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Contribution to knowledge of Apennine colline-submontane garigues on terrigenous rock types

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Abstract

This study provides new data and an in-depth syntaxonomic analysis of Apennine garigues in the *Cisto cretici-Micromerietea julianae* class, relative to terrigenous substrates in temperate bioclimates. In this context, it is proposed to elevate the suballiance *Astragalenion monspessulani* Biondi, Allegrezza & Zuccarello 2005 to the rank of alliance, with the name of *Astragalion monspessulani*, and to introduce the new *Astragaletales monspessulani* order. The study also describes a number of new associations and subassociations belonging to the *Astragalion monspessulani* and *Cisto cretici-Ericion manipuliflorae* alliances.

Key words: Apennines, new *syntaxa*, garigue vegetation.

Introduction

In the Apennines, many studies have been carried out on chamaephytic-nanophanerophytic vegetation with a discontinuous structure and garigue physiognomy in the temperate macrobioclimate (including the submediterranean variant) relative to carbonate substrates (Pirone, 1995; Pirone & Tammaro, 1997; Allegrezza *et al.*, 1997; Biondi, 1997; Allegrezza, 2003; Biondi & Vagge, 2004; Taffetani *et al.*, 2004; Biondi *et al.*, 2005; Cutini *et al.*, 2007; Di Pietro & Wagensommer, 2008; Tardella *et al.*, 2010; De Sillo *et al.*, 2012; Pirone *et al.*, 2014; etc.) and this is therefore relatively well known. However, in the same geographical-climatic context, little is known about aspects associated with terrigenous substrates (sandstones, clays, marls, etc.).

An initial contribution concerning this latter subject is included in a synthesis by Biondi *et al.* (2005) relative to the syntaxonomic revision of Apennine pastures in the *Brometalia erecti* order and analysis of their relationships with vegetation of the *Rosmarinetea officinalis* class. In that study, within the *Artemisio albae-Saturejon montanae* alliance describing thermo-xerophilous Apennine garigues in the temperate macrobioclimate (Allegrezza *et al.*, 1997), the authors propose the suballiance *Astragalenion monspessulani*, relative to submediterranean chamaephytic garigues growing on marly limestone, sandstone and conglomerate substrates in the northern and central Apennines. Referring in the quoted work to the western Mediterranean *syntaxa Rosmarinetalia officinalis* and *Rosmarinetea officinalis*, the alliance has recently been transferred by Biondi *et al.* (2014a) to the new *Artemisio*

albae-Saturejetalia montanae order, describing the pioneer, rupicolous calcicolous chamaephytic and nanophanerophytic vegetation growing in the submediterranean variant of the temperate macrobioclimate, with mesotemperate to supratemperate thermotype. Typical of Apennine elevations, the order is also present in the Alpine sector and Balkan Peninsula, and in the area indicated is the vicariant of the *Ononidetalia striatae* order, with a western south European gravitation (Biondi *et al.*, 2014b). In turn, the new order has been ascribed to the east Mediterranean *Cisto cretici-Micromerietea julianae* class. The characteristic and differential species of the *Astragalenion monspessulani* are indicated by the authors as *Astragalus monspessulanus*, *Coronilla minima*, *Thymus vulgaris*, *Anthericum liliago*, *Onosma helvetica*, *Cleistogenes serotina*, *Carex liparocarpos*, *Chrysopogon gryllus*, *Stipa pennata s.l.*, *Fumana ericoides*, *Inula spiraeifolia*, *Argyrobolium zanonii*, *Centaurea ambigua*, *Dianthus sylvestris*, *Leontodon rosani* (= *Leontodon villarsii*).

Mucina *et al.* (2016) consider the *Artemisio albae-Saturejetalia montanae* order as synonymous with *Erysimo-Jurineetalia bocconeii* S. Brullo 1984, included in the class *Festuco hystricis-Ononidetalia striatae* Rivas-Martínez *et al.* 2002.

As emphasised on other occasions (Pirone *et al.*, 2014), we believe that Apennine garigue vegetation cannot be attributed to this latter class, given its greater floristic and phytogeographical affinity to the Balkan Peninsula. We also believe that on syntaxonomic level, predominantly chamaephytic vegetation should be separated from mainly hemicryptophytic vegetation (Ciaschetti *et al.*, 2016; 2018). For this reason, in this

study reference is made to the Vegetation Prodrome of Italy (Biondi *et al.*, 2014b).

The subject was further investigated and a number of ecological and syntaxonomic aspects were clarified by field surveys of garigues on terrigenous substrates in the Apennines in Abruzzo, but also to a lesser extent in Basilicata, and comparison with research in literature covering other parts of Italy.

A number of garigue communities, all pertaining to terrigenous substrates in Abruzzo, belonging to the *Cisto cretici-Ericion manipuliflorae* alliance are described here.

Study area

The study considered the Abruzzo Apennines in both the north (Monti della Laga) and south (Trigno and Sinello valleys, Altipiani Maggiori high plateaus) of the region, together with part of the Agri valley in Basilicata.

With regard to Abruzzo, the lithology consisted mainly of sandstones, clays, marly limestones (turbiditic) and arenaceous-marly flysch in the case of the communities studied on the Monti della Laga, and of sandstones, marly limestones, marls and clayey marls in the case of the Trigno and Sinello valleys. All lithologic units dated from the Miocene (Geological Map from the Italian Environment Ministry National Cartographic Portal (Portale Cartografico Nazionale). The climate was described with reference to mean monthly temperature and precipitation data published by the Presidency of the Council of Ministers' Hydrographic Office (Ufficio Idrografico della Presidenza del Consiglio dei Ministri) for a period of thirty years. The Rivas-Martínez (2008) bioclimatic classification was adopted. The bioclimatic range is between the lower

mesomediterranean and upper supratemperate, with ombrotypes from upper arid to upper humid.

In the case of Basilicata, reference was made to the Phytoclimatic Map of Italy (Carta Fitoclimatica d'Italia) (Blasi & Michetti, 2005), available on the Italian Environment Ministry National Cartographic Portal. Relevés of garigue in the Agri valley were performed on Miocene arenaceous-marly rock types in a mesotemperate/mesomediterranean bioclimate with humid/hyperhumid ombrotype.

Materials and methods

The vegetation was studied using the Zurich-Montpellier sigmatist method (Braun-Blanquet, 1931; Géhu & Rivas-Martínez, 1981; Theurillat, 1992; Biondi, 2011).

