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## The Vegetation of the Ranunculo-Nardion in the Southern Apennines (S. – Italy)

By

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With 3 Figures

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### Summary

TOMASELLI M., BERNARDO L. & PASSALACQUA N. 2003. The vegetation of the Ranunculo-Nardion in the Southern Apennines (S. – Italy). – *Phyton* (Horn, Austria) 43 (1): 39–57, 3 figures. – English with German summary.

In Italy snow-beds are distributed mostly in the Alps, whereas they become more and more rare as far as one proceeds along the Apennines from North to South. The present contribution aims at: i) filling the gap in the basic knowledge of snow-bed vegetation in the southern Apennines; ii) detecting snow-bed plant species at risk of local extinction, as a consequence of warming induced by climate change. The study is based on 60 phytosociological relevés taken on the massifs of Pollino and of Sirino-Papa. The relevés were numerically classified by the method of minimum increase of sum of squares agglomeration based on the chord distance. Two main physiognomic vegetation units were detected, corresponding to close grasslands respectively dominated by *Nardus stricta* or by *Crepis aurea* subsp. *glabrescens* and *Plantago atrata*. These vegetation units were classified into phytosociological syntaxa according to the BRAUN-BLANQUET principle of species fidelity. The communities were

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integrated within the three associations: *Nardo-Luzuletum pindicae* BONIN 1972 (lectotypus h.l. design.; with three new subass. descr. h.l.), *Plantagini serpentinae-Nardetum strictae* TOMASELLI, BERNARDO & PASSALACQUA (new ass. descr. h.l.) and *Bellidi pusillae-Alopecuretum gerardi* TOMASELLI, BERNARDO & PASSALACQUA (new ass. descr. h.l., with two new subass. descr. h.l., one of them with two variants), occurring in different ecological conditions and showing a certain degree of floristic heterogeneity and, therefore, subdivided into subassociations and variants. Floristic differences within associations could be best explained by altitudinal and inclination gradients. Furthermore, the hypothetical risk of local extinction of seven species concentrated in the *Bellidi pusillae-Alopecuretum gerardi* stands, as consequence of warming induced by climate change, was evaluated.

### Zusammenfassung

TOMASELLI M., BERNARDO L. & PASSALACQUA N. 2003. Die Vegetation des *Ranunculo-Nardion* im Süd-Apennin (S. – Italien). *Phyton* (Horn, Austria) 43 (1): 39–57, 3 Abbildungen. – Englisch mit deutscher Zusammenfassung.

In Italien sind die Schneetälchen hauptsächlich in den Alpen verbreitet, während sie im Apennin gegen Süden immer seltener werden. Die vorliegende Arbeit soll eine Lücke in den Kenntnissen über die Schneetälchen Vegetation im südlichen Apennin (Pollino und Sirino Gebirge) füllen. Die Arten dieser Schneetälchen sind wegen der Klimaerwärmung gefährdet. 60 pflanzensoziologische Aufnahmen wurden mit Hilfe numerischer Verfahren (sum of squares agglomeration mit der Chord distance als Unähnlichkeitskoeffizienten) klassifiziert. Es wurden zwei deutlich charakterisierte physiognomische Hauptvegetationstypen unterschieden. Sie entsprechen Rasen dominiert von *Nardus stricta* bzw. von *Crepis aurea* subsp. *glabrescens* und *Plantago atrata*. Vom syntaxonomischen Gesichtspunkt wurden diese Vegetationstypen drei Assoziationen zugeordnet: *Nardo-Luzuletum pindicae* BONIN 1972 (Lectotypus h.l. design.; mit drei neuen Subass. descr. h.l.), *Plantagini serpentinae-Nardetum strictae* TOMASELLI, BERNARDO & PASSALACQUA (ass. nova descr. h.l.) und *Bellidi pusillae-Alopecuretum gerardi* TOMASELLI, BERNARDO & PASSALACQUA (ass. nova descr. h.l., mit zwei neuen Subass. descr. h.l., eine davon mit zwei Varianten). *Nardo-Luzuletum pindicae* und *Bellidi pusillae-Alopecuretum gerardi* werden aufgrund geomorphologischer Faktoren (Seehöhe und Inklinatation) in verschiedene Subassoziationen und Varianten unterteilt. Die floristischen Unterschiede korrelierten gut mit den untersuchten geomorphologischen Parametern Seehöhe und Inklinatation. Schließlich, wird die Gefahr des wahrscheinlichen Aussterbens für sieben Arten des *Bellidi pusillae-Alopecuretum gerardi* diskutiert.

### 1. Introduction

In the alpine zone hollows, depressions and lee slopes, with extended snow cover (called snow patches or snow beds) are colonized by plant species protected by this snow cover against exposure to low temperature extremes and desiccation during the cold season (KÖRNER 1999). These plants are restricted in their growth by the short length of the growing season. For this reason, snow patches have a vegetation cover formed by small plants adapted to a short vegetation period (ELLENBERG 1986).

