

LICHEN BIODIVERSITY AND HUMAN IMPACT ON DUNAL ECOSYSTEMS: A CASE-STUDY ON THE DISTRIBUTION OF THE RARE LICHEN SPECIES *SEIROPHORA VILLOSA* IN THE FOREST RESERVE OF CASTELVOLTURNO (CASERTA, SOUTHERN ITALY)

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Abstract – Along the Tyrrhenian coast, in Caserta province, the priority habitat "coastal dunes with *Juniperus sp.*" is well represented, though in a somehow patchy pattern. Since 1977, the "State Reserve of Castelvolturno" is a 268 ha protected area owned to the State Forest Service. In this area, the rare lichen *Seiophora villosa* (Ach.) Frödén, an endangered species indicator of ecological continuity, was recently found. A census of lichen epiphytic flora was conducted in the *Juniperus* stands of this area, in order to ascertain their naturalness level and to identify the most relevant factors linked to *Seiophora* distribution.

The work is aimed at studying how biotic and abiotic factors affect the distribution of this species, also to define better criteria to use it as a new indicator of ecological continuity in protected areas.

Riassunto – Lungo la costa Casertana, è presente l'habitat prioritario "Dune costiere con *Juniperus sp.*". Una porzione di tale area comprende la "Riserva Statale Castel Volturno", un'area protetta dal 1977, di proprietà del Corpo Forestale dello Stato che si estende per circa 268 ettari. In questa zona di recente è stata segnalata per la prima volta nel meridione della penisola, la *Seiophora villosa* (Ach.) Frödén, un lichene epifita ritenuto in via di regressione e indicatore, con la sua presenza, di continuità ecologica. La flora lichenica epifitica dei ginepreti presenti nella Riserva è stata censita per accertarne il livello di naturalità e identificare i fattori connessi alla distribuzione di *Seiophora*.

L'indagine è rivolta in particolare a comprendere come i fattori ambientali, biotici ed abiotici abbiano condizionato la distribuzione di questa specie, al fine di meglio definirne il valore come indicatore di continuità ecologica nelle aree protette.

Introduction

Coastal environments are very complex natural systems, whose equilibrium depends on the interaction of soils, rivers, sea and atmosphere. Preserving habitats and

species in these environments is one the aims of the European directive 92/43/CEE, as well as the recovering of green areas around urban settlements close to the sea. During last decades, Mediterranean littorals were interested by the development of new settlements, such as tourism villages and harbours, that induced a heavy reduction of dunal habitats and challenged the survival of several protected species.

Lichen are among the most interesting organisms related to ecological stability of natural habitats. The role of lichens as biological tools to monitor air quality has long been recognized [6, 18]. Their peculiar morphology and physiology allow them to be used either as biomonitors or bioaccumulators in several studies related to atmospheric pollutants [1, 17]. Moreover, since these organisms are often highly responsive to environmental variables such as light and humidity, they are going to be increasingly adopted as indicators of "naturalness" in woody ecosystems. In particular, some lichen species are only found in environments that were not disturbed significantly during several years, and tend to disappear as soon as disturbance factors enter to the system [3].

Seiophora villosa (Ach.) Frödén (Fig. 1) is a rare endangered lichen species with only few records known in Italy (Tuscany, Lazio, Sardinia and Pelagian Islands). In Europe, this species is only known to be present in Balearic Islands, namely Formentera, Ibiza e Maiorca. *Seiophora* is considered a good indicator of habitat continuity, since it seems to colonize only undisturbed dunal and post-dunal *Juniperus* stands. This species is actually considered to be endangered according to IUCN criteria [2]. Recently, *Seiophora* was found in the "State Reserve Castel Volturno" [4], a protected area owned to the State Forest Service of Italy. This was the first recovering for Southern Italy, opening new perspectives for biological conservation over this area.

With the aim of identifying the most relevant conditions correlated with *Seiophora* distribution in this relict stand, a census of lichen epiphytic flora was conducted in the *Juniperus* stands of this area, trying to correlate the frequency of this with disturbance levels present over the area.



Figure 1 – *Seiophora villosa* (Ach.) Frödén.

Figura 1 – *Seiophora villosa* (Ach.) Frödén.

Materials and Methods

This study was conducted in the "State Reserve of Castelvolturno", a protected area owned to the State Forest Service in Caserta province (Fig. 2). In this area, the priority habitat "coastal dunes with *Juniperus* sp." is well represented, though in a somehow patchy pattern. The reserve is protected since 1977, extending over 268 hectares between the outfalls of Regi Lagni on the North and Patria Lake at South.