Species present just once were eliminated from the original matrix of relevés, with the exception of species diagnostic of the *Cisto-Micromerietea* class. The resulting new matrix of 123 species x 45 relevés was then processed using the Syntax-2000 multivariate analysis package (Podani, 2001). In particular, a cluster analysis was performed on the quantitative data using the "similarity ratio" as the distance coefficient and "complete linkage" as the clustering strategy (Fig. 1). A PCoA was also performed on the same matrix, again using the "similarity ratio" as the distance coefficient (Fig. 2). A second similar PCoA (Fig. 3) was performed on part of the matrix corresponding to the relevés of cluster III in Fig. 1, as due to the great variability of the original data, this group containing less differences appeared "flattened" in the first sorting (Fig. 2).

The nomenclature of the plant species complies with that proposed by Conti *et al.* (2005).

For the higher syntaxonomic units (alliance, order

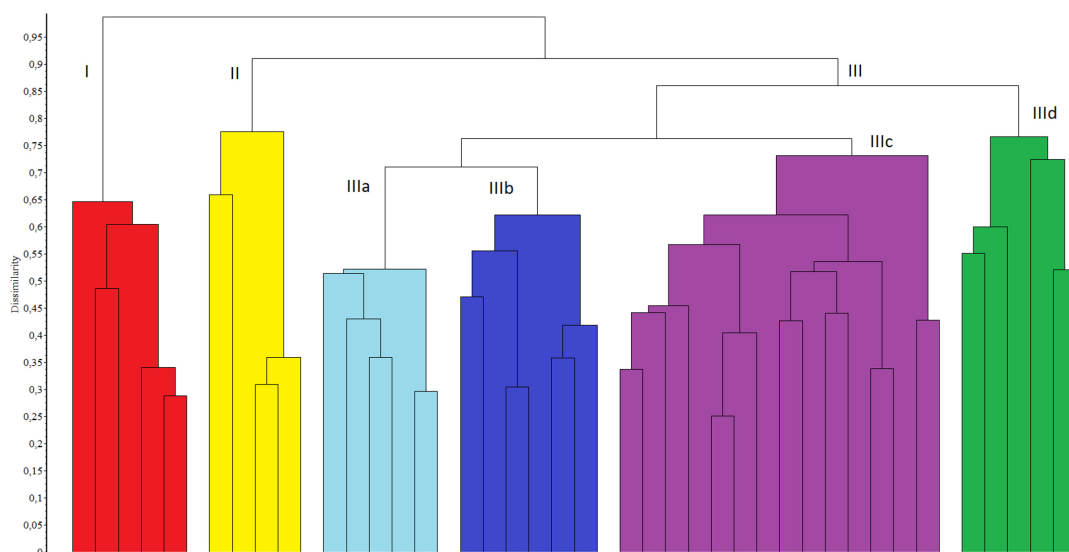


Fig. 1 - Cluster analysis of the relevés.

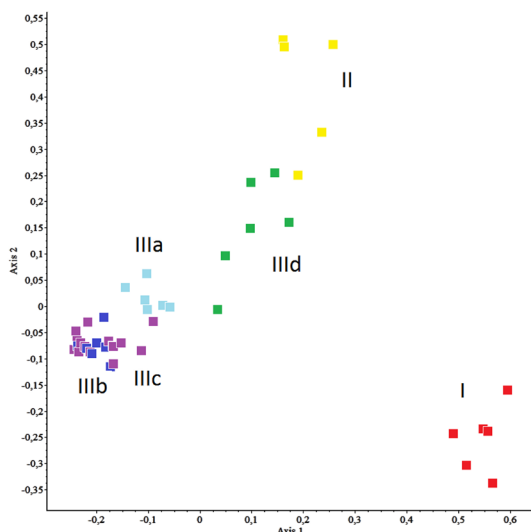


Fig. 2 - PCoA of the relevés.

and class), reference is made to the Vegetation Prodomo of Italy (Biondi *et al.*, 2014b).

Results and discussion

ASTRAGALION MONSPESSULANI (Biondi, Allegrezza & Zuccarello 2005) stat. nov. and *ASTRAGALETALIA MONSPESSULANI* ord. novo

Garigues in the *Astragalenion monspessulani* suballiance on terrigenous substrates have a floristic composition in which strictly calcicolous chamaephytic and nanophanerophytic species (together with a number of large hemicryptophytes) are absent or sporadic. These include *Satureja montana* subsp. *montana*, *Globularia meridionalis*, *Sideritis italica*, *Cytisus spinescens*, *Micromeria graeca* subsp. *graeca*, *Helianthemum oelandicum* subsp. *incanum*, *Rhamnus saxatilis*, *Hyssopus officinalis* subsp. *aristatus*, *Matthiola fruticulosa* subsp. *fruticulosa*, *Ruta graveolens*, *Cephalaria leucantha*, *Centaurea ambigua* subsp. *ambigua*, *Cerastium tomentosum*, *Euphorbia myrsinites*, *Osyris alba*, *Centaurea rupestris* s.l., etc., representing the species of predominant, if not exclusive, diagnostic importance with reference to the alliances described for Apennine garigues on carbonate substrates in a temperate bioclimate, with incursions into mesomediterranean, namely *Cytiso spinescentis-Saturejon montanae* (Pirone & Tammaro, 1997) and *Artemisio albae-Saturejon montanae* (Allegrezza *et al.*, 1997).

The water retention of the two rock types is also very different, very low in the case of carbonate rocks, good with sandstones, clays, marls and similar. The coolness of the latter type of substrate hinders the establishment of xerophilous garigue species in favour of mesophilous *Bromus* grassland species (*Ononis spinosa*, *Dorycnium herbaceum*, *Galium mollugo* subsp. *erectum*,

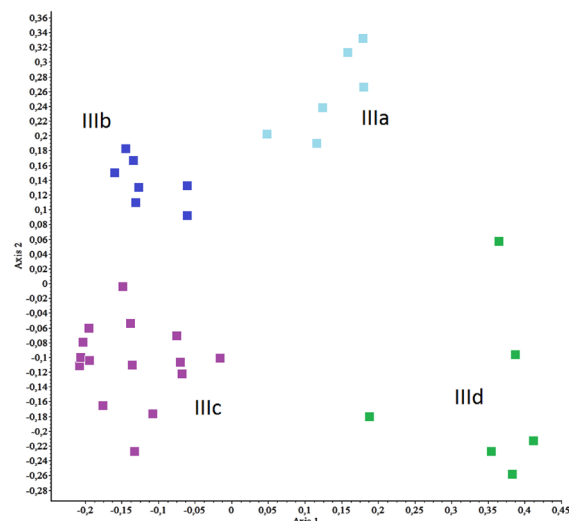


Fig. 3 - PCoA of the relevés of the cluster III.

Leucanthemum vulgare subsp. *vulgare*, *Briza media*, *Rhinantus alectorolophus*, *Blackstonia perfoliata*, *Trifolium pratense* subsp. *pratense*, etc.), contributing to further differentiating the plant communities on terrigenous substrates.

