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The class *Scheuchzerio-Caricetea nigrae* in Sicily: a new association of the *Caricion nigrae* from the Madonie Mountains

Abstract

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The presence of hygrophilous vegetation aspects related to the *Scheuchzerio-Caricetea nigrae* class is analyzed and reported in Sicily, on the Madonie Mountains. It is represented today by a single association which in the same mountains has had greater extension in the past. Despite the damage and severe reductions suffered in the last decades of the last century, the small Sicilian peaty stations still survive in the only locality of Scorzone locality, in the territory of Geraci Siculo (Palermo) and host phytocoenoses that are unprecedented from a phytosociological point of view. In the case of Scorzone area, it is an unprecedented association that is established and described here with the name of *Sphagno auriculati-Caricetum echinatae*. Its floristic composition and both biological and biogeographic structure are analyzed. Its syntaxonomic classification is also proposed within the *Caricion nigrae* alliance (*Caricetalia nigrae*), sintaxon so far also indicated in the southern Apennines, up to Calabria, on the Aspromonte. The new association has an affinity with the *Sphagno inundati-Caricetum stellulatae* from the extreme region of Italian Peninsula. *Sphagno auriculati-Caricetum echinatae*, however, differs from the continental one for the greater floristic richness. Given the precariousness of the biotope, the study takes into consideration its state of conservation and the looming dangers that the described association runs, which for the European territory marks the extreme southern limit of the *Scheuchzerio-Caricetea nigrae* class.

Key words: Vegetation, *Sphagno auriculati-Caricetum echinatae*, *Caricetalia nigrae*, Madonie Mountains, Mediterranean islands.

Introduction

The *Scheuchzerio palustris-Caricetea nigrae* class includes all associations linked to large and small peat bogs in Europe. The latter in Italy are widespread from the Alps to the most extreme Apennine regions. Since these are environments in which the bryophytes - in particular the species of the genus *Sphagnum* - help to define and characterize its phytocoenoses, it is natural that they are found in the areas and environments in which these particular bryophytes can be planted and found.

In the Italian territory, the cited class is present with dozens of associations mainly located in the Alps and in the Apennines up to Calabria (Biondi & al. 2014). In this extreme peninsular region, their placement took place recently for Aspromonte area (Brullo & al. 2001).

In Sicily, not the genus *Sphagnum* but the small sphagnum peat bogs were reported for the first time in the Madonie Mountains by Raimondo & Dia (1978). The same authors reported various taxa of the aforementioned genus to Sicily, then progressively reunited in only three species: *Sphagnum auriculatum* Schimp., *S. contortum* Schultz, and *S. subsecundum* Nees (Aleffi & al. 2020).

In the central and largest island of the Mediterranean, the genus *Sphagnum* is found at the extreme southern limit of the European range. Its presence in Sicily was and remains very localized: the Madonie Mountains, as well as for other boreal species, constitute its only seat.

The residual and only Sicilian sphagnum peat bogs stations, in the above-mentioned mountains, are mainly located in the territory of Petralia Sottana, Petralia Soprana and Geraci Siculo (Fig. 1) (Raimondo & Romano 1984). They are located in a small area which, due to climatic, geo-pedological and vegetational affinities, can be considered the most extreme offshoot of the Apennines. Mount Catarineci (1660 m a.s.l.) (Fig. 2), located in the easternmost part of the mountain system (Fig. 3), in its northern slopes was rich in the most beautiful expressions of sphagnum peat bogs, almost all destroyed in the years 1974-1980 for the capture of small springs of mineral waters for commercial purposes. The aforementioned study by Raimondo & Dia (1987) listed and localized as many as 26 (Fig. 4). Today the situation has considerably regressed and only two stations can be confirmed with respect to those previously ascertained (Fig. 4).

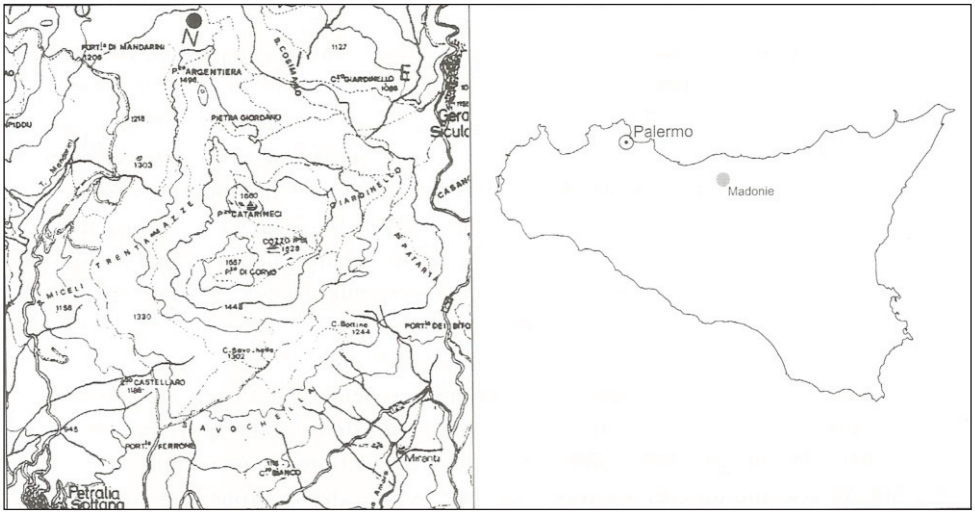

Fig. 1. Location in Sicily of the studied area in the Madonie Mountains.

