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LICHEN DIVERSITY OF OLD-GROWTH FORESTS IN MOLISE (CENTRAL-SOUTHERN ITALY)

The role of lichens as indicators of environmental continuity is widely reported in central and northern European forests. Management plans consider them e.g. *to predict the presence of valuable species and for the selection of key woodland habitats. Nevertheless, effects of management to many forest-associated lichens in Mediterranean environments are poorly known and threats are only recently investigated.*

Aim of this work is to contribute to the identification of lichen communities colonizing old-growth forests and variables influencing their diversity.

The study was carried out in two large forested areas in the high Molise region, belonging to the network identified under the PRIN 2007 "Metodi innovativi per la identificazione, caratterizzazione e gestione dei boschi vetusti in ambito Mediterraneo". Abeti Soprani (Pescopennataro, Isernia) and Collemeluccio (Pescolanciano, Isernia) are the selected stands because of their historical value and phytogeographical interest.

These stands represent two different habitat types: Abeti Soprani is a Southern Apennine silver fir forest and Collemeluccio a is mixed forest of silver fir and turkey oak.

The Lichen Diversity Values (LDV) was releved according to a randomized stratified sampling design within a plot of one hectare in each study area. The percentage contributions to the total lichen diversity of each growth form, photobiont and reproductive strategy were taken into account in order to assess the differences among the plots.

The paper reports the results obtained during the first year of survey as a starting point for planning a long-term monitoring. The LDV seems to be very high in these Mediterranean old-growth forests confirming their important role in lichen diversity conservation.

Key words: forest ecosystems; epiphytic lichen diversity; biological indicators.
Parole chiave: ecosistemi forestali; diversità dei licheni epifiti; indicatori biologici.

1. INTRODUCTION

Epiphytic lichen communities are widespread in many forested habitats where they usually constitute an important component of the total biodiversity (DETTKI and ESSEEN, 2003; WILL-WOLF *et al.*, 2002) and can

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give indirect information on their environmental continuity and status of conservation (ROSE, 1976; GUSTAFSSON *et al.*, 2004; HILMO and SASTAD, 2001; KUUSINEN, 1996; CAMPBELL and FREDEEN, 2004).

The value of mature and old-growth forests for biodiversity and especially for rare and threatened species conservation is widely accepted. *Taxa* associated with old-growth forests may be restricted to such stands depending on certain microhabitats not found in younger forests (for a review, see HUMPHREY, 2005).

Although several studies demonstrated the importance of old-growth characters, old tree and dead wood for lichen conservation (ULICZKA and ANGELSTAM 1999; SILLETT *et al.*, 2000; JOHANSSON *et al.*, 2007), effects of management to many forest-associated lichens in Mediterranean habitats were poorly studied and only recently investigated (NASCIMBENE *et al.*, 2007, 2008; BRUNIALTI *et al.*, 2010). Furthermore, there are very few long-term monitoring programs which consider also lichens (CHIARUCCI and BONINI, 2005; Giordani *et al.*, 2006; BACARO *et al.*, 2008).

This study was carried out in two permanent plots in the high Molise region. It represents the initial survey of a program that aims at monitoring lichen diversity related to last remains of the Apennine silver fir forest in Central-Southern Italy.

2. STUDY AREA

The silver fir forests of Molise belong to two main nuclei. The northern one (which includes the stand "Abeti Soprani", 1.275-1.300 m a.s.l.) is located in the high basin of the Sangro river where several woods stretch from Molise to Abruzzo (Figure 1). These formations are considered as fragments of a single forest which occupied the entire north slope of the mountains Campo, S. Nicola, S. Onofrio e Rocca l'Abate above 850-900 m a.s.l. (BORGHETTI and GIANNINI, 1984) on Rendzina soils, Miocenic-clay soils and Cretacic white limestone (FERRARI and WOLF, 1970).

The conifer often grows in pure to nearly pure stands in association with beech at the highest altitude, showing a tendency to form mesohygrophilous consortia. These mixed woods have been recently referred to *Pulmonario apenninae-Abietetum albae* (ALLEGREZZA and BIONDI, 2008).

This area (meteorological station of Capracotta: 1921-1955) is characterized by a cold-humid climate which lacks of summer aridity: the mean annual temperature is 8.2 °C, the annual mean precipitation is 1.153 mm. January is the coldest month (mean: -4.2 °C) and July is the warmest month (mean: 28.1 °C) (ABBATE, 1990).

