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Phytosociological and ecological study of springs in Trentino (south-eastern Alps, Italy)

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ABSTRACT

A phytosociological survey of the crenic vegetation was made in Trentino (south-eastern Alps), combining the field method of the Braun-Blanquet approach with a numerical syntaxonomical analysis. A set of 139 phytosociological relevés, including vascular plants and bryophytes, were classified using cluster analysis. The vegetation types were assigned to 7 different phytosociological classes: Platyhypnidio-Fontinalietea antipyreticae*,* Montio-Cardaminetea*,* Adiantetea*,* Scheuchzerio-Caricetea nigrae*,* Molinio-Arrhenatheretea*,* Galio-Urticetea*,* Mulgedio-Aconitetea*. The classes* Platyhypnidio-Fontinalietea antipyreticae *and* Montio-Cardaminetea *represent the core of crenic vegetation, including permanently or intermittently submerged plant communities, mostly made up of bryophytes, or non-submerged communities dominated by bryophytes or vascular plants. The other classes include chasmophytic bryophyte-rich communities and hygrophilous or tall herb communities lying around the periphery of the springs. 23 vegetation types were identified and, whenever possible, classified at the association level, or as phytocoena. The environmental parameters showed different ranges among vegetation types. A number of environmental variables were recorded during the vegetation survey, including altitude, shading, discharge, flow velocity, with exhaustive hydrochemical sampling. Conductivity, alkalinity and pH showed similar distribution patterns, clearly separating the vegetation types into two distinct groups, differing in the nature of the substratum. The altitudinal range was very broad and shading was also very variable. Nitrate and phosphate levels showed that the majority of vegetation types were irrigated by oligotrophic crenic waters. Finally, the bryophyte-dominated vegetation types belonging to the class* Platyhypnidio-Fontinalietea antipyreticae *occurred in springs with the highest discharge values and variation. Discriminant analysis confirmed that the environmental descriptors that best accounted for the among-group variation were pH and alkalinity (first variate); the second variate reflected a gradient of altitude and discharge.*

Key words: crenon, vegetation, phytosociology, numerical syntaxonomy

1. INTRODUCTION

Interest in the description of crenic vegetation depends mainly on its very peculiar floristic composition (Zechmeister & Mucina 1994). The bulk of the crenic flora in montane regions is, in fact, composed of species adapted to particular habitat conditions, such as constant low water temperature, high air humidity (also in summer) and high oxygen saturation, due to the frequently turbulent water flow (Cantonati *et al*. 2006). In particular, the constancy of thermal conditions in this habitat leads to the establishment of stenothermic plants, many being relicts of past climatic periods, that survive in this typical refugial habitat (Wilmanns 1989).

Crenic vegetation is typically composed of a mixture of vascular plants and bryophytes, with the former prevailing in shaded sites at lower altitudes, and the latter dominating the communities of open habitats, from the subalpine to alpine vegetation belts (Zechmeister & Mucina 1994; Spitale *et al*. 2009).

Vegetation diversity in springs is primarily determined by a combination of interacting physical and chemical factors. Of the physical factors, solar radiation, water temperature, and current flow velocity play a major role in determining floristic diversity and structure in crenic vegetation (Hinterlang 1992). The most important hydrochemical factors are pH, water hardness, oxygen saturation and nutrient content (Warnke & Bogenrieder 1985). Duration of snow cover, which affects duration of the growing season, can also play an important role in conditioning crenic vegetation diversity at high altitudes (Zechmeister & Mucina 1994).

Despite its undisputable floristic and ecological interest, very few geobotanists and plant ecologists have focussed their attention on crenic vegetation. Maas (1959) produced an historical, comprehensive monograph on the crenic vegetation of Central Europe. In the Alps, crenic vegetation has mostly been sampled and characterised within comprehensive surveys of particular areas, where its contribution is limited (Braun-Blanquet & Braun-Blanquet 1931; Guinochet 1938; Braun-Blanquet 1954; Giacomini & Pignatti 1955; Wikus 1960; Giacomini *et al*. 1962; Boiti *et al*. 1989; Herter 1990; Theurillat 1992; Gerdol 1994; Dirnböck *et al*. 1999). Moreover, the definition and classification of crenic vegetation types is uneven across these accounts. Very few authors have published regional studies centred on bryophyte-dominated crenic vegetation (Hébrard 1973; Miserere & Buffa 2001). The only general monograph devoted to the springs of the Alps is that of

Geissler (1976), however this is restricted to sites within the alpine vegetation belt.

This paper aims to fill this gap by providing a regional survey focused on the crenic vegetation of part of the south-eastern Italian Alps. For the first time, a systematised sampling technique is applied across the crenic vegetation, along an altitudinal gradient from the collinar to the alpine vegetation belt. The data on physical and chemical variables collected in the field were primarily used to characterise the vegetation types from an ecological viewpoint. We also tried to identify the major environmental determinants of crenic vegetation, which control crenic floristic diversity in the area.

2. METHODS

2.1. The study area

The research was conducted in the Autonomous Province of Trento (the geographic name of the area is Trentino), located in the south-eastern Italian Alps. More than 100 springs, representing habitat variability in the area, were identified on the basis of specific and standardized requirements, such as perennial flow and naturalness (no man-made water-collection systems). 81 springs, distributed homogenously throughout the Province, were selected for the study. All the morphological types distinguished by Thienemann (1922), from seepages and tufa springs to large karstic rheocrenes, were sampled. The springs were located over a wide altitudinal range (from 170 to 2792 m a.s.l.), from the collinar to the nival vegetation belt, and on a variety of lithologies, from limestones and dolomites, to siliceous rocks (metamorphic, microcrystalline, crystalline). A more detailed description of the whole environmental dataset can be found in Spitale *et al*. (2009).

2.2. Field sampling

Vegetation in the 81 selected springs was sampled systematically according to the phytosociological method (Braun-Blanquet 1964; Westhoff & van der Maarel 1973). Sampling was conducted once at all sites during the summers of 2005 and 2006. 139 relevés were taken in relatively uniform stands, whose delimitation was the first critical step. As explained in Tomaselli (2007), we defined "spring area" as the surface influenced by the water flowing from the spring (i.e. the surface covered by flushing water and the area reached by water spray). Within this area, we identified homogeneous stands in which both floristic composition and structure were relatively uniform. Because springs frequently have a mosaic structure, we ensured that we sampled all relevant homogeneous patches inside the spring area. For each phytosociological relevé a visual estimate of the cover-abundance of each species was carried out according to the Braun-Blanquet scale: *r* (one or few individuals with negligible cover); + (occasional individuals and <1% cover); 1 (1-5% cover); 2 (>5-25%) cover; 3 (>25-50% cover); class 4 (>50-75% cover); class 5 (>75-100%).

The geographical coordinates and altitude of each spring were recorded by GPS (Garmin GPSMAP 76S). Temperature was recorded in the field using a digital probe, and the highest current velocity was measured with an OTT propeller flow meter. In large springs the velocity/area method (e.g., Gordon *et al*. 2004) was applied, whereas in small springs discharge estimates were made using graduated containers and a chronometer. Water for hydrochemical analyses (including the measurement of pH, conductivity and nutrients) was collected in acid-cleaned graduated bottles, following the standard methods of the American Public Health Association (APHA 2000). As indicator of shading, canopy was estimated visually in four classes: 1 = 0 ÷ 25%, 2 = 25 ÷ 50%, 3 = 50 ÷ 75%, and 4 = 75 ÷ 100% (Spitale 2007).

2.3. Vegetation analysis

The original 139 vegetation relevés were first classified into phytosociological classes, according to the species fidelity principle (Braun-Blanquet 1964). The bulk of the original set (127 relevés) was then divided into two subsets. These correspond to permanently or intermittently submerged plant communities mostly made up of bryophytes (*Platyhypnidio-Fontinalietea antipyreticae* class), and to non-submerged, or only occasionally submerged, plant communities dominated by bryophytes or vascular plants (*Montio-Cardaminetea* class). The residual 12 relevés form a further small, heterogeneous subset including chasmophytic bryophyte-rich communities and hygrophilous and tall herb communities around the inner margins of the springs. Both subsets were subjected to numerical classification to obtain clusters of relevés. The Braun-Blanquet cover-abundance estimates for all species of every relevé were transformed according to van der Maarel (1979). The clustering procedure used the incremental sum of squares based on the chord distance. Computations were performed using SYN-TAX 2000 (Podani 2001).

The clusters obtained were considered as local vegetation types to be compared with the Braun-Blanquet syntaxa. Comparisons were based both on local monographic studies (Gerdol & Tomaselli 1988; 1997; Marstaller 1987; Schmidt 1993; Privitera & Puglisi 2004) and more general vegetation surveys covering broader areas (Geissler 1976; Philippi & Oberdorfer 1992; Grabherr & Mucina 1993; Mucina *et al*. 1993; Zechmeister 1993; Zechmeister & Mucina 1994). The list of diagnostic vascular species was compiled from these authors, whereas that for bryophytes was integrated from Dierßen (2001).

Several relevé clusters were evaluated as independent vegetation units, but they could not be referred to an association, because the dominant species had weak diagnostic power and no other species could be retained

as characteristic. We decided to classify each relevé cluster as a phytocoenon following the suggestion of Kopecký & Hejný (1978). The different phytocoena were designated by the names of the dominant species.

Species nomenclature follows Aeschimann *et al*. (2004) for vascular plants, Hill *et al*. (2006) for mosses and Ros *et al*. (2007) for liverworts. Nomenclature of the syntaxa follows Zechmeister (1993) and Zechmeister & Mucina (1994) and is in accordance with the rules of the "Code of Phytosociological Nomenclature" (Weber *et al*. 2000).

2.4. Ecological inferences

Variation ranges of environmental parameters within the vegetation types were tabulated, indicating median, lower and upper quartiles. To determine the extent to which a set of environmental variables explained the phytosociological grouping, we performed a discriminant analysis (Legendre & Legendre 1998). We first tested the different functions for statistical significance, retaining only significant functions for further examination. Significance was tested (1) by computing the Wilks lambda (which assumes values of 0 = perfect discrimination, to 1 = no discrimination) and (2) by a chi-square statistic. To interpret the discriminant functions we reported the structure coefficients for each variable for each significant function. The factor structure coefficients are the correlations between the variables in the model and the discriminant functions. Finally, in order to determine which groups are discriminated by respective functions, we projected the group centroids in the canonical discriminant space. Only associations and phytocoena that occurred at least twice were used for the analysis.

3. RESULTS

3.1. Vegetation analysis

3.1.1. Submerged bryophyte vegetation (*Platyhypnidio-Fontinalietea antipyreticae*)

A first classification dendrogram of 34 phytosociological relevés is shown in figure 1a. It includes the phytosociological relevés inside stands of permanently or intermittently submerged plant communities, almost exclusively composed by bryophytes.

All the relevés in the dendrogram can be incorporated within the class *Platyhypnidio-Fontinalietea antipyreticae*, comprising bryophyte communities forming a submerged stratum within fast-flowing springs, from the collinar to the montane vegetation belt. Five different communities were recorded in the study area.

1. Scapanietum undulatae (SU - Tab. 1)

Cluster SU includes 4 relevés where *Fontinalis antipyretica* (generally dominant) and *Scapania undulata* are the only constant bryophytes. Few other bryophythes occur with any frequency and, of them, only *Plagiochila porelloides* attains a measure of prominence. Vascular plants are few in number and typically of low cover.

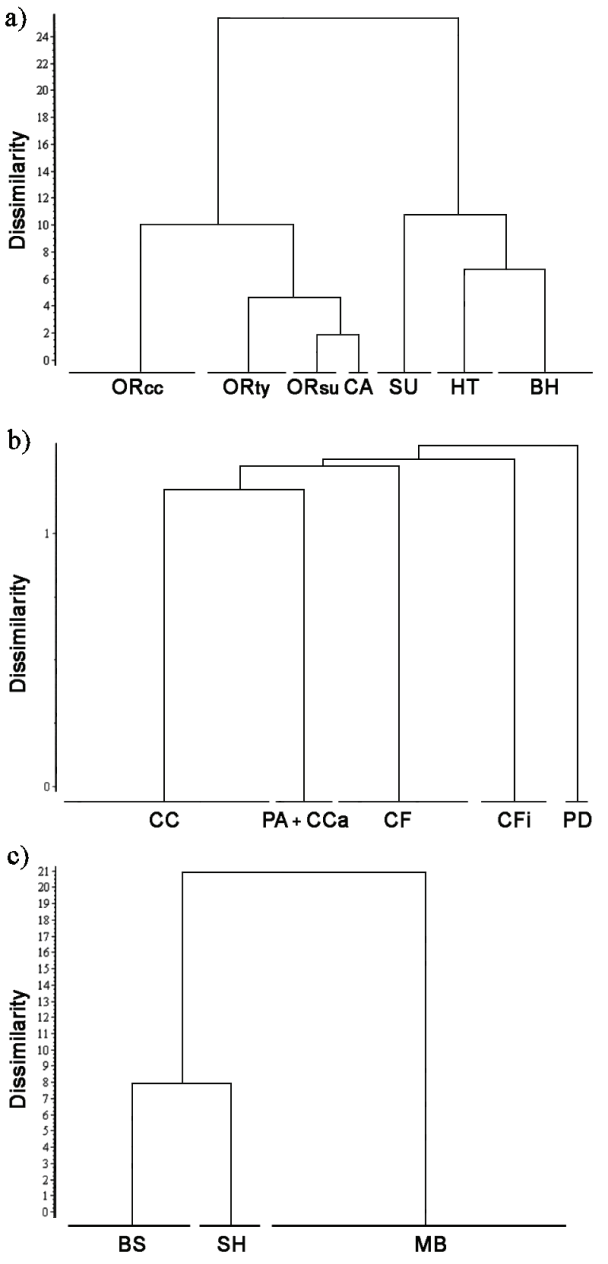

Fig. 1. Dendrogram of vegetation types: a) class *Platyhypnidio-Fontinalietea antipyreticae*; b) alliance *Cratoneurion commutati*; c) alliance *Cardamino-Montion*. Acronyms as in the text.

The plant community is comparatively close to the *Scapanietum undulatae* subass. *fontinalietosum antipyreticae*, owing to the constancy of both the character species of the association (*Scapania undulata*) and the differential species of the subassociation (*Fontinalis antipyretica*). Relevé 4 is differentiated by the domi-

nance of *Plagiochila porelloides* and by the prominence of *Porella platyphylla* (variant of *Plagiochila porelloides*).

In the study area, the association is the only representative of the alliance *Racomitrion acicularis* and of the order *Brachythecietalia plumosi*, including the acidophilous communities dominated by submerged bryophytes on siliceous substrata, from the collinar to the subalpine vegetation belt.

The *Scapanietum undulatae* usually occurs within montane springs, irrigated strongly by base-poor and oligotrophic waters. The subassociation *fontinalietosum antipyreticae* and the variant of *Plagiochila porelloides* correspond to somewhat more disturbed habitats with nutrient-enriched (mostly nitrogen) crenic waters.

2. Oxyrrhynchietum rusciformis (OR - Tab. 2)

Cluster OR includes 18 relevés in which *Platyhypnidium riparioides* is the only constant bryophyte, almost always dominant or codominant. The only other, relatively frequent, bryophyte is the moss *Palustriella commutata*, which is sometimes so abundant as to be codominant or dominant. Other locally prominent bryophytes are *Brachythecium rivulare*, *Scapania undulata*, *Jungermannia atrovirens* and *Cratoneuron filicinum*. The associated vascular flora is fairly consistent, contributing about one third of species richness of the community. Nevertheless, vascular species only occur occasionally, even if their cover is often remarkable (mostly *Cardamine amara*).