It was therefore felt appropriate to modify the syntaxonomic profile of Apennine garigues ascribed to the *Astragalenion monspessulani* suballiances as follows:

- modification of the hierarchical level of the *Astragalenion monspessulani* suballiance, elevating it to the rank of alliance with the name of *Astragalion monspessulani* (Biondi, Allegrezza & Zuccarello 2005) stat. nov. (*Holotypus*: *Astragalo monspessulani-Lomelosietum pseudisetensis* Biondi, Allegrezza & Frattaroli 1992 *nom.corr. hoc loco*);
- institution within the *Cisto-Micromerietea* class of a new order of garigue on terrigenous substrates, the *Astragaletalia monspessulani* ord. novo *hoc loco* [*Holotypus*: *Astragalion monspessulani* (Biondi, Allegrezza & Zuccarello 2005) stat. nov.], vicariant of the *Artemisio albae-Saturejetalia montanae* and *Cisto cretici-Ericetalia manipuliiflorae* orders on cool terrigenous substrates.

As the diagnostic and differential species of the alliance and order with respect to the calcicolous *syn-taxa*, we propose: *Astragalus monspessulanus* subsp. *monspessulanus*, *Ononis spinosa* s.l., *Genista tinctoria*, *Anthericum liliago*, *Leontodon rosani* (= *L. villarsii*), *Dorycnium herbaceum*, *Leucanthemum vulgare* subsp. *vulgare*, *Onobrychis viciifolia*, *Briza media* and *Chamaecytisus hirsutus*. The majority of these species have a Mediterranean s.l. distribution; in particular, the last three (marked with an asterisk in the table) are hemicryptophytes preferentially associated with mesophilous *Bromus* grassland.

Astragalus monspessulanus subsp. *monspessulanus*

is associated with heavy soils and has a Euro-Mediterranean distribution. It is known in all Italian regions, with the exception of Friuli Venezia Giulia, Sardinia and Veneto where it was no longer recorded (Bartolucci et al., 2018). In terms of physiognomy, although a hemicryptophyte, this is the species most representative of open garigue communities on eroded soils deriving from terrigenous rock types. *Ononis spinosa* is a striking suffruticose chamaephyte with a Mediterranean distribution, widespread in all Italian regions. *Genista tinctoria* is a suffruticose chamaephyte with a Eurasiatic distribution, associated with heaths, forest margins and mesophilous e/o acidophilous grassland; it is present throughout Italy, with the exception of Sicily and Sardinia. *Anthericum liliago*, a bulbous geophyte with a Mediterranean/sub-Atlantic distribution, is a component of grassland, preferably on siliceous rock types throughout almost all Italy. *Leontodon rosani* is a north-western Mediterranean rosulate hemicryptophyte present in peninsular Italy, Piedmont and Veneto; it grows on uncultivated land and arid slopes, but is particularly associated with chamaephytic communities on marly sandstone substrates. *Dorycnium herbaceum* is a perennial herbaceous species, often woody at the base, associated with mesophilous pastures and forest margins, with a south European-Pontic distribution, present throughout Italy with the exception of Valle d'Aosta and doubtful in Sicily. *Onobrychis vicifolia*, a Mediterranean montane species, is widely cultivated but believed to be native in almost all Italy where it is found in both Mediterranean pastures and hay meadows. *Briza media*, with a Euro-Siberian distribution, is another species of mesophilous *Bromus* grassland and hay meadows, present throughout Italy with the exception of Sicily and Apulia where it was no longer recorded. *Rhinanthus alectorolophus*, with a central European distribution, is associated principally with secondary grassland.

The alliance and order describe high-colline and submontane Apennine garigues on terrigenous substrates (sandstones, clays, marls, etc.) in a temperate bioclimate with mesotemperate to supratemperate thermotypes, with possible incursions into a Mediterranean bioclimate with mesomediterranean thermotype.

It is emphasised that the proposed syntaxonomy considers the similar scenario pertaining to the secondary hemicryptophytic Apennine pastures. In fact, in the *Festuco valesiacaе-Brometea erecti* class, the mesophilous pasture communities are ascribed to the *Brometalia erecti* order and *Polygalo mediterraneae-Bromion erecti* alliance (Di Pietro et al., 2015), while the xerophilous and semi-mesophilous communities are included in the *Phleo ambiguï-Brometalia erecti* order and *Phleo ambiguï-Bromion erecti* alliance (Biondi et al., 2014b). Numerous observations in the Apennine area confirm that the calcicolous xerophilous garigues

are in serial contact with the pastures in the *Phleo ambiguï-Bromion erecti* alliance, while the mesophilous garigues on terrigenous substrates are in serial contact with pastures in the *Polygalo mediterraneae-Bromion erecti* alliance.

We believe that the associations listed below belong to the *Astragalion monspessulani* alliance. Of these, the *Teucrio polii-Thymetum vulgaris* and *Helianthemum canis-Brometum erecti* have already been included in the synthesis by Biondi et al. (2005). Table 1 gives a brief comparison of these associations. As the aim of this study is not to revise the individual associations, the diagnostic species given in Table 1 are those suggested by the original authors.

- *Astragalo monspessulani-Lomelosietum pseudisetensis* (Biondi, Allegranza & Frattaroli 1992) *nom. corr.* Abruzzo and Molise Apennines (Villetta Barrea, Alfedena, Montenero); lithology: sandstones and clays; altitudes: 910-1190 m; bioclimate: temperate, humid-hyperhumid supratemperate belt (Biondi et al., 1992a). Original classification: *Mesobromion* Br.-Bl. & Moor 1938 em. Oberd. 1957, *Brometalia* Br.-Bl. 1936, *Festuco-Brometea* Br.-Bl. & Tx. 1943. Abruzzo and Marche Apennines (Monti della Laga); lithology: sandstones, clays, marls; altitudes: 490-1015 m; bioclimate: temperate, humid/subhumid mesotemperate and humid supratemperate belts (Tab. 2).

- *Putorio calabricae-Lomelosietum crenatae* (Biondi, Ballelli & Taffetani 1992) *nom. corr.* Basilicata, river Bradano basin; lithology: flaky clays of the badland formations; altitudes 570-580 m; bioclimate: Mediterranean, subhumid mesomediterranean belt (Biondi et al., 1992b). Original classification: *Xerobromion* Br.-Bl. & Moor 1938, *Brometalia* Br.-Bl. 1936, *Festuco-Brometea* Br.-Bl. & Tx. 1943. Basilicata, Agri valley; lithology: sandstones and marls; altitudes: 605-620 m; bioclimate: Mediterranean/temperate, humid/hyperhumid mesomediterranean/mesotemperate belt (Tab. 4).