Figure 1– Study area: Abeti Soprani and Collemeluccio in Molise (Central Southern Italy).

A second group of mixed silver fir and turkey oak forests is along the basin of Trigno river. Such coenosis represents the more southern nucleus and, despite its small extension, it is very important to reconstruct the historical distribution of silver fir in the Apennines because of its particular position at 7 km from the northern nucleus.

The stand of "Collemeluccio" is a plain area (850 m a.s.l.) located in the MaB (Man & Biosphere, UNESCO) reserve Collemeluccio-Montedimezzo on Miocenic Flysch formations, acid brown clay soils often showing hydromorphic phenomena. The vegetation has recently been referred to *Aremonio agrimonioidis-Quercetum cerridis* subass. *abietetosum albae* ALLEGREZZA and BIONDI, 2008.

The mean annual temperature is 8.2 °C, the annual mean precipitation is 907 mm (1973-1983). January is the coldest month (mean: -2.1 °C) and July is the warmest month (mean: 22.4 °C) also showing a peak of subaridity (ABBATE, 1990).

3. MATERIALS AND METHODS

Lichen monitoring followed STOFER *et al.* (2003). In each plot, only trees with a minimum circumference of 50 cm at "breast height" (130 cm above ground level) were considered. Four strata were considered, on the basis of the pH of the bark (acidic or less neutral bark, data from literature) and of the diameter at breast height (DBH ≤ 36 cm and DBH >36 cm). The proportion of trees on the plot in the following four groups was then calculated and for each of the four strata, a proportional number of trees was then randomly selected on the plot to have a total of 12 sampling trees for each stand.

To achieve better estimation of the species richness of the plot, for each of the four pre-stratified groups, additional trees were randomly selected until at least three trees per group were represented.

The Lichen Diversity Value (LDV) was calculated on each selected tree according to ASTA *et al.* (2002) as the sum of the frequency of each epiphytic lichen species occurring within four 10 x 50 cm grids placed systematically on the cardinal points N, E, S, W at 100 cm above ground level. Species difficult to identify in field were collected for identification in laboratory.

Growth forms, photobionts and reproductive strategies were taken into account to detect the characteristics of lichen colonization.

The nomenclature, bio-ecological characterization and distribution of lichen species followed the online checklist of Italian lichens (NIMIS and MARTELLOS, 2008), the nomenclature of vascular plants followed PIGNATTI (1982).

4. RESULTS

A total of 31 relevés have been carried out: 15 in Abeti Soprani (9 on *A. alba*, 6 on *F. sylvatica*), 16 in Collemeluccio (5 on *A. alba*, 4 on *Q. cerris*, 3 on *C. betulus*, 3 on *A. campestre*). A total of 51 lichen *taxa* were identified. Among them, 22 are exclusive of Abeti Soprani, 13 of Collemeluccio, 16 are in common between the stands (Table 1).

Though epiphytic lichens distribution depends on a complex set of environmental and substrate-related variables, acting from the tree to the

Table 1 – List of the 51 species releved in the survey area with their frequency for each layer. LDV both of each layer and each stand is also reported.

Stand	**AS**				**C**			
Layer **Tree (n. and kind)**	**A** **5Aa**	**B** **4Aa**	**C** **3Fs**	**D** **3Fs**	**A** **2Aa, 2Qc**	**B** **3Aa, 2Qc**	**C** **1Ac, 3Cb**	**D** **2Ac, 1Fs**
Pertusaria flavida (DC.) J.R.Laundon	3	2						
Physcia leptalea (Ach.) DC.	5	17	32	6				
Caloplaca herbidella (Hue) H.Magn.	15	25		4				
Lecanora allophana Nyl.	1		18					
Parmelia saxatilis (L.) Ach.	12							
Arthonia radiata (Pers.) Ach.	1		17	4				
Porina aenea (Wallr.) Zahlbr.	1	6	20	11				
Pertusaria leioplaca DC.		2	19					
Aplotomma turgida (A.Massal.) A.Massal.		6	3	12				
Bacidia circumspecta (Vain.) Malme		5		2				
Pertusaria albescens (Huds.) M.Choisy & Werner		2						
Pleurosticta acetabulum (Neck.) Elix & Lumbsch		2						
Rinodina sp.		1						
Chrysothrix candelaris (L.) J.R.Laundon		12						
Lecanora carpinea (L.) Vain.		3	20	1				
Lecanora expallens Ach.		15						
Micarea prasina Fr.		1						
Lecanora intumescens (Rebent.) Rabenh.		21	19					
Phaeophyscia hirsuta (Mereschk.) Essl.		1						
Tephromela atra v. *torulosa* (Flot.) Hafellner			3					
Graphis scripta (L.) Ach.			2					
Lecanora argentata (Ach.) Malme			4					
Arthonia didyma Körb.	16	6		6	3		2	
Lepraria sp.	74	54		10	69	75	21	9
Melanelixia fuliginosa (Duby) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	62	35	4	19	30	11	8	
Parmelia sulcata Taylor	14	39	4	11	28	35	1	
Pertusaria amara (Ach.) Nyl.	72	63	7	22	29	29	5	1
Phlyctis argena (Spreng.) Flot.	100	60	47	48	33	44	17	
Physconia servitii (Nádv.) Poelt	66	57	1	4	1			
Ramalina sp.	18	19	10	3	7	1		
Bacidia rosella (Pers.) De Not.	6			2	1			
Lecidella elaeochroma (Ach.) M.Choisy	16	10	56	22	5	9	6	
Arthopyrenia cinereopruinosa (Schaer.) A.Massal.	1			1	1	16	20	
Pertusaria pertusa (Weigel) Tuck.	7	3		29		1		
Ramalina farinacea (L.) Ach.		8			3			
Evernia prunastri (L.) Ach.		1		4	16	4		

