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EVALUATION OF VEGETATION CLASSIFICATIONS FROM PEATLANDS IN THE DOLOMITES (S-ALPS)

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Abstract. Numerical classifications of peatland communities from the Dolomites are compared by means of information functions. Classifications were evaluated considering both the structure of contingency tables (species groups *x* relevé groups) and the correlation between vegetation types and peat chemistry. A remarkable result is the coincidence of the results obtained by internal and external criteria.

Introduction

Vegetation classifications obtained by different methods may differ substantially from each other (Orlóci, 1978; Feoli & Gerdol, 1982). Because of this, the need of evaluating clustering results on a formal basis arises. An evaluation may be done either by internal or by external criteria (Feoli *et al.*, 1981). When internal criteria are used, the evaluation is concerned with the sharpness of differences between sets of relevés in terms of species composition. If external criteria are used, the predictivity of a given clustering result with respect to external variables (not included in the classification; e.g. abiotic parameters measured in relevé sites) is the basis for evaluation.

The main aim of this paper is to evaluate the efficiency of clustering procedures applied to peatland vegetation. The criteria include i) the correlation between ecological species groups and relevé sets (internal criterion) and ii) the predictivity of vegetation types regarding peat chemistry (external criterion).

The study area

The Dolomites are part of the Southern Alps (Fig. 1). Rocks deposited in the Mesozoic are most common, primarily dolomite, giving rise to the imposing mountain groups well-known to climbers all over the world, and secondarily limestones, carbonaceous sandstones as well as marls.

Peatlands are rather uncommon in the Dolomites, as the above mentioned rock types greatly enhance drainage. Nevertheless, peatlands are developed from the thalwegs to the alpine vegetation belt. They rarely cover areas larger than 5 ha.

Examples of fairly large peatlands are found only at the Alpe di Siusi (Seiseralm) on impermeable sandstones and marls. Siliceous rocks (mainly porphyrites and phyllites) are sporadic in the Dolomites. The peatlands developed on siliceous substratum were not considered in this study, since their ecology and syntaxonomy can be solved only within a vast scale research work.

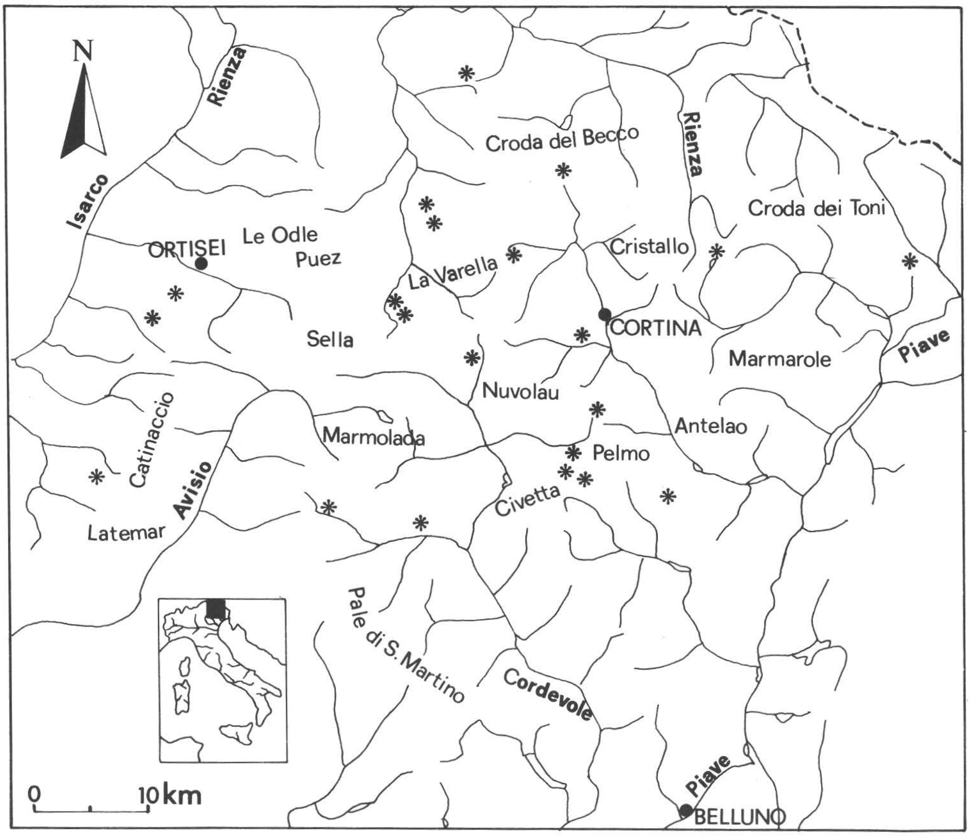

Fig. 1 — Map of the study area. Asterisks indicate the relevé sites.

