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Phytosociology and ecology of the *Festuca puccinellii*-grasslands in the Northern Apennines (N-Italy)

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Abstract

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The Violet Fescue pastures in the northern Apennines were studied on the basis of 58 phytosociological relevés taken according to the Braun-Blanquet method. Relevés were numerically classified for detecting vegetation types. From the syntaxonomical viewpoint, these vegetation types were assigned to the association Trifolio thalii-Festucetum puccinellii, here described for the first time. The Trifolio thalii-Festucetum puccinellii showed a certain degree of floristic heterogeneity and, therefore, it was subdivided into three subassociations, occurring in different geographical areas and ecological conditions. The Trifolio thalii-Festucetum puccinellii typicum is restricted to the carbonatic and jasper outcrops in the Apuan Alps, whereas the Trifolio thalii-Festucetum puccinellii alchemilletosum alpinae and the Trifolio thalii-Festucetum puccinellii plantaginetosum alpinae are encountered only in the Tuscan-Emilian Apennines. The former subassociation is confined to the steepest slopes on sandstone or marly-arenaceous outcrops with very shallow soil, while the latter is a close grassland on less steep slopes on marls or sandstones with moderately deep soil. Furthermore, the Trifolio-thalii-Festucetum puccinellii plantaginetosum alpinae was subdivided into three variants corresponding to different edaphic and microclimatic conditions.

Key words: Seslerietea albicantis, grasslands above timberline, syntaxonomy, high-mountain soils, soil-vegetation correlations.

Introduction

The Violet Fescue pastures (*Festuca violacea* agg.-*Trifolium thalii* communities) are plant communities intermediate between the Rusty Sedge meadows (Caricetum ferrugineae) occurring on fairly damp soils in the subalpine and alpine belts of the outer Alps and the Blue Moorgrass-Evergreen Sedge grasslands (Seslerio-Caricetum sempervirentis) widespread in

the alpine belt on relatively dry ground of the eastern Alps (Ellenberg 1986). The Violet Fescue pastures are currently restricted at altitudes corresponding to both subalpine and alpine vegetation belts, where they occur on the northern slopes with a fairly long snow cover (Braun-Blanquet 1948, Grabherr & Mucina 1993). These grasslands are met with on calcium-rich soils in the outer Alps, whereas in the central Alps they are confined to small areas with a locally better water regime. Outside the Alps, *Festuca violacea* agg.-*Trifolium thalii* grasslands were reported for the northern and central Apennines.

Numerous phytosociological studies have been made of this vegetation in the Alps (Braun-Blanquet & Jenny 1926, Guinochet 1938, Braun-Blanquet 1949, 1954, Giacomini et al. 1962, Knapp 1962, Campell & Trepp 1968, Dierschke 1969, Hartmann 1971, Dalmas 1975, Gensac 1979, Montacchini et al., 1982, Grabherr & Mucina 1993) and in the Apennines (Furrer & Furnari 1960, Furnari 1961, Bruno et al. 1965, Bruno & Furnari 1966, Migliaccio 1970, Barbero & Bono 1973, Bazzichelli & Furnari 1979, Barbero & Bonin 1980, Brambilla & Speranza 1980, Credaro et al. 1980, Rossi 1991, Petriccione & Persia 1995). Despite this large number of studies, there are still several gaps in our knowledge about this vegetation. The basic gap is of taxonomic nature, involving the correct identification of the taxon that in most of the above quoted studies is generically indicated as *Festuca violacea*.

After the work by Braun-Blanquet & Jenny (1926), which described the Trifolio thalii-Festucetum violaceae in the central Alps, several studies have looked at the taxonomy of the *Festuca violacea* aggregate (Markgraf-Danneberg 1980, Pils 1980, Kerguelen & Plonka 1989, Conert 1996). These studies resolved this aggregate into a complex of several independent species strictly correlated from the phylogenetic point of view, but different in their morphology, distribution and ecological requirements. A further taxonomical and chorological revision of the *Festuca violacea* aggregate in the Alps and the Apennines was given by Foggi et al. (1998, 1999). Concerning the Apennines, these authors distinguished two taxa: *F. violacea* subsp. *puccinellii* occurring in the northern Apennines and *F. violacea* subsp. *italica*, distributed in the central and southern Apennines. The latter subspecies, however, grows outside the Violet Fescue pastures (see also Biondi et al. 1999).

All these recent taxonomical and chorological studies furnished a good reason for undertaking a comprehensive review of the Violet Fescue pastures along their whole distribution range. This study can be viewed as "a first step" toward this main goal.

In this paper we present a study on the Violet Fescue pastures in the northern Apennines. These pastures are dominated by *Trifolium thalii* and *Festuca violacea* subsp. *puccinellii*, a taxon whose distribution range was recently restricted to this mountain system (Foggi et al. 1999). Specifically the aims of this paper are: 1) to perform a compositional (i.e. floristic) analysis of this vegetation; 2) to provide a syntaxonomic account; 3) to investigate the ecology of vegetation units, with a peculiar attention paid to soil features.

Study area

The northern Apennines form a mountain barrier 250 km long which separates the Po plain to the North from the Italian peninsula to the South at latitude 44° N. In this mountain region a distinction is made between the Ligurian-Emilian Apennines, the Tuscan-Emilian Apennines and the Apuan Alps. Our study sites are located in the Tuscan-Emilian district and in the Apuan Alps, that are separated by large and deep valleys from which the Serchio and the Magra rivers flow into the Tyrrhenian sea (Fig. 1).

In the Tuscan-Emilian Apennines vegetation was surveyed in the highest sector, comprised between Cisa Pass to the Northwest and the Valley of the Reno river to the Southeast.

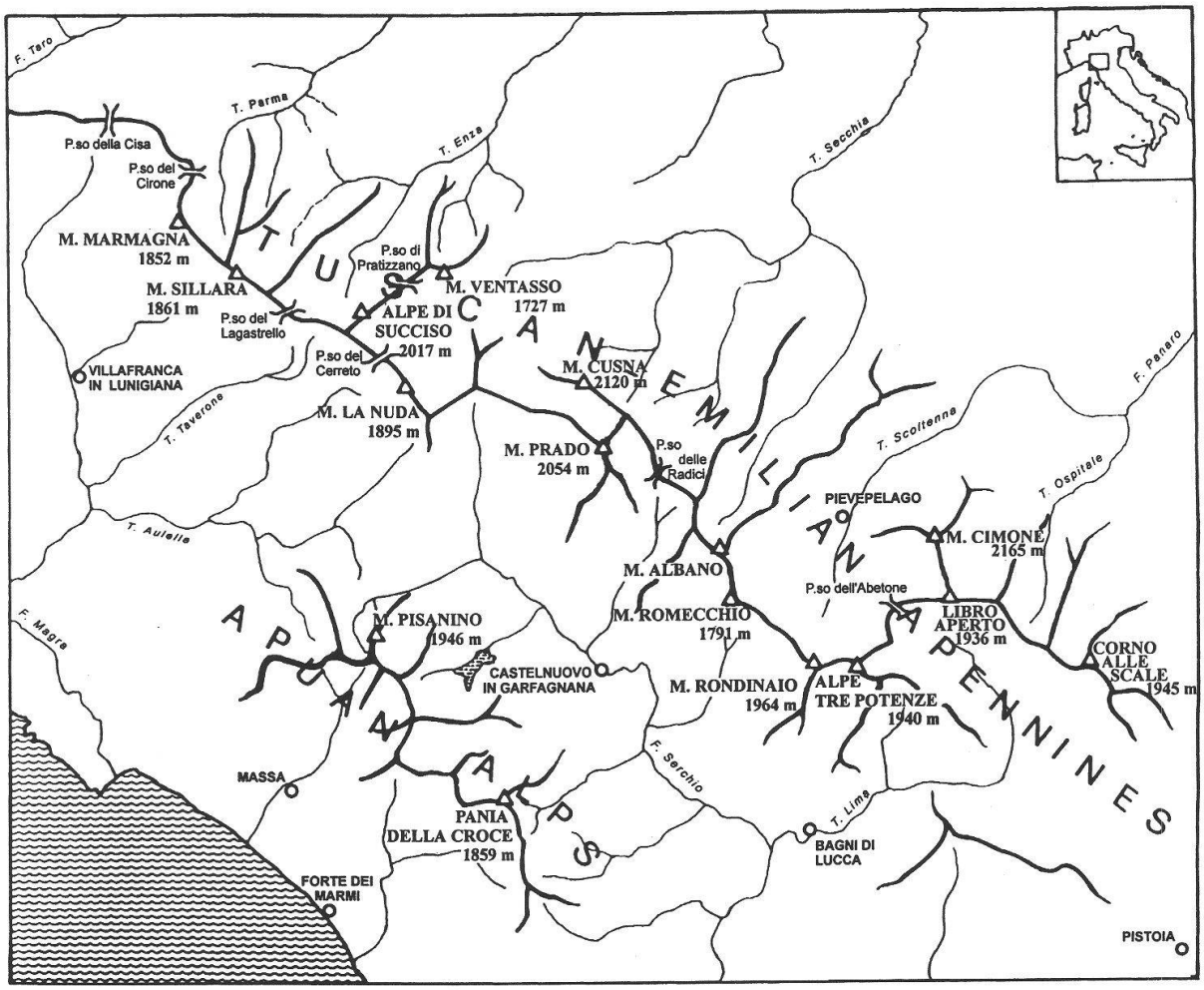

Fig. 1. Schematic map of the Tuscan-Emilian Apennines and the Apuan Alps.

The altitude of this sector ranges from about 100 m a.s.l. to 2165 m a.s.l. at the highest peak (M. Cimone). In the summit areas the geological substrate consists of a turbiditic compact-textured sandstone (upper Oligocene-lower Miocene) corresponding to the "Macigno" formation, of sandstones and marls (upper Oligocene) ascribed to the M. Modino-M. Cervarola complex, of marls and silty marls (Marmoreto and Pievepelago marls) dating back from upper Oligocene to the lower Miocene.

The Tuscan-Emilian Apennines were subject to glaciation during the Quaternary (Losacco 1982). Although there are no longer active glaciers, both glacial and periglacial modelling left clear traces on the northern slopes of the chain (Carton & Panizza 1988). At the highest altitudes, relict glacial cirques, which originated during the Würm period, dominate the landscape.

The climate in the Tuscan-Emilian Apennines can be defined as cool temperate. At the summit (M. Cimone), the mean annual temperature is 2.1°C. Precipitation, influenced by the Tyrrhenian sea, is more abundant on the southern slope than on the more continental northern slope. At 1000 m, mean annual rainfall is about 2300 mm on the southern slope and about 1400 mm on the northern slope; on the summit, it is about 2000 mm.

The Apuan Alps lie in NW Tuscany, about 10 Km from the Tyrrhenian sea. The massif rises from a few metres a.s.l. to 1946 m at its highest peak (M. Pisanino). The geology in-

cludes both carbonatic rocks (limestones, dolomites and marbles) and siliceous ones ("verrucano", porphyroids, sandstones and jaspers). Carbonatic substrata largely dominate at the highest altitudes.

The substratum directly conditions the morphology of the landscape, which is mainly made up of sharp peaks and narrow valleys with high rocky walls. This justifies the name "Alps" for this Apennine massif. Karst processes are among the main morphogenetic agents in the Apuan Alps. In the summit areas karst forms are locally superimposed on flat surfaces modelled by the Quaternary glaciers.