In the Italian mountains, snow patches and the related plant communities are distributed mostly in the Alps, whereas they become more and more rare as one proceeds along the Apennines from North to South (TOMASELLI 1991). The reduction of the frequency of snow patches throughout the Apennines is, no doubt, largely due to a climatic gradient. The traits of Mediterranean climate progressively increase, in fact, throughout the Apennine chain, according to a latitudinal gradient (SESTINI 1957). In the alpine zone, this typically leads to a general reduced persistence of snow cover. The frequency of snow patches in the Apennines is also caused by the geological conditions (predomination of calcareous bedrock). The hollows occurring on limestone are mostly stony. For this reason, they dry out quickly, owing to cracks in the rock through which the melting snow can drain away (ELLENBERG 1986).

The climatic gradient and the prevailing bedrock condition also account for compositional changes in the snow beds throughout the Apennines, conditioning a gradual decline of the character species of the class Salicetea herbaceae, representative of the snow-bed vegetation. Plant communities belonging to this class are still encountered in the northern Apennines, where, however, they occur very sparsely and are markedly impoverished from the floristic point of view (TOMASELLI 1991). In the central Apennines, snow-bed vegetation is documented by a number of accounts published to date, which report a further reduction of the nucleus of the Salicetea herbaceae species (FURRER & FURNARI 1960, BRUNO & al. 1965, BRUNO & FURNARI 1966, MIGLIACCIO 1970, FEOLI-CHIAPPELLA & FEOLI 1977, BONIN 1978, BAZZICHELLI & FURNARI 1979, PEDROTTI 1981, PETRICCIONE 1993, PETRICCIONE & PERSIA 1995, BIONDI & al. 1999, 2000). In the southern Apennines, the vegetation colonizing the sites with a prolonged snow cover received scarcely any attention prior to the accounts by BONIN 1972, 1978. These studies, were, however, restricted to the less extreme situations represented by the mesophytic grasslands dominated by *Nardus stricta*.

Our primary objective within the present contribution is to attempt at filling the gap in the knowledge of snow-bed vegetation in the southern Apennines. This objective will be pursued by typifying vegetation based on numerical classification of phytosociological relevés and by defining vegetation types from the syntaxonomical viewpoint.

Another purpose of this paper is to detect plant species at potential risk of extinction in the snow beds of the southern Apennines. Long-term records provide undeniable evidence for an ongoing climate warming in the areas above tree line (PRICE & BARRY 1997; GRABHERR & al. 2000). Direct and indirect effects of this climate change may affect biodiversity and may lead to local extinction of plant species (GRABHERR & al. 1994; GOTTFRIED & al. 1998). This risk for biodiversity losses seems to be particularly high in

the southern Apennines, where snow beds occur at their southernmost distribution border in Italy.

## 2. Description of the Study Area

The massifs of Sirino-Papa (2005 m) and of Pollino (2267 m) are the highest mountain ranges in the southern Apennines (Fig. 1). The massif of Sirino-Papa ( $40^{\circ} 05' - 40^{\circ} 11' N$ ,  $15^{\circ} 44' - 15^{\circ} 53' E$ ) is entirely comprised within the Basilicata region; whereas the massif of Pollino ( $39^{\circ} 49' - 40^{\circ} 06' N$ ,  $15^{\circ} 53' - 16^{\circ} 20' E$ ) extends from the southern Basilicata to the northern Calabria.

Both massifs are mostly formed by calcareous rocks (SCANDONE 1972; IPPOLITO & al. 1973) and their summits show modelling by Würmian glaces (ACQUAFREDDA & PALMENTOLA 1986).

The climate in the summit areas of the two massifs is fairly different (CANTORE & al. 1987). The main difference concerns the precipitation regime. Precipitation on the massif of Sirino-Papa, with a mean annual value of about 2000 mm, is strongly influenced by the humid winds blowing

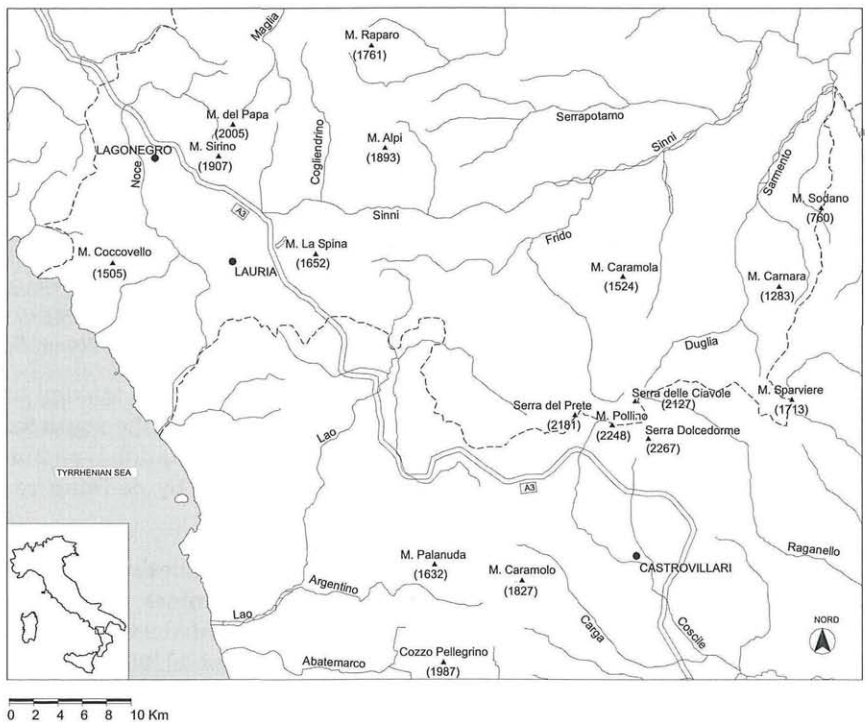


Fig. 1. Schematic map of the study area. - borders of the region Basilicata.

from the Tyrrhenian Sea. M. Pollino has an annual precipitation ranging from 1300 to 1500 mm. The climate is drier, due to the interior location of this massif. The average annual temperature is between 5° and 6° C on Pollino and about 6° C on Sirino-Papa.