Methods

The vegetation sampling followed the Braun-Blanquet method. Relevés were taken from localities considered representative of peatland vegetation in the study area (Fig. 1). The original data set was reduced by exclusion of i) species occuring in one relevé only; ii) species not belonging to the characteristic combination of species (see Braun-Blanquet, 1964) not present in more than two relevés and iii) species accounting for less than 10% of the mutual information (Orlòci, 1976) of the matrix obtained after elimination of the rare species as identified above. All computations started from the reduced matrix.

Species nomenclature follows Pignatti (1982) for vascular plants and Augier (1966) for bryophytes. The clustering techniques employed for classifying the relevés include average linkage clustering between merged groups (ALCB) based on the similarity ratio, average linkage clustering within new groups (ALCW) based on the similarity ratio, and sum of squares clustering (SSA) based on the Euclidean distance. The species were clustered by ALCB based on the product moment correlation coefficient. Description of the clustering algorithms and computer programs is given in Anderberg (1973). Both binary and cover data were utilized in the classifications. The latter are transformations of the Braun-Blanquet cover values according to the following scale: $r = 1$, $+ = 2$, $1 = 3$, $2 = 5$, $3 = 7$, $4 = 8$, $5 = 9$ (van der Maarel, 1979).

An analysis of concentration (Feoli & Orlòci, 1979) was applied to the contingency matrix built up by calculating the mean cover values of each of the species groups in the vegetation types resulting from the relevé classification. The association between species groups and sets of relevés was demonstrated in this way.

Chemical determinations were made in water pressed from peat samples from 19 relevé sites; pH and electrical conductivity were measured since these variables are usually considered important characteristics of peatlands (Sjörs, 1950). As discussed in the introduction, these measurements were used to evaluate the classification results. They were not intended to provide a complete ecological description for which still other variables would be required, such as anion and cation concentration (Malmer & Sjörs, 1955; Malmer, 1958; Sonesson, 1970; Waughman, 1980). pH was measured by a Hanna HI-8014 portable pHmeter equiped with a glass electrode. Electrical conductivity was measured by a Hanna HI-8033 portable conductivitymeter equiped with a polyvinylchloride electrode. The conductivity values were not corrected by substracting the conductivity due to hydrogen ions, as suggested by Sjörs (1950), because the original values are presumed to be weakly affected by the H^+ influence owing to the relatively high pH values measured in all samples.

For evaluating the classification results in terms of species composition (internal criterion), several contingency tables were constructed. They include the mean cover values of each species group in the sets of relevés recognized at different hierarchical levels in the corresponding dendrogram. The following index (Feoli & Lausi, 1980) was calculated for each of the tables:

$$D(F_h; F_i) = I(F_h; F_i) / (2I(F_h, F_i) - I(F_h; F_i))$$

where $I(F_h; F_i)$ is the mutual information

$I(F_h, F_i)$ is the joint information.

For evaluating the classification results in terms of their predictivity regarding ecological conditions (external criterion), the mutual information was calculated for the contingency tables including the frequency distributions of the equivalence classes for the chemical variables in the vegetation types at the hierarchical levels tested by internal criteria. The formula is (Feoli, 1976);

$$I = \sum_{i}^{r} \sum_{j}^{c} f_{ij} \ln (f_{ij} f_{..} / f_{i.} f_{.j})$$

where r = number of rows in table
c = number of columns in table
f_{ij} = a value in the ij-cell
$f_{i.}$ = a row total
$f_{.j}$ = a column total
$f_{..}$ = the grand total.

Results

Data reduction

The data matrix obtained by species reduction as described above is given in Table 1. Species and relevés are arranged in groups according to the results of cluster analysis. Four species occuring in nearly all relevés account for less than 10% of the mutual information: *Trichophorum caespitosum, Molinia caerulea, Potentilla erecta* and *Carex fusca*; these species were eliminated. The list of rare species is available on request by the authors.

Table 1 - Phytosociological table.
SM - *Sphagnetum magellanici;* SC - *Sphagnum compactum* community; SW - *Sphagnum warnstorfii* community; SL - *Scorpidio-Caricetum limosae;* ES - *Eriophoretum scheuchzeri;* PC - *Parnassio-Caricetum fuscae.*

		SM									SC		SW							SL		ES					PC																								
	Relevé n.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1	Vaccinium myrtillus						2	2	2																																										
1	Calypogeia arguta						2	2	2																																										
1	Sphagnum rubellum						8	9	3																																										
1	Calluna vulgaris	3	2	3	5	3	5	5	5	3			2	2																																2					
1	Eriophorum vaginatum	3	3	7	2		3	3	5				2	3		2	2																																		
1	Sphagnum magellanicum		3	5			3	2	2	5				3																																					
1	Carex pauciflora	5	7	2			3	5	2																																										
1	Sphagnum quinquefarium	9	8	8											5																																				
2	Mylia anomala				5	2		3		2																																									
2	Sphagnum acutifolium				5	3				5																																									
	Vaccinium uliginosum			2	2	5	3	2	3				2	2	2				1																																
	Polytrichum strictum			3	5	7	5		5	3			3	3	5			3	3																																
	Avenella flexuosa				2	5	2		3				2	2					2																																
	Vaccinium vitis-idaea			3		2	3		3					3																																					