The climate in the Apuan Alps is subatlantic owing to the sea effect. The dominant winds blow from the Tyrrhenian sea (West) causing high precipitation (over 3000 mm close to the summit, Ferrarini 1966). The mean annual temperature is 7,5 °C at timberline.

Methods

Vegetation sampling

Vegetation was studied during the summer months from 1992 to 1997, using the phytosociological method (Braun-Blanquet 1964). A systematic vegetation sampling was made through the whole range of the study area. The cover of species in the relevés was estimated using the current Braun-Blanquet cover-abundance scale, as slightly modified by Pignatti & Mengarda (1962): r = rare species; + = cover <1%; 1 = cover 1–20%; 2 = cover 21–40%; 3 = cover 41–60%; 4 = cover 61–80%; 5 = cover 81–100%.

Soil sampling

Soil was sampled in a limited number of sites, corresponding to stands of the different vegetation units, defined as described below (see data analysis). The nature and distribution of soils were determined by examinations of excavated pits, natural and artificial exposures and auger borings. Profiles were described using standard pedological procedures and sampled. After air drying, the soils were sieved through a 2 mm sieve and the following analyses were carried out following Soil Conservation Service U. S. D. A. (1972) methods: pH (in H_2O and KCl), total and active carbonates, organic carbon (O. C.) and organic matter (O. M.), total N, exchangeable bases and cation exchange capacity (C. E. C.) and particle-size distribution.

Data analysis

The vegetation relevés were summarised into a floristic table. The rare species occurring in one relevé only were eliminated (the list is available from the authors). The resulting data set (a matrix of 103 species x 58 relevés) was classified by the method of minimum increase of sum of squares agglomeration based on the chord distance, using the package SYN-TAX V (Podani 1993). This calculation was based on the cover data of species corresponding to the transformations of the Braun-Blanquet scale as proposed by van der Maarel (1979). The units obtained by the cluster analysis were then compared with the syntaxonomical types deduced by literature, mainly Grabherr & Mucina (1993). The source of nomenclature for vascular plants is Pignatti (1982), with the exceptions of genus *Dactylorhiza* (Perazza 1992), *Agrostis vinealis* (Tutin 1980), *Brachypodium genuense* (Lucchese 1987), *Carlina acaulis* subsp. *simplex* (Webb 1976), *Cerastium suffruticosum* (Bechi 1998), *Festuca riccerii* and *F. rubra* subsp. *commutata* (Foggi & Rossi 1996), *F. violacea* subsp. *puccinellii* (Foggi et al. 1999), *Taraxacum aemilianum* (Foggi & Ricceri 1991). The nomenclature of the syntaxa above the association rank follows Grabherr & Mucina (1993).

Soils were classified according to Soil Survey Staff U. S. D. A. (1975, 1994), considering the soil moisture regime to be udic. As for the soil temperature, a limit was set at 1900 m altitude between the frigid and cryic regime, as already reported by Bidini et al. (1982) for the Emilian-Apennines.

Results

Vegetation typology

The Violet Fescue pastures are species-rich and varied grasslands with a dense growth of grasses and herbaceous dicotyledons. The herbage is relatively high, usually up to 30 cm, and the cover is generally closed or almost so. *Festuca violacea* subsp. *puccinellii* is the dominant grass in most part of the stands. *Poa alpina* is another constant species, that occasionally is co-dominant too. The only other grass which is at all frequent throughout and occasionally abundant is *Festuca rubra* subsp. *commutata*. Beneath the canopy formed by these taller grasses is usually a thick understorey of small herbaceous dicotyledons. The most prominent of them are *Crepis aurea* subsp. *glabrescens* and *Trifolium thalii*, which often attains co-dominance.

From the syntaxonomical viewpoint, the 58 phytosociological relevés carried out within the Violet Fescue pastures are characterized by the occurrence of many species characterizing different syntaxa within the class Seslerietea albicantis (Tab. 1). Among these, there are several character species of the order Seslerietalia coeruleae and a reduced number of character or differential species of the alliance Caricion ferrugineae. The dominant and constant species, viz. the endemic grass *Festuca violacea* subsp. *puccinellii*, is clearly centered in these grasslands (Rossi 1991). For this reason, it can be regarded as character species of an association here newly described and named Trifolio thalii-Festucetum puccinellii Tomaselli, Rossi & Dowgiallo ass. nova hoc loco (Tab. 2, nomenclatural type: rel. 3 (holotypus)). The character species combination also includes the Balkan-Apennine taxon *Crepis aurea* subsp. *glabrescens*, the Apennine endemic *Ranunculus pollinensis* as regional (sensu Westhoff & van der Maarel 1973) character species and *Sagina glabra* and the endemic *Taraxacum aemilianum* as differential species. The Trifolio thalii-Festucetum puccinellii is included in the alliance Caricion ferrugineae, order Seslerietalia coeruleae and class Seslerietea albicantis for the reasons discussed above.

Numerical classification of the 58 relevés produced a dendrogram (Fig. 2), reflecting a certain degree of floristic heterogeneity within the association. Three main clusters are individuated at a sum of squares of about 17. They are floristically similar to each other based on the common presence of most alliance, order and class species, as well as of the main companions. Owing to their floristic differences, these three groups can be syntaxonomically defined as subassociations.

The group TF (Fig. 2; Tab. 1, 2) consists of 13 relevés taken in the summit areas of the Apuan Alps. The stands are formed by swards varying from fairly open to closed (average herbaceous cover 80%). *Festuca violacea* subsp. *puccinellii* and *Crepis aurea* subsp. *glabrescens* are the dominant species in most of the stands. The other diagnostic species of the association (*Ranunculus pollinensis*, *Taraxacum aemilianum* and *Sagina glabra*) are also constant or relatively frequent. The character species of alliance, order and class are well represented in all the relevés. Based on these compositional features the group TF can be syntaxonomically defined as the typical subassociation of the Trifolio thalii-Festucetum puccinellii (Trifolio thalii-Festucetum puccinellii typicum Tomaselli, Rossi et Dowgiallo subass. nova hoc loco; Tab. 2, nomenclatural type: rel. 3 (holotypus)).

Two subgroups can be distinguished within the Trifolio thalii-Festucetum puccinellii typicum in the dendrogram at a sum of squares of about 4.5. The former group has no differential species (see Tab. 2, rel. 1–8); therefore it can be regarded as the typical variant of the Trifolio thalii-Festucetum puccinellii typicum. The latter group is species-poorer and has *Polygonum viviparum* and the Apuan endemic *Cerastium apuanum* as differential species; more-

Table 1. Synoptical table. TF: Trifolio thalii-Festucetum puccinellii typicum; TF1: typical variant; TF2: variant of Polygonum viviparum; TA: Trifolio thalii-Festucetum puccinellii alchemilletosum alpinae; TA1: typical variant; TA2: variant of Agrostis rupestris; TP: Trifolio thalii-Festucetum puccinellii plantaginetosum alpinae; TP1: typical variant; TP2: variant of Plantago atrata; TP3: variant of Luzula lutea. D: differential species; R: regional character species.

Vegetation types	**TF**	TF1	TF2	**TA**	TA1	TA2	**TP**	TP1	TP2	TP3
N. of relevés	**13**	8	5	**8**	4	4	**37**	13	11	13
Association										
Festuca violacea Gaudin subsp. puccinellii (Parl.) Foggi, Graz. Rossi et Signorini	**100**	100	100	**100**	100	100	**95**	100	100	85
Crepis aurea (L.) Cass. subsp. glabrescens (Caruel) Arcangeli (R)	**100**	100	100	**62**	75	50	**86**	77	100	85
Sagina glabra (Willd.) Fenzl. (D)	**46**	75	0	**62**	25	100	**70**	100	54	54
Taraxacum aemilianum Foggi et Ricceri (D)	**77**	87	60	**0**	0	0	**27**	15	54	15
Ranunculus pollinensis (Terr.) Chiov. (R)	**85**	87	80	**0**	0	0	**0**	0	0	0
Variant										
Polygonum viviparum L.	**38**	0	**100**	**0**	0	0	**3**	0	0	8
Cerastium apuanum Parl.	**31**	0	**80**	**0**	0	0	**0**	0	0	0
Subassociations										
Alchemilla alpina L.	**38**	62	0	**100**	100	100	**46**	46	73	23
Saxifraga paniculata Miller	**8**	12	0	**100**	100	100	**13**	23	9	8
Carum heldreichii Boiss.	**0**	0	0	**37**	75	0	**8**	8	9	8
Plantago alpina L.	**0**	0	0	**12**	25	0	**89**	92	91	85
Ranunculus apenninus Chiov.	**0**	0	0	**12**	25	0	**54**	54	36	69
Geum montanum L.	**0**	0	0	**12**	0	25	**51**	85	18	46
Variants										
Agrostis rupestris All.	**23**	37	0	**50**	0	**100**	**24**	23	9	38
Juncus trifidus L.	**0**	0	0	**37**	0	**75**	**8**	0	0	**23**
Luzula lutea (All.) Lam. et DC.	**0**	0	0	**37**	0	**75**	**27**	8	0	**69**
Luzula alpino-pilosa (Chaix.) Breistr.	**0**	0	0	**0**	0	0	**22**	8	0	**54**
Armeria marginata (Levier) Bianchini	**0**	0	0	**0**	0	0	**19**	8	0	**46**
Gentiana nivalis L.	**0**	0	0	**0**	0	0	**19**	0	9	**46**
Achillea stricta Schleicher	**0**	0	0	**0**	0	0	**11**	0	**36**	0
Arenaria bertolonii Fiori	**23**	25	20	**25**	50	0	**11**	0	**36**	0
Valeriana montana L.	**0**	0	0	**12**	25	0	**8**	0	**27**	0
Caricion ferrugineae										
Trifolium thalii Vill.	**100**	100	100	**100**	100	100	**100**	100	100	100
Erigeron alpinus L.	**54**	37	80	**0**	0	0	**8**	8	9	8

Table 1. (Continued).