Platyhypnidium riparioides is a typical moss of fast-flowing and well oxygenated crenic waters. Because it can be encountered on both limestone and siliceous substrata, it occurs within a variety of submerged crenic communities (Schmidt 1993). Nevertheless, *Platyhypnidium riparioides* reaches a peak of abundance within the *Oxyrrhynchietum rusciformis* association, of which it is considered a weak character species (Marstaller 1987). Our 18 relevés can be clearly allocated to this association, the only one within the *Platyhypnidion rusciformis* alliance, belonging to the order *Leptodictyetalia riparii*. This order includes the submerged bryophyte communities of springs found within the collinar vegetation belt, irrigated by neutral to alkaline waters (Schmidt 1993).

From the classification dendrogram (Fig. 1a) the *Oxyrrhynchietum rusciformis* is a fairly heterogeneous vegetation type. The particularly species-poor subcluster ORty (rel. 1-6) corresponds to the typical subassociation. Within the subassociation a variant differentiated by *Cratoneuron filicinum* can be identified (rel. 5-6). The subcluster ORcc (rel. 7-15) is noticeably less species-poor than the typical subassociation, from which it is clearly differentiated by the prominence of *Palustriella commutata* and the occurrence of several vascular species. It can be referred to the *Oxyrrhynchietum rusciformis* subass. *cratoneuretosum commutati*, first described by Schmidt (1993) from central Germany. Finally, the subcluster ORsu (rel. 16-18), showing clear transitional features to the *Scapanietum undulatae*, can be assigned to the *Oxyrrhynchietum rusciformis* subass. *scapanietosum undulatae*, first typified by Marstaller (1987).

The *Oxyrrhynchietum rusciformis* is the submerged bryophyte community most commonly found in the study area. Both the *Oxyrrhynchietum rusciformis typicum* and the subassociation *cratoneuretosum commutati* are restricted to the collinar vegetation belt, in springs flowing from limestone substrata, with alkaline, base-rich, calcareous and mesotrophic waters. The *Oxyrrhynchietum rusciformis scapanietosum undulatae* has a very local distribution at a spring within the montane vegetation belt on a porphyritic substratum. Crenic waters are neutral, base-poor and oligotrophic.

3. Cinclidotetum aquatici (CA - Tab. 3)

This community (cluster CA) corresponds to an extremely species-poor stand dominated by the water moss *Cinclidotus aquaticus*, also including *Platyhypnidium riparioides* as the only other species. *Cinclidotus aquaticus* is a robust moss with strongly thickened leaf margins, adapted to fast-flowing waters. It has been reported as abundant on submerged carbonate rocks, especially in large karstic systems subjected to summer drought (Reynolds 1998).

The stand can be regarded as a floristically impoverished form of the association *Cinclidotetum aquatici*, that is placed in the alliance *Cinclidotion fontinaloidis* and in the order *Leptodictyetalia riparii*. The alliance includes crenic bryophyte communities occurring on limestone, which are intermittently irrigated in the summer.

A stand of the *Cinclidotetum aquatici* occurs in the collinar belt of the southern slopes of the Brenta Dolomites, within the Rio Bianco spring, which has a very high discharge flow and alkaline, base-rich, calcareous and nutrient-rich waters.

4. Brachythecio rivularis-Hygrohypnetum luridi (BH - Tab. 4)

Cluster BH includes 7 relevés in which the moss *Brachythecium rivulare* is generally the most abundant and only constant plant, and other bryophytes (mainly *Palustriella commutata* and *Plagiomnium undulatum*) can sometimes contribute to the mat. Moreover, the floristic composition of these relevés is markedly enriched by the vascular element, with *Cardamine amara* being relatively frequent, and *Geranium robertianum* and *Epilobium alsinifolium* locally prominent.

Our vegetation relevés have sufficient floristic similarity with the *Brachythecio rivularis-Hygrohypnetum luridi* to be subsumed within it. The absence of the differential species *Hygrohypnum luridum* does not negate this syntaxonomical diagnosis, because it also occurs in other phytosociological tables of the associa-

tion (Marstaller 1987, Schmidt 1993). Nevertheless, the dominant moss *Brachythecium rivulare* can be regarded no more than a weak character species of the association, due to its broad ecological amplitude (Dierßen 2001). The *Brachythecio rivularis-Hygrohypnetum luridi* belongs within the alliance *Brachythecion rivularis*, including the amphibian neutro-basophilous associations colonizing running waters, from the plain to the alpine belts.

As reflected in the classification dendrogram, the *Brachythecio rivularis-Hygrohypnetum luridi* exhibits a certain degree of floristic heterogeneity. According to Schmidt (1993) relevés 1-4 can be assigned to the typical variant of the association, whereas relevés 5-7 correspond to the subvariant of *Rhizomnium punctatum*.

The stands of the *Brachythecio rivularis-Hygrohypnetum luridi* are only intermittently submerged and occur in springs flowing from limestone outcrops (except for rel. 1). Crenic waters are generally alkaline, base-rich, calcareous and oligotrophic. The typical variant was encountered only in the montane vegetation belt, whereas the subvariant of *Rhizomnium punctatum* seems to be restricted to the high-collinar one.

5. Phytocoenon of *Hygroamblystegium tenax* (HT - Tab. 5)

Cluster HT includes 4 relevés, in which *Hygroamblystegium tenax* is the only constant species, also occurring as dominant or, in one case, as codominant. Other relatively frequent bryophytes are *Brachythecium rivulare* and *Conocephalum conicum*. Vascular species are few in number, concentrated within rel. 3 and not abundant (except *Cardamine amara*).

From the floristic viewpoint, the community shows clear affinities with the *Brachythecio rivularis-Hygrohypnetum luridi*, as reflected in the classification dendrogram (Fig. 1a). It is, however, fairly well distinguished from this association, mainly by the constancy of *Hygroamblystegium tenax* and the occurrence of *Conocephalum conicum*. Considering that the community seems to be floristically unique, we assigned it to a phytocoenon of *Hygroamblystegium tenax*. This syntaxonomic choice is only provisional, because this type of vegetation has been under-sampled in the project; further study may characterise it better.

The phytocoenon of *Hygroamblystegium tenax* is restricted to the collinar vegetation belt. Crenic waters are alkaline, base-rich, calcareous and mesotrophic.

3.1.2. Non-submerged bryophyte or vascular plant vegetation (*Montio-Cardaminetea*)

About two thirds of relevé set (93) include crenic communities only occasionally submerged by flowing waters. Bryophytes are dominant in most stands, forming dense mats from which vascular plants, of minor structural importance, emerge, although some of them can sometimes be abundant. Vascular plants only achieve constant dominance in shaded stands.

All non-submerged crenic communities are grouped together in the comprehensive class *Montio-Cardaminetea*, with its single order, the *Montio-Cardaminetalia* (Zechmeister & Mucina 1994). The largest component of the order is the alliance *Cratoneurion commutati*, including the most species-rich communities, usually occurring on carbonate substrata. Other alliances represented in the study area are the *Cardamino-Montion*, including crenic communities on siliceous substrata, with oligotrophic and acidic waters, and the *Caricion remotae*, whose communities, occurring at oligophotic sites, are dominated by phanerogams.

CRATONEURION COMMUTATI

The numerical classification of 49 relevés which could readily be incorporated within the *Cratoneurion commutati* produced a dendrogram, in which six different plant communities can be distinguished (Fig. 1b). Most of them exhibit marked bryophyte dominance. In only two communities do dominant tall herbs form a thick herbaceous layer, whose shading effect inhibits the development of a dense bryophyte carpet.

6. Cratoneuretum commutati (CC - Tab. 6)

The community (cluster CC) includes 21 relevés in which the moss, *Palustriella commutata*, is consistently dominant, often forming mounds or banks. Other bryophytes that contribute to the mat, although typically in a minor way, are *Bryum pseudotriquetrum*, *Plagiomnium undulatum*, *Palustriella falcata*, *Brachythecium rivulare* and *Conocephalum conicum*. Vascular plants are numerically predominant compared to bryophytes, but many are only scattered in occurrence and have low cover values. Several species (*Crepis paludosa*, *Deschampsia caespitosa*, *Petasites albus*, *Chaerophyllum hirsutum*) contribute relatively frequently, occasionally with consistent abundance.

Palustriella commutata is a eurasiatic moss normally found in mineral-rich springs on carbonate substrata, under relatively mild climatic conditions. It is regarded as the only character species of the association *Cratoneuretum commutati*, to which our stands correspond closely. Relevés 17 to 21 are clearly differentiated by the constancy and significant occurrence of the moss *Palustriella falcata*. They are to be assigned to a variant of *Palustriella falcata*, which can be seen as a floristic transition to the following community (*Cratoneuretum falcati*). The higher species richness of these relevés confirms their ecotonal floristic nature.

The *Cratoneuretum commutati* is an association occurring on permanently moist ground, irrigated by base-rich, calcareous, oligotrophic to mesotrophic waters. In most cases the association has the character of a flush, with the dominant moss forming a carpet over gently-sloping ground; more rarely it can occur

over steep surfaces. The *Cratoneuretum commutati* is the most widespread *Cratoneurion commutati*-community in the study area, where it spans a wide altitudinal range. The typical form occurs from the upper collinar to the montane vegetation belt, whereas the *Palustriella falcata* variant is restricted to the upper montane vegetation belt and is irrigated by slightly more oligotrophic waters.

7. Cratoneuretum falcati (CF - Tab. 7)

This community, corresponding to the cluster CF, was sampled through 15 relevés. Most of them are characterized by the large predominance of the moss *Palustriella falcata*, a circumboreal species that can colonise irrigated calcareous rocks, springs and fens (Dierßen 2001). Only two other bryophytes (*Palustriella commutata* and *Bryum pseudotriquetrum*) have more than 50% frequency. Globally, this community is poorer in vascular species than the *Cratoneuretum commutati*, and vascular plants occur sporadically and with generally low cover. In some stands only *Epilobium alsinifolium* and *Cardamine amara*, and *Caltha palustris* and *Carex paniculata* (two sites) can attain prominence.

Relevés 1-6, are particularly species-poor and here *Palustriella falcata* achieves its maximum prevalence. They correspond to a floristically impoverished form of the association *Cratoneuretum falcati* that is distributed throughout the Alps. Relevés 7-13 are less species-poor and differentiated by the constant and prominent occurrence of *Palustriella commutata*. They correspond to a variant of *Palustriella commutata* of the *Cratoneuretum falcati* and have a clear transitional nature towards the *Cratoneuretum commutati*. Relevé 14 and 15 are differentiated by the cover peaks of *Caltha palustris* and *Carex paniculata*, respectively. They are treated here as further variants of the *Cratoneuretum falcati*.

The impoverished form of the *Cratoneuretum falcati* was encountered in springs from the upper montane to the subalpine vegetation belt, whereas the variant of *Palustriella commutata* seems to be restricted to the montane one. Crenic waters of both types are base-rich and calcareous. Trophic status ranges from (more frequently) oligotrophic in the impoverished form, to (generally) mesotrophic in the variant of *Palustriella commutata*. The variant of *Caltha palustris* occurs along the edge of a spring flowing from dolomite rocks; whereas the variant of *Carex paniculata* was sampled within a sulphurous helocrene.

8. Phytocoenon of *Cratoneuron filicinum* (CFi – Tab. 8)

This community (cluster CFi) comprises 7 somewhat heterogeneous relevés from the floristic viewpoint. Floristically, the lowest common denominator is the occurrence of the moss *Cratoneuron filicinum* as a constant and dominant species within the bryophyte layer, where *Palustriella commutata* and *Philonotis calcarea* are also fairly frequent and abundant. The associated vascular flora includes a majority of sporadical species, with several that can be locally conspicuous (*Cardamine amara*, *Mentha longifolia*, *Rorippa amphibia*, *Epilobium parviflorum*).

This distinctive vegetation type is syntaxonomically rather isolated. Bryophyte species such as *Cratoneuron filicinum*, *Palustriella commutata* and *Philonotis calcarea* provide a link with the crenic communities of the *Cratoneurion commutati*, whereas the occurrence of *Mentha longifolia*, *Rorippa amphibia* and *Epilobium parviflorum* suggests some affinity with disturbed habitats within the class *Molinio-Arrhenatheretea*. In spite of this floristic ambiguity, the community can be placed inside the alliance *Cratoneurion commutati*, as a phytocoenon of *Cratoneuron filicinum*. It is impossible to arrange it as a true association, due to the broad ecological amplitude of the dominant moss. Relevés 6 and 7 are distinguished by the exclusive occurrence of *Rorippa amphibia*, *Epilobium parviflorum* and *Calliergonella cuspidata*, differentiating a variant of *Rorippa amphibia*.

The phytocoenon of *Cratoneuron filicinum* is a prevalently collinar crenic vegetation, sometimes occurring at anthropogenically disturbed sites. The dominant moss is relatively common at lower altitudes and it seems to be characteristic of somewhat eutrophic waters (Birse 1980; Philippi & Oberdorfer 1992). In our samples the waters are base-rich, calcareous, generally mesotrophic and, occasionally eutrophic, due to agricultural nitrate input.

9. Phytocoenon of *Palustriella decipiens* (PD – Tab. 9)

Palustriella decipiens is a eurasiatic moss that is preferentially encountered on calcareous micaschists in crenic waters with low mineral content (Dierßen 2001). It must also survive more severe climates than *Palustriella commutata*. We sampled a crenic stand in which *Palustriella decipiens* was largely dominant within a floristic assemblage with low bryophyte number and cover and numerically prevalent, and sometimes prominent, vascular plants. Due to the prominence of *Palustriella decipiens* this unique relevé was located in the alliance *Cratoneurion commutati*. Too little phytosociological material is available to typify the community at the association level.

The phytocoenon of *Palustriella decipiens* occurs in a spring in the upper montane belt of the Fassa Dolomites. Crenic waters are relatively base-rich, calcareous and oligotrophic.

10. Chaerophyllo-Cardaminetum asarifoliae (CCa - Tab. 10)

This community occurs very rarely in the study area, being recorded from only one site. From the floristic viewpoint, the sampled stand is overwhelmingly dominated by the tall perennial herb, *Cardamine asarifolia*,

with *Cirsium montanum*, *Chaerophyllum hirsutum* and *Petasites albus* the most prominent vascular associates. Bryophytes are scarcer than in the other *Cratoneurion commutati* communities. Only *Brachythecium rivulare*, *Cratoneuron filicinum*, *Plagiomnium undulatum* attain extensive cover.

The most obvious floristic affinities of this stand are with the *Chaerophyllo-Cardaminetum asarifoliae*. This association was described by Gerdol & Tomaselli (1988) from the Northern Apennines, where it occurs on acidic sandstone outcrops. In contrast, our stand occurs on lime-rich bedrock, which explains some of the floristic differences with the Apennine stands. For this reason, it is possible to distinguish a calcicolous *Petasites albus*-variant of the original *Chaerophyllo-Cardaminetum asarifoliae.*

This variant was encountered at a spring in the montane vegetation belt, irrigated by base-rich, calcareous and mesotrophic waters.

11. Phytocoenon of *Petasites albus* (PA -Tab. 11)

This community corresponds to the PA cluster and was sampled through four relevés. It comprises fragmentary stands united by the dominance of the tall herb *Petasites albus*. As a group, vascular plants make the most notable contribution to the vegetation cover, with *Cirsium montanum*, *Chaerophyllum hirsutum* and *Crepis paludosa* the most frequent associates, and *Eupatorium cannabinum* occasionally prominent. Bryophytes may also contribute to the ground cover, though as a group they are far less frequent and abundant than the vascular plants. *Palustriella commutata* and *Cratoneuron filicinum* are the most prominent bryophyte species.