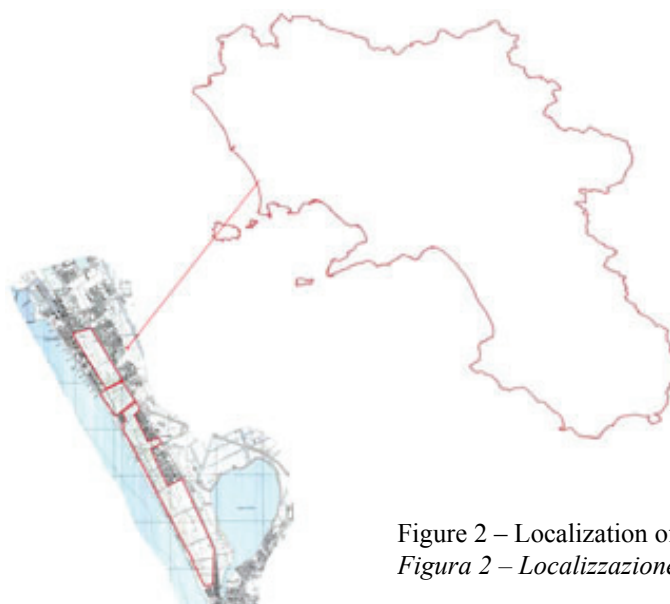


Figure 2 – Localization of the study site.

Figura 2 – Localizzazione dell'area di studio.

The climate is typically Mediterranean with a mean annual temperature of 13,6 °C and an average rainfall of 761 mm (Ischitella meteorological station, 15 m a.s.l., period.1999/2011). Precipitations mostly occur in autumn and winter and a drought period in summer, with an average value of 22.9 mm and a minimum value of 3.2 mm in July.

The vegetation of the area is a mosaic of different plant patches: the northern part is characterized by a coppice stand of *Quercus ilex* L. sparsely mixed with *Pinus pinea* L. and with a shrubby understory of *Phyllirea angustifolia* L., *Pistacia lentiscus* L., *Myrtus communis* L., *Rhamnus alaternus* L., *Arbutus unedo* L., *Ruscus aculeatus* L. and *Cistus* sp. [7]. An increasing presence of invasive species (i.e. *Carpobrothus* sp., *Pittosporum tobira*) was recorded during recent years.

Inside this area three stands about 15 ha wide were selected and designed as A, B and C. The three stands were characterized by similar vegetation type, but differed for the intensity of human disturbance. Stand A was the one in which *Seiophora* was found for the first time, and resulted to be the less disturbed site in the reserve. Stands B and C presented an increasing impact of human presence, mainly depending on car transit and parking towards beach resorts, with considerable loss of spontaneous species and occurrence of invasive species.

Twenty-three random sampling plots of 600 m² (30 m x 20 m) were selected inside the three stands (10 in stand A, 7 in stand B and 6 in stand C respectively). Lichen sampling was executed on four abundant plant substrates: *Cistus* sp., *Rosmarinus officinalis*, *Phyllirea angustifolia* and *Juniperus oxycedrus*. In each plot 8 shrubs (two for species) were sampled. On each shrub, 5 branches 50 cm long were chosen. Lichen species frequency on these branches was measured and expressed in a 0-5 range.

Thalli were collected during field sampling and brought to laboratory for any dubious identification. Taxonomic determination was done referring to Nimis [9; 10,11], Ozenda & Clauzade [16], Clauzade & Roux [5]. Nomenclature follows Nimis & Martellos [12].

Ecological indices, expressing the level of biological tolerance of the species regarding environmental features, were calculated referring to the criteria of ITALIC system (<http://dibiobs.univ.trieste.it>) [12]. The ecological attributes included response to pH, light levels, water availability, geographical distribution and evenness. In addition, we determined two indices related to the degree of human impact on the atmosphere, the indices of eutrophication and poleophoby. The former is related to the frequency of lichens tolerating (or escaping) nitrogen compounds dispersed as dust in the atmosphere. The second is related to the frequency at which lichens tolerating (or escaping) urban environment are found, so accounting for the general degree of human disturbance over an area. Finally, indices related to lichen morphology, photobiont association and reproductive type were calculated.

Descriptive statistic was performed making use of the SPSS 13.0 package. Data were also submitted to multivariate analysis, making use of the software Syntax 2000 per windows.

Results and discussions

A total of 28 lichen taxa was found on the three studied stands (Tab. 1). Among these, it was interesting the finding of *Caloplaca aegatica* recorded for the first time in Campanian region. Previously this species had only been recorded for Southern Italy in Apulia [14]. It was also noteworthy the finding of *Lecanora lividocinerea* and *Pyrrhospora quernea*, that were not found in Campania region since about a century [8].