- *Teucrio poli-Thymetum vulgaris* Castelli 1995. Liguria-Piedmont Apennines; lithology: marls and sandstones; altitudes: 210-640 m; climate: temperate continental Apennine sub-littoral (Castelli, 1995). Original classification: *Xerobromion* Br.-Bl. & Moor 1938, *Brometalia* Br.-Bl. 1936, *Festuco-Brometea* Br.-Bl. & Tx. 1943.

- *Helianthemum canis-Brometum erecti* Zanotti, Ubaldi & Puppi 1995. Emilia-Romagna, Pliocene spur; lithology: sandstones; climate: mesotemperate (Zanotti A.L., Ubaldi D., Puppi G., 1995). Original classification: *Xerobromion* Br.-Bl. & Moor 1938, *Brometalia* Br.-Bl. 1936, *Festuco-Brometea* Br.-Bl. & Tx. 1943.

There is also some affinity with the association *Coronillo minimae-Astragaletum monspessulani* Biondi & Ballelli in Biondi, Ballelli & Principi 1985. However, this association refers to grassland aspects and has rightly been included in the *Brometalia erecti* or-

Tab. 1 - Associations of the *Astragalion monspessulani* alliance: 1) *Astragalo monspessulani-Lomelosietum pseudisetensis* (Abruzzo-Molise Apennines); 2) *Astragalo monspessulani-Lomelosietum pseudisetensis* (Marche-Abruzzo Apennines); 3) *Astragalo monspessulani-Lomelosietum pseudisetensis galietosum erecti* subass. nova (Abruzzo Apennines); 4) *Putorio calabricae-Lomelosietum crenatae* (Basento Valley - Basilicata); 5) *Putorio calabricae-Lomelosietum crenatae dorycnietosum herbacei* subass. nova (Agri Valley- Basilicata); 6) *Teucro polii-Thymetum vulgare* (Liguria-Piedmont Apennine); 7) *Helianthemo cani-Brometum erecti* (Emilian Apennine).

Life form	1	2	3	4	5	6	7
<i>Astragalo monspessulani-Lomelosietum pseudisetensis</i>							
Ch Lomelosia crenata ssp. pseudisetensis		V	V	V	.	.	.
<i>Astragalo monspessulani-Lomelosietum pseudisetensis galietosum erecti</i>							
H Galium mollugo ssp. erectum		.	.	V	.	.	.
Ch Acinos alpinus ssp. meridionalis		.	.	IV	I	.	.
H Leucanthemum vulgare ssp. vulgare		.	.	III	.	.	.
Ch Cerastium arvense ssp. suffruticosum		.	.	II	.	.	.
<i>Putorio calabricae-Lomelosietum crenatae</i>							
Ch Lomelosia crenata ssp. crenata		.	.	.	V	V	.
NP Putoria calabrica		.	.	.	IV	V	.
H Galium corrudifolium		.	.	.	V	.	.
H Hieracium piloselloides		.	.	.	V	.	.
Ch Thymus spinulosus		.	.	.	III	.	.
T Moricandia arvensis		.	.	.	III	.	.
<i>Putorio calabricae-Lomelosietum crenatae dorycnietosum herbacei</i>							
H Dittrichia viscosa ssp. viscosa		III	.
H Achnatherum bromoides		III	.
H Daucus carota ssp. carota		II	.
<i>Teucro polii-Thymetum vulgare</i>							
Ch Thymus vulgaris ssp. vulgaris		V
Ch Teucrium capitatum ssp. capitatum		II	V
H Achnatherum calamagrostis		IV
H Centaurea aplolepa		III
<i>Helianthemo cani-Brometum erecti</i>							
Ch Helianthemum oelandicum ssp. incanum		I	.	.	.	.	V
H Bothriochloa ischaemum		IV
H Silene otites ssp. otites		II
H Peucedanum oreoselinum		III
<i>Astragalion/Astragalealia monspessulani</i>							
H Astragalus monspessulanus ssp. monspessulanus		V	V	V	V	V	I II
H/Ch Dorycnium herbaceum*		IV	II	IV	.	IV	I
H Leontodon rosani		II	V	IV	IV	.	.
H Onobrychis vicifolia*		I	IV	III	.	.	.
Ch Ononis spinosa s.l.		IV	II	III	.	.	.
Ch Genista tinctoria		.	V	III	.	.	.
H Briza media*		I	.	I	.	.	.
G Anthericum liliago		II	I
<i>Cisto cretici-Micromerietea julianae</i>							
Ch Teucrium chamaedrys ssp. chamaedrys		.	IV	V	II	II	V II
Ch Coronilla minima ssp. minima		I	V	IV	.	.	I V
Ch Helichrysum italicum ssp. italicum		.	V	I	III	IV	II
Ch Linum tenuifolium		.	V	I	.	I	IV
Ch Thymus longicaulis ssp. longicaulis		IV	IV	IV	.	.	.
Ch Fumana procumbens		.	III	.	.	IV	V
Ch Helianthemum nummularium s.l.		.	III	I	.	.	III
Ch Dorycnium hirsutum		.	.	.	II	II	I
Ch Asperula purpurea ssp. purpurea		.	IV	.	.	IV	.
Ch Dianthus sylvestris s.l.		.	.	IV	.	.	III
H Ononis pusilla ssp. pusilla		.	I	.	.	.	I
Ch Ononis natrix ssp. natrix		I	.
Ch Cytisus spinescens		I	.	.	I	.	.
Ch Fumana ericoides		I	II
Ch Micromeria graeca ssp. graeca		.	.	I	.	III	.
Ch Argyrolobium zanonii ssp. zanonii		.	.	.	I	.	III
Ch Artemisia alba		I	IV
Ch Teucrium montanum		I	III
Ch Plantago sempervirens		.	III	.	.	.	.
NP Cistus salviifolius		.	II	.	.	.	.
H Centaurea ambigua ssp. ambigua		.	.	I	.	.	.
Ch Osyris alba		.	.	I	.	.	.