Despite the human impact, particularly strong at the lowest altitudes, vegetation belts are still recognizable. The mediterranean vegetation belt with *Quercus ilex*-woods is confined to the steep and rough southern slope until 900 m. It is succeeded in altitude by a supramediterranean belt, characterized by deciduous mixed woods, with a prevalence of *Quercus cerris* and from about 1100 m by a montane vegetation belt, dominated by beech (*Fagus sylvatica*) woods. According to UBALDI 1989, the vegetation above timberline (about 2000 m) corresponds to an alpine belt of Apennine type, where *Sesleria nitida*-grasslands are largely prevailing.

### 3. Materials and Methods

#### 3.1. Vegetation Sampling

The vegetation was studied using the phytosociological method (BRAUN-BLANQUET 1964). A systematic vegetation sampling was made through the whole range of the study area, taking 53 phytosociological relevés. This relevé set was integrated by adding 7 phytosociological relevés taken and modified (concerning nomenclature and cover values) from BONIN 1978. The sites of relevés are the following ones: Serra Dolcedorme (DD), Serra del Prete (DP), Grande Porta del Pollino (GP), M. Pollino (PO) and Piani di Pollino (PP) on the massif of Pollino and M. Papa (PA), Schiena d'Asino (SA) and M. Sirino (SI) on the massif of Sirino-Papa.

The cover of species in the relevés was estimated using the BRAUN-BLANQUET cover-abundance scale, as modified by PIGNATTI & MENGARDA 1962: r = rare species; + = cover <1%; 1 = cover >1–20%; 2 = cover >20–40%; 3 = cover >40–60%; 4 = cover >60–80%; 5 = cover >80–100%.

#### 3.2. Data Analysis

The 60 relevés are presented in a floristic table. The rare species occurring in one relevé only were eliminated (the list is available from the authors). The relevés included within the resulting matrix (73 species × 60 relevés) were numerically classified by the method of minimum increase of sum of squares agglomeration based on the chord distance. This calculation was based on the cover data of species corresponding to the following transformations of the Braun-Blanquet scale, as proposed by VAN DER MAAREL 1979 (r = 1; + = 2; 1 = 3; 2 = 5; 3 = 7; 4 = 8; 5 = 9).

The vegetation units obtained by the cluster analysis were then compared with the syntaxonomical types deduced by literature, mostly BONIN 1978 and BIONDI & al. 1999, 2000. The syntaxonomic arrangement to syntaxa higher than association was based on BIONDI & al. 1999, 2000 and GRABHERR & MUCINA 1993. The source of nomenclature for vascular plants is PIGNATTI 1982, with the exception of *Brachypodium genuense* (LUCCHESI 1987). The syntaxonomical nomenclature of syntaxa is in accordance with the rules defined by WEBER & al. 2000.

The analysis of variance was applied for evaluating to what extent could compositional differences between vegetation types be related to variations in altitude and inclination.

The species particularly at risk of reduction or extinction, were detected by a numerical classification of all the species of the above quoted matrix. For this classification, the method of minimum increase of sum of squares agglomeration based on the correlation coefficient was adopted. Numerical classifications were performed using the SYN-TAX V package (PODANI 1993); the program ANOVA from the SPSS package (NORUSIS 1993) was used for the analysis of variance.

## 4. Results

### 4.1. Vegetation Types

Numerical classification of the 60 phytosociological relevés produced a dendrogram, where three main clusters were recognized at a sum of squares of ca. 12 (Fig. 2). The clusters NL and PN correspond to vegetation units dominated by *Nardus stricta*, whereas the cluster BA corresponds to a vegetation unit, where *Crepis aurea* subsp. *glabrescens* and *Plantago atrata* are the codominant species.

As reflected in the dendrogram (Fig. 2), the two vegetation units corresponding to *Nardus stricta*-grasslands are floristically well differentiated and, therefore, they can be evaluated as independent associations from a syntaxonomic point of view. A first distinction between the two associations, is based on the presence or absence of *Luzula pindica*. This species occurs only within the relevés belonging to the cluster NL (Tab. 1). These relevés, taken in the massif of Pollino, show a high floristic correspondence with those taken by BONIN 1972 on the same massif and ascribed by this author to an independent association, named Nardo-Luzuletum pindicae. For this reason, also our relevés are to be assigned to the Nardo-Luzuletum pindicae, mostly due to the occurrence of *Luzula pindica*, the only character species of the association. The nomenclatural type (lectotype) of the Nardo-Luzuletum pindicae, not reported in the original diagnosis, is here established (h.l. relevé 50, current number 7, in Table 1, drawn from BONIN 1972: 273, tab. 1, current number 2).

