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Epiphytic lichens of the sacred natural site "Bosco di Sant'Antonio" (Majella National Park – Abruzzo)

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Abstract

Sacred Natural Sites are relevant for biodiversity conservation, as in the case of forest sites that, across centuries, developed old growth structures and are now crucial for the conservation of epiphytic lichens and other specialized forest organisms. In this study, we investigated the epiphytic lichen flora of a small forest patch included in the Majella National Park (Abruzzo), whose old growth features and naturalness reflect its long lasting spiritual role that perfectly fits with the concept of Sacred Natural Site. Results revealed that the "Bosco di Sant'Antonio" hosts a rich and interesting epiphytic lichen flora, thus indicating the potential of this Sacred Natural Site for lichen conservation. Fifty-six species were found including two species newly recorded in Abruzzo, two red-listed species, and the sensitive species *Lobaria pulmonaria*. This study corroborates the hypothesis that sacred forest sites are relevant for the conservation of specialized epiphytic lichens. In particular, in the Italian forest landscape where old-growth stands are practically absent, sacred forest sites may provide unique old-growth structures and buffer anthropogenic disturbance.

Keywords

conservation, forest lichens, lichen red-list, *Lobaria pulmonaria*, old-growth stands

Introduction

Sacred Natural Sites are relevant for biodiversity conservation (Avtzis et al. 2018; Frascaroli et al. 2016) since their spiritual value is intrinsically associated with the maintenance of inspiring natural habitats by non-intervention or non-intensive management. This is, for example, the case of several forest sites that are not exploited for timber production due to the presence of a small church, a shrine, or a crucifix. Across centuries, these forests are allowed to develop old-growth structures that are crucial for the conservation of several forest organisms, such as epiphytic lichens (Nascimbene et al. 2013a).

Epiphytic lichens are a species-rich component of the forest biota playing several ecological roles, thus contributing to forest functioning and underpinning relevant ecosystem services (Zedda and Rambold 2015). Their diversity patterns are strongly influenced by forest structure and dynamics that, in turn, are affected by forest management. In particular, forestry is among the main causes of species loss across European forests (Nascimbene et al. 2013b) due to the exploitation of old trees, short rotation cycles, excessive canopy cover, or excessive exposure to direct light in the final part of the rotation cycle. In contrast, their diversity is enhanced by increasing tree age, which especially benefits rare, threatened (red-listed), and late successional species (Ellis 2012). Old trees provide different and highly variable bark structure as well as other microhabitats such as rot holes, growth anomalies, and moss cover (e.g. Fritz and Heilmann-Clausen 2010). Large old trees also enhance the establishment of dispersal-limited species that have more time for colonization, higher surface availability, and more stable substrate conditions (Nascimbene et al. 2013b).

In this study, we investigated the epiphytic lichen flora of a small forest patch included in the Majella National Park, whose old-growth features (i.e., occurrence of old trees) and naturalness reflect its age-old spiritual role that perfectly fits with the concept of Sacred Natural Site.

Methods

2.1 Study area

The study area, "Bosco di Sant'Antonio", is located in the "Altipiani Maggiori" of the Abruzzo Administrative Region (41°56.745'N, 14°1.648'E), with an elevation that varies between 1290 and 1360 m a.s.l. This forest, covering a surface of 450 ha, was the first Natural Reserve established in Abruzzo, back in 1985. Since 1991, it has been included in the Majella National Park. Furthermore, the forest has become part of the Natura 2000 network, being included in the SCI IT7110204 "Majella sud-ovest".

Based on information retrieved from the meteorological station of Pescocostanzo (1395 m a.s.l.), the climate of the forest is temperate-cold with moderate continentality. The annual precipitation exceeds 900 mm, with maximum in November-December and minimum in July-August. The mean annual temperature is 8.1°C, with a maximum mean in August (18.1°C) and a minimum mean in January (0.1°C).

The forest is dominated by beech (*Fagus sylvatica* L.), mixed with *Acer campestre* L., *Acer pseudoplatanus* L., *Prunus avium* (L.) L., *Quercus cerris* L., *Ilex aquifolium* L., and *Pyrus communis* L. subsp. *pyraster* (L.) Ehrh. (Pirone et al. 2004). The current physiognomy of the Sant'Antonio forest is characterized by the presence of monumental trees that have a typical "candlestick" posture, conferred by pollarding practice. This technique can be associated to the ancient traditional forms of pasture in forests (Manzi 1997). The sacredness of the site is clearly emphasized by the name of the forest, dedicated to St. Anthony of Padua, and by the presence of a church, founded by a religious congregation.

