°29.61' E, 1130m a.s.l., 09/07/2020, scarp slope calcareous steps.
Rel. 11: Vico Equense, towards Mt. S. Michele on 308 path, 40°39.05' N; 14°29.83' E, 1210m a.s.l., 09/07/2020.
Rel. 12–13–14: Vico Equense, path to Mt. S. Angelo, 40°39.15' N; 14°29.51' E – 40°39.15' N; 14°29.50' E – 40°39.11' N; 14°29.53' E, 1170m; 1160m; 1160m a.s.l., 09/07/2020, on cliffs.
Rel. 15–16–17: Sorrento, Bagni Regina Giovanna, 41°32.08' N; 14°20.56' E – 41°32.08' N; 14°20.56' E – 40°38.05' N; 14°21.10' E, 20m; 15m; 25m a.s.l., 09/07/2020, on the ruins of the Roman villae.
Rel. 18: Sorrento, Bagni Regina Giovanna, 40°37.98' N; 14°21.05' E, 5m a.s.l., 09/07/2020, calcareous cliff.
Rel. 19–20–21: Napoli, Trentaremi bay, 40°47.70' N; 14°10.91' E – 40°47.68' N; 14°10.91' E – 40°47.71' N; 14°10.90' E, 10m a.s.l., 25/08/2020, on cliff of "Tufo di Trentaremi".
Rel. 22–23: Napoli, Posillipo, 40°47.51' N; 14°11.15' E – 40°47.53' N; 14°11.18' E, 5m a.s.l., 25/08/2020, on cliff of "Tufo Giallo Napoletano".
Rel. 24: Napoli, Gaiola, 40°47.51' N; 14°11.20' E, 10m a.s.l., 25/08/2020, on cliff of "Tufo Giallo Napoletano".
Rel. 25: Napoli, Marechiaro, 40°47.61' N; 14°11.31' E, 5m a.s.l., 25/08/2020, on cliff of "Tufo Giallo Napoletano".

N. Relevé	Municipality	Locality	Coordinates (WGS84 DDM)	Altitude	Date	Notes
Rel. 1	Vico Equense	road to Mt. Faito	40°40.08' N; 14°27.58' E	730m	08/07/2020	
Rel. 2	Vico Equense	Mt. Faito	40°40.21' N; 14°28.16' E	1030m	08/07/2020	
Rel. 3	Vico Equense	Mt. Faito	40°40.21' N; 14°28.16' E	1030m	08/07/2020	
Rel. 4	Vico Equense	road to Mt. Faito	40°39.71' N; 14°27.95' E	620m	08/07/2020	
Rel. 5	Vico Equense	road to Mt. Faito	40°39.91' N; 14°27.95' E	660m	09/07/2020	cliff along the road
Rel. 6	Vico Equense	Mt. Faito	40°40.21' N; 14°28.30' E	1030m	09/07/2020	glade among pine trees
Rel. 7	Vico Equense	road to S. Michele sanctuary	40°39.43' N; 14°29.86' E	1240m	09/07/2020	
Rel. 8	Vico Equense	towards Mt. S. Michele on 308 path	40°39.15' N; 14°29.50' E	1160m	09/07/2020	
Rel. 9	Vico Equense	towards Mt. S. Michele on 308 path	40°39.06' N; 14°29.61' E	1130m	09/07/2020	scarp slope calcareous steps
Rel. 10	Vico Equense	towards Mt. S. Michele on 308 path	40°39.06' N; 14°29.61' E	1130m	09/07/2021	scarp slope calcareous steps
Rel. 11	Vico Equense	towards Mt. S. Michele on 308 path	40°39.05' N; 14°29.83' E	1210m	09/07/2020	
Rel. 12	Vico Equense	path to Mt. S. Angelo	40°39.15' N; 14°29.51' E	1170m	09/07/2020	on cliffs
Rel. 13	Vico Equense	path to Mt. S. Angelo	40°39.15' N; 14°29.50' E	1160m	09/07/2021	on cliffs
Rel. 14	Vico Equense	path to Mt. S. Angelo	40°39.11' N; 14°29.53' E	1160m	09/07/2022	on cliffs
Rel. 15	Sorrento	Bagni Regina Giovanna	41°32.08' N; 14°20.56' E	20m	09/07/2020	on the ruins of the Roman villae
Rel. 16	Sorrento	Bagni Regina Giovanna	41°32.08' N; 14°20.56' E	15m	09/07/2021	on the ruins of the Roman villae
Rel. 17	Sorrento	Bagni Regina Giovanna	40°38.05' N; 14°21.10' E	25m	09/07/2022	on the ruins of the Roman villae
Rel. 18	Sorrento	Bagni Regina Giovanna	40°37.98' N; 14°21.05' E	5m	09/07/2020	calcareous cliff
Rel. 19	Napoli	Trentaremi bay	40°47.70' N; 14°10.91' E	10m	25/08/2020	on cliff of "Tufo di Trentaremi"
Rel. 20	Napoli	Trentaremi bay	40°47.68' N; 14°10.91' E	10m	25/08/2021	on cliff of "Tufo di Trentaremi"
Rel. 21	Napoli	Trentaremi bay	40°47.71' N; 14°10.90' E	10m	25/08/2022	on cliff of "Tufo di Trentaremi"
Rel. 22	Napoli	Posillipo	40°47.51' N; 14°11.15' E	5m	25/08/2020	on cliff of "Tufo Giallo Napoletano"
Rel. 23	Napoli	Posillipo	40°47.53' N; 14°11.18' E	5m	25/08/2021	on cliff of "Tufo Giallo Napoletano"
Rel. 24	Napoli	Gaiola	40°47.51' N; 14°11.20' E	10m	25/08/2020	on cliff of "Tufo Giallo Napoletano"
Rel. 25	Napoli	Marechiaro	40°47.61' N; 14°11.31' E	5m	25/08/2020	on cliff of "Tufo Giallo Napoletano"