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DISTRIBUTION OF EPIPHYTIC LICHENS ON *QUERCUS PUBESCENS* ALONG AN ALTITUDINAL GRADIENT ON THE ADRIATIC SIDE OF CENTRAL ITALY

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Abstract: The distribution of epiphytic lichens on *Quercus pubescens* on the Adriatic side of Central Italy (Abruzzo) was studied along an altitudinal gradient from 0 to 1000 m by multivariate techniques. The general response of epiphytic lichens to elevation was similar to that found on the Tyrrhenian side of Italy, with great differences in community structure and the altitude of 500 m as an ecotone. However, suboceanic species, which are widespread on the Tyrrhenian side, were rare and confined to higher elevations, or not present at all in the Adriatic gradient. The use of epiphytic lichens as phytoclimatic indicators is discussed.

Introduction

Altitude is a primary parameter for the distribution and development of lichen communities. According to Pirintsos *et al.* (1995), it is the main factor determining the spatial heterogeneity of epiphytic lichens on *Fagus*. Pirintsos *et al.* (1993) found changes in the community structure of epiphytic lichen vegetation on *Pinus* along an altitudinal gradient in Greece. Loppi *et al.* (1997) investigated the distribution of epiphytic lichens on *Quercus pubescens* along an altitudinal gradient in Tuscany (Central Italy), and found great differences in community structure, with the altitude of 500 m as an ecotone.

Nimis & Tretiach (1995) outlined the main phytoclimatic features of Italy based on the distribution of lichens, and found that the Italian peninsula is divided into an east-west partition due to the more pronounced suboceanic climate of the Tyrrhenian side. Since climatic parameters (i.e. temperature and rainfall) are closely related to elevation, knowledge of the response of lichens to altitudinal gradients is essential if these organisms are to be used as phytoclimatic indicators (Bates & Farmer, 1992).

In the present study, we repeated the investigation of Loppi *et al.* (1997), with the same methodological standards, in an area located at the same latitude, but on the Adriatic side of Italy. The study had two aims: 1) to investigate the distribution of epiphytic lichens on *Quercus pubescens* along an altitudinal gradient from 0 to 1000 m on the Adriatic side of Central Italy; 2) to compare the distribution with that along the same gradient on the Tyrrhenian side of the country.

Data and Methods

The study was performed in the Abruzzo Region, in an area extending from the Adriatic sea to 1000 m on the eastern slopes of the Gran Sasso massif in the Apennines (Fig. 1). The topography is highly varied and the landscape roughly consists of coast and river plains, sandy and clayey hills, and sedimentary mountains. Climate is transitional between the continental and the Mediterranean ones, and is strongly influenced by distance from the sea and elevation (Tab. 1).

The study area was divided into ten 100 m altitudinal belts, and for each belt the epiphytic lichen vegetation was surveyed in 5 stations located in areas far from local sources of air pollution (Fig. 1). Each station consisted of 5 free-standing *Quercus pubescens* trees, where lichens were sampled using a rectangular template of 30x50 cm placed on the bole at breast height (mean bole circumference was 128 ± 36 cm), for each of the 4 cardinal compass directions. Part of

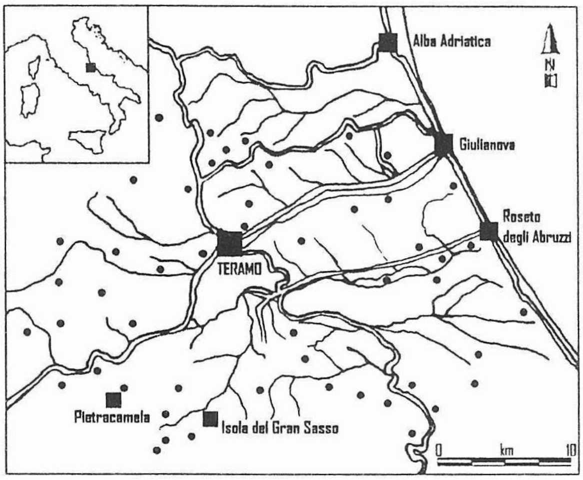

Fig. 1 - Study area with location of sampling sites.

these data were used for an air quality survey of the whole Teramo province (Olivieri *et al.*, 1997).

For each species, the cover and frequency of occurrence were taken into account simultaneously to calculate the importance value (IV), according to the relationship: IV = % relative cover + % relative frequency, where, for each sampling belt, % relative cover = 100 x ((cover / maximum possible total cover) and % relative frequency = 100 x (number of occupied templates / total number of templates).

The data were processed by Detrended Correspondence Analysis (DCA) (Hill & Gauch, 1980) for a preliminary inspection of microhabitat spatial heterogeneity, and by Two-Way Indicator Species Analysis (TWINSPAN) (Hill *et al.*, 1975) for further grouping of samples and species (Gauch, 1982).

Results

Seventy-seven epiphytic lichen species were recorded during the survey. Their importance values in each belt are shown in Tab. 2. Ordination of sampling belts and lichen species in the plane of the first two axes of DCA and classification of both emerging from TWINSPAN are shown in Fig. 2. The first ordination axis accounted for 81% and the second for 13% of the total variance of the data.

The sampling belts fell into two main groups (A and B) at the first level of TWINSPAN classification. The two groups were disposed on the first axis of DCA in relation to elevation, with group A including lower sampling belts (< 500 m) and group B higher ones (> 500 m). Elevation was statistically significant as discriminant factor (99.9% confidence interval, Kolmogorov-Smirnov two-sample test).