2.2 Data collection, species traits and nomenclature

In summer 2018, we carried out a floristic survey aiming at maximizing species capture. In particular, two skilled lichenologists and four collaborators were engaged in six hours of field work. This floristic survey was focused exclusively on epiphytic lichens and the four main tree substrates (*Acer campestre*, *A. pseudoplatanus*, *Fagus sylvatica* and, *Quercus cerris*) were explored in detail. For each species, at least one specimen was collected for identification and stored in the personal herbarium of JN.

The species' ecological traits were evaluated using the ecological indicator factors retrieved from Nimis and Martellos (2017). These factors indicate, on a 5-class ordinal scale, the ecological requirements of each species for (a) pH of the substrate (1 = on very acid substrata; 2 = on acid substrata; 3 = on sub-acid to sub-neutral substrata; 4 = on slightly basic substrata; 5 = on basic substrata); (b) light (1 = in very shaded situations; 2 = in shaded situations; 3 = in sites with plenty of diffuse light but scarce direct solar irradiation; 4 = in sun-exposed sites, but avoiding extreme solar irradiation; 5 = in sites with very high direct solar irradiation); (c) moisture (1 = hygrophytic species; 2 = rather hygrophytic species; 3 = mesophytic species; 4 = xerophytic species living in dry situations, but absent from extremely arid stands; 5 = very xerophytic species); (d) eutrophication (1 = no eutrophication; 2 = very weak eutrophication; 3 = weak eutrophication; 4 = rather high eutrophication; 5 = very high eutrophication).

Species biological traits (growth forms, reproductive strategies, and photobiont) were also retrieved from Nimis and Martellos (2017). Foliose lichens include both those with narrow (*Physcia*-like) and large (*Parmelia*-like) lobes; fruticose lichens; crustose lichens include true crustose, leprose and squamulose species. Reproductive strategies were classified as: (a) mainly sexual reproduction by ascospores, mainly asexual reproduction by (b) isidia, (c) soredia, and (d) thallus fragmentation. The photobiont can be a chlorococcoid green alga other than *Trentepohlia* (Ch), a Trentepohlioid green alga (Tr) or a cyanobacterium (Cy).

Nomenclature follows Nimis (2016), while the conservation importance of the species is based on their inclusion in the red list of the Italian epiphytic lichens (Nascimbene et al. 2013c).

Results

Fifty-six species were found (Table 1), representing 17% of the known epiphytic lichen flora of Abruzzo. They include two species that were new records for this Region, namely *Arthonia mediella* and *Gyalecta ulmi*, the second of which is also a red-listed species together with *Sclerophora pallida*. An additional interesting species is *Lobaria pulmonaria*, occurring with a well-established, but clustered, population including several fertile thalli.

The checklist mainly includes crustose and large-lobed foliose lichens with chlorococcoid green algae as photobiont and sexually reproducing by ascospores. However, we found a high percentage of cyanolichens (17.9%) and vegetatively reproducing species (42.8%), representing about 28% and 20%, respectively of the species occurring at the Regional level.

The analysis of the ecological indicator values (Table 2) revealed that the epiphytic lichen flora of the "Bosco di Sant'Antonio" mainly includes sub-acidophytic-neutrophytic species related to mesic-shaded and humid-mesic conditions, and avoiding or tolerating moderate eutrophication.

Discussion

Results reveal that the "Bosco di Sant'Antonio" hosts a rich and interesting epiphytic lichen flora, thus indicating the potential of this sacred natural site for lichen conservation. Actually, our field observations in several forest sites of the Majella National Park support the view that this small forest patch may represent a refuge for several lichen species that are virtually missing in the surrounding forest landscape. While for small-sized species (e.g. *Sclerophora pallida*) there could be a bias related to intrinsic species detectability, for large-sized species this observation could be reliable, as in the case of the large foliose lichen *Lobaria pulmonaria* whose population in the "Bosco di Sant'Antonio" seems to be unique to the Majella National Park. This species has suffered a general decline throughout Europe as a consequence of air pollution and intensive forest management and is currently red-listed in several European countries (Benesperi et al. 2018). In Italy, it is expected to strongly decline in the next decades due to reduced climatic suitability related to climate change that may exacerbate the effect of local impacts (Nascimbene et al. 2016). In the Majella National Park, the studied sacred forest site is crucial for the conservation of this sensitive and charismatic species, also able to ensure the conservation of co-occurring red-listed species (Nascimbene et al. 2013b).