Vegetation types	**TF**	TF1	TF2	**TA**	TA1	TA2	**TP**	TP1	TP2	TP3
N. of relevés	**13**	8	5	**8**	4	4	**37**	13	11	13
Trifolium pratense L. (D)	**54**	75	20	**25**	50	0	**27**	8	**55**	23
Plantago atrata Hoppe	**0**	0	0	**0**	0	0	**16**	6	**55**	0
Seslerietalia coeruleae										
Phyteuma orbiculare L.	**69**	75	60	**0**	0	0	**0**	0	0	0
Carduus carlinaefolius Lam.	**38**	37	40	**0**	0	0	**30**	23	45	23
Lotus alpinus (DC.) Schleicher	**31**	50	40	**0**	0	0	**11**	0	9	23
Alchemilla nitida Buser	**31**	12	80	**0**	0	0	**0**	0	0	0
Acinos alpinus Moench	**31**	12	60	**0**	0	0	**0**	0	0	0
Myosotis alpestris Schmidt	**23**	37	0	**0**	0	0	**0**	0	0	0
Veronica aphylla L.	**23**	25	20	**0**	0	0	**0**	0	0	0
Carlina acaulis L. subsp. simplex (Waldst. et Kit.) Nyman	**8**	12	0	**0**	0	0	**14**	23	9	8
Linum alpinum Jacq. subsp. julicum (Hayech) Gams	**8**	12	0	**0**	0	0	**8**	8	9	8
Pulsatilla alpina (L.) Delarbre	**0**	0	0	**25**	0	50	**0**	0	0	0
Bupleurum ranunculoides L. subsp. caricinum (DC.) Arcang.	**0**	0	0	**0**	0	0	**3**	0	0	8
Scabiosa lucida Vill.	**0**	0	0	**0**	0	0	**3**	0	0	8
Seslerietea albicantis										
Gentiana verna L.	**61**	75	40	**50**	100	0	**57**	31	64	77
Euphrasia salisburgensis Funk.	**46**	37	60	**0**	0	0	**0**	0	0	0
Thymus polytrichus Kerner	**38**	12	80	**87**	75	100	**54**	69	64	31
Galium anisophyllum Vill.	**38**	12	80	**50**	50	50	**57**	54	73	46
Gentiana clusii Perr. et Song.	**23**	37	0	**0**	0	0	**0**	0	0	0
Sesleria tenuifolia Schrader	**15**	12	20	**0**	0	0	**0**	0	0	0
Minuartia verna (L.) Hiern	**0**	0	0	**25**	25	25	**3**	0	0	8
Biscutella laevigata L.	**8**	0	20	**0**	0	0	**3**	0	0	8
Hieracium villosum L.	**0**	0	0	**12**	25	0	**0**	0	0	0
Potentilla crantzii (Crantz) Beck	**0**	0	0	**0**	0	0	**3**	0	9	0
Companions										
Loiseleurio-Vaccinietea – Vaccinio-Piceetea										
Hypericum richeri Vill.	**61**	87	20	**25**	0	50	**3**	8	0	0
Vaccinium myrtillus L.	**0**	0	0	**25**	0	50	**11**	15	0	15
Luzula sieberi Tausch	**0**	0	0	**0**	0	0	**16**	31	18	0
Vaccinium vitis-idaea L.	**0**	0	0	**12**	0	25	**0**	0	0	0
Vaccinium gaultherioides Bigelow	**0**	0	0	**0**	0	0	**3**	8	0	0
Homogyne alpina (L.) Cass.	**0**	0	0	**0**	0	0	**3**	0	0	8

Table 1. (Continued).

Vegetation types	**TF**	TF1	TF2	**TA**	TA1	TA2	**TP**	TP1	TP2	TP3
N. of relevés	**13**	8	5	**8**	4	4	**37**	13	11	13
Calluno-Ulicetea										
Nardus stricta L.	**23**	37	0	**12**	25	0	**24**	38	0	31
Botrychium lunaria (L.) Swartz	**0**	0	0	**25**	50	0	**13**	8	36	0
Antennaria dioica (L.) Gaertner	**0**	0	0	**0**	0	0	**5**	0	0	15
Hieracium pilosella L.	**0**	0	0	**0**	0	0	**3**	8	0	0
Luzula multiflora (Ehrh.) Lej.	**0**	0	0	**0**	0	0	**3**	0	9	0
Meum athamanticum Jacq.	**0**	0	0	**0**	0	0	**3**	0	9	0
Caricetea curvulae										
Phyteuma hemisphaericum L.	**0**	0	0	**0**	0	0	**19**	15	0	38
Euphrasia minima Jacq.	**38**	62	20	**12**	0	25	**40**	15	54	54
Leontodon helveticus Merat	**8**	12	0	**12**	0	0	**16**	8	9	31
Festuca riccerii Foggi et Graz. Rossi	**0**	0	0	**62**	50	75	**27**	0	36	46
Pedicularis tuberosa L.	**46**	50	40	**0**	0	0	**19**	15	9	31
Viola calcarata L. subsp. cavillieri (W. Becker) Merxm. et Lippert	**0**	0	0	**12**	0	25	**24**	23	18	31
Anthoxanthum alpinum Loewe et Loewe	**0**	0	0	**12**	25	0	**19**	38	18	0
Luzula spicata (L.) DC. subsp. mutabilis Chrtek et Krisa	**0**	0	0	**12**	0	25	**8**	0	0	23
Silene acaulis (L.) Jacq. subsp. exscapa (All.) Br.-Bl. (R)	**0**	0	0	**12**	0	25	**5**	0	9	8
Potentilla aurea L.	**0**	0	0	**0**	0	0	**3**	8	0	0
Euphrasia alpina Lam.	**8**	12	0	**12**	0	25	**38**	15	64	39
Solidago virgaurea L. subsp. alpestris (W. et K.) Rchb.	**0**	0	0	**12**	0	25	**0**	0	0	0
Festuco-Brometea										
Cerastium suffruticosum L.	**46**	75	0	**37**	50	25	**38**	31	54	31
Avenula praetutiana (Parl.) Pign.	**8**	0	20	**37**	62	0	**11**	0	18	15
Asperula aristata L. fil. subsp. oreophila (Briq.) Hayek	**8**	0	20	**0**	0	0	**6**	0	0	22
Pedicularis comosa L.	**0**	0	0	**25**	50	0	**0**	0	0	0
Cirsium acaule (L.) Scop.	**0**	0	0	**0**	0	0	**3**	0	8	0
Pimpinella alpestris (Sprengel) Schultes	**0**	0	0	**0**	0	0	**14**	8	27	8
Molinio-Arrhenatheretea										
Poa alpina L.	**100**	100	100	**100**	100	100	**97**	100	100	92
Lotus corniculatus L.	**31**	37	20	**25**	50	0	**24**	38	36	0
Phleum alpinum L.	**23**	37	0	**0**	0	0	**22**	31	18	15
Taraxacum officinale Weber	**0**	0	0	**12**	25	0	**5**	8	9	0
Trifolium repens L.	**0**	0	0	**0**	0	0	**8**	0	18	9

Table 1. (Continued).

Vegetation types	**TF**	TF1	TF2	**TA**	TA1	TA2	**TP**	TP1	TP2	TP3
N. of relevés	**13**	8	5	**8**	4	4	**37**	13	11	13
Leontodon hispidus L.	**31**	25	40	**0**	0	0	**0**	0	0	0
Deschampsia caespitosa (L.) Beauv.	**0**	0	0	**0**	0	0	**5**	8	9	0
Cerastium holosteoides Fries. subsp. triviale (Link.) Moeschl	**0**	0	0	**0**	0	0	**3**	0	9	0
Thlaspietea rotundifolii										
Leucanthemum ceratophylloides (All.) Nyman	**15**	12	20	**25**	50	0	**0**	0	0	0
Ranunculus oreophilus Bieb.	**0**	0	0	**25**	50	0	**0**	0	0	0
Hutchinsia alpina (L.) R. Br.	**15**	0	40	**0**	0	0	**0**	0	0	0
Aquilegia bertolonii Schott.	**15**	25	0	**0**	0	0	**0**	0	0	0
Robertia taraxacoides (Loisel.) DC.	**8**	0	20	**0**	0	0	**11**	8	27	0
Sedum atratum L.	**15**	0	40	**0**	0	0	**0**	0	0	0
Arabis alpina L.	**0**	0	0	**12**	25	0	**0**	0	0	0
Other companions										
Festuca rubra subsp. commutata (Gaudin) Markgr.-Dann.	**77**	87	60	**37**	25	12	**81**	100	64	77
Alchemilla flabellata Buser	**61**	100	0	**50**	50	50	**84**	85	82	85
Cirsium bertolonii Sprengel	**61**	87	20	**50**	100	0	**40**	38	54	31
Aster bellidiastrum (L.) Scop.	**15**	25	0	**87**	100	75	**35**	54	18	54
Campanula scheuchzeri Vill.	**54**	62	40	**25**	0	50	**30**	38	27	23
Gentianella campestris (L.) Borner	**38**	50	20	**12**	0	25	**27**	0	45	38
Brachypodium genuense (DC.) Roemer et Schultes	**46**	75	0	**0**	0	0	**11**	8	27	0
Alchemilla saxatilis Buser	**0**	0	0	**12**	0	25	**43**	54	9	61
Carex sempervirens Vill.	**38**	50	20	**0**	0	0	**22**	23	9	31
Parnassia palustris L.	**54**	75	20	**12**	0	25	**0**	0	0	0
Soldanella alpina L.	**46**	75	0	**12**	0	25	**0**	0	0	0
Avenella flexuosa (L.) Parl.	**0**	0	0	**25**	12	12	**19**	23	0	31
Viola biflora L.	**31**	25	40	**0**	0	0	**0**	0	0	0
Sedum alpestre Vill.	**0**	0	0	**0**	0	0	**13**	15	0	23
Geranium argenteum L.	**0**	0	0	**12**	0	12	**8**	8	0	15
Gentianella ciliata Borkh.	**8**	12	0	**0**	0	0	**5**	0	18	0
Saxifraga moschata Wulfen	**0**	0	0	**12**	0	25	**5**	0	0	15
Gnaphalium supinum L.	**0**	0	0	**0**	0	0	**3**	0	0	8
Alchemilla connivens Buser	**15**	25	0	**0**	0	0	**0**	0	0	0
Pinguicula leptoceras Rchb.	**15**	12	20	**0**	0	0	**0**	0	0	0
Cirsium morisianum Rchb.	**0**	0	0	**0**	0	0	**5**	8	9	0
Hieracium pallidum Bivona	**0**	0	0	**0**	0	0	**3**	8	0	0

Table 2. Trifolio thalii-Festucetum puccinellii typicum Rel. 1–8: typical variant; rel. 9–13: variant of Polygonum viviparum. D: differential species; R: regional character species.