From the syntaxonomic point of view, the stands of the Nardo-Luzuletum pindicae are formed by close swards marked by the pale wiry foliage of *Nardus*. Close observation of the swards reveals the presence of other grasses and herbaceous dicotyledons. Among them, *Festuca rubra* subsp. *microphylla* and *Viola aethnensis* subsp. *splendida* are the only constant species. *Festuca rubra* subsp. *microphylla* shows codominance with *Nardus stricta* in several stands (Tab. 1).

The Nardo-Luzuletum pindicae can be subdivided into three different subassociations (Fig. 2, Tab.1). The first subassociation (Tab.1, current nrs. 1 to 11), including most of the original relevés taken by BONIN, has no differential species; consequently it can be regarded as the typical sub-

association of the Nardo-Luzuletum pindicae (Nardo-Luzuletum pindicae typicum).

The second subassociation (Tab. 1, current nrs. 12 to 19) is differentiated by some xerophilous species, such as *Galium verum*, *Achillea collina* and *Potentilla calabra*. This subassociation is here newly described (Nardo-Luzuletum pindicae galietosum veris TOMASELLI, BERNARDO et PASSALACQUA subass. nova hoc loco; Tab. 1, nomenclatural type: rel. 40 (holotypus)).

The third subassociation (Table 1, current nrs. 20 to 26) includes a set of differential species (*Genista depressa*, *Gentiana lutea*, *Ajuga tenorii*, *Dactylorhiza sambucina* and *Silene otites*). Also this subassociation is here newly described (Nardo-Luzuletum pindicae genistetosum depressae TOMASELLI, BERNARDO et PASSALACQUA subass. nova hoc loco; Tab. 1, nomenclatural type: rel. 3 (holotypus)).

The stands dominated by *Nardus stricta* occurring in the massif of Sirino-Papa have no *Luzula pindica* at all. For this reason, the six relevés taken within these stands (Fig. 2, cluster PN and Tab. 2, current nrs. 1 to 6) cannot be referred to the Nardo-Luzuletum pindicae. These relevés are characterized by *Plantago serpentina*, here achieving codominance in several stands. Moreover, they are differentiated from the relevés ascribed to the Nardo-Luzuletum pindicae by *Asperula aristata* subsp. *scabra*, *Brachypodium genuense*, *Euphrasia stricta* and *Carex caryophylla*. For these reasons, the relevés are here assigned to a new association (Plantagini serpentinae-Nardetum strictae TOMASELLI, BERNARDO et PASSALACQUA ass. nova hoc loco; Tab. 2, nomenclatural type: rel. 1 (holotypus)).

From the physiognomical point of view, the stands of the Plantagini serpentinae-Nardetum strictae are closed grasslands, where *Nardus stricta* is generally codominant with the grass *Festuca rubra* subsp. *microphylla* and the mat-forming herb *Plantago serpentina*. Other constant species are: the grass *Anthoxanthum odoratum* s.l. and the herbaceous dicotyledons *Asperula aristata* subsp. *scabra*, *Dianthus deltoides*, *Euphrasia stricta*, *Lotus corniculatus*, *Potentilla rigoana* and *Trifolium pratense* subsp. *semipurpureum* (Tab. 2).

The community dominated by *Crepis aurea* subsp. *glabrescens* and *Plantago atrata* (cluster BA in the dendrogram of Fig. 2) has a very low and closed turf, in which mat-forming herbs and tussock grasses provide the most distinctive element. The mat-forming herbs *Crepis aurea* subsp. *glabrescens* and *Plantago atrata* are constant throughout and codominant or alternatively dominant (Tab. 3). Other very frequent species are: among the grasses, *Alopecurus gerardi*, *Festuca rubra* subsp. *microphylla* and *Poa alpina* and among herbaceous dicotyledons, *Viola aethnensis* subsp.









Table 2. Plantagini serpentinae-Nardetum strictae. D: differential species, R: regional character species.