Stand: AS = Abeti Soprani, C = Collemeluccio. Layer (based on the diameter of the trunk and on the acidity of the bark): A = acid bark with DBH < 36 cm; B = acid bark with DBH > 36 cm; C subneutral bark with DBH < 36 cm, D subneutral bark with DBH > 36 cm. Tree: Aa = *Abies alba* Mill., Fs = *Fagus sylvatica* L., Qc = *Quercus cerris* L., Ac = *Acer campestre* L.; Cb = *Carpinus betulus* L.

(Continued)

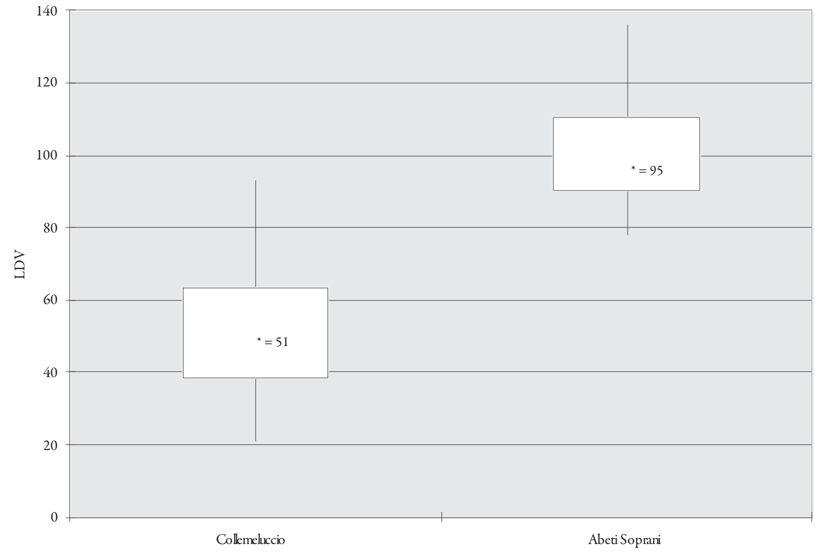
Contunued Table 1

Stand	**AS**				**C**			
Layer **Tree (n. and kind)**	**A** **5Aa**	**B** **4Aa**	**C** **3Fs**	**D** **3Fs**	**A** **2Aa, 2Qc**	**B** **3Aa, 2Qc**	**C** **1Ac, 3Cb**	**D** **2Ac, 1Fs**
Melanohalea laciniatula (H. Olivier) O. Blanco, A.Crespo, Divakar, Essl., D. Hawksw & Lumbsch		20	33		0	17		
Pachyphiale carneola (Ach.) Arnold		1		7	7			
Anaptychia ciliaris (L.) Körb.			3					
Gyalecta truncigena (Ach.) Hepp			3	5	4	12		
Lecanora chlarotera Nyl.			7	9	14			
Acrocordia gemmata (Ach.) A.Massal.				5				
Lobaria pulmonaria (L.) Hoffm.			19	16	14			
Phaeophyscia chloantha (Ach.) Moberg			2		9			
Bacidia laurocerasi (Duby) Zahlbr.			1	3				
Lecidea sp.			5		1			
Opegrapha varia Pers.				8	2	15		
Phlyctis agelaea (Ach.) Flot.				2	13	12		
Pertusaria coccodes (Ach.) Nyl.				6				
Pertusaria multipuncta (Turner) Nyl.				21				
Bacidia fraxinea Lönnr.				14	5			
Frequency	**490**	**475**	**295**	**254**	**262**	**299**	**177**	**77**
Lichen Diversity Value (LDV) in relation with the strata	**98,00**	**118,75**	**98,33**	**84,67**	**65,50**	**59,80**	**44,25**	**25,67**
LDV	**100,93**				**50,94**			