Relevé n.	1	2	3	4	5	6	7	8	9	10	11	12	13	Fr
Site	TA	TA	TA	CV	CV	CV	CV	CV	TA	TA	TA	TA	TA	
Elevation (m x 10)	162	168	170	165	164	162	170	166	170	184	174	183	172	
Aspect	N	NW	NE	NNW	NW	NE	NNW	WNW	N	N	N	NNW	NW	
Slope angle (°)	35	40	35	25	30	25	35	30	15	35	10	20	15	
Relevé area (sqm)	15	10	50	30	30	30	30	100	10	10	10	5	10	
Cover (%)	75	70	90	100	100	75	90	95	60	80	70	60	80	
Rare species	–	–	4	2	–	3	1	1	–	–	–	2	2	
N. of species	25	27	27	30	27	23	31	26	17	19	18	18	22	
Association														
Festuca violacea subsp. puccinellii	2	2	2	2	2	2	3	2	2	2	2	2	1	100
Crepis aurea subsp. glabrescens (R)	2	2	2	2	2	1	1	1	2	3	2	2	3	100
Ranunculus pollinensis (R)	+	.	+	1	+	+	1	+	+	+	.	+	1	85
Taraxacum aemilianum (D)	.	r	+	+	+	+	+	+	+	+	+	.	.	77
Sagina glabra (D)	+	+	.	1	+	.	1	+	.	.	.	.	.	46
Variant														
Polygonum viviparum	.	.	.	.	.	.	.	.	1	1	1	1	+	38
Cerastium apuanum	.	.	.	.	.	.	.	.	.	+	+	1	+	31
Alliance (Caricion ferrugineae)														
Trifolium thalii	1	1	2	2	1	3	2	1	.	.	+	.	+	77
Trifolium pratense (D)	+	+	.	+	+	.	+	2	+	.	.	.	.	54
Erigeron alpinus	+	+	.	.	.	+	.	.	+	.	+	+	+	54
Order (Seslerietalia coeruleae)														
Phyteuma orbiculare	.	r	.	1	+	+	1	+	.	r	+	.	+	69
Carduus carlinaefolius	.	.	1	.	+	+	.	.	+	.	.	.	+	38
Alchemilla nitida	.	+	.	.	.	.	.	.	+	r	+	.	r	38
Lotus alpinus	.	.	.	1	+	+	.	1	.	.	.	.	.	31
Acinos alpinus	.	r	.	.	.	.	.	.	.	+	.	+	+	31
Myosotis alpestris	.	.	.	+	+	.	.	+	.	.	.	.	.	23
Veronica aphylla	.	.	+	.	.	.	r	.	.	+	.	.	.	23
Sedum atratum	.	.	.	.	.	.	.	.	.	.	.	+	+	15
Linum alpinum subsp. julicum	.	.	.	.	.	.	.	1	.	.	.	.	.	8
Carlina acaulis subsp. simplex	.	.	+	.	.	.	.	.	.	.	.	.	.	8
Class (Seslerietea albicantis)														
Gentiana verna	.	.	+	1	+	+	+	+	r	.	r	.	.	61
Euphrasia salisburgensis	+	+	1	.	.	.	.	.	.	.	+	+	1	46
Galium anisophyllum	.	.	+	.	.	.	.	.	+	1	+	.	+	38
Thymus polytrichus	.	+	.	.	.	.	.	.	+	.	+	+	+	38
Gentiana clusii	.	.	+	.	+	.	r	.	.	.	.	.	.	23
Sesleria tenuifolia	.	.	r	.	.	.	.	.	.	.	.	+	.	15
Biscutella laevigata	.	.	.	.	.	.	.	.	.	.	.	r	.	8
Companions														
Poa alpina	1	1	+	1	+	1	1	+	1	1	+	1	2	100
Festuca rubra subsp. commutata	1	1	.	2	2	1	1	1	+	+	+	.	.	77
Alchemilla flabellata	1	1	1	+	+	+	+	2	.	.	.	.	.	61
Cirsium bertolonii	2	.	+	+	1	1	+	3	.	.	.	.	+	61
Hypericum richeri	+	+	+	+	1	+	.	1	r	.	.	.	.	61
Parnassia palustris	1	+	+	1	+	.	1	.	.	+	.	.	.	54
Campanula scheuchzeri	+	+	.	+	.	.	1	1	.	.	+	+	.	54
Soldanella alpina	+	+	.	1	+	+	1	.	.	.	.	.	.	46
Pedicularis tuberosa	.	.	.	+	.	+	1	+	r	+	.	.	.	46
Cerastium suffruticosum	.	+	+	+	+	.	+	1	.	.	.	.	.	46
Brachypodium genuense	+	+	.	+	.	+	+	+	.	.	.	.	.	46
Alchemilla alpina	.	.	+	1	+	1	1	.	.	.	.	.	.	38
Carex sempervirens	.	.	+	.	.	r	1	+	.	.	.	+	.	38
Euphrasia minima	+	+	.	1	+	.	.	+	.	.	.	.	.	38
Gentianella campestris	+	+	.	r	.	.	+	.	+	.	.	.	.	38
Lotus corniculatus	+	+	1	.	.	.	.	.	.	.	.	.	+	31
Leontodon hispidus	.	+	+	.	.	.	.	.	.	.	+	.	+	31
Viola biflora	+	+	.	.	.	.	.	.	.	+	.	.	+	31
Nardus stricta	+	1	.	.	+	.	.	.	.	.	.	.	.	23
Phleum alpinum	+	.	.	1	+	.	.	.	.	.	.	.	.	23
Agrostis rupestris	.	.	.	+	+	.	+	.	.	.	.	.	.	23
Arenaria bertolonii	+	.	.	.	.	.	+	.	.	+	.	.	.	23
Saxifraga rotundifolia	.	.	.	.	+	.	r	+	.	.	.	.	.	23
Hutchinsia alpina	.	.	.	.	.	.	.	.	.	+	.	+	.	15
Aquilegia bertolonii	.	.	.	.	.	.	r	+	.	.	.	.	.	15
Aster bellidiastrum	.	.	.	+	.	.	r	.	.	.	.	.	.	15
Leucanthemum ceratophylloides	r	.	.	.	.	.	.	.	.	.	+	.	.	15
Pinguicula leptoceras	.	.	.	.	.	.	+	.	.	r	.	.	.	15

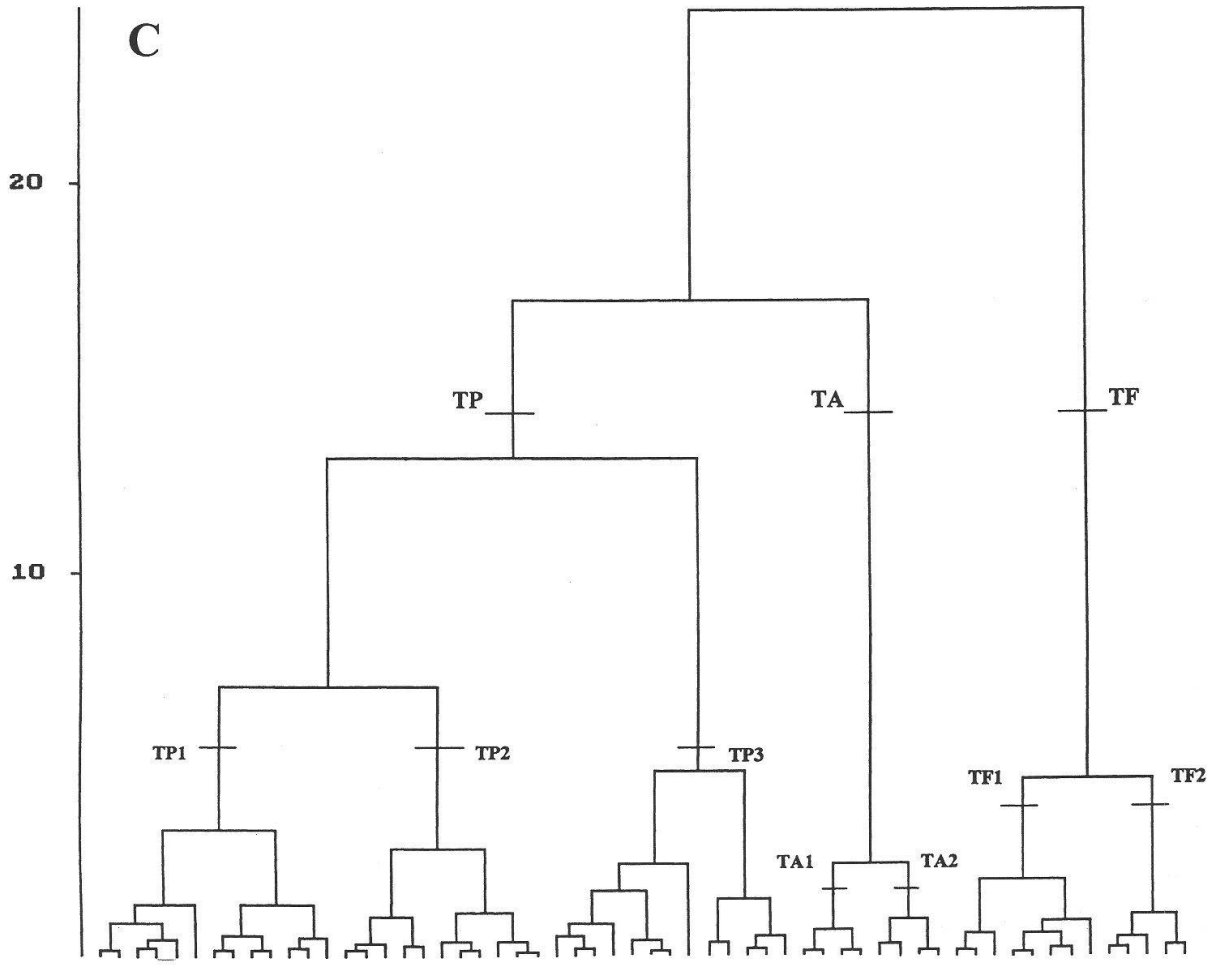

Fig. 2. Classification dendrogram of relevés. C: chord distance. Other symbols as in Table 1.

over, *Trifolium thalii* is much more restricted in its occurrence and cover values (Tab. 2, rel. 9–13). Syntaxonomically, this subgroup can be regarded as a variant of *Polygonum viviparum* of the Trifolio thalii-Festucetum puccinellii typicum.

The group TA consists of only 8 relevés (Tab. 3), taken in fairly open stands with the herbaceous cover varying from 70 to 90%. *Festuca violacea* subsp. *puccinellii* is also here constant, but never dominant and co-dominant only in two stands. The dominant species are usually herbaceous dicotyledons, such as *Trifolium thalii* and *Alchemilla alpina*. Among the diagnostic species of the association, only *Crepis aurea* subsp. *glabrescens* and *Sagina glabra* are represented here. *Alchemilla alpina*, *Saxifraga paniculata* and, to a lesser extent, *Carum heldreichii* are clearly centered in this group (Table 1). For this reason, they can be regarded as differential species of a subassociation of the Trifolio thalii-Festucetum puccinellii (Trifolio thalii-Festucetum puccinellii alchemilletosum alpinae Tomaselli, Rossi et Dowgiallo subass. nova hoc loco; Tab. 3, nomenclatural type: rel. 2 (holotypus)).

Relevés 1–4 in Tab. 3, lacking any differential species, correspond to the typical variant of the subassociation; whereas relevés 5-8, differentiated by several Caricetea curvulae-species (*Agrostis rupestris*, *Juncus trifidus*, *Luzula lutea*) can be referred to a variant of *Agrostis rupestris*.

Table 3. Trifolio thalii-Festucetum puccinellii alchemilletosum alpinae. Rel. 1–4: typical variant; rel. 5–8: variant of Agrostis rupestris. D: differential species; R: regional character species.