NP Cistus creticus ssp. eriocephalus	.	.	.	.	.	I	.	.
Ch Onosma helvetica ssp. helvetica	.	.	.	.	.	II	.	.
Ch Helianthemum apenninum ssp. apenninum	.	.	.	.	.	.	.	V
Other species								
H Bromus erectus ssp. erectus	V	V	V	V	.	III	V	.
H Sanguisorba minor s.l.	V	V	II	.	IV	III	I	.
H Brachypodium rupestre	IV	II	III	.	I	.	.	.
H Hippocrepis comosa ssp. comosa	I	III	.	.	.	II	II	.
H Hieracium pilosella	III	IV	.	.	.	.	II	.
T Odontites luteus	.	I	II	.	.	.	II	.
P Cytisophyllum sessilifolium	.	II	I	.	.	I	II	.
H Scabiosa columbaria s.l.	.	III	.	.	.	.	I	.
H Lotus corniculatus ssp. corniculatus	.	III	III	.	.	.	.	.
H Picris hieracioides s.l.	III	.	II	.	I	.	.	.
T Blakstonia perfoliata s.l.	II	.	I	.	I	.	.	.
P Spartium junceum	.	.	.	.	IV	III	II	.
H Reichardia picroides	.	II	I	.	III	.	.	.
H Eryngium amethystinum	.	IV	.	.	.	.	.	.
Ch Sedum rupestre ssp. rupestre	.	.	.	II	.	II	.	.
H Rhinanthus alectorolophus ssp. alectorolophus	I	.	I	.	.	.	.	.
P Juniperus communis	.	II	.	.	.	.	III	.
H/Ch Cota tinctoria ssp. tinctoria	.	II	IV	.	.	.	.	.
H Trifolium pratense ssp. pratense	.	I	I	.	.	.	.	.
H Globularia bisnagarica	.	.	.	.	.	III	IV	.

der and *Leucanthemo vulgaris-Bromenalia erecti* suborder (Biondi *et al.*, 2005). This association has also been used by Ubaldi (1997) as *typus* to describe the *Coronillo minimae-Astragalion monspessulani* alliance, which, in the recent classification of European vegetation by Mucina *et al.* (2016), is considered synonymous with the *Festuco-Bromion* Barbero et Loisel 1972.

The dendrogram obtained from the cluster analysis (Fig. 1) shows three main groups of relevés, corresponding to three different associations, described below. The most numerous group contains four distinct subgroups, corresponding to different subassociations, as described below. PCoA of the data (Fig. 2) confirms the separation of the three principal groups, arranged along the first axis which can be considered as a thermal gradient.

PCoA of group III alone (Fig. 3) confirms the separation of the subclusters which, in the previous analysis, appeared "flattened" by the presence of very different communities, such as those in groups I and II. The horizontal axis can again be considered as a thermal/altitudinal gradient.

Garigues of the Abruzzo Apennines in the Astragalion monspessulani alliance

ASTRAGALO MONSPESSULANI-LOMELOSIIETUM PSEUDISETENSIS (Biondi, Allegranza & Frattaroli 1992) *nom. corr.* (cluster III)

LOMELOSIIETOSUM PSEUDISETENSIS subass. nova *hoc loco* subass. *typus* (rels. 1-6, Tab. 2 - cluster IIIa)

CISTETOSUM ERIOCEPHALI subass. nova *hoc loco* (rels. 7-12, Tab. 2; *Holotypus*: rel. 9, Tab. 2 - cluster IIIb)

ASTRAGALETOSUM SEMPERVIRENTIS subass. nova *hoc loco* (rels. 13-19, Tab. 2; *Holotypus*: rel. 15, Tab. 2 - cluster IIIb)

GALIETOSUM ERECTI subass. nova *hoc loco* (rels. 20-34, Tab. 2; *Holotypus*: rel. 28, Tab. 2 - cluster IIIc)

These associations are linked to arenaceous-clayey substrates eroded by meteoric water, described with the name of *Astragalo monspessulani-Scabioisetum crenatae* by Biondi *et al.* (1992) for a number of areas at the border between Abruzzo and Molise (Villetta Barrea, Alfedena, Montenero). As mentioned above, we believe that the association belongs to the *Astragalion monspessulani* alliance.

The name requires correction (art. 43 Code of Phytosociological Nomenclature, Weber *et al.*, 2000) as *Lomelosia crenata* subsp. *crenata* is currently believed to be absent from the area where the association was described, where the subsp. *pseudisetensis* is present (Conti & Bartolucci, 2015).

Table 2 includes the relevés performed in the Monti della Laga, Trigno valley and Altipiani Maggiori high plateaus and ascribed to the *Astragalo-Lomelosietum*.

Relevés 1-6 correspond to the typical aspects, formalized in the subassociation *lomelosietosum pseudisetensis* subass. nova *hoc loco*.

Relevés 7-12 represent a thermophilous low altitude aspect, formalized by us in the new subassociation *cistetosum eriocephali*, differentiated by *Cistus creticus* subsp. *eriocephalus*, *Teucrium capitatum* subsp. *capitatum*, *Argyrolobium zanonii* subsp. *zanonii*, *Osyris alba*, *Dorycnium hirsutum* and *Fumana thymifolia*. This subassociation, present above all in the Trigno valley, represents the transition to garigue communities on terrigenous substrates ascribed to the *Cisto eriocephali-Ericion manipuliflorae* alliance. Within the subassociation, relevés 12 and 13 refer to impoverished aspects in which the species of the higher units are poorly represented.

Relevés 13-19 describe the altitudinal aspect, ascribed by us to the new subassociation *astragaletosum sempervirentis*, differentiated by *Astragalus sempervirens* and *Carlina acanthifolia* subsp. *acanthifolia*, together with *Tussilago farfara* with a markedly pioneering character and emphasising the particularly cool clay-rich substrate in the area. Characteristic of this aspect is an impoverishment of the diagnostic species of the class, probably due to its location at the upper limit for this vegetation.

Relevés 20-34 pertain to the upper valley of the river Sinello (Alto Vastese, southern Abruzzo) on flyschoid rock types with easily erodible marls, sandstones and clays. Here the particular coolness of the substrate, relatively high altitude and significant rainfall have selected plant communities characterised by a greater presence of mesophilous species from the surrounding pastures ascribed to the *Polygalo mediterraneae-Bromion erecti* alliance and a scarce presence of species in the *Cisto-Micromerietea* class. For this aspect, we propose the new subassociation *galietosum erecti*, indicating the differential species as *Galium mollugo* subsp. *erectum*, *Acinos alpinus* subsp. *meridionalis*,

Leucanthemum vulgare subsp. *vulgare* and *Cerastium arvense* subsp. *suffruticosum*.

Garigues of the Abruzzo Apennines on terrigenous substrates in the Cisto cretici-Ericion manipuliflorae alliance

CISTO CRETICI-LOMELOSIIETUM PSEUDIISETENSIS ass. nova *hoc loco* (Holotypus: rel. 4, Tab. 3)

On sandstones in the valleys of the rivers Sangro and Trigno at altitudes between 100 and 400 m a.s.l. in a Mediterranean bioclimate with lower mesomediterranean thermotype and upper arid/lower subhumid ombrotype, plant communities dominated by *Lomelosia crenata* subsp. *pseudisetensis* and *Cistus creticus* subsp. *creticus* were found.