The species fell into four groups and were disposed in relation to elevation along the first DCA axis. Group A contained species recorded exclusively in lower belts (< 500 m) and group D contained species recorded exclusively in higher ones (> 500 m). Groups B and C included species present throughout the range of altitudes (B), or with a slight preference for higher elevations (C).

Discussion

The epiphytic lichens found on isolated *Quercus pubescens* trunks in the study area seem to be quite typical of this tree species, and comparison with the list reported by Loppi *et al.* (1997) for *Q. pubescens* in Tuscany showed 40% similarity (43 species in common, out of 71 in Tuscany and 77 in Abruzzo). The main difference with respect to Tuscany was the scarcity or the low

Table 1 - Mean monthly temperature (T, °C) and rainfall (P, mm) in three climatic stations representative of the study area (data from Ministero LL.PP., Servizio idrografico, 1960-1990).

	J	F	M	A	M	J	J	A	S	O	N	D
	Giulianova (2 m asl) 14.8°C - 647 mm											
T	7.1	8.2	10.6	14.3	18.6	22.1	24.8	25.1	21.7	17.2	12.1	8,9
P	47	38	50	55	41	54	36	53	64	74	57	53
	Teramo (300 m asl) 14.5°C - 758 mm											
T	6.1	7.1	9.6	12.9	17.1	20.8	23.9	23.7	20.4	15.8	10.8	7.6
P	55	52	65	66	60	65	47	55	69	74	75	61
	Pietracamela (1000 m asl) 11.2°C - 1198 mm											
T	3.0	3.3	5.3	8.5	12.9	16.6	19.6	19.4	16.2	11.8	7.6	4.9
P	76	74	88	97	75	73	45	51	77	105	127	89

Table 2 - Lichen species with their importance values in each zone, arranged according to TWINSPAN. Nomenclature follows Nimis (1993).

Sampling Zones	Group A					Group B				
	1	2	3	4	5	6	7	8	9	10
Species Group A										
Hyperphyscia adglutinata	184	192	165	192	130	46	32		9	
Physconia grisea	26	52	45	21	39		30		8	
Rinodina pyrina		1	2	4	4				6	
Chrysotrix candelaris		1			3					
Lecidella elaeochroma	3	7		4	4		5			
Lepraria incana					3					
Lecanora hagenii	7		3		3					
Phaeophyscia hirsuta	23	25	10	5	16					
Caloplaca ferruginea			2							
Catapyrenium psoromoides				5						
Diplotomma alboatrum			2	4						
Lecanora horiza	71	55	34	25	3					
Opegrapha varia	49	31	15	4	3					
Rinodina exigua	2	7	2							
Species Group B										
Parmelia subrudecta	1		2		12	9			5	
Pertusaria albescens		1	8	4	10	33	29		61	70
Xanthoria fallax					6		30			
Candelaria concolor	4	4	36	23	62	103	67	29	20	20
Physcia biziana	38	66	74	86	60	42	22	83	13	20
Phaeophyscia orbicularis	22	20	74	100	103	120	103	70	50	41
Physcia adscendens	86	87	99	66	139	144	128	179	135	142
Physcia aipolia	3	14	37	56	68	121	81	139	87	102
Physcia tenella	57	78	67	75	21	28	67	43	75	83
Physconia distorta	5	24	60	108	85	116	157	100	125	118
Xanthoria parietina	148	160	156	144	113	111	96	131	103	116
Caloplaca cerina	3	8	11	8	11	24	73		54	24
Caloplaca cerinella	3	5	5		7	36	5		20	
Species Group C										
Collema ligerinum				4	3		32		22	31
Phaeophyscia ciliata	2				21	12	22	98	104	58
Hypogymnia physodes			6						14	
Pertusaria coccodes					6	14				
Candelariella vitellina			2		3		9		28	
Collema furfuraceum	1	2	2		3	39	57	15	65	48
Lecidella euphorea	2		5		12	128	25	64	85	183
Parmelia acetabulum			2	4	3		15	15	52	83
Parmelia glabra				4	10	9	56	46	73	131
Parmelia tiliacea			5		30	73	80	29	57	97
Physconia servitii	1		3	5	3	73	40	33	15	77
Candelariella reflexa	2	3	7		14	83	42		21	10

Collema subflaccidum	1				8		10		23	
Lecanora chlarotera	3	6	4		14	62	22	35	60	63
Parmelia subargentifera					6		5			33
Physconia perisidiosa			8	17	30	74	61	14	57	96
Bacidia rubella				5	3				28	13
Lepraria sp.			2						20	
Species Group D										
Caloplaca flavorubescens	1				3	19	31	29	83	85
Lepraria lobificans			2				13		5	9
Parmelia caperata					3	10			10	9
Candelariella xanthostigma	1		4		3	76	27	68	47	33
Megaspora verrucosa v. *mutabilis*		1							5	
Parmelia sulcata			2			11			42	63
Arthonia radiata							5			
Collema nigrescens							7			
Buellia griseovirens									11	
Collema flaccidum							5		12	9
Evernia prunastri								14	14	10
Leptogium hildebrandii							7		22	9
Leptogium saturninum									11	
Physconia enteroxantha									10	27
Physconia venusta									10	
Usnea hirta									10	
Anaptychia ciliaris							5	15	10	28
Caloplaca haematites	1					32	6		10	30
Lecanora carpinea						10	17	45	46	79
Parmelia glabratula						9			12	9
Parmelia subaurifera						9			15	55