Stand: AS = Abeti Soprani, C = Collemeluccio. Layer (based on the diameter of the trunk and on the acidity of the bark): A = acid bark with DBH < 36 cm; B = acid bark with DBH > 36 cm; C subneutral bark with DBH < 36 cm, D subneutral bark with DBH > 36 cm. Tree: Aa = *Abies alba* Mill., Fs = *Fagus sylvatica* L., Qc = *Quercus cerris* L., Ac = *Acer campestre* L.; Cb = *Carpinus betulus* L.

landscape level (NIMIS *et al.*, 2002), many authors pointed out the role of climatic factors (MCCUNE *et al.*, 1997; GOWARD and SPRIBILLE, 2005; HAUCK and SPRIBILLE, 2005; GIORDANI 2006, 2007; GIORDANI and INCERTI, 2008). Some species releved only in Abeti Soprani confirm their montane character mostly related to a cold-humid climate (GIORDANI and INCERTI, 2008; NIMIS and MARTELLOS, 2008): *Arthonia radiata*, *Aplotomma turgida*, *Lecanora allophana*, *L. argentata*, *L. carpinea*, *L. intumescens*, *Micarea prasina*, *Parmelia saxatilis*, *Pertusaria albescens*, *P. flavida*, *P. leioplaca*, *Tephromela atra* v. *torulosa* while the epiphytic lichen flora of Collemeluccio shows a strong suboceanic affinity (41% of lichen species).

The plots exhibited quite different lichen diversities, probably due to ecological variables. Collemeluccio LDV is comparable with similar data from montane coniferous forested areas of Italian Western Alps (GIORDANI, 2007) while the Silver Fir forest of Abeti Soprani shows the highest LDV (Figure 2).



Stand: C = Collemeluccio, AS = Abeti Soprani.

Figure 2 – Lichen Diversity Value (LDV): AS = 100,93; C 0 50,94. For each stand are reported: median (*), max. and min., range of 25°-75° percentile value.

The percentage contributions to the total LDV of each growth form, photobiont and reproductive strategy are reported in Figures 3-5.

Both of the plots were dominated by crustose and leprose species (Figure 3), with a percentage frequency usually higher than 65%. This result appears to be related to high humidity and reduced light, which are characteristic of these stands. In fact, these features have been observed to favour the dominance of crustose (TOPHAM, 1977; PIRINTSOS *et al.*, 1995; RAVERA *et al.*, 2006), which interact positively with other lichens and with mosses; crustose lichens are also favoured by the selectivity of the smooth bark of the trees.

Lichens with foliose lobes show frequencies of about 25% but the occurrence of broad and narrow-lobed thalli is quite different between the stands. The higher frequency of narrow-lobed thalli in Abeti Soprani improves the LDV. These results confirm the general trend observed during the application of the lichen biodiversity method (GIORDANI *et al.*, 2001). Epiphytic fruticose lichens occurred with very low percentage frequencies usually preferring more light niches, *e.g.* branches or higher parts of a bole.