	SM									SC		SW							SL		ES					PC																								
Relevé n.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
3 Nardus stricta	3	3		3	3	2	2	3		2		3	3	5		2		3																																
Luzula sudetica	2			2	2		2	2		2		2	2	2	2	2	2	2																																2
Leontodon helveticus				2	1							2	2					2																																
Sphagnum recurvum												3	7	5			2	3																																
Sphagnum molle								8				5						5																																
Homogyne alpina							1	2	3		2	2	2	2																																				
Odontoschisma sphagni										5	5		2																																					
Sphagnum compactum										5	3		2																																					
4 Carex stellulata	2									3	3	3	3				2	2									2				2	2	3	2	2					3										
Trichophorum alpinum										3	3				3	3	2	2								3				2	3	2	3	3	2							2		2				2		2
Campanula scheuchzeri									1							2	2	2																											1					2
Sphagnum warnstorfii										2	2		5		7	8	7	5		2																														
Aulacomnium palustre	3	3	3				5	2	5				5	3	3	5	3	3											2																					
Dicranum bonjeani	2										2	2				3		2																																
Meesea triquetra																2											2																							
5 Carex rostrata	1					2		2		3	3	5	3	5	2	3	5	3	3	3					5			2		5	2	3	5	3	3	3						3	2				2	3		5
Potentilla palustris														3											2																									2
Deschampsia caespitosa												2		2	2		3	3			3	3	2	2	2							2														2				
Viola palustris												2		3			5	3	2	2					2																									
Anthoxanthum odoratum														2	2	2	2	2										2				2														2			2	
Festuca rubra	2	2	2	2									2	2	2			3								2			2	3		2													2					2
Sphagnum auriculatum											2								2	3																														
6 Scorpidium scorpioides																			5	5																														
Drosera anglica																	2		2	2																														
Carex limosa																			3	5																														
Carex foetida																						2			3																									
Philonotis calcarea																					3	3			3	5																		2	2				1	
Eriophorum scheuchzeri																					5	5	5	5	3																									
7 Cratoneurum commutatum var. falcatum																					5	5	7	3	5	3		2	2										2								2	2	5	2
Bryum pseudotriquetrum																					2	3	5	3	3	2	2	2	2	2		2				2	2						2	2	2		2	2	2	2
Juncus triglumis																					2		2	2	3										2			2					2	2					2	2
Polygonum viviparum									1													2	3		3	2		2	2	2								1	2		2		2	2			2		2	2
Triglochin palustre																						2	3	2														2	2			2		1					2	
Kobresia simpliciuscula																																													3	2	2	3	2	2
Fissidens adiantoides																																											2		2	2	3	2		2
Carex capillaris															2													2				2			2		2						2	2	2	2	2	2	2	3
Aster bellidiastrum																																			3						2	2	3	2	3	3		2	2	
Sesleria uliginosa															3	3	2									3	3						2	2	3		2	2				3	3	3	2	2	2	3	2	2
Scabiosa lucida															5	5		2																	2			2				2	1	2		2	2	2		2
Bartsia alpina											2			2	2	2	2								2	2	2		3	2	2	2		3	3	2	2	2					2	3	3	3	2	3	3	2
Ranunculus montanus															2	2	2												2												2		2		2		2	2		
Pinguicula vulgaris										2	2					2												2	2	2	2		2	2	2	2	2	2	2	2	3	2	2		2		2			2
Selaginella selaginoides									2	2	3			2		2		2		1						2	2	2	2		2	2	2	2	3		2	2	2	2	2	2	3	2	2	2	2	2	2	2
Juncus alpino-articulatus																								2		2	2	3									3	3	2	3	2	3	3	2	2	3	2	2	3	
Drepanocladus revolvens																						2		2		5	3	5	5				3	3	3	8	7	5	7	5	8	5	7	3	5	3	3	3	2	3
Carex lepidocarpa																		2							2	5	3	2	3	2	2	2	2	2	2	2	2	3	3	2	3		3	2	2	2	2	3	3	3
Parnassia palustris																2										3	3	3	3	3	3	3	2		2	2	2	3	3	3	2	2	2	2	3	2	3	2	3	2
Valeriana dioica															2											2	2	2	2	2		2	2		2	3	2	2	2	2	2		2	2	2				3	3
Carex panicea																								2		2	2	3	3	3	2	2		2		1		2	3	3	3	3	3	2	2			2	3	2
Primula farinosa																												2	2	2	2	2	2	2		2	2	2	3	2	2	2	2	2	3	2	2	3	2	2
Campylium stellatum															2	2								3			2	3	3	7	5	3	7	5	2	3	3	3	5	3		5	2	2	3	3	5	7	3	3
Tofieldia calyculata																										2	2	2	2	2	3	3	2	2	2	2				2	2		2	3	2	2	2	2	2	
Agrostis tenuis															2											2	2	2	2	2	2	2	2	2	2	2						2	2	2	2		2	2	2	2
Carex davalliana									2						3												2	3	3	2	2	2	3	5	3	2	2	3	2	3	3	2	5	7	3	3	3	2	2	
8 Carex hostiana																													2			2				2				3	2				3	2			2	2
Eriophorum angustifolium										3	3	2	3	2	3	2	2			2		2	5		3	3	3	2	3	3	2		3	2	3	2	2	2	2	2	2	2	2	2	2	3	3	2	3	2
Blysmus compressus																					2							2									2	2			2		3	2					3	
Briza media									2						2	2											2	3	2	2	2	3			2						2		2		2	2		2		
Cirsium palustre									2																			2				2									2									
Trollius europaeus									2						2	2												2	2															2		2		2		2
Carex flacca																												3	2										2		2			2						
Lotus corniculatus																												3	2	2									2					2	2				1	
Epipactis palustris																														2									2											
Menyanthes trifoliata																			2							7	5	2	3	5	3					7						3								
Mnium seligeri																										2		2		2						2														2
Pedicularis palustris																										2	2	2		2				2	2	2	2					2	2	2						2
Rhinanthus minor																										2	2	2	2	2				2	2						2							2		2
Dactylorhiza cruenta																													2	3	2					2					2									
Tomenthypnum nites																3												3	7	5	2			2	2	2														
Linum catharticum																														2	2	2							1											
Equisetum fluviatile																														3	2	2																		
Equisetum palustre	2																									5	3	5	2	7	7	7				7	5	3	2	2	3	2	3	2	3	3	3	2	2	3
Breidleria pratensis																										3	3	2	2	3	5	2				2									3	2		2	2	
Dactylorhiza traunsteineri																												2		2	2	2				2					2				2					
Trifolium pratense																												2	2	2	2													3					2	2
Dactylorhiza majalis																										2	2	2	2	2	2	2																	3	2
Crepis paludosa																												2		2	2	2									2						3		2	2
Allium sibiricum																										2																		2			2			
Caltha palustris ssp. laeta									2																																		2	3			3			2
9 Carex dioica																																	3	2										2						
Willemetia stipitata																																	2	2	2			2					2	2			2		2	
Calliergon trifarium																																	3	2		3	3													