The community is fairly variable in its floristics, although invariably characterized by the dominance of *Petasites albus*. Because this species has only a weak diagnostic power, the community could not be typified at the association level, but only as a phytocoenon of *Petasites albus*. This was accommodated within the *Crautonerion commutati*, based on the frequent occurrence of several species belonging to this alliance.

The phytocoenon of *Petasites albus* bears some floristic resemblance to the *Petasites albus*-variant of the *Chaerophyllo-Cardaminetum asarifoliae*, from which it differs mainly by the impoverished combination of characteristic species and the occurrence of several tall hygrophilous herbs belonging to the alliance *Calthion*. These floristic differences can be explained; the phytocoenon of *Petasites albus* generally forms a transition zone around the spring core.

The phytocoenon is restricted to the montane vegetation belt and to lime-rich outcrops. Waters are base-rich, calcareous and from oligotrophic to mesotrophic.

Tab. 1. *Scapanietum undulatae* (SU). (D) = differential species.

Relevè n.	1	2	3	4	Fr (%)
Spring Code	AD1353	CV1435	CV1421	AD1353	
Altitude (m a.s.l.)	1353	1435	1421	1353	
Inclination (°)	1	3	20	70	
Relevé area (m^2)	1.5	1	1	0.4	
Vascular plant cover (%)	-	-	15	-	
Bryophyte cover (%)	100	90	80	90	
N. of species	2	5	6	4	
SCAPANIETUM UNDULATAE RACOMITRION ACICULARIS and BRACHYTHECIETALIA PLUMOSI					
Scapania undulata	1	1	2	2	100
Subass. FONTINALIETOSUM ANTIPYRETICAE					
Fontinalis antipyretica (D)	5	5	4	1	100
PLAGIOCHILA PORELLOIDES - variant					
Plagiochila porelloides (D)	.	.	.	4	25
PLATYHYPNIDIO-FONTINALIETEA ANTIPYRETICAE					
Brachythecium rivulare	.	+	.	.	25
COMPANIONS MONTIO-CARDAMINETEA					
Cardamine amara	.	.	1	.	25
Saxifraga stellaris	.	.	1	.	25
OTHER COMPANIONS					
Porella platyphylla	.	.	.	2	25
Crepis paludosa	.	.	+	.	25
Plagiothecium cavifolium	.	+	.	.	25
Rhizomnium magnifolium	.	+	.	.	25

Tab. 2. *Oxyrrhynchietum rusciformis* (OR). (D) = differential species.

Relevè n.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Fr (%)
Spring Code	BR0470	BR0679	BR0470	MB0335	CV0992	LD0584	AD0905	SC0250	PG0474	LD1160	AD0905	LD0584	PG0453	MB0335	BR0679	CV1200	CV1200	CV1200	
Altitude (m a.s.l.)	470	679	470	335	992	586	905	250	474	1160	905	586	453	335	679	1200	1200	1200	
Inclination (°)	50	20	50	10	5	10	5	5	5	30	5	10	70	15	20	3	70	90	
Relevé area (m^2)	0.5	0.5	0.5	0.7	2.3	0.5	4	0.8	1.2	3	1.5	0.6	2	2	2	0.7	0.8	1.2	
Vascular plant cover (%)	-	-	-	-	5	-	40	30	15	15	-	-	5	30	40	-	-	10	
Bryophyte cover (%)	100	100	95	60	60	90	40	90	90	80	50	80	90	90	80	80	90	80	
N. of species	1	3	4	2	5	2	9	6	7	6	8	6	9	12	18	5	2	6	
Rare species	-	-	-	-	1	-	3	-	2	1	-	1	3	4	5	1	-	2	
OXYRRHINCHIETUM RUSCIFORME																			
PLATYHYPNIDION RUSCIFORME																			
Platyhypnidium riparioides	5	5	4	3	3	3	2	3	2	2	2	3	4	4	3	2	3	3	100
CRATONEURON FILICINUM-variant																			
Cratoneuron filicinum (D)	.	.	.	.	1	3	.	.	.	.	1	.	.	.	.	.	.	.	12
Subass. CRATONEURETOSUM COMMUTATI																			
Palustriella commutata (D)	.	1	2	.	.	.	+	2	4	2	2	3	3	3	3	.	.	.	59
Subass. SCAPANIETOSUM UNDULATAE																			
Scapania undulata (D)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	3	3	18
LEPTODYCTYETALIA RIPARII																			
PLATYHYPNIDIO-FONTINALIETEA ANTIPYRETICAE																			
Brachythecium rivulare	.	.	.	.	.	.	1	1	1	3	2	.	.	.	.	.	.	.	24
Hygrohypnum luridum	.	.	.	.	1	.	.	.	.	.	+	2	+	.	.	.	.	.	18
Hygroamblystegium tenax	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	2	18
Chyloscyphus polyanthos	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	+	12
COMPANIONS																			
MONTIO-CARDAMINETEA																			
Cardamine amara	.	.	.	.	.	.	2	2	1	.	.	.	.	.	.	.	.	.	18
Palustriella falcata	.	.	.	.	.	.	1	.	.	.	2	.	.	.	.	.	.	.	6
Stellaria alsine	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	6
Chrysosplenium alternifolium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	6
OTHER COMPANIONS																			
Jungermannia atrovirens	.	.	.	2	.	.	+	.	.	.	1	.	2	2	.	.	.	.	24
Eurhynchium striatum	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	.	.	.	12
Phyllitis scolopendrium	.	.	.	.	.	.	.	.	.	.	.	1	.	2	.	.	.	.	12
Plagiomnium undulatum	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	.	.	.	12
Chaerophyllum hirsutum	.	.	.	.	.	.	.	.	.	.	.	.	.	r	2	.	.	.	12
Cirsium montanum	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1	.	.	.	12
Pellia epiphylla	.	1	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	12
Saxifraga rotundifolia	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1	.	.	12
Kindbergia praelonga	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	12
Geranium robertianum	.	.	.	.	.	.	.	r	.	.	.	.	.	.	1	.	.	.	12
Plagiomnium rostratum	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	12
Viola biflora	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	r	.	.	12
Eupatorium cannabinum	.	.	.	.	.	.	.	.	.	.	.	.	+	.	r	.	.	.	12
Mycelis muralis	.	.	+	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	12

Tab. 3.*Cinclidotetum aquatici* (CA).

Relevè n.	1
Spring Code	BR0686
Altitude (m a.s.l.)	686
Inclination (°)	5
Relevé area (m^2)	0.8
Vascular plant cover (%)	-
Bryophyte cover (%)	100
N. of species	2
CINCLIDOTETUM AQUATICI	
CINCLIDOTION FONTINALOIDIS	
Cinclidotus aquaticus	5
LEPTODYCTYETALIA RIPARII	
PLATYHYPNIDIO-FONTINALIETEA ANTIPYRETICAE	
Platyhypnidium riparioides	1

Tab. 4. Brachythecio rivularis-Hygrohypnetum luridi (BH). (D) = differential species.

Relevè n.	1	2	3	4	5	6	7	Fr (%)
Spring Code	AD1300	PS1880	BR1315	BR1315	BR0804	MP0656	MP0656	
Altitude (m a.s.l.)	1300	1880	1315	1315	804	656	656	
Inclination (°)	4	30	5	1	5	5	15	
Relevé area (m^2)	0.5	1	0.6	1.2	1.5	3.4	2.3	
Vascular plant cover (%)	-	30	20	30	80	15	55	
Bryophyte cover (%)	60	85	90	80	95	100	90	
N. of species	3	3	8	4	10	6	9	
Rare species	-	1	3	-	2	1	3	
BRACHYTHECIO RIVULARIS-HYGROHYPNETUM LURIDI								
BRACHYTHECION RIVULARIS								
Brachythecium rivulare	4	3	5	5	4	3	2	100
RHIZOMNIUM PUNCTATUM-subvariant								
Plagiomnium undulatum (D)	.	.	.	.	+	3	2	43
Rhizomnium punctatum (D)	.	.	.	.	.	.	3	14
LEPTODYCTYETALIA RIPARII								
PLATYHYPNIDIO-FONTINALIETEA ANTIPYRETICAE								
Chyloscyphus polyanthos	1	.	.	.	.	.	.	14
COMPANIONS								
MONTIO-CARDAMINETEA								
Cardamine amara	.	1	1	1	3	.	.	57
Palustriella commutata	.	.	+	.	2	1	2	57
Epilobium alsinifolium	.	.	3	2	.	.	.	29
Cratoneuron filicinum	.	.	.	.	1	.	.	14
Palustriella falcata	.	.	.	1	.	.	.	14
OTHER COMPANIONS								
Geranium robertianum	.	.	.	.	2	2	1	43
Chaerophyllum hirsutum	1	.	+	.	1	.	.	43
Crepis paludosa	.	.	.	.	r	+	1	43

Tab. 5. Phytocoenon of *Hygroamblystegium tenax* (HT). (D) = differential species.

Relevè n.	1	2	3	4	Fr (%)
Spring Code	BR0470	BR0470	CV0250	BC0170	
Altitude (m a.s.l.)	470	470	250	170	
Inclination (°)	75	75	5	5	
Relevé area (m2)	0.5	0.8	3	1	
Vascular plant cover (%)	-	-	40	-	
Bryophyte cover (%)	90	95	60	70	
N. of species	4	6	8	4	
Phytocoenon of HYGROAMBLYSTEGIUM TENAX					
Hygroamblystegium tenax	3	2	3	3	100
BRACHYTHECION RIVULARIS					
Brachythecium rivulare	.	3	2	.	50
Conocephalum conicum (D)	1	+	.	.	50
Cratoneuron filicinum (D)	.	.	.	1	25
COMPANIONS					
MONTIO-CARDAMINETEA					
Cardamine amara	.	.	3	.	25
Palustriella commutata	.	2	.	.	25
OTHER COMPANIONS					
Didymodon tophaceus	1	1	.	.	50
Hygroamblystegium varium	.	.	.	2	25
Jungermannia sp.	.	2	.	.	25
Brachythecium rutabulum	.	.	.	1	25
Cirsium montanum	.	.	1	.	25
Epilobium parviflorum	.	.	1	.	25
Equisetum sylvaticum	.	.	1	.	25
Jungermannia atrovirens	1	.	.	.	25
Calystegia sepium	.	.	+	.	25
Viola biflora	.	.	+	.	25

Tab. 6. Cratoneuretum commutati (CC). (D) = differential species.

Relevè n.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Fr(%)
Spring Code	AD1077	AN1474	AN1474	AN1000	AN1474	BR0790	LD0720	PS1255	BR0950	BR0950	BS0705	MP0656	BS0705	CV0854	LD0720	LD0930	AD1654	PS1880	BR1358	LD1502	BR1605	
Altitude (m a.s.l.)	1077	1474	1474	1000	1474	790	720	1255	950	950	705	656	705	854	720	930	1654	1880	1358	1502	1605	
Inclination (°)	25	7	7	45	7	30	-	5	7	7	7	30	7	3	2	40	10	60	5	85	45	
Relevé area (m^2)	3.0	1.0	1.0	2.0	1.0	8.0	0.3	1.0	5.0	2.0	1.0	3.0	1.0	0.4	1.7	2.0	4.0	4	0.6	1	8.0	
Vascular plant cover (%)	70	70	80	10	80	75	20	25	20	40	60	35	100	20	95	5	60	75	20	35	60	
Bryophyte cover (%)	70	90	100	30	100	30	100	90	90	70	75	50	95	60	70	20	85	90	50	85	70	
N. of species	9	5	10	9	7	3	2	3	15	6	5	13	7	12	11	9	22	17	17	13	21	
Rare species	3	-	-	-	-	1	1	-	4	-	-	4	1	4	2	4	3	4	4	6	9	
CRATONEURETUM COMMUTATI																						
Palustriella commutata	4	5	5	3	5	5	5	5	5	4	5	3	3	4	4	2	5	4	2	3	4	100
PALUSTRIELLA FALCATA-variant																						
Palustriella falcata (D)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	1	3	1	24
CRATONEURION COMMUTATI																						
Palustriella decipiens	.	.	.	+	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	+	.	19
Cratoneuron filicinum	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	1	1	.	.	14
Saxifraga aizoides	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	+	.	10
Pinguicula alpina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	10
Equisetum variegatum (D)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	5
Philonotis calcarea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	5
MONTIO-CARDAMINETALIA and MONTIO-CARDAMINETEA																						
Brachythecium rivulare (D)	.	.	.	.	1	.	.	.	.	1	.	1	.	.	.	.	.	+	1	.	.	24
Epilobium alsinifolium	.	.	2	.	3	.	.	.	.	.	.	.	.	.	.	.	1	2	.	.	.	19
Cardamine amara	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3	.	.	.	14
Saxifraga stellaris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	+	.	.	.	10
Chyloscyphus pallescens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	5
COMPANIONS																						
ADIANTETEA																						
Pellia endiviifolia (D)	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	10
Hymenostylium recurvirostre	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	5
Hymenostylium recurvirostre var. latifolium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	5
OTHER COMPANIONS																						
Crepis paludosa	1	2	1	1	1	1	.	.	.	.	2	.	3	.	.	.	1	.	1	+	1	57
Deschampsia caespitosa	3	3	1	.	1	.	.	1	+	.	.	.	.	1	3	.	+	.	.	.	.	43
Petasites albus	1	1	2	1	1	.	.	.	1	1	.	.	.	.	.	.	1	.	1	.	.	43
Chaerophyllum hirsutum	.	.	.	.	.	.	.	.	1	2	3	1	.	.	.	.	2	+	2	2	.	38
Bryum pseudotriquetrum	1	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	+	1	+	1	1	38
Plagiomnium undulatum	.	.	.	+	.	.	.	.	1	2	+	1	3	.	1	.	.	.	.	.	.	33
Viola biflora	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	1	1	33
Adenostyles glabra	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	2	24
Conocephalum conicum	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	2	.	.	1	+	.	24
Cirsium montanum	1	.	.	2	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	19
Geranium robertianum	.	.	.	.	.	.	.	.	r	.	1	2	.	.	.	+	.	.	.	.	.	19
Equisetum sylvaticum	.	.	.	.	.	.	.	2	1	.	.	.	.	1	.	.	.	.	.	.	.	14
Plagiomnium elatum	.	.	.	.	.	.	.	.	.	.	.	.	1	.	+	.	.	.	2	.	.	14
Eupatorium cannabinum	.	.	.	.	.	.	.	.	.	.	.	.	.	+	3	.	.	.	.	.	.	10
Agrostis stolonifera	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	1	.	.	10
Carex flacca	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	10
Saxifraga rotundifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	10
Aneura pinguis	1	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	10
Calliergonella cuspidata	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	.	.	.	.	.	10
Polygonum viviparum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	10
Sesleria caerulea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	10
Tofieldia calyculata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	1	10
Arabis alpina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	10
Oxyrrhynchium schleicheri	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.	10
Filipendula ulmaria	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	10
Stellaria nemorum	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	10
Brachypodium sylvaticum	.	.	.	.	.	.	.	.	.	.	.	+	r	.	.	.	.	.	.	.	.	10
Mycelis muralis	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	+	.	.	.	.	.	10

Table 7. Cratoneuretum falcati (CF). (D) = differential species.