Chlorococcoid green Algae were the most widespread photobionts

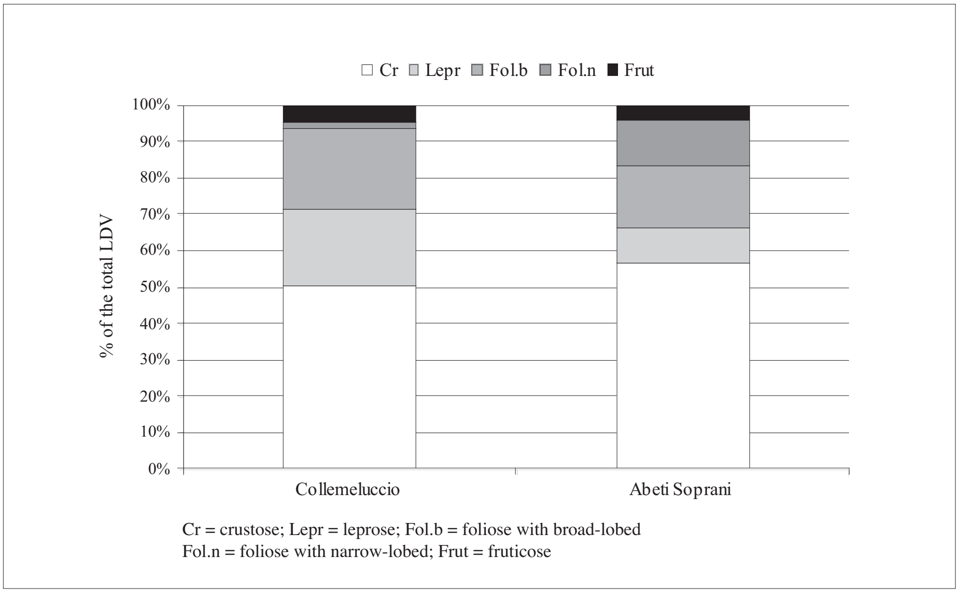


Figure 3 – Relative contribution of species with different growth forms to the total Lichen Diversity Value (LDV).

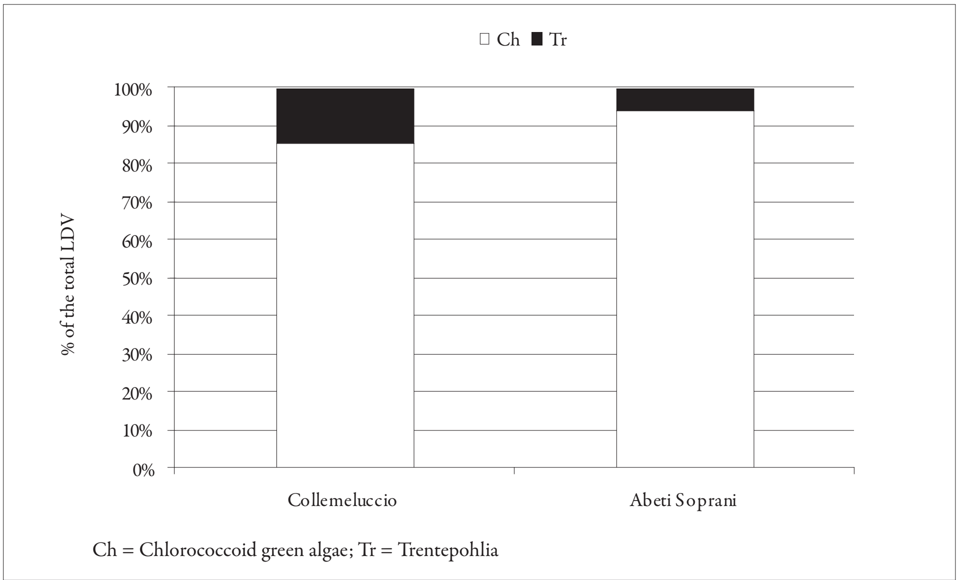


Figure 4 – Relative contribution of species with different photobionts to the total Lichen Diversity Value (LDV).

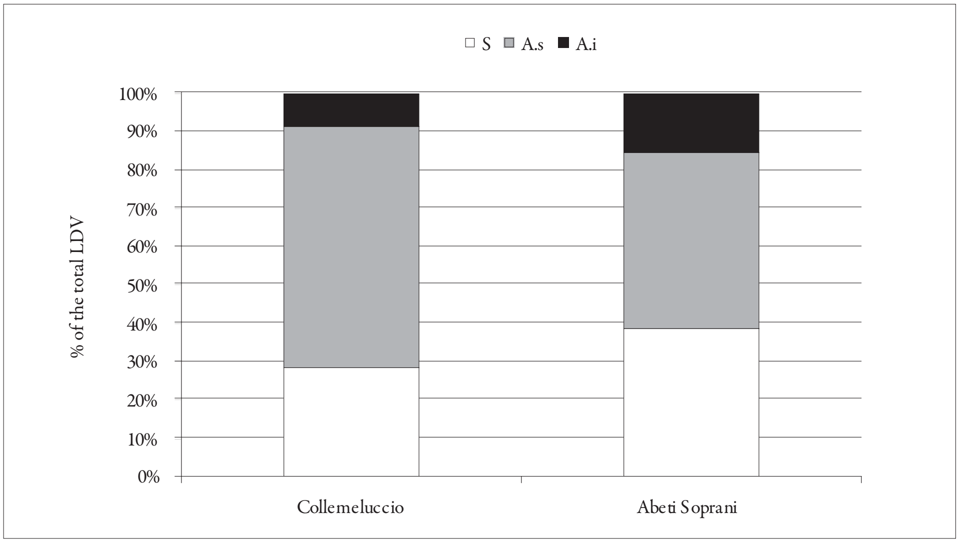


Figure 5 – Relative contribution of species with different reproductive strategy to the total Lichen Diversity Value (LDV).