Current numbers of relevé	1	2	3	4	5	6	Const.
N. of relevé	44	45	46	47	48	49	in %
Site	SI	SI	SA	PA	PA	PA	
Elevation (m × 10)	184	185	183	197	196	198	
Aspect	E	ESE	SW	ESE	NE	NE	
Slope angle (°)	20	25	25	5	30	20	
Relevé area (sqm)	100	100	100	50	100	80	
Cover (%)	95	100	100	100	100	100	
Rare species	3	3	3	-	1	1	
N. of species	26	21	22	18	22	18	
ASSOCIATION							
<i>Plantago serpentina</i> (R)	3	2	3	2	3	2	100
<i>Asperula aristata</i> subsp. <i>scabra</i> (D)	1	+	+	+	1	1	100
<i>Euphrasia stricta</i> (D)	+	+	+	+	+	.	83
<i>Brachypodium genuense</i> (D)	2	2	2	.	+	.	67
<i>Carex caryophyllea</i> (D)	1	1	1	.	.	.	50
ALLIANCE							
(RANUNCULO-NARDION)							
<i>Potentilla rigoana</i>	+	1	+	+	+	+	100
<i>Viola aethnensis</i> subsp. <i>splendida</i>	.	r	+	.	+	+	67
<i>Plantago atrata</i> (R)	.	.	.	1	1	1	50
<i>Polygala angelisii</i>	.	+	.	+	+	.	50
<i>Crepis aurea</i> subsp. <i>glabrescens</i>	.	.	.	.	1	2	33
<i>Bellis pusilla</i>	+	.	1	.	.	.	33
<i>Ranunculus pollinensis</i>	.	.	.	+	+	.	33
ORDER (NARDETALIA)							
<i>Nardus stricta</i>	3	3	3	4	3	2	100
<i>Dianthus deltooides</i>	+	+	1	2	+	.	83
<i>Botrychium lunaria</i> (D)	.	.	.	.	+	1	33
<i>Meum athamanticum</i>	.	.	+	.	.	.	17
CLASS (CALLUNO-ULICETEA)							
<i>Anthoxanthum odoratum</i> s.l.	1	2	1	.	2	1	83
<i>Hieracium pilosella</i>	2	1	1	+	.	.	67
<i>Luzula multiflora</i>	.	.	1	+	.	.	33
<i>Danthonia decumbens</i>	.	.	1	.	.	.	17
COMPANIONS							
<i>Festuca rubra</i> subsp. <i>microphylla</i>	3	3	3	3	3	3	100
<i>Lotus corniculatus</i>	1	+	+	+	1	1	100
<i>Trifolium pratense</i> subsp. <i>semipurpureum</i>	1	1	.	+	1	1	83
<i>Poa alpina</i>	1	.	1	1	+	.	67
<i>Cerastium tomentosum</i>	+	.	.	+	+	+	67
<i>Hippocrepis comosa</i>	+	1	.	.	.	+	50
<i>Ameria canescens</i> subsp. <i>gracilis</i>	.	.	+	.	+	+	50
<i>Minuartia verna</i> subsp. <i>attica</i>	r	+	.	+	.	.	50
<i>Cartex otaibelliana</i>	.	.	.	.	1	1	33
<i>Jasione orbiculata</i>	+	.	1	.	.	.	33
<i>Carduus carlinaefolius</i>	.	.	.	.	+	+	33
<i>Cirsium tenoreanum</i>	+	+	.	.	.	.	33
<i>Galium anisophyllum</i>	+	.	.	+	.	.	33
<i>Petrorhagia saxifraga</i>	+	+	.	.	.	.	33
<i>Pimpinella lithophila</i>	+	+	.	.	.	.	33
<i>Silene multicaulis</i>	+	r	.	.	.	.	33

*splendida*, *Ranunculus pollinensis* and *Trifolium pratense* subsp. *semi-purpureum*.

From the syntaxonomical point of view, this community is here described as a new association: *Bellidi pusillae-Alopecuretum gerardi* TOMASELLI, BERNARDO et PASSALACQUA ass. nova hoc loco, Table 3, nomenclatural type: rel. 12 (holotypus). The diagnostic species of the association are *Alopecurus gerardi*, *Trifolium repens* subsp. *prostratum* and *Bellis pusilla*, a taxon clearly differentiated in its field ecology, but taxonomically not yet well defined.

According to the classification dendrogram (Fig. 2), the *Bellidi pusillae-Alopecuretum gerardi* can be split into two subassociations (Tab. 3). In the first one (*Bellidi pusillae-Alopecuretum gerardi* typicum, Tab. 3, current nrs. 1 to 16) the species belonging to the characteristic species combination are, generally, more abundant and frequent.

The second subassociation (Tab. 3, current nrs. 17 to 28) is differentiated by *Armeria canescens* subsp. *gracilis*, *Lotus corniculatus* and *Potentilla rigoana*. This subassociation is here newly described (*Bellidi pusillae-Alopecuretum gerardi armerietosum gracilis* TOMASELLI, BERNARDO et PASSALACQUA subass. nova hoc loco; Tab. 3, nomenclatural type: rel. 2 (holotypus)).

The *Bellidi pusillae-Alopecuretum gerardi armerietosum gracilis* shows a certain degree of floristic heterogeneity. The relevés taken in the massif of Pollino (with the exception of the relevé with current nr. 20) belong to a typical variant (Tab. 3, current nrs. 17 to 20), whereas the relevés taken in the massif of Sirino-Papa can be assigned to a variant differentiated by *Carex kitaibeliana* and *Plantago serpentina* (variant of *Carex kitaibeliana*, Tab. 3, current nrs. 21 to 26). Furthermore, the relevés with current nrs. 27 and 28 (Tab. 3), in which the endemic chamaephyte *Astragalus sirinicus* is particularly abundant, correspond to stands with transitional features to the *Pimpinello lithophilae-Astragaletum sirinici*, a xerophytic association widespread in the summit areas of the massif of Sirino-Papa (CAPUTO 1969).

#### 4.2. Syntaxonomy

The position of the *Nardo-Luzuletum pindicae*, the *Plantagini serpentinae-Nardetum strictae* and of the *Bellidi pusillae-Alopecuretum gerardi* within higher syntaxonomic units is still unclear. There is a considerable floristic overlap between these associations and, consequently, they must be included in the same alliance: *Ranunculo-Nardion strictae* BONIN 1972. In the southern Apennines the set of the diagnostic species of the *Ranunculo-Nardion* is given by *Ajuga tenorii*, *Crepis aurea* subsp. *glabrescens*, *Polygala angelisii*, *Potentilla rigoana*, *Ranunculus pollinensis*, *Sagina glabra* and *Viola aethnensis* subsp. *splendida*.