Relevé n.	1	2	3	4	5	6	7	8	Fr
Site	SP	SP	CP	VP	GI	GI	PR	PR	
Elevation (m x 10)	170	169	177	163	190	176	195	194	
Aspect	NW	N	NE	N	NNE	N	NW	NW	
Slope angle (°)	35	40	45	30	30	35	25	40	
Relevé area (sqm)	10	25	50	20	50	20	50	8	
Cover (%)	80	90	70	75	80	80	90	75	
Rare species	3	2	1	1	4	3	7	2	
N. of species	20	21	22	18	18	20	22	18	
Association									
Festuca violacea subsp. puccinellii	2	2	+	+	2	3	1	1	100
Crepis aurea subsp. glabrescens (R)	.	+	+	+	+	+	.	.	62
Sagina glabra (D)	.	+	.	.	+	+	+	+	62
Subassociation									
Alchemilla alpina	2	3	2	2	2	2	2	2	100
Saxifraga paniculata	1	1	2	1	+	+	+	+	100
Variant									
Agrostis rupestris	.	.	.	.	+	+	+	+	50
Juncus trifidus	.	.	.	.	.	1	1	1	37
Luzula lutea	.	.	.	.	+	.	+	1	37
Alliance (Caricion ferrugineae)									
Trifolium thalii	2	2	2	2	3	3	3	2	100
Trifolium pratense (D)	r	.	.	+	.	.	.	.	25
Order (Seslerietalia coeruleae)									
Hieracium villosum	.	.	+	.	.	.	.	.	12
Class (Seslerietea albicantis)									
Thymus polytrichus	.	+	+	+	1	1	1	+	87
Gentiana verna	+	+	+	+	.	.	.	.	50
Galium anisophyllum	+	.	.	+	.	.	+	r	50
Minuartia verna	.	.	+	.	.	.	.	+	25
Pulsatilla alpina	.	.	.	.	.	.	r	+	25
Companions									
Poa alpina	1	1	1	1	+	1	+	1	100
Aster bellidiastrum	+	1	+	1	.	+	+	1	87
Festuca riccerii	.	.	1	1	.	+	1	1	62
Alchemilla flabellata	r	r	.	.	+	1	.	.	50
Cirsium bertolonii	+	+	+	+	.	.	.	.	50
Avenula praetutiana	.	1	1	1	.	.	.	.	37
Carum heldreichii	1	+	1	.	.	.	.	.	37
Festuca rubra subsp. commutata	1	1	.	.	+	.	.	.	37
Cerastium suffruticosum	+	.	+	.	.	r	.	.	37
Pedicularis comosa	.	1	1	.	.	.	.	.	25
Arenaria bertolonii	.	.	+	1	.	.	.	.	25
Campanula scheuchzeri	.	.	.	.	1	+	.	.	25
Avenella flexuosa	.	.	+	.	.	+	.	.	25
Botrychium lunaria	+	+	.	.	.	.	.	.	25
Hypericum richeri	.	.	.	.	.	.	+	+	25
Leucanthemum ceratophylloides	+	+	.	.	.	.	.	.	25
Lotus corniculatus	.	.	+	+	.	.	.	.	25
Ranunculus oreophilus	+	+	.	.	.	.	.	.	25
Vaccinium myrtillus	.	.	.	.	+	+	.	.	25
Hieracium pallidum	.	.	+	r	.	.	.	.	25

The group TP, including 37 relevés (Tab. 4), corresponds to the most widespread type of Violet Fescue pasture in the data set. The herbaceous cover is generally closed, or almost so, in all the stands with very few exceptions (rel. 33 and 34). *Trifolium thalii*, *Poa alpina* and *Festuca violacea* subsp. *puccinellii* are the most frequent plants, with *Trifolium thalii* usually attaining dominance. Other constant species are the grass *Festuca rubra* subsp. *commutata* and the herbaceous dicotyledon *Alchemilla flabellata*. Among the diagnostic species of the association, *Crepis aurea* subsp. *glabrescens* is constant and usually abundant, *Sagina glabra* is common, but only occasionally prominent and *Taraxacum aemilianum* is relatively uncommon. *Plantago alpina*, *Ranunculus apenninus* and *Geum montanum* clearly differentiate this group (Tab. 1). On this basis a further subassociation of the *Trifolio thalii-Festucetum puccinellii* can be established (Trifolio thalii-Festucetum puccinellii plantaginetosum alpinae Tomaselli, Rossi et Dowgiallo subass. nova hoc loco; Tab. 4, nomenclatural type: rel. 10 (holotypus)).

This subassociation shows a certain degree of floristic heterogeneity, that is reflected in the dendrogram (Fig. 2), where three different subgroups, merging at a sum of squares of ca. 13, can be clearly identified. The subgroup TP1, (Tab. 4, rel. 1–13) has no differential species and, therefore, it can be regarded as the typical variant of the Trifolio thalii-Festucetum puccinellii plantaginetosum alpinae. The subgroup TP2 (Tab. 4, rel. 14–24) is differentiated by *Plantago atrata* and *Trifolium pratense*, respectively character and differential species of the Caricion ferrugineae, but clearly here concentrated. Moreover, this subgroup is differentiated also by *Achillea stricta* and by lithophytes such as *Arenaria bertolonii* and *Valeriana montana*. Consequently, a variant of *Plantago atrata* within the Trifolio thalii-Festucetum puccinellii plantaginetosum alpinae can be defined. The subgroup TP3 (Tab. 4, rel. 25–37) is differentiated by a set of species (*Luzula lutea*, *L. alpino-pilosa*, *Armeria marginata*, *Gentiana nivalis* and *Juncus trifidus*), that are confined to the highest altitudes of the summit areas of the northern Apennines. As consequence, the corresponding relevés are assigned to a variant of *Luzula lutea* of the Trifolio thalii-Festucetum puccinellii plantaginetosum alpinae.

Synecology

The Trifolio thalii-Festucetum puccinellii is confined to slopes having a general northern aspect, from west-north-west through to north-east, where the snow melts slowly, providing a good water supply to this community. Moreover, the association shows a clear preference for alkaline and weakly acidic soils, derived from the weathering of calcareous or marly substrata (see below).

The distribution of the Trifolio thalii-Festucetum puccinellii typicum is limited to the Apuan Alps, where it is encountered only in a restricted area corresponding to the northern slopes of M. Tambura and M. Cavallo. The former peak consists of marbles, while the latter one consists of cherty limestones and jaspers. The Trifolio thalii-Festucetum puccinellii typicum prefers carbonatic substrata, occurring only occasionally on jaspers.

The stands of this association range in altitude from 1620 to 1840 m. They are confined to slopes ranging from 10° to 40°. The typical variant occurs at lower altitudes (average altitude 1659 m) and on steeper slopes (from 25° to 40°), whereas the variant of *Polygonum viviparum* is found at higher altitudes (average altitude 1766 m) and mostly on small hollows slightly sloping. Moreover, the stands of the variant of *P. viviparum* are confined to marble substrata. The soils beneath the Trifolio thalii-Festucetum puccinellii typicum were sampled only in the typical variant. They are mainly Mollisols, highly humiferous throughout the profile (>10% of organic matter in the top layer, 3–4% near the base of the solum), rich in exchangeable Ca (20–30 meq/100g) and with a high base saturation (>75%), although lacking free carbonates in the matrix. On M. Tambura, on marbles, quite deep soils with an ABwC

Table 4. Trifolio thalii-Festucetum puccinellii plantaginetosum alpinae. Rel. 1–13: typical variant; rel. 14–24:

Relevé n.	1	2	3	4	5	6	7	8	9	10	11	12	13
Site	CI	OM	CS	CS	GI	CI	CI	CI	BR	NU	GI	GI	GI
Elevation (m x10)	181	171	176	169	187	197	181	198	174	168	170	170	191
Aspect	NNW	N	WNW	N	NNE	W	NNW	NE	NNE	N	–	–	N
Slope angle (°)	35	50	40	20	30	25	15	30	30	45	–	–	25
Relevé area (sqm)	30	40	10	10	20	10	10	5	50	80	10	20	40
Cover (%)	95	95	95	80	100	75	75	100	95	90	100	95	85
Rare species	1	1	2	1	–	–	2	–	–	2	–	1	–
N. of species	29	23	24	21	16	18	20	16	16	24	10	13	21
Association													
Festuca violacea subsp. puccinellii	1	1	2	1	2	1	1	2	2	2	1	1	1
Crepis aurea subsp. glabrescens (R)	1	1	.	1	.	.	1	2	1	2	2	2	3
Sagina glabra (D)	+	+	+	+	+	+	+	+	+	+	1	1	10
Taraxacum aemilianum (D)	.	.	.	.	.	.	.	.	.	.	.	+	r
Subassociation													
Plantago alpina	+	+	+	1	+	+	1	1	+	+	.	2	1
Ranunculus apenninus	1	+	r	+	1	.	.	+	.	.	.	.	+
Variants													
Achillea stricta	.	.	.	.	.	.	.	.	.	.	.	.	.
Arenaria bertolonii	.	.	.	.	.	.	.	.	.	.	.	.	.
Valeriana montana	.	.	.	.	.	.	.	.	.	.	.	.	.
Luzula lutea	r	.	.	.	.	.	.	.	.	.	.	.	.
Luzula alpino-pilosa	.	.	.	.	.	.	.	.	.	.	.	.	+
Armeria marginata	.	.	.	.	.	.	.	.	.	.	.	.	+
Gentiana nivalis	.	.	.	.	.	.	.	.	.	.	.	.	.
Juncus trifidus	.	.	.	.	.	.	.	.	.	.	.	.	.
Alliance (Caricion ferrugineae)													
Trifolium thalii	3	3	4	2	2	2	3	3	4	3	4	2	2
Trifolium pratense (D, Dv1)	.	.	.	.	.	.	.	.	.	1	.	.	.
Plantago atrata (Dv1)	.	.	.	.	.	.	.	.	.	.	.	.	.
Erigeron alpinus	.	.	.	.	.	+	.	.	.	.	.	.	.
Order (Seslerietalia coeruleae)													
Carduus carlinaefolius	.	.	.	.	.	+	+	+	.	.	.	.	.
Carlina acaulis subsp. simplex	+	.	.	.	.	.	.	.	1	+	.	.	.
Lotus alpinus	.	.	.	.	.	.	.	.	.	.	.	.	.
Linum alpinum subsp. julicum	.	.	.	.	.	+	.	.	.	.	.	.	.
Bupleurum ranunculoides subsp. caricinum	.	.	.	.	.	.	.	.	.	.	.	.	.
Potentilla crantzii	.	.	.	.	.	.	.	.	.	.	.	.	.
Scabiosa lucida	.	.	.	.	.	.	.	.	.	.	.	.	.
Class (Seslerietea albicantis)													
Galium anisophyllum	+	.	.	+	1	+	+	+	.	1	.	.	.
Gentiana verna	+	.	.	+	.	.	.	r	.	.	.	.	+
Thymus polytrichus	1	1	+	1	.	1	1	.	+	1	.	.	+
Biscutella laevigata	.	.	.	.	.	.	.	.	.	.	.	.	.
Minuartia verna	.	.	.	.	.	.	.	.	.	.	.	.	.
Companions													
Poa alpina	1	1	1	1	1	2	1	1	1	1	1	1	+
Alchemilla flabellata	1	+	+	+	+	1	+	1	+	1	.	.	+
Festuca rubra subsp. commutata	2	2	2	2	1	1	2	1	1	2	2	2	1
Geum montanum	+	1	+	+	+	.	+	1	+	1	r	.	1
Alchemilla alpina	.	+	1	2	1	.	.	.	.	1	.	.	1
Alchemilla saxatilis	+	2	.	.	+	1	+	.	+	.	.	+	.
Cirsium bertolonii	.	.	+	+	.	+	.	+	.	r	.	.	.
Euphrasia minima	+	.	.	.	.	.	.	.	.	+	.	.	.
Euphrasia alpina	.	.	.	.	.	.	.	.	+	+	.	.	.
Cerastium suffruticosum	.	.	+	.	.	+	.	.	+	+	.	.	.
Aster bellidiastrum	+	r	+	.	+	.	.	.	.	.	.	.	.
Campanula scheuchzeri	+	.	+	.	.	.	+	.	.	+	.	.	+

variant of Plantago atrata; Rel. 25–37: variant of Luzula lutea. D: differential species; R: regional character species.