Classification of species

Nine clusters were recognized in the classification dendrogram of species at a correlation level of about 0.20 (Fig. 2a). These clusters can be interpreted as ecological species groups. Each species group is designated by the name of two phytosociologically and ecologically significant species. Comments regarding composition are given in the following. The list of species is given in Table 1

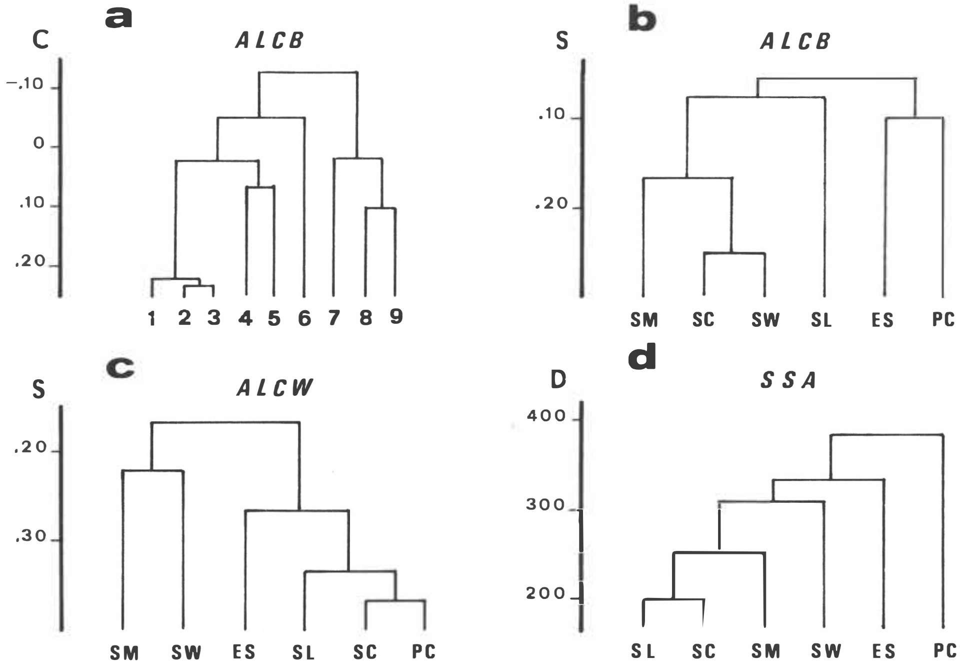

Fig. 2 — Classification dendrograms of species (a) and of vegetation types (b-d). The symbols indicate methods as in the main text; the symbols indicating vegetation types are those used in Table 1. C = product moment correlation coefficient; S = similarity ratio; D = Euclidean distance.