Relevè n.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Fr (%)
Spring Code	BR1436	BR1765	LD1502	SL1724	BR2240	BR2240	LD1400	BR1379	BR1436	BR1379	BR1765	LD1502	PS1880	SL1724	PS1255	
Altitude (m a.s.l.)	1436	1765	1502	1724	2240	2240	1400	1379	1436	1379	1765	1502	1880	1724	1255	
Inclination (°)	90	60	85	2	30	20	7	30	30	15	15	10	20	2	10	
Relevé area (m^2)	1	0.7	0.5	1	0.7	1.5	3.0	0.3	0.8	0.6	3	1	1	1.5	2	
Vascular plant cover (%)	-	-	-	5	5	5	-	25	80	25	10	-	60	80	95	
Bryophyte cover (%)	100	100	98	95	95	70	10	70	90	100	90	80	100	95	20	
N. of species	5	1	1	5	8	3	9	13	5	3	15	9	8	6	9	
Rare species	2	-	-	-	2	-	3	5	1	-	6	1	1	1	1	
CRATONEURETUM FALCATI																
Palustriella falcata	5	5	5	5	5	4	1	2	3	4	5	3	5	5	2	100
Polygonum viviparum (D)	.	.	.	.	+	.	.	.	.	.	.	.	1	.	.	13
PALUSTRIELLA COMMUTATA-variant																
Palustriella commutata (D)	.	.	.	.	.	.	1	4	2	3	2	2	1	.	2	53
CALTHA PALUSTRIS-variant																
Caltha palustris (D)	.	.	.	.	.	.	.	.	.	.	.	.	.	4	.	7
CAREX PANICULATA-variant																
Carex paniculata (D)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	7
CRATONEURION COMMUTATI																
Cratoneuron filicinum	.	.	.	1	1	.	+	.	.	.	+	+	.	.	.	33
Palustriella decipiens	.	.	.	.	.	.	.	1	.	.	.	2	.	.	.	13
Saxifraga aizoides	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	7
Arabis subcoriacea	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	7
MONTIO-CARDAMINETALIA and MONTIO-CARDAMINETEA																
Brachythecium rivulare (D)	.	.	.	.	.	2	.	.	.	.	1	2	.	.	.	20
Epilobium alsinifolium	.	.	.	.	.	.	.	.	.	2	1	.	.	2	.	20
Cardamine amara	.	.	.	1	.	.	.	.	.	.	.	.	1	2	.	20
Silene pusilla	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	7
Saxifraga stellaris	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	7
COMPANIONS																
SCHEUCHZERIO-CARICETEA NIGRAE																
Aneura pinguis	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	13
Campylium stellatum	.	.	.	.	.	.	.	.	.	.	.	+	.	.	r	13
Juncus alpino-articulatus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	7
Scorpidium revolvens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	7
Tofieldia calyculata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	7
Carex frigida	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	7
Selaginella selaginoides	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	7
OTHER COMPANIONS																
Bryum pseudotriquetrum	.	.	.	.	+	1	.	2	2	.	2	1	.	+	1	53
Jungermannia sp.	1	.	.	.	.	.	+	.	1	.	.	.	.	.	.	20
Jungermannia atrovirens	.	.	.	.	.	.	+	.	.	.	.	1	.	.	.	13
Poa alpina	.	.	.	.	+	.	.	.	.	.	.	.	1	.	.	13
Viola biflora	.	.	.	+	.	.	.	.	.	.	.	.	1	.	.	13
Hymenostylium recurvirostre var. latifolium	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	13
Lophozia ventricosa	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	13

Tab. 8. Phytocoenon of *Cratoneuron filicinum* (CFi). (D) = differential species.

Relevè n.	1	2	3	4	5	6	7	Fr (%)
Spring Code	AN0590	BR1379	AN0430	AN0590	CS1350	BC0565	BC0565	
Altitude (m a.s.l.)	590	1379	430	590	1350	565	565	
Inclination (°)	15	5	1	15	35	7	5	
Relevé area (m^2)	2.5	0.3	1	2.7	2.3	1.5	1.5	
Vascular plant cover (%)	40	5	80	40	100	30	30	
Bryophyte cover (%)	90	90	30	90	10	45	40	
N. of species	7	10	7	8	8	14	5	
Rare species	2	5	3	2	3	7	-	
Phytocoenon of CRATONEURON FILICINUM								
Cratoneuron filicinum	2	3	2	5	2	2	2	100
RORIPPA AMPHIBIA-variant								
Rorippa amphibia (D)	.	.	.	.	.	1	3	29
Epilobium parviflorum (D)	.	.	.	.	.	2	1	29
Calliergonella cuspidata (D)	.	.	.	.	.	1	1	29
CRATONEURION COMMUTATI								
Palustriella commutata	1	3	2	1	.			57
Philonotis calcarea	.	2	.	.	.	1	1	43
MONTIO-CARDAMINETALIA and MONTIO-CARDAMINETEA								
Cardamine amara	r	.	5	3	3	.	.	57
Brachythecium rivulare (D)	.	.	+	.	1	.	.	29
Philonotis seriata	.	2	.	.	.	.	.	14
Philonotis fontana	.	.	.	.	.	+	.	14
COMPANIONS								
MOLINIO-ARRHENATHERETEA								
Mentha longifolia	.	.	.	2	4	.	.	29
Equisetum palustre	r	.	.	1	.	.	.	29
Mentha aquatica	4	.	.	.	.	.	.	14
Agrostis stolonifera	.	.	.	.	.	1	.	14
Ranunculus repens	1	.	.	.	.	.	.	14
Potentilla reptans	.	.	.	.	.	+	.	14
OTHER COMPANIONS								
Bryum pseudotriquetrum	2	1	.	1	.	.	.	29
Equisetum arvense	.	.	.	.	r	+	.	29

Tab. 9. Phytocoenon of *Palustriella decipiens* (PD).

Relevè n.	1
Spring Code	MD1670
Altitude (m a.s.l.)	1670
Inclination (°)	5
Relevé area (m^2)	1
Vascular plant cover (%)	40
Bryophyte cover (%)	70
N. of species	15
Phytocoenon of PALUSTRIELLA DECIPIENS	
CRATONEURION COMMUTATI	
Palustriella decipiens	4
MONTIO-CARDAMINETALIA and MONTIO-CARDAMINETEA	
Cardamine amara	2
Epilobium alsinifolium	+
COMPANIONS	
Tussilago farfara	2
Poa alpina	1
Rhizomnium punctatum	1
Viola biflora	1
Alchemilla lineata	+
Aster bellidiastrum	+
Bryum pseudotriquetrum	+
Campylium stellatum	+
Deschampsia caespitosa	+
Geum rivale	+
Petasites albus	+
Cerastium fontanum	r

Tab. 10. Chaerophyllo-Cardaminetum asarifoliae (CCa). (D) = differential species.

Relevè n.	1
Spring Code	AD1235
Altitude (m a.s.l.)	1235
Inclination (°)	45
Relevé area (m2)	8
Vascular plant cover (%)	80
Bryophyte cover (%)	30
N. of species	13
CHAEROPHYLLO-CARDAMINETUM ASARIFOLIAE	
Cardamine asarifolia	4
Chaerophyllum hirsutum (D)	2
PETASITES ALBUS-variant	
Petasites albus (D)	2
CRATONEURION COMMUTATI	
Cratoneuron filicinum	2
MONTIO-CARDAMINETALIA and MONTIO-CARDAMINETEA	
Brachythecium rivulare (D)	3
COMPANIONS	
Cirsium montanum	3
Plagiomnium undulatum	2
Platyhypnidium riparioides	1
Saxifraga rotundifolia	1
Bryum pseudotriquetrum	+
Geranium robertianum	+
Plagiomnium rostratum	+
Conocephalum conicum	r

Tab. 11. Phytocoenon of *Petasites albus* (PA). (D) = differential species.

Relevè n.	1	2	3	4	Fr (%)
Spring Code	AT1052	AD0905	BR0658	BS1527	
Altitude (m a.s.l.)	1052	905	658	1527	
Inclination (°)	3	5	20	10	
Relevé area (m2)	1	2	5.4	1.7	
Vascular plant cover (%)	40	95	85	50	
Bryophyte cover (%)	5	40	20	40	
N. of species	7	23	13	14	
Rare species	2	10	8	5	
Phytocoenon of PETASITES ALBUS					
Petasites albus (D)	2	3	4	2	100
Cirsium montanum (D)	1	2	.	+	75
CRATONEURION COMMUTATI					
Palustriella commutata	1	.	2	.	50
Cratoneuron filicinum	.	1	.	2	50
Saxifraga aizoides	.	1	.	.	25
Palustriella decipiens	.	.	.	+	25
MONTIO-CARDAMINETALIA and MONTIO-CARDAMINETEA					
Brachythecium rivulare (D)	.	2	.	.	25
Epilobium alsinifolium	.	.	.	2	25
Pohlia wahlenbergii	.	.	+	.	25
Cardamine amara	r	.	.	.	25
COMPANIONS					
CALTHION					
Chaerophyllum hirsutum	1	1	.	+	75
Crepis paludosa	.	1	.	2	50
Mentha longifolia	.	1	.	.	25
Geum rivale	.	.	.	+	25
ADIANTION					
Conocephalum conicum	.	+	1	.	50
Pellia endiviifolia	.	1	+	.	50
OTHER COMPANIONS					
Plagiomnium elatum	.	1	.	+	50

CARDAMINO-MONTION

Another 30 phytosociological relevés were crudely separated from the original data set and assigned to the alliance *Cardamino-Montion* based on a preliminary analysis of their floristic composition. The numerical classification of these relevés produced a dendrogram (Fig. 1c), in which three different plant communities can clearly be distinguished.

12. Montio-Bryetum schleicheri (MB - Tab. 12)

This community was sampled through 18 relevés and it is labelled as MB in the classification dendrogram. The physiognomy of the stands is rather variable, because bryophytes and vascular plants vary considerably in their cover and variety. The moss carpet attains dominance in the majority of stands, even if there are quite frequent stands in which the vascular element prevails.

Among the bryophytes, *Brachythecium rivulare* is the only constant and sometimes dominant species. *Bryum pseudotriquetrum* is the only other moss that is frequent throughout. *Scapania undulata*, *Philonotis seriata*, *P. fontana* and *Sanionia uncinata* are less consistent through the community as a whole, but locally prominent.

The vascular flora is rather varied in its composition and cover. The only constant species is *Saxifraga stellaris*, whose scattered rosettes are very characteristic. Other herbs that are frequent throughout are *Deschampsia caespitosa*, *Cardamine amara* and *Epilobium alsinifolium*, while *Stellaria nemorum* and *Viola biflora* are more occasional. Among the rarer vascular plants, *Stellaria alsine* attains dominance at one stand.

The classification of this community raises particular difficulties because it is troublesome to characterise it with diagnostic species. Neither the dominant moss (*Brachythecium rivulare*), nor the dominant vascular plant (*Saxifraga stellaris*) can be used to typify an association, because their coenological amplitudes are too large. There are also general floristic and habitat similarities between our community and the *Montio-Bryetum schleicheri* association, which forms the most widespread and common *Cardamino-Montion* association in the subalpine and alpine belts of the Alps. Nevertheless, phytosociologically it is difficult to place our relevés in the typical variant of this association, because its character species (*Bryum schleicheri*) is absent from all our stands. One solution would be to consider *Epilobium alsinifolium* as a territorial characteristic species of the *Montio-Bryetum schleicheri*, because this species is centred in this community within the study area.

The high occurrence of *Brachythecium rivulare* and *Cardamine amara* is helpful for assigning our relevés to a variant of the *Montio-Bryetum schleicheri*, differentiated by these two species. This variant was reported from the Swiss Alps by Geissler (1976), where it colonises subalpine and alpine springs with fast-flowing waters. Relevés 17 and 18, in which *Stellaria alsine* becomes an important component, are to be attributed to another specific variant.

In Trentino the *Brachythecium rivulare-Cardamine amara* variant of the *Montio-Bryetum schleicheri* is mostly widespread from the high-montane to the subalpine vegetation belt of the siliceous massifs. Springs are generally typical helocrenes with circumneutral, base-poor and oligotrophic waters. The *Stellaria alsine*-variant was encountered at a spring in the montane vegetation belt of the Lagorai range with slightly more alkaline, less base-poor waters.

13. Solenostomo-Hygrohypnetum smithii (SH – Tab. 13)

This community includes 4 relevés, labelled SH in the dendrogram, in which the alpine moss *Hygrohypnum smithii* is the only constant species. The associated flora is a rather species-poor assemblage, with rare, and especially sparse, vascular plants. Bryophytes largely prevail numerically, but none of them rivals *Hygrohypmnum smithii* in abundance and frequency. Some of them (*Jungermannia exsertifolia* subsp. *cordifolia*, *Sciuro-hypnum latifolium*, *Sanionia uncinata*) are locally prominent. The most abundant vascular species is *Saxifraga stellaris*.

The community has close floristic affinities with the alpine association, *Solenostomo-Hygrohypnetum smithii*, described by Geissler (1976), sharing the two character species (*Hygrohypnum smithii* and *Jungermannia exsertifolia* subsp. *cordifolia*). Relevé 1 corresponds to the typical variant of the *Solenostomo-Hygrohypnetum smithii* and relevé 2, with only two species, to an extremely impoverished form of the association. Relevés 3 and 4 belong to a chionophilous *Anthelia juratzkana*-variant, also differentiated by *Marsupella brevissima*, *Pohlia obtusifolia*, *P. drummondii*. Other species, such as *Cephalozia ambigua*, *Kiaeria starkei*, *Luzula alpinopilosa*, *Marsupella boeckii*, *Salix herbacea*, provide a further link between this variant and the chionophilous communities of the *Salicetea herbaceae*.

The *Solenostomo-Hygrohypnetum smithii* is restricted to the alpine vegetation belt of the siliceous massifs, where spring-heads are generally associated with late snow-beds, flowing from the debris cover of some rock-glaciers. Waters are cold, subneutral, base-poor and oligotrophic.

14. Blindio-Scapanietum undulatae (BS - Tab. 14)

This community was sampled with 8 relevés, labelled as BS in the classification dendrogram (Fig. 1c). It has a quite distinct general character, but shows a certain range of compositional variation, more particularly in the proportion of its different structural components, bryophytes and vascular plants. However, bryophytes, prevail numerically and as cover in the majority of stands. The constants of the community are very few,

only *Scapania undulata* (bryophytes) and *Saxifraga stellaris* (vascular plants). Among the bryophytes, *Warnstorfia exannulata* attains high frequency and abundance also *Philonotis seriata* is fairly common. Of the vascular plants, only *Deschampsia caespitosa* is also quite frequent and abundant throughout.

Our relevés show a close floristic resemblance with the association *Blindio-Scapanietum undulatae* to which they can be assigned. The linkage between our stands and this association is given by the constant occurrence of *Scapania undulata* (treated here as a differential species), the presence of *Blindia acuta* (the only true character species of the association) and the occurrence of other bryophytes belonging to the specific character combination of the association (*Philonotis seriata* and *Marsupella emarginata*). The occurrence of many mire species among the companions provides further support to the syntaxonomical attribution. The first six relevés of table 14 fit the typical form of the association well; whereas relevés 7 and 8, differentiated by the leafy hepatics *Cephalozia bicuspidata* and *Gymnocolea inflata* and by the occurrence of some chionophilous species of the class *Salicetea herbaceae*, can be referred to a specific *Cephalozia bicuspidata*-variant.

The *Blindio-Scapanietum undulatae* occurs from the upper montane to the subalpine vegetation belt of siliceous massifs. Crenic waters are base- and nutrient-poor with pH values ranging from 5.9 to 7.0 (average value 6.2). The *Cephalozia bicuspidata*-variant is restricted to the subalpine belt and is irrigated by slightly more acidic and oligotrophic waters.

