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The lichen family *Pannariaceae* in Calabria (S Italy)

Abstract

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Thirteen species of *Pannariaceae* are enumerated for Calabria, South Italy. Regional distribution maps and data on habitat are presented. Difference in local distribution patterns of the species are discussed on the basis of environmental data.

Introduction

For a long time, only three species of *Pannariaceae* were known from Calabria: *Degelia plumbea*, *Pannaria pezizoides* and *Pannaria conoplea* (Jatta 1889). Two recent floristic studies (Puntillo 1987, 1993) have increased their number to 12. Whereas most of these species decline in Europe (Wirth 1987, Rose 1988), they are still well represented in Calabria.

Codogno & Puntillo (1991) already mentioned these species in a phytogeographical study, but did not report detailed distribution data. The aims of the present paper are to describe the distribution and habitat ecology of the species in Calabria and to relate their different distribution patterns to local environmental factors.

The country

Calabria is the southermost part of the Italian Peninsula (Fig. 1). It is a 250 km long and up to 100 km broad territory, which extends from north to south between the Tyrrhenian and Ionian Seas. It mainly consists of mountains: the plains occupy only 9 % surface area.

The main mountain systems are (Fig. 1): Pollino (2267 m), Coast Range (1541 m), Sila (1928 m), Serre (1423 m) and Aspromonte (1955 m). Whereas the Pollino massif is calcareous, the other mountain groups are mainly siliceous, with igneous or metamorphic rocks (Ogniben 1973).

The Mediterranean climate of Calabria is characterized by a perhumid winter season (Ciancio 1971) and presents a broad range of variation related to altitude and exposure (Fig. 2). Because of the humid western winds, the Tyrrhenian side (Belvedere Marittimo) is more humid than the Ionian side (Crotone), and the climate of the Coast Range (Fagnano Castello) is mild and very rainy. Here the moist air masses often condense also in summer, giving rise to a cloud cap. At high elevations (Trepidò and Gambarie

d'Aspromonte) the summer drought season is very brief. At same altitudes, the climate of Aspromonte (Gambarie) is more oceanic (more rainy and with a shorter winter frost period) than that of Sila (Trepidò).

Materials and methods

This study is based on material deposited in the herbarium of the Botanical Garden of the University of Calabria (CLU). Altogether, more than 300 herbarium specimens have been analysed. The authors have also studied the species in the field.

Nomenclature follows Nimis (1993). Joergensen (1978) does not treat the genus *Moelleropsis* in his monograph of European *Pannariaceae*, following Henssen (1969) who places this genus in *Placynthiaceae*. However, Joergensen (1978: 112) remarks that in this genus the morphology of the apothecia and of the spores is within the variation range of *Pannariaceae* and that the different anatomy of the thallus could be interpreted as a conseguence of reduction. On the basis of this remark, *Moelleropsis* has been included in the present study.

The interpretation of the distribution maps of the species is based on climatic data found in the literature (Kanter 1930, Caloiero 1975), and aims at estabilish correlations between distribution patterns and environmental factors.

Results

Altogether, 13 species of *Pannariaceae* were found in Calabria. The specimens were collected in about 70 localities (Fig. 3) spread almost throughout Calabria. The species and their distribution patterns in Calabria are listed in the following.

Degelia atlantica (Degel.) P. M. Joerg. & P. James — Distribution in Calabria: Fig. 4.

In Calabria, *Degelia atlantica* usually grows at altitudes of 250-1000 m (Pollino, Coast Range, Sila, Crati Valley, Serre of Catanzaro and Aspromonte). This species is epiphytic (both directly on the bark and on corticicolous bryophytes). Some specimens (5, from 2 localities) were collected above 1200 m. The phorophytes are, in order of frequency: *Quercus pubescens*, *Castanea sativa*, *Quercus frainetto*, *Olea europaea* and *Juniperus* sp. (this latter on Timpa di Cassano, Pollino). The specimens virtually always lack apothecia: only one, collected in the Rovito Valley by Cosenza, is covered by many apothecia.

Degelia plumbea (Lightf.) P. M. Joerg. & P. James — Distribution in Calabria: Fig. 4.

In Calabria, *Degelia plumbea* is the most widespread species of *Pannariaceae* (Pollino, Coast Range, Sila, Crati Valley, Serre of Catanzaro and Aspromonte). It grows at altitudes of 300-1700 m, mainly on trees (directly on the bark or on epiphytic bryophytes): at the higher altitudes it is also found on acid rock. The most common phorophytes are, in Calabria, *Castanea sativa*, *Quercus cerris*, *Q. pubescens* and *Fagus sylvatica*. It also grows on *Alnus cordata*, *Quercus petraea*, *Q. frainetto*, *Abies alba* and *Olea europaea*. All specimens collected in Calabria develop numerous knob-like accessory lobules (but not true isidia as in *D. atlantica*; see Joergensen 1978).

Moelleropsis nebulosa (Hoffm.) Gyeln. — Distribution in Calabria: Fig. 5.

In Calabria, *Moelleropsis nebulosa* is a relatively widespread species (Verbicaro Mountains, Coast Range, Sila, Crati Valley, Serre of Catanzaro and Aspromonte). It grows both on bare sandy soil and on terricolous bryophytes, at altitudes of 290-1380 m.

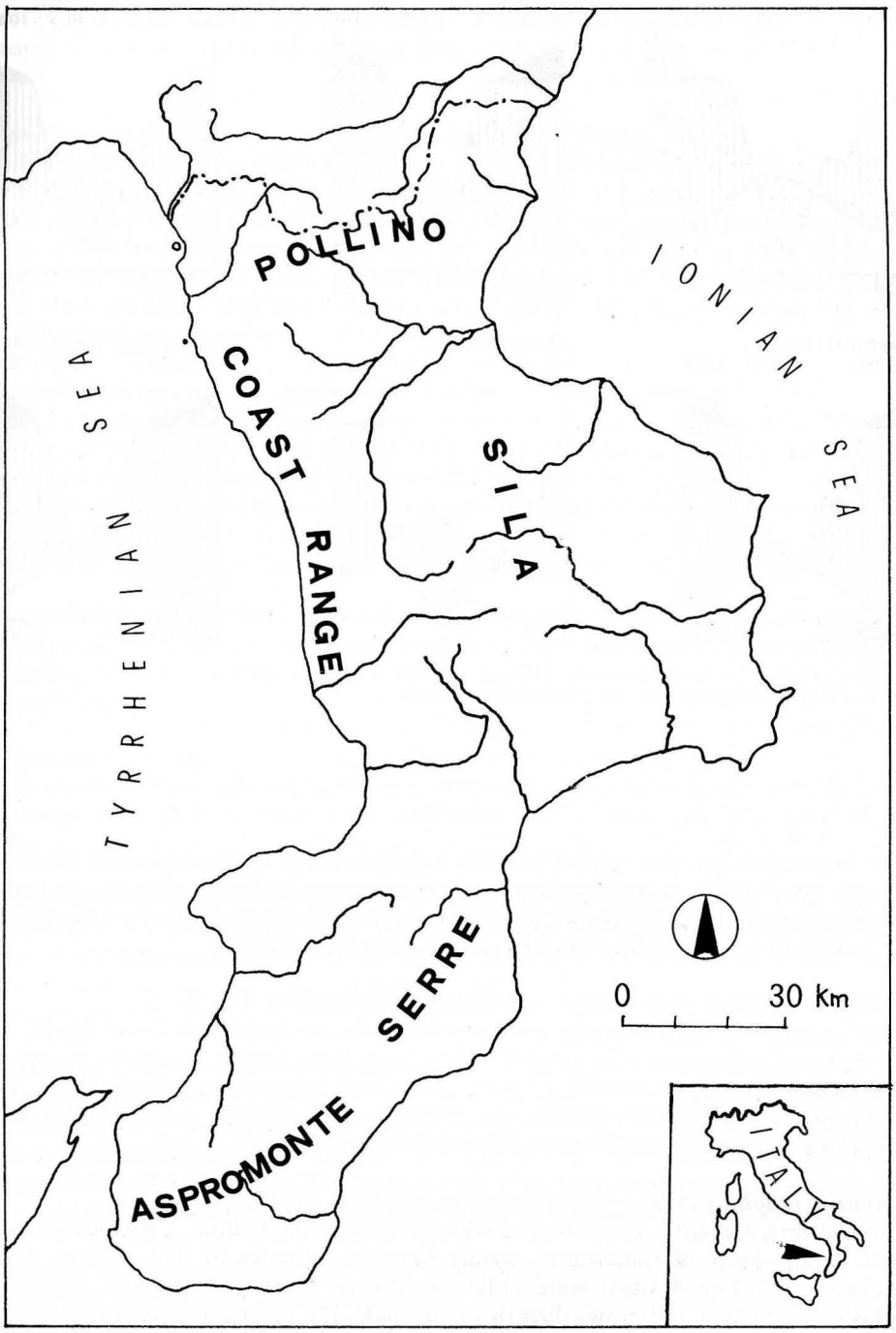

Fig. 1. Map of Calabria.