1) *Sphagnum magellanicum - Eriophorum vaginatum* group. This group is mainly composed of the *Oxycocco-Sphagnetea* species (*Sphagnum magellanicum, Eriophorum vaginatum, Carex pauciflora, Sphagnum rubellum*) and species frequently occurring in raised bogs (*Sphagnum quinquefarium* and *Calluna vulgaris*).
2) *Mylia anomala - Sphagnum acutifolium* group. These are the only species in this group. Both are characteristic of *Oxycocco-Sphagnetea.*
3) *Polytrichum strictum - Nardus stricta* group. This group includes the *Oxycocco-Sphagnetea* species *Polytrichum strictum* and other frequent companions in raised-bog communities (*Sphagnum recurvum, Vaccinium vitis-idaea, Vaccinium uliginosum*). In addition, there are also the species of acidiphytic grasslands, such as *Nardus stricta. Avenella flexuosa* and *Leontodon helveticus.*
4) *Odontoschisma sphagni - Sphagnum compactum* group. This group is characterized by the *Oxycocco-Sphagnetea* species *Odontoschisma sphagni* and *Sphagnum compactum. Carex stellulata* and *Trichophorum alpinum* are associated as was determined from the data.
5) *Sphagnum warnstorfii - Aulacomnium palustre* group. This group includes species generally occuring in poor fens. Among them, *Potentilla palustris. Meesea triquetra* and *Viola palustris* are considered

characteristic of the *Scheuchzerio-Caricetea fuscae; Sphagnum warnstorfii, Aulacomnium palustre* and *Dicranum bonjeani* are companion species, but frequently occuring in the associations belonging to *Oxycocco-Sphagnetea* and *Scheuchzerio-Caricetea fuscae*. There are also grassland species present, such as *Anthoxanthum odoratum* and *Festuca rubra*.

6) *Scorpidium scorpioides - Carex limosa* group. To this group belong three *Scheuchzerietalia palustris* species (*Scorpidium scorpioides, Carex limosa* and *Drosera anglica*) and *Sphagnum auriculatum* which usually occur on wet poor fens.

7) *Cratoneurum commutatum* var. *falcatum - Eriophorum scheuchzeri* group. This group is characterized by *Eriophorum scheuchzeri*, characteristic of *Eriophoretum scheuchzeri*, and by mosses linked to the *Montio-Cardaminetea* vegetation of springs and streams: *Cratoneurum commutatum* var. *falcatum* and *Philonotis calcarea*. To this group belongs, moreover, the *Salicetea herbaceae* species *Carex foetida*.

8) *Drepanocladus revolvens - Parnassia palustris* group. This group is essentially formed of the *Scheuchzerio-Caricetea fuscae* species. Most of them are basiphilous, considered characteristic of *Tofieldietalia: Tofieldia calyculata, Parnassia palustris, Primula farinosa, Drepanocladus revolvens, Bartsia alpina, Juncus alpino-articulatus, Pinguicula vulgaris, Selaginella selaginoides, Sesleria uliginosa, Carex lepidocarpa, Carex davalliana, Carex hostiana, Campylium stellatum, Carex capillaris, Epipactis palustris* and *Kobresia simpliciuscula*. *Aster bellidiastrum*, though not being considered characteristic of any *Scheuchzerio-Caricetea fuscae* syntaxon, is a common species in the N-alpic basiphytic fen communities (Oberdorfer, 1977). There are also the *Molinietalia* species, such as *Valeriana dioica, Cirsium palustre, Dactylorhiza majalis, Trollius europaeus, Crepis paludosa* and *Linum catharticum*.

9) *Calliergon trifarium - Willemetia stipitata* group. This group includes some *Scheuchzerio-Caricetea fuscae* species linked to subalpine fens (*Allium schoenoprasum* ssp. *sibiricum, Willemetia stipitata, Carex dioica, Calliergon trifarium*) and also *Caltha palustris* ssp. *laeta*, a common species in the stream vegetation.

Classification of relevés and definition of vegetation types

The classifications, based on binary and cover data, yielded practically identical results for all of the employed methods. Therefore, only dendrograms obtained for cover data are given (Fig. 2b-d). Interestingly, six relevé groups of nearly identical composition can be identified in the dendrograms. These correspond to plant communities recognizable in the field which are, in fact, considered as the main vegetation types in the studied peatlands.

The mean cover values of the 9 species groups in each vegetation type are given in Table 2. The results of concentration analysis are represented in Fig. 3. This diagram clearly indicates correlation between species groups and vegetation types. The correlations, and information about ecology and syntaxonomy from literature, served as the basis for a phytosociological interpretation of the vegetation types. The main points are synthesized in the following.