14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	Fr
GI	CA	CA	CP	SB	AD	CU	CU	CU	CU	CU	CU	CI	CI	CI	CU	CI	CI	CI	CI	CI	CI	CU	CU	
167	167	175	166	166	199	189	193	195	190	198	195	190	197	203	206	200	196	190	199	195	192	195	197	
NNW	N	NNE	N	N	–	NNE	NNE	NNE	NNE	ENE	N	NNE	NNE	NW	N	N	NNE	NNW	N	NNW	N	NE	N	
30	35	30	40	30	–	10	30	40	25	40	30	30	20	20	35	40	35	15	35	30	40	40	35	
10	50	50	30	120	50	50	50	30	30	10	10	10	20	30	30	30	30	100	10	20	150	15	10	
95	100	100	95	90	95	100	100	85	100	100	90	85	100	100	100	85	95	100	60	50	100	95	100	
2	–	2	1	1	–	–	–	1	–	–	–	–	–	1	1	–	1	1	1	2	2	–	–	
21	20	25	21	22	25	19	26	20	22	19	19	22	29	13	22	28	18	31	10	19	31	20	26	
2	2	2	3	2	2	2	2	2	1	1	2	.	2	.	2	2	2	1	3	2	3	3	4	95
1	2	1	+	2	2	2	2	1	1	+	.	1	1	1	1	2	2	1	-	+	+	1	1	86
+	1	1	.	1	1	.	+	.	.	.	+	+	+	+	+	+	.	.	.	.	.	+	.	70
.	+	+	.	+	+	.	+	+	.	.	.	.	.	1	.	.	.	.	.	.	.	.	+	27
1	+	+	.	+	1	1	1	1	+	+	+	+	1	+	1	1	1	1	.	.	1	1	+	89
r	+	1	.	.	.	.	r	.	.	.	+	+	.	+	.	+	+	+	.	r	+	.	1	54
.	.	.	.	.	.	+	+	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	11
.	.	.	+	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	11
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.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	1	.	.	.	.	+	+	.	+	19
.	.	.	.	.	+	.	.	.	.	.	+	+	+	+	+	.	.	.	.	.	+	.	.	19
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	+	.	.	8
3	3	3	2	2	3	2	3	3	5	5	2	3	3	4	3	3	3	1	1	+	2	2	1	100
.	+	+	+	+	+	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	2	27
.	.	+	.	.	+	+	.	+	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	16
.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	8
.	.	.	.	.	.	+	+	+	.	+	+	.	.	.	.	.	+	.	.	.	+	+	.	30
.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	14
.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	+	.	.	+	.	.	.	.	.	11
.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	8
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	3
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.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	3
+	+	.	+	.	.	+	+	+	+	+	.	.	+	.	.	.	+	1	+	.	+	+	.	57
.	.	r	+	.	+	+	+	.	+	+	+	+	r	+	+	+	+	+	.	.	+	+	.	57
+	+	+	.	.	1	.	+	1	+	.	1	.	.	.	1	-	-	+	.	.	.	+	.	54
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	3
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	3
1	1	1	1	1	1	1	1	+	1	1	2	1	1	2	1	1	1	.	1	2	1	1	+	97
+	+	+	1	.	+	1	+	.	+	1	+	2	1	+	1	+	1	1	.	.	1	+	1	84
.	+	.	1	1	.	1	1	.	1	1	1	1	1	+	.	1	1	.	.	1	1	1	1	81
r	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	1	.	.	.	+	1	1	+	51
+	.	2	2	2	.	1	+	1	1	.	.	.	.	.	.	.	.	.	.	1	.	1	1	46
.	.	.	.	1	.	.	.	.	.	.	1	2	1	.	.	1	1	.	+	.	1	2	.	43
1	1	1	1	1	.	.	.	+	.	.	.	.	.	.	.	+	r	.	+	.	+	.	.	40
+	.	.	+	+	+	+	+	.	.	.	+	+	1	.	.	.	+	.	.	.	+	1	+	40
.	.	.	1	.	1	+	+	+	+	+	.	.	+	.	.	.	.	1	.	.	1	+	+	38
.	+	+	.	.	+	.	.	+	.	1	1	.	.	+	.	.	.	.	.	.	+	1	1	38
.	.	+	.	.	.	.	.	r	.	.	+	+	+	.	+	+	.	+	.	.	+	.	.	35
r	.	+	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	1	30

Table 4. Continued

Relevé n.	1	2	3	4	5	6	7	8	9	10	11	12	13
Site	CI	OM	CS	CS	GI	CI	CI	CI	BR	NU	GI	GI	GI
Elevation (m x10)	181	171	176	169	187	197	181	198	174	168	170	170	191
Aspect	NNW	N	WNW	N	NNE	W	NNW	NE	NNE	N	–	–	N
Slope angle (°)	35	50	40	20	30	25	15	30	30	45	–	–	25
Relevé area (sqm)	30	40	10	10	20	10	10	5	50	80	10	20	40
Cover (%)	95	95	95	80	100	75	75	100	95	90	100	95	85
Rare species	1	1	2	1	–	–	2	–	–	2	–	1	–
N. of species	29	23	24	21	16	18	20	16	16	24	10	13	21
Festuca riccerii	.	.	.	.	.	.	.	.	.	.	.	.	.
Gentianella campestris	.	.	.	.	.	.	.	.	.	.	.	.	.
Lotus corniculatus	.	.	+	+	.	.	+	.	.	.	+	+	.
Nardus stricta	+	.	.	.	.	.	.	+	.	.	+	1	+
Agrostis rupestris	.	+	.	.	.	.	.	.	.	r	.	.	+
Viola calcarata subsp. cavillieri	+	r	.	.	+	.	.	.	.	.	.	.	.
Phleum alpinum	.	.	.	.	.	.	+	+	.	+	.	1	.
Carex sempervirens	+	.	.	+	+	.	.	.	.	.	.	.	.
Anthoxanthum alpinum	1	+	+	+	+	.	.	.	.	.	.	.	.
Avenella flexuosa	1	+	.	+	.	.	.	.	.	.	.	.	.
Phyteuma hemisphaericum	.	+	.	.	.	.	.	.	.	.	.	.	+
Pedicularis tuberosa	.	.	+	.	.	.	+	.	.	.	.	.	.
Luzula sieberi	1	+	+	r	.	.	.	.	.	.	.	.	.
Leontodon helveticus	.	.	.	.	.	.	.	.	+	.	.	.	.
Pimpinella alpestris	r	.	.	.	.	.	.	.	.	.	.	.	.
Saxifraga paniculata	+	.	.	.	.	+	.	.	.	.	.	.	r
Sedum alpestre	.	r	+	.	.	.	.	.	.	.	.	.	.
Botrychium lunaria	+	.	.	.	.	.	.	.	.	.	.	.	.
Avenula praetutiana	.	.	.	.	.	.	.	.	.	.	.	.	.
Brachypodium genuense	.	.	.	.	.	.	.	.	.	+	.	.	.
Robertia taraxacoides	.	.	+	.	.	.	.	.	.	.	.	.	.
Vaccinium myrtillus	.	+	.	.	.	.	.	.	+	.	.	.	.
Geranium argenteum	.	.	.	.	.	2	.	.	.	.	.	.	.
Luzula spicata subsp. mutabilis	.	.	.	.	.	.	.	.	.	.	.	.	.
Carum heldreichii	.	.	.	.	.	+	.	.	.	.	.	.	.
Trifolium repens	.	.	.	.	.	.	.	.	.	.	.	.	
Deschampsia caespitosa	.	.	.	.	.	.	.	.	.	.	1	.	.
Gentianella ciliata	.	.	.	.	.	.	.	.	.	.	.	.	.
Saxifraga moschata	.	.	.	.	.	.	.	.	.	.	.	.	.
Antennaria dioica	.	.	.	.	.	.	.	.	.	.	.	.	.
Asperula aristata subsp. oreophila	.	.	.	.	.	.	.	.	.	.	.	.	.
Cirsium morisianum	.	.	.	.	.	.	r	.	.	.	.	.	.
Silene acaulis subsp. exscapa	.	.	.	.	.	.	.	.	.	.	.	.	.
Taraxacum officinale	.	.	r	.	.	.	.	.	.	.	.	.	.

profile are found, which are fine-textured and contain abundant calcareous stones in all horizons (Tab. 5, prof. AP1/92: Eutrochreptic Rendoll). On M. Cavallo, where jasper is by far the dominant rock type, soils are shallow with an AC profile, slightly acidic to neutral (Tab. 5, prof. AP2/92: Lithic Haploboroll).

The Trifolio thalii-Festucetum puccinellii alchemilletosum alpinae is distributed only in the Tuscan-Emilian Apennines, on marly layers within arenaceous outcrops (M. Cervarola and M. Modino sandstones). The subassociation covers a broad altitudinal range from 1630 to 1950 m and it is confined to the slopes subjected to erosion with angle generally exceeding 25° up to 45°. The typical variant occurs only below 1800 m of altitude; whereas the variant of *Agrostis rupestris* is restricted to an altitudinal range from 1760 to 1950 m. Both variants are found in strongly eroded areas with shallow and poorly differentiated soils, con-

Table 4. Continued

14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	Fr
GI	CA	CA	CP	SB	AD	CU	CU	CU	CU	CU	CU	CI	CI	CI	CU	CI	CI	CI	CI	CI	CI	CU	CU	
167	167	175	166	166	199	189	193	195	190	198	195	190	197	203	206	200	196	190	199	195	192	195	197	
NNW	N	NNE	N	N	–	NNE	NNE	NNE	NNE	ENE	N	NNE	NNE	NW	N	N	NNE	NNW	N	NNW	N	NE	N	
30	35	30	40	30	–	10	30	40	25	40	30	30	20	20	35	40	35	15	35	30	40	40	35	
10	50	50	30	120	50	50	50	30	30	10	10	10	20	30	30	30	30	100	10	20	150	15	10	
95	100	100	95	90	95	100	100	85	100	100	90	85	100	100	100	85	95	100	60	50	100	95	100	
2	–	2	1	1	–	–	–	1	–	–	–	–	–	1	1	–	1	1	1	2	2	–	–	
21	20	25	21	22	25	19	26	20	22	19	19	22	29	13	22	28	18	31	10	19	31	20	26	
1	1	1	.	.	+	.	.	.	.	.	.	1	1	+	1	.	.	2	.	+	.	.	.	27
.	.	.	+	.	+	+	+	.	.	r	+	+	+	.	.	.	.	.	.	.	+	.	+	27
.	+	1	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	24
.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	.	.	.	.	+	.	.	24
.	.	.	.	+	.	.	.	.	.	.	.	1	+	.	.	.	.	+	+	+	.	.	.	24
.	.	.	.	.	+	.	r	.	.	.	+	.	.	.	.	+	+	.	.	.	.	.	+	24
.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	22
.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	1	.	.	+	.	1	22
+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	19
.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	+	.	+	.	.	.	19
.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	+	.	+	.	.	+	.	.	19
r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	r	.	.	.	.	+	.	+	19
.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	16
.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	+	16
.	.	.	.	.	+	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	14
.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	13
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	+	+	.	.	.	13
+	r	r	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	13
.	.	.	.+	.	.	.	.	+	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	11
+	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	11
.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	11
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	11
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.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	r	.	.	.	1	.	.	.	8
.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	8
.	.	.	.	+	.	.	+	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	8
.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5
.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5
.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	5
.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	+	.	.	.	.	.	5
.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	+	.	.	.	.	.	5
.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5
.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	5
+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5

sisting of an ochric or mollic epipedon 20–30 cm thick, directly overlying a stony C horizon (classified as Lithic Udorthents and Lithic Haploborolls respectively). These soils generally have lower contents of organic matter if compared with the soils of the Trifolio thalii-Festucetum puccinellii typicum. As for the chemical characteristics, depending upon the nature of the parent material, the profile corresponding to the typical variant (Tab. 6, prof. COR6/97) is alkaline, highly saturated and very rich in exchangeable Ca (>30 meq/100g), whereas some profiles corresponding to the variant of Agrostis rupestris (Tab. 6, prof. PR19/93, GIO19/95) are moderately acidic with quite low levels of exchangeable Ca (<10 meq/100g).