The conservation importance of this site is further corroborated by 1) the high percentage of cyanolichens, and 2) vegetatively reproducing species that compose its lichen flora. Cyanolichens are a group of functionally relevant species (i.e., they are involved in atmospheric nitrogen fixation) sensitive to climate change and local anthropogenic disturbance that are dramatically declining across Europe, including Italy (Nascimbene et al. 2016). In many Italian regions, the occurrence of most species

Table 1. Checklist of the epiphytic lichens recorded in the "Bosco di Sant'Antonio". Species' biological traits (growth forms and reproductive strategies) were retrieved from Nimis and Martellos (2017). Foliose lichens include both those with narrow (*Physcia*-like; Fol.n) and large (*Parmelia*-like; Fol.l) lobes; fruticose lichens (Frut); crustose lichens include true crustose (Cr), and squamulose (Sq) species. Reproductive strategies are classified as: (a) mainly sexual reproduction by ascospores (S), mainly asexual reproduction by (b) isidia (A.i), and (c) soredia (A.s). The photobiont can be a chlorococcoid green alga other than *Trentepohlia* (Ch), a Trentepohlioid green alga (Tr) or a cyanobaterium (Cy). Tree species: AC = *Acer campestre*; AP = *Acer pseudoplatanus*; FS = *Fagus sylvatica*; QC = *Quercus cerris*. Nomenclature follows Nimis (2016), while the conservation importance of the species follows the Italian red list (Nascimbene et al. 2013c).

Species	Red List	New to Abruzzo	Growth form	Reproductive strategy	Photobiont	Tree species
Alyxoria varia (Pers.) Ertz & Tehler			Cr	S	Tr	AC; FS
Anaptychia ciliaris (L.) A. Massal.			Frut	S	Ch	AC; AP; FS
Arthonia atra (Pers.) A. Schneid.			Cr	S	Tr	FS
Arthonia mediella Nyl.		+	Cr	S	Tr	AC; FS
Arthonia radiata (Pers.) Ach.			Cr	S	Tr	FS
Athallia pyracea (Ach.) Arup, Frödén & Søchting			Cr	S	Ch	FS
Bacidia rubella (Hoffm.) A. Massal.			Cr	S	Ch	AC; FS
Calicium salicinum Pers.			Cr	S	Ch	FS
Caloplaca cerina (Hedw.) Th. Fr. s.lat.			Cr	S	Ch	FS
Candelariella faginea Nimis, Poelt & Puntillo			Cr	S	Ch	FS
Cladonia chlorophaea (Sommerf.) Spreng.			Frut	A.s	Ch	FS
Collema flaccidum (Ach.) Ach.			Fol.b	A.i	Cy	AC; FS
Collema furfuraceum Du Rietz			Fol.b	A.i	Cy	AC; AP; FS
Collema subflaccidum Degel.			Fol.b	A.i	Cy	AC; FS
Collema subnigrescens Degel.			Fol.b	S	Cy	AC; FS
Diplotomma alboatrum (Hoffm.) Flot.			Cr	S	Ch	AC
Evernia prunastri (L.) Ach.			Frut	A.s	Ch	AC; FS
Gyalecta ulmi (Sw.) Zahlbr.	NT	+	Cr	S	Tr	AC; AP
Lecanora allophana (Ach.) Nyl. f. *allophana*			Cr	S	Ch	AC
Lecanora chlarotera Nyl. subsp. *chlarotera*			Cr	S	Ch	FS
Lecanora horiza (Ach.) Linds.			Cr	S	Ch	FS
Lecanora subcarpinea Szatala			Cr	S	Ch	FS
Lecidella elaeochroma (Ach.) M. Choisy var. *elaeochroma* f. *elaeochroma*			Cr	S	Ch	FS
Lepra albescens (Huds.) Hafellner			Cr	A.s	Ch	FS; QC
Leptogium saturninum (Dicks.) Nyl.			Fol.b	A.i	Cy	FS
Lobaria pulmonaria (L.) Hoffm.			Fol.b	A.s	Ch	FS; QC
Melanelixia glabra (Schaer.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch			Fol.b	S	Ch	AC; FS
Melanelixia glabratula (Lamy) Sandler & Arup			Fol.b	A.i	Ch	AC; FS
Melanelixia subargentifera (Nyl.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch			Fol.b	A.s	Ch	AC; FS
Melanohalea elegantula (Zahlbr.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch			Fol.b	A.i	Ch	AC; FS
Myriolecis hagenii (Ach.) Sliwa, Zhao Xin & Lumbsch			Cr	S	Ch	AC; FS
Nephroma resupinatum (L.) Ach.			Fol.b	A.i	Cy	FS
Ochrolechia pallescens (L.) A. Massal.			Cr	S	Ch	FS; QC
Parmelia sulcata Taylor			Fol.b	A.s	Ch	AC; AP; FS; QC
Parmelina tiliacea (Hoffm.) Hale			Fol.b	A.i	Ch	AC; AP; FS; QC
Peltigera collina (Ach.) Schrad.			Fol.b	A.s	Cy	FS
Peltigera horizontalis (Huds.) Baumg.			Fol.b	S	Cy	FS
Peltigera praetextata (Sommerf.) Zopf			Fol.b	A.i	Cy	FS
Pertusaria coronata (Ach.) Th. Fr.			Cr	A.i	Ch	FS
Phaeophyscia orbicularis (Neck.) Moberg			Fol.n	A.s	Ch	AP; FS

