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Dry grasslands on fluvial terraces of the middle reaches of river Piave in the North East Italy

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Key words: *Astragalo onobrychidis-Koelerietum pyramidatae*, *Chamaecytiso hirsuti-Chrysopogonetum grylli*, Po plain, river Brenta, *Scorzoneretalia villosae*, Veneto.

Ključne besede: *Astragalo onobrychidis-Koelerietum pyramidatae*, *Chamaecytiso hirsuti-Chrysopogonetum grylli*, Padska nižina, reka Brenta, *Scorzoneretalia villosae*, Benečija.

Abstract

Dry grassland vegetation on fluvial terraces along middle reaches of river Piave and river Brenta in Northeastern high Po plain were investigated through a phytosociological approach. Comparisons with ecologically analogous communities described from neighbouring territories lead to the description of a new association belonging to *Centaureion dichroanthae* alliance: *Astragalo onobrychidis-Koelerietum pyramidatae*. Residual fragments of *Chrysopogon gryllus*-dominated grassland on slighly deeper soils are refered to *Chamaecytiso hirsuti-Chrysopogonetum grylli*.

Izvleček

S fitocenološkim pristopom smo preučili suha travišča na aluvialnih terasah vzdolž srednjega tek rek Piave in Brente v višje ležeči severozahodni Padski nižini. Primerjava z ekološko podobnimi združbami, opisanimi na sosednjih območjih, je pokazala, da smo opisali novo asociacijo, ki jo uvrščamo v zvezo *Centaureion dichroanthae* alliance: *Astragalo onobrychidis-Koelerietum pyramidatae.* Preostale fragmente travišč s prevladujočo vrsto *Chrysopogon gryllus,* ki uspevajo na malo globljih tleh, pa uvrščamo v asociacijo *Chamaecytiso hirsuti-Chrysopogonetum grylli*.

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Introduction

Rivers are the most fitting example of ecological corridor concept in nature conservation. They mitigate negative effects of increasing habitat fragmentation by connecting patches or territories with high natural values and allowing species movements (e.g. Beier & Noss 1998; Gonzalez et al. 1998). In man-made landscapes, such as Po plain, rivers in themselves constitute core areas by hosting animal and plant populations and habitat which are absent in the poor countryside outside their banks (Buffa & Lasen 2010). Hydraulic safety reasons, natural disturbances connected to the hydraulic regime and inherent constraints due to poor soils often allow the development of mainly herbaceous vegetation with scattered shrubs and trees or groves. Prevailing communities are dry grasslands, which have been recognized at grain sizes below 100 m^2 as the most species-rich habitat worldwide (Wilson et al. 2012). On the other hand, they are assessed in Europe as the most threatened terrestrial and freshwater habitats, excluding mires and bogs, primarily because of the abandonment of traditional managements (Janssen et al. 2016). This concerns secondary grasslands, i.e. anthropogenic communities at sites whose potential vegetation is forest, whereas herbaceous vegetation investigated in the present work at least in part can be considered as extrazonal, spreading within forest biomes but in too dry and shallow soils to support tree growth (Dengler et al. 2014).

As many long stretches of northeastern Italian rivers, also the middle river Piave (SAC IT3240023 – Grave del Piave) and Brenta (SCI-SAC IT3260018 – Grave e zone umide della Brenta) are protected in EU under Council Directives 92/43/EEC and/or 79/409/EEC. Military bondages have for a long-time ensured the preservation of some dry grassland surfaces along the Piave, as in Friuli (Nimis & Fonda 1997), by avoiding land-use exploitations which are detrimental to natural environment (gravel extraction, vineyard planting etc.). A planned project of an overflow basin to retain flood waters could today compromise the preservation of the little but meaningful fragments remaining, contrasting with the principles of the EU environmental legislation (Habitats Directive). Hence, this contribution runs the risk of being reduced to mere documentary material before the complete disappearance of such natural emergencies, as has been advanced in recent years in Friuli-Venezia Giulia for some meadows and grasslands communities (Poldini & Oriolo 1994).

Notwithstanding their naturalistic relevance, no analytical phytosociological study was carried out nor on Piave either along near Brenta Grave, where dry communities are very rare and more impoverished. Recently, the Grave di Ciano, in the core of Piave study area, was designated as a wilderness area (Zunino 2018). On the basis of this

Figure 1: The landscape in the middle course of river Piave with the Venetian Prealps in the background. The investigated dry grasslands in the foregrounds.
Slika 1: Pokrajina v srednjem teku reke Piave z Beneškimi Predalpami v ozadju. Preučevana travišča so v ospredju.

institution, the only available to date vegetation paper was published, in order to produce a vegetation map not supported by relevés (Pedrotti & Murrja 2020).

The relationship of Venetian terrace river grasslands with ecologically close communities described from neighbouring Friulian territories were tested by means of a phytosociological approach. In fact, Friuli-Venezia Giulia has a well-established tradition of vegetation studies concerning xeric grasslands on gravel bed deposited by pre-Alpine rivers (Zenari 1928; Pignatti 1952; Lorenzoni 1964; Lorenzoni 1967; Feoli Chiapella & Poldini 1994).

The aim of this research is to clarify floristic composition, structure and syntaxonomy of residual dry grasslands occurring in middle reaches (locally *grave*) of river Piave, before their possible disappearance or degradation due to human pressures (Figure 1). Observations have been partly extended to river Brenta in order to make the study more exhaustive.

Study area

The study area encompasses the middle courses of the river Piave and, to a lesser extent, of the river Brenta in the eastern high Venetian plain (western sector of the Venetian–Friulian plain, North East Italy; Figure 2).

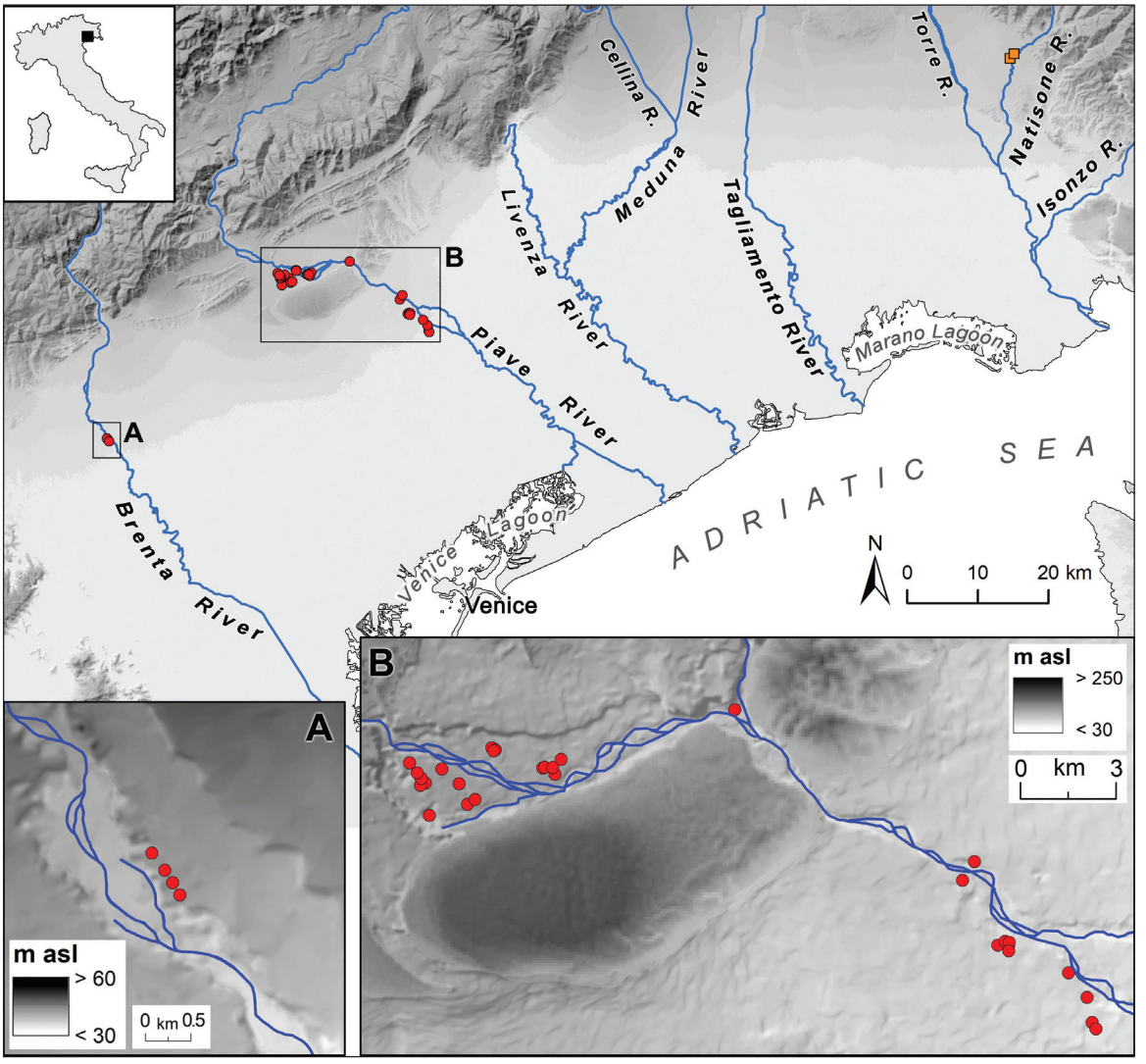

Figure 2: Original relevés (●) in the middle reaches of river Brenta (A) and river Piave (B) in the eastern high Venetian plain. Also published relevés (■) from Natisone river (Lorenzoni, 1964) are given (see text).

Slika 2: Originalni Izvirni popisi (●) v srednjem teku rek Brentea (A) in Piavea (B) v višje ležeči severozahodni Padski nižini. Prikazani so tudi že objavljeni popisi (■) ob reki Natisone/Nadiža (Lorenzoni 1964) (glej besedilo).

The high Venetian-Friulian plain area is bounded to the north by the pre-Alpine chain, whereas the southern limit fades with the resurgence belt about 30 km south of the Alpine foothills. Large portions of the northeastern Po plain formed during the Last Glacial Maximum on late Pleistocene (12.000 b.p.). This period featured great sedimentary activity of the Adige, Brenta, Piave and Tagliamento Rivers, which received fluvio-glacial deposits from the eastern Alps glaciers and formed telescopic coalescent alluvial megafans (Fontana et al. 2014). These deposits are composed of gravels and small rocks, locally mixed with sands, according to a depositional model linked to a braided watercourse that alternates phases of flood, with huge solid transport, with lean phases in which it flows below the very permeable alluvial mattress. The gravel bedrock typically varies on size and composition: small-stone and gravel prevalence in the foothill sector, silt and clay widespread presence in correspondence of the resurgence belt (Michelutti et al. 2003). The lithological types reflect the prevalently carbonate nature of the mountain basins to which the two rivers belong. The Piave drains large part of the Dolomites, and its sediments are 50–70% carbonate, with a significant magmatic component, while Brenta sediments are 20–35% carbonate and have a high content of porphyric rocks (Fontana et al. 2014). Therefore, in the study area substrata are constituted by gravels and few, very permeable sand lenses. Currently, the Piave flows between 10 m high erosion scarps at Grave di Ciano, in its medium course, where the riverbed is 3 km wide and includes some large fluvial islands.