CARICION REMOTAE

A further set of 14 relevés was extracted from the original data set and attributed to the alliance *Caricion remotae*. The relevé set is homogeneous and can therefore be referred to a unique vegetation type.

15. Cardamino-Chrysosplenietum alternifolii (CCh - Tab. 15)

This community is characterized by the general predominance of vascular plants in frequency and cover, with usually subordinate bryophytes. However, the bryophyte flora is fairly rich, but variable in species number and cover. On occasions it makes a substantial contribution to the ground layer, although the frequent species are very few.

No vascular species is constant. *Chaerophyllum hirsutum* is most frequent and often fairly abundant, while *Cardamine amara* is less frequent, but more abundant, also dominant or codominant in several stands. *Petasites albus* attains 50% frequency and is generally fairly abundant and sometimes prominent. Other vascular plants occurring with some frequency throughout are *Oxalis acetosella*, which is concentrated in some stands, *Chrysosplenium alternifolium*, *Saxifraga rotundifolia*, *Stellaria nemorum*, *Crepis paludosa* and *Geranium robertianum*. Finally, the sedge *Carex remota* is no more than occasional, although this community is important for it.

Among the bryophytes, *Brachythecium rivulare* is constant, but only rarely conspicuous, *Rhizomnium punctatum* is frequent, dominant or subdominant in several stands, and *Plagiomnium undulatum* is common and fairly abundant.

The affinities of our relevés are clearly with the *Cardamino-Chrysosplenietum alternifolii*, an association occurring on the mountains of Central Europe, where it colonises montane springs in shaded situations. *Chrysosplenium alternifolium* is the only character species of this association, in which it is generally constant and dominant (Zechmeister 1993). Nevertheless, in their general floristics, our stands differ significantly from the typical form of the *Cardamino-Chrysosplenietum alternifolii*. In particular two features distinguish our community. Firstly, both *Chrysosplenium alternifolium* and the moss *Plagiomnium affine* are much reduced, the first largely replaced by *Chaerophyllum hirsutum*. Secondly, some stands are clearly differentiated by the high occurrence of *Oxalis acetosella* and the moss *Sanionia uncinata*. The relevés 1-10, where *Chaerophyllum hirsutum* is constant and fairly abundant, can be referred to the *Cardamino-Chrysosplenietum alternifolii* subass. *chaerophylletosum hirsuti* Zechmeister et Steiner 1993. In the study area the subassociation is also differentiated by *Petasites albus* and *Crepis paludosa*. Having *Oxalis acetosella* as a constant and subdominant element relevés 11-14 should be assigned to a new subassociation, *Cardamino-Chrysosplenietum alternifolii* subass. *oxalidetosum acetosellae* Tomaselli, Spitale et Petraglia subass. nova hoc loco; table 15, nomenclatural type: relevé 14 (holotypus). *Lamium galeobdolon* subsp. *flavidum*, *Urtica dioica* and the moss *Sanionia uncinata* are additional differential species of the subassociation, to the above quoted *Oxalis acetosella*. Another striking, distinctive feature of the subassociation is the extensive cover of the moss layer, that can exceed that of vascular plants. The subassociation is labelled as CChoa in the subsequent figures.

Both subassociations of the *Cardamino-Chrysosplenietum alternifolii* occur in the montane vegetation belt at oligophotic sites, where shade is provided by trees or tall herbs. Crenic waters are circumneutral, relatively base- and nutrient-poor. High nitrogen content was reported in the *Cardamino-Chrysosplenietum alternifolii oxalidetosum acetosellae*. This is presumably a consequence of the more peripheral position of this community with respect to the spring-head determining water flow through soils that are richer in organic nutrients.

3.1.3. Chasmophytic bryophyte-rich communities

This small subset only includes four relevés occurring in typical rheocrenes on lime-rich bedrocks. The relevés are distributed between two clearly distinct

communities, both belonging to the alliance *Adiantion capilli-veneris*. In our opinion, this alliance must be placed in the independent order *Adiantetalia capilli-veneris* and the class *Adiantetea*, according to the traditional syntaxonomical approach (Braun-Blanquet *et al.* 1952). This approach has recently been followed for the Mediterranean area, the principal centre of distribution and diversity of the *Adiantetea*-vegetation (Deil 1996; Privitera & Puglisi 2004).

Zechmeister's (1993) and Zechmeister & Mucina's (1994) alternative placing of this alliance within the class *Montio-Cardaminetea* cannot be maintained, because there is only one character species of this class (*Palustriella commutata*) occurring with high frequencies in part of these vegetational communities (see the synoptic table of the *Adiantion* in Zechmeister & Mucina 1994).

16. Eucladietum verticillati (EV - Tab. 16)

This community, sampled through 3 phytosociological relevés, is typically dominated by an extensive mat of bryophytes. Among them, *Eucladium verticillatum* and *Palustriella commutata* are constant and quite prominent. Other bryophytes, of which *Hymenostylium recurvirostre* is frequent and abundant, characteristically play a subordinate part in the ground cover. *Pellia endiviifolia*, *Bryum pseudotriquetrum* and *Jungermannia atrovirens* are more occasional through the community as a whole. The only vascular plant (*Pinguicula alpina*) has a negligible cover.

The closest floristic affinities of this community are with the association *Eucladietum verticillati*, occurring from the Mediterranean to central Europe. The *Eucladietum verticillati* was encountered in some rheocrenes flowing from calcareous rock-faces. In this habitat mosses and algae build calcareous deposits by removing CO_2 from the water (Wilmanns 1989). The community is restricted to the collinar vegetation belt; crenic waters are base-rich, calcareous and usually mesotrophic.

17. Phytocoenon of *Pellia endiviifolia* (PE - Tab. 17)

This community was sampled in a hygropetric, almost vertical, rheocrene spring, occurring in the montane belt of the Brenta massif. Like the *Eucladietum verticillati*, this is essentially bryophytic vegetation, floristically easily defined by the dominance of the thalloid hepatic, *Pellia endiviifolia*, probably favoured by the locally shaded condition of the vertical rock face. The vascular element is only represented by *Adenostyles glabra* and *Sesleria caerulea* and attains low cover.

The community seems to be floristically sufficiently distinct to be recognised. Nonetheless, new data must be added to improve the classification beyond the level of a phytocoenon named from the dominant species and allocated to the alliance *Adiantion*.

The crenic waters are base-rich, calcareous and oligotrophic.

3.1.4. Hygrophilous communities

This very small subset of 3 relevés comprises all the vegetation types recorded in typical helocrenes which are clearly fragments of mire communities and, therefore, to be placed in the class *Scheuchzerio-Caricetea nigrae*.

18. Phytocoenon of *Eriophorum angustifolium* (EA - Tab. 18)

Eriophorum angustifolium generally forms species-poor communities in shallow pools within nutrient-poor mires, and along the shores of mountain small lakes (Gerdol & Tomaselli 1997). Small stands dominated by the common cotton-grass can occasionally also be encountered at a distance from springheads, where water-flow is less vigorous and gentle slopes allow more diffuse irrigation. Our relevés were taken in such areas, within stands where *Eriophorum angustifolium* dominated a floristic assemblage in which character species of different syntaxa belonging to the class *Scheuchzerio-Caricetea nigrae* largely prevailed. Our syntaxomic treatment of the community is in accordance with Dierßen (1982, 1996) and Gerdol & Tomaselli (1997).

In the study area the phytocoenon of *Eriophorum angustifolium* is restricted to the lower subalpine belt of siliceous massifs and is irrigated by circumneutral, base-poor, oligotrophic to mesotrophic waters.

19. Caricetum nigrae (CN - Tab. 19)

The *Caricetum nigrae* is the most widespread fen association in the South-Eastern Alps, where it has been reported from a number of sites (Gerdol 1994; Gerdol & Tomaselli 1997). Its occurrence within springs is very occasional and restricted to sites where the conditions (gentle sloping, reduced flow) allow a small mire to be formed. The our unique relevé is well characterized by its floristics, including two character species of the association *Caricetum nigrae* (*Carex canescens* and *Juncus filiformis*), and a core of species of the class *Scheuchzerio-Caricetea nigrae*. The occurrence of some species of the classes *Montio-Cardaminetea and Platy-hypnidio-Fontinalietea antipyreticae* as companions emphasises the floristic relationships of the community with the crenic habitat.

The *Caricetum nigrae*-stand was sampled in the montane belt of the siliceous Presanella-massif. Waters are subneutral, base-poor and mesotrophic.

3.1.5. Tall herb communities

Within this last small subset, composed of only 5 relevés, we grouped all the residual vegetation types having floristic assemblages dominated by tall herbs.

Nevertheless, the resulting group is rather heterogeneous, including types of plant communities belonging to different phytosociological classes. However, these communities are not particularly relevant to our analysis, because they are confined to the peripheral areas of the springs, and generally represent a floristic transition between the crenic habitat and the surrounding vegetation. Such stands are generally discrete, but form part of a fragmented zonation. This, combined with their marginal position and ecotonal nature, also posed classificatory problems. In only one case was it possible to refer our relevé to an already-known association. In all other cases classification was only provisional due to the scarcity of data.

20. Phytocoenon of *Mentha aquatica* (MA - Tab. 20)

This community is composed of a heterogeneous stand, in which a number of tall herbs form an intricate vegetational mosaic with a dense mat of the pleustophyte, *Lemna minor*. Among the herbs, *Mentha aquatica* is largely prevalent, and the bulk of the assemblage comprises species diagnostic of *Calthion*, *Molinietalia* and *Molinio-Arrhenatheretea*. This spring is the only limnocrene in our dataset. It is characterized by largely lentic waters, forming a large pool, 50 and 90 cm deep. The limnocrene lies in the collinar vegetation belt. Crenic waters are base-rich, calcareous and oligotrophic.

21. Phytocoenon of *Eupatorium cannabinum* (EC - Tab. 21)

This community is characterized floristically by the dominance of the tall herb, *Eupatorium cannabinum*, and by the occurrence of a set of diagnostic species of the order *Convolvuletalia sepium* and the class *Galio-Urticetea*. The assemblage includes also some bryophytes (*Palustriella decipiens* and *Plagiomnium rostratum*).

The phytocoenon of *Eupatorium cannabinum* was encountered at the edge of a spring lying at about 800 m a.s.l., with base- and electrolyte-rich, calcareous and oligotrophic water. The spring is somewhat disturbed by the presence of cement walls to which metal meshes are anchored to prevent rock falls.

22. Chaerophyllo-Petasitetum officinalis (CP – Tab. 22)

The most important diagnostic species of this community is *Petasites hybridus*, whose large leaves confer the stand's typical, distinctive physiognomy. The dominant species is *Mentha longifolia*. Among the vascular plants, *Petasites hybridus* and *Cardamine amara* are abundant and subdominant, and the bryophytes are represented by the mosses, *Cratoneuron filicinum* and *Brachythecium rivulare*.

The community corresponds most obviously to the association *Chaerophyllo-Petasitetum officinalis*, typical of stream and river banks from the collinar to the montane belt. The association is placed in the alliance *Petasition officinalis* (order *Convolvuletalia sepium* and class *Galio-Urticetea*).

In the study area, the association was sampled at the edge of a spring in the montane vegetation belt, lying close to meadows that are only occasionally cut. Crenic waters are base- and electrolyte-rich, calcareous and mesotrophic.

23. Phytocoenon of *Mentha longifolia* (ML - Tab. 23)

This community, sampled through 2 relevés, also has *Mentha longifolia* as a dominant species. The assemblage is, however, quite different from that of the *Chaerophyllo-Petasitetum officinalis*. Here the floristic bulk is contributed by tall herbs that occur preferentially at sites with moist and nitrogen-rich soils within the montane and subalpine belts. From the phytosociological viewpoint these species are diagnostic of the alliance *Rumicion alpini* (order *Rumicetalia alpini*, class *Mulgedio-Aconitetea*). For this reason a new phytocoenon must be established, with the name of the dominant species, and placed in this new syntaxonomic context.

The *Mentha longifolia* phytocoenon was sampled at a spring in the montane vegetation belt, close to a cattle shelter within a pasture. It is probably occasionally disturbed by cattle trampling. The spring has a limited discharge, with base-rich, calcareous and eutrophic waters.

Tab. 12. Montio-Bryetum schleicheri (MB). (D) = differential species; (TC) = territorial character species.

Relevè n.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Fr (%)
Spring Code	CV1421	CV1575	CV1655	AN1685	AN1950	CV1940	LT1911	LT1911	OC2056	CV1215	AD1790	CV2085	AD1990	AD1990	AD1944	CV2126	CV1623	CV1623	
Altitude (m a.s.l.)	1421	1575	1655	1685	1950	1940	1911	1911	2056	1215	1790	2085	1990	1990	1944	2126	1623	1623	
Inclination (°)	5	5	25	15	10	2	3	7	15	35	5	7	30	40	1	20	3	5	
Relevé area (m^2)	1	2.5	0.7	2.5	4	1.5	1	5	4	1	2	0.5	4	2	0.5	0.5	0.7	2	
Vascular plant cover (%)	20	95	30	75	90	70	25	80	70	80	95	30	70	60	40	30	70	100	
Bryophyte cover (%)	25	95	75	90	60	20	80	50	95	95	15	25	85	50	90	80	70	10	
N. of species	6	12	18	26	28	14	6	12	20	17	10	9	10	10	8	18	13	16	
Rare species	-	1	2	4	2	3	-	2	6	5	-	1	-	2	-	2	3	6	
MONTIO-BRYETUM SCHLEICHERI																			
Epilobium alsinifolium (TC)	.	.	1	+	+	.	.	.	1	.	3	2	1	2	.	.	1	1	55
BRACHYTHECIUM RIVULARE-CARDAMINE AMARA-variant																			
Brachythecium rivulare	2	5	1	3	1	.	.	.	3	2	2	1	4	2	2	+	+	1	83
Cardamine amara	2	5	3	1	4	3	1	2	+	+	.	.	.	.	.	1	2	2	72
STELLARIA ALSINE-variant																			
Stellaria alsine (D)	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1	4	17
CARDAMINO-MONTENION																			
Luzula alpinopilosa (D)	.	.	.	.	+	+	.	1	.	.	.	.	+	.	.	.	.	.	22
Carex frigida (D)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	5
CARDAMINO-MONTION																			
Saxifraga stellaris	1	1	1	3	4	1	2	+	1	3	2	2	4	3	2	2	+	.	94
Scapania undulata (D)	2	r	3	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	28
Philonotis seriata	.	.	.	.	.	.	.	.	.	.	+	.	.	.	4	2	1	.	22
Epilobium anagallidifolium	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	1	.	.	11
Warnstorfia exannulata (D)	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	5
Jungermannia exsertifolia subsp. cordifolia	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	5
Warnstorfia sarmentosa (D)	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	5
MONTIO-CARDAMINETALIA and MONTIO-CARDAMINETEA																			
Philonotis fontana	.	.	.	2	3	1	+	.	.	.	.	.	.	.	.	.	.	.	22
Palustriella decipiens	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	1	.	.	11
Chrysosplenium alternifolium	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	11
Chyloscyphus pallescens	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	11
Palustriella falcata	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	5
Philonotis calcarea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	5
Cratoneuron filicinum	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	5
Dichodontium palustre	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	5
Pohlia wahlenbergii	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	5
COMPANIONS																			
SCHEUCHZERIO-CARICETEA NIGRAE																			
Carex nigra	.	.	.	.	1	.	.	.	.	.	+	.	.	.	.	.	.	+	17
Oncophorus virens	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	1	.	.	11
Campylium stellatum	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	11
Aneura pinguis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	5
Carex canescens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	5
Carex panicea	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	5
Pinguicula vulgaris	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	5
Sphagnum palustre	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5
Straminergon stramineum	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	5
Cardamine rivularis	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	5
OTHER COMPANIONS																			
Deschampsia caespitosa	.	.	+	2	3	2	.	1	+	1	2	.	1	1	1	2	2	2	78
Bryum pseudotriquetrum	.	.	2	2	+	1	.	+	1	3	.	+	.	+	.	3	.	+	61
Stellaria nemorum	.	1	.	+	+	.	.	3	2	+	.	.	1	1	.	.	.	.	44
Rhizomnium punctatum	+	.	+	1	.	1	.	.	1	+	.	+	.	.	+	.	.	.	44
Viola biflora	.	.	.	1	+	+	.	+	2	.	+	+	.	.	.	.	.	.	39
Sanionia uncinata	.	.	+	+	.	+	4	1	.	.	.	.	.	.	.	1	.	.	33
Rhizomnium pseudopunctatum	.	.	.	1	.	.	1	2	.	.	.	.	+	.	.	+	.	.	28
Peucedanum ostruthium	.	r	.	.	+	.	.	.	.	.	.	1	1	.	.	+	.	.	28
Alchemilla lineata	.	.	.	r	r	.	.	.	.	.	+	.	.	.	1	.	+	.	28
Plagiomnium affine	.	.	.	.	.	.	.	.	+	2	.	.	.	+	+	.	.	.	22
Chyloscyphus polyanthos	.	+	.	+	+	.	.	.	.	.	.	.	.	+	.	.	.	.	22
Pellia epiphylla	.	+	.	+	.	.	.	.	.	+	.	.	+	.	.	.	.	.	22
Oxalis acetosella	.	.	+	+	.	.	.	.	.	2	.	.	.	.	.	.	.	.	17
Saxifraga rotundifolia	.	.	1	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	17

(continued)

Tab. 12. Continuation.