The Trifolio thalii-Festucetum puccinellii plantaginetosum alpinae occurs only in the Tuscan-Emilian Apennines, on marly outcrops (Marmoreto marls) and on marly layers within arenaceous outcrops belonging to M. Cervarola and M. Modino sandstones. The subassoci-

Table 5. Physical-chemical characteristics of the profiles concerning Trifolio thalii-Festucetum pucci-

Site	Profile	Hor.	depth (cm)	Colour (humid)	pH (H_2O)	pH (KCl)	Total $CaCO_3$ (%)	Org.C (%)	Org. Matt. (%)	Tot. N (%)	C/N	C. E.C (cmol/kg)
M. Tambura	AP1/92	A1	0–15	10YR3/3	7.0	6.2	0	7.12	12.24	0.84	8.5	63.35
	(Tab.2 rel.3)	A2	15–30	10YR3/3	7.1	n.d.	0	5.62	9.66	0.86	6.5	54.77
		A3	30–40	10YR3/4	7.2	6.5	0	4.58	7.87	0.50	9.0	48.07
		B1	40–55	10YR4/4	7.1	6.7	0	3.27	5.63	0.42	11.7	35.24
		B2	55–80	10YR4/6	7.5	6.8	0	2.03	3.49	0.34	6.0	33.15
M. Cavallo	AP2/92	A	0–15/18	10YR2/2	6.6	6.0	0	11.23	19.32	0.84	13.0	45.54
	(Tab.2 rel.4)	C	18–40	10YR5/8	6.8	6.2	0	1.64	2.82	0.2	8.0	9.92

Table 6. Physical-chemical characteristics of the profiles concerning Trifolio thalii-Festucetum pucci-

Site	Profile	Hor.	depth (cm)	Colour (humid)	pH (H_2O)	pH (KCl)	Total $CaCO_3$ (%)	Org.C (%)	Org. Matt. (%)	Tot. N (%)	C/N	C. E.C (cmol/kg)
M. Cupolino	COR6/97 (Tab.3 rel.3)	AC	0–20	10YR4/2	8.1	7.2	1	4.90	8.43	0.37	13.0	38.30
M.Prado	PR19/93	A	0–25	10YR3/2	6.3	5.4	0	2.09	3.60	0.16	13.0	15.10
	(Tab.3 rel.7)	AC	25–40	10YR4/4	6.2	5.1	0	0.59	1.03	0.09	6.5	10.32
M.Giovo	GIO19/95	A1	0–5	2.5Y4/2	5.6	4.1	0	1.91	3.28	0.25	7.6	19.34
	(Tab. 3 rel.6)	A2	5–28	2.5Y4/3	5.9	n.d.	0	0.76	1.31	0.18	4.2	n.d.

ation extends in altitude from 1680 to 2060 m, on fairly steep slopes (average slope angle about 28°). The typical variant extends from 1680 to 1970 m (with an average altitude of 1795 m), while the variant of *Luzula lutea* is restricted to the highest summits above 1900 m (with an average altitude of 1965 m). The variant of *Plantago atrata* includes all the stands growing on Marmoreto marls, showing a more marked preference for marly substrata.

The typical variant of the Trifolio thalii-Festucetum puccinellii plantaginetosum alpinae is found on moderately deep soils with ABwC profile (Tab. 7, prof. GIO15/94: Dystric Eutrochrept); they are moderately acidic, with low levels of exchangeable Ca and a base saturation slightly over 50% and have quite low contents of organic matter (2%).

The *Luzula lutea* variant occurs on steep slopes where soils are mainly shallow, high gravelly and stony, with an AC profile (Lithic Cryorthents, like prof. CIM17/97 and CIM19/97, Tab. 7); but this variant has been found also on very deep soils with ABC profile, developed from colluvial deposits accumulated at the foot of slopes (prof. CIM1/92: Typic Cryoboroll, Tab. 7). In both cases soils are moderately to slightly acidic, have medium levels of exchangeable Ca, a base saturation comprised between 50 and 75%, slightly higher organic matter contents in comparison with soils of the typical variant (4–7%).

The *Plantago atrata* variant resulted to be related with subalkaline soils having high levels of Ca, very high base saturation and, in some profiles, free carbonates in the matrix. Organic matter content is quite high (6–10% in the topsoil). Their profile consists of an ochric

nellii typicum.

Exch. Bases (cmol/kg) Ca	Mg	K	Na	Exch. Acid. (cmol/kg)	Base Satur. (%)	Sand (%) coarse	medium	fine	Silt (%) coarse	fine	Clay (%)	Classification (U.S.D.A.)
39.36	10.38	0.27	0.24	13.1	79.3	4.3	2.4	6.2	5.0	45.6	36.5	Eutrochreptic rendoll
36.00	10.27	0.20	0.20	8.1	85.2	7.1	1.8	3.6	13.7	29.7	44.0	
29.66	9.22	0.11	0.19	8.9	81.4	5.7	1.3	2.8	19.9	31.3	38.9	
22.55	7.49	0.10	0.20	4.9	86.0	5.3	1.4	3.5	16.8	31.6	41.4	
21.74	7.08	0.09	0.14	4.1	87.6	5.2	2.3	5.9	19.6	46.0	21.0	
30.17	1.09	0.25	0.23	13.8	69.7	3.5	3.0	25.4	32.9	19.5	15.6	Lithic haploboroll
8.07	0.20	0.04	0.21	1.4	86.0	9.4	2.9	20.8	49.9	15.0	2.0	

nellii alchemilletosum alpinae.

Exch. Bases (cmol/kg) Ca	Mg	K	Na	Exch. Acid. (cmol/kg)	Base Satur. (%)	Sand (%) coarse	medium	fine	Silt (%) coarse	fine	Clay (%)	Classification (U.S.D.A.)
33.74	0.57	0.27	0.14	3.6	90.6	8.1	9.2	20.3	10.1	37.1	15.2	Lithic udorthent
9.36	0.64	0.07	0.04	5.0	67.0	34.9	25.0	21.9	8.3	8.0	2.0	Lithic haploboroll
7.26	0.49	0.04	0.03	2.5	76.0	23.2	23.0	35.9	11.9	4.0	2.0	
7.70	1.42	0.18	0.14	9.8	49.4	18.9	12.6	27.3	9.2	26.0	6.0	Lithic udorthent
	n.d.			n.d.	n.d.							

epipedon directly overlying the marly debris (Lithic Cryorthent, prof. CUS2/92, Tab. 7) or, more frequently a yellowish blocky cambic B horizon (Tab. 7, prof. CUS1/92: Typic Cryochrept; prof. COR5/97 and prof. ARC15/97: Dystric Eutrochrepts).

Discussion

In the northern Apennines the Violet Fescue pastures typically comprise rich and intimate mixtures of grasses and herbaceous dicotyledons in continuous, or almost so, closed swards. Floristically, the Trifolio thalii-Festucetum puccinellii remains well defined in relation to the other pasture types occurring in the northern Apennines (Tomaselli 1994). Substantially, it differs from the communities dominated by *Nardus stricta* or by *Brachypodium genuense* for the higher occurrence of the species belonging to the syntaxa including the subalpine and alpine grasslands on carbonatic soils (Caricion ferrugineae, Seslerietalia coeruleae and Seslerietea albicantis) (Tab. 1).

The species of the Seslerietalia coeruleae and the S. albicantis are mostly prominent in the stands from the Apuan Alps, where the carbonatic rocks form large complexes. This is the reason why we have assigned the relevés taken in the Apuan Alps to the Trifolio thalii-Festucetum puccinellii typicum.

Table 7. Physical-chemical characteristics of the profiles concerning Trifolio thalii-Festucetum pucci-

Site	Profile	Hor.	depth (cm)	Colour (humid)	pH (H_2O) (%)	pH (KCl)	Total $CaCO_3$ (%)	Org.C (%)	Org. Matt. (%)	Tot. N (%)	C/N	C. E.C (cmol/kg)
M. Giovo	GIO15/94	A1	0–15	2.5Y3/3	5.5	4.2	0	1.50	2.50	0.17	8.8	14.68
	(Tab.4 rel.5)	A2	15–30	2.5Y4/3	5.9	4.2	0	0.79	1.30	0.12	6.6	15.87
		BC	30–60	2.5Y4/3	6.4	4.9	0	0.87	1.50	0.10	8.7	15.20
M.Cimone	CIM17/97	A	0–20	10YR4/3	5.7	4.4	0	2.91	5.01	0.21	13.9	21.10
	(Tab.4 rel.30)	AC	20–45	10YR4/3	5.7	4.3	0	2.42	4.15	0.18	13.4	16.10
M.Cimone	CIM19/97	A	0–7	10YR3/3	6.1	5.1	0	3.44	5.92	0.24	14.3	20.45
	(Tab.4 rel.31)	AC	7–35	10YR4/3	6.0	5.0	0	2.35	4.04	0.23	10.3	19.77
M.Cimone	CIM1/92	A1	0–10	10YR3/3	6.1	4.7	0	4.06	6.97	0.27	15.0	22.30
	(Tab.4 rel.35)	A2	10–30	2.5Y3/2	5.9	n.d.	0	3.28	5.63	0.27	12.0	16.90
		B1	30–95	2.5Y4/2	6.3	4.2	1	2.57	4.43	0.25	10.0	21.70
		2B2	95 130	2.5Y4/3	6.2	4.5	1	2.03	3.49	0.27	7.5	20.10
M. Cusna	CUS1/92	A1	0–5	10YR3/3	7.4	n.d.	3	5.54	9.52	0.36	15.4	42.39
	(Tab.4 rel.23)	A2	5–23	2.5Y4/2	7.5	7.2	3	2.50	4.29	0.23	11.0	33.35
		B1	23–60	2.5Y4/2	7.7	7.4	7	1.25	2.15	0.26	4.8	33.14
		B2	60–90	2.5Y4/2	7.8	7.5	5	0.94	1.61	0.12	7.8	31.61
M. Cusna	CUS2/92	A1	0–15	2.5Y4/2	7.7	7.2	4.9	6.01	10.33	0.54	11.0	35.30
	(Tab.4 rel.24)	A2	15–30	2.5Y4/2	7.6	7.2	1.9	0.86	1.48	0.21	4.0	31.70
Corno Scale	COR5/97	A1	0–2	7.5YR2/2	7.7	6.9	0	5.90	10.14	0.49	12.0	37.90
	(Tab.4 rel.16)	A2	2–16	10YR3/2	7.7	7.1	0	2.27	3.91	0.28	8.0	31.57
		B1	16–60	10YR4/3	7.8	6.8	0	1.60	2.75	0.23	7.0	27.60
		B2	60–80	10YR4/4	8.0	6.7	0	1.05	1.81	0.17	6.3	25.97
Passo Croce Arcana	ARC15/97	A	0–8	10YR3/3	6.3	5.4	0	3.60	6.19	0.34	10.5	33.10
	(Tab.4 rel.15)	B1	8–35	10YR4/2	7.8	6.5	0.5	1.33	2.28	0.25	5.2	35.60
		B2	35–60	10YR4/2	8.2	7.3	1	0.84	1.44	0.21	4.0	47.70

In the Tuscan-Emilian Apennines, where limestone-rich rocks are substantially represented by scattered marly outcrops interspersed among sandstones, calcicolous species tend generally to be replaced by acidophilous species belonging to the Caricetea curvulae (Tab. 1). This is particularly effective for the variant of *Luzula lutea* of the Trifolio thalii-Festucetum puccinellii plantaginetosum alpinae, whose most stands occur on calcium-deficient sandstones (M. Modino sandstones). Also the Trifolio thalii-Festucetum puccinellii alchemilletosum alpinae, occurring on lithomorphic soils mostly derived from sandstones, is markedly impoverished in calcicolous species, here replaced by several xerophilous species of Festuco-Brometea and lithophilous species of Thlaspietea rotundifolii (Tab. 1). On the contrary, the variant of *Plantago atrata* of the Trifolio thalii-Festucetum puccinellii plantaginetosum alpinae, whose occurrence is restricted to marly substrates (Marmoreto marls) and to relatively calcareous sandstones (M. Cervarola sandstones), is less markedly impoverished in calcicolous species.