The same study reported for the Madonie Mountains as many as 6 species of the genus *Sphagnum*: the mentioned *S. auriculatum*, *S. contortum*, *S. subsecundum,* but also *S. obesum* (Wilson) Warnst. (= *S. inundatum* Russow)*, S. rufescens* (Nees & Hornsch.) Warnst., and *S. magellanicum* Brid. subsequently recognized as *S. contortum* and *S. subsecundum*.

In the same years, several species of *Carex* L. new to the Sicilian flora were also reported in these same small peat bogs: *C. paniculata* L., *C. pallescens* L. (Marcenò & Raimondo 1977), *Carex* × *boenninghausiana* Weihe (Raimondo 1979), *C. demissa* Hornem. (Raimondo 1980) and *C. laevigata* Sm. (Raimondo & Ottonello 1981). Later, *C. stellulata* L. (= *C. echinata* Murray) was still reported in the locality Scorzone, the only small sphagnum peat bog that remained partially free from systematic water catchments (Raimondo & Spadaro, 2002). In this limited environment, the plant community in which *C. stellulata* occurred (Fig. 3) was almost dominated by *Sphagnum auriculatum*. Following this discovery, the first phytosociological surveys were made which subsequently allowed their elaboration. The result was an unprecedented plant community for the vegetation of the Sicilian mountains. In this contribution, it is today analyzed and typified phytosociologically. The result is a new association proposed with the name *Sphagno auriculati-Caricetum echinatae*. From a syntaxonomic point of view it is framed in the *Scheuzerio-Caricetea nigrae* class which, thus, is also represented on the island of Sicily, in the heart of the Mediterranean Basin.

Fig. 2. The quartzarenite relief of Monte Catarineci (1660 m a.s.l.) located in the eastern sector of the Madonie Mountains, in contact with the Nebrodi Mountains.

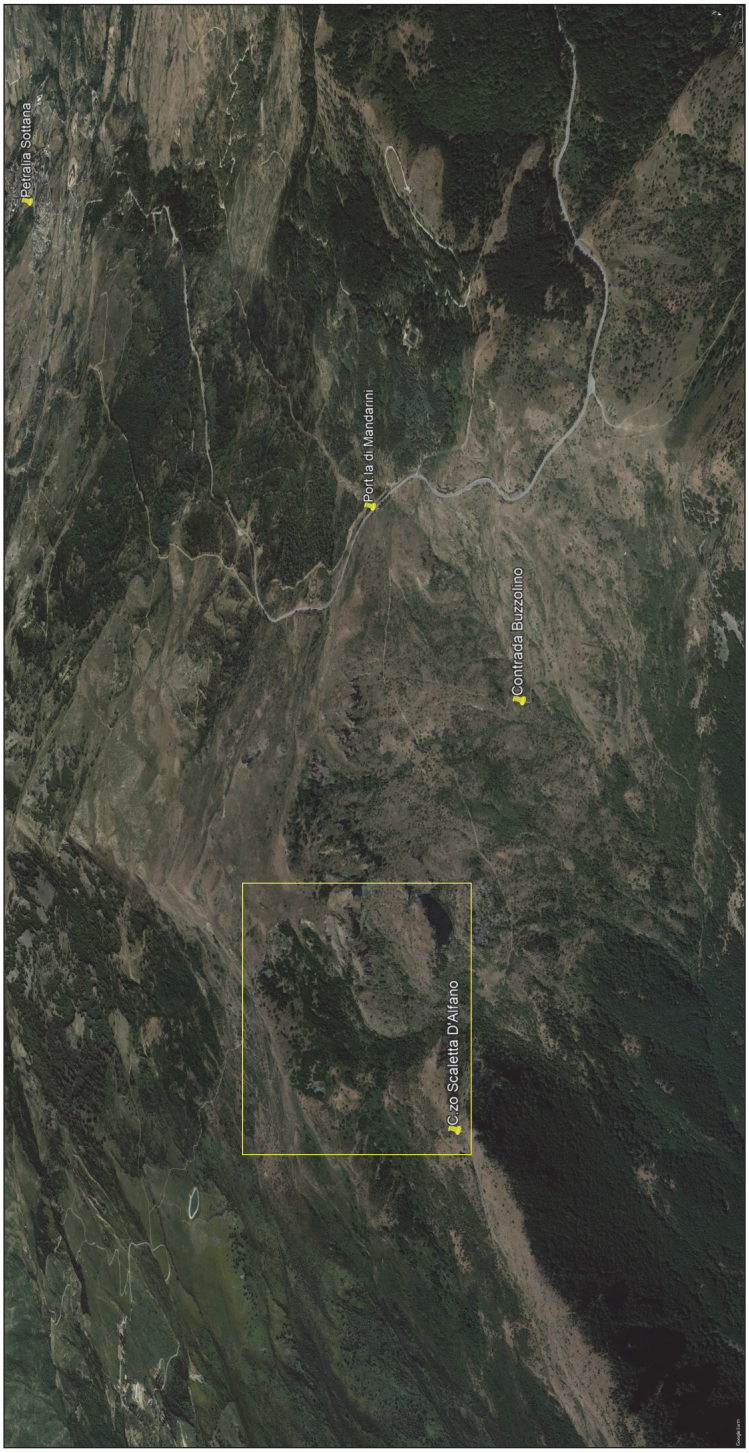

Fig. 3. The studies area of Madonie Mountains (C-N Sicily) (prepared by Google Earth Pro).