Relevè n.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Fr (%)
Spring Code	CV1421	CV1575	CV1655	AN1685	AN1950	CV1940	LT1911	LT1911	OC2056	CV1215	AD1790	CV2085	AD1990	AD1990	AD1944	CV2126	CV1623	CV1623	
Altitude (m a.s.l.)	1421	1575	1655	1685	1950	1940	1911	1911	2056	1215	1790	2085	1990	1990	1944	2126	1623	1623	
Inclination (°)	5	5	25	15	10	2	3	7	15	35	5	7	30	40	1	20	3	5	
Relevé area (m^2)	1	2.5	0.7	2.5	4	1.5	1	5	4	1	2	0.5	4	2	0.5	0.5	0.7	2	
Vascular plant cover (%)	20	95	30	75	90	70	25	80	70	80	95	30	70	60	40	30	70	100	
Bryophyte cover (%)	25	95	75	90	60	20	80	50	95	95	15	25	85	50	90	80	70	10	
N. of species	6	12	18	26	28	14	6	12	20	17	10	9	10	10	8	18	13	16	
Rare species	-	1	2	4	2	3	-	2	6	5	-	1	-	2	-	2	3	6	
Plagiochila porelloides	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.	17
Chaerophyllum hirsutum	.	.	r	r	.	.	.	.	.	.	+	.	.	.	.	.	.	.	17
Climacium dendroides	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	1	.	11
Crepis paludosa	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	11
Dicranum scoparium	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	11
Luzula sudetica	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	11
Plagiomnium undulatum	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	11
Rhizomnium magnifolium	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	11
Ranunculus montanus aggr.	.	.	.	r	+	.	.	.	.	.	.	.	.	.	.	.	.	.	11
Aconitum napellus	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	r	.	.	11

Tab. 13. Solenostomo-Hygrohypnetum smithii (SH). (D) = differential species.

Relevè n.	1	2	3	4	Fr (%)
Spring Code	CA2153	AD2739	AD2314	AD2314	
Altitude (m a.s.l.)	2153	2739	2314	2314	
Inclination (°)	30	15	3	10	
Relevé area (m^2)	0.8	0.5	1	7	
Vascular plant cover (%)	25	-	-	2	
Bryophyte cover (%)	80	2	20	10	
N. of species	13	2	15	11	
Rare species	8	1	5	3	
SOLENOSTOMO-HYGROHYPNETUM SMITHII					
Hygrohypnum smithii	5	1	1	2	100
Jungermannia exsertifolia subsp. cordifolia	2	.	.	.	25
ANTHELIA JURATZKANA-variant					
Anthelia juratzkana (D)	.	.	1	1	50
Marsupella brevissima (D)	.	.	+	1	50
Lophozia opacifolia (D)	.	.	.	1	25
Pohlia obtusifolia (D)	.	.	1	.	25
CARDAMINO-MONTENION					
Luzula alpinopilosa (D)	.	.	.	+	25
CARDAMINO-MONTION					
Saxifraga stellaris	3	.	.	.	25
Philonotis seriata	2	.	.	.	25
Scapania undulata (D)	1	.	.	.	25
MONTIO-CARDAMINETALIA and MONTIO-CARDAMINETEA					
Pohlia wahlenbergii	.	.	1	.	25
Philonotis tomentella	.	.	.	+	25
COMPANIONS					
SALICETEA HERBACEAE					
Pohlia drummondi	.	.	1	.	25
Cephalozia ambigua	.	.	+	.	25
Kiaeria starkei	.	.	+	.	25
Marsupella boeckii	.	.	+	.	25
Salix herbacea	.	.	.	+	25
OTHER COMPANIONS					
Sciuro-hypnum latifolium	.	.	2	.	25
Sanionia uncinata	.	.	.	2	25

Tab. 14. Blindio-Scapanietum undulatae (BS). (D) = differential species.

Relevè n.	1	2	3	4	5	6	7	8	Fr (%)
Spring Code	AD1853	AD1853	AD1944	CA1642	CV2051(2)	CA1642	AD2153	AD2153	
Altitude (m a.s.l.)	1853	1853	1944	1642	2051	1642	2153	2153	
Inclination (°)	5	30	8	5	15	5	5	10	
Relevé area (m2)	4.8	0.5	2.5	1.2	2.5	1	1.6	4	
Vascular plant cover (%)	15	20	55	65	40	90	80	15	
Bryophyte cover (%)	50	80	80	40	50	40	25	65	
N. of species	22	5	14	8	14	17	17	9	
Rare species	8	-	1	-	2	6	5	-	
BLINDIO-SCAPANIETUM UNDULATAE									
Scapania undulata (D)	3	3	1	3	1	3	2	5	100
Blindia acuta	+	.	.	.	.	.	.	1	25
CEPHALOZIA BICUSPIDATA-variant									
Cephalozia bicuspidata (D)	+	.	.	.	.	.	1	1	25
Gymnocolea inflata (D)	.	.	.	.	.	.	1	1	25
CARDAMINO-MONTENION									
Carex frigida (D)	.	.	+	.	.	.	r	.	25
Luzula alpinopilosa (D)	.	.	.	.	.	.	2	.	13
CARDAMINO-MONTION									
Warnstorfia exannulata (D)	2	3	2	1	3	2	.	.	75
Philonotis seriata	+	.	2	2	.	1	.	.	50
Marsupella emarginata	2	2	.	1	.	.	.	.	50
Jungermannia exsertifolia subsp. cordifolia	.	.	.	1	.	.	.	.	13
Scapania paludosa	.	.	.	.	.	1	.	.	13
Viola palustris (D)	.	.	.	.	+	.	.	.	13
MONTIO-CARDAMINETALIA and MONTIO-CARDAMINETEA									
Saxifraga stellaris	2	2	2	4	2	2	2	r	100
Dichodontium palustre	+	.	1	.	+	.	.	.	38
Philonotis fontana	.	.	.	.	+	.	.	1	25
Cardamine amara	.	.	.	.	.	1	.	.	13
Chyloscyphus pallescens	.	.	+	.	.	.	.	.	13
COMPANIONS									
SCHEUCHZERIO-CARICETEA NIGRAE									
Eriophorum angustifolium	.	.	+	.	+	2	.	.	38
Carex echinata	.	.	+	.	1	.	.	.	25
Sphagnum subsecundum	+	.	.	.	1	.	.	.	25
Straminergon stramineum	+	.	.	.	.	1	.	.	25
Campylium stellatum	.	.	+	.	.	.	.	+	25
Carex nigra	.	.	1	.	.	.	.	.	13
Scorpidium revolvens	.	.	1	.	.	.	.	.	13
Sphagnum cuspidatum	.	.	.	.	1	.	.	.	13
Juncus filiformis	.	.	.	.	+	.	.	.	13
Warnstorfia fluitans	.	.	.	.	.	.	.	+	13
Parnassia palustris	.	.	.	.	.	.	r	.	13
SALICETEA HERBACEAE									
Soldanella pusilla	.	.	.	.	.	1	.	.	13
Anthelia juratzkana	.	.	.	.	.	.	.	+	13
Veronica alpina	.	.	.	.	.	.	r	.	13
OXYCOCCO-SPHAGNETEA									
Sphagnum capillifolium	.	.	.	1	.	.	1	.	25
Sphagnum rubellum	1	1	.	.	.	.	.	.	25
Calypogeia fissa	+	.	.	.	.	.	.	.	13
OTHER COMPANIONS									
Deschampsia caespitosa	r	.	2	2	1	3	1	.	75
Viola biflora	.	.	.	.	.	1	1	.	25
Pellia neesiana	+	.	.	.	.	.	+	.	25

Tab. 15. Cardamino-Chrysosplenietum alternifolii (CCh). (D) = differential species.

Relevè n.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Fr (%)
Spring Code	OC0981	CV0962	CV1200	CV0962	CV0962	MC1115	CV1435	CV1280	MC1115	MC1115	AD1300	CV1200	CV1254	CV1254	
Altitude (m a.s.l.)	981	962	1200	962	962	1115	1435	1280	1115	1115	1300	1200	1254	1254	
Inclination (°)	45	2	5	2	2	45	3	15	45	45	5	5	15	5	
Relevé area (m^2)	1	1	1.5	1	1	1	6	2	1	1	1	2.2	1.3	0.25	
Vascular plant cover (%)	100	40	70	70	60	75	95	30	60	100	65	30	25	100	
Bryophyte cover (%)	10	30	20	20	20	50	30	40	45	10	90	60	70	70	
N. of species	14	9	5	10	6	7	10	10	8	15	11	13	16	10	
Rare species	3	-	-	-	1	1	4	2	1	2	2	4	6	1	
CARDAMINO-CHRYSOSPLENIETUM ALTERNIFOLII															
Plagiomnium undulatum (D)	2	1	.	1	1	2	.	4	2	2	2	.	.	.	64
Chrysosplenium alternifolium	1	.	.	1	.	.	.	.	.	+	1	.	.	3	36
Subass. CHAEROPHYLLETOSUM HIRSUTI															
Chaerophyllum hirsutum (D)	2	2	2	+	1	2	1	1	1	1	2	2	.	.	86
Subass. OXALIDETOSUM ACETOSELLAE															
Oxalis acetosella (D)	.	.	.	+	.	.	.	.	.	+	2	3	2	1	43
CARICENION REMOTAE															
Athyrium filix-foemina (D)	r	.	.	.	.	.	.	.	.	.	.	.	r	1	21
Impatiens noli-tangere (D)	.	.	.	2	.	.	.	.	.	.	1	.	.	.	14
CARICION REMOTAE															
Rhizomnium punctatum (D)	.	2	3	+	1	.	.	.	.	+	3	4	3	3	64
Carex remota	.	+	.	.	.	.	.	.	+	1	.	.	.	.	21
Plagiochila asplenioides (D)	.	.	2	.	.	.	.	.	.	.	.	1	.	.	14
MONTIO-CARDAMINETALIA and MONTIO-CARDAMINETEA															
Brachythecium rivulare (D)	1	1	1	+	1	1	1	1	+	3	2	+	2	2	100
Cardamine amara	.	1	3	3	4	5	5	3	3	2	.	.	.	.	64
Cratoneuron filicinum	.	.	.	.	.	.	.	.	.	.	.	.	1	.	7
Saxifraga stellaris	.	.	.	.	.	.	+	.	.	.	.	.	.	.	7
COMPANIONS															
MULGEDIO-ACONITETEA															
Saxifraga rotundifolia	.	.	.	.	.	.	.	1	2	4	+	1	.	.	36
Crepis paludosa	r	1	.	.	.	.	.	1	.	+	.	.	.	.	29
Peucedanum ostruthium	.	.	.	.	.	.	.	.	.	.	.	.	1	4	14
Aconitum lycoctonum	2	.	.	.	.	.	.	.	.	.	.	.	.	.	7
Aconitum variegatum	2	.	.	.	.	.	.	.	.	.	.	.	.	.	7
Viola biflora	.	.	.	.	.	.	.	.	.	1	.	.	.	.	7
OTHER COMPANIONS															
Petasites albus	3	1	.	.	.	2	1	3	.	1	.	3	.	.	50
Stellaria nemorum	.	.	.	+	.	.	1	1	.	.	2	.	.	.	29
Geranium robertianum	1	.	.	1	.	.	.	.	.	+	.	.	r	.	29
Urtica dioica	1	.	.	.	.	.	.	.	.	.	.	.	2	1	21
Sanionia uncinata	.	.	.	.	.	.	.	.	.	.	.	+	1	2	21
Lamium galeobdolon subs. *flavidum*	.	.	.	.	.	.	.	.	.	.	.	.	2	2	14
Equisetum telmateja	.	+	.	.	.	.	.	.	+	.	.	.	.	.	14
Plagiomnium medium	.	.	.	.	.	+	.	.	.	.	.	+	.	.	14

Tab. 16. Eucladietum verticillati (EV). (D) = differential species.

Relevè n.	1	2	3	Fr (%)
Spring Code	LD0509	PG0453	VF0745	
Altitude (m a.s.l.)	509	453	745	
Inclination (°)	60	90	55	
Relevé area (m^2)	1	2.4	0.5	
Vascular plant cover (%)	-	-	20	
Bryophyte cover (%)	50	30	60	
N. of species	3	5	7	
EUCLADIETUM VERTICILLATI				
Eucladium verticillatum	3	3	2	100
ADIANTION, ADIANTETALIA and ADIANTETEA				
Hymenostylium recurvirostre	.	4	2	67
Hymenostylium recurvirostre var. *latifolium*	.	.	2	33
Pellia endiviifolia (D)	2	.	.	33
COMPANIONS				
MONTIO-CARDAMINETEA				
Palustriella commutata (D)	5	3	3	100
OTHER COMPANIONS				
Orthothecium rufescens	.	+	+	67
Bryum pseudotriquetrum	.	.	1	33
Jungermannia atrovirens	.	1	.	33
Pinguicula alpina	.	.	r	33

Tab. 17. Phytocoenon of *Pellia endiviifolia* (PE).

Relevè n.	1
Spring Code	BR1605
Altitude (m a.s.l.)	1605
Inclination (°)	45
Relevé area (m^2)	0.5
Vascular plant cover (%)	15
Bryophyte cover (%)	70
N. of species	6
Phytocoenon of PELLIA ENDIVIIFOLIA	
Pellia endiviifolia	4
CRATONEURION COMMUTATI	
Palustriella commutata	1
COMPANIONS	
Adenostyles glabra	1
Eurhynchium praelongum	1
Jungermannia atrovirens	1
Sesleria caerulea	1

Tab. 18. Phytocoenon of *Eriophorum angustifolium* (EA).