Parnassio-Caricetum fuscae (PC). This is the most widespread peatland community in the Dolomites, in the elevation belts of 1300-2000 m. It is characterized by species from the *Drepanocladus revolvens - Parnassia palustris* and *Calliergon trifarium - Willemetia stipitata* groups (see Fig. 3); this fact indicates nutrient richness. All species of the characteristic combination for *Parnassio-Caricetum fuscae* are present. Contrary to Oberdorfer's scheme (1977), however, this association should really be included in the order *Tofieldietalia (= Caricetalia davallianae)*, as suggested by Dierssen (1978), because the *Tofieldietalia* species are much more abundant than the *Caricetalia fuscae* ones.

Eriophoretum scheuchzeri (ES). This is the only peatland community found in the alpine belt in the Dolomites. The relevés in the sample are very poor in species, almost all belonging to the *Cratoneurum commutatum* var. *falcatum - Eriophorum*

Table 2 - Mean cover values of the species groups in the main vegetation types. Legends of the symbols are those used in Table 1.

	SM	SC	SW	SL	ES	PC
1	*2.24*	-	0.37	-	-	-
2	*1.39*	-	-	-	-	-
3	1.27	0.30	*1.57*	-	-	-
4	0.05	*3.75*	0.86	-	-	0.42
5	0.39	0.55	*1.84*	0.55	0.38	0.27
6	-	0.25	0.07	*3.37*	-	0.10
7	0.01	-	-	-	*2.55*	0.53
8	0.03	0.19	0.27	0.06	0.12	*1.26*
9	0.04	-	-	-	-	*0.40*

scheuchzeri group. The dominance of *Eriophorum scheuchzeri* and the presence of some other *Scheuchzerio-Caricetea fuscae* species (*Eriophorum angustifolium, Juncus triglumis* and *Drepanocladus revolvens*) clearly justify the inclusion of this community in the *Eriophoretum scheuchzeri.* This association is quite uncommon in the Dolomites, owing to the fact that suitable morphological features only exceptionally exist in the alpine belt of this region. Characteristically, water slowly flows on the surface. This is reflected by the abundance of mosses (above all *Cratoneurum commutatum* var. *falcatum* and *Philonotis calcarea*) characteristic of springs and streams.

Sphagnum warnstorfii community (SW). This community forms very low hummocks settled here and there on fens occupied by the *Parnassio-Caricetum fuscae.* It is characterized by species of the group *Polytrichum strictum - Nardus stricta* and the group *Sphagnum warnstorfii - Aulacomnium palustre.* Both groups include species indicating nutritionally poor conditions, mainly characterizing *Scheuchzerio-Caricetea fuscae* syntaxa, but frequently occuring in *Oxycocco-Sphagnetea* associations too. This community is fairly similar to the *Sphagno-Caricetum dioicae* described from the French Jura (Gillet, 1982) and assigned to the alliance *Sphagno-Tomenthypnion* (class *Scheuchzerio-Caricetea fuscae*). The Dolomitic *Sphagnum warnstorfii* community differs, however, from the *Sphagno-Caricetum dioicae* mainly because of the absence of *Carex dioica*, which is considered characteristic of the *Sphagno-Caricetum dioicae.*