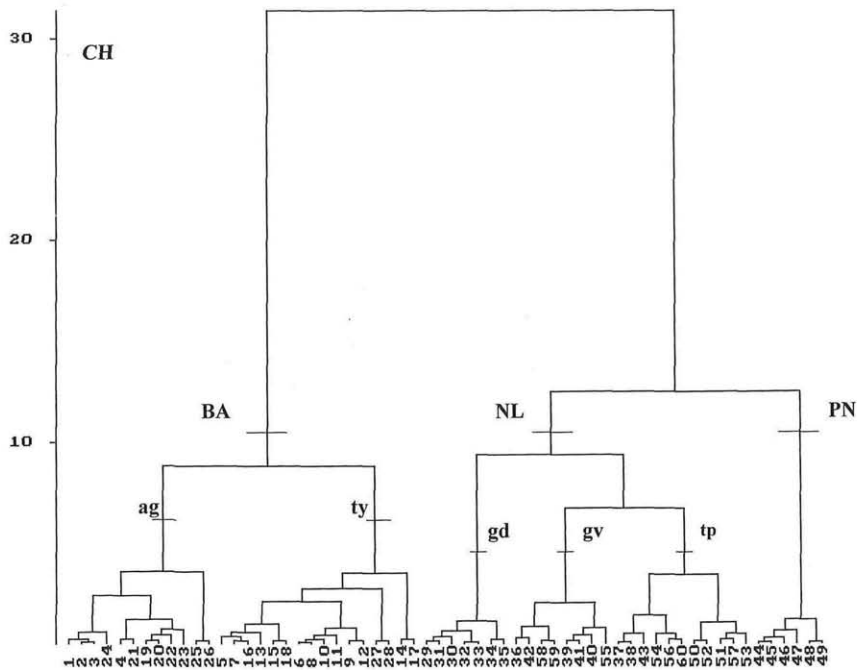


Fig. 2. Classification dendrogram of vegetation relevés. CH = chord distance; BA: Bellidi pusillae-Alopecuretum gerardi; ag: Bellidi pusillae-Alopecuretum gerardi armerietosum gracilis; ty: Bellidi pusillae-Alopecuretum gerardi typicum; NL: Nardo-Luzuletum pindicae; gd: Nardo-Luzuletum pindicae genistetosum depressae; gv: Nardo-Luzuletum pindicae galietosum veris; tp: Nardo-Luzuletum pindicae typicum; PN: Plantagini serpentinae-Nardetum strictae.

According to BONIN 1972 and BIONDI & al. 1999, 2000, the Ranunculo-Nardion represents a Mediterranean alliance included in the order Nardetalia strictae and in the class Nardetea strictae, substituting the centro-European Nardion in the central and southern Apennines. Nevertheless, the list of the diagnostic species indicated by BONIN 1972 and BIONDI & al. 1999, 2000 for the Nardetalia and Nardetea strictae is somewhat heterogeneous, including only *Botrychium lunaria*, *Hieracium lactucella* and *Luzula multiflora* among the generally recognized diagnostic species of this order and class, accompanied by a lot of species transgressive from the class Molinio-Arrhenatheretea (*Campanula scheuchzeri*, *Crocus albi-florus*, *Poa alpina*, *Phleum alpinum*) and Caricetea curvulae (*Euphrasia minima*).

In our opinion the Ranunculo-Nardion should be assigned to the order Nardetalia strictae, by modifying the list of the diagnostic species indicated for this order, by the above quoted authors. In the southern Apen-

nines this list includes: *Botrychium lunaria*, *Dianthus deltoides*, *Gnaphalium sylvaticum*, *Meum athamanticum*, *Nardus stricta* and *Poa violacea*.

As far as the rank of class is concerned, we regard the name *Nardetea strictae* only as a syntaxonomic synonym of *Calluno-Ulicetea*, according to the opinion of GRABHERR & MUCINA 1993. In the snow beds of the southern Apennines, the set of the diagnostic species of the class *Calluno-Ulicetea* includes only *Anthoxanthum odoratum*, *Danthonia decumbens*, *Hieracium pilosella* and *Luzula multiflora*.

### 4.3. Synecology

The *Nardo-Luzuletum pindicae* is distributed on the massif of Pollino, with an altitudinal range between 1860 and 2200 m and with an average altitude of 1975 m (Tab. 4). The association is concentrated in the eastern quadrants, broadly ranging from North to South. The inclination of the slopes over which the *Nardo-Luzuletum pindicae* has developed, ranges from 0 to 45°.

Most stands of the *Nardo-Luzuletum pindicae* *typicum* occur above 2000 m (with an average altitude of 2020 m) and on fairly gentle slopes, ranging from 5 to 15°. Four stands occur on steeper slopes, with an inclination ranging from 30 to 45°.

The *Nardo-Luzuletum pindicae galietosum veris* occurs on flat surfaces with a broad altitudinal range (from 1860 to 2180). All the stands are located on the southern slope of the massif of Pollino. Also the *Nardo-Luzuletum pindicae genistetosum depressae* occurs on flat surfaces. This subassociation is confined to lower altitudes (1920 m on average) and it shows a very restricted altitudinal range (from 1910 to 1930 m), depending on its very local distribution on the northern slope of the massif of Pollino (see Tab. 4).