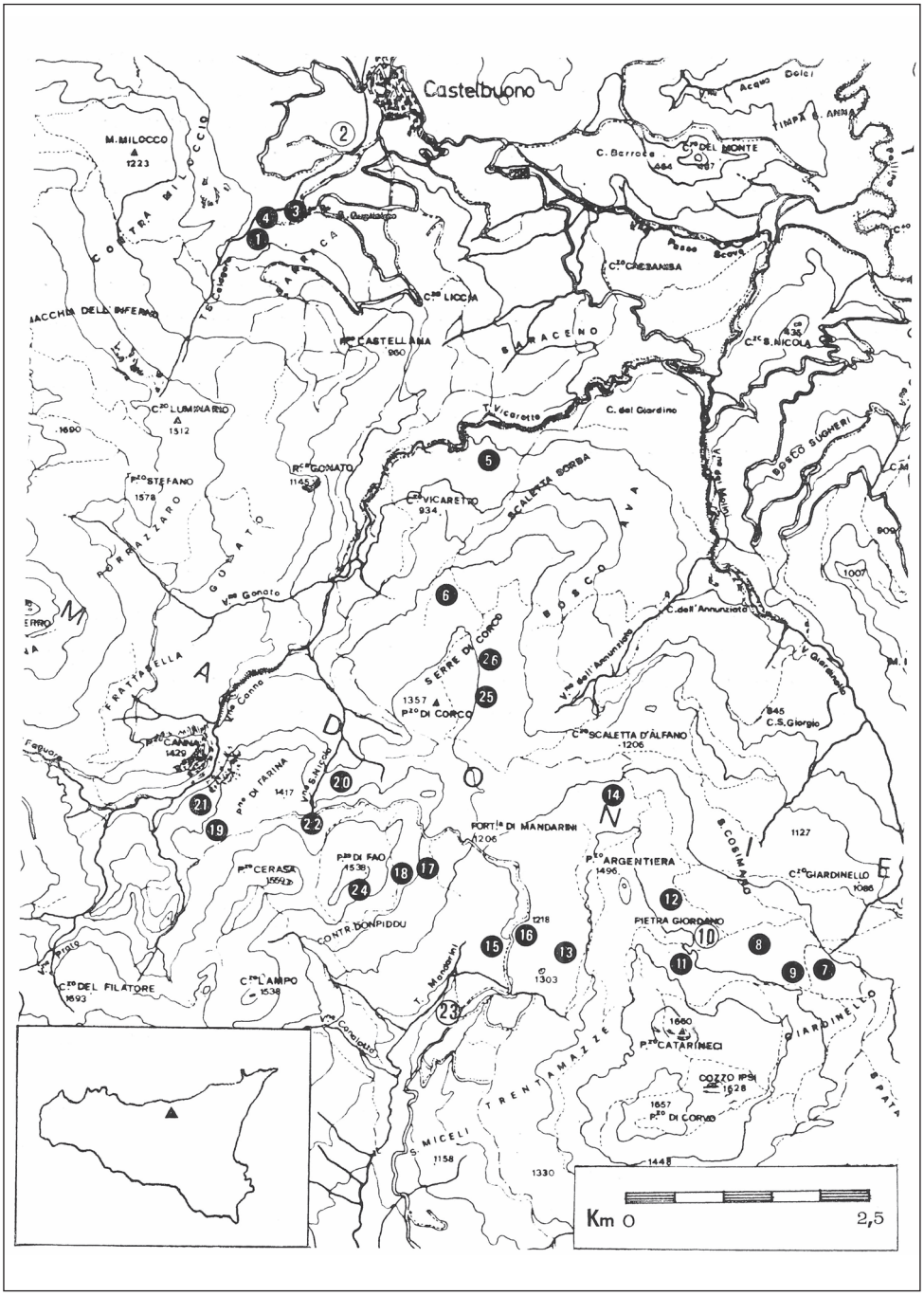

Fig. 4. Distribution of the small sphagnum peat bogs in Sicily (Madonie Mountains) surveyed by Raimondo & Dia (1978).

Ecological and phytocenotic characteristics of peaty sphagnum stations ascertained in Sicily

As mentioned, the small sphagnum peat bogs in Sicily are located exclusively on the Madonie Mountains. Censored by Raimondo & Dia (1978), they have been referred to a special habitat: the so-called - as defined by Petronici & al. (1978) - "Triemule a briofite acidofile" (trempling bog with acidophilic bryophytes). It was characterized by some chemical characteristics of peat; in particular for the rather low pH (in some stations 3.05), and organic carbon values around 35%; total limestone was absent.

The sphagnum peat bogs under examination had their main seat within the relict holly vegetation belt, in the potential area of mixed submontane woods (*Quercetalia pubescenti-petraeae* Klika 1933) (see Di Martino & al. 1977; Raimondo 1984) where they were often imprisoned. In the wetter valleys they descended to about 700-600 meters, in the full Mediterranean horizon, in the potential area of Mediterranean woods (*Quercetalia ilicis* Br.-Bl. 1936).

Especially in these thermophilic stations, colonies of *Sphagnum rufescens* s. l. and *S. auriculatum* alternate with luxuriant groupings with *Osmunda regalis*, L., *Athyrium filix-femina* (L.) Roth, *Blechnum spicant* (L.) Roth, *Juncus effusus* L., *J. articulatus* L. s.l., *Carex remota* L., *Eupatorium cannabinum* L., *Holcus lanatus* L., etc. The plant community physiognomized by *Osmunda regalis* is believed to have characterized the most evolved phase of the wet aspect of the sphagnum peat bogs. The more mesophilic stations were less rich in this fern and other pteridophytes, although some species were found there almost constantly. They passed through *Cyperaceae*, *Juncaceae* and *Poaceae* formations, towards the remains of the *Ilici-Quercetum austrotyrrhrenicae* which, like a circular vise, narrowed with a centripetal trend, as the peat freed itself from the aquifer.