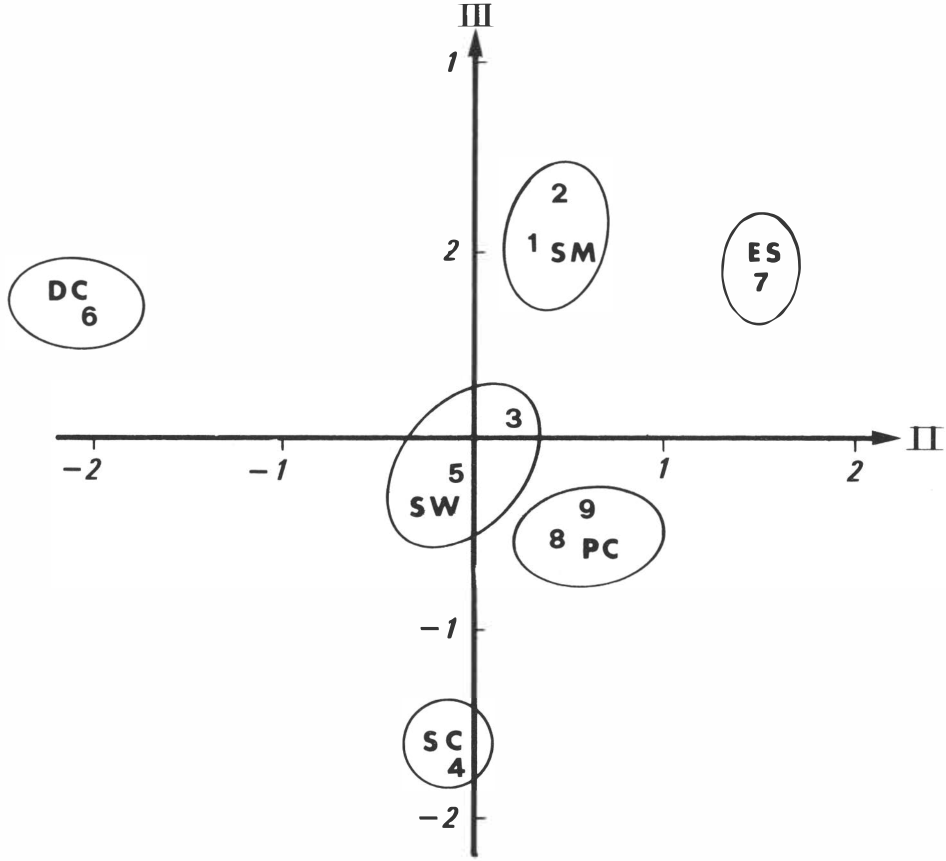

Fig. 3 — Reciprocal ordering of species groups (numbers) and vegetation types (letters) according to the analysis of concentration. The symbols indicating vegetation types are as in Table 1. 1 - *Sphagnum magellanicum - Eriophorum vaginatum* group; 2 - *Mylia anomala - Sphagnum acutifolium* group; 3 - *Polytrichum strictum - Nardus stricta* group; 4 - *Odontoschisma sphagni - Sphagnum compactum* group; 5 - *Sphagnum warnstorfii - Aulacomnium palustre* group; 6 - *Scorpidium scorpioides - Carex limosa* group; 7 - *Cratoneurum commutatum* var. *falcatum - Eriophorum scheuchzeri* group; 8 - *Drepanocladus revolvens - Parnassia palustris* group; 9 - *Calliergon trifarium - Willemetia stipitata* group.

Sphagnetum magellanici (SM). This community forms isolated well-developed hummocks within the *Parnassio-Caricetum fuscae.* Exceptionally, it may cover areas larger than few square meters: then, the morphology of the *Sphagnum* cover resembles that of raised bogs. This vegetation type is characterized by species of the *Sphagnum magellanicum - Eriophorum vaginatum* group, most of which are considered characteristic of different syntaxa within the class *Oxycocco-Sphagnetea.* The characteristic combination of species coincides with that of the *Sphagnetum magellanici.* The relevés (see Table 1) are somewhat heterogeneous as several *Sphagnum* species (*S. rubellum, S. quinquefarium, S. acutifolium*) may dominate, dependent on the water level (Dierssen, 1978).

Sphagnum compactum community (SC). This community is very rare in the Dolomites as it is found only at the top of well-developed peat bodies, established on impermeable marls. This vegetation type is characterized by species of the *Odontoschisma sphagni - Sphagnum compactum* group. It is fairly similar both to the *Sphagno compacti - Trichophoretum germanici* and to the *Eriophoro - Trichophoretum caespitosi* (Oberdorfer, 1977). Our relevés differ from the former of these associations, owing to the absence of *Trichophorum germanicum*, and from the latter as *Sphagnum compactum* is not so frequent in the *Eriophoro-Trichophoretum caespitosi*.

Scorpidio-Caricetum limosae (SL). Also this community is very rare in the Dolomites. It colonizes only depressions within well-developed peat bodies. This vegetation type is characterized by species of the *Scorpidium scorpioides - Carex limosa* group, including indicator species of wet mesotrophic fens, most of which are considered characteristic of the order *Scheuchzerietalia palustris*. The relevés were assigned to the *Scorpidio-Caricetum limosae* (Krisai, 1971), owing to the abundance of *Scorpidium scorpioides*.

Evaluation of classifications

The dendrograms of relevés are identical at the 6-cluster level, but rather different at higher hierarchical levels (Figs. 2b-d). Classification efficiency was tested only at the 3- and the 2- cluster level, since the corresponding groups represent the most inclusive vegetation types in the studied wetland vegetation.

Table 3 - Contingency tables (species groups x relevé sets) and values of the D indices. (See explanation in the text).

ALCB

3 clusters

	SM SC SW	SL	ES PC
1-5	*1.09*	*0.17*	*0.13*
6	*0.05*	*3.37*	*0.08*
7-9	*0.11*	*0.04*	*0.98*

$D(F_h;F_i) = 0.359$

2 clusters

	SM SC SW SL	ES PC
1-6	*0.93*	*0.13*
7-9	*0.11*	*0.98*

$D(F_h;F_i) = 0.230$

	3 clusters				*2 clusters*	

ALCW

3 clusters:

	SM	SW	ES SL SC PC
1-5	*1.08*	*1.21*	*0.17*
6	-	*0.07*	*0.29*
7-9	*0.03*	*0.21*	*0.87*

$D(F_h;F_i) = 0.112$

2 clusters:

	SM SW	ES SL SC PC
1-6	*1.02*	*0.18*
7-9	*1.08*	*0.87*

$D(F_h;F_i) = 0.020$

SSA

3 clusters:

	SM SC SW SL	ES	PC
1-5	*1.00*	*0.12*	*0.14*
6	*0.39*	-	*0.10*
7-9	*0.11*	*0.45*	*1.08*

$D(F_h;F_i) = 0.119$

2 clusters:

	SM SC SW SL ES	PC
1-6	*0.77*	*0.13*
7-9	*0.17*	*1.08*

$D(F_f;F_i) = 0.159$

The efficiency of the classifications was evaluated by calculating the mean cover of the species groups formed at the 3- and respectively at the 2- clusters levels (see the classification dendrogram of species; Fig. 2a) in the relevé clusters identified at the same hierarchical levels (see the classification dendrograms of the types; Fig. 2b-d). The contingency tables and the $D(F_h; F_i)$ values calculated for each are reported in Table 3. On the basis of this test, the classification obtained by ALCB proved to be the most efficient at both levels.