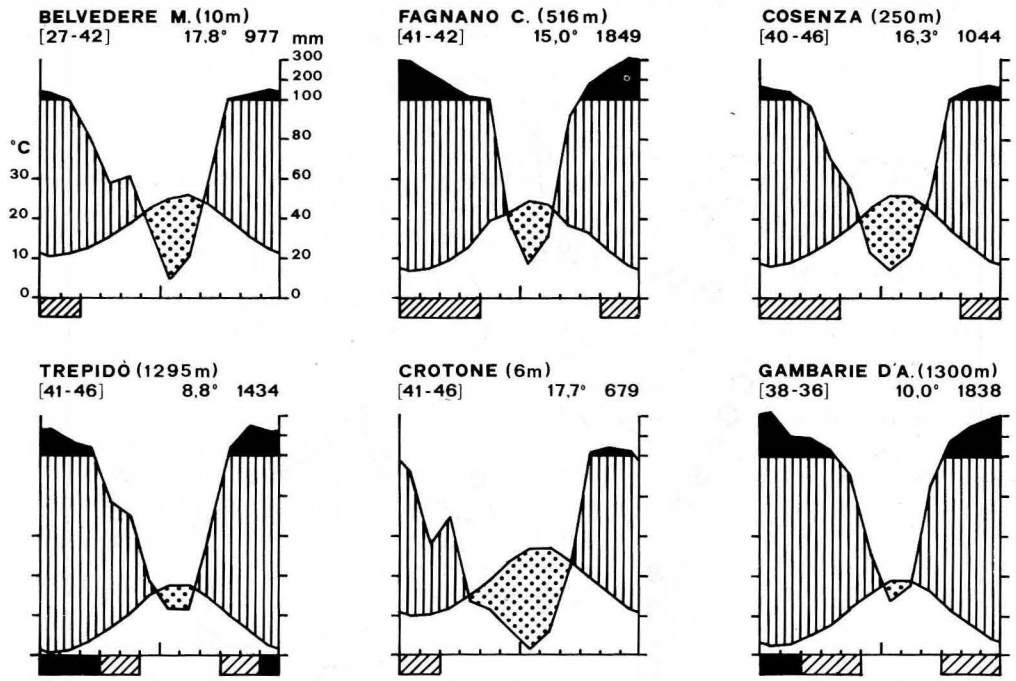

Fig. 2. Climatic diagrams of some Calabrian stations.

At lower altitudes, this species presents a deeper bluish thallus of widely dispersed granules, paler apothecia, and it is frequentely muscicolous. At higher altitudes, the thallus is more compact, the apothecia are red-brown and the species grows on bare sandy, acid soil, usually in open *Pinus laricio* or *Quercus petraea*-communities.

Pannaria conoplea (Ach.) Bory — Distribution in Calabria: Fig. 6.

In Calabria, *Pannaria conoplea* grows on the Verbicaro Mountains, Coast Range, Sila and Serre of Catanzaro (the latter locality from Jatta 1889). It grows mainly on corticicolous bryophytes (usually on *Castanea sativa*), rarely directly on the bark. Two specimens (Laghicello, Coast Range; Macchia di Pietro, Sila) were collected on epilithic bryophytes. All localities are between 400 and 1500 m of altitude.

Pannaria ignobilis Anzi — Distribution in Calabria: Fig. 7.

In Calabria, *Pannaria ignobilis* is a widespread species (Pollino, Coast Range, Sila, Crati Valley, Serre of Catanzaro), mainly found at altitudes of 250-1000 m. Some specimens (8, from 4 sites) were collected also at 1200-1500 m. This species is exclusively epiphytic and grows directly on the bark. The more common phorophytes in Calabria are *Quercus* spp. and *Castanea sativa*. It grows also on *Olea europaea*, *Alnus cordata* and *Salix* sp. The thallus and the apothecia of the specimens on *Olea europaea* (from Rovito Valley near Cosenza) are particularly pale.

Pannaria leucophaea (Vahl) P. M. Joerg. — Distribution in Calabria: Fig. 5.

In Calabria, *Pannaria leucophaea* was collected only in two localities, on the Sila massif (at 1240 m) and on the Aspromonte (at 1650 m), both times on acid metamorphic rock.

Pannaria mediterranea C. Tav. — Distribution in Calabria: Fig. 8.

In Calabria, *Pannaria mediterranea* is common at altitudes of 250-1250 m (Verbicaro Mountains, Coast Range, Sila, Crati Valley and Serre of Catanzaro). Three specimens were collected above 1300 m. This species is mainly corticicolous (both directly on the bark and on epiphytic bryophytes): only one specimen (collected at 1360 m) grew on terricolous mosses. The most common phorophytes are at lower altitudes *Quercus pubescens*, at higher altitudes *Castanea sativa*, *Quercus cerris*, *Q. frainetto*, *Q. robur*, *Fagus sylvatica* and *Acer* sp.

Pannaria olivacea P. M. Joerg. — Distribution in Calabria: Fig. 8.

In Calabria, *Pannaria olivacea* grows mainly at altitudes of 250-1100 m (Verbicaro Mountains, Coast Range, Sila, Crati Valley, Serre of Catanzaro and Aspromonte). One specimen (Serra Ripollata, Sila) was collected at 1620 m. It is exclusively corticicolous; the most common phorophytes are *Quercus pubescens* and *Castanea sativa*. It is found also on *Olea europaea*, *Alnus cordata* and *Quercus cerris*. At the limits of its altitudinal range, the apothecia are few and poorly developed (see the discussion, and Fig. 11).

Pannaria pezizoides (Web.) Trev. — Distribution in Calabria: Fig. 9.

Pannaria pezizoides is found both on bare acid soil and on terricolous bryophytes. In Calabria, it grows mainly above 1000 m on Sila, Pollino, Serre of Catanzaro and Aspromonte.

Pannaria rubiginosa (Ach.) Bory — Distribution in Calabria: Fig. 5.

In Calabria, *Pannaria rubiginosa* was collected only in one locality, on corticicolous bryophytes, on *Quercus ilex*, in the Argentino Valley, Verbicaro Mountains (Puntillo 1993).

Parmeliella testacea P. M. Joerg. — Distribution in Calabria: Fig. 6.

In Calabria, *Parmeliella testacea* grows only on the Verbicaro Mountains, Coast Range and Savuto Valley, at altitudes of 450-800 m (only one specimen was collected at 1100 m). This species is exclusivelly epiphytic and mostly grows directly on the bark of *Castanea sativa*.

Parmeliella triptophylla (Ach.) Müll. Arg.— Distribution in Calabria: Fig. 9.

In Calabria, *Parmeliella triptophylla* usually grows at altitudes above 1000 m; only two occurrences, on *Castanea sativa* bark, are at 450 m (Caronte Valley near Cosenza and San Benedetto Ullano, Coast Range). This species was collected on the Pollino, Coast Range, Sila and Aspromonte. The more common phorophytes are *Fagus sylvatica*, *Abies alba* and *Quercus petraea*; frequently it grows also on terricolous and epilithic bryophytes.

Psoroma hypnorum (Vahl) S. F. Gray — Distribution in Calabria: Fig. 9.

Psoroma hypnorum is found on terricolous bryophytes at altitudes above 1200 m. Only two specimens were collected on corticicolous bryophytes on conifers (*Pinus laricio* and *Abies alba*) and only one locality is at 560 m, in the Caronte Valley near Cosenza. In Calabria, this species grows on Pollino, Coast Range (rarely), Sila and Aspromonte.

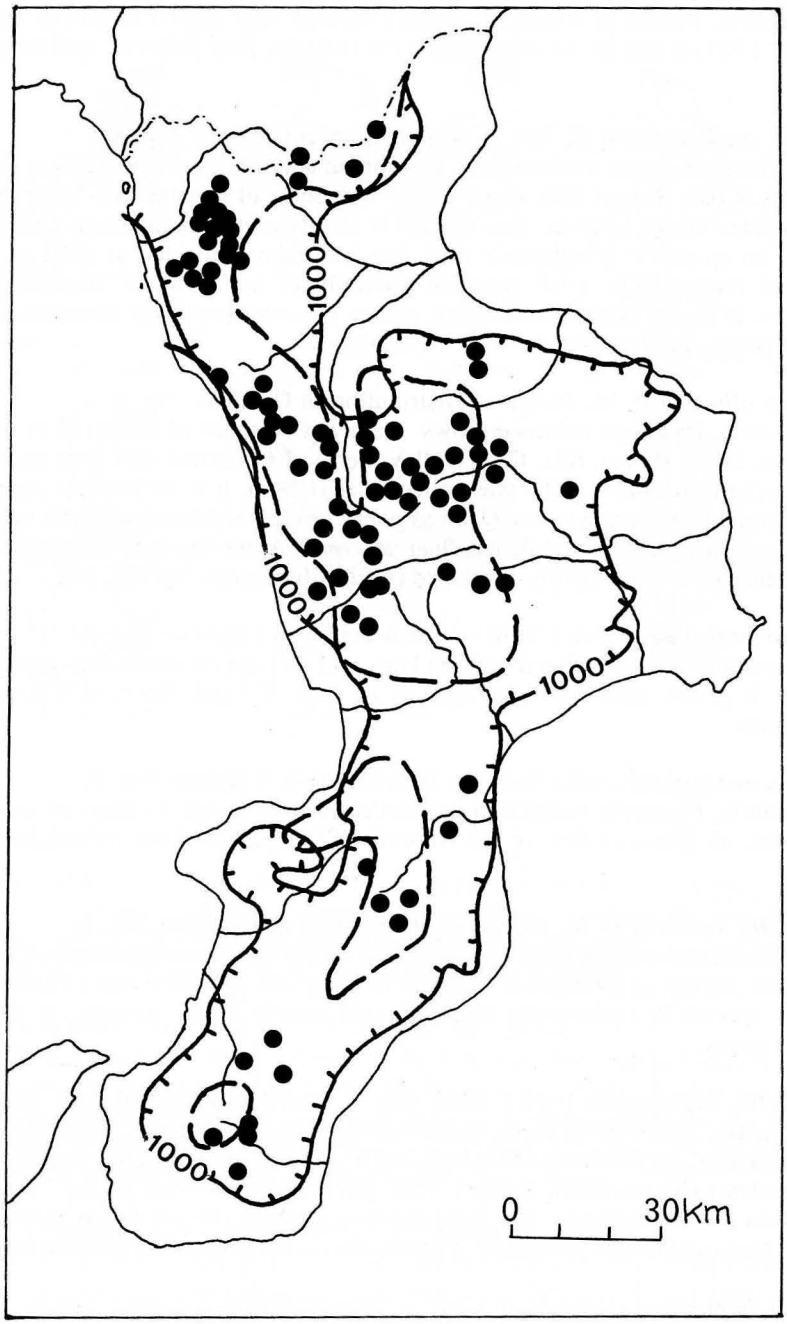

Fig. 3. Distribution of the collecting sites. The isohyete 1000 mm/year is reported (Caloiero 1975). Broken lines include the mountain areas with summer drought period (average precipitation less than 100 mm) that is shorter than 2 months (Kanter 1930).