For these communities, the authors propose the new *Cisto cretici-Lomelosietum pseudisetensis* association, with *Lomelosia crenata* subsp. *pseudisetensis* and *Cistus creticus* subsp. *creticus* as the diagnostic species. The association is ascribed to the *Cisto cretici-Ericion manipuliflorae* alliance (*Cisto-Ericetalia*, *Cisto-Mi-*

Tab. 3 - *Cisto cretici-Lomelosietum pseudisetensis*.

Relevé number	1	2	3	4*	5
Altitude (m a.s.l.)	150	200	230	320	350
Slope (°)	45	35	30	40	30
Aspect	SSW	SSW	ESE	S	S
Coverage (%)	65	65	60	40	50
Area (mq)	15	20	20	30	25
<i>Cisto cretici-Lomelosietum pseudisetensis</i> ass. nova					
Ch <i>Lomelosia crenata</i> ssp. <i>pseudisetensis</i>	2	2	2	2	1
Ch <i>Cistus creticus</i> ssp. <i>creticus</i>	2	2	2	2	2
<i>Cisto-Ericion/Cisto-Ericetalia/Cisto-Micromerietea</i>					
Ch <i>Micromeria graeca</i> ssp. <i>graeca</i>	+	+	+	+	1
Ch <i>Galium corrudifolium</i>	+	+	+	+	+
Ch <i>Dorycnium hirsutum</i>	1	+	.	1	1
Ch <i>Fumana thymifolia</i>	.	2	+	1	2
H <i>Dianthus ciliatus</i> ssp. <i>ciliatus</i>	.	1	1	+	+
Ch <i>Linum tenuifolium</i>	.	+	+	+	+
H <i>Cephalaria leucantha</i>	.	1	.	1	1
Ch <i>Teucrium capitatum</i> ssp. <i>capitatum</i>	.	1	.	+	+
Ch <i>Coronilla minima</i> ssp. <i>minima</i>	.	+	.	1	+
Ch <i>Osyris alba</i>	2	.	1	.	.
Ch <i>Thesium humifusum</i>	+	.	+	.	.
Ch <i>Ononis pusilla</i> ssp. <i>pusilla</i>	+	.	.	.	+
Ch <i>Thymus longicaulis</i> ssp. <i>longicaulis</i>	.	+	.	.	+
Ch <i>Helychrysum italicum</i> ssp. <i>italicum</i>	.	.	2	.	+
Ch <i>Teucrium flavum</i> ssp. <i>flavum</i>	.	.	.	+	+
Ch <i>Cistus salviifolius</i>	3	.	.	.	.
Ch <i>Onosma echinoides</i>	.	1	.	.	.
Ch <i>Argyrolobium zanonii</i> ssp. <i>zanonii</i>	.	+	.	.	.
Ch <i>Helianthemum apenninum</i> ssp. <i>apenninum</i>	.	.	.	.	+
Other species					
P <i>Juniperus oxycedrus</i> ssp. <i>deltoides</i>	+	1	.	1	1
G <i>Allium sphaerocephalon</i>	.	+	+	+	+
H <i>Bromus erectus</i> ssp. <i>erectus</i>	+	+	.	.	+
H <i>Hyparrhenia hirta</i> ssp. <i>hirta</i>	.	1	.	1	1
P <i>Quercus ilex</i> ssp. <i>ilex</i>	.	+	.	+	+
H <i>Brachypodium rupestre</i>	1	.	+	.	.
P <i>Spartium junceum</i>	1	.	1	.	.
H <i>Sanguisorba minor</i> ssp. <i>balearica</i>	+	.	+	.	.
G <i>Arundo plinii</i>	.	+	1	.	.
H <i>Asperula cynanchica</i>	.	+	+	.	.
H <i>Convolvulus cantabrica</i>	.	+	+	.	.
P <i>Clematis flammula</i>	.	.	+	.	+
H <i>Stachys recta</i> s.l.	.	.	.	+	+
Sporadic species	10	1	6	5	8

cromerietea).

It should be noted that in the Trigno valley, *Lomelosia crenata* subsp. *pseudisetensis* also characterises another type of garigue along the gravely river bed, included in the *Artemisia variabilis-Lomelosietum pseudisetensis* association (Pirone *et al.*, 2009)

FUMANO THYMIFOLIAE-PHAGNALONETUM ILLYRICI Pirone, Ciaschetti & Frattaroli 2004

One aspect of this association, already known for Abruzzo and found only on gypsum outcrops in the Trigno valley (Pirone *et al.*, 2004), was also identified on the conglomerates of Punta Vignola (Vasto) in the coastal part to the south of Chieti province. The details of the relative relevé are given below:

Date: 10/03/2004; altitude: 4 m a.s.l.; slope: 85°; exposure: E; plant cover: 60%; area surveyed: 15 sq m. Diagnostic species of the *Fumano thymifoliae-Phagnalonetum illyrici*: *Phagnalon rupestre* subsp. *illyricum* (2), *Fumana thymifolia* (1); diagnostic species of the *Cisto-Ericion/Cisto-Ericetalia/Cisto-Micromerietea* units: *Micromeria graeca* subsp. *graeca* (+), *Teucrium flavum* subsp. *flavum* (1), *Coronilla valentina* (2), *Teucrium capitatum* subsp. *capitatum* (+); other species: *Asparagus acutifolius* (+), *Silene vulgaris* (1), *Rhamnus alaternus* (+), *Lonicera implexa* (+).

OSYRIDO ALBAE-KLASEETUM CICHORACEAE ass. nova *hoc loco* (*Holotypus*: rel. 2, Tab. 1 in Pirone *et al.*, 2004)

On the marly limestones interspersed with layers of clayey marl at San Giovanni Lipioni at altitudes of 200-300 m a.s.l. in the Trigno valley, Pirone *et al.* (2004) had surveyed a number of garigue communities with *Klasea flavescens* subsp. *cichoracea* (= *Serratula cichoracea* subsp. *cichoracea*), a striking scapose hemicryptophyte with a south-western Mediterranean distribution, known in Abruzzo only in this one location (Conti *et al.*, 1998). This garigue had been indicated as a grouping of *Cistus creticus* subsp. *eriocephalus* and *Serratula cichoracea* (Tab. 1, rels. 1-4 in Pirone *et al.*, 2004), ascribed to the *Cisto-Ericion/Cisto Ericetalia/Cisto Micromerietea* units.

For the above relevés, we propose the new *Osyrido albae-Klaseetum cichoraceae* association, ascribed to the *Cisto cretici-Ericion manipuliflorae* alliance, with *Klasea flavescens* subsp. *cichoracea*, *Osyris alba* and *Galium corrudifolium* as the diagnostic species.