Climatic parameters and bioclimatic indices of the study area are based on thermopluviometric data of Cittadella (48 m a.s.l., for river Brenta) and Volpago del Montello (94 m a.s.l., for river Piave) stations (https://www.arpa.veneto.it). Both stations, 45 km away, are in high Po plain. The mean annual temperature is 13.5 °C and the mean annual rainfall is 1180 mm. According to the 'Worldwide Bioclimatic Classification System' (Rivas-Martinez & Rivas-Saenz 1996–2020), the study area is in a transition region between the temperate continental bioclimate, subtype weak subcontinental (Cittadella thermopluviometric station) and the temperate oceanic bioclimate, subtype strong semicontinental (Volpago del Montello thermopluviometric station); the thermotype is upper mesotemperate, the ombrotype lower humid (Figure 3). The humid trait of the bioclimate is mitigated by the porosity of the gravelly soil, which determines a rapid percolation of the rainwater with consequent edaphic aridity.

As regards landscape, Piave and Brenta riverbeds constitute the geosigmetum of glareicolous, lowland and hygrophilous riverbed vegetation of the high Venetian plain, which includes xeric grasslands (sub *Saturejion subspicatae*) on third-level terraces (Pedrotti & Murrja 2020). In these consolidated and exceptionally flooded terraces, the original vegetation-plot records were carried out.

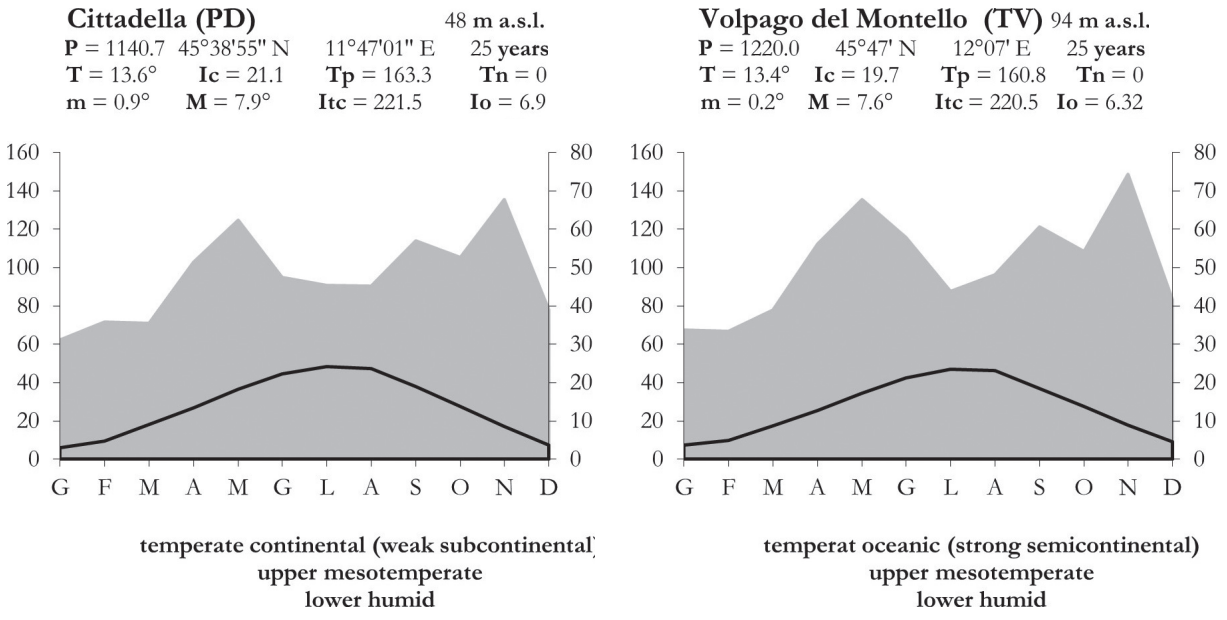

Figure 3: Climograms of Cittadella (PD) and Volpago del Montello (TV) thermopluviometric stations.
Slika 3: Klimadiagram za klimatski postaji Cittadella (PD) in Volpago del Montello (TV).

Materials and Methods

A total of 36 phytosociological relevés was carried out, 32 on river Piave terraces and 4 on the river Brenta terraces (Figure 2), ranging from 45 m to 140 m a.s.l. Data were collected according to Braun-Blanquet (1964) methodology in summer 2020, except for 5 stands, 2 dating back to 1994, one to 2012 and 2 to 2018. The modified Braun-Blanquet scale was used in 2020 vegetation plot records as regards '2a' and '2b' cover values (Barkman et al. 1964).

Comparisons with published data were restricted to materials describing communities sharing common ecological, altitudinal and phytogeographic traits. In particular, the following data was selected from literature:

– *Centaureo dichroanthae-Globularietum cordifoliae* (Tab. 1: rel. 1–14, in Feoli Chiapella & Poldini 1994)
– *Saturejo variegatae-Brometum condensati* (Tab. 2: rel. 1–18, in Feoli Chiapella & Poldini 1994; they include 3 relevés which Lorenzoni (1964) had attributed to *Astragalo-Stipetum*)
– *Saturejo variegatae-Brometum condensati* (Tab. 3: rel. 29–39, in Tasinazzo 2001)
– *Saturejo variegatae-Brometum condensati* (Tab. 1: rel. 2-3-4–20-21-22–26-27, in Lasen 1995)
– *Bromo condensati-Stipetum eriocaulis* (Tab. 1: rel. 5-6-7-8–10–11-12-13-14-15-16-17-18-19–33, in Lasen 1995)
– *Bromo condensati-Stipetum eriocaulis* (Tab. 1: tipologia 1, in Scortegagna & Curti 2000)
– *Schoeno nigricantis-Chrysopogonetum grylli* (Tab. 4: rel. 1–10, in Feoli Chiapella & Poldini 1994)
– *Chamaecytiso hirsuti-Chrysopogonetum grylli* (Tab. 5: rel. 1–7, in Feoli Chiapella & Poldini 1994)
– *Onobrychido arenariae-Brometum erecti avenuletosum pubescentis* var. a *Chrysopogon gryllus* (Tab. 6: rel. 1–7, in Feoli Chiapella & Poldini 1994)
– *Astragalo onobrychidis-Artemisietum albae* (Tab. 28: rel. 1–17, in Biondi et al. 1997)

At first, binary (presence/absence) data were employed in multivariate analyses, and in a second step computation of similarity was indirectly tested from the site scores on the ordination axis of Principal Component Analysis (Jongman et al. 1995), obtained from a cover data matrix. As regards the latter and the classification of original relevés, before to perform cover data analysis, values were converted to van der Maarel (1979) ordinal scale. Also percentage cover values were used in multivariate analyses, adopting the approximations given in Gigante et al. (2012; Fig. 1: Braun Blanquet mod. by Barkman et al. 1964) and after square-root-transformation of input data. All multivariate analyses were conducted with Syn-Tax 2000 package (Podani 2001).

Due to difficult and often controversial determinations and to overcome possible bias in analysis results, some elementary taxa were grouped prior of analyses (e.g. *Koeleria pyramidata* aggr., *Thymus serpyllum* aggr., *Centaurea scabiosa* s.l.).

Biological and chorological spectra were weighted using percentage cover values with above approximations. Ecological indicator values and chorotypes (except for *Bromopsis condensata*, east-Alpic endemic instead of endemic) are in accordance with Pignatti (2005). For the comparison analyses, chorotypes were grouped (see Appendix 3).

The nomenclature of vascular plant species follows Bartolucci et al. (2018). The diagnostic species of alliance, suborder, order and class *Festuco-Brometea* are according to Terzi (2015); some integrations were derived from Mucina et al. (2016) for the *Festuco-Brometea* class. *Bromopsis condensata*, that in Terzi (2015) was not separated from *B. erecta*, and *Carex liparocarpos*, absent in the same author's analysis, were considered diagnostic of *Centaureion dichroanthae* alliance (for the latter see also Feoli Chiapella & Poldini 1994). *Campanula sibirica*, also lacking in Terzi (2015), was included amongst order diagnostic species (Sburlino et al. 2008). Bryophytes and lichens were disregarded. New syntaxon names are in accordance with the rules of the International Code of Phytosociological Nomenclature (Theurillat et al. 2020).

Results and Discussion

The binary numerical classification proved the independence of original relevés with respect to other stands and coenosis coming from neighbouring and ecologically comparable north-eastern Italian territories (cluster A in Figure 4). Only Lorenzoni's relevés (1964) from the river Natisone in Friuli-Venezia Giulia joined the cluster grouping the Venetian river terrace stands. According to Feoli Chiapella & Poldini (1994) these 3 relevés merge in *Saturejo variegatae-Brometum condensati* identifying within it the subass. *astragaletosum onobrychidis*, whereas Lorenzoni (1964) had attributed them to the independent coenosis *Astragalo-Stipetum pennatae*. Table of *Saturejo-Brometum* from Friuli includes also 3 Pignatti's relevés (subass. *epilobietosum dodonaei*) reported by the author sub "Aggr. ad *Artemisia campestris* ed *Epilobium dodonaei*" and referred to *Epilobion fleischeri* (Pignatti, 1952). On the basis of the overall floristic affinity, Feoli Chiapella & Poldini (1994) address the issue and attribute the Pignatti's relevés to *Saturejo-Brometum*. The ambiguity emerged again in our

analysis which enucleates these stands in a cluster totally separated not only from *Saturejo-Brometum* but also from the other compared xeric cenoses (cluster I in Figure 4). Our results are in some way in accordance with the initial Pignatti's interpretation (1952), dealing with 'a vegetation of sandy and stony gravel bed', but further focused studies may provide insights into the referring class of these *Festuco-Brometea*-species poor vegetation. *Artemisia campestris* constitutes together with *Epilobium dodonaei* also on gravel bed of river Brenta a glareicolous community with strong pioneer traits on substrates that are not fully consolidated and subject to episodic flooding. The typical aspect of *Saturejo-Brometum* coincides with subass. *seslerietosum albicantis* containing the holotypus (Feoli Chiapella & Poldini 1994) and which merges with other relevés from Grappa Massif (cluster D in Figure 4).