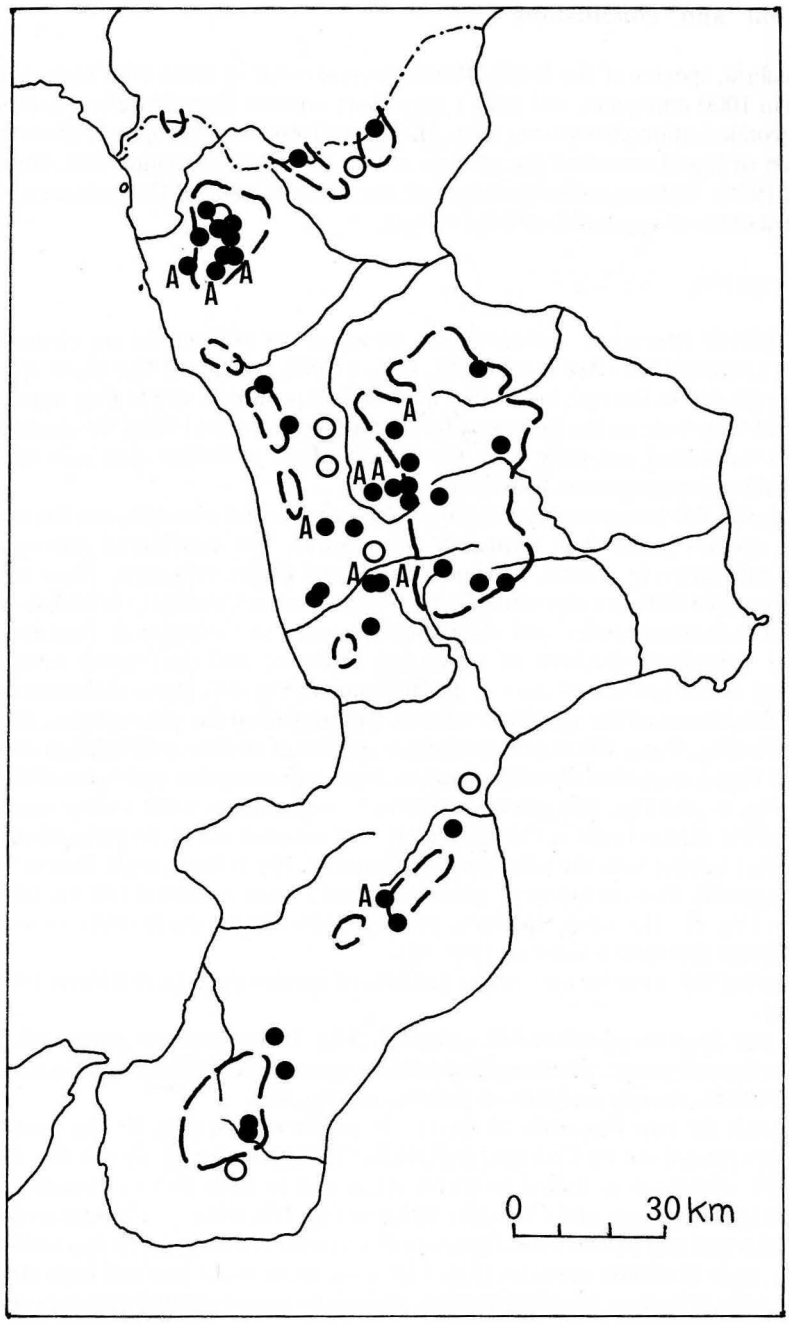

Fig. 4. Distribution of *Degelia atlantica* and *D. plumbea*. Open circles: *D. atlantica*; full circles: *D. plumbea*; full circles marked with A: both species. Broken lines include the mountain areas with at least 3 months of snow lie (Kanter 1930).

Discussion and conclusions

In Calabria, species of the family *Pannariaceae* occur in areas with high precipitation (more than 1000 mm/year), and with a very short summer drought period with, however, frequent condensation phenomena (Fig. 3). This reflects the ombrophytic character (ready absorption of liquid water) of the species of this family (Bachmann 1923, Goebel 1926, Degelius 1935). With regard to the substrate, the *Pannariaceae* of Calabria are epiphytic (9 spp.), terricolous (3 spp.) and epilithic (1 sp.).

Epiphytic species

All epiphytic species of *Pannariaceae* which occur in Calabria are characteristic of *Lobarion* communities (Barkman 1958). Rose (1988) points out that these species have become restricted in Europe, but not on the Italian Apennines, where they appear to be as widespread they were in the last century. According to Rose (1988), the decline of these species is correlated not only with the effects of air pollution, but also with drastic changes in forest management techniques.
Fig. 10 shows the percent occurrences on the commonest phorophytes for each of the epiphytic species (other than *Pannaria rubiginosa*). The considered phorophytes are: *Quercus pubescens*, *Q. cerris*, *Castanea sativa* and *Fagus sylvatica*. These tree species characterize three different altitudinal belts of vegetation in Calabria («Schibljak-Macchien-Stufe», «Trockenwaldstufe» and «Wolkenwaldstufe» in Codogno & Puntillo 1988). A combined altitudinal gradient of increasing moisture and decreasing temperature is represented on the horizontal axes of the diagrams in Fig. 10. These diagrams show three different tendencies of the epiphytic species with regard to the phorophytes. *Parmeliella triptophylla* (Fig. 9 and 10) is a microthermic species of cool to cold habitats on *Castanea sativa* and *Fagus sylvatica*. *Degelia plumbea*, *Pannaria conoplea*, and *Parmeliella testacea* (Fig. 4, Fig. 6 and Fig. 10) grow in relatively warm areas with a very short summer drought period (dashed area in Fig. 6), mainly on *Castanea sativa*. *Degelia plumbea* is less linked to this habitat than the other two species (Fig. 10): it has a wide thermic range and grows frequently also on *Quercus pubescens* and *Fagus sylvatica* (on the latter in cold areas; see Fig. 4). The other epiphytic species grow almost exclusively in warm areas, under different moisture conditions (Fig. 10).

Comparing the distributions of the partners of species pairs (sensu Poelt 1970) is very interesting.

In the pair *Degelia plumbea* - *D. atlantica* (Fig. 4) the primary species (*D. plumbea*) has a large thermic range, whereas the secondary species (the isidiate *D. atlantica*) is linked to warm stations, mainly on *Quercus pubescens* (Fig. 10).

As regards the pair *Pannaria olivacea* - *P. mediterranea* (Fig. 8), the analysis of the phorophytes carried out by Codogno & Puntillo (1991) has already shown that the primary species (*P. olivacea*) is linked to warm areas and to trees that constitute the climax vegetation (*Quercus* spp. and *Castanea sativa* in Fig. 10), whereas *P. mediterranea* grows also on cultivated and azonal trees. However *P. olivacea* is frequent, and has well-developed apothecia, only at middle altitudes (Fig. 11): it seems to avoid low and high altitudes that are characterized by low absolute thermic minima in winter (higher areas) or high degree of disturbance by man (lower areas). The secondary species (the sorediate *P. mediterranea*) seems to have a wider thermic range (it grows also on *Fagus sylvatica*; see Fig. 10) and, contrary to *P. olivacea*, is more frequent at low and high altitudes (Fig. 10). Probably, the wider distribution of *P. mediterranea* does not reflect a broader ecological amplitude, as suggested by Codogno & Puntillo (1991), but may rather be due to the different