(Figure 4), with frequencies higher than 85% as usual in montane coniferous forested areas (NIMIS and MARTELLOS, 2008).

About the reproductive strategy of epiphytic lichens in the plots (Figure 5), vegetative propagation by means of soredia (non-corticated propagules containing both fungal hyphae and algal cells) was predominant. This result confirm similar data from montane coniferous forested areas (GIORDANI *et al.*, 2006). Lichens adopting sexual reproduction by means of fungal spores exhibited the highest percentage frequency in Abeti Soprani.

5. CONCLUSION

Collemeluccio and Abeti Soprani support an interesting lichen flora confirming the high potential in lichen diversity of silver fir forests observed in Southern Italy (PUNTILLO, 1996). A few species are known only for these stands in Molise: *Bacidia circumspecta* and *Micarea prasina* seem to be exclusive of Abeti Soprani, *Acrocordia gemmata*, *B. laurocerasi* and *Pertusaria multipuncta* of Collemeluccio, while *Arthopyrenia cinereopruinosa* grows in both of them.

The two specific habitat types select two different lichen communities, the former (in Abeti Soprani) rich in truly montane elements, the latter (in Collemeluccio) with a strong suboceanic affinity. This character, usually correlated to a humid Mediterranean and Submediterranean lichen flora, confirms the transitional character from Central to Southern Apennine of these coenosis.

About 10% of the species are typical of undeveloped, natural environments (index of poleophoby = 0). The recovery of such lichens (*e.g. B. laurocerasi*, *B. rosella*, *Pachyphiale carneola*) in these stands supports the correctness of forest planning choices and the importance of maintaining continuity among silver fir nuclei of the Central-Southern Apennine to help preserve ecosystem function and biodiversity. Furthermore a high LDV confirms the important role of the Mediterranean old-growth forests in lichen diversity conservation.

RIASSUNTO

Diversità lichenica nei boschi vetusti del Molise

Il ruolo dei licheni come indicatori di continuità ambientale è ampiamente riportato per le foreste dell'Europa centrale e settentrionale dove sono usati nella gestione di aree boscate ad esempio come predittori della presenza di specie di pregio e come caratteristici di habitat forestali. Al contrario, le dinamiche che influiscono sulla presenza e sulla diversità lichenica dei boschi mediterranei sono ancora poco note e solo recentemente investigate. Con lo scopo di contribuire alla conoscenza delle variabili forestali che influenzano la colonizzazione lichenica in questi ambiti, è stato avviato uno studio in due boschi vetusti dell'Alto Molise appartenenti alla rete delle aree di studio individuate nell'ambito del PRIN 2007 «Metodi innovativi per la identificazione, caratterizzazione e gestione dei boschi vetusti in ambito Mediterraneo».

Le aree di studio sono quelle del Bosco di Abeti Soprani e della Riserva MAB di Collemeluccio e rappresentano due diverse tipologie forestali (rispettivamente foreste di *Abies alba* e *Fagus sylvatica* e ad *A. alba* e *Quercus cerris* dominanti). In corrispondenza di ciascuna area di studio, all'interno di un plot di un ettaro, è stata rilevata la diversità dei licheni epifiti su alberi selezionati in base ad un campionamento randomizzato stratificato.

Per stimare le differenze tra le due aree, sono inoltre stati considerati i contributi percentuali alla diversità lichenica totale della forma di crescita, del fotobionte e della strategia riproduttiva.

Il contributo riporta i risultati ottenuti nel corso della prima campagna di rilevamento come punto di partenza per la pianificazione di un monitoraggio a lungo termine. Gli indici di diversità rilevati risultano particolarmente alti, confermando anche in questi ambiti mediterranei il ruolo importante dei boschi vetusti nella conservazione della diversità lichenica.