Sphagnum obesum (= *S. inundatum*), often constituted submerged monospecific aspects. *Carex demissa* Hornem. and *Utricularia australis* R. Br. were found, respectively, at the points of emergence or in the small depressions. *Mentha aquatica* L., *Dactylorhiza saccifera* L. and *Juncus articulatus* L. s.l., find each other with difficulty but with constancy. Furthermore, *S. contortum* and *Sphagnum rufescens* were the species that often mixed with *Aulacomnium palustre* (Hedw.) Schwaegr., another very interesting moss of these acidophilic environments, on which a specific phytogeographic survey was conducted (Raimondo & al. 1984).

Among the sphagnum peat bogs of the stations of the Madonie Mountains liverworts have been found such as *Calypogeia trichomanis* (L.) Corda, *C. fi*ssa (L.) Corda, *C. arguta* Nees & Mont., *Lophocolea bidentata* (L.) Dum., *Bazzania trilobata* (L.) Gray and, among the other mosses, *Polytrichum commune* Hedw., often in developed autonomous consortia linked more to the less hygrophilous phytocenosis dominated by *Osmunda regalis* (see Raimondo & al. 1981). *Pellia epiphylla* (L.) Corda, among the thalose liverworts, often settled on *Sphagnum rufescens*, while the more open spaces were colonized by *Solenostoma crenulatum* (Sm.) Mitt. On the soaked sphagnum some macrophytes were found including *Solenopsis minuta* subsp. *nobilis* (F. E. Wimm.) Meikle, *Bellis hybrida* Ten., *Ranunculus fontanus* C. Presl, *Samolus*

valerandi L., *Carex punctata* Gaudin, *Lysimachia nemorum* L., *Hypericum tetrapterum* Fries and *Dactylorhiza saccifera* L.

The phytosociological classification of these mentioned aspects of vegetation constituted a considerable problem which was partly addressed many years later.

Materials and methods

The investigation area is limited to the eastern part of the Madonie Mountains. It is located almost entirely within the territory of Geraci Siculo. (Fig.1). Meaningful relief in this sector are Monte Catarineci (1660 m a.s.l.) (Fig. 2). The vegetation examined was that of the small streams in the southern slopes of the cited Monte Catarineci (Figs. 3, 5), space occupied by deciduous oaks with dominance of *Ilex aquifolium* L. (*Quercion pubescentis-petraeae*) (Fig. 6a) below and thermophilous beech forests (*Geranio versicoloris-Fagion*) (Fig. 6b). The vegetation survey was carried out in summer (august), following the phytosociological method of the Zurich-Monpellier school. The individual surveys have been brought together in Table 1.

In our contribution, in presence of the updated summaries by Biondi & al. (2014) for the vegetation of Italy, rather the latest synthesis on a European scale, proposed by Mucina & al. (2016), we preferred referring to the first authors, considering it more responsive to the Sicilian vegetation. Therefore, the phytosociological classification of the vegetation analyzed here, is referred to the syntaxa units recognized by Biondi & al. (2014) which are also followed for the nomenclature of the mentioned syntaxa in the text and Annex *a*. The nomenclature of the plants cited in text, captions, tables, and Annex *b* follows Bartolucci & al. (2018), except a few cases. Furthermore, both for biological categories and for chorological types, reference is made to Raimondo & al. (2010). The reunion in six contingents of the numerous chorological types, represented in the detected florulae, follows Di Martino & Raimondo (1979). The calculation of the qualitative (florula) and quantitative (vegetation) weight of the biological and chorological types is based on the work of Di Martino & Raimondo (1976).

Results and discussion

The analysis of the data in Table 1 allows us to frame the examined vegetation in a new association called *Sphagno auriculati-Caricetum echinatae*. It is presented and described below

Sphagno auriculati-Caricetum echinatae Raimondo & Di Gristina *ass. nov. hoc loco* (Table 1)

Type: Rel. 2 in Table 1 (geographic coordinates: 37°51'58.171"N/14°07'01.64"E).

Table 1. **Sphagno auriculati-Caricetum echinatae** *ass. nov. hoc loco* (*Caricion nigrae*, *Caricetalia nigrae*, *Scheuchzerio-Caricetea nigrae*)

Biological form	**Chorological type**	Relevé (n°)	1	2	3	4	5	Presence	Frequency
		Altitude (m a.s.l.)	1215	1220	1225	1231	1228		
		Exposure	N-W	N-W	N-W	N-W	N-W		
		Slope (°)	10	12	12	14	12		
		Total cover (%)	100	100	100	100	100		
		Everage height (cm)	25	30	30	35	30		
		Area (m^2)	9	9	9	9	9		
		Species per elevé (n°)	26	20	15	25	13		
		Char. **Association**							
H caesp	Euroamer. (Anfiatl.)	*Carex echinata*	2.3	3.4	2.3	3.4	3.4	5	V
Tall	Boreale	*Sphagnum auriculatum*	4.4	4.5	4.4	3.4	4.4	5	V
H caesp	NE-Medit.-Mont.	*Ranunculus fontanus*	+.2	1.2	+.2	.	+.2	4	IV
T scap	W-Stenomedit.	*Solenopsis bivonae*	+.2	+.2	.	+.2	.	3	III
		Char. **alleance, order and class**							
H caesp	Euroamer. (Anfiatl.)	*Carex demissa*	+.2	1.2	1.2	1.2	1.2	5	V
H caesp	Eurimedit.-Subatl.	*Carex punctata*		+.2	+.2	+.2	+.2	4	IV
Tall	Boreal	*Aulacomnium palustre*	1.2	1.2	.	+.2	.	3	III
Tall	Subboreal	*Polytrichum commune*	+.2	+.2	.	.	.	2	II
		Other taxa							
H rept	Paleotemp.	*Trifolium repens*	+.2	1.2	.	+.2	.	3	III
T scap	Subtrop.	*Isolepis setacea*	+.2	+.2	.	.	+.2	3	III
H caesp	Eurimedit.	*Carex distans*	+.2	+.2	.	.	.	2	II
H caesp	Eurosib.	*Juncus conglomertus*	+.2	.	.	+.2	.	2	II
H scap	Eurasiat.	*Lysimachia nemorum*	.	+.2	+	.	+	3	III
H caesp	Eurasiat.	*Poa trivialis*	+.2	+.2	.	1.2	+	3	III
G rhiz	Paleosubtrop.	*Juncus fontanesii*	.	1.2	.	+.2	+.2	3	III
H caesp	Cosmopol.	*Samolus valerandi*	.	+	+.2	.	.	2	II
H scap	Cosmopol.	*Veronica anagallis-aquatica*	+.2	.	.	+.2	.	2	II
H scap	Eurimedit.	*Galium palustre* subsp. *elongatum*	.	+.2	.	+.2	.	2	II
H ros	Subendemic	*Bellis perennis* subsp. *hybrida*	.	+.2	.	+.2	.	2	II
H ros	Paleotemp.	*Potentilla reptans*	+.2	.	.	+.2	.	2	II
H caesp	Eurimedit.	*Festuca circummediterranea*	.	.	+.2	+	.	2	II
H scap	Paleotemp. Boreal	*Lycopus europaeus*	.	.	+.2	.	+.2	2	II
Tall	Temperate	*Calliergonella cuspidate*	.	.	+.2	+.2	.	2	II
H scap	Paleotemp.	*Mentha aquatica*	+.2	.	+.2	.	.	2	II
H scap	Paleotemp.	*Hypericum tetrapterum*	.	+.2	.	+.2	.	2	II
G bulb	Stenomedit.	*Dactylorhiza maculata* subsp. *saccifera*	+	.	.	+	.	2	II
P caesp	Stenomedit.	*Salix pedicellata*	+.2	.	.	1.2	.	2	II
H scap	Europ.-Caucas.	*Teucrium scordium*	+.2	.	+.2	.	.	2	II
G rhiz	Subcosmop.	*Osmunda regalis*	+.2	.	.	+.2	.	2	II
H ros	Subcosmop.	*Athyrium filix-foemina*	+.2	.	.	+.2	.	2	II
H ros	Circumbor.	*Struthiopteris spicant*	+.2	.	.	+.2	.	2	II
G rhiz	Cosmopol.	*Pteridium aquilinum*	+.2	.	.	.	+.2	2	II
H scap	Paleotemp.	*Eupatorium cannabinum*	.	.	+.2	+.2	.	2	II
H scap	Eurimedit.	*Pulicaria dysenterica*	+.2	.	.	.	+.2	2	II
H scap	Eurimedit.	*Mentha pulegium*	+.2	.	+.2	.	.	2	II
H caesp	Circumbor.	*Holcus lanatus*	.	.	+.2	.	+.2	2	II
Tall		*Calypogeia* sp.	.	+.2	.	.	.	1	I
H caesp	Subcosmop.	*Deschampsia cespitosa*	+.2	.	.	.	.	1	I
H caesp	Europ.-Caucas.	*Carex paniculata*	.	.	.	+.2	.	1	I
H rept	Eurasiat.	*Veronica beccabunga*	.	+	.	.	.	1	I
NP		*Rubus* sp.	.	.	.	+	.	1	I
Tall		*Mnium* sp.	+.2	.	.	.	.	1	I

Fig. 5. View of the area where the small sphagnum bog falls on the north-western slopes of Mount Catarineci (Madonie Mountains, Sicily) (from Google Earth).

It is a hygrophilous herbaceous vegetation, essentially consisting of *Carex echinata* and *Sphagnum auriculatum* (Fig. 7).

Characteristic species – It characterizes this association the species mentioned, *Carex echinata* and *Sphagnum auriculatum*. Among the other characteristics there are *Ranunculus fontanus* - a Mediterranean mountain element and *Solenopsis bivonae,* other Mediterranean element. Theirs role in the Sicilian association is respectively local and territorial, playing roles as characteristics of other associations of different phytosociological classes in the Italian Peninsula and Sicily.

Floristic organization – The herbaceous hygrophilous vegetation investigated (Fig. 7) consists basically of two species: the bryophyte *Sphagnum auriculatum* and the vascular plant *Carex echinata*. Other bryophytes and many other vascular plants, particularly perennials, help to structure the very special and rare Sicilian mountain vegetation (see Table 1).

Biological and chorological structure – The examined association consists of species belonging to different biological categories, among which, the hemicryptophytes (66.7 and 67,4 %) and the thallophytes (14.2 and 14.3 %) (Fig. 8) stand out, both qualitatively and quantitatively. Geophytes, chamaephytes and phanerophytes, equivalent in weight, they have little influence on the structure of the proposed association (Fig. 9).

From the biogeographical point of view, the florula is represented by different chorological contingent. The boreal contingent (41and 40 %), the Mediterranean (23.1 and 20 %) (Fig. 10), and Western contingent (7.7 and 14.7 %) play a considerable role (Fig. 11).

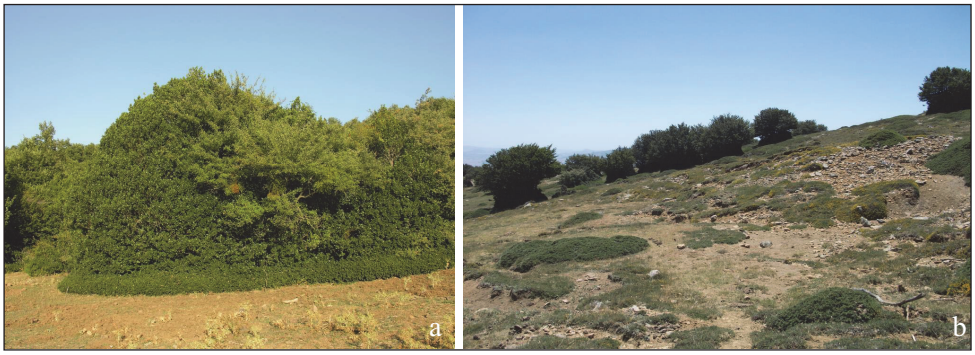

Fig. 6. Degraded aspects of the forest vegetation within which the small sphagnum peat bogs of the Madonie Mountains (Sicily) were found: a) the remains of the oak and holly wood; b) remains of the beech and holly wood.

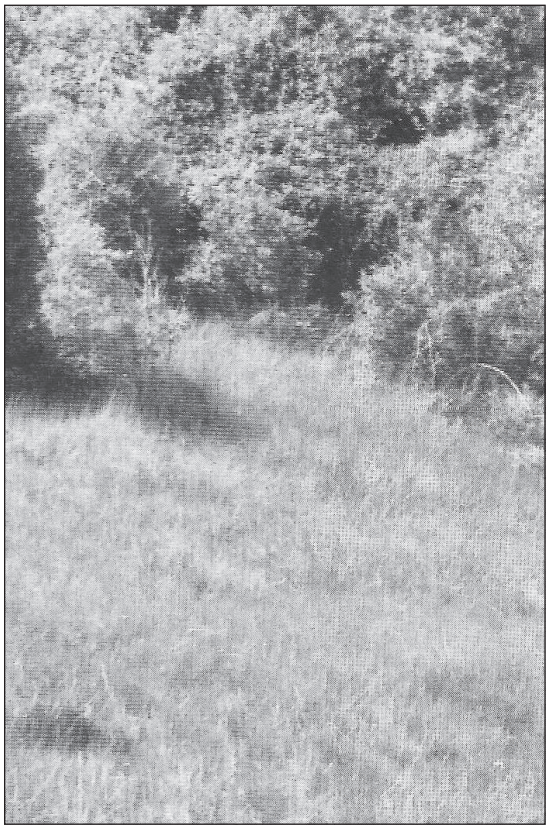

Fig. 7. Typical aspect of the new association *Sphagno auriculati-Caricetum echinatae* from Scorzone locality (from Raimondo & Spadaro 2002).

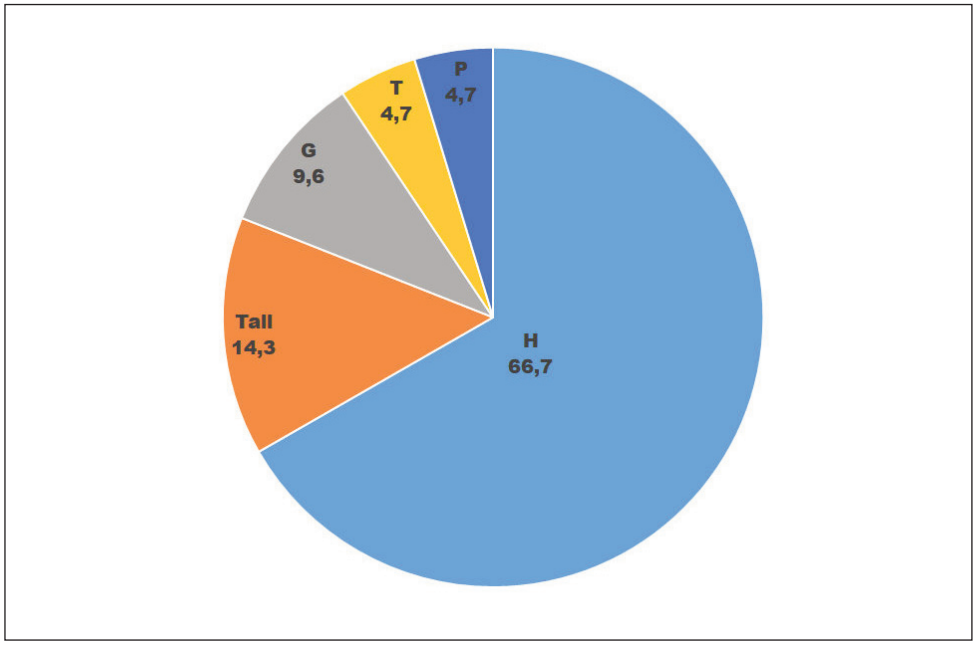

Fig. 8. Biological spectrum of the florula.

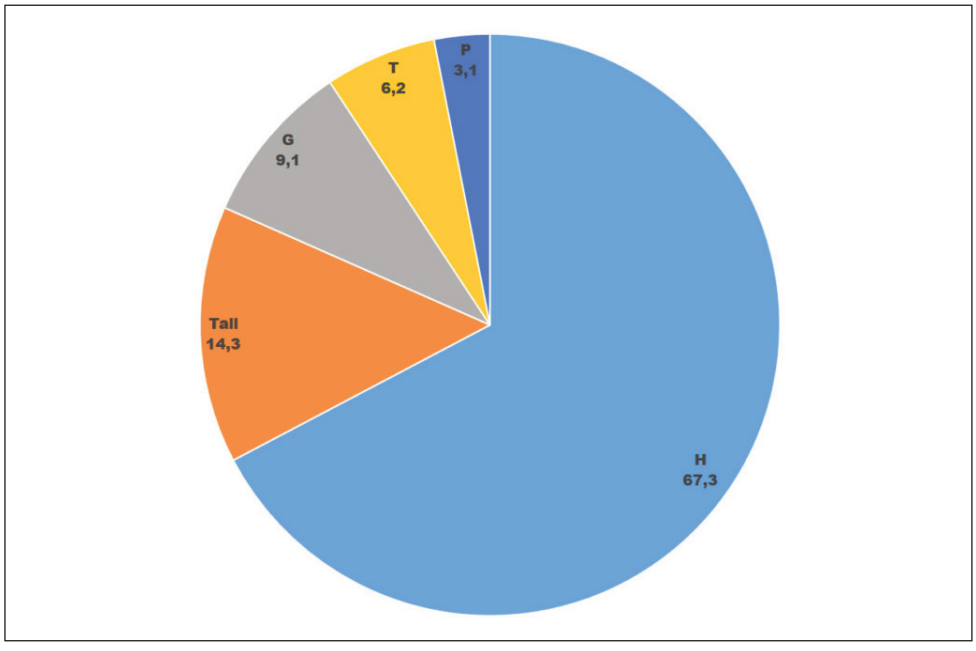

Fig. 9. Biological spectrum of the vegetation.

There was a significant increase in the weight of this contingent, represented by 3 species, in the vegetation: from 7.7 in the flora to 14.7% in the vegetation. In the boreal contingent there are some taxa that in Sicily are found exclusively in mountain areas.

Ecology, dynamics and distribution – The vegetation examined occupies a little area surrounded by forest vegetation that has been degraded due to strong grazing (Fig. 5). It therefore tends to evolve towards grassland formations of *Cynosurion cristati* and subsequently towards the mixed forest of oak and holly (*Quercetalia pubescenti-petraeae*) falling within the relict vegetation belt of the colchic type recalled by Cambria & Raimondo (2021).

Phytosociological framework – In the floristic frame of Table 1, the contingent of species characteristic of the class *Scheuchzerio-Caricetea nigrae,* and of the units subordinate to it (*Caricetalia* and *Caricion nigrae)*, is well represented. In particular the mentioned syntaxa are represented by *Aulacomnuin palustre, Polytrichum commune, Carex punctata* and *Carex demissa.* For this, and for its ecological and other floristic character, the *Sghagno auriculati-Caricetum echinatae* association is here referred to the alliance *Caricion nigrae*, order *Caricetalia nigrae,* class *Scheuchzerio palustris-Caricetea nigrae.*

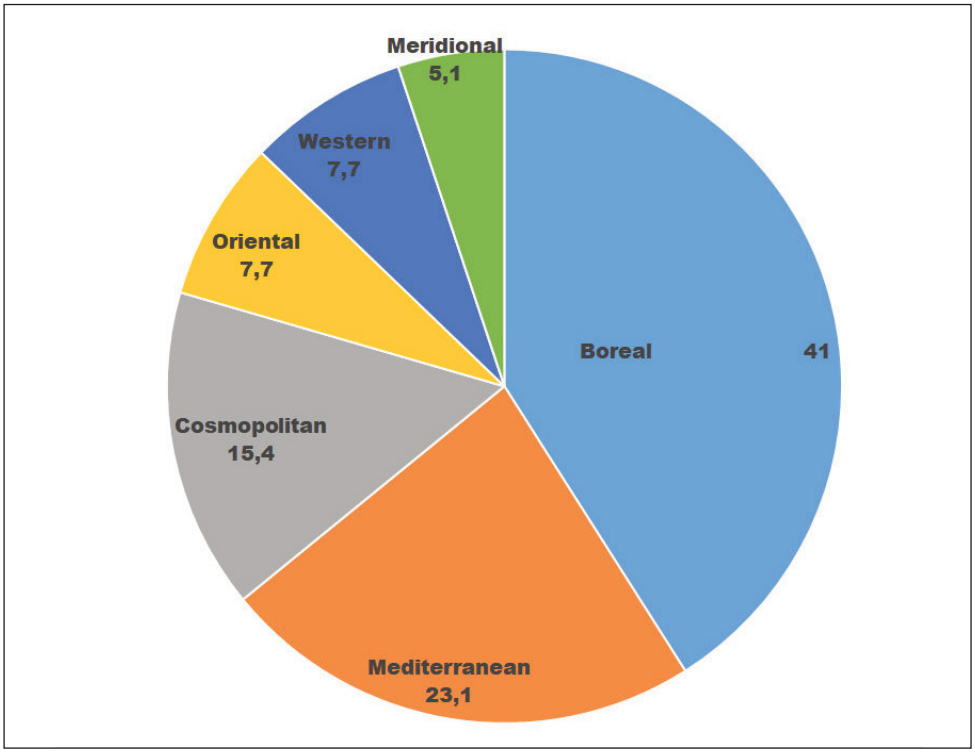

Fig. 10. Chorological spectrum of the florula.

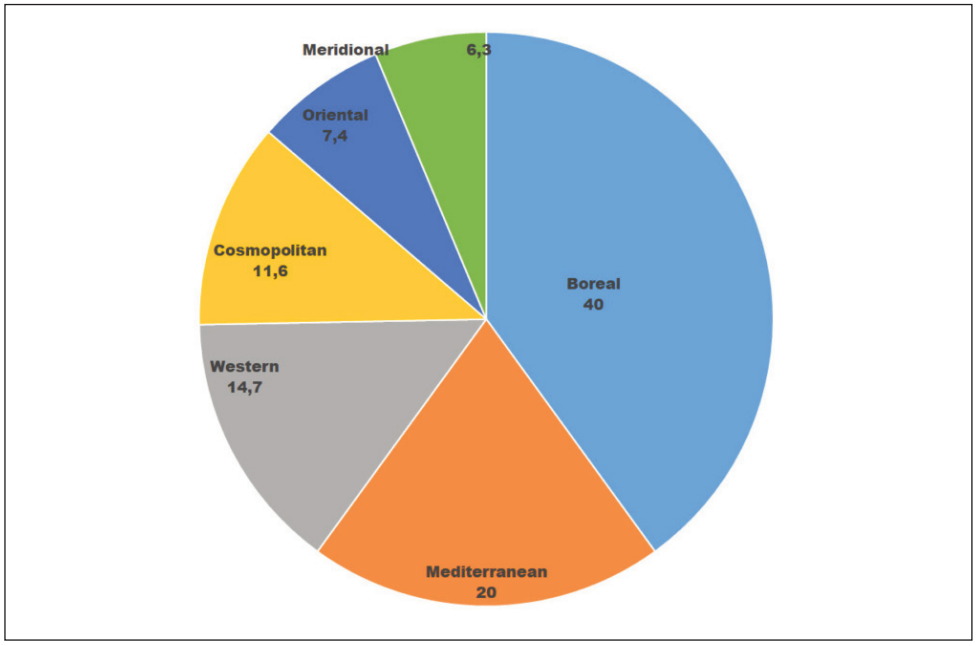

Fig. 11. Chorological spectrum of the vegetation.

Conclusion

The presence in Sicily of aspects of vegetation referable to the *Parvocaricetea* Westhoff in Westhoff & Den Held 1969 [syntax. syn. of *Scheuchzerio palustris-Caricetea nigrae* nom. mut. propos. ex Steiner 1992; original name *Scheuchzerio-Caricetales fuscae* Tüxen 1937] was hypothesized 40 years ago by Raimondo & al. (1980). Since then, no studies have been developed and after years the type of environment and vegetation that was then attracted to scholars, has undergone a sharp reduction. Miraculously, one of the 26 small sphagnum peat bogs in Sicily documented by Raimondo & Dia (1978) was spared from the works of capturing the water source, and this allowed us to be able to analyze it phytosociologically and to be able to document that in reality the mentioned class of vegetation goes south as far as Sicily, thanks to the new association described here.

Due to the presence of some characteristic species of the alliance and order *Caricion* and *Caricetalia nigrae*, it is linked to the *Scheuchzerio-Caricetea nigrae* class. As mentioned, this class brings together the plant associations of humid places with a prevalence of *Sphagnum* and various helophytes. It is a syntaxon distributed with boreal distribution: the *Caricion nigrae* alliance affects the entire Italian peninsula; from the Alps it reaches Calabria where it presents itself with a couple of associations including the *Sphagno inundati-Caricetea stellulate* from Aspromonte. With the aforementioned association, the *Sphagno auriculati-Caricetum echinatae*,

shares various species and among these the same *Carex echinata (= C. stellulata*) which in Sicily takes on the role of territorial characteristic in the new association. Although it has also been represented, it remains exposed to serious risks of damage and further reduction, due to the proliferation of wild suidae and fallow deer, carelessly introduced into the territory of the Madonie protected natural area.

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ANNEXES

Annex 1. – List of the syntaxa cited in the texte and Table 1.

Caricetalia nigrae Koch 1926
Caricion nigrae Koch 1926 *em.* Klika 1934
Cynosurion cristati Tüxen 1947
Geranium versicoloris-Fagion sylvaticae Gentile 1970
Parvocaricetea Westhoff in Westhoff & Den Held 1969
Quercetalia pubescenti-petraeae Klika 1933
Quercion pubescenti-petraeae Br.-Bl. 1932
Quercetalia ilicis Br.-Bl. 1936
Quercion ilicis Br.-Bl. ex Mol. 1934 em. Riv.-Mart. 1975
Scheuchzerio palustris-Caricetea nigrae Steiner 1992
Scheuchzerio-Caricetea fuscae Tüxen 1937
Sphagno auriculati-Caricetum echinatae Raimondo & Di Gristina *ass. nov. hoc loco*
Sphagno inundati-Caricetum stellulatae Brullo, Scelsi & Spampinato 2001

Annex 2 - Alphabetical list of specific and subspecific taxa named in Table 1.

VASCULAR PLANTS

Athyrium filix-foemina (L.) Roth
Bellis perennis subsp. *hybrida* (Ten.) Nyman
Carex demissa Hornem.
Carex distans L.
Carex echinata Murray
Carex paniculata L.
Carex punctata Gaudin
Dactylorhiza maculata subsp. saccifera (Brongn.) Diklić
Deschampsia cespitosa (L.) P. Beauv.
Eupatorium cannabinum L.
Festuca circummediterranea Patzke
Galium palustre subsp. *elongatum* (C. Presl) Arcang.
Holcus lanatus L.
Hypericum tetrapterum Fr.
Isolepis setacea (L.) R. Br.
Juncus conglomertus L.
Juncus fontanesii J. Gay
Lycopus europaeus L.
Lysimachia nemorum L.
Mentha aquatica L.
Mentha pulegium L.
Osmunda regalis L.
Poa trivialis L.

Potentilla reptans L.
Pteridium aquilinum (L.) Kuhn
Pulicaria dysenterica (L.) Bernh.
Ranunculus fontanus C. Presl
Rubus sp.
Salix pedicellata Desf.
Samolus valerandi L.
Solenopsis bivonae (Tineo) M.B. Crespo, Serra & Juan
Struthiopteris spicant (L.) Weiss
Teucrium scordium L.
Trifolium repens L.
Veronica anagallis-aquatica L.
Veronica beccabunga L.

BRYOPHYTES

Aulacomnium palustre (Hedw.) Schwaegr.
Calliergonella cuspidate (Hedw.) Loeske
Calypogeia sp.
Mnium sp.
Polytrichum commune Hedw.
Sphagnum auriculatum Schimp.

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