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## Phytogeographical considerations on the fumarole bryoflora from Mediterranean and Macaronesian areas

### Abstract

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The bryoflora of fumaroles occurring in some volcanic localities of C Mediterranean and Canary Islands is examined. The phytogeographical analysis has emphasized the presence of very rare species mainly belonging to the endemic, Mediterranean-Tropical and Atlantic elements. The very peculiar hot-humid ecological conditions of tropical type lead to the establishment of very specialized communities. The new combination *Campylopus pilifer* subsp. *vaporarius* is proposed.

### Introduction

In the frame of the researches on the bryophyte flora and vegetation of the Mediterranean region, a study regarding the fumaroles of the volcanic areas was carried out. Considering the remarkable interest of these peculiar habitats, the investigations were subsequently extended to some other fumaroles of the Canary Islands.

The fumaroles are linked to secondary volcanic phenomena characterized by emission of hot fumes, up to 80°C, sometimes including a high percentage of sulphur. Their mouth is generally covered around by cushions of bryophytes, replaced in the innermost part by a layer of *Cyanophyceae*, much more resistant to the high temperatures (60-70°C).

The present study concerns some C Mediterranean territories, such as the islands of Pantelleria, Vulcano, Linosa (Sicily), the island of Ischia and Pozzuoli near Neaple (S Italy), and moreover the volcano Teide in Tenerife, (fig. 1).

Up to now, only fragmentary bryological records from these habitats are mentioned in literature (e.g. Bottini 1907, Bruneau de Miré & Quézel 1959, Thyssen 1965, Lübenau & Lübenau 1970, Privitera & Puglisi 1989, Gonzalez Mancebo & al. 1991).

### Results

The fumarole bryoflora is peculiar and quite specialized; it is characterized by some very rare species in Europe and in the whole Mediterranean area, showing an important role from

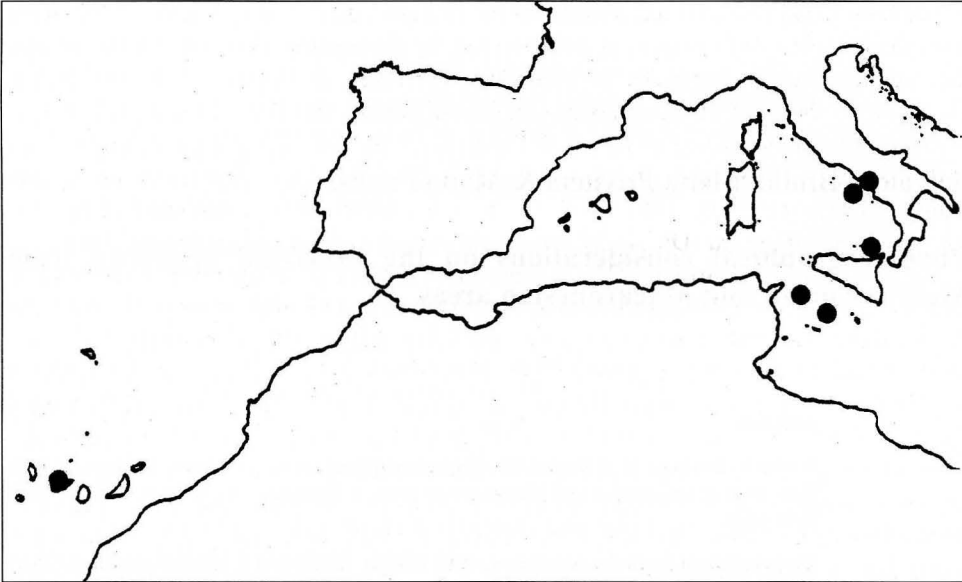


Fig. 1. Location of the investigated areas.

the ecological and chorological point of view. The most significant are *Calymperes erosum* Müll. Hal., *Isopterygium tenerum* (Sw.) Mitt., *Trematodon longicollis* Michx., *Barbella strongylensis* Bott., *Campylopus pilifer* Brid. and *C. introflexus* (Hedw.) Brid.

*Calymperes erosum* is the only representative in Europe of the tropical genus *Calymperes* and is known only from some fumaroles of Pantelleria. This species was described as *Calymperes sommieri* by Bottini (1907) who firstly found it; subsequently, it was considered by Edwards (1980) a synonym of *Calymperes erosum*. Really, the populations of Pantelleria are very like to the tropical ones of *Calymperes erosum*, apart from a constant irregular papillosity in the abaxial surface of the leaf cost. In the "Red Data Book of European Bryophytes" (Schumacker & al. 1997) *Calymperes erosum* is considered as vulnerable. It is very rare at Pantelleria, occurring in few places, such as "Bagno asciutto", Kazen and Cuddia di Mida, where it is confined to caves characterized by a considerable emission of fumes.

*Isopterygium tenerum* is known from few localities of Italy, Spain, Azores, and N America (Schumacker & al. 1997). Quoted also as *Hypnum bottinii* Breidl. or *Sematophyllum bottinii* (Breidl.) Podp., it represents the only species of the genus occurring in Europe. It is an endangered taxon, found in Italy only in Tuscany, Ischia and Pozzuoli. In the last two localities, it grows around the mouth of small fumaroles placed at the surface level; here it is mixed to *Cyperus polystachyus* Rothb., a tropical vascular plant known in the Mediterranean area only from the fumaroles of Ischia (Merola 1957), and Latium at Tor Caldara near Anzio (Moraldo & al. 1989).

*Trematodon longicollis* is a tropical species occurring in the Mediterranean area only in the fumaroles of Ischia, Pantelleria where it is quite frequent, Crete and Azores (Düll 1984-85).

*Barbella strongylensis* is a C Mediterranean endemic, described by Bottini (1907) from Stromboli (Eolian Archipelago) and discovered, in photo-sciophilous conditions, around the mouth of some fumaroles of Pantelleria (Privitera & Puglisi 1989) and Ischia. However, on the basis of recent taxonomic investigations, this Bottini's species has been transferred to *Rhynchostegium* (Buck & Privitera 1999). Anyway, the binomial *Barbella strongylensis* is maintained just now. The report *B. strongylensis* f. *cavernarum* Herzog from Vulcano (Herzog 1961) has to be considered as a misidentification for *Rhynchostegiella tenella* (Dicks.) Limpr., as confirmed by our revision of specimens.

*Campylopus pilifer* Brid. (= *C. polytrichoides* De Not.) is widespread in the tropical regions, showing oceanic-submediterranean exigencies in its European range. As concerns the Mediterranean area, it is represented by the subsp. *pilifer*, with wider ecological requirements, and by the subsp. *vaporarius* (De Not.) comb. nov., exclusive of the fumarole habitat. On the basis of literature (Bruneau de Miré & Quézel 1959; Smith 1984a, 1984b; Gonzalez Mancebo & al. 1991) and personal field investigations, *Campylopus pilifer* has a remarkable physiognomic role in the colonization of the fumaroles. In particular, *C. pilifer* subsp. *pilifer* frequently occurs in the fumaroles on the top of the Teide volcan, as emphasized by Gonzalez Mancebo & al. (1991) too; on the contrary *C. pilifer* subsp. *vaporarius* is very frequent in the fumaroles of the Mediterranean area, where it is exclusively localized at their mouth.

*Campylopus introflexus* is distributed in the southern austral hemisphere, while it results a recently introduced neophyte in the Atlantic Europe. It also occurs on the top of Teide; here it is localized in the fumaroles, representing a new record to the Canary Islands. Records from Ischia (Thyssen 1965) are to be confirmed.

## Discussion

The phytogeographical analysis of the bryophyte flora occurring in the fumaroles of the various investigated localities has pointed out the presence of a conspicuous set of species belonging to the Mediterranean and Atlantic elements. The Mediterranean element consists of proper Mediterranean species (e.g. *Timmia barbuloidea*, *T. anomala*), submediterranean species (e.g. *Bryum bicolor*, *Pleurochaete squarrosa*, *Trichostomum brachydonium*), Mediterranean-oceanic species (*Cephaloziella turneri*, *Bryum donianum*, *Tortella nitida*, *Grimmia lisae*), submediterranean-oceanic species (e.g. *Campylopus pilifer* subsp. *pilifer*, *Bryum dunense*, *Scleropodium touretii*), suboceanic-Mediterranean species (e.g. *Epipterygium tozeri*), suboceanic-submediterranean species (e.g. *Bryum alpinum*, *Gongylanthus ericetorum*, *Pterogonium gracile*, *Tortella flavovirens*). On the whole, the Mediterranean s. str. and Submediterranean species, apart from Linosa (62.5%) where the typical fumaroles are scarce, are poorly represented in Pantelleria (13.6%), Vulcano (9.1%) and Ischia (17.6%), in spite of their geographical position (fig. 2); the same thing occurs in Tenerife (11.1%). On the contrary, the oceanic-Mediterranean species have a higher incidence (25% Pantelleria, 63.6% Vulcano, 23.5% Ischia, 44.5% Tenerife), according to the microclimatic features of the investigated habitats.

The most relevant set of species belongs to Mediterranean-Tropical element (*Calymperes erosum* and *Trematodon longicollis*), as well as the endemic one (*Barbella strongylensis* and

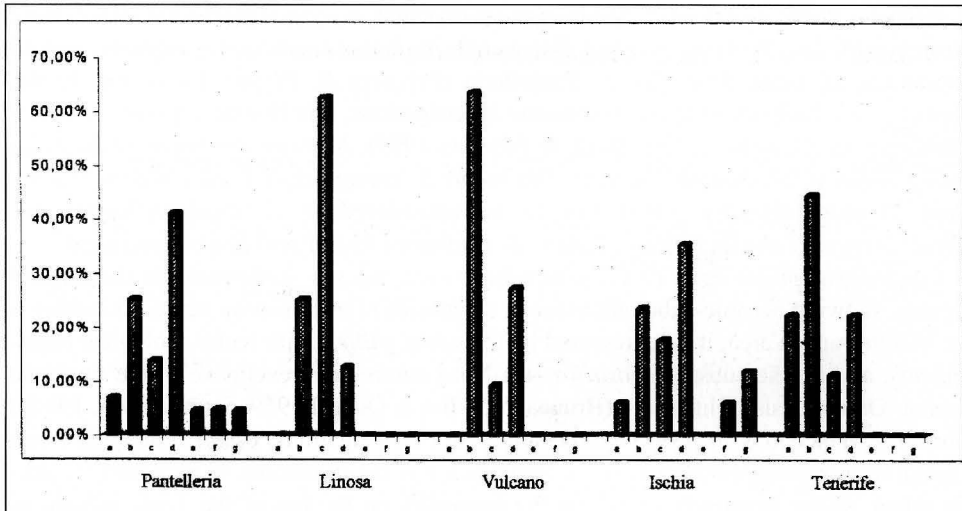


Fig. 2. Chorotypes percentage of Bryophytes collected in the investigated areas. a: oceanic; b: oceanic-mediterranean; c: mediterranean s.s. and submediterranean; d: temperate; e: boreal; f: mediterranean/tropical; g: endemic.

*Campylopus pilifer* subsp. *vaporarius*). The occurrence of these mosses, clearly linked to particularly hot-humid microclimatic conditions of tropical type, gives to the fumarole habitat the significance of conservative environment. In fact, it represents a refuge site for relict taxa of the Tertiary tropical flora, enabling also the speciation processes.

The Atlantic element is composed by species with oceanic (e.g. *Isopterygium tenerum*) and suboceanic distribution (e.g. *Archidium alternifolium*, *Campylopus introflexus*, *C. pyriformis*, *Amphidium mougeotii*). On the whole, the Atlantic element has a quite good incidence, above all in Tenerife (22.2%), taking also in account that the Mediterranean-oceanic species have been included into the Mediterranean element.

Less significant is the Circumboreal element, represented almost exclusively by temperate species and occurring with high percentage mainly in the Mediterranean islands (41% at Pantelleria, 35.3% at Ischia).

### List of the species collected

#### LIVERWORTS:

*Cephaloziella divaricata* (Sm.) Schiff. – Temperate. Tenerife: Teide

*Cephaloziella turneri* (Hook.) Müll. Frib. – Oceanic-Mediterranean-montane. Pantelleria:

Fossa del Russo. Vulcano: Vulcanello. Tenerife: Teide.

*Fossombronia caespitiformis* De Not. ex Rabenh. – Mediterranean. Pantelleria: Cuddia di Mida. Vulcano: Vulcanello.

*Frullania tamarisci* (L.) Dumort. – Boreal-montane. Pantelleria: Fossa del Russo.

*Gongylanthus ericetorum* (Raddi) Nees – Submediterranean-suboceanic. Vulcano: Vulcanello.

*Jungermannia hyalina* Lyell – Temperate-montane. Vulcano: Vulcanello.  
*Phaeoceros laevis* (L.) Prosk. –Mediterranean. Pantelleria: Fossa del Russo.

## MOSSES:

- Amphidium mougeotii* (Bruch & Schimp.) Schimp. – Suboceanic-montane. Tenerife: Teide.
- Archidium alternifolium* (Hedw.) Schimp. – Suboceanic. Pantelleria: Fossa del Russo, Bagno asciutto, Cuddia di Mida.
- Barbella strongylensis* Bott. – C Mediterranean endemic. Pantelleria: Fossa del Russo. Ischia: M. Rotaro.
- Barbula convoluta* Hedw. – Temperate. Pantelleria: Cuddia di Mida.
- Bartramia pomiformis* Hedw. – Boreal (-montane). Pantelleria: Fossa del Russo.
- Brachythecium velutinum* (Hedw.) Bruch & al. – Temperate. Pantelleria: Bagno asciutto, Kazen.
- Bryum alpinum* With. – Suboceanic-submediterranean-montane. Pantelleria: Favare Grandi, Cuddia di Mida.
- Bryum argenteum* Hedw. – Temperate. Pantelleria: Favare Grandi.
- Bryum bicolor* Dicks. – Submediterranean. Pantelleria: Cuddia di Mida. Linosa: M. Vulcano. Tenerife: Teide.
- Bryum caespiticium* Hedw. – Temperate. Pantelleria: Favare Grandi, Cuddia di Mida.
- Bryum capillare* Hedw. – Temperate. Pantelleria: Favare Grandi, Fossa del Russo, Ischia: M. Rotaro. Linosa: M. Vulcano. Vulcano: Vulcanello.
- Bryum donianum* Grev. – Oceanic-Mediterranean. Ischia: M. Rotaro.
- Bryum dunense* A. J. E. Sm. ex Whitehouse – Oceanic-submediterranean. Pantelleria: Cuddia di Mida. Linosa: M. Vulcano. Tenerife: Teide
- Bryum pseudotriquetrum* (Hedw.) P. Gaertn. & al. – Temperate. Pantelleria: Cuddia di Mida.
- Bryum rubens* Mitt. – Temperate. Pantelleria: Favare Grandi, Bagno asciutto. Ischia: M. Rotaro. Pozzuoli: Solfatare. New record from S Italy.
- Calymperes erosum* Müll. Hal. –Tropical/Mediterranean. Pantelleria: Bagno asciutto, Cuddia di Mida, Kazen.
- Campylopus introflexus* (Hedw.) Brid. – Suboceanic. Tenerife: Teide.
- Campylopus pilifer* Brid. subsp. *pilifer* – Oceanic-submediterranean. Tenerife: Teide.
- Campylopus pilifer* Brid. subsp. *vaporarius* (De Not.) Brullo, Privitera & Puglisi comb. nov.
- Bas.: *C. polytrichoides* var. *vaporarius* De Not., Atti Univ. Genova 1: 646, 1869.
- Syn: *Campylopus vaporarius* Bolle, in De Not., Atti Univ. Genova 1: 646, 1869, pro syn.; *C. introflexus* (Hedw.) Brid. var. *vaporarius* (De Not.) Moenk, Eur. Laubm.: 225, 1927.
- It differs from *C. pilifer* s. str. by having a more robust and very rigid habit (tufts up to 6-7 cm high), felt of long rhizoids along the stem denser, reddish-brown to reddish, leaves more long-acuminate, with very wide nerve (3/4-4/5 of the leaf base), basal cells hyaline, more reduced in extension or scarcely evident (not forming a distinct hyaline base), alar cells well differentiated, reddish-brown, whitish in the upper leaves, forming projecting auricles constituted by rectangular cells 30-35 × 60-100 µm, hair point erect

- or sometimes reflexed. – C Mediterranean endemic. Pantelleria: Favare Grandi, Fossa del Russo, Bagno asciutto, Cuddia di Mida. Ischia: M. Rotaro.
- Campylopus pyriformis* (Schultz) Brid. – Suboceanic. Pantelleria: Favare Grandi. New record from Sicily.
- Ceratodon purpureus* (Hedw.) Brid. – Temperate. Pozzuoli: Solfatare.
- Dicranella heteromalla* (Hedw.) Schimp. – Temperate. Pantelleria: Favare Grandi, Fossa del Russo. Ischia: M. Rotaro, M. Cinto. Pozzuoli: Solfatare.
- Dicranella howei* Renauld & Cardot – Oceanic-Mediterranean. Vulcano: Vulcanello.
- Dicranella varia* (Hedw.) Schimp. – Temperate. Tenerife: Teide.
- Didymodon luridus* Hornsch. – Submediterranean. Linosa: M. Vulcano.
- Ditrichum pallidum* (Hedw.) Hampe – Submediterranean. Ischia: M. Rotaro.
- Entosthodon attenuatus* (Dicks.) Bryhn – Submediterranean-suboceanic. Pantelleria: Fossa del Russo.
- Epipterygium tozeri* (Grev.) Lindb. – Suboceanic-Mediterranean. Ischia: M. Cinto.
- Eurhynchium praelongum* (Hedw.) Bruch & al. – Temperate. Pantelleria: Fossa del Russo.
- Eurhynchium pumilum* (Wilson) Schimp. – Submediterranean-suboceanic. Pantelleria: Bagno asciutto.
- Fissidens viridulus* (Sw.) Wahlenb. – Submediterranean. Pantelleria: Fossa del Russo, Bagno asciutto. Linosa: M. Vulcano.
- Grimmia laevigata* (Brid.) Brid. – Submediterranean-suboceanic-montane. Pantelleria: Favare Grandi, Fossa del Russo.
- Grimmia lisae* De Not. – Mediterranean-oceanic. Vulcano: Vulcanello.
- Grimmia trichophylla* Grev. – Temperate. Pantelleria: Favare Grandi, Fossa del Russo, Ischia: M. Rotaro.
- Hypnum cupressiforme* Hedw. – Temperate. Pantelleria: Fossa del Russo, Cuddia di Mida.
- Isopterygium tenerum* (Sw.) Mitt. – Sub oceanic. Ischia: M. Rotaro, M. Cinto. Pozzuoli: Solfatare.
- Isothecium myosuroides* Brid. – Suboceanic (-submediterranean). Pantelleria: Fossa del Russo. Vulcano: Vulcanello.
- Philonotis arnellii* Husn. – N suboceanic (-montane). Pantelleria: Bagno asciutto.
- Pleurochaete squarrosa* (Brid.) Lindb. – Submediterranean. Pantelleria: Favare Grandi, Fossa del Russo, Bagno asciutto, Cuddia di Mida, Kazen. Ischia: M. Rotaro, M. Cinto.
- Pohlia nutans* (Hedw.) Lindb. – Subboreal. Pantelleria: Favare Grandi.
- Polytrichum formosum* Hedw. – Temperate. Pantelleria: Favare Grandi.
- Pottia* sp. – Pantelleria: Fossa del Russo.
- Pterogonium gracile* (Hedw.) Sm. – Suboceanic-submediterranean-montane. Pantelleria: Fossa del Russo. Ischia: M. Rotaro.
- Rhynchostegium megapolitanum* (Weber & D. Mohr) Bruch & al.: Pantelleria: Fossa del Russo.
- Schistidium apocarpum* (Hedw.) Bruch & Schimp. – Temperate. Pantelleria: Favare Grandi.
- Scleropodium purum* (Hedw.) Limpr. – Temperate. Ischia: M. Rotaro, M. Cinto.
- Scleropodium touretii* (Brid.) L. F. Koch – Oceanic-submediterranean. Ischia: M. Rotaro.
- Scorpiurium circinatum* (Brid.) M. Fleisch. & Loeske – Oceanic-Mediterranean. Pantelleria: Fossa del Russo. Linosa: M. Vulcano.

- Timmiella anomala* (Bruch & Schimp.) Limpr. — Mediterranean. Pantelleria: Fossa del Russo.
- Timmiella barbuloidea* (Brid.) Mönk. — Mediterranean. Linosa: M. Vulcano.
- Tortella flavovirens* (Bruch) Broth — Suboceanic-submediterranean. Pantelleria: Fossa del Russo. Vulcano: Vulcanello.
- Tortella inclinata* (R. Hedw.) Limpr. — Temperate. Pantelleria: Fossa del Russo, Cuddia di Mida.
- Tortella nitida* (Lindb.) Broth. — Oceanic-Mediterranean. Tenerife: Teide.
- Tortula subulata* Hedw. var. *subinermis* (Brid.) Wilson — Suboceanic-submediterranean-montane. Pantelleria: Fossa del Russo.
- Trematodon longicollis* Michx. — Subtropical/Mediterranean. Pantelleria: Favare Grandi, Fossa del Russo, Cuddia di Mida. Ischia: M. Rotaro, M. Cinto.
- Trichostomum brachydontium* Bruch — Submediterranean-montane. Pantelleria: Fossa del Russo, Cuddia di Mida, Kazen. Bagno asciutto. Ischia: M. Rotaro. Linosa: M. Vulcano. Pozzuoli: Solfatare.
- Trichostomum brachydontium* Bruch var. *littorale* (Mitt.) C. E. O. Jens. — Oceanic-Mediterranean. Pantelleria: Fossa del Russo, Cuddia di Mida. Vulcano: Vulcanello.
- Trichostomum crispulum* Bruch — Temperate-montane. Pantelleria: Cuddia di Mida. Vulcano: Vulcanello.
- Weissia controversa* Hedw. — Temperate. Pantelleria: Fossa del Russo, Bagno asciutto. Ischia: M. Rotaro.

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