The *Plantagino serpentinae-Nardetum strictae* is entirely confined to the massif of Sirino-Papa, where it occurs at altitudes ranging from 1830 to 1980 m, generally on fairly steep slopes (from 20 to 30°).

The *Bellidi pusillae-Alopecuretum gerardi* is distributed on both massifs (Pollino and Sirino-Papa), occurring between 1900 and 2220 m (with an average altitude of 2069 m, Tab. 4). The association is concentrated in the northern quadrants from North-West to East, with a slope angle varying from 0 to 35°.

The *Bellidi pusillae-Alopecuretum gerardi typicum* is restricted to the bottom of dolines or to flat surfaces at the highest summits of the Massif of Pollino (from 2080 to 2220 m of altitude), where the snow lasts longer.

The *Bellidi pusillae-Alopecuretum gerardi armerietosum gracilis* occurs on both massifs at lower altitudes (mostly from 1900 to 2000 m), over fairly inclined and generally N.-exposed slopes. The typical variant of this association is restricted to the massif of Pollino, where it occurs on flat

Table 4. Average values of altitude and inclination (in old °) within the vegetation types.

	Altitude (m a.s.l.)	Inclination (°)
<b>Luzulo pindicae-Nardetum strictae</b>	<b>1992 (± 90)</b>	<b>10</b>
Luzulo pindicae-Nardetum typicum	2024 (± 70)	20
Luzulo pindicae-Nardetum galietosum veris	2011 (± 121)	3
Luzulo pindicae-Nardetum genistetosum depressae	1919 (± 7)	2
<b>Plantagini serpentinae-Nardetum strictae</b>	<b>1905 (± 57)</b>	<b>21</b>
<b>Bellidi pusillae-Alopecuretum gerardi</b>	<b>2069 (± 110)</b>	<b>10</b>
Bellidi pusillae-Alopecuretum typicum	2150 (± 47)	5
Bellidi pusillae-Alopecuretum armerietosum gracilis	1962 (± 67)	16

surfaces between 1900 and 1920 m of altitude. The variant of *Carex kitai-beliana* occurs mostly on the massif of Sirino-Papa, at higher altitudes and on steeper slopes.

The analysis of variance reveals that floristic differences within the Nardo-Luzuletum pindicae are mostly correlated with variations of the slope angle (F: 9.40;  $P < 0.001$ ); whereas in the Bellidi pusillae-Alopecuretum gerardi the most significant correlation is with the altitudinal gradient (F: 76.78;  $P < 0.001$ ).

#### 4.4. Species Classification

Seven species mostly occurring in the Bellidi pusillae-Alopecuretum gerardi stands were individuated by clustering the 73 species occurring in the original matrix, according to their distribution in the 60 relevés (Fig. 3). The list includes *Alopecurus gerardi* (AG), *Bellis pusilla* (BP), *Astragalus depressus* (AD), *Crepis aurea* subsp. *glabrescens* (CG), *Plantago atrata* (PA), *Sagina glabra* (SG), *Trifolium repens* subsp. *prostratum* (TP). *Crepis aurea* subsp. *glabrescens* and *Plantago atrata* are constant and abundant throughout; *Alopecurus gerardi* is frequent and it occurs in most stands with fairly high cover-abundance values; *Trifolium repens* subsp. *prostratum* is relatively frequent and it can be prominent in some stands; *Bellis pusilla* and *Sagina glabra* are also relatively frequent (about 50%), though with low cover-abundance values, whereas *Astragalus depressus* is occasional, constantly scarce and concentrated in the stands of the typical subassociation. The species at potential risk of local reduction or extinction, as a consequence of the global warming, could be *Bellis pusilla* and *Astragalus depressus*. *Sagina glabra*, though occurring with low cover values is in fact, represented by a fairly consistent number of individuals. For this reason it seems to be regarded as a less vulnerable species.

## 5. Discussion

Numerical classification identified three different plant communities occurring at the sites with a prolonged snow cover located in the Pollino and Sirino-Papa massifs. The floristic composition of these plant communities is completely different from that of the snow beds of the Alps and of the northern Apennines, belonging to the class *Salicetea herbaceae*. The southernmost border of this type of snow beds, must in fact, be placed in the central Apennines (BIONDI & al. 2000).

From the phytogeographical point of view, the *Nardo-Luzuletum pindicae*, the *Plantagini serpentinae-Nardetum strictae* and the *Bellidi pusillae-Alopecuretum gerardi* have clear floristic affinities with the corresponding vegetation types from the central Apennines (*Luzulo italicae-Nardetum* BIONDI & al. 1992 and *Ranunculo pollinensis-Plantaginetum atratae* BIONDI & al. 2000). Moreover, these associations occurring in the snow beds of the southern Apennines also share a certain number of species with the association with *Luzula pindica* and *Nardus stricta* and with the association with *Alopecurus gerardi* and *Gnaphalium hoppeanum* respectively, which were described by QUEZEL 1964 from similar habitats on