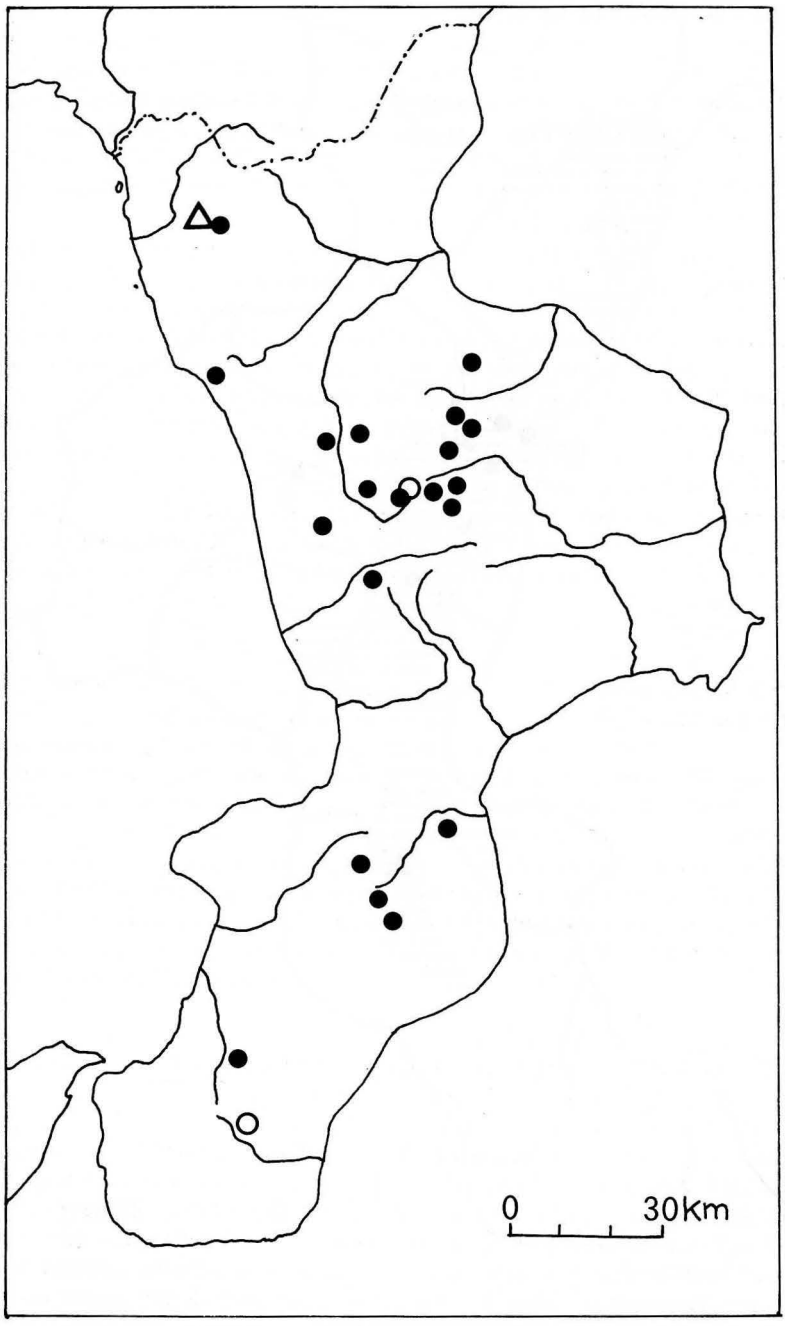

Fig. 5. Distribution of *Moelleropsis nebulosa* (full circles), *Pannaria leucophaea* (open circles) and *P. rubiginosa* (open triangle).

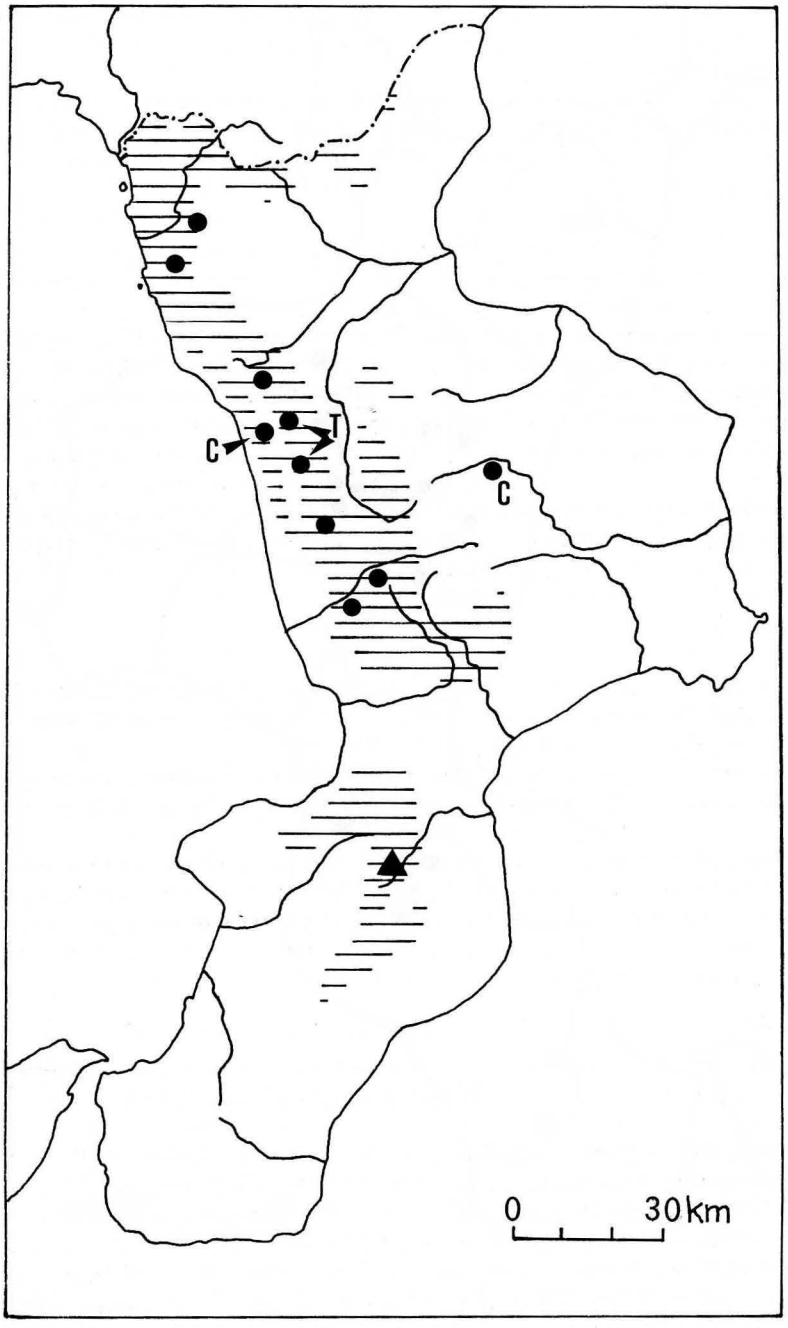

Fig. 6. Distribution of *Pannaria conoplea* and *Parmeliella testacea*. C: only *P. conoplea*; T: only *P. testacea*. Full triangle: *P. conoplea* according to Jatta (1889). Areas with summer drought period that is shorter than 2 months, and with a very short snow lie, are dashed (Kanter 1930).

microhabitats of the two species: *P. mediterranea* grows in fissures of coarse bark or amongst mosses, whereas *P. olivacea* grows directly on the projecting areas of the bark. Therefore, *P. mediterranea* occurs in more protected habitats with little microclimatic variation over the year.

The occurrence of *Pannaria rubiginosa* in Calabria is remarkable: according to Degelius (1935), this species with a markedly oceanic distribution is quite rare in Italy.

Terricolous species

These species grow on bare sandy soil or amongst bryophytes. *Pannaria pezizoides* and *Psoroma hypnorum* (Fig. 9) were collected almost always in areas with a long snow lie in winter: probably, the abundance of available liquid water derived from snow melting is important for these species. On the contrary, *Moelleropsis nebulosa* (Fig. 5) is widespread in Calabria. For explaining the distribution of this species in Calabria, the law of the relative constancy of the ecological factors (Walter & Straka 1970), already confirmed for some lichens by Poelt (1987), is valid. At higher altitudes with long snow lie in winter *M. nebulosa* grows on bare sandy soil, whereas at lower altitudes without or in places with very short snow lie it grows on bryophytes wich are characterized by a high retention of liquid water. It is remarkable, moreover, that this species is still widespread in Calabria, whereas elsewhere it has disappeared from many localities of its wide range, from the Mediterranean Basin to the Scandinavian Peninsula (Wirth 1987).

Epilithic species

In Calabria, the only exclusively epilithic species of *Pannariaceae* is *Pannaria leucophaea* (Fig. 5), which grows on metamorphic acid rocks. The liquid water necessary for this species derives mainly from seepage on the rock.

In conclusion, the main factors influencing the distribution patterns of *Pannariaceae* in Calabria are similar to those known elsewhere in Europe (Degelius 1935; Joergensen 1978).

The occurrence of no fewer than 13 species of *Pannariaceae* in Calabria is notheworthy. It confirms (1) the "oceanic" character of the local climate and (2) the relatively low degree of environmental disturbance by forest management practices in this area, as compared to northern and central Europe, as witnessed by the decline of the epiphytic species and *Moelleropsis nebulosa* in Europe.

Appendix

List of the specimen localities (RC = prov. Reggio Calabria, CZ = prov. Catanzaro; CS = prov. Cosenza; EP = epiphytic; EG = terricolous; EL = epilithic):

Degelia atlantica — *Pollino*: Timpa di Cassano (Monte Pollino, CS), 1300 m, EP (*Juniperus* sp.); Monte Palanuda, c/o casa forestale Masseti (Orsomarso, CS), 950 m, EP (*Quercus ilex*); Il Monte (Grisolia, CS), 780 m, EP (*Castanea sativa*); San Donato di Ninea (CS), 780 m, EP (*Castanea sativa*); La Mula, Piano di Marco (San Donato di Ninea, CS), 1020 m, EP (*Quercus cerris*). — *Coast Range*: Cozzo d'Orlando (Montalto Uffugo, CS), 260 m, 270 m, EP (*Quercus frainetto, Quercus pubescens*); Piano di Maio (Rende, CS), 280 m, EP (*Quercus pubescens*); Valle del Caronte (Mendicino, CS), 350 m, 370 m, 460 m, EP (*Quercus pubescens*) — *Sila*: Varco San Mauro (Rose, CS), 1240 m, EP (*Castanea sativa, Quercus frainetto*); Vallone di Rovito (CS), 320 m, EP (*Olea europaea*); Spezzano Piccolo (CS), 1020 m, EP (*Castanea sativa, Quercus pubescens*); Rogliano (CS), 660 m, EP (*Quercus pubescens*); Carpanzano (CS), 1000 m, EP (*Castanea*