By the analysis of biological indices produced by Nimis and Martellos [12], lichen flora was mainly constituted by crustose epiphytic species, with green algae as photobiont. As expected, the preferred substrates were acid and subacid, pointing out that bark environments were not strongly subject to secondary eutrophication. Regard to environmental requirements, the species were mainly mesophytic with preference for open exposure. Poleophobic and eutrophication index both showed that most of these species are linked to not disturbed and not eutrophyc environments. Besides the extremely rare *Seiophora*, four lichen species were found that result to be very rare in the humid-Mediterranean phytoclimatic region [12]: *Graphis scripta*, *Bacidia rubella*, *Lecanora livideocinerea* and *Lecanora sambuci*. The first of these species is rare in this habitat but is quite common in mountain belts of the Apennines, whereas the others are typical of this phytoclimatic region but are usually considered rare even in their optimal environment.

Table 1 – List of lichen species found three stands and four plant substrates of the protected area under study.

Tabella 1 – Lista delle specie licheniche rinvenute nei tre stands sui quattro substrati vegetali dell'area protetta studiata.

Lichen taxa found in the Forest reserve of Castelvolturno (Campania region, Southern Italy)	
<i>Amandinea punctata</i> (Hoffm.) Coppins & Scheid.	<i>Lecanora lividocinerea</i> Bagl.
<i>Bacidia rubella</i> (Hoffm.) A.Massal.	<i>Lecanora sambuci</i> (Pers.) Nyl.
<i>Caloplaca aegatica</i> Giralt, Nimis & Poelt	<i>Lecidella elaeochroma</i> (Ach.) M. Choisy
<i>Caloplaca cerina</i> (Hedw.) Th.Fr. var. <i>cerina</i>	<i>Naetrocymbe punctiformis</i> (Pers.) R.C.Harris.
<i>Caloplaca cerinella</i> (Nyl.) Flagey	<i>Pertusaria pertusa</i> (Weigel) Tuck.
<i>Caloplaca ferruginea</i> (Huds.) Th. Fr.	<i>Physcia adscendens</i> (Fr.) H. Olivier
<i>Caloplaca pyracea</i> (Ach.) Th.Fr.	<i>Physcia leptalea</i> (Ach.) DC.
<i>Catillaria nigroclavata</i> (Nyl.) Schuler	<i>Pyrrhospora quemea</i> (Dicks.) Körb.
<i>Diploicia canescens</i> (Dickson) Massal.	<i>Ramalina canariensis</i> J. Steiner
<i>Diplotomma alboatrum</i> (Hoffm.) Flot.	<i>Rinodina pyrina</i> (Ach.) Arnold
<i>Evernia prunastri</i> (L.) Ach.	<i>Rinodina sophodes</i> (Ach.) A. Massal.
<i>Flavoparmelia caperata</i> (L.) Hale	<i>Seiophora villosa</i> (Ach.) Frödén
<i>Graphis scripta</i> (L.) Ach.	<i>Tephromela atra</i> (Huds.) Hafellner v. <i>atra</i>
<i>Lecanora chlarotera</i> Nyl.	<i>Xanthoria parietina</i> (L.) Th. Fr.

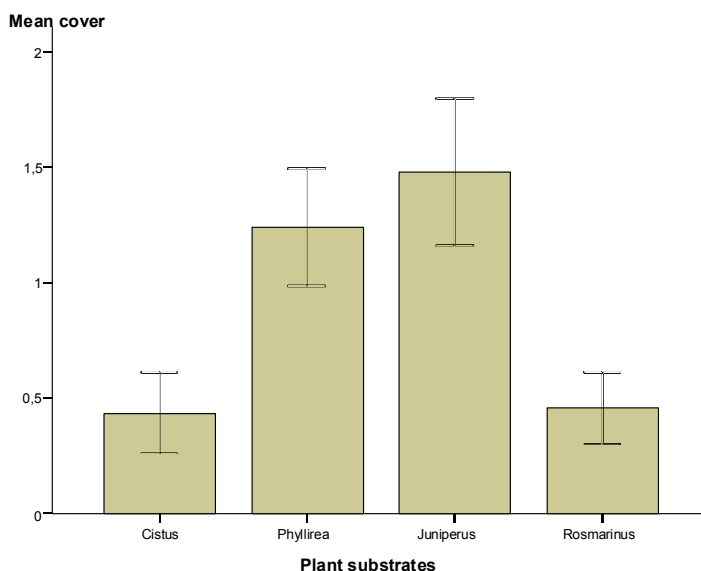


Figure 3 – *Seiophora* mean cover on the four plant substrates.

Figura 3 – Copertura media di *Seiophora villosa* sui quattro substrati rilevati.