REFERENCES

ABBATE G., 1990 – *Le foreste della riserva MAB "Collemeluccio-Montedimezzo" (Molise, Italia meridionale)*. Doc. phytosociol., 12: 291-303.

ALLEGREZZA M., BIONDI E., 2008 – *Studio fitosociologico sull'area forestale "Abeti* *soprani" (Alto Molise - Appennino meridionale).* Fitosociologia, 45 (1): 161-176.

ASTA J., ERHARDT W., FERRETTI M., FORNASIER F., KIRSCHBAUM U., NIMIS P.L., PURVIS W., PIRINTSOS S., SCHEIDEGGER C., VAN HALUWYN C., WIRTH V., 2002 – *Mapping lichen diversity as an indicator of environmental quality.* In: Nimis P.L., Scheidegger C., Wolseley P. (Eds.). Monitoring with lichens - Monitoring lichens. Kluwer, NATO Science Series, Earth and Envir., Ser. 7: 273-279.

BACARO G., ROCCHINI D., BONINI I., MARIGNANI M., MACCHERINI S., CHIARUCCI A., 2008 – *The role of regional and local scale predictors for plant species richness in Mediterranean forests*. Plant Biosyst., 142 (3): 630-642.

BORGHETTI M., GIANNINI R., 1984 – *Indagini sulla rinnovazione naturale nei boschi puri e misti di abete bianco dell'Appennino centro-meridionale*. L'Italia Forestale e Montana, 39: 161-184.

BRUNIALTI G., FRATI L., ALEFFI M., MARIGNANI M., ROSATI L., BURRASCANO S., RAVERA S., 2010 – *Lichens and bryophytes as indicators of old-growth features in Mediterranean forests.* Plant Biosystems, 144 (1): 221-233.

CAMPBELL J., FREDEEN L., 2004 – Lobaria pulmonaria *abundance as an indicator of macrolichen diversity in Interior Cedar-Hemlock forests of east-central British Columbia.* Can. J. Bot., 82: 970-982.

CHIARUCCI A., BONINI I., 2005 – *Quantitative floristics as a tool for the assessment of plant diversity in Tuscan forests*. For. Ecol. Manage., 212: 160-170.

DETTKI, H., ESSEEN, P.A., 2003 – *Modelling long-term effects of forest management on epiphytic lichens in northern Sweden*. Forest Ecol. Manage., 175: 223-238.

FERRARI G.A., WOLF U., 1970 – *Considerazioni sui suoli e la rinnovazione naturale dell'Abete bianco (*Abies alba *Mill.) del Bosco "Abeti Soprani" (Pescopennataro, IS).* Ann. Acc. It. Sci. For., 19: 423-439.

GIORDANI P., 2006 – *Variables influencing the distribution of epiphytic lichens in heterogeneous areas: a case-study for Liguria (NW-Italy).* J. Veg. Sci., 17: 195-206.

GIORDANI P., 2007 – *Is the diversity of epiphytic lichens a reliable indicator of air pollution? A case study from Italy*. Env. Poll., 146: 317-323.

GIORDANI P., INCERTI G., 2008 – *The influence of climate on the distribution of lichens: a case study in a borderline area (Liguria, NW Italy).* Plant. Ecol., 195: 257-272.

GIORDANI P., BRUNIALTI G., MODENESI P., 2001 – *Applicability of the lichen biodiversity method (L.B.) to a Mediterranean area (Liguria, NW Italy).* Cryptogamie, Mycol., 22 (3): 193-208.

GIORDANI P., BRUNIALTI G., NASCIMBENE J., GOTTARDINI E., CRISTOFOLINI F., ISOCRONO D., MATTEUCCI E., PAOLI L., 2006 – *Aspects of biological diversity in the CONECOFOR plots. III. Epiphytic lichens.* Ann. Ist. Sper. Selv., 30 (2): 43-50.

GOWARD T., SPRIBILLE T., 2005 – *Lichenological evidence for the recognition of inland rain forests in western North America.* J. Biogeogr., 32: 1209-1219.

GUSTAFSSON L., APPELGREN L., JONSSON F., NORDIN U., PERSSON A., WESLIEN J-O., 2004 – *High occurrence of red-listed bryophytes and lichens in mature managed forests in boreal Sweden.* Basic Appl. Ecol., 5: 123-129.

HAUCK M., SPRIBILLE T., 2005 – *The significance of precipitation and substrate chemistry for epiphytic lichen diversity in spruce-fir forests of the Salish Mountains, Montana.* Flora, 200: 547-562.