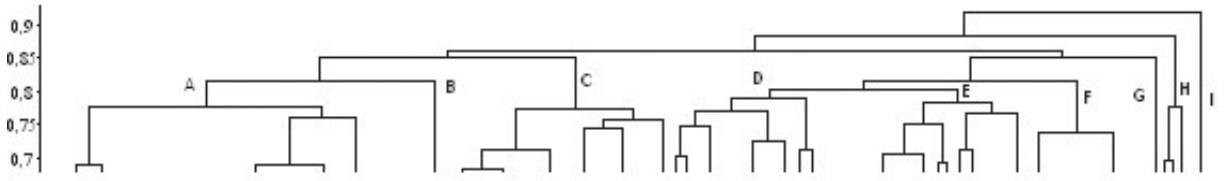

Figure 4: Classification of original and Lorenzoni's releves (1964) (A) in relation to other *Scorzoneretalia* relevés from NE-Italy (semplified dendrogram; average link, Jaccard index; binary data). B: stands from Berici Hills; C: *Schoeno-Chrysopogonetum* + *Chamaecytiso-Chrysopogonetum* + *Onobrychido-Brometum* + 1 rel. of *Saturejo-Brometum*, all from Friuli-Venezia Giulia; D: *Saturejo-Brometum* from Grappa Massif and Friuli-Venezia Giulia (including holotypus) + 3 rel. of *Bromo-Stipetum* from M. Summano; E: *Bromo-Stipetum* from Grappa Massif and M. Summano; F: *Centaureo-Globularietum*; G: 1 rel. of *Saturejo-Brometum* from Friuli-Venezia Giulia; H: 3 rel. of *Saturejo-Brometum* from Friuli-Venezia Giulia; I: 3 rel. of *Saturejo-Brometum* from Friuli-Venezia Giulia (corresponding to '*Artemisia campestris* ed *Epilobium dodonaei*' aggr. in Pignatti (1952)).

Slika 4: Klasifikacija izvirnih in Lorenzonijevih popisov (1964) (A) v primerjavi z ostalimi popisi reda *Scorzoneretalia* iz severovzhodne Italije (poenostavljen dendrogram; povprečna povezava, Jaccardov indeks; binarni podatki). B: sestoji z gričevja Berici; C: *Schoeno-Chrysopogonetum* + *Chamaecytiso-Chrysopogonetum* + *Onobrychido-Brometum* + 1 popis *Saturejo-Brometum*, vsi iz Furlanije-Julijske krajine; D: *Saturejo-Brometum* z masiva Grappa in Furlanije-Julijske krajine (vključno s holotipom) + 3 popisi *Bromo-Stipetum* z gore Summano; E: *Bromo-Stipetum* z masiva Grappa in gore Summano; F: *Centaureo-Globularietum*; G: 1 popis *Saturejo-Brometum* iz Furlanije-Julijske krajine; H: 3 popisi *Saturejo-Brometum* iz Furlanije-Julijske krajine; I: 3 popisi *Saturejo-Brometum* iz Furlanije-Julijske krajine (ustreza '*Artemisia campestris* ed *Epilobium dodonaei*' aggr. iz Pignatti (1952)).

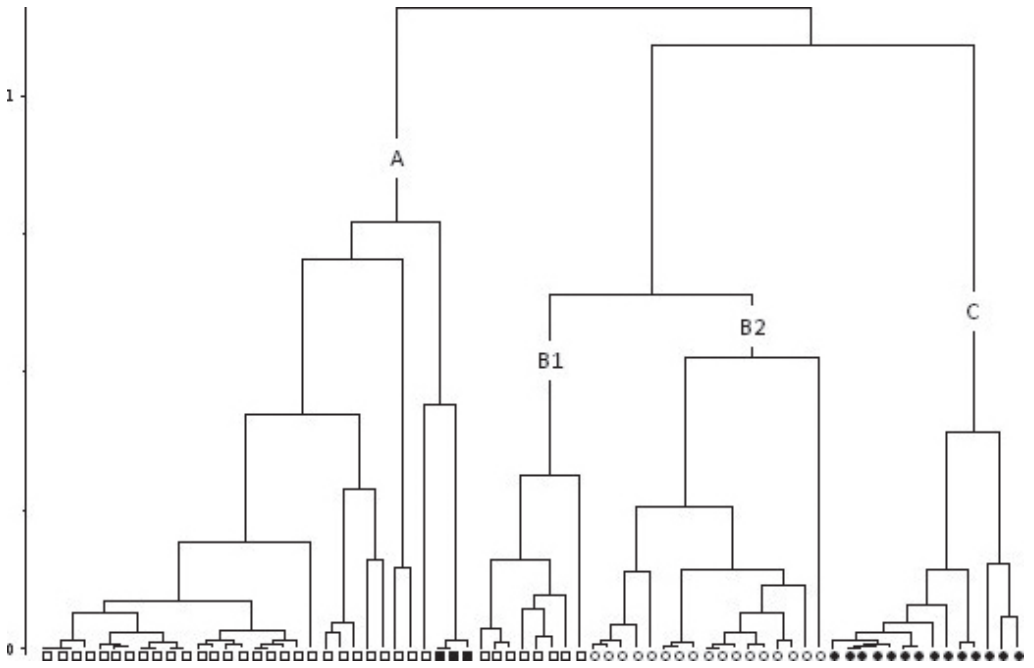

Figure 5: Classification of PCA coordinates of original relevés (□; this study), Lorenzoni's relevés from F. Natisone (■; Lorenzoni, 1964), *Schoeno-Chrysopogonetum* + *Chamaecytiso-Chrysopogonetum* (○; Feoli Chiapella & Poldini 1994) and *Centaureo-Globularietum* (●; Feoli Chiapella & Poldini 1994) from Friuli-Venezia Giulia (cover data matrix).

Slika 5: Klasifikacija PCA koordinat originalnih popisov (□; ta raziskava), Lorenzonijevih popisov z reke Natisone/Nadiže (■; Lorenzoni, 1964), *Schoeno-Chrysopogonetum* + *Chamaecytiso-Chrysopogonetum* (○; Feoli Chiapella & Poldini 1994) in *Centaureo-Globularietum* (●; Feoli Chiapella & Poldini 1994) iz Furlanije-Julijske krajine (matrika podatkov s pokrovnostjo).

Indeed, according to the itself authors' statement the original description of *Saturejo-Brometum* is representative of a very articulated coenosis, appearing very heterogeneous also to our analysis.

Owing to the impossibility of ascribing original relevés to *Saturejo-Brometum* or to other hilly and submontane already typified coenosis, a close examination involved only ecologically comparable communities (known as '*magredi*' grasslands) scattered on alluvial fans covering northern Friulian plain between 50 and 300 m elevation: the most pioneer stage *Centaureo-Globularietum*, the intermediate successional coenosis *Schoeno-Chrysopogonetum* and the most mature stage *Chamaecytiso-Chrysopogonetum*. The resulting classification of PCA coordinate values better describes evidences for observed ecological differences amongst original relevés (Figure 5). The Venetian stands are divided into two main groups: a numerically prevalent one on more primitive soils constitutes an independent cluster (A) including the already mentioned relevés from Natisone, the minority one (B1) on more well-developed soils merges with the other Friulian stands and particularly with *Schoeno- Chrysopogonetum* and *Chamaecytiso-Chrysopogonetum* (B2); *Centaureo-Globularietum* forms an independent cluster (C).

Astragalo onobrychidis-Koelerietum pyramidatae

As regards the cluster A, the framing in *Festuco-Brometea* class (Table 1) is clearly highlighted by a rich content of high frequency species often occurring also with high cover values, such as *Koeleria pyramidata*, *Helianthemum nummularium* subsp. *obscurum*, *Fumana procumbens* and *Thymus pulegioides* (V frequency class). Its membership in steppic submediterranean pastures of the SE-European–Illyrian order *Scorzoneretalia villosae* is clear despite it appears weak due to the marginality of the study area with respect to the distribution area of the order itself. In fact, character species are well-represented only in the relevés coming from eastern Friuli (¢ in Figure 5; rel. 29–31 in Table 1), whereas they decrease sharply in westernmost surveys along the Brenta in Veneto (rel. 1–4 in Table 1). The most common diagnostic species of the order include *Plantago holosteum* and *Chrysopogon gryllus* (III frequency class) (Table 1). More evident is the framing in the lower syntaxonomical level. The presence, often with high frequency and cover values, of *Potentilla pusilla*, *Carex liparocarpos*, *Bromopsis condensata*, *Cytisus purpureus* assures the attribution to *Centaureion dichroanthae*, alliance encompassing prealpic submediterranean grasslands on shallow soils (Mucina et al. 2016). With regard to the association rank, because of phytogeographical reasons it is not possible to refer the vegetation plot records to *Astragalo-Stipetum pennatae*, as proposed by Lorenzoni (1964). *Astragalo-Stipetum* is a community described for continental inner Alps and distinguished by mostly continental species such as *Poa perconcinna*, *Koeleria vallesiana*, *Minuartia rostrata*, *Androsace septentrionalis*, *Oxytropis halleri/velutina*, *Stipa capillata* etc. It belongs to steppic rocky grasslands of deep intramontane valleys of the Alps (*Stipo-Poion xerophilae*). Floristic composition of *Astragalo-Koelerietum* attributes unique traits with respect to the other *Scorzoneretalia* associations so far described. The comparison by means of chorological groups, extended to *Astragalo onobrychidis-Artemisietum albae* of fluvial terraces of the Taro flowing in low Po plain in the Apennine area, shows closer relationship with Friulian *Centaureo-Globularietum* (Figure 6) as consequence of higher rates of orophytes attesting a marked primitiveness of the substratum. Lower percentages of the eurasiatic group constitute additional reason for their closeness (Table 2). *Centaureo-Globlularietum* belongs to *Centaureion* alliance too, whereas *Schoeno-Chrysopogonetum* and *Chamaecytiso-Chrysopogonetum* are attributed to *Scorzonerion villosae* alliance (Terzi 2015).