Garigue of the Basilicata Apennines in the Astragalion monspessulani alliance

PUTORIO CALABRICAE-LOMELOSIIETUM CRENATAE Biondi, Ballelli & Taffetani 1992

DORYCNIETOSUM HERBACEI subass. nova *hoc loco* (*Holotypus*: rel. 2, Tab. 4)

This is the association dominated by *Lomelosia cre-*

nata subsp. *crenata* (= *Scabiosa crenata* subsp. *crenata*) and *Putoria calabrica* described by Biondi *et al.* (1992b) for the flaky clays in the eroded badlands of the Camastra torrent in the river Bradano basin in Basilicata.

Table 4 of this study reports the relevés performed in the mid-Agri valley, along the slopes surrounding the artificial Pietra del Pertusillo reservoir, relative to a different geomorphological context, given that our case involved Miocene sandstone and marly sandstone rock formations.

The floristic combination in the Agri valley also includes a number of species, *Dorycnium herbaceum* in particular, indicative of the greater water retention capacity of the substrate.

For the plant communities of the Agri valley, we propose a new subassociation named *dorycnietosum herbacei*, with *Dorycnium herbaceum*, *Dittrichia viscosa*, *Sanguisorba minor* and *Daucus carota* subsp. *carota* as the differential species.

Tab. 4 - *Putoria calabricae-Lomelosietum crenatae*.

Life form	Relevé number	1	2*	3	4	5	6
	Altitude (m a.s.l.)	580	540	585	550	570	545
	Slope (°)	80	70	65	75	80	85
	Aspect	SW	SSW	SSE	NE	ENE	ENE
	Coverage (%)	25	70	50	30	25	70
	Area (mq)	30	30	60	30	30	15
<i>Putoria calabricae-Lomelosietum crenatae</i> Biondi, Ballelli & Taffetani 1992							
NP	<i>Putoria calabrica</i>	2	4	2	2	2	3
Ch	<i>Lomelosia crenata</i> ssp. <i>crenata</i>	1	2	3	1	1	2
<i>dorycnietosum herbacei</i>							
H	<i>Dorycnium herbaceum</i>	+	1	.	+	+	+
H	<i>Achnatherum bromoides</i>	+	1	1	.	.	+
H	<i>Dittrichia viscosa</i> ssp. <i>viscosa</i>	+	+	.	+	+	.
H	<i>Daucus carota</i> ssp. <i>carota</i>	.	.	.	+	.	+
<i>Astragalion/Astragaleitalia monspessulani</i>							
H	<i>Astragalus monspessulanus</i> ssp. <i>monspessulanus</i>	+	+	2	2	2	2
<i>Cisto cretici-Micromerietea juliana</i>							
Ch	<i>Micromeria graeca</i> ssp. <i>graeca</i>	+	2	.	1	.	1
Ch	<i>Helichrysum italicum</i> ssp. <i>italicum</i>	+	.	.	2	2	1
Ch	<i>Teucrium capitatum</i> ssp. <i>capitatum</i>	+	2	1	.	.	.
Ch	<i>Dorycnium hirsutum</i>	.	+	+	1	.	.
Ch	<i>Teucrium chamaedrys</i> ssp. <i>chamaedrys</i>	.	+	.	.	+	+
Ch	<i>Linum tenuifolium</i>	.	+	.	.	+	.
Ch	<i>Fumana ericoides</i>	.	2	.	.	.	.
Ch	<i>Cistus creticus</i> ssp. <i>eriocephalus</i>	.	.	.	+	.	.
Other species							
H	<i>Cephalaria transylvanica</i>	+	1	.	+	1	1
P	<i>Spartium jnceum</i>	.	1	2	+	+	+
H	<i>Sanguisorba minor</i> ssp. <i>balearica</i>	.	1	+	+	+	1
H	<i>Reichardia pieroides</i>	.	1	1	.	+	+
H	<i>Anthyllis vulneraria</i> s.l.	.	.	.	+	+	+
H	<i>Brachypodium rupestre</i>	1	.	.	.	.	+
T	<i>Blakstonia perfoliata</i> s.l.	+	.	+	.	.	.
H	<i>Dactylis glomerata</i> ssp. <i>hispanica</i>	+	.	.	+	.	.
T	<i>Avena barbata</i>	.	+	+	.	+	+
H	<i>Picris hieracioides</i> ssp. <i>hieracioides</i>	.	.	.	+	+	.
T	<i>Bromus madritensis</i>	.	.	.	.	+	+
	Sporadic species	2	8	2	0	2	3

Syntaxonomic scheme

CISTO CRETICI-MICROMERIETEA JULIANAE Oberdorfer ex Horvatić 1958

ASTRAGALETALIA MONSPESSULANI ord. novo *hoc loco*

Astragalion monspessulani (Biondi, Allegrezza & Zuccarello 2005) stat. nov.

Astragalo monspessulani-Lomelosietum pseudisetensis Biondi, Allegrezza & Frattaroli 1992 *nom. corr. hoc loco*

lomelosietosum pseudisetensis subass. nova *hoc loco*

cistetosum eriocephali subass. nova *hoc loco*

astragaletosum sempervirentis subass. nova *hoc loco*

galietosum erecti subass. nova *hoc loco*

Putorio calabricae-Lomelosietum crenatae Biondi, Ballelli & Taffetani 1992 *nom. corr. hoc loco*

dorycnietosum herbacei subass. nova *hoc loco*

CISTO CRETICI-ERICETALIA MANIPULIFLORAE Horvatić 1958

Cisto cretici-Ericion manipuliflorae Horvatić 1958

Cisto cretici-Lomelosietum pseudisetensis ass. nova *hoc loco*

Fumano thymifoliae-Phagnalonetum illyrici Pirone, Ciaschetti & Frattaroli 2004

Osyrido albae-Klaseetum cichoraceae ass. nova *hoc loco*

Other syntaxa quoted in the text

Artemisia albae-Saturejetalia montanae (Allegrezza, Biondi, Formica & Ballelli 1997) Biondi & Allegrezza in Biondi et al. 2014; *Artemisia albae-Saturejon montanae* Allegrezza et al. 1997; *Astragalenion monspessulani* Biondi et al. 2005; *Astragalo monspessulani-Scabiosetum crenatae* Biondi et al. 1992; *Brometalia* Br.-Bl. 1936; *Brometalia erecti* Koch 1926; *Coronillo minimae-Astragaletum monspessulani* Biondi & Ballelli in Biondi et al. 1985; *Coronillo minimae-Astragalion monspessulani* Ubaldi 2003; *Cytiso spinescentis-Saturejon montanae* Pirone & Tammaro 1997; *Erysimo-Jurineetalia bocconeii* Brullo 1984; *Festuco hystricis-Ononidetea striatae* Rivas-Martínez et al. 2002; *Festuco-Brometea* Br.-Bl. & Tx. 1943; *Festuco valesiacae-Brometea erecti* Br.-Bl. & Tüxen ex Br.-Bl. 1949; *Helianthemocani-Brometum erecti* Zanotti et al. 1995; *Leucanthemo vulgaris-Bromenalia erecti* Biondi et al. 1995; *Mesobromion* Br.-Bl. & Moor 1938 em. Oberd. 1957; *Ononidetalia striatae* Br.-Bl. 1950; *Phleo ambiguus-Brometalia erecti* Biondi, Allegrezza, Blasi & Galdenzi in Biondi et al. 2014; *Phleo ambiguus-Bromion erecti* Biondi, Ballelli, Allegrezza & Zuccarello ex Biondi & Galdenzi 2012; *Polygalo mediterraneae-Bromion erecti* (Biondi et al. 2005) Di Pietro in Di Pietro et al. 2015; *Rosmarinetalia officinalis* Br.-Bl. ex Molinier 1934; *Rosmarinetea officinalis* Rivas-Martínez et al. 2002; *Teucrido polii-Thymetum vulgaris* Castelli 1995; *Xerobromion* Br.-Bl. & Moor 1938.