HILMO O., SASTAD S.M. 2001 – *Colonization of old-forest lichens in a young and an old boreal* Picea abies *forest: An experimental approach.* Biol. Conserv., 102: 251-259.

HUMPHREY J.W., DAVEY S., PEACE A.J., FERRIS R., HARDING K., 2002 – *Lichen and bryophyte communities of planted and seminatural forests in Britain: The influence of site type, stand structure and deadwood.* Biol. Conserv., 107: 165-180.

JOHANSSON P., RYDIN H., THOR G., 2007 – *Tree age relationships with epiphytic lichen diversity and lichen life history traits on ash in southern Sweden.* Ecoscience, 14 (1): 81-91.

KUUSINEN, M., 1996 – *Cyanobacterial macrolichens on* Populus tremula *as indicators of forest continuity in Finland.* Biological Conservation, 75: 43-49.

MCCUNE B., DEY J., PECK J., CASSELL D., HEIMAN K., WILL-WOLF S., NEITLICH P., 1997 – *Repeatability of community data: species richness versus gradient scores in large-scale lichen studies*. Bryologist, 100: 40-46.

NASCIMBENE J., MARINI L., NIMIS P.L., 2007 – *Influence of forest management on epiphytic lichens in a temperate beech forest of northern Italy.* For. Ecol. Manag., 247: 43-47.

NASCIMBENE J., MARINI L., MOTTA R., NIMIS P.L., 2008 – *Influence of tree age, tree size and crown structure on lichen communities in mature Alpine spruce forests.* Biodivers. Conserv., 18 (6): 1509-1522.

NIMIS P. L., MARTELLOS S., 2008 – *ITALIC. The Information System on Italian Lichens.* Version 4.0 University of Trieste, Dept. of Biology, IN3.0/2 <http://dbiodbs.univ.trieste.it/>.

NIMIS P.L., SCHEIDEGGER C., WOLSELEY P. (Eds.), 2002 – *Monitoring with lichens - Monitoring lichens*. Kluwer, NATO Science Series, Earth and Envir., Ser. 7.

PIGNATTI S., 1982 – *La Flora d'Italia*. I-II-III Voll., Edagricole. Bologna.

PIRINTSOS S.A., DIAMANTOPOULOS J., STAMOU G.P., 1995 – *Analysis of the distribution of epiphytic lichens within homogeneous* Fagus sylvatica *stands along an altitudinal gradient (Mount Olympos, Greece).* Vegetatio, 116: 33-40.

PUNTILLO D., 1996 – *Contributi alle conoscenze floristiche sui licheni d'Italia. VIII. Florula lichenica del Bosco di Santa Maria (Serra San Bruno, Vibo Valentia, Calabria)*. Webbia, 50 (1): 51-66.

RAVERA S., MASSARI G., GENOVESI V., 2006 – *Phytoclimatic characterization of lichen habitats in central Italy*. Nova Hedwigia, 82 (1-2): 143-165.

ROSE F., 1976 – *Lichenological indicators of age and environmental continuity in woodlands.* In: Brown D.H., Hawksworth D.L., Bailey R.H. (Eds.). Lichenology: Progress and problems. London, Academic Press, p. 279-307.

SILLETT S.C., MCCUNE B., PECK J.E., RAMBO T.R., RUCHTY A., 2000 –*Dispersal limitations of epiphytic lichens result in species dependent on old-growth forests*. Ecological Applications, 10: 789-799.

STOFER S., CATALAYUD V., FERRETTI M., FISCHER R., GIORDANI P., KELLER C., STAPPER N., SCHEIDEGGER C., 2003 – *Epiphytic Lichen Monitoring within the EU/ICP Forests Biodiversity Test-Phase on Level II plots. (http//www.forest-biota.org).*

TOPHAM P.B.,1977 – *Colonization, Growth, Succession and Competition.* In: Seaward M.R.D. (Ed.). Lichen Ecology, Academic Press, London, p. 31-68.

ULICZKA H., ANGELSTAM P., 1999 – *Occurrence of epiphytic macrolichens in relation to tree species and age in managed boreal forest*. Ecography, 22: 396-405.

WILL-WOLF S., ESSEEN P.A., NEITLICH P., 2002 – *Monitoring biodiversity and ecosystem function: forests*. In: Nimis P.L., Scheidegger C., Wolseley P. (Eds.). Monitoring with lichens - Monitoring lichens. Kluwer, NATO Science Series, Earth and Envir., Ser. 7: 203-222.