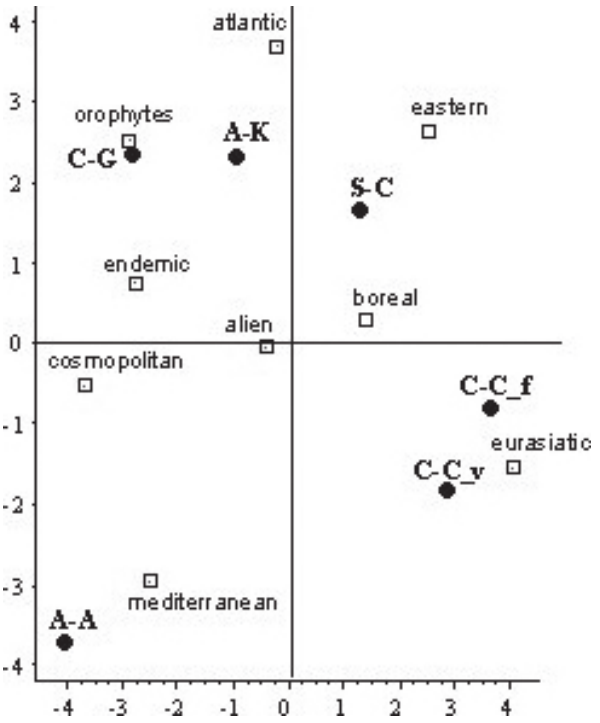

Figure 6: PCA of dry grassland of northeastern Italian plain (●) in relation to chorotype groups (□). First axis accounts for 48.9% of total variance, second axi for 31.6% (square-root-transformed percentage cover data). Community abbreviations as in Table 2, chorotype group as in Appendix 3.

Slika 6: PCA suhih travišč iz severovzhodne italijanske nižine (●) v odnosu do horoloških skupin (□). Prva os pojasni 48,9% skupne variance, druga pa 31,6% (pokrovnost transformirana s korenjenjem). Okrajšave združb so enake kot v Tabeli 2, horološke skupine pa v Prilogi 3.

At a more detailed examination, the new community differs from *Centaureo-Globularietum* in lacking both all the character species of this association (*Euphorbia triflora/kerneri*, *Matthiola fruticulosa/valesiaca*, *Brassica glabrescens* and *Crambe tataria*) and many significant and often very frequent alliance species such as *Centaurea dichroantha*, *Carex mucronata*, *Sesleria caerulea*, *Polygala forojulensis*, *Lomelosia graminifolia*, *Hieracium porrifolium* ecc. Many of these are endemic elements (*Euphorbia triflora/kerneri*, *Matthiola fruticulosa/valesiaca*, *Brassica glabrescens*, *Centaurea dichroantha*) contributing to mark the absolute phytogeographic originality of the coenosis and more generally of the high Friulian Plain where it thrives (e.g. Poldini 1973). From the synecological point of view Lorenzoni (1967) already outlined the independence of the two coenosis, however occurring in closely contact in Friuli-Venezia Giulia. He observed the hypothesized *Astragalo-Stipetum* on consolidated gravel deposits with initial humus accumulation, thriving between *Centaureo-Globularietum* closer to river bed where there are no evidence of organic matter and *Chrysopogonetum* s.l. lying on well-developed, decalcified soils. Ordination through soil indicator values confirms author's observations (Figure 7). *Centaureo-Globularietum* and *Astragalo-Koelerietum* share the presence of *Gypsophila repens*, a de-Alpine entity ingressive from *Thlaspietea*, that Feoli Chiapella & Poldini (1994) consider differential of the former. Thereby, this glareophyte should be regarded as diagnostic of *Centaurenion*. The exclusive entities *Potentilla pusilla*, *Astragalus onobrychis* and *Erucastrum nasturtiifolium* may be considered the good differential entities of the new community (Table 3). *Astragalus onobrychis* is also included amongst differential species of *Astragalo-Artemisietum*, a coenosis

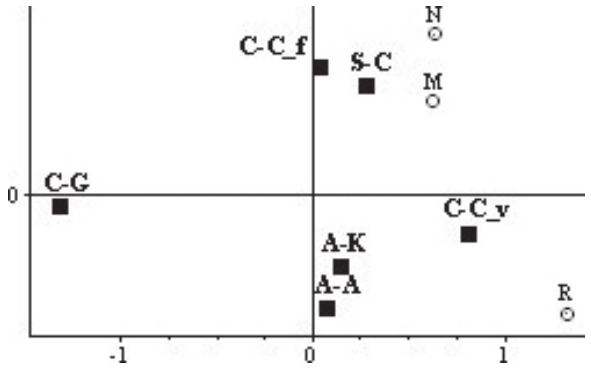

Figure 7: PCA of dry grassland of northeastern Italian plain (■) in relation to soil indication values (○). M: moisture, N: nitrogen, R: reaction. First axis accounts for 72.9% of total variance, 2° axis: 24.9%; weighted cover data). Community abbreviations as in Table 2.
Slika 7: PCA suhih travišč iz severovzhodne italijanske nižine (■) v odnosu do indikatorskih vrednosti tal (○). M: vlažnost, N: dušik, R: reakcija. Prva os pojasni 72,9% skupne variance, druga os: 24,9%; tehtani podatki pokrovnosti). Okrajšave združb so enake kot v Tabeli 2.

very rich in *Festuco-Brometea* species, but lacking in diagnostic species of *Scorzoneretalia* and lower syntaxonomical rank levels. In any case, it is attributed to *Ononido-Rosmarinetea* (Biondi et al. 1997).

On the basis of the above, the relevés in Table 1 may relate to a new association, named *Astragalo onobrychidis-Koelerietum pyramidatae*.

***Astragalo onobrychidis-Koelerietum pyramidatae* ass. nova hoc loco (holotypus rel. 8 in Table 1)**

Differential species. *Potentilla pusilla*, *Astragalus onobrychis* and *Erucastrum nasturtiifolium*

Floristic composition. It is a discontinuous para-steppic dry grassland with largely dominant hemicryptophytes, with *Stipa eriocaulis* often structuring the herbaceous landscape (Figure 8). *Stipa eriocaulis*, *Koeleria pyramidata*, *Bromopsis condensata*, *Oreoselinum nigrum* and *Centaurea scabiosa* are the tall constant grasses and forbs forming the sparse high vegetation cover. The richer lower layer includes *Potentilla pusilla*, *Helianthemum nummularium/obscurum*, *Fumana procumbens*, *Thymus pulegioides*, *Globularia bisnagarica*, *Sanguisorba minor*, *Carex liparocarpos*, *Astragalus onobrychis* etc. among the entities more frequent or abundant.

A cryptogamic layer is always present and sometimes significant in terms of coverage.

Life forms and chorotypes. Hemicryptophytes 72.2%, chamaephytes 19.5%, geophytes 5.3%, therophytes 2.3%, nanophanerophytes 0.2%, phanerophytes 0.5%.

Synecology. The coenosis thrives on consolidated gravel and pebble sediments, on flat ground or secondly gentle slopes, of river terraces, where it occupies Calcixerepts-Haploxerepts soils (Soil Survey Staff 2015). The small share of wide-ranging species agrees with initial stages of colonization. Dryness and stoniness of the habitat are also underlined by the occurrence of species ingressive from *Thlaspietea rotundifolii* (*Gypsophila repens*, *Erucastrum nasturtiifolium*).

Ecological spectrum. Light 5.07, temperature 5.89, continentality 5.82, moisture 2.91, soil reaction 5.95, nitrogen 2.20.

Syntaxonomy. The cluster analysis allows us to recognise three different aggregation types (Figure 9). The rel. 8–31 represent the typical one thriving on consolidated terraces of river Piave, with the exception of the last three stands collected along river Natisone by Lorenzoni (1964). Only rel. 8–31 include *Gypsophila repens* and *Erucastrum nasturtiifolium*. Diagnostic taxa of *Centaureion* alliance, *Koelerienalia* suborder and *Scorzoneretalia* order are here numerically well represented. Here *Stipa eriocaulis* occurs, often attaining high cover values, in a such way to outline

Figure 8: The new association *Astragalo onobrychidis-Koelerietum pyramidatae* in the Grave di Ciano in the middle course of river Piave.
Slika 8: Nova asociacija *Astragalo onobrychidis-Koelerietum pyramidatae* v kraju Grave di Ciano v srednjem teku reke Piave.

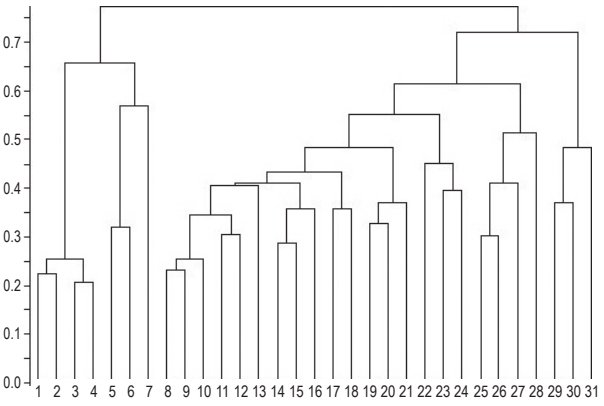

Figure 9: Dendrogram of relevés of Table 1 (algorithm: average link, similarity ratio; cover data).
Slika 9: Dendrogram popisov iz Tabele 1 (algoritem: povprečna povezava, delež podobnosti; podatki s pokrovnostjo).

the structure of the habitat. The rel. 1–4, from terraces of river Brenta, are the most species-poor stands, with very scarce occurring alliance, suborder and order diagnostic species and with an important bryophyte cover. *Artemisia campestris* differentiate this western provenance. Habitat appears highly localised, very fragmented and disappearing, so relevés are in partly degraded conditions. Further research can clarify the possibility of their framing in different vegetation types; at present, we think that the synecology and the occurrence of two differential species justifies their inclusion in *Astragalo-Koelerietum*. The remaining relevés (5–7) are representative of a degraded aspect differentiated by large cover of *Bothriochloa ischaemum* a species with apophyte traits. These stands are also liable to belong to another vegetation type due to the lacking of the greater part of the most significative species.

Synchorology. The community occurs on the middle reaches (*grave*) of rivers Piave and, partly, Brenta in Veneto, but according to Lorenzoni's observations (1964, 1967) its distribution area extended up to eastern Friuli-Venezia Giulia across rivers Tagliamento, Torre and Natisone. It is likely that it might occurs also on river Isonzo, but all Friulian data need confirmation (see Appendix 4).

Chorological spectrum. Atlantic 25.4, Eurasiatic 24.4, orophytes 14.8, Eastern 13.5, Mediterranean 9.4, Cosmopolitan 8.4, Boreal 2.2, alien 1.8, Endemic 0.1.