Species	Red List	New to Abruzzo	Growth form	Reproductive strategy	Photobiont	Tree species
Phlyctis argena (Spreng.) Flot.			Cr	A.s	Ch	AC; AP; FS; QC
Physcia adscendens H. Olivier			Fol.n	A.s	Ch	AC; AP; FS
Physcia aipolia (Humb.) Fürnr.			Fol.n	S	Ch	AC; FS
Physconia detersa (Nyl.) Poelt			Fol.n	A.s	Ch	FS
Physconia distorta (With.) J.R. Laundon			Fol.n	S	Ch	AC; AP; FS
Physconia enteroxantha (Nyl.) Poelt			Fol.n	A.s	Ch	AC; FS
Physconia perisidiosa (Erichsen) Moberg			Fol.n	A.s	Ch	AC; FS
Physconia venusta (Ach.) Poelt			Fol.n	S	Ch	FS; QC
Placynthiella icmalea (Ach.) Coppins & P. James			Cr	A.i	Ch	FS
Pleurosticta acetabulum (Neck.) Elix & Lumbsch			Fol.b	S	Ch	AC; AP; FS; QC
Ramalina fastigiata (Pers.) Ach.			Frut	S	Ch	FS
Ramalina fraxinea (L.) Ach.			Frut	S	Ch	FS; QC
Rinodina sophodes (Ach.) A. Massal.			Cr	S	Ch	FS
Sclerophora pallida (Pers.) Y.J. Yao & Spooner	VU		Cr	S	Tr	AC; FS
Scytinium lichenoides (L.) Otálora, P.M. Jørg. & Wedin			Sq	S	Cy	FS
Xanthoria parietina (L.) Th. Fr.			Fol.b	S	Ch	AC; AP; FS

Table 2. Ecological requirements of the species represented by 4 indicator factors ranging on a five-level ordinal scale. Values in the table are percentages of species referred to the total for each of the five-levels of the ordinal scale (each species may have a range of values for each indicator factor).

Class	Substrate pH	Light	Moisture	Eutrophication
1	16.1	0.0	8.9	50.0
2	80.4	10.7	57.1	75.0
3	87.5	66.1	78.6	62.5
4	23.2	82.1	32.1	21.4
5	7.1	46.4	5.4	5.4

is only documented by records dating back more than a century ago (Nimis 2016; Nimis and Martellos 2017). Vegetative reproduction is a strategy that characterizes late successional communities (Nascimbene et al. 2017). This may reflect the fact that vegetative propagules are probably poorly adapted to bear harsh conditions typical of pioneer stages, while they meet more favorable conditions in old, more stable sites. The production of vegetative propagules enhances the local competitiveness of the species due to a rapid recruitment of new thalli. This is likely to result in a species-rich community that effectively saturates the available ecological niches.

The ecology of the species, as indicated by the values of the ecological indicators, reflects the main substrate and habitat features, with a high incidence of subacidophytic-neutrophytic species growing on beech bark in mesic-shaded and humid conditions. Interestingly, only a few species moderately tolerate eutrophication, probably reflecting a sporadic grazing activity. Our field observations in some forest patches nearby the sacred site revealed an intensive grazing activity that resulted in the establishment of a nitrogen-tolerant lichen flora, while most of the species inventoried in the "Bosco di Sant'Antonio" were almost absent. This situation further supports its important conservation status, likely related to its spiritual value.

Conclusions

This study corroborates the hypothesis that sacred forest sites may be relevant for epiphytic lichen conservation. In particular, in the Italian forest landscape where old-growth stands are scarce, such sites may provide unique old-growth structures and buffer anthropogenic disturbance. This would fit with the concept of 'shadow network' (Dudley et al. 2009) that considers Sacred Natural Sites as nodes of a non-official conservation network that may integrate the one based on protected areas. In this perspective, further sampling-based studies are required to confirm these promising speculations.