Relevè n.	1	2	Fr (%)
Spring Code	AD1790	CV1940	
Altitude (m a.s.l.)	1790	1940	
Inclination (°)	5	2	
Relevé area (m^2)	3.5	1.5	
Vascular plant cover (%)	95	70	
Bryophyte cover (%)	15	20	
N. of species	7	2	
Phytocoenon of ERIOPHORUM ANGUSTIFOLIUM			
Eriophorum angustifolium	3	4	100
CARICION LASIOCARPAE			
SCHEUCHZERIETALIA PALUSTRIS			
Carex lasiocarpa	+	.	50
Sphagnum contortum	+	.	50
SCHEUCHZERIO-CARICETEA NIGRAE			
Warnstorfia exannulata	.	1	50
Pinguicula vulgaris	+	.	50
COMPANIONS			
MONTIO-CARDAMINETEA			
Dichodontium palustre	2	.	50
OTHER COMPANIONS			
Bryum pseudotriquetrum	+	.	50
Potentilla erecta	+	.	50

Tab. 19. *Caricetum nigrae* (CN).

Relevè n.	1
Spring Code	AD1353
Altitude (m a.s.l.)	1353
Inclination (°)	1
Relevé area (m^2)	3
Vascular plant cover (%)	70
Bryophyte cover (%)	80
N. of species	23
CARICETUM NIGRAE	
Carex canescens	1
Juncus filiformis	1
CARICION and CARICETALIA NIGRAE SCHEUCHZERIO-CARICETEA NIGRAE	
Carex nigra	3
Eriophorum angustifolium	2
Carex rostrata	1
COMPANIONS MONTIO-CARDAMINETEA	
Brachythecium rivulare (D)	1
Philonotis fontana	1
PLATYHYPNIDIO-FONTINALIETEA ANTIPYRETICAE	
Chyloscyphus polyanthos	1
OTHER COMPANIONS	
Calliergonella cuspidata	3
Climacium dendroides	3
Festuca nigrescens	2
Mentha longifolia	2
Alchemilla lineata	1
Luzula sudetica	1
Mnium lycopodioides	1
Myosotis scorpioides	1
Plagiomnium affine	1
Ranunculus repens	1
Anthoxanthum alpinum	+
Bartramia sp.	+
Pellia epiphylla	+
Radula lindbergiana	+
Sanionia uncinata	+

Tab. 20. Phytocoenon of *Mentha aquatica* (MA). (D) = differential species.

Relevè n.	1
Spring Code	BC0503
Altitude (m a.s.l.)	503
Inclination (°)	-
Relevé area (m2)	1.5
Vascular plant cover (%)	100
N. of species	6
Phytocoenon of MENTHA AQUATICA	
Mentha aquatica	4
LEMNA MINOR-FACIES	
Lemna minor	5
CALTHION	
Lysimachia vulgaris	+
Epilobium parviflorum	r
MOLINIETALIA and MOLINIO-ARRHENATHERETEA	
Galium palustre (D)	1
Equisetum palustre	+

Tab. 21. Phytocoenon of *Eupatorium cannabinum* (EC). (D) = differential species.

Relevè n.	1
Spring Code	BR0790
Altitude (m a.s.l.)	790
Inclination (°)	60
Relevé area (m^2)	3
Vascular plant cover (%)	95
Bryophyte cover (%)	60
N. of species	7
Phytocoenon of EUPATORIUM CANNABINUM	
Eupatorium cannabinum	4
CONVOLVULETALIA SEPIUM	
Mentha longifolia (D)	3
GALIO-URTICETEA	
Geranium robertianum	1
Urtica dioica	r
COMPANIONS	
MONTIO-CARDAMINETEA	
Palustriella decipiens	3
OTHER COMPANIONS	
Arrhenatherum elatius	2
Plagiomnium rostratum	1

Tab. 22. Chaerophyllo-Petasitetum officinalis (CP). (D) = differential species.

Relevè n.	1
Spring Code	CS1350
Altitude (m a.s.l.)	1350
Inclination (°)	35
Relevé area (m^2)	2.3
Vascular plant cover (%)	100
Bryophyte cover (%)	10
N. of species	8
CHAEROPHYLLO-PETASITETUM OFFICINALIS	
Mentha longifolia (D)	4
Petasites hybridus	3
PETASITION OFFICINALIS	
Cardamine amara (D)	3
Chaerophyllum hirsutum (D)	1
LAMIO ALBI-CHENOPODIETALIA BONI-HENRICI	
GALIO-URTICETEA	
Urtica dioica	1
COMPANIONS	
MONTIO-CARDAMINETEA	
Cratoneuron filicinum	2
Brachythecium rivulare (D)	1
OTHER COMPANIONS	
Equisetum arvense	r

Tab. 23. Phytocoenon of *Mentha longifolia* (ML). (D) = differential species.

Relevè n.	1	2	Fr (%)
Spring Code	MB1440	MB1440	
Altitude (m a.s.l.)	1440	1440	
Inclination (°)	20	10	
Relevé area (m^2)	1	1	
Vascular plant cover (%)	90	100	
Bryophyte cover (%)	5	5	
N. of species	11	10	
Phytocoenon of MENTHA LONGIFOLIA			
Mentha longifolia	3	3	100
RUMICION and RUMICETALIA ALPINI			
MULGEDIO-ACONITETEA			
Chaerophyllum hirsutum	2	2	100
Saxifraga rotundifolia	2	1	100
Adenostyles alliariae	1	2	100
Alchemilla hirtipes (D)	r	2	100
Viola biflora	+	1	100
Geum rivale	.	2	50
COMPANIONS			
CRATONEURION COMMUTATI			
Palustriella decipiens	1	.	50
Cratoneuron filicinum	+	.	50
MONTIO-CARDAMINETEA			
Brachythecium rivulare (D)	+	.	50
OTHER COMPANIONS			
Myosotis sylvatica	r	2	100
Cerastium arvense subsp. suffruticosum	1	1	100
Poa alpina	.	+	50

3.2. Ecological analysis

3.2.1. Variation range of environmental parameters

The environmental parameters show different ranges among the vegetation types (Tab. 24). The altitudinal range is very broad, between 170 and 2739 m a.s.l. Most crenic vegetation types are, however, concentrated within the montane vegetation belt, from 800 to 1600 m. Shading is also very variable. Most vegetation types belong to classes 3 and 4, corresponding to more than 50% shading. Only *Solenostomo-Hygrohypnetum smithii* and *Blindio-Scapanietum undulatae* are restricted to the very sunny sites of class 1 (shading 0-25%).

Conductivity and alkalinity also show similar distribution patterns, with the vegetation types clearly separated into two distinct groups. The first, including the majority of types, has between 200 and 400 μS cm^{-1} conductivity and 100 and 200 mg L^{-1} $CaCO_3$ alkalinity. It comprises all types around springs flowing through carbonate bedrock. In the second group, conductivity and alkalinity are below 100 μS cm^{-1} and 50 meq L^{-1}, respectively. All these vegetation types occur on siliceous bedrocks. The variance of conductivity and alkalinity within the same vegetation type is generally low, apart from the *Cratoneuron filicinum* phytocoenon, in which both parameters are enhanced in two stands by excessive nitrate. pH shows a similar distribution pattern, with the vegetation types on carbonate substrata having pH values around 8.0. The vegetation types on siliceous massifs show a clear trend toward higher variation between stands, especially the *Cardamino-Chrysosplenietum alternifolii* and the *Montio-Bryetum schleicheri*, where pH ranges from 6.5 and 7.5, and the *Blindio-Scapanietum undulatae*, whose stands have pH values between 5.9 and 7.0. Sulphate behaves very peculiarly, because six vegetation types have very high internal variation, whereas all the other ones have low sulphate values (below 10 mg L^{-1}). However the high sulphate values of some vegetation are explained by one or more relevés from sulphurous springs.

Nutrient availability for the different vegetation types is shown in the nitrate and phosphate columns. Nitrate concentration is below the mesotrophic-eutrophic boundary for all the vegetation types, with the exception of the *Mentha longifolia* phytocoenon. The majority of vegetation types are irrigated by oligotrophic crenic waters, while a few have continuous irrigation with mesotrophic waters. The broad variation within the *Cratoneuron filicinum* phytocoenon is determined by the relevé from a spring close to a farm (see above). The phosphate column shows that all vegetation types have less than 25 μg L^{-1} available-P, corresponding to the oligotrophic-mesotrophic boundary. Most vegetation types occur in springs with water with less than 5 μg L^{-1} phosphate. The highest values are recorded for some tall herb communities (including *Chaerophyllo-Cardaminetum asarifoliae* and the *Cardamino-Chrysosplenietum alternifolii* subass. *oxalidetosum acetosellae*).

Flow velocity in crenic habitats is a synthetic variable, variously influenced by discharge and slope, and therefore both discharge and flow velocity should be

Tab. 24. Median, lower and upper quartile (25th -75th) of the main environmental variables in the phytosociological units.

phytosociological unit	N	Altitude (m a.s.l.)			Shading class			El. cond. (µS cm^{-1})			Alkal (mg L^{-1} $CaCO_3$)			pH		
		median	25th	75th	median	25th	75th	median	25th	75th	median	25th	75th	median	25th	75th
1. Scapanietum undulatae	4	1387	1353	1428	2.5	2.0	3.5	33	31	34	11.5	9.5	12.0	6.77	6.67	6.84
2. Oxyrrhynchietum rusciformis	18	633	470	992	4.0	3.0	4.0	267	232	313	143.5	103.0	174.0	7.92	7.67	8.00
3. Cinclidotetum aquatici	1	686	686	686	3.0	3.0	3.0	180	180	180	104.0	104.0	104.0	7.88	7.88	7.88
4. Brachythecio rivularis-Hygrohypnetum luridi	7	1300	656	1315	3.0	3.0	4.0	225	207	297	130.0	118.0	132.0	7.96	7.91	8.04
5. Phytocoenon of *Hygroamblystegium tenax*	4	360	210	470	3.5	3.0	4.0	269	252	294	112.0	103.0	140.5	7.92	7.83	8.00
6. Cratoneuretum commutati	21	1000	790	1474	4.0	3.0	4.0	345	241	392	149.0	131.0	220.0	7.97	7.91	8.09
7. Cratoneuretum falcati	15	1502	1400	1765	3.0	2.0	4.0	212	179	221	120.0	98.0	132.0	8.04	7.88	8.14
8. Phytocoenon of *Cratoneuron filicinum*	7	590	565	1350	2.0	2.0	4.0	301	204	796	170.0	149.0	437.0	7.94	7.47	8.04
9. Phytocoenon of *Palustriella decipiens*	1	1670	1670	1670	4.0	4.0	4.0	223	223	223	123.0	123.0	123.0	7.87	7.87	7.87
10. Chaerophyllo-Cardaminetum asarifoliae	1	1235	1235	1235	4.0	4.0	4.0	198	198	198	109.0	109.0	109.0	8.03	8.03	8.03
11. Phytocoenon of *Petasites albus*	4	979	782	1290	3.5	2.0	4.0	293	227	358	165.4	112.4	217.5	7.96	7.69	8.17
12. Montio-Bryetum schleicheri	18	1911	1623	1990	1.5	1.0	2.0	33	28	60	11.7	7.9	17.0	6.86	6.60	7.03
13. Solenostomo-Hygrohypnetum smithii	4	2314	2234	2527	1.0	1.0	1.0	19	18	23	4.4	3.8	7.5	6.54	6.29	6.80
14. Blindio-Scapanietum undulatae	8	1899	1748	2102	1.0	1.0	1.0	16	12	22	3.6	3.2	6.8	6.17	5.93	6.40
15. Cardamino-Chrysosplenietum alternifolii	14	1158	981	1254	4.0	4.0	4.0	72	44	120	28.5	19.0	56.7	7.17	6.85	7.54
16. Eucladietum verticillati	3	509	453	745	4.0	1.0	4.0	333	240	340	177.0	138.0	205.0	7.87	7.86	8.19
17. Phytocoenon of *Pellia endiviifolia*	1	1605	1605	1605	2.0	2.0	2.0	241	241	241	147.0	147.0	147.0	8.32	8.32	8.32
18. Phytocoenon of *Eriophorum angustifolium*	2	1865	1790	1940	1.5	1.0	2.0	34	28	39	12.8	10.5	15.0	6.90	6.85	6.95
19. Caricetum nigrae	1	1353	1353	1353	2.0	2.0	2.0	33	33	33	12.0	12.0	12.0	6.84	6.84	6.84
20. Phytocoenon of *Mentha aquatica*	1	503	503	503	4.0	4.0	4.0	241	241	241	131.0	131.0	131.0	7.98	7.98	7.98
21. Phytocoenon of *Eupatorium cannabinum*	1	790	790	790	4.0	4.0	4.0	368	368	368	220.0	220.0	220.0	7.91	7.91	7.91
22. Chaerophyllo-Petasitetum officinalis	1	1350	1350	1350	2.0	2.0	2.0	301	301	301	170.0	170.0	170.0	8.20	8.20	8.20
23. Phytocoenon of *Mentha longifolia*	2	1440	1440	1440	2.0	2.0	2.0	261	261	261	143.0	143.0	143.0	8.07	8.07	8.07

phytosociological unit	N	SO_4 (mg L^{-1})			N-NO_3 (µg L^{-1})			P-PO_4 (µg L^{-1})			Discharge (L s^{-1})			Flow vel. (cm s^{-1})		
		median	25th	75th	median	25th	75th	median	25th	75th	median	25th	75th	median	25th	75th
1. Scapanietum undulatae	4	2.1	1.8	3.0	864	483	1012	1.3	1.2	3.8	12.5	3.0	20.0	34	10	53
2. Oxyrrhynchietum rusciformis	18	2.8	2.1	5.6	709	361	1197	5.2	1.6	7.0	4.5	3.0	7.0	9	5	13
3. Cinclidotetum aquatici	1	1.9	1.9	1.9	333	333	333	4.4	4.4	4.4	120.0	120.0	120.0	1	1	1
4. Brachythecio rivularis-Hygrohypnetum luridi	7	5.6	3.0	35.5	659	309	738	3.0	1.3	3.5	2.3	1.0	7.0	25	5	50
5. Phytocoenon of *Hygroamblystegium tenax*	4	4.1	1.3	15.4	665	427	1498	3.8	2.6	10.2	16.5	2.0	30.0	0	0	10
6. Cratoneuretum commutati	21	7.4	4.7	16.6	597	318	768	1.5	1.2	2.5	0.5	0.3	1.5	15	10	20
7. Cratoneuretum falcati	15	3.1	1.3	7.1	543	247	746	2.3	1.1	2.5	1.0	0.3	3.0	20	10	40
8. Phytocoenon of *Cratoneuron filicinum*	7	6.8	5.4	33.0	893	803	6885	6.9	5.5	13.1	1.0	0.8	1.0	10	4	20
9. Phytocoenon of *Palustriella decipiens*	1	6.6	6.6	6.6	605	605	605	0.9	0.9	0.9	0.5	0.5	0.5	10	10	10
10. Chaerophyllo-Cardaminetum asarifoliae	1	3.8	3.8	3.8	973	973	973	9.8	9.8	9.8	0.9	0.9	0.9	20	20	20
11. Phytocoenon of *Petasites albus*	4	3.0	2.1	6.0	458	212	694	2.9	1.9	6.9	0.5	0.3	3.8	18	3	30
12. Montio-Bryetum schleicheri	18	3.2	1.9	6.4	312	231	464	2.8	2.0	6.0	1.0	0.2	2.5	18	7	30
13. Solenostomo-Hygrohypnetum smithii	4	1.0	0.9	1.2	843	437	1137	1.2	1.2	2.0	0.6	0.5	7.9	28	8	40
14. Blindio-Scapanietum undulatae	8	1.5	1.1	3.3	254	197	301	1.0	1.0	1.2	2.9	1.5	3.3	40	8	45
15. Cardamino-Chrysosplenietum alternifolii	14	3.7	2.5	5.2	361	108	717	6.1	2.3	7.0	0.3	0.2	3.0	15	10	25
16. Eucladietum verticillati	3	4.3	2.3	18.9	915	654	969	1.0	0.0	1.0	0.3	0.2	2.0	25	20	30
17. Phytocoenon of *Pellia endiviifolia*	1	1.9	1.9	1.9	238	238	238	1.2	1.2	1.2	0.3	0.3	0.3	40	40	40
18. Phytocoenon of *Eriophorum angustifolium*	2	1.6	1.2	2.0	716	297	1135	2.8	2.4	3.1	0.5	0.2	0.7	23	20	25
19. Caricetum nigrae	1	1.8	1.8	1.8	1012	1012	1012	1.3	1.3	1.3	20.0	20.0	20.0	53	53	53
20. Phytocoenon of *Mentha aquatica*	1	10.2	10.2	10.2	333	333	333	2.0	2.0	2.0	3.0	3.0	3.0	5	5	5
21. Phytocoenon of *Eupatorium cannabinum*	1	2.7	2.7	2.7	318	318	318	5.5	5.5	5.5	1.0	1.0	1.0	15	15	15
22. Chaerophyllo-Petasitetum officinalis	1	6.8	6.8	6.8	893	893	893	13.1	13.1	13.1	1.0	1.0	1.0	22	22	22
23. Phytocoenon of *Mentha longifolia*	2	3.8	3.8	3.8	1823	1823	1823	7.5	7.5	7.5	0.2	0.2	0.2	10	10	10