Natura 2000. 62A0

Chamaecytiso hirsuti-Chrysopogonetum grylli

Also original relevés in cluster B1 (Figure 5) can be easily attributed to *Festuco-Brometea* and *Scorzoneretalia villosae*, but inclusion in lower syntaxonomical levels is not equally clear. Stands were gathered on middle reaches of the river Piave, on residual fragments of well-developed soils representing higher terraces. The community is characterised by the large predominance of *Chrysopogon gryllus*, in place of *Stipa eriocaulis*, but this vicariance is not associated with the occurring of *Hypochaeridenion* and *Scorzonerion* species as it might be expected, diagnostic taxa of *Centaureion* prevail (Table 4). Small size patches are responsible for a reduction in vegetation homogeneity due to a mass effect induced by wider shallow-soil surrounding areas that favour the penetration of species better-tolerating more severe dryness conditions. Nevertheless, a set of mesophilous species enter the community by acting as good indicators of improved growth conditions (*Dactylis glomerata*, *Bromus erectus*, *Salvia pratensis* etc.). Despite the uncertain alliance position and following the cluster analysis outcome (Figure 5), the most viable option was the comparison with similar *Chrysopogon gryllus*-rich associations described from the high plain of Friuli-Venezia Giulia: *Schoeno-Chrysopogonetum* and *Chamaecytiso-Chrysopogonetum*, belonging to *Hypochaeridenion* suballiance. The hypothesis to refer relevés to *Onobrychido-Brometum avenuletosum pubescentis* var. a *Chrysopogon gryllus* was excluded by initial step of the analysis. Our relevés fit better with *Chamaecytiso-Chrysopogonetum* on the basis of a common chorological framework in which the high incidence of the eurasiatic group stands out (Figure 4). This is in line with Feoli Chiapella & Poldini (1994) postulate's according to which its distribution area should go beyond the western regional borders. Hence, relevés in Table 4 are referred to *Chamaecytiso-Chrysopogonetum*. Venetian material lacks the differential species of association reported by the authors for Friulian territory. However, *Anacamptis coriophora* shows its ecological optimum in this association occurring almost exclusively within it in Venetian stands and in no other dry semi-natural grassland community outside this one in Friuli-Venezia Giulia (Feoli Chiapella & Poldini 1994). So, in our opinion, this species may be added to the differential entities of the association. *Cytisus pseudoprocumbens* and *Medicago prostrata* can be regarded as differential species of the Venetian provenance of the coenosis. This coenosis has suffered a drastic reduction in Friuli during last decades, because of intensive cultivation (maize). It appears highly likely that the coenosis was widespread outside the actual river banks of Piave, where now vineyards dominate the countryside.

Syntaxonomic scheme
Festuco-Brometea Br.-Bl. et Tx. ex Soó 1947
Scorzoneretalia villosae Kovačević 1959
Koelerienalia splendentis (Horvatić 1973) Terzi 2015
Centaureion dichroanthae Pignatti 1952
Astragalo onobrychidis-Koelerietum pyramidatae ass. nova hoc loco (holotypus: Table 1, rel. 8) (syn. *Astragalo-Stipetum pennatae* Br.-Bl. 1961 sensu Lorenzoni 1964)
Scorzonerion villosae Horvatić ex Kovačević 1959
Hypochoeridenion maculatae Poldini & Feoli Chiapella ex Terzi 2011
Chamaecytiso hirsuti-Chrysopogonetum grylli Pignatti ex Feoli Chiapella & Poldini 1994

Conclusions

The present research from gravel-bed rivers Piave and Brenta in north-eastern Italian plain resulted in the identification of an already described coenosis and in the formalization of a new dry grassland association. The new knowledge provides a valuable tool for the geographical demarcation of the distribution area of orders *Scorzoneretalia villosae*, *Brachypodietalia pinnati* and *Festucetalia valesiacae*, in a biogeographical context where the limits of these syntaxonomic levels have not yet been well clarified. The reported *Chamaecytiso-Chrysopogonetum* and *Astragalo-Koelerietum* are xeric coenosis hosting many grassland specialists. They belong to Paleartic grasslands, a series of habitat well known for their high biodiversity, but also for their strongly decline during last century due to practice intensification in agriculture, natural succession, artificial afforestation, transformation into arable lands, quarry opening (Dengler et al. 2014). The disappearance risk of most of remaining areas of *Chamaecytiso-Chrysopogonetum* and *Astragalo-Koelerietum* on gravel terraces of rivers Piave lies in the construction project of an overflow basin to retain flood waters. They both have to be referred to Habitat 62A0, are included in Natura 2000 network and deserve the attention of a society that wants to define itself cultured and civilised, at least for legal reasons. The very low rate of alien species underlines the good conservation status of the studied vegetation plot records, but the invasive *Amorpha fruticosa* spreading copiously along fluvial terraces threatens their biodiversity preservation. A regulated use of the most intact areas and the exclusion of land use changes as well as the maintenance of high proportion of ecologically valuable habitat in the surroundings (Janišova et al. 2014) could assure the conservation of these surviving communities.

Other syntaxa quoted in the text

Astragalo onobrychidis-Artemisietum albae Biondi, Vagge, Baldoni & Taffetani 1997
Astragalo onobrychidis-Stipetum pennatae Braun-Blanquet 1961
Bromo condensati-Stipetum eriocaulis Lasen ex Terzi 2015
Centaureo dichroanthae-Globularietum cordifoliae Pignatti 1952
Chamaecytiso hirsuti-Chrysopogonetum grylli Pignatti ex Feoli Chiapella & Poldini 1994
Onobrychido arenariae-Brometum erecti Poldini & Feoli Chiapella in Feoli Chiapella & Poldini 1994
Ononido-Rosmarinetea Br.-Bl. in A. Bolòs y Vayreda 1950
Saturejo variegatae-Brometum condensati Poldini & Feoli Chiapella in Feoli Chiapella & Poldini 1994
Schoeno nigricantis-Chrysopogonetum grylli Pignatti ex Feoli Chiapella & Poldini 1994
Stipo-Poion xerophilae Br.-Bl. et Richard 1950

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Appendix 1:

Localities, dates and geographical coordinates (WGS84 system) of relevés of Table 1.

Rel. 1: Ballin-Miotto (Fontaniva-PD), 9/06/2020, 45,640309 N – 11,726687 E; rel. 2: Ballin-Miotto (Fontaniva-PD), 9/06/2020, 45,641383 N – 11,725807 E; rel. 3: Ballin-Miotto (Fontaniva-PD), 9/06/2020, 45,642984 N – 11,723962 E; rel. 4: Ballin-Miotto (Fontaniva-PD), 9/06/2020, 45,639141 N – 11,727511 E; rel. 5: S.Lucia di Piave (TV), 9/07/2020, 45,80646 N – 12,26598 E; rel. 6: S. Lucia di Piave (TV), 9/07/2020, 45,8116 N – 12,27109 E; rel. 7: Salettuol (Maserada sul Piave-TV), 13/07/2020, 45,77922 N – 12,3071 E; rel. 8: Grave di Ciano (Crocetta del Montello-TV), 30/05/2020, 45,8392528 N – 12,06488611 E; rel. 9: Grave di Ciano (TV), 30/05/2020, 45,8334167 N – 12,06795278 E; rel. 10: Grave di Ciano (TV), 20/06/2020, 45,841191 N – 12,049816 E; rel. 11: Isola dei Morti (Moriago d. Battaglia-TV), 12/06/2020, 45,84907 N – 12,07862 E; rel. 12: Isola dei Morti (TV), 12/06/2020, 45,848436 N – 12,080083 E; rel. 13: Grave di Ciano (TV), 20/06/2020, 45,839898 N – 12,051321 E; rel. 14: Grave di Ciano (TV), 30/05/2020, 45,8347056 N – 12,07106389 E; rel. 15: Grave di Ciano (TV), 30/05/2020, 45,84363611 N – 12,0581722 E; rel. 16: Falzè di Piave (TV), 12/06/2020, 45,85712 N – 12,17706 E; rel. 17: Grave di Ciano (TV), 20/06/2020, 45,830689 N – 12,05247 E; rel. 18: Grave di Ciano (TV), 20/06/2020, 45,839245 N – 12,049357 E; rel. 19: Isola dei Morti (TV), 01/06/2012, 45,840876 N – 12,103676 E; rel. 20: Isola dei Morti (TV), 24/05/2018, 45,8427778 N – 12,0988889 E; rel. 21: Isola dei Morti (TV), 24/05/2018, 45,845 N – 12,1063889 E; rel. 22: Grave di Ciano (TV), 30/05/2020, 45,84363611 N – 12,0581722 E; rel. 23: Grave di Ciano (TV),

30/05/2020, 45,845688 N – 12,04533611 E; rel. 24: Salettuol (TV), 13/07/2020, 45,77205 N – 12,31414 E; rel. 25: Parabae (Maserada sul Piave-TV), 15/06/2020, 45,76498 N – 12,31571 E; rel. 26: Spresiano (TV), 15/06/2020, 45,78845 N – 12,28371 E; rel. 27: Spresiano (TV), 20/06/1994, 45,787821 N – 12,279095 E; rel. 28: Spresiano (TV), 20/06/1994, 45,787786 N – 12,283453 E; rel. 29: rel. 4 in Table 2 in Feoli Chiapella & Poldini 1994; rel. 30: rel. 5 in Table 2 in Feoli Chiapella & Poldini 1994; rel. 31: rel. 6 in Table 2 in Feoli Chiapella & Poldini 1994.

Appendix 2:

Localities, dates and geographical coordinates of relevés of Table 4.
Rel. 1: Spresiano (TV), 20/06/1994, 45,78882 N – 12,282104 E; rel. 2: Parabae (Maserada sul Piave-TV), 15/06/2020, 45,76314 N – 12,31719 E; rel. 3: Grave di Ciano (Crocetta del Montello-TV), 20/06/2020, 45,842808 N – 12,048247 E; rel. 4: Isola dei Morti (Moriago d. Battaglia-TV), 12/06/2020, 45,842974 N – 12,099714 E; rel. 5: Isola dei Morti (TV), 12/06/2020, 45,848223 N – 12,079289 E; rel. 6: Palazzon (Spresiano-TV), 15/06/2020, 45,78612 N – 12,28332 E; rel. 7: Isola dei Morti (TV), 12/06/2020, 45,842842 N – 12,102824 E; rel. 8: Palazzon (TV), 15/06/2020, 45,78771 N – 12.27907 E.