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Appendix I: Localities and dates of the relevés

Tab. 2 - Rels. 1, 2: Pagliaroli (Cortino, TE) 14/07/1989; rels. 3, 5: between Comignano and Cortino (TE) 14/07/1989; rel. 4: between Comignano and Cortino (TE) 17/07/1989; rel. 6: between Comignano and Pagliaroli (Cortino, TE) 14/07/1989; rels. 7, 8, 9: Celenza sul Trigno (CH) 02/07/1994; rel. 10: Acquasanta Terme (AP) 08/07/1994; rels. 11, 12: M. Freddo (Palmoli, CH) 11/05/2006; rels. 13, 14, 18, 19: between Pietransieri and Roccaraso (AQ), 28/06/1990; rels. 15, 16, 17: Pietransieri (AQ), 28/06/1990; rels. 20, 21, 22: Al Monte (Castiglione Messer Marino, CH) 23/07/1988; rels. 23, 24: between Castiglione Messer Marino and Montazzoli (CH) 23/07/1988; rel. 25: Castiglione Messer Ma-

rino (CH) 24/07/1988; rels. 26, 27: between Castiglione Messer Marino and Montazzoli (CH) 25/07/1988; rel. 28: between Colledimezzo and Montazzoli (CH) 19/06/1989; rel. 29: between Castiglione Messer Marino and Torrebruna (CH) 19/06/1989; rel. 30: between Castiglione Messer Marino and Fraine (CH) 19/06/1989; rels. 31, 32: between Castiglione Messer Marino and Montazzoli (CH) 19/06/1989; rels. 33, 34: between Castiglione Messer Marino and Fraine (CH) 29/06/1989. Tab. 3 - Rel. 1: Trigno Valley, at the Dogliola (CH) junction, 02/07/1994; rels. 2, 3: Trigno Valley, between Tuffillo (CH) and Mafalda (CB), 02/07/1994; rels. 4, 5: between Casoli and Casoli Lake (CH), 04/08/1994. Tab. 4 - Rels. 1-6: Pietra del Pertusillo Lake (PZ), 12/07/1990.

Appendix II: Sporadic species

Tab. 2 - Rel. 2: *Trifolium stellatum*, *Centaurium erythraea* subsp. *erythraea*; rel. 3: *Plantago lanceolata*; rel. 6: *Euphrasia salisburgensis*; rel. 8: *Asparagus acutifolius*; rel. 10: *Erica arborea*, *Globularia bisnagarica*, *Achillea setacea* subsp. *setacea*; rel. 11: *Tragopogon porrifolius* subsp. *porrifolius*; rel. 12: *Sonchus oleraceus*, *Dittrichia viscosa* subsp. *viscosa*, *Scorpiurus muricatus*, *Crepis sancta* subsp. *sancta*; rel. 13: *Avenula praetutiana*, *Crepis lacera*; rel. 14: *Trifolium repens* s.l., *Festuca pratensis* subsp. *apennina*; rel. 18: *Polygala monspeliaca*, *Minuartia verna* s.l., *Sorbus aria* subsp. *aria*, *Laburnum anagyroides* subsp. *anagyroides*; rel. 19: *Gymnadenia conopsea*; rel. 20: *Euphrasia stricta*; rel. 24: *Digitalis*

lutea subsp. *australis*; rel. 28: *Silene vulgaris* subsp. *vulgaris*, *Melampyrum arvense* subsp. *arvense*; rel. 30: *Diplotaxis erucoides* subsp. *erucoides*; rel. 31: *Anacamptis pyramidalis*, *Origanum vulgare* subsp. *vulgare*, *Linum strictum* subsp. *strictum*; rel. 33: *Melilotus officinalis*.

Tab. 3 - Rel. 1: *Cota tinctoria* subsp. *tinctoria*, *Dorycnium herbaceum*, *Anthyllis vulneraria* subsp. *maura*, *Artemisia campestris* s.l., *Dactylis glomerata* subsp. *glomerata*, *Emerus major* subsp. *major*, *Hypericum perforatum*, *Onobrychis caput-galli*, *Petrorhagia saxifraga* subsp. *saxifraga*, *Reichardia picroides*; rel. 2: *Cytisophyllum sessilifolium*; rel. 3: *Carlina corymbosa*, *Centaurea deusta* s.l., *Eryngium amethystinum*, *Pallenis spinosa* subsp. *spinosa*, *Phyllirea latifolia*, *Sulla coronaria*; rel. 4: *Trachynia distachya*, *Melica ciliata* subsp. *ciliata*, *Odontites luteus*, *Pyracantha coccinea*, *Quercus pubescens* subsp. *pubescens*; rel. 5: *Asparagus acutifolius*, *Fraxinus ornus* subsp. *ornus*, *Globularia bisnagarica*, *Linum strictum* subsp. *strictum*, *Pistacia terebinthus* subsp. *terebinthus*, *Seseli tommasinii*, *Achnatherum bromoides*, *Trifolium scabrum* subsp. *scabrum*.

Tab. 4 - Rel. 1: *Sedum rupestre* subsp. *rupestre*, *Bromus erectus* subsp. *erectus*; rel. 2: *Sulla capitata*, *Bituminaria bituminosa*, *Pallenis spinosa* subsp. *spinosa*, *Allium sphaerocephalon*, *Convolvulus cantabrica*, *Crupina crupinastrum*, *Carlina vulgaris* subsp. *spinosa*, *Acinos arvensis* s.l.; rel. 3: *Dactylis glomerata* subsp. *glomerata*, *Quercus pubescens* subsp. *pubescens*; rel. 5: *Plantago lanceolata*, *Hypericum perforatum*; rel. 6: *Brachypodium retusum*, *Catapodium rigidum* subsp. *rigidum*, *Eryngium campestre*.