RESPONSES OF LICHENS TO CLIMATE: EXPERIMENTAL APPLICATIONS FROM THE ORGANISM TO THE COMMUNITY LEVEL

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ABSTRACT
The response of lichens to climate-related factors was detectable at different organisational levels. Several species were significant related to rainfall and temperature gradients area and they have been proved to be efficient bioclimatic indicator in a long-term perspective. Their photosyntetic efficiency, tested with experimental transplants along macro- and mesoscale, resulted a valuable tool to define the ecological niche of photoautotroph organisms related to the environmental condition. Finally, a controlled atmosphere experiment suggested the best microclimatic conditions for setting forthcoming evaluations of the temporal response of the species to climate change.

KEYWORDS
Mediterranean, dsertification, photosynthetic efficiency, diversity, cryptogam

INTRODUCTION

Climate change and wrong land exploitation are the reasons of soil degradation and desertification: this is a worldwide spread phehomenon, that occurs also in the Mediterranea region, especially Greece, Portugal and Southern Spain, due to the intensive agropastoral activities. In this contribution we report a synopsis of the main outcomes of the FISR-MICENA project, aimed to study the effect of climatic variations on lichens, along organizational (from the organism(s) to the community level), spatial and temporal scale of action and response.

THE EFFECTS OF CLIMATE CHANGE ON LICHEN DIVERSITY AND DISTRIBUTION

In this part of the work, we aimed to quantify the relationship between epiphytic lichen distribution and macroclimatic variables in the study area and to provide a case study for evaluating the predictive role of epiphytic lichens as bioclimatic indicators. The study was carried out in the Liguria region (NW-Italy), a small (5432 km^2) borderline area, where phytoclimatic features range from the dry Mediterranean to the Alpine in a few kilometers. Epiphytic lichen diversity was sampled using a standardised protocol (Asta et al. 2002). Abundance of the species in the sampling sites was related to macroclimatic parameters (yearly average temperature and rainfall) and non-parametric multivariate models were calculated to find significative relationships among predictive and response variables. Fifty-nine species showed highly significant relation with macroclimatic parameters. Four groups were selected, by means of a cluster analysis, related to four climatic niches (warm-humid, cold-humid, mesothermic-humid, warm-dry). Distributional pattern of the groups in the survey area showed a good correspondence with the bioclimatic units of Liguria region described by Nimis & Martellos (2008). A significant subset of epiphytic lichen species in the study area have been proved to be efficient bioclimatic indicator and it is supposed to give good results to monitor climatic changes, in a long-term perspective (Giordani & Incerti 2008).

THE EFFECTS OF CLIMATE CHANGE ON LICHEN DIVERSITY AND DISTRIBUTION. EXPLORING THE SIGNAL-TO-NOISE RATIO AGAINST ENVIRONMENTAL BACKGROUND VARIABILITY

Mediterranean ecosystems, in spite of summer climatic drought, host peculiar epiphytic and epilithic lichen communities, ranging from xerophytic to igrophytic. Previous studies showed that water availability is a limiting factor for lichens at regional and landscape level (Giordani, 2006; Ellis *et al.*, 2009), while at ecosystem and community scale lichen diversity is affected by several substrate- and stand-related factors (Hedenas and Hedstrom, 2007; Caruso and Rudolphi, 2009). We explored this complex ecological framework in an intensive field-study carried out in Sardinia (Mediterranean Italy), which is the Italian region most threatened by desertification. Seventy-five variables, from bark and rock micro-topography to vegetation structure, macroclimate and landcover, were collected at 70 macro-plots, following a nested stratified random design, including 4008 bark quadrats, 668 grids, 200 trees for epiphytes and 5000 quadrats and more than 200 grids for epilithic lichens. By applying nonparametric multivariate statistics and multiplicative regressive models (McCune, 2006) different predictors resulted significantly related to lichen diversity (e.g. host-tree morpho-structural gradient), distribution of most representative species (light radiation through the canopy) and of morpho-functional guilds (bark texture and competitors frequency).

THE EFFECTS OF CLIMATE CHANGE ON LICHENS: A MACROSCALE VS. MESOSCALE COMPARISON

We used transplants of *Parmotrema perlatum* (Huds) M. Choisy to investigate whether its distribution along macro- and microclimatic gradients is correlated to a different capability of phyisiological adaptation (Lange et al., 2001; Gauslaa & Solhaug, 2004). To check this hypothesis, we studied the relationship between chlorophyll a fluorescence and environmental atmospheric condition (temperature, relative humidity and solar radiation). Samples of thalli collected in a pristine site of Ligurian Apennine (NW-Italy), characterized by humid sub-Mediterranean climate, were re-transplanted at the same site and in two other sites in an arid area of west Sardinia. In the Sardinia site we transplanted samples both in a woodland area and in a sparsely vegetated area. Data from microclimatic stations confirmed the differences between all site. Measurement of chlorophyll a fluorescence (Strasser et al., 2004) took place in different seasonal session (Baruffo & Tretiach, 2007). This parameter resulted a valuable tool to define the ecological niche of photoautotroph organisms related to the environmental condition. In particular, we observed that similar micro-climatic condition between the woodland Sardinia area and the control site provide for macro-climatic condition. Data of chlorophyll a fluorescence were confirmed by measurements of chlorophyll degradation carried out by spectrophotometric analysis.

THE EFFECTS OF CLIMATE CHANGE ON LICHENS: MESOSCALE STUDIES ALONG GRADIENTS OF LANDUSE INTENSITY AND DESERTIFICATION RISK

In order to estimate the criticity of this phenomenon, a field experiment was carried out by using transplants of the lichen *Evernia prunastri*, that have been exposed during summer-autumn season for 4 months in 15 sites, characterized by different land use and environmental sensitive areas classes (ESA, Kosmas et al. 1999). Physiological analysis were then conduced to determine membrane degradation, by measure of electrical conducibility, and photosynthetic efficiency, by analysis of F_V/F_M and Performance Index. Fluorimetric parameters resulted valid indicator of photosynthetic efficiency in transplants, differently

correlated to tested variables (RH, temperature, Leaf Area Index, land use, ESA, Heat Index), whereas electrical conducibility seems to be weakly correlated to Heat Index only.

THE EFFECTS OF CLIMATE CHANGE ON LICHENS: CONTROLLED ATMOSPHERE SIMULATIONS.

A controlled atmosphere experiment was carried out in order to study short term variations of F_V/F_M to different values of RH, temperature and light intensity. Besides *E. prunastri*, olther 3 species with different ecological requirements were tested (*Parmotrema reticulatum*, *Parmotrema perlatum*, *Xanthoparmelia tinctina*). With this simulation we showed a rapid response of photosynthetic efficiency, that changes after 2 days of exposition to the parameters, and found out the best climatic condition for tested species, thus low values of temperature and luminous intensity and intermediate values of RH.

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