Appendix 3:

Chorotype grouping in statistical analysis.
cosmopolitan group: cosmopolitan, subcosmopolitan and thermocosmopolitan chorotypes
boreal group: circumboreal, Eurosiberian and Arctic-alpine chorotypes
eurasiatic group: paleotemperate, eurasiatic, S-European-S-Siberian, European-W Asiatic, European-Caucasian, European, C-European, S-C-European and NC-European chorotypes
eastern group: NE-eurimediterranean, NE-Mediterranean-montane, SE-European-pontic, SE-European, SE-European-S-Siberian, E-Alpic endemic and SE-Alpic endemic chorotypes
Mediterranean group: stenomediterranean, W-stenomediterranean, SW-stenomediterranean, eurimediterranean, N-eurimediterranean, eurimediterranean-pontic and eurimediterranean-Turanian chorotypes
Atlantic group: W-European and subatlantic chorotypes
orophyte group: N-Mediterranean-montane, E-Mediterranean-montane, W-Mediterranean-montane, orophytic S-European, orophytic S-European-Caucasian, orophytic SE-European, orophytic European and orophytic C-European chorotypes
endemic group: endemic and Alpic-endemic chorotypes
alien

Appendix 4:

After the acceptance of the article, the occurrence of *Astragalo onobrychidis-Koelerietum pyramidatae* was confirmed along river Tagliamento. The corresponding relevé is here reported. Locality: S. Martino al Tagliamento (PN); date: 12/06/2021; geographical coordinates: 46,02141 N - 12,90508 E; altitude: 70 m a.s.l.; area: 60 m^2; cover: 65%; cover Musci: 25%; slope 0°. Species: *Stipa eriocaulis* 3, *Bothriochloa ischaemum* 2b, *Bromus condensatus* 2a, *Fumana procumbens* 2a, *Astragalus onobrychis* 1, *Euphorbia cyparissias* 1, *Helianthemum nummularium/obscurum* 1, *Sanguisorba minor* 1, *Asparagus officinalis* +, *Asperula purpurea* +, *Carex caryophyllea* +, *Carex liparocarpos* +, *Centaurea jacea/gaudinii* +, *Chrysopogon gryllus* +, *Erigeron annuus* +, *Globularia bisnagarica* +, *Hypericum perforatum* +, *Koeleria pyramidata* +, *Ligustrum vulgare* (pl+B2) +, *Linum tenuifolium* +, *Potentilla pusilla* +, *Reseda lutea* +, *Satureja montana/variegata* +, *Ophrys holosericea* r, *Oreoselinum nigrum* r.

Table 1: *Astragalo onobrychidis-Koelerietum pyramidatae* ass. nova. *: sub *K. vallesiana* (Sut.) Gaud.; pl: plantulae; B2: lower shrub layer; na: not available. Geographical area: B river Brenta, P river Piave, N river Natisone.

Tabela 1: *Astragalo onobrychidis-Koelerietum pyramidatae* ass. nova. *: sub *K. vallesiana* (Sut.) Gaud.; pl: plantulae; B2: spodnja grmovna plast; na: ni na voljo. Geografsko območje: B: reka Brenta, P: reka Piava, N: reka Natisone/Nadiža.

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		
area (m2)	30	50	100	100	70	60	60	100	100	100	80	60	60	80	100	60	80	80	100	50	100	50	60	70	100	100	100	60	25	30	50		
cover (%)	30	60	60	60	80	60	75	80	95	85	85	85	70	80	80	70	90	80	100	95	75	70	95	75	80	80	90	90	100	100	95		
cover Musci+lichens (%)	60	50	<5	80	15	35	15	15	10	10	10	25	50	15	15	20	30	30	nd	10	30	<5	10	25	35	30	nd	nd	nd	nd	nd		
slope (°)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	70		
altitude (m a.s.l.)	40	40	40	40	62	63	44	127	125	132	125	125	132	124	131	91	124	131	116	118	116	131	134	39	37	52	52	51	na	na	na		
species number	20	21	19	23	28	27	25	28	32	31	37	32	23	31	26	26	35	37	36	40	42	28	33	30	31	31	26	30	38	37	37	pr.	fr.%
geographical area	B	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	N	N	N		
diff sp of *Astragalo-Koelerietum*																																	
Potentilla pusilla (All)	+	1	+	1	1	+	2a	+	+	+	1	2a	2a	1	1	1	+	+	1	1	1	2a	1	1	+	1	+	1	+	+		30	97
Astragalus onobrychis (Cl)	2a	2a	1	1				+	1	+	+	+		r	+	2a	+		+	1	+			+	+	+	+		1	+	1	23	74
Erucastrum nasturtiifolium								+	+	+			+	+				+				+										7	23
Centaureion dichroanthae																																	
Carex liparocarpos	2b	2a	2b	3	2a	1		1	1	1	+	1	1	2a	2b	1	1	1		+	+		+	+	+	1	1					24	77
Bromus condensatus								2a	2b	2b	3	2a	1	1				2b	1	+					1	2a	2b	3		+	+	16	52
Cytisus purpureus								2a	1	1		+		+	+	1	+	+	1	1	1					+						13	42
Gypsophila repens								+		+	+			+			+	+	+	+	1	+	+									11	35
Cytisus pseudoprocumbens									+			+							1	1					1		1					6	19
Koelerienalia splendentis																																	
Stipa eriocaulis								3	4	3	4	3	4	4	2b	2a	2a	2b	4	3	4	3	2a	1	2b	1	3	+	3	3	2	24	77
Teucrium montanum								2a	1	+	2a	+					1	+	+	+	+				+	1	1		1	+	+	16	52
Trinia glauca																									1	1	1	+				4	13
Inula ensifolia																					+								1	+	1	4	13
Globularia cordifolia									1		+																			+		3	10
Satureja montana/variegata																													+	+	+	3	10
Potentilla heptaphylla/australis																													+			1	3
Scorzoneretalia villosae																																	
Plantago holosteum								+	+		+	1		+	2a	1			+	1			+		1	1	1	1	+	1	+	17	55
Chrysopogon gryllus				+				1			+	+						+	2a	3	2a				2b	2a	+	+	+	+		14	45
Scabiosa triandra		+		+			+				+						+	+	+			+	r	+							+	11	35
Salvia pratensis									+		+		r		+				+	+	+			+					+	+		10	32

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	pr.	fr.
Campanula sibirica																				1	+							+	+	+	+	6	19
Eryngium amethystinum																									+	+		+	+	1		5	16
Centaurea jacea/gaudinii									+	+											+								+		+	5	16
Medicago prostrata											+														1	+	+	+				5	16
Thymus oenipontanus					+	1					2a							+														4	13
Festuca valesiaca																													+	+	+	3	10
Hypochaeris maculata																					+									+	+	3	10
Rhinanthus freynii																	+												+		+	3	10
Filipendula vulgaris																			+										+			2	6
Lotus herbaceus					+																											1	3
Ononis spinosa																															+	1	3
Prunella grandiflora											+																					1	3
Pseudolysimachion barrelieri/nitens																															+	1	3
Ferulago campestris																															+	1	3
Festuco-Brometea																																	
Koeleria pyramidata	2a	2a	1	1	1	+	+	3	2b	2a	2a	2b	1	2a	3	2b	3	3	2a	2b	2b	3	2b	3	2a	1	1	2	+	+	+	31	100
Helianthemum nummularium/obscurum	1	2a	1	1	1	+	1	1	1	2a	1	1	1	+	1		1	+	1	1	1	+	1	2b	2a	1	1	1		+	+	29	94
Fumana procumbens	2a	2a	1	+	1	+		2a	1	1	+	1	2a	1	1	1	1	1	+	1	+	2b	+	+	+	+	+		+		+	28	90
Thymus pulegioides	1	2a	+	1	2a	2a	+	2a	2a	+	2a	2b	+	1	2a	2b	+	+	2a	2a	1			1	1	2a	2b	1				26	84
Globularia bisnagarica					2a	+		+	+	+	1	+	+	+	1	1	1	2a	1	1	1	+	1	2a	+			+	+	+	+	24	77
Sanguisorba minor	+	+	+	1	+	1	+		1		+	+	+	+		+	+	+		+		+	+	+	+	+		+		+	+	24	77
Centaurea scabiosa s.l.			+		+				+	+	+	+	+	+	+	+	1	+	+	1	1	+	1	1	r				+	+	+	22	71
Thesium humifusum								r	+	+	1	+		+	+	+	+	1	+	1	+	+		+	1	+		1	1	2	1	21	68
Artemisia alba					+	+		+	+	1	+	+	+	+	2a	2a	3	2b	1	2a	+	2a	1	+				1				20	65
Bothriochloa ischaemum	+	2a	1	2a	4	4	4	+	+	1	1	1	2a		+	1	+		+					2b	1	2b						20	65
Euphorbia cyparissias	r		+	+	+		1			+	1	2a		+	+	+	+	+	+		1	1	1	+		1		1				20	65
Leontodon crispus								+	+	+	+	+	+	+	1		+	+	+	1	+	+	+		r	r	+	+				19	61
Galium verum								+	+	+	+						+		+	+	+			+		+	+	+	+	+	+	15	48
Onobrychis arenaria/arenaria								1	+	1	1	+	1	+	+	+	2a	+	+	+	1							+				15	48
Bromus erectus							1			+	+	1	+	+	+		2a			2b		1	4	2b	+							13	42
Brachypodium rupestre										+	+	+			+		+	+	1	2a	2a	+	+	1								12	39
Carex humilis								+				1					1	1	2a	+	2a		+		1	2a	+	1				12	39
Carex caryophyllea							2a		+		+							+		1		1	1	2a					1			9	29
Festuca stricta/sulcata							+														+				2a	1	1	2	+	+	+	9	29
Hippocrepis comosa											+			+			+	+	+				1	+					+		+	9	29
Asperula cynanchica										+		+					+	+	+	+					+	r						8	26

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	pr.	fr.
Allium carinatum	1	+	1	1												+												r				6	19
Teucrium chamaedrys												1									+				2a	2a	1				+	6	19
Galium lucidum											+	+									1					+						4	13
Linum tenuifolium																	+	+			+							+				4	13
Lotus corniculatus							+													+			+	+								4	13
Odontites luteus	+	+	+	+																												4	13
Anacamptis pyramidalis																					+								+		+	3	10
Orobanche gracilis																			+	+	+											3	10
Trifolium montanum																			+	2a	+											3	10
Anacamptis coriophora																							+		r							2	6
Anthyllis vulneraria s.l.																														+	+	2	6
Campanula glomerata																													+	+		2	6
Ononis natrix		1	+																													2	6
Pimpinella saxifraga																													+	+		2	6
Polygala comosa																						+	+									2	6
Thymus serpyllum agg.																														+	+	2	6
Asperula purpurea													+																			1	3
Kengia serotina																		+														1	3
Medicago falcata																												+				1	3
Ophrys holoserica																			+													1	3
Orchis militaris																				r												1	3
Seseli annuum																													+			1	3
Stachys recta																															+	1	3
Trifolio-Geranietea																																	
Oreoselinum nigrum	r	+						+	+	+	+	+	+	+	+	+	+	+	1	1	1	+				+			1	1		20	65
Anthericum ramosum									+					+	1				+										1	1	1	7	23
Buphtalmum salicifolium																	+															1	3
Clematis recta																					+											1	3
Lilium bulbiferum																															+	1	3
Trifolium rubens																															+	1	3
Koelerio-Corynephoretea+Sedo-Scleranthetea																																	
Petrorhagia saxifraga	+	+	+	1	+	+	+					+				+									+		+	+	1	+	1	15	48
Sedum sexangulare	+	+	2b	1	+		+									+											+			+		9	29
Medicago minima		+	+	+		1										+										+						6	19
Dianthus sylvestris											r														+	+						3	10