considered. Most vegetation types occur at springs with less than 5 L s^{-1} discharge. The bryophyte-dominated vegetation types belonging to the class *Platyhypnidio-Fontinalietea antipyreticae* were encountered at springs with the highest discharge and variation. Among them, the *Cinclidotetum aquatici* was sampled inside a spring with the highest values for both discharge and flow velocity, where the dominant moss is totally submerged. On the other hand, most bryophyte and vascular species in the *Caricetum nigrae* are non-submerged around the helocrene, where flow velocity is lower despite the constant high discharge.

3.2.2. Discriminant Analysis

Discriminant analysis of the environmental variables among the vegetation types showed that the first three canonical variates were highly significant, and accounted for more than 88% cumulative proportion of explained variance (Tab. 25). The factor structure coefficients for the first three canonical variates (Tab. 25) indicated that the environmental descriptors that best accounted for the among-group variation were pH and alkalinity, and altitude (first variate); altitude and discharge (second variate); alkalinity and nitrate, and shading (third variate). Figure 2 shows the position of the centroids of the 20 vegetation types in relation to the first two canonical axes. According to figure 2, the vegetation types were mainly distributed along three gradients. The first gradient, corresponding to the first axis, reflects differences in pH and alkalinity; the second axis separated the vegetation types occurring at high altitude (positive values) and those with a high dis-

Tab. 25. Structure coefficients for the first three significant canonical variates. Values in bold are the most significant. See text for details.

	Canonical variate I	Canonical variate II	Canonical variate II
Wilk's Λ	0.037	0.129	0.271
χ^2	383.2	237.8	151.4
df	144	120	98
P	>0.001	>0.001	>0.001
Discriminant variable			
altitude	**-0.475**	**0.595**	-0.266
shading	0.274	-0.126	**0.548**
conductivity	0.190	0.112	-0.129
alcalinity	**0.540**	0.107	**-0.526**
pH	**0.643**	0.276	0.069
sulphate	0.030	0.104	0.011
nitrate	0.110	-0.125	**-0.506**
phosphate	0.039	-0.246	-0.208
discharge	0.060	**-0.347**	0.122
flow velocity	-0.066	0.168	0.025
Eigenvalue	9.264	2.500	1.107
Cum. Prop.	0.639	0.812	0.888

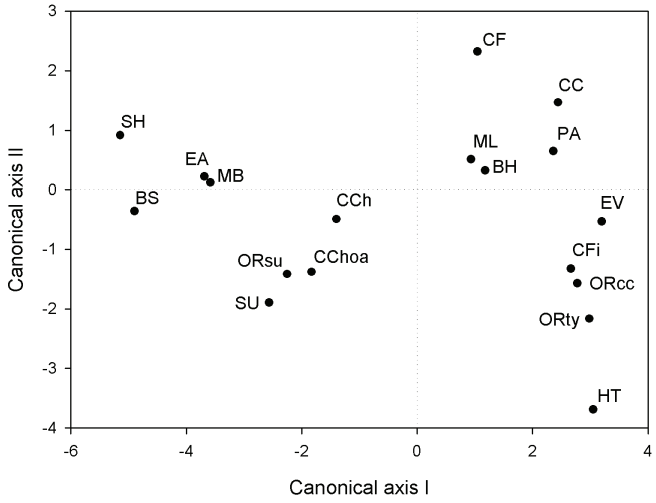

Fig. 2. Centroids in the canonical discriminant space of the vegetation types occurring in the investigated spring habitats (only the vegetation types with more than two cases were considered, see text for acronyms and more details).

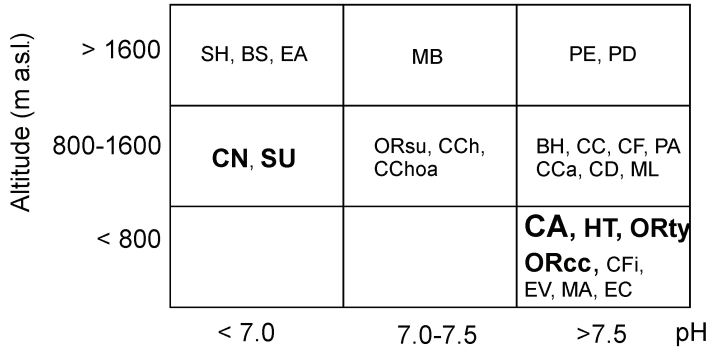

Fig. 3. Schematic diagram showing the arrangement of vegetation types along the main environmental gradients: altitude, pH and discharge. Boldface acronyms correspond to vegetation types occurring at springs with higher discharge. Acronyms are those reported in the text.

charge (negative values). A schematic diagram (Fig. 3) shows how the syntaxa were arranged across the three main gradients, altitude, pH and discharge. About 55% of vegetation types have alkaline waters with pH above 7.5, distributed below 1600 m a.s.l.; whereas all the vegetation types with neutral or acid waters, pH less than 7.0, occur above 800 m a.s.l. These patterns can be explained by the different altitudinal distribution of carbonate and siliceous substrata in the study area. The vegetation types within springs with high discharge are

printed in bold. The majority of them occur at low altitudes and almost all belong to the class *Platyhypnidio-Fontinalietea antipyreticae*.

4. DISCUSSION AND CONCLUSIONS

The syntaxonomical arrangement of crenic vegetation in Trentino is synthesized in table 26. It includes 23 plant communities, 14 typified as associations (two of them including also two or more subassociations), and 9 arranged as phytocoena. The high number of phytocoena is reasonable for plant communities often characterized by extreme paucity of their floristic assemblage, where the dominant species may have only a weak diagnostic value.

The classes *Platyhypnidio-Fontinalietea antipyreticae* and *Montio-Cardaminetea* subsume most of what is regarded as "crenic vegetation". They include about two thirds of the vegetation types identified here, of which almost two thirds belong to the class *Montio-Cardaminetea*, comprising non-submerged plant communities containing variable mixtures of bryophytes and vascular plants. The *Cratoneurion commutati* alliance, represented by 6 different vegetation types, forms the core of the class. The two commonest and most widespread plant communities of the alliance are the *Cratoneuretum commutati* and the *Cratoneuretum falcati*, with well-defined peaks of altitudinal occurrence, but, in spite of this, reciprocally connected along the altitudinal gradient by subcommunities.

Tab. 26. Syntaxonomical scheme.

CLASS: PLATYHYPNIDIO-FONTINALIETEA ANTIPYRETICAE Philippi 1956
ORDER: BRACHYTHECIETALIA PLUMOSI Philippi 1956
ALLIANCE: RACOMITRION ACICULARIS v.Krusenstjerna 1945
1. Scapanietum undulatae Schwickerath 1944
subass. fontinalietosum antipyreticae Schmidt 1993
ORDER: LEPTODICTYETALIA RIPARII Philippi 1956
ALLIANCE: PLATYHYPNIDION RUSCIFORMIS Philippi 1956
2. Oxyrrhynchietum rusciformis Kaiser ex v. Hübschmann 1953
subass. typicum
subass. cratoneuretosum commutati Schmidt 1993
subass. scapanietosum undulatae Marstaller 1987
ALLIANCE: CINCLIDOTION FONTINALOIDIS Philippi 1956
3. Cinclidotetum aquatici Philippi 1956
ALLIANCE: BRACHYTHECION RIVULARIS Hertel 1974
4. Brachythecio rivularis-Hygrohypnetum luridi Philippi 1965
5. Phytocoenon of *Amblystegium tenax*

CLASS: MONTIO-CARDAMINETEA Br.-Bl. et R. Tx. ex Klika et Hadač 1944 em. Zechmeister 1993
ORDER: MONTIO-CARDAMINETALIA Pawlowski 1928 em. Zechmeister 1993
ALLIANCE: CRATONEURION COMMUTATI Koch 1928
6. Cratoneuretum commutati Aichinger 1933
7. Cratoneuretum falcati Gams 1927
8. Phytocoenon of *Cratoneuron filicinum*
9. Phytocoenon of *Palustriella decipiens*
10. Chaerophyllo-Cardaminetum asarifoliae Gerdol et Tomaselli 1988
11. Phytocoenon of *Petasites albus*
ALLIANCE: *CARDAMINO MONTION* Br.-Bl. 1926 em. Zechmeister 1993
12. Montio-Bryetum schleicheri Br.-Bl. 1925
13. Solenostomo-Hygrohypnetum smithii Geissler 1976
14. Blindio-Scapanietum undulatae Geissler 1976
ALLIANCE: *CARICION REMOTAE* Kästner 1941 em.Zechmeister et Mucina 1994
15. Cardamino-Chrysosplenietum alternifolii Maas 1959 em. Zechmeister 1993
subass. chaerophylletosum hirsuti Zechmeister et Steiner 1993
subass. oxalidetosum acetosellae subass. nova hoc loco

CLASS: ADIANTETEA: Br.-Bl. in Br.-Bl., Roussine et Nègre 1952
ORDER: ADIANTETALIA CAPILLI-VENERIS Br.-Bl. ex Horvatić 1934
ALLIANCE: ADIANTION Br.-Bl. 1931
16. Eucladietum verticillati Allorge ex Braun 1968
17. Phytocoenon of *Pellia endiviifolia*

CLASS: SCHEUCHZERIO-CARICETEA NIGRAE nom. mut. propos ex Steiner 1992
ORDER: SCHEUCHZERIETALIA PALUSTRIS Nordhagen 1936
ALLIANCE: CARICION LASIOCARPAE Vanden Berghen in Lebrun et al. 1949
18. Phytocoenon of Eriophorum angustifolium
ORDER: CARICETALIA NIGRAE nom. mut. propos ex Steiner 1992
ALLIANCE: CARICION NIGRAE nom. mut. propos ex Steiner 1992
19. Caricetum nigrae nom. mut. propos ex Steiner 1992

(continued)

Tab. 26. Continuation.

CLASS: MOLINIO-ARRHENATHERETEA R.Tx. 1937 em. R. Tx. 1970
ORDER: MOLINIETALIA Koch 1926
ALLIANCE: CALTHION R.Tx. 1937 em. Balátová-Tuláčková 1978
20. Phytocoenon of *Mentha aquatica*

CLASS: GALIO-URTICETEA Passarge ex Kopecký 1969
ORDER: CONVOLVULETALIA SEPIUM R. Tx. 1950 em. Mucina 1993
21. Phytocoenon of *Eupatorium cannabinum*
ALLIANCE: PETASITION OFFICINALIS Sillinger 1933
22. Chaerophyllo-Petasitetum officinalis Kaiser 1926

CLASS: MULGEDIO-ACONITETEA Hadač et Klika in Klika et Hadač 1944
ORDER: RUMICETALIA ALPINI Mucina in Karner et Mucina 1993
ALLIANCE: RUMICION ALPINI Rübel ex Klika in Klika et Hadač 1944
23. Phytocoenon of *Mentha longifolia*

The other communities within the *Cratoneurion commutati* are scattered throughout the study area. Moreover, they are not as clearly characterized from a floristical viewpoint, except the *Chaerophyllo-Cardaminetum asarifoliae*. This association has been briefly mentioned in the literature, reported only from the northern Apennines, but it seems likely that its full range roughly matches that of the dominant species, including the Western Alps, with scattered localities in the Eastern Alps, as far as the Autonomous Province of Trento.

The *Cardamino-Montion* alliance appears with only 3 associations, restricted to the upper montane to the alpine vegetation belt. They represent little under half the associations of this alliance reported from the Alps. This could be explained by the low occurrence of high-altitude helocrene-type springs on the siliceous massifs, further supported by the complete absence of crenic communities belonging to the alliance *Dermatocarpion*.

The *Caricion remotae* alliance is also under-represented in the study area, where it occurs with only one association. *Caricion remotae* communities are strictly linked to montane shaded springs, with acidic to circumneutral waters. Their occurrence in Trentino is, therefore, restricted to the porphyritic rocks of the Lagorai range, and inhibited elsewhere by limestone rocks. On the other hand, the carbonate lithology prevailing within the collinar and montane vegetation belts enhances the occurrence of basiphilous communities belonging to the class *Platyhypnidio-Fontinalietea antipyreticae*. The most widespread and floristically diversified association is the *Oxyrrhynchietum rusciformis*.

From its core, represented by the classes *Platyhypnidio-Fontinalietea antipyreticae* and *Montio-Cardaminetea*, crenic vegetation shows a number of floristic trends towards other physically and ecologically "peripheral" communities. Among them, those belonging to the *Adiantion* and to the *Scheuchzerio-Caricetea nigrae* have the closest affinities with the "true" crenic vegetation. The more or less nitrophilous, tall herb communities have their coenological foci outside springs. They occur more frequently within small springs, where boundary delimitation with the surrounding habitats is problematic.

The ecological analysis revealed that phytocoenological diversity within the crenic vegetation sampled in Trentino can be mainly explained by abiotic variables, such as alkalinity and pH, reflecting the nature of the substrata from which springs emerge. Temperature, mirrored by altitude, also has a strong influence on the floristic composition of crenic communities. Discharge mainly explains the floristic differences between the submerged bryophyte communities and the others. Floristic differences among the communities of the class *Platyhypnidio-Fontinalietea antipyreticae* are also conditioned by discharge. In general, as reported in Spitale *et al*. (2009), discharge affects crenic complexity, area and species richness. The largest springs with higher discharge have maximal floristic richness and phytocoenological diversity.

When discharge is reduced by more or less intensive water-collection, as frequently happens in lower areas, crenic area and species richness are, in turn, reduced. In these cases, vegetation looses its typical features and becomes a mosaic of fragmentary small stands, in which the original crenic species are replaced by "invader" species from the surrounding habitats.

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