For evaluating classifications by external criteria, contingency tables were constructed, correlating the frequency distributions of the equivalence classes for both pH and electrical conductivity in the vegetation types at the same hierarchical levels. The contingency tables and 2I values are given in Tables 4 and 5. It appears that the most predictive classification for both pH and electrical conductivity is again that obtained by ALCB at the specified hierarchical levels.

Table 4 - Contingency tables for pH and values of the 2I index. (See explanation in the text).

ALCB

3 clusters

	SM SC SW	SL	ES PC
5-5.99	*6*	-	*1*
6-6.99	*2*	*1*	*2*
7-8	-	-	*7*

2I = 16.27 (99.7)

2 clusters

	SM SC SW SL	ES PC
5-6.49	*7*	*1*
6.50-8	*2*	*9*

2I = 9.83 (99.8)

ALCW

3 clusters

	SM	SW	ES SL SC PC
5-5.99	*4*	*1*	*2*
6-6.99	-	*2*	*3*
7-8	-	-	*7*

2I = 14.46 (99.4)

2 clusters

	SM SW	ES SL SC PC
5-6.49	*5*	*3*
6.50-8	*2*	*9*

2I = 3.99 (95.4)

SSA

3 clusters

	SM SC SW SL	ES	PC
5-5.99	*6*	-	*1*
6-6.99	*3*	-	*2*
7-8	-	*2*	*5*

2I = 15.48 (99.6)

2 clusters

	SM SC SW SL ES	PC
5-6.49	*7*	*1*
6.50-8	*4*	*7*

2I = 5.41 (98)

Table 5 - Contingency tables for electrical conductivity (μs) and values of the 2I index. (See explanation in the text).

ALCB

3 clusters

	SM SC SW	SL	ES PC
≤ 50	*8*	–	*1*
51–100	–	*1*	*3*
> 100	–	–	*6*

2I = 21.79 (100)

2 clusters

	SM SC SW SL	ES PC
≤ 75	*9*	*3*
> 75	–	*7*

2I = 12.79 (100)

ALCW

3 clusters

	SM	SW	ES SL SC PC
≤ 50	*4*	*3*	*2*
51–100	–	–	*4*
> 100	–	–	*6*

2I = 15.47 (99.6)

2 clusters

	SM SW	ES SL SC PC
≤ 75	*7*	*5*
> 75	–	*7*

2I = 8.71 (99.7)

SSA

3 clusters

	SM SC SW SL	ES	PC
≤ 50	*8*	*1*	–
51–100	*1*	–	*3*
> 100	–	*1*	*5*

2I = 20.11 (100)

2 clusters

	SM SC SW SL ES	PC
≤ 75	*10*	*2*
> 75	*1*	*6*

2I = 9.31 (99.8)

Discussion

The efficiency tests applied to the contingency matrices show that all classifications are highly predictive for the environmental conditions ($P < 0.05$). It is noteworthy that the evaluations based on external criteria support those obtained by internal criteria: in both cases the classification by ALCB proved to be the most efficient. This coincidence of evaluations might be owing to the fact that peatlands are natural and not disturbed environments. Interestingly, when classifications from secondary grasslands were compared by similar methods (Feoli *et al.*, 1981), the results obtained based on internal and external criteria did not coincide. This conclusion cannot be, however, generalized since insufficient data are available for comparison. Further research will be devoted to this topic.

The groups distinguished at the 3-cluster level (Fig. 2b) are interpretable as phytosociological units: the cluster including the *Sphagnetum magellanici*, the *Sphagnum compactum* community and the *Sphagnum warnstorfii* community may correspond to the order *Sphagnetalia magellanici*; the cluster including the *Scorpidio-Caricetum limosae* to the order *Scheuchzerietalia palustris*; and the cluster of *Eriophoretum scheuchzeri* and *Parnassio-Caricetum fuscae* to the order *Tofieldietalia*.

Riassunto. Le comunità vegetali delle torbiere dolomitiche sono state indagate con il metodo fitosociologico. I dati vegetazionali sono stati classificati con vari metodi di *cluster analysis*. I risultati così ottenuti sono stati valutati su base quantitativa considerando sia la struttura delle tabelle di contingenza gruppi di specie *x* gruppi di rilievi (predittività interna) sia la correlazione esistente fra tipi vegetazionali e chimismo della torba (predittività esterna). Un risultato interessante è dato dal fatto che le valutazioni ottenute con i due criteri sono fra loro coincidenti.

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