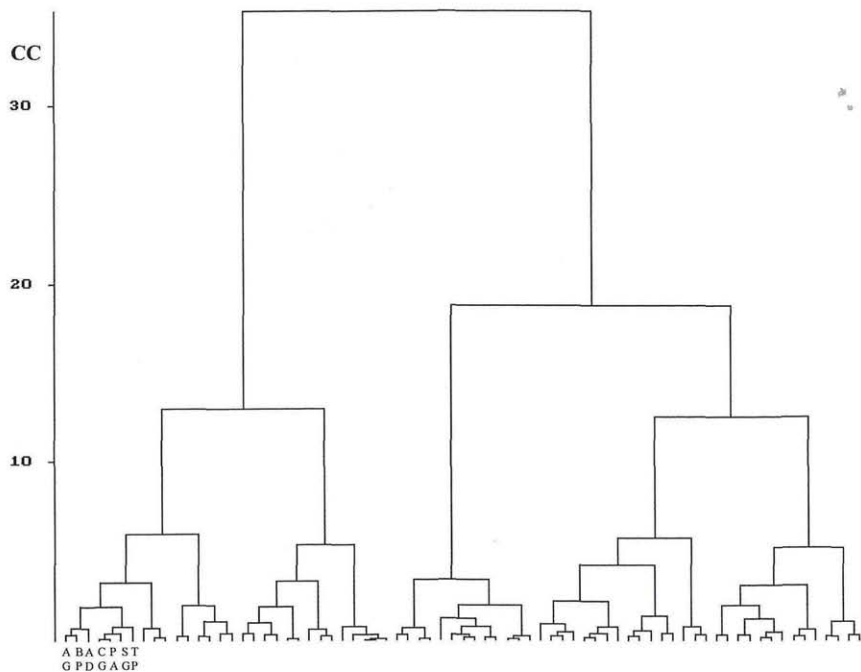


Fig. 3. Classification dendrogram of species. CC = Correlation coefficient. Abbreviations of species names are reported in the text (chapter 3.4.).



the highest mountains of Greece. Despite this floristic overlap, the associations described by QUEZEL are clearly differentiated by a consistent group of species endemic from Greece, that are lacking in the associations of the southern Apennines.

From the ecological point of view, the floristic variation within the *Luzulo pindicae*-*Nardetum* and the *Bellidi pusillae*-*Alopecuretum gerardi* can be mostly related to the duration of snow cover. Within the *Luzulo pindicae*-*Nardetum* the different duration of snow-cover is conditioned mostly by the inclination, whereas in the *Bellidi pusillae*-*Alopecuretum gerardi* the differences in snow-cover duration are mostly influenced by the altitudinal gradient.

As a consequence of the global warming, biodiversity losses in the snow-bed vegetation of the southern Apennines could be expected. The most striking changes in vascular plant biodiversity could occur in the *Bellidi pusillae*-*Alopecuretum gerardi armerietosum gracilis*, where the species at potential risk of local reduction or extinction occur more rarely and with lower cover values.

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## Recensio

SCHULZ Bernd 1999. **Gehölzbestimmung im Winter**. – Lex. 8°, 329 Seiten, 1450 Abb.; geb. – Eugen Ulmer Verlag, Stuttgart. – € 76.–. – ISBN 3-8001-5074-3.

In diesem gewichtigen Band werden Zweige und Winterknospen von ca. 700 Gehölzen aus über 80 Familien behandelt; berücksichtigt sind in Mittel- und Westeuropa einheimische, eingebürgerte oder kultivierte Arten (Laubhölzer, sommergrüne Nadelhölzer und *Ephedra*). Das Werk besticht und beeindruckt vor allem durch die ca. 1400 ausgezeichneten, detailreichen Farbabbildungen von Knospen und Zweigen nach Aquarellen des Autors, zu denen man nur gratulieren kann!

Der allgemeine Teil beginnt mit einem kurzen historischen Abriss über die Behandlung von Knospen in der Botanik (p. 11–15). Die morphologischen Grundlagen für die Merkmale der Knospen und Zweige sind übersichtlich, und unterstützt durch zahlreiche Schemata, dargestellt (inkl. Knospenschuppen, Blattstellung, Blattspuren, Beiknospen etc.; p. 18–35). Daran schließen sich Bestimmungsschlüssel (p. 36–51). Der Hauptteil (p. 56–323) bringt dann die Beschreibung der Gehölze nach Familien geordnet, wobei im Bedarfsfalle innerhalb der Familien und Gattungen ebenfalls Schlüssel gebracht werden. Für die einzelnen Arten gibt es neben den Abbildungen noch kurze Beschreibungen. Die Merkmale sind erstklassig dargestellt. Man stößt hier auf interessante, sonst wenig benutzte Merkmale wie z.B. Blattpolsterbehaarung bei *Laburnum anagyroides* bzw. *L. alpinum* oder das gefächerte Mark bei *Paulownia tomentosa* im Gegensatz zum vollen bei *Catalpa bignonioides*.

Bei Sämlingen oder Schößlingen hat *Paulownia tomentosa* aber ab einigen Internodien unter dem Vegetationspunkt hohle Sproßachsen, während *Catalpa bignonioides* von Anfang an ein volles Mark besitzt. Da das Unterscheiden der extrem großblättrigen Jugendstadien öfters Probleme bereitet, seien bei dieser Gelegenheit noch einige weitere Merkmale genannt. *P. t.*: Blätter (beiderseits) und

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