As far as the alliance level is concerned, the Trifolio thalii-Festucetum puccinellii is placed in the Caricion ferrugineae, despite the poor representation of the corresponding species

nellii plantaginetosum alpinae.

Exch. Bases (cmol/kg)				Exch.	Base	Sand (%)			Silt (%)		Clay	Classification
Ca	Mg	K	Na	Acid. (cmol/kg)	Satur. (%)	coarse	medium	fine	coarse	fine	(%)	(U.S.D.A.)
5.25	0.95	0.18	0.10	8.2	44.0	24.7	10.4	20.6	23.9	13.7	7.0	Typic dystrochrept
5.77	1.05	0.11	0.14	8.8	44.5	17.8	8.8	20.1	5.2	35.0	13.0	
7.62	0.92	0.11	0.19	6.4	58.0	12.9	8.6	20.3	12.1	33.0	13.0	
11.32	0.85	0.23	0.14	8.6	59.4	5.6	13.7	33.6	9.2	27.3	10.5	Lithic cryorthent
8.05	0.80	0.16	0.17	6.9	57.0	5.4	12.9	33.9	16.6	18.7	12.5	
13.96	1.14	0.49	0.14	4.7	77.0	3.1	7.5	28.2	8.2	36.0	16.9	Lithic cryorthent
13.32	1.12	0.26	0.11	4.9	75.0	19.1	9.1	17.3	8.5	37.0	9.0	
12.1	0.78	0.34	0.08	9.0	59.0	3.8	14.4	30.6	11.0	23.0	7.0	Typic cryoboroll
8.93	0.38	0.04	0.04	7.5	55.0	16.8	13.5	29.1	3.8	21.0	16.0	
12.12	0.63	0.22	0.14	8.7	60.0	17.7	11.6	22.0	11.6	27.0	10.0	
10.62	0.56	0.14	0.07	8.7	56.8	9.0	10.7	21.1	11.2	14.0	34.0	
28.35	0.42	0.25	0.47	12.9	69.5	27.7	11.0	14.7	5.9	38.5	22.0	Typic cryochrept
30.17	0.47	0.15	0.16	2.4	93.0	24.9	9.7	9.8	14.8	22.1	18.7	
31.36	0.37	0.27	0.14	1.0	97.0	22.6	8.3	10.8	7.2	30.0	21.0	
30.18	0.37	0.17	0.17	0.7	98.0	18.5	9.1	8.8	10.6	30.0	23.0	
28.21	0.62	0.28	0.10	6.1	82.7	30.0	14.8	15.7	9.3	14.6	15.7	Lithic cryorthent
26.18	0.55	0.23	0.14	4.6	85.5	25.8	10.5	9.7	7.0	26.0	21.0	
31.4	0.45	0.42	0.16	5.5	85.5	12.5	7.7	14.8	9.5	39.9	15.4	Dystric eutrochrept
26.88	0.35	0.21	0.13	4.0	87.3	20.0	8.6	12.1	19.0	28.0	12.0	
24.08	0.40	0.13	0.11	2.9	89.5	13.4	8.3	9.4	10.9	44.0	14.0	
23.38	0.55	0.13	0.11	1.8	93.0	21.8	7.1	9.6	7.5	38.0	16.0	
27.58	0.80	0.24	0.17	4.3	87.0	9.7	9.4	19.3	12.7	29.7	19.1	Dystric eutrochrept
32.20	0.45	0.15	0.17	2.9	92.0	28.1	10.5	11.1	11.9	14.5	12.0	
43.33	0.50	0.24	0.17	3.5	92.7	29.7	10.4	13.3	5.6	25.0	16.0	

throughout the relevés. This syntaxonomic choice was made for the following reasons: i) the Trifolio thalii-Festucetum puccinellii has close floristic affinities with other vegetation types included in this alliance, mostly with the Trifolio thalii-Festucetum nigricantis Br.-Bl. in Br.-Bl. et Jenny corr. Grabherr, Greimler et Mucina 1993; ii) the northern Apennines represent the southern distributional border in Italy for the Caricion ferrugineae (Tomaselli 1994) and it has recently been recognized that syntaxa at their borderline area show floristic impoverishment in their diagnostic combination (Werger & van Gils 1976, Tomaselli & Rossi 1994).

From the synchorological viewpoint, the Trifolio thalii-Festucetum puccinellii as a whole must be regarded as an endemic association, exclusively located in the northern Apennines, where it replaces the Trifolio thalii-Festucetum nigricantis of the Alps.

The distinctive physiognomy and the attractive floristic diversity of the Trifolio thalii-Festucetum puccinellii require a certain balance of grazing, traditionally by sheep. During recent decades, grazing was consistently reduced, notwithstanding this association remains the major permanent pasture type in the summit areas of the northern Apennines. That is because the Trifolio thalii-Festucetum puccinellii includes a great majority of palatable species and

several valuable herbage grasses and dicotyledons (*Festuca puccinellii*, *F. rubra* subsp. *commutata*, *Poa alpina*, *Trifolium thalii*, *T. pratense*, *Crepis aurea* subsp. *glabrescens*).

The floristic composition of the Trifolio thalii-Festucetum puccinellii is relatively constant and, therefore, this community can be regarded as a stable seminatural vegetation.

Also from a pedological standpoint, the Trifolio thalii-Festucetum puccinellii is a well defined plant community: in fact, in comparison with all the other pasture types occurring on the northern Apennines above the timberline, this one is related to soils having the highest pH values (from slightly acidic to subalkaline) and the highest levels of bases (particularly Ca), due to the presence of a more basic type of substratum. In general, soils of the Violet Fescue pastures are quite deep, with a well differentiated profile, consisting of a rather thick, highly humiferous mollic epipedon overlying a yellowish blocky cambic Bw horizon.

The different subassociations of the Trifolio thalii-Festucetum puccinellii are not equally distributed within the study area. The stands of the Trifolio thalii-Festucetum puccinellii typicum are few in number, small and fragmentary. This vegetation is usually disposed in small patches at the foot of N-facing rock walls, at sites with long snow cover. In general, the typical subassociation is restricted to the northern sector of the Apuan Alps.

The Trifolio thalii-Festucetum puccinellii alchemilletosum alpinae occurs in isolated stands on steep N-faced slopes subject to erosion. Its distribution is limited to the central part of the Tuscan-Emilian Apennines from M. Prado northwards to M. Spigolino southwards. This subassociation mostly occurs on very steep unstable slopes or in severely eroded areas, where rather shallow and stony AC profiles, with low contents of humus and bases are found.

The Trifolio thalii-Festucetum puccinellii plantaginetosum alpinae is found in larger stands in comparison with the other subassociation. It occurs from gentle to fairly steep snow-bound slopes, in and around areas where the snow melts late. The Trifolio thalii-Festucetum puccinellii plantaginetosum alpinae occurs locally in the central and southern sectors of the Tuscan-Emilian Apennines, ranging from Mt. Cusna in the North to Corno alle Scale in the South.

As outlined above, most of the floristic variation among the different variants of the Trifolio thalii-Festucetum puccinellii plantaginetosum alpinae is related to edaphic differences, particularly with regard to the chemical characteristics of the horizons. The presence of a calcareous matrix and subalkaline pH values, along with a very high base saturation, are, in fact, characteristic of the *Plantago atrata* variant, whereas on more acidic, less saturated soils the *Luzula lutea* variant is often found.

Appendix – List of the labels of the sites and geographical coordinates of the sites of relevés typus.

Apuan Alps: CV (M. Cavallo); TA (M. Tambura)

Tuscan-Emilian Apennines: (AD) Upper valley of Dardagna creek, close to "Le Malghe"; (BR) Balzo delle Rose; CA (Croce Arcana pass); CI (M. Cimone); CP (M. Cupolino); CS (Corno alle Scale); CU (M. Cusna); GI (M. Giovo); NU (M. Nuda); OM (Cima dell'Omo); PR (M. Prado); SB (Sassi Bianchi); SP (M. Spigolino); VP (Vista del Paradiso).

Geographical coordinates of the sites of relevés typus. Trifolio thalii-Festucetum puccinellii typicum (Tab. 2, Rel. 3): 44°06′42″N, 10°14′07″E; Trifolio thalii-Festucetum puccinellii alchemilletosum alpinae (Tab. 3, Rel. 3): 44°07′03″N, 10°49′06″E; Trifolio thalii-Festucetum puccinellii plantaginetosum alpinae (Tab. 4, Rel. 10) 44°09′44″N, 10°35′24″E.

Riassunto

I pascoli a festuca violacea dell'Appennino settentrionale sono stati studiati sulla base di 58 rilievi fitosociologici. La classificazione dei rilievi è stata eseguita con metodi di analisi statistica multivariata. Le unità vegetazionali risultanti dalla classificazione sono state attribuite all'associazione Trifolio thalii-Festucetum puccinellii, descritta per la prima volta in questa sede. L'associazione presenta un certo grado di eterogeneità floristica interna. Per questa ragione è stata suddivisa in tre subassociazioni distinte, localizzate in differenti settori geografici dell'Appennino settentrionale e caratterizzate da diverse condizioni ecologiche. Il Trifolio thalii-Festucetum puccinellii typicum è limitato alle Alpi Apuane in corrispondenza di substrati carbonatici e diasprini, mentre il Trifolio thalii-Festucetum puccinellii alchemilletosum alpinae e il Trifolio thalii-Festucetum puccinellii plantaginetosum alpinae si rinvengono soltanto nell'Appennino tosco-emiliano. Il Trifolio thalii-Festucetum puccinellii alchemilletosum alpinae è confinato ai versanti più acclivi, su substrati arenacei o marnoso-arenacei con suolo sottile. Il Trifolio thalii-Festucetum puccinelli plantaginetosum alpinae forma popolamenti elementari chiusi, su versanti meno acclivi su marne o arenarie, con suolo moderatamente profondo. Quest'ultima subassociazione è stata suddivisa in tre varianti, corrispondenti a differenti condizioni edafiche e microclimatiche.

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