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JN and AC conceived the idea; JN, VDC, LDM, PG, CL, CV performed the field work and species identification; FF, PZ, AC contributed expertise in the field of Sacred Natural Sites; JN prepared the first draft of the ms and all the authors contributed to the final version.

References

Avtzis DN, Stara K, Sgardeli V, Betsis A, Diamandis S, Healey JR, Kapsalis E, Kati V, Korakis G, Marini Govigli V, Monokrousos N, Muggia L, Nitsiakos V, Papadatou E, Papaioannou H, Rohrer A, Tsiakiris R, Van Houtan KS, Vokou D, Wong JLG, Halley JM (2018) Quantifying the conservation value of Sacred Natural Sites. Biological Conservation 222: 95–103. https://doi.org/10.1016/j.biocon.2018.03.035

Benesperi R, Nascimbene J, Lazzaro L, Bianchi E, Tepsich A, Longinotti S, Giordani P (2018) Successful conservation of the endangered forest lichen *Lobaria pulmonaria* requires knowledge of fine-scale population structure. Fungal Ecology 33: 65–71. https://doi.org/10.1016/j.funeco.2018.01.006

Dudley N, Higgins-Zogib L, Mansourian S (2009) The Links between Protected Areas, Faiths, and Sacred Natural Sites. Conservation Biology 23: 568–577. https://doi.org/10.1111/j.1523-1739.2009.01201.x

Ellis CJ (2012) Lichen epiphyte diversity: a species, community and trait-based review. Perspectives in Plant Ecology, Evolution and Systematics 14: 131–152. https://doi.org/10.1016/j.ppees.2011.10.001

Frascaroli F, Bhagwat S, Guarino R, Chiarucci A, Schmid B (2016) Shrines in Central Italy conserve plant diversity and large trees. Ambio 45: 468–479. https://doi.org/10.1007/s13280-015-0738-5

Fritz Ö, Heilmann-Clausen J (2010) Rot holes create key microhabitats for epiphytic lichens and bryophytes on beech (*Fagus sylvatica*). Biologica Conservation 143: 1008–1016. https://doi.org/10.1016/j.biocon.2010.01.016

Manzi A (1997) Gli alberi e gli dei, I luoghi degli dei. Sacro e natura nell'Abruzzo italico, Carsa Edizioni Pescara, 184 pp.

Nascimbene J, Dainese M, Sitzia T (2013a) Contrasting responses of epiphytic and dead wood-dwelling lichen diversity to forest management abandonment in silver fir mature woodlands. Forest Ecology and Management 289: 325–332. https://doi.org/10.1016/j.foreco.2012.10.052

Nascimbene J, Thor G, Nimis PL (2013b) Effects of forest management on epiphytic lichens in temperate deciduous forests of Europe – a review. Forest Ecology and Management 298: 27–38. https://doi.org/10.1016/j.foreco.2013.03.008

Nascimbene J, Nimis PL, Ravera S (2013c) Evaluating the conservation status of epiphytic lichens of Italy: a red list. Plant Biosystems 147: 898–904. https://doi.org/10.1080/11263504.2012.748101

Nascimbene J, Casazza G, Benesperi R, Catalano I, Cataldo D, Grillo M, Isocrono D, Matteucci E, Ongaro S, Potenza G, Puntillo D, Ravera S, Zedda L, Giordani P (2016) Climate change fosters the decline of epiphytic *Lobaria* species in Italy. Biological Conservation 201: 377–384. https://doi.org/10.1016/j.biocon.2016.08.003

Nascimbene J, Mayrhofer H, Dainese M, Bilovitz PO (2017) Assembly patterns of soil-dwelling lichens after glacier retreat in the European Alps. Journal of Biogeography 44: 1393–1404. https://doi.org/10.1111/jbi.12970

Nimis PL, Martellos S (2017) ITALIC – The Information System on Italian Lichens. Version 5.0. University of Trieste, Trieste. http://dryades.units.it/italic

Nimis PL (2016) The Lichens of Italy – A Second Annotated Catalogue. EUT, Trieste, 739 pp.

Pirone G, Ciaschetti G, Frattaroli AR (2004) La vegetazione del Bosco di Sant'Antonio (Pescocostanzo, Abruzzo). Micologia e Vegetazione Mediterranea 19: 163–176.

Zedda L, Rambold G (2015) The diversity of lichenised fungi: ecosystem functions and ecosystem services. In: Upreti DK, Divakar PK, Shukla V, Bajpai R (Eds) Recent Advances in Lichenology, New Delhi, 121–145. https://doi.org/10.1007/978-81-322-2235-4_7