Seiophora was only found inside stand A, the one subjected to the lower disturbance by anthropic pressure, with maximum concentration approximately in the center of the stand. *Juniperus* and *Phyllirea* were the most colonized plant species (Fig. 3), whereas only scattered individuals of *Rosmarinus* and *Cistus* were hosted by this lichen. It may be hypothesized that human disturbance lead to the disappearance of this species in

stands B and C. Besides car transit, we observed the presence of several resort building in these sites, that could have limited the flux of salt spray and atmospheric humidity by sea wind. Since propagule diffusion of this species seems to be sensibly favored by such elements, the buildings posed along the beach line could result to be one of the most relevant factors limiting its distribution.

Stand A was the most rich of lichen species, with 25 taxa represented, followed by B (24 taxa) and C (17 taxa). Thus, the number of lichen species tended to decrease along the gradient of human disturbance. Also lichen species frequency among the three stands tended to mark this gradient of increasing disturbance effects in the order $A < B < C$.

The species *Tephromela atra*, for instance, quite well represented in stand A, drastically decreased in stand C and totally disappeared in stand B. This is in agreement with the findings of Nimis & Schiavon [15], that characterized this species as one of the best indicators of the undisturbed maquis vegetation of Thyrrenian coastal dunes. Globally, the most represented lichen species were *Xanthoria parietina*, *Diploicia canescens*, *Ramalina canariensis* and *Lecidella elaeochroma*, typical taxa of coastal undisturbed sites [15].

Cluster analysis executed on the submatrix of stand A, the only one in which *Seiophora* was found, allowed to identify the groups of species most probably related to *Seiophora* presence (Fig. 4). This species was included in a wide cluster of 12 species, with 3 sub-clusters (1a, 1b and 1c). The most relevant character of this cluster was the marked preference of *Juniperus* as plant substrate. This preference was quite exclusive for

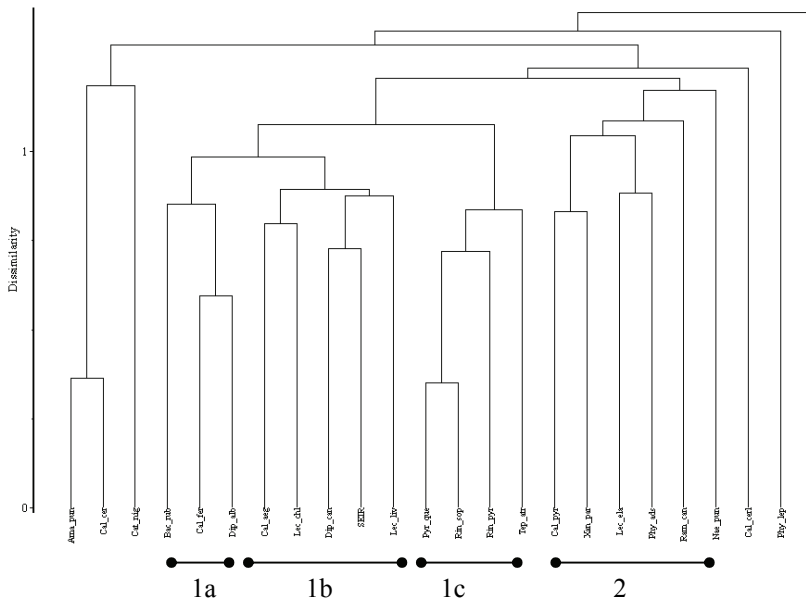


Figure 4 – Dendrogram resulting by a cluster analysis performed on lichen species found in stand A, with group average linkage and chord distance.

Figura 4 – Dendrogramma delle specie licheniche rinvenute nello stand A, effettuato secondo il legame medio e la distanza sulla corda.

the species of both subclusters 1a and 1c, whereas cluster, the one containing *Seiophora*, also tended to colonize *Phyllirea* and to a lesser extent *Cistus* and *Rosmarinus*. A second large cluster (cluster 2) was found, mainly constituted by species distributed on all substrates or preferring *Cistus* and *Rosmarinus*. The other clusters were mainly constituted by sporadic species. The dendrograms related to stands B and C (data not shown) tended to confirm the distribution previously described, mainly related to the differences in lichen species preferences for the various plant substrates. Thus, *Juniperus* seemed to be the plant substrate on which is maximum the probability of finding *Seiophora* or the group of companion species.

Conclusions

The observations presented here show that disturbance is the main factor conditioning the presence or the absence of *Seiophora* in the field. In fact, in this study several environmental factors were involved, but disturbance was the only factor that significantly varied among the studied stands. *Seiophora* clearly showed a preference for *Juniperus* and *Phyllirea* as plant substrate. Both these species were equally represented in all the studied stands, but no presence of *Seiophora* was found in any of these plants inside the most disturbed stands. Car transit and building barriers along coastal line have been proposed as the most relevant factors limiting the spread of this endangered species. Further studies will be conducted in order to clarify the mechanisms involved in the described dynamics.

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