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	pr.	fr.
Allium lusitanicum																					1											1	3
Catapodium rigidum						+																										1	3
Cerastium semidecandrum																											+					1	3
Trifolium campestre					r																											1	3
other species																																	
Erigeron annuus		+	+	+	1	1	3	+	r	r			+		+	r	+	+		+		+	+	+								18	58
Asparagus officinallis								+	r	+			+	+	r	+	r		+	r		+	r									12	39
Reseda lutea					+			+	+	+			+	+		+		+				1		+	+							11	35
Echium vulgare	+	+		r	+																	r	r	r				+				8	26
Populus nigra (pl+B2)	+					+	1	+									r	+					+									7	23
Amorpha fruticosa (B2)					+	+	+													+				+								5	16
Ligustrum vulgare (pl+B2)														+						1	+	+	+									5	16
Artemisia campestris	2a	2b	2b	2b																												4	13
Cornus sanguinea (pl+B2)					+					+													+	r								4	13
Diplotaxis tenuifolia	+			r										r													+					4	13
Hypericum perforatum							+											+					+	r								4	13
Rosa sp. pl. (pl+B2)					+	+	r															+										4	13
Sporobolus neglectus					+	1	1									+																4	13
Centaurium erythraea					+																					+			+			3	10
Centaurea stoebe		+		+			r																									3	10
Plantago lanceolata							+																				+	+				3	10
Rhamnus saxatilis (B2)											+	+									1											3	10
Salix eleagnos (pl+B2)														+	+		+															3	10
Arenaria serpyllifolia						+																					1					2	6
Bromus squarrosus					+	r																										2	6
Cephalanthera damasonium																													+		+	2	6
Chondrilla juncea					+	+																										2	6
Cytisus hirsutus																													+	+		2	6
Erica carnea																													+		+	2	6
Euphorbia maculata	+			1																												2	6
Gymnadenia conopsea																					+									+		2	6
Hieracium murorum agg.																													+	+		2	6
Pilosella piloselloides																		+				+										2	6
Lembotropis nigricans (B2)																													+	+		2	6
Prunus spinosa (pl+B2)																				+	+											2	6
Silene vulgaris																								r				+				2	6

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	pr.	fr.
Thymelaea passerina					r	+																										2	6
Biscutella laevigata																														+		1	3
Calamintha nepeta						+																										1	3
Berberis vulgaris (B2)																						+										1	3
Carex sylvatica							r																									1	3
Clematis vitalba																		+														1	3
Crepis foetida						r																										1	3
Cynodon dactylon														+																		1	3
Dactylis glomerata							+																									1	3
Daucus carota																												r				1	3
Epilobium dodonaei																							r									1	3
Frangula alnus																							+									1	3
Fraxinus ornus (pl+B2)																							+									1	3
Molinia arundinacea																					+											1	3
Poa compressa							1																									1	3
Salvia verticillata																														+		1	3
Teucrium botrys						+																										1	3
Torylis cf japonica						+																										1	3

	A-K	C-G	S-C	C-C_v	C-C_f	A-A
cosmopolitan	8,37	6,04	5,31	0,59	0,03	22,06
boreal	2,19	0,83	1,91	0,99	8,35	0,40
eurasiatic	24,35	21,02	42,94	75,16	65,91	25,05
eastern	13,51	10,65	24,94	10,01	17,51	0,32
mediterranean	9,38	4,65	4,38	8,97	4,35	39,74
atlantic	25,44	5,44	14,48	1,64	0,93	0,24
orophytes	14,80	35,64	4,46	2,36	2,78	6,89
endemic	0,11	15,73	1,58	0,00	0,17	4,90
alien	1,84	0,00	0,00	0,27	0,00	0,40

Table 2: Percentage distribution of chorological groups in different comparison coenosis (percentage cover values). A-K: *Astragalo-Koelerietum* (this study); C-C_v: *Chamaecytiso-Chrysopogonetum* from Veneto (this study); C-G: *Centaureo-Globularietum* (Feoli Chiapella & Poldini 1994); S-C: *Schoeno-Chrysopogonetum* (Feoli Chiapella & Poldini 1994); C-C_f: *Chamaecytiso-Chrysopogonetum* from Friuli-Venezia Giulia (Feoli Chiapella & Poldini 1994); A-A: *Astragalo-Artemisietum* (Biondi et al. 1997).

Tabela 2: Odstotni delež horoloških skupin v primerjanih združbah (pokrovnost v odstotkih) A-K: *Astragalo-Koelerietum* (ta raziskava); C-C_v: *Chamaecytiso-Chrysopogonetum* iz Benečije (ta raziskava); C-G: *Centaureo-Globularietum* (Feoli Chiapella & Poldini 1994); S-C: *Schoeno-Chrysopogonetum* (Feoli Chiapella & Poldini 1994); C-C_f: *Chamaecytiso-Chrysopogonetum* iz Furlanije-Julijske krajine (Feoli Chiapella & Poldini 1994); A-A: *Astragalo-Artemisietum* (Biondi et al. 1997).

Table 3: Synoptic table of dry grassland communities on fluvial terraces of gravel bed deposits from North-eastern Po plain. Abbreviations as in Table 2. Companion species occurring at least once in ≥ II frequency class were included.

Tabela 3: Sinoptična tabela združb suhih travišč na rečnih prodnatih terasah v severovzhodni Padski nižini. Okrajšave so enake kot v Tabeli 2. Prikazane so spremljevalne vrste, ki se pojavljajo vsaj enkrat s frekvenčnim razredom večjim od II.

	A-K	C-G	C-C_v	C-C_f	S-C	A-A
relevés (n°)	31	14	8	7	10	17
diff sp of *Astragalo-Koelerietum*						
Astragalus onobrychis (Cl)	74		38			59
Potentilla pusilla (All)	97		63			6
Erucastrum nasturtiifolium	23					
diff sp of *Centaureo-Globularietum*						
Euphorbia triflora/kerneri (All)		93			30	
Matthiola fruticulosa/valesiaca		57				
Brassica glabrescens		36				
Crambe tataria		36				
diff sp of *Chamaecytiso-Chrysopogonetum*						
Dianthus sanguineus				71		
Prunella laciniata (All2)				43		
Serapias vomeracea				43		
Anacamptis coriophora	6		63	14		
Cytisus pseudoprocumbens (All)	19	50	88	14	60	
Medicago prostrata (O)	16	7	75		10	
diff sp of *Schoeno-Chrysopogonetum*						
Globularia bisnagarica (Cl)	77	14	50	14	90	65
diff sp of *Astragalo-Artemisietum*						
Artemisia alba (Cl)	65	29	63			100
Festuca robustifolia						76
Centaurea aplolepa/lunensis						76
Centaureion dichroanthae						
Bromopsis condensata	52	71	50	57	100	
Cytisus purpureus	42	57	50		80	
Centaurea dichroantha		100			70	
Carex liparocarpos	77	14	50		20	6
Gypsophila repens	35	79	13		10	
Carex mucronata		93			10	
Sesleria caerulea		86				
Polygala forojulensis		43			20	
Lomelosia graminifolia		36			10	
Hieracium porrifolium		36				
Euphrasia cuspidata		14				
Allium ochroleucum		7				
Gentiana clusii		7				
Leontodon incanus s.l.		7				
Hypochoeridenion maculatae						
Centaurea scabiosa/fritschii				86	50	
Knautia ressmannii				29	50	

	A-K	C-G	C-C_v	C-C_f	S-C	A-A
relevés (n°)	31	14	8	7	10	17
Rhinanthus freynii	10			29	20	
Carex montana				43		
Prunella grandiflora	3			14	10	
Cirsium pannonicum					20	
Scorzonerion villosae (All 2)						
Hypochaeris maculata	10	14		86	70	
Filipendula vulgaris	6			86	50	
Plantago media			25	14	40	
Ononis spinosa	3			43	10	18
Lotus herbaceus	3		13		20	
Knautia illyrica				14	10	
Scorzonera villosa				14		
Euphorbia brittingeri					10	
Ferulago campestris	3					
Scorzoneretalia villosae						
Chrysopogon gryllus	45	64	100	100	100	
Plantago holosteum	55	86	50	14	70	
Salvia pratensis	32		88	43	50	6
Scabiosa triandra	35	14	25	57	70	
Centaurea jacea/gaudinii	16	7	50	57	50	
Betonica officinalis/serotina		7		57	60	
Eryngium amethystinum	16	21	50			
Campanula sibirica	19	21	25		10	
Plantago argentea/liburnica		21			30	
Noccaea praecox				14		
Centaurea triumfettii					10	
Festuca valesiaca	10					
Pseudolysimachion barrelieri/nitens	3					
Koelerienalia splendentis						
Teucrium montanum	52	93	50		10	24
Stipa eriocaulis/eriocaulis	77	93	50			
Trinia glauca	13	71	50		40	
Globularia cordifolia	10	100			30	
Inula ensifolia	13	86	13			
Potentilla heptaphylla/australis	3	43			50	
Scorzonera austriaca		57			20	
Genista sericea		64			10	
Seseli kochii		43			10	
Satureja montana/variegata	10	14				
Festuco-Brometea						
Thymus serpyllum agg.	90	71	100	86	90	88
Koeleria pyramidata	100	100	100	71	80	
Helianthemum nummularium/obscurum	94	64	100	71	70	29
Sanguisorba minor	77	21	63	29	90	82
Galium verum	48	21	88	100	100	
Euphorbia cyparissias	65	21	88	57	20	47

	A-K	C-G	C-C_v	C-C_f	S-C	A-A
relevés (n°)	31	14	8	7	10	17
Carex humilis	39	86	63	29	70	
Fumana procumbens	90	93	38			59
Lotus corniculatus	13	29	38	100	100	
Thesium humifusum	68	71	88		40	6
Brachypodium rupestre	39		50	71	100	12
Festuca stricta/sulcata	29	14	63	57	80	
Leontodon crispus	61	43	25	43	60	
Asperula cynanchica	26	43	13	57	80	
Galium lucidum	13	93	38	14	50	6
Bothriochloa ischaemum	65	7	25		10	100
Hippocrepis comosa	29	36	38	14	80	
Teucrium chamaedrys	19	29	63	14	60	12
Bromopsis erecta	42		88			65
Carex caryophyllea	29	14	25	43	70	
Trifolium montanum	10		50	71	50	
Briza media			13	86	60	
Anthyllis vulneraria s.l.	6	36		57	40	
Pimpinella saxifraga	6		13	71	40	
Centaurea scabiosa	71		50			
Pilosella officinarum		14		57	40	6
Anacamptis morio		43		14	50	
Linum catharticum		7		29	70	
Anacamptis pyramidalis	10	14	25	14	40	
Asperula purpurea	3	14		14		71
Linum tenuifolium	13	57	13			6
Onobrychis arenaria/arenaria	48		38			
Campanula glomerata	6			57	10	
Carex flacca				14	40	
Odontites luteus	13					41
Plantago sempervirens						53
Ranunculus bulbosus				29	20	
Stachys recta s.l.	3					41
Polygala comosa	6		38			
Ononis natrix	6					35
Eryngium campestre						41
Allium coloratum				29		12
Melica ciliata		7				29
Medicago lupulina				14	20	
Orchis militaris	3		25			
Neotinea tridentata					20	
Allium carinatum	19					
Ophrys apifera		7			10	
Medicago falcata	3		13			
Kengia serotina	3					12
Asperula aristata						12
Carlina vulgaris						12
Orobanche gracilis	10					
Carlina acaulis		7				
Alyssum montanum		7				

	A-K	C-G	C-C_v	C-C_f	S-C	A-A
relevés (n°)	31	14	8	7	10	17
Gentianella pilosa		7				
Ophrys holoserica	3					
Seseli annuum	3					
Molinio-Arrhenatheretea						
Dactylis glomerata	3	29	63	43	90	59
Gymnadenia conopsea	6	29	13	29	20	
Tragopogon pratensis aggr.				43	30	12
Leontodon hispidus				14	70	
Jacobaea vulgaris		14		43	10	
Prunella vulgaris		14			50	
Ranunculus tuberosus				43		
Rumex acetosa				43		
Linum bienne						41
Trifolium pratense				14	20	
Arrhenatherum elatius				29		
Holcus lanatus				29		
Trifolio-Geranietea						
Oreoselinum nigrum	65	93	88	100	80	
Anthericum ramosum	23	43	38	43		
Buphtalmum salicifolium	3	7	25	57	40	
Trifolium rubens	3			71		
Vincetoxicum hirundinaria		7	13	14	30	
Cruciata glabra		7		29		
Viola hirta				29		
Koelerio-Corynephoretea+Sedo-Scleranthetea						
Sedum sexangulare	29		25		10	35
Petrorhagia saxifraga	48		25		10	
Catapodium rigidum	3					24
Sedum acre						24
Sedum sediforme						24
Thlaspietea rotundifolii+Asplenietea trichomanis						
Pilosella piloselloides	6	50		71	60	
Achnatherum calamagrostis		14				24
Epilobium dodonaei	3					24
Elyno-Seslerietea						
Biscutella laevigata	3	50		86	40	
Leucanthemum heterophyllum					60	
Rhinanthus glacialis		14			40	
Dianthus sternbergii		36				
Helianthemum alpestre		36				
Dryas octopetala		21				
other species						
Plantago lanceolata	10		25	57	30	53
Erica carnea	6	93			50	
Schoenus nigricans		79			60	

	A-K	C-G	C-C_v	C-C_f	S-C	A-A
relevés (n°)	31	14	8	7	10	17
Leucanthemum vulgare agg.				86		29
Hypericum perforatum	13		13			88
Cytisus hirsutus	6			86	10	
Asparagus officinalis	39		38			18
Anthoxanthum odoratum				86		
Erigeron annuus	58		25			
Reseda lutea	35	21	25			
Polygala vulgaris				71	10	
Genista tinctoria				57	20	
Blackstonia perfoliata		7			50	18
Potentilla erecta				43	30	
Diplotaxis tenuifolia	13	21	13			18
Agrostis capillaris				57		
Centaurium erythraea	10	7	38			
Amorpha fruticosa (B2)	16		38			
Chondrilla juncea	6					47
Dittrichia viscosa						53
Silene vulgaris	6				20	18
Potentilla alba				43		
Cota tinctoria						41
Avena barbata						41
Setaria viridis						41
Ligustrum vulgare (pl+B2)	16		25			
Echium vulgare	26					12
Erigeron canadensis						35
Erigeron sumatrensis						35
Sixalix atropurpurea						35
Rhamnus saxatilis (B2)	10		25			
Crepis froelichiana/dinarica					30	
Thalictrum minus s.l.					30	
Potentilla pedata						29
Scabiosa columbaria						29
Populus nigra (pl+B2)	23					6
Serratula tinctoria s.l.		7			20	
Helichrysum italicum						24
Inula spiraeifolia						24
Epipactis atrorubens					20	
Genista germanica					20	
Scirpoides holoschoenus					20	

Table 4: *Chamaecytyso hirsuti-Chrysopogonetum grylli* Venetian provenance. Abbreviations as in Table 1.
Tabela 4: *Chamaecytyso hirsuti-Chrysopogonetum grylli* iz Benečije. Okrajšave so enake kot v Tabeli 1.

relevé n°	1	2	3	4	5	6	7	8		
area (m2)	60	80	60	100	80	60	100	60		
cover (%)	100	100	95	95	100	95	100	90		
cover Musci+lichens (%)	na	5	-	5	-	15	-	10		
altitude (m a.s.l.)	52	36	132	118	125	51	117	51		
species number	32	26	36	36	30	30	47	30	pr	fr%
geographical area	P	P	P	P	P	P	P	P		
diff sp of *Chamaecytiso-Chrysopogonetum*										
Cytisus pseudoprocumbens (All)	1	2a		2b	+	+	1	+	7	88
Medicago prostrata (O)	+	+			+	1	+	2a	6	75
Anacamptis coriophora			+	+	1	+	+		5	63
Centaureion dichroanthae										
Potentilla pusilla agg.		+		1		+	+	1	5	63
Bromus condensatus	1				+	1		2a	4	50
Cytisus purpureus			1		+	+	2a		4	50
Carex liparocarpos	+	+				+		1	4	50
Gypsophila repens			+						1	13
Scorzonerion villosae										
Plantago media				+			+		2	25
Lotus herbaceus							+		1	13
Scorzoneretalia villosae										
Chrysopogon gryllus	5	3	4	3	4	3	4	2b	8	100
Salvia pratensis	r	+	+		+	+	+	+	7	88
Plantago holosteum	1	1		+				2a	4	50
Centaurea jacea/gaudinii			+	+	+		+		4	50
Eryngium amethystinum	+	+				+		+	4	50
Scabiosa triandra			+		+				2	25
Campanula sibirica				+			1		2	25
Koelerienalia splendentis										
Teucrium montanum	+	+				+		+	4	50
Stipa eriocaulis/eriocaulis	+				r		+	+	4	50
Trinia glauca	1	+				+		1	4	50
Inula ensifolia				+					1	13
Festuco-Brometea										
Thymus pulegioides	1	1	+	1	1	1	1	2b	8	100
Koeleria pyramidata	1	1	1	1	1	+	1	+	8	100
Helianthemum nummularium/obscurum	1	1	1	1	+	1	1	1	8	100
Bromus erectus	+	3	2b	3	2a	2a	2a		7	88
Euphorbia cyparissias	+	+	+	+	1	2a	+		7	88
Galium verum	1	+		1	+	1	+	2b	7	88
Thesium humifusum	+	+		+	+	+	+	+	7	88
Artemisia alba	1		+	2a	+		1		5	63

relevé n°	1	2	3	4	5	6	7	8	pr.	fr.
Carex humilis			1	+		2b	1	1	5	63
Festuca stricta/sulcata	1	2b				2a	+	1	5	63
Sanguisorba minor	+	+				+	+	+	5	63
Teucrium chamaedrys	1	1	+			2a		2b	5	63
Brachypodium rupestre	+		+		1		2a		4	50
Centaurea scabiosa s.l.			+	+		+	+		4	50
Globularia bisnagarica	+			1	+	1			4	50
Trifolium montanum			+	1	+		1		4	50
Fumana procumbens	+		+		+				3	38
Galium lucidum	1	+						1	3	38
Hippocrepis comosa			+		+		+		3	38
Lotus corniculatus			+	+	+				3	38
Onobrychis arenaria	+					+	+		3	38
Polygala comosa			+	+			+		3	38
Astragalus onobrychis				+			+	+	3	38
Anacamptis pyramidalis				+			+		2	25
Bothriochloa ischaemum						1		1	2	25
Carex caryophyllea				+			+		2	25
Leontodon crispus	+			+					2	25
Orchis militaris			r	+					2	25
Asperula cynanchica				+					1	13
Briza media							2a		1	13
Gymnadenia conopsea							+		1	13
Linum tenuifolium				+					1	13
Medicago falcata	+								1	13
Pimpinella saxifraga							r		1	13
Trifolio-Geranietea										
Peucedanum oreoselinum	+	+	+	+	+	+	+		7	88
Anthericum ramosum	+					r	+		3	38
Buphtalmum salicifolium			+				+		2	25
Clematis recta			+						1	13
Vincetoxicum hirundinaria			+						1	13
other										
Dactylis glomerata		+	+	1	1		1		5	63
Amorpha fruticosa (B2)			+		+		+		3	38
Asparagus officinallis			+	+			+		3	38
Centaurium erythraea	r		+			+			3	38
Erigeron annuus				+			+		2	25
Ligustrum vulgare (pl+B2)			+				+		2	25
Petrorhagia saxifraga		+						+	2	25
Plantago lanceolata				+	+				2	25
Reseda lutea		+						+	2	25
Rhamnus saxatilis (B2)					+		+		2	25
Sedum sexangulare		+		+					2	25
Achillea millefolium agg.					+				1	13
Chenopodium album								+	1	13
Diplotaxis tenuifolia								+	1	13

relevé n°	1	2	3	4	5	6	7	8	pr.	fr.
Fraxinus ornus (pl+B2)							+		1	13
Hypericum perforatum			r						1	13
Inula salicina							+		1	13
Medicago minima								+	1	13
Pyrus communis (B2)			r						1	13
Salix eleagnos (pl+B2)			1						1	13
Solanum nigrum								r	1	13
Ulmus minor (pl+B2)							r		1	13
Vicia cracca s.l.			+						1	13