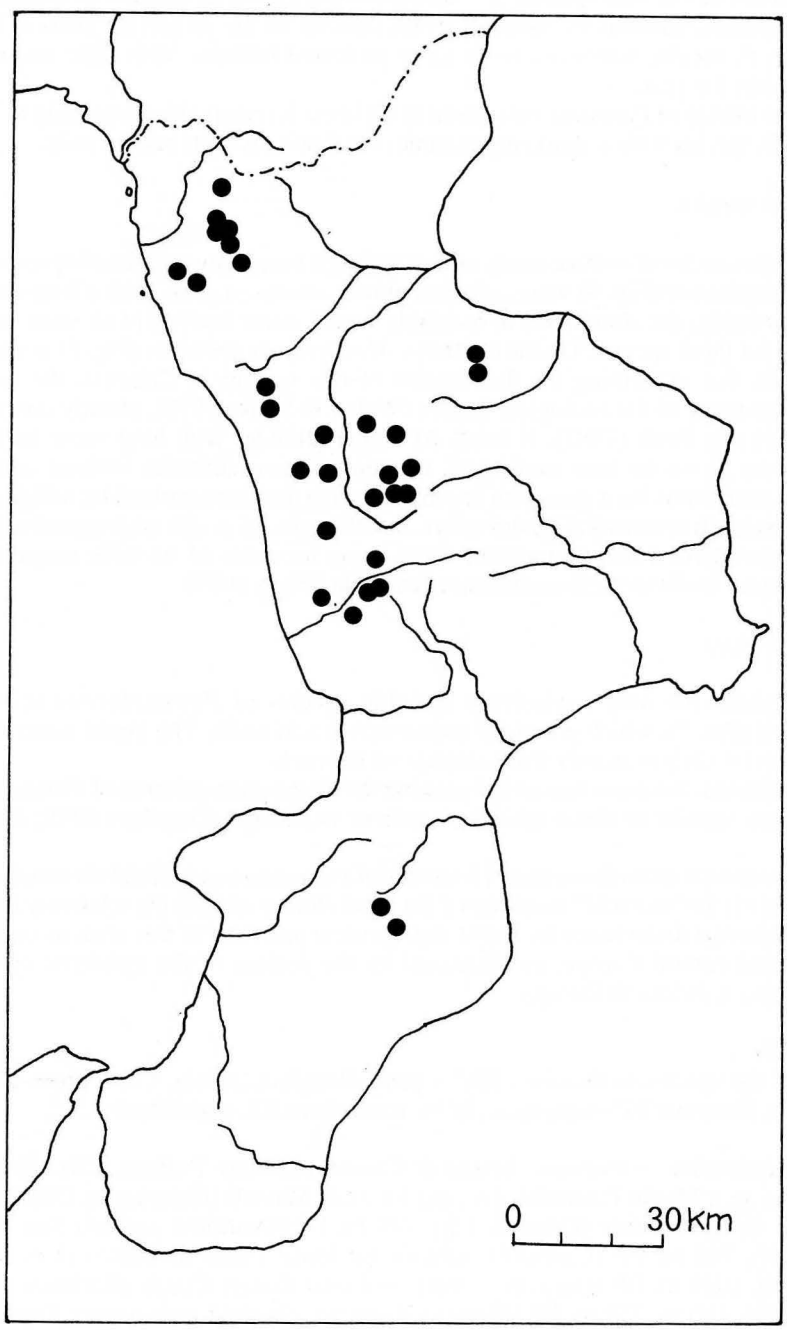

Fig. 7. Distribution of *Pannaria ignobilis*.

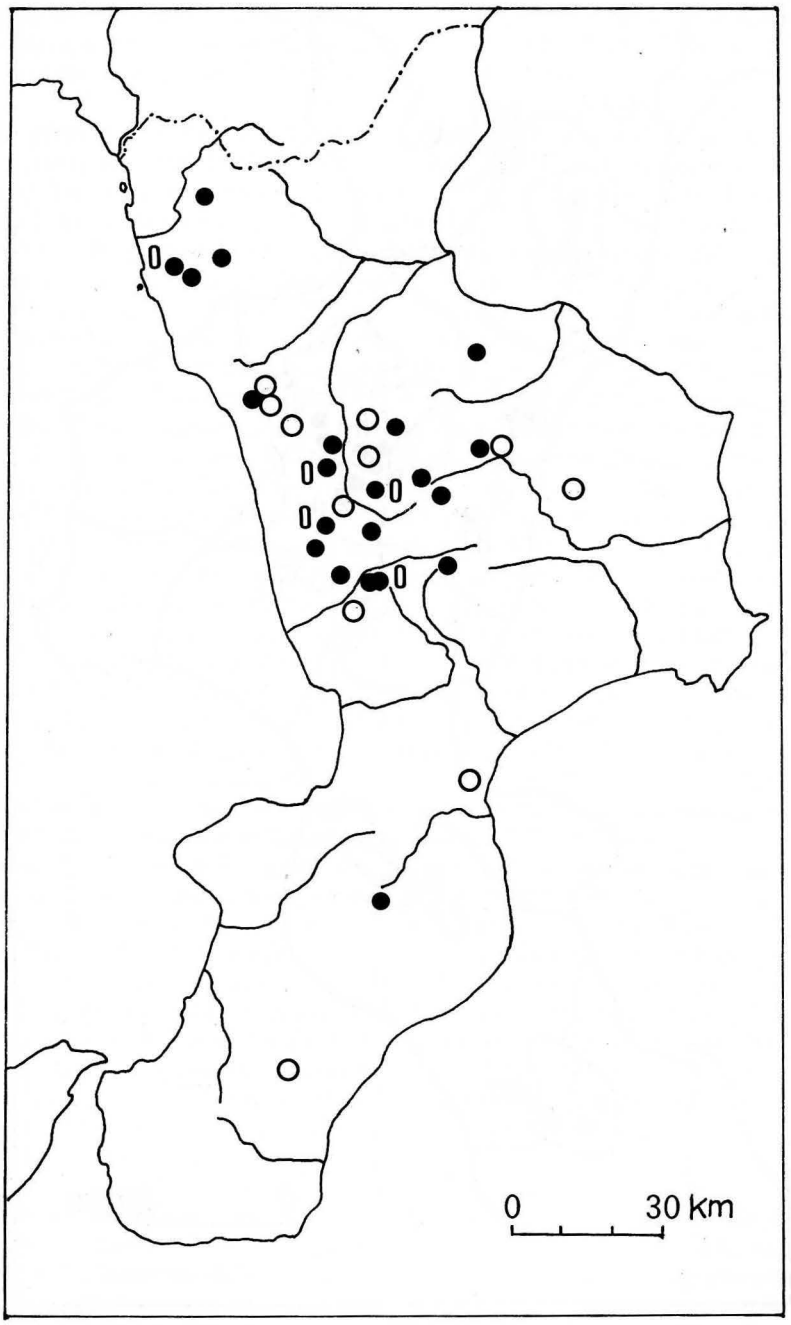

Fig. 8. Distribution of *Pannaria olivacea* and *P. mediterranea*. Open circles: *P. olivacea*; full circles: *P. mediterranea*; full circles marked with O: both species.

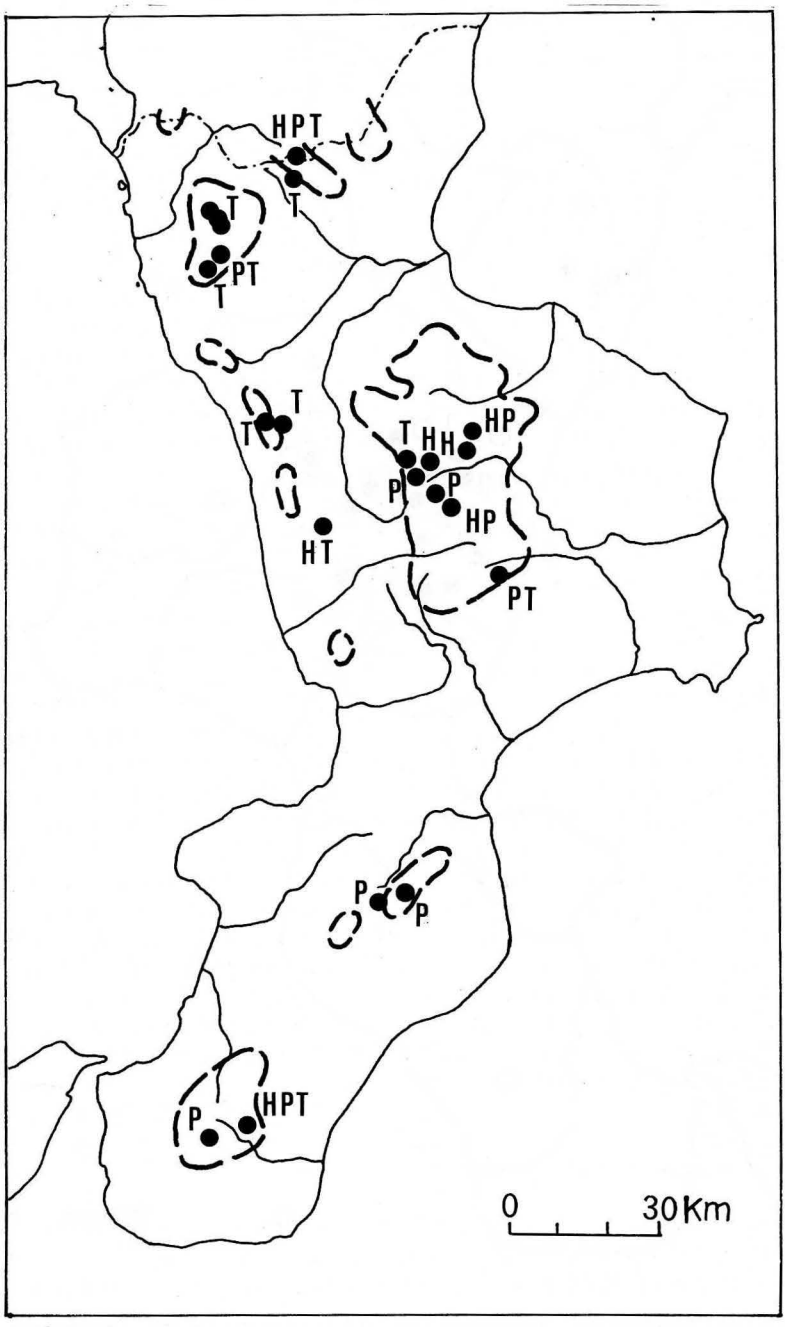

Fig. 9. Distribution of *Psoroma hypnorum* (H), *Pannaria pezizoides* (P) and *Parmeliella triptophylla* (T). Broken lines as in Fig. 4.

sativa, Quercus pubescens); Piano del Medico (Carpanzano, CS), 1000 m, 1100 m, EP (*Castanea sativa*); idem, 1020 m, EP (*Quercus pubescens*). — *Serre*: Squillace (CZ), 300 m, EP (*Quercus* sp.); Bosco di Santa Maria (Serra San Bruno, CZ), 860 m, EP (*Populus nigra*) — *Aspromonte*: Caruso d'Africo (RC), 670 m, EP (*Quercus frainetto*).

Degelia plumbea — *Pollino*: Monte Sparviere (Alessandria del Carretto, CS), 1690 m, EP (*Quercus cerris*); Colle Impisu (Monte Pollino, CS), 1680 m, EP (*Fagus sylvatica*); Malvicino (Orsomarso, CS), 980 m, EP (*Quercus* sp.); Monte Palanuda, Bosco Tavolara (Orsomarso, CS), 1250 m, EP (*Alnus* sp.); Valle dell'Argentino (Orsomarso, CS), 260 m, EP (*Quercus pubescens*); Alta Valle dell'Argentino, Timpone Camagna (Orsomarso, CS), 1310 m, EP (*Alnus cordata*); Alta Valle dell'Argentino, Varco della Gatta (Orsomarso, CS), 860 m, EP (*Ostrya carpinifolia*); Alta Valle dell'Argentino, Rifugio Fornelli, (Orsomarso, CS), 1180 m, EP (*Alnus cordata, Malus* sp.); Il Monte (Grisolia, CS), 780 m, EP (*Castanea sativa, Quercus cerris*); Cozzo del Pellegrino, Piano di Lanzo (San Donato di Ninea, CS), 1330 m, EP (*Fagus sylvatica*); San Donato di Ninea (CS), 780 m, EP (*Castanea sativa*); La Mula, Piano di Marco (San Donato di Ninea, CS), 1200 m, EP (*Quercus cerris*) — *Coast Range*: Fagnano Castello (CS), 640 m, EP (*Castanea sativa*); San Benedetto Ullano (CS), 450 m, EP (*Castanea sativa*); Valle del Caronte (Mendicino, CS), 350 m, 370 m, 460 m, 650 m, EP (*Quercus pubescens*); idem, 370 m, 720 m, 730 m, EP (*Castanea sativa*); idem, 600 m, 620 m, EP (*Alnus cordata*); idem, 600 m, EP (*Juglans regia*); Dipignano (CS), 600 m, EP (*Castanea sativa*); Valle Scura (Aiello Calabro, CS), 600 m, EP (*Quercus pubescens*); Monte Faggeto (Aiello Calabro, CS), 890 m, EP (*Prunus* sp.); Monte Reventino (CZ), 1380 m, EP (*Alnus cordata*) — *Sila*: Varco San Mauro (Rose, CS), 1240 m, EP (*Castanea sativa, Quercus frainetto*); Serra Ripollata (Sila Grande, CS), 1650 m, EP (*Quercus cerris*); Cozzo del Pesco (Sila Greca, CS), 910 m, EP (*Quercus dalechampii*); Cavaliere di Lorica (Sila Grande, CS), 1360 m, EL, EP (*Fagus sylvatica*); Valle del Cannavino (Celico, CS), 1540m, EP (*Castanea sativa*); Spezzano Piccolo (CS), 1020 m, EP (*Castanea sativa*); Valle del Cardone (Spezzano, CS), 1200 m, EP (*Castanea sativa*); Craticello (Aprigliano, CS), 1240 m, EL; Vallone di Rovito (CS), 320 m, EP (*Olea europaea, Quercus* sp.); Carpanzano (CS), 1000 m, EP (*Quercus pubescens*); Piano del Medico (Carpanzano, CS), 1020 m, EP (*Quercus pubescens*); idem, 1020 m, 1100 m, EP (*Castanea sativa*); Vivoli (Colosimi, CS), 1250 m, EP (*Castanea sativa*); Monte Gariglione, Valle del Tacina (Sila Piccola, CZ), 1440 m, EP (*Fagus sylvatica*); Monte Gariglione (Sila Piccola, CZ), 1650 m, 1670 m, EP (*Fagus sylvatica*) — *Serre*: Monte Fiorino, Peppamaio (Satriano, CZ), 680 m, EP (*Castanea sativa*); Bosco di Santa Maria (Serra San Bruno, CZ), 830 m, EP (*Populus nigra*); Passo di Pietra Spada (Ferdinandea, RC), 1335 m, EP (*Quercus dalechampii*) — *Aspromonte*: Cittanova (RC), 370 m, EP (*Olea europaea*); Ciminà, Località Moleti (RC), 1000 m, EP (*Quercus frainetto*); Pietra Impiccata (RC), 1650 m, EP (*Abies alba*); idem, 1680 m, 1750 m, EP (*Quercus petraea*); Villaggio Canovai (RC), 1354 m, EP (*Fagus sylvatica*).

Moelleropsis nebulosa — *Pollino*: Monte Palanuda, Timpone Fornelli (Orsomarso, CS), 1240 m, EG — *Coast Range*: Cetraro, San Michele (CS), 130 m, EG; Orto Botanico dell'Università (Rende, CS), 290 m, EG; Valle del Caronte (Mendicino, CS), 650 m, EG, EP (*Castanea sativa*) — *Sila*: Rose (CS), 650 m, EG; Cava dell'Orso (Sila Grande, CS), 1280 m, EG; Cecita, Molarotta (Sila Grande, CS), 1280 m, EG; Bosco di Gallopane (Sila Grande, CS), 1511 m, EG; Cozzo del Pesco (Sila Greca, CS), 910 m, EG; Lorica (Sila Grande, CS), 1320 m, EG; Cavaliere di Lorica (Sila Grande, CS), 1360 m, EG; Pino Collito (Sila Grande, CS), 1350 m, 1380 m, EG; Vallone di Rovito (CS), 295 m, EP (*Quercus pubescens*); Craticello (Aprigliano, CS), 1240 m, EL; Piano del

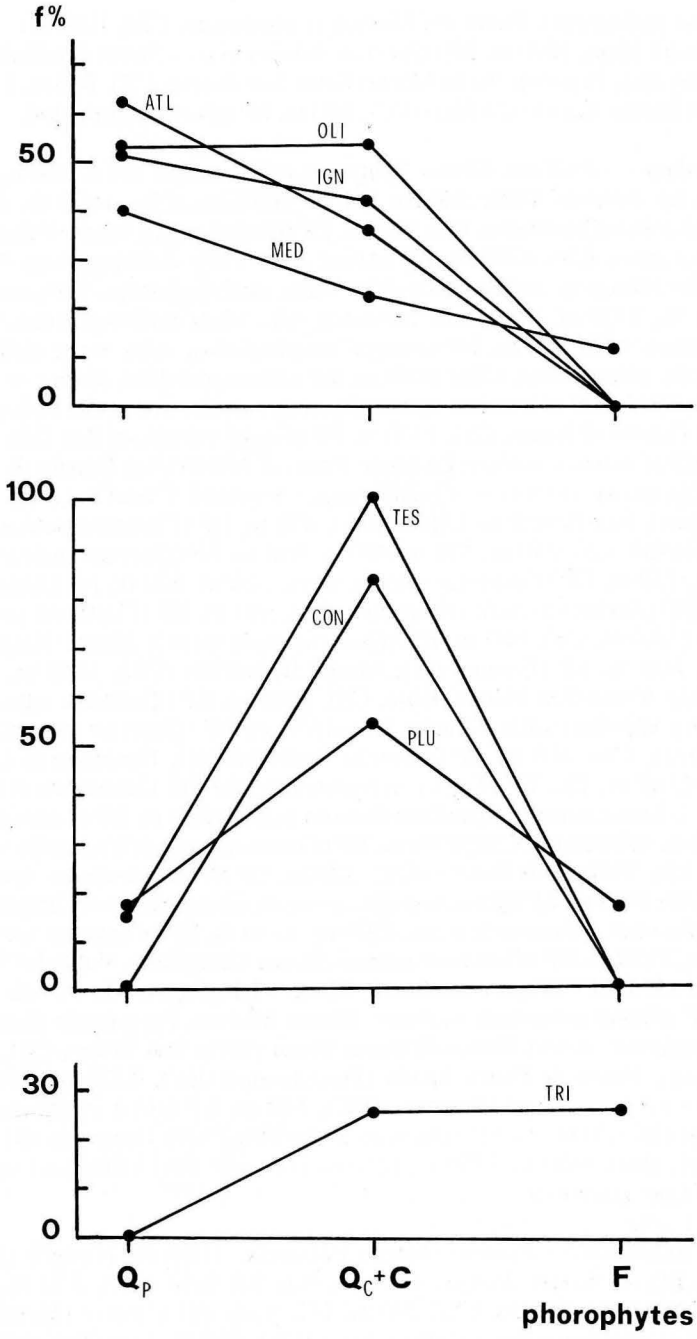

Fig. 10. Relative frequencies of epiphytic *Pannariaceae* on some phorophytes. The sequence of the latter on the horizontal axis reflects their altitudinal preferences. Qp: *Quercus pubescens*; Qc: *Quercus cerris*; C: *Castanea sativa*; F: *Fagus sylvatica*. The epiphytic lichen species are indicated by the first three letters of their specific epithet.

Medico (Carpanzano, CS), 1020 m, EL — *Serre*: Monte Fiorino, Peppamaio (Satriano, CZ), 680 m, EG; Bosco di Santa Maria (Serra San Bruno, CZ), 840 m, EG; Passo di Pietra Spada, (Ferdinandea, RC),1320 m, EG; Sorianello (CZ), 480 m, EG — *Aspromonte*: Piani d'Aspromonte (Santo Stefano d'Aspromonte, RC), 1100 m, EG.

Pannaria conoplea (Ach.) Bory — *Pollino*: Monte Palanuda, c/o casa forestale Masseti (Orsomarso, CS), 910 m, 980 m, EP (*Quercus ilex*); Il Monte (Grisolia, CS), 780 m, EP (*Castanea sativa, Quercus cerris*) — *Coast Range*: Laghicello (San Benedetto Ullano, CS), 910 m, EL; Fagnano Castello (CS), 640 m, EP (*Castanea sativa*); Valle del Caronte (Mendicino, CS), 460 m, 650 m, 720 m, EP (*Castanea sativa*); San Fili di Martirano (CZ), 660 m, EP (*Castanea sativa*) — *Sila*: Macchia di Pietro (Sila Grande, CS), 1450 m, EL; Piano del Medico (Carpanzano, CS), 1100 m, EP (*Castanea sativa*).

Pannaria ignobilis Anzi — *Pollino*: Mormanno (CS), 960 m, EP (*Quercus pubescens*); Monte Palanuda, Bosco Tavolara (Orsomarso, CS), 1250 m, EP (*Alnus* sp.); Monte Palanuda, c/o casa forestale Masseti (Orsomarso, CS), 930 m, EP (*Quercus ilex*); Alta Valle dell'Argentino, Rifugio Fornelli, (Orsomarso, CS), 1180 m, EP (*Malus* sp.); Alta Valle dell'Argentino, Varco della Gatta (Orsomarso, CS), 860 m, EP (*Ostrya carpinifolia*); Valle del Vaccuta, Pantanelli (Grisolia, CS), 650 m, EP (*Salix eleagnos*); Il Monte (Grisolia, CS), 780 m, EP (*Castanea sativa, Quercus cerris*); San Donato di Ninea (CS), 780 m, EP (*Castanea sativa*) — *Coast Range*: Fagnano Castello (CS), 640 m, EP (*Castanea sativa*); Varconcello (Mongrassano, CS), 580 m, EP (*Quercus cerris*); Cozzo d'Orlando (Montalto Uffugo, CS), 270 m, EP (*Quercus frainetto*); San Fili (CS), 650 m, EP (*Castanea sativa*); Piano di Maio (Rende, CS), 280 m, EP (*Quercus pubescens*); Valle del Caronte (Mendicino, CS), 370 m, 460 m, 490 m, EP (*Quercus pubescens*); idem, 370 m, 460 m, 650 m, EP (*Castanea sativa*); idem, 600 m, EP (*Alnus cordata*); Valle Scura (Aiello Calabro, CS), 600 m, EP (*Quercus pubescens*); San Fili di Martirano (CZ), 660m, EP (*Quercus pubescens*) — *Sila*: Luzzi (CS), 380 m, EP (*Quercus pubescens*); Varco San Mauro (Rose, CS), 1240 m, EP (*Quercus frainetto*); Cozzo del Pesco (Sila Greca, CS), 910 m, EP (*Quercus cerris*); Rossano, Bosco del Patire (Sila Greca, CS), 730 m, EP (*Quercus pubescens*); Vallone di Rovito (CS), 320 m, EP (*Olea europaea*); idem, 295 m, 310 m, EP (*Quercus pubescens*); Celico (CS), 840 m, EP (*Castanea sativa*); Valle del Cannavino (Celico, CS), 1540 m, EP (*Castanea sativa*); Spezzano Piccolo (CS), 1020 m, 1100 m, EP (*Castanea sativa, Quercus pubescens*); Valle del Cardone (Spezzano, CS), 750 m, EP (*Quercus pubescens*); Rogliano (CS), 660 m, EP (*Quercus pubescens*); Carpanzano (CS), 1000 m, EP (*Castanea sativa*); Piano del Medico (Carpanzano, CS), 1020 m, 1100 m, EP (*Castanea sativa, Quercus pubescens*) — *Serre*: Bosco di Santa Maria (Serra San Bruno CZ), 830 m, EP (*Populus nigra*); Passo di Pietra Spada (Ferdinandea, RC), 1335 m, EP (*Quercus dalechampii*).

Pannaria leucophaea — *Sila*: Craticello (Aprigliano, CS), 1240 m, EL — *Aspromonte*: Pietra Impiccata (RC), 1650 m, EL.

Pannaria mediterranea — *Pollino*: Monte Palanuda, Cardillo c/o Piano di Campolungo (Orsomarso, CS), 1250 m, EP (*Fagus sylvatica*); Cozzo del Pellegrino, Piano di Lanzo (San Donato di Ninea, CS), 1330 m, EP (*Fagus sylvatica*); Il Monte (Grisolia, CS), 780 m, EP (*Quercus cerris, Castanea sativa*); Valle del Vaccuta, Pantanelli (Grisolia, CS), 650 m, EP (*Salix eleagnos*) — *Coast Range*: Sponda del lago Trifoglietti (Fagnano Castello, CS), 1070 m, EP (*Salix* sp.); Orto Botanico dell'Università (Rende, CS), 290 m, EP (*Quercus pubescens*); Piano di Maio (Rende, CS), 280 m, EP (*Quercus pubescens*); Valle del Caronte (Mendicino, CS), 370 m, 460 m, EP (*Quercus pubescens*);

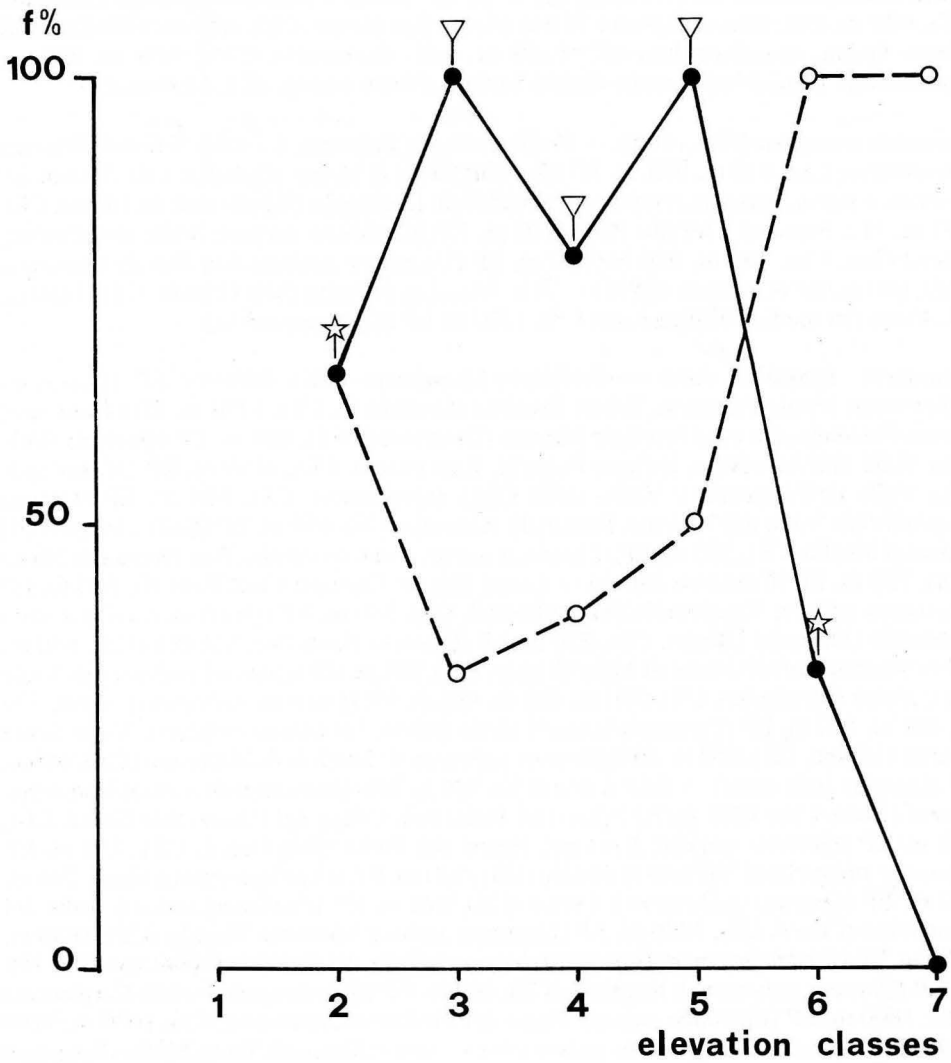

Fig. 11 - Relative frequency of *Pannaria olivacea* (solid line) and *P. mediterranea* (broken line) at different altitudes. The elevation classes range from 0 to 1400 m and are 200 m wide. Stars: specimens of *P. olivacea* with few and ill-developed apothecia; triangles: id., with well-developed apothecia.

Monte Cocuzzo (Mendicino, CS), 1150 m, EP (*Juglans regia*); Monte Faggeto (Grimaldi,CS), 1140 m, EP (*Quercus cerris*) — *Sila*: Varco San Mauro (Rose, CS), 1240 m, EP (*Quercus frainetto*); Valle del Moccone (Sila Grande, CS), 1320 m, EP (*Acer* sp.); Vallone di Cecita (Sila Grande, CS), 1150 m, EP (*Fagus sylvatica*); Cavaliere di Lorica (Sila Grande, CS), 1360 m, EG, EP (*Fagus sylvatica*); Rossano, Bosco del Patire (Sila Greca, CS), 730 m, EP (*Quercus pubescens*); Vallone di Rovito (CS), 295 m, EP (*Quercus pubescens*); Donnici Inferiore (CS), 380 m, EP (*Quercus pubescens*); Carpanzano (CS), 1000 m, EP (*Castanea sativa*); Piano del Medico (Carpanzano, CS), 1020 m, EP (*Quercus pubescens*); Vivoli (Colosimi, CS), 1250 m, EP (*Castanea sativa*) — *Serre*: Bosco di Santa Maria (Serra San Bruno, CZ), 830 m, EP (*Quercus robur*, *Populus nigra*).

Pannaria olivacea — *Pollino*: Il Monte (Grisolia, CS), 780 m, EP (*Castanea sativa*) — *Coast Range*: Selva dei Castagni (San Benedetto Ullano, CS), 450 m, 720 m, EP (*Castanea sativa*); Fagnano Castello (CS), 640 m, EP (*Castanea sativa*); Varconcello (Mongrassano, CS), 580 m, EP (*Quercus cerris*); Piano di Maio (Rende, CS), 280 m, EP (*Quercus pubescens*); Cosenza (via Monaco), 300 m, EP (*Olea europaea*); Valle del Caronte (Mendicino, CS), 370 m, 440 m, 460 m, 490 m, EP (*Quercus pubescens*); idem, 460 m, 650 m, 720 m, EP (*Castanea sativa*); idem, 620 m, EP (*Alnus* sp.); San Fili di Martirano (CZ), 660 m, EP (*Quercus pubescens*) — *Sila*: Luzzi (CS), 380 m, EP (*Quercus pubescens*); Redipiano (CS), 850 m, EP (*Castanea sativa*); Serra Ripollata (Sila Grande, CS), 1620 m, EP (*Fagus sylvatica*); Castelsilano (CZ), 650 m, EP (*Quercus pubescens*); Vallone di Rovito (CS), 300 m, 310 m, EP (*Quercus pubescens*); Piano del Medico (Carpanzano, CS), 1020 m, EP (*Quercus pubescens*); idem, 1100 m, EP (*Castanea sativa*) — *Serre*: Squillace (CZ), 300 m, EP (*Quercus pubescens*) — *Aspromonte*: Ciminà, Località Moleti (RC), 1000 m, EP (*Quercus frainetto*).

Pannaria pezizoides — *Pollino*: Passo Gaudolino (Monte Pollino, CS) , 1650 m, 1680 m, EG, EP (*Fagus sylvatica*); Cozzo del Pellegrino, Cozzo del Mangano (San Donato di Ninea, CS), 1690 m, EG — *Sila*: Cava dell'Orso (Sila Grande, CS), 1280 m, EG; Monte Botte Donato, Fontana del Colonnello (Sila Grande, CS), 1700 m, EG; Pino Collito (Sila Grande, CS), 1380 m, EG; Cavaliere di Lorica (Sila Grande, CS), 1360 m, EG; Monte Gariglione, Valle del Tacina (Sila Piccola, CZ), 1435 m, 1440 m, EG — *Serre*: Bosco di Santa Maria (Serra San Bruno, CZ), 840 m, EG; Bosco di Stilo (RC), 1096 m, EG — *Aspromonte*: Pietra Impiccata (RC), 1620 m, 1650 m, EG; Valle del Menta (RC), 1450 m, EG; idem, 1500 m, EP (*Pinus laricio*).

Pannaria rubiginosa — *Pollino*: Monte Palanuda, Castello di Noceto (Orsomarso, CS), 710 m, EP (*Quercus ilex*).

Parmeliella testacea — *Pollino*: Il Monte (Grisolia, CS), 820 m, EP (*Quercus cerris*); Monte Palanuda, Creste di Tortora (Orsomarso, CS), 620 m, EP (*Quercus ilex*) — *Coast Range*: Selva dei Castagni (San Benedetto Ullano, CS), 450 m, 520 m, 720 m, EP (*Castanea sativa*); Fagnano Castello (CS), 640 m, EP (*Castanea sativa*); San Fili (CS), 650 m, EP (*Castanea sativa*); Valle del Caronte (Mendicino, CS), 460 m, 560 m, 630 m, 720 m, EP (*Castanea sativa*); idem, 460 m, EP (*Quercus pubescens*); San Fili di Martirano (CZ), 660 m, EP (*Castanea sativa*) — *Sila*: Piano del Medico (Carpanzano, CS), 1100 m, EP (*Castanea sativa*).

Parmeliella triptophylla — *Pollino*: Passo Gaudolino (Monte Pollino, CS), 1680 m, EP (*Fagus sylvatica*); Pollinello (Monte Pollino, CS), 1760 m, EP (*Fagus sylvatica*); La Mula, Piano di Marco (San Donato di Ninea, CS), 1020 m, EP (*Quercus cerris*); Cozzo

del Pellegrino, Cozzo del Mangano (San Donato di Ninea, CS), 1690 m, EL; Monte Palanuda, Castel Brancato (Orsomarso, CS), 910 m, EP (*Fagus sylvatica*); Monte Palanuda, c/o casa forestale Masseti (Orsomarso, CS), 950 m, EP (*Quercus ilex*); Monte Palanuda, Timpone Fornelli (Orsomarso, CS), 1250 m, EP (*Pinus leucodermis*, *Fagus sylvatica*); Monte Palanuda, Schiena di Rossale (Saracena, CS), 1180 m, EP (*Fagus sylvatica*); Monte Palanuda, Costa d'Acine (Saracena, CS), 1520 m, EP (*Fagus sylvatica*) — *Coast Range*: Valle del Caronte (Mendicino, CS), 460 m, EP (*Castanea sativa*); Selva dei Castagni (San Benedetto Ullano, CS), 450 m, 520 m, EP (*Castanea sativa*); Laghicello (San Benedetto Ullano, CS), 920 m, EP (*Fagus sylvatica*). — *Sila*: Monte Gariglione, Valle del Tacina (Sila Piccola, CZ), 1435 m, 1460 m, EG, EL; Montescuro (Sila Grande, CS), 1650 m, EP (*Abies alba*) — *Aspromonte*: Pietra Impiccata (RC), 1620 m, 1650 m, EG, EP (*Quercus dalechampii*).

Psoroma hypnorum — *Pollino*: Passo Gaudolino (Monte Pollino, CS), 1650 m, EG — *Coast Range*: Valle del Caronte (Mendicino, CS), 560 m, EG — *Sila*: Cava dell'Orso (Sila Grande, CS), 1280 m, EG; Valle del Camigliati, c/o Camigliatello (Sila Grande, CS), 1250 m, EG; Pietra Bianca (Sila Grande, CS), 1420 m, EG; Pino Collito (Sila Grande, CS), 1350 m, EP (*Pinus laricio*) — *Aspromonte*: Pietra Impiccata (RC), 1620 m, 1650 m, EG, EP (*Abies alba*).

References

Bachmann, E. 1923: Untersuchungen über den Wasserhaushalt einiger Felsenflechten. — Jahrb. Wiss. Bot. **62**: 20-64.

Barkman, J. J. 1958: Phytosociology and ecology of cryptogamic epiphytes. — Assen.

Caloiero, D. 1975: Le precipitazioni in Calabria nel cinquantennio 1921-70 e carta delle isoiete alla scala 1 : 500.000. — Cosenza.

Ciancio, O. 1971: Sul clima e sulla distribuzione altimetrica della vegetazione forestale in Calabria. — Ann. Ist. Sperim. Selvic. **2**: 321-372.

Codogno, M. & Puntillo, D. 1988: Über die Veränderungen der Höhenstufenfolge in kleineren Bereichen des Mittelmeerraums (insbesondere innerhalb Kalabriens, S Italien). — Sauteria **4**: 141-148.

— & — 1991: The use of multivariate analysis in phytogeography at regional level. An example on the lichen family *Pannariaceae* in Calabria (S Italy). — Bot. Chron. **10**: 911-920.

Degelius, G. 1935: Das ozeanische Element der Strauch- und Laubflechtenflora von Skandinavien. — Acta Phytogeogr. Suec. **7**.

Goebel, K. 1926: Die Wasseraufnahme der Flechten. — Ber. Deutsch. Bot. Ges., **44**: 158.

Henssen, A. 1969: Die Entstehung des Thallusrandes bei den Pannariaceen (Lichenes). — Ber. Deutsch. Bot. Ges. **82**: 235-248.

Jatta, A. 1889: Monographia lichenum italiae meridionalis. — Trano.

Joergensen, P. M. 1978: The lichen family *Pannariaceae* in Europe. — Opera Bot., **45**.

Kanter, H. 1930: Kalabrien. - Abh. Auslandsk., Reihe C., Naturswiss., **33**.

Nimis, P. L. 1993: The lichens of Italy. An annotated catalogue. — Torino.

Ogniben, L. 1973: Schema geologico della Calabria in base ai dati odierni. — Geolog. Romana **12**: 243-585.

Poelt, J. 1970: Das Konzept der Artenpaare bei den Flechten. - Vortr. Gesamtgel. Bot., ser. 2, **4**: 187-198.

— 1987: Das Gesetz der relativen Standortskonstanz bei den Flechten. — Bot. Jahrb. Syst. **108**: 363-371.

Puntillo, D. 1987: Contributi alle conoscenze floristiche sui licheni d'Italia. 4. Florula lichenica della Valle del Caronte (Catena Costiera, Calabria). — Webbia, **41**: 315-335.

— 1993: Contributi alle conoscenze floristiche sui licheni d'Italia. 6. Florula lichenica della Valle del Fiume Argentino (Calabria, Italia). — Webbia, **47**: 163-186.

Rose, F. 1988: Phytogeographical and ecological aspects of *Lobarion* communities in Europe. — Bot. J. Linn. Soc. **96**: 69-79.
Walter, H. & Straka, H. 1970: Arealkunde. Floristisch historische Geobotanik, ed. 2. — Stuttgart.
Wirth, V. 1987: Die Flechten Baden-Württembergs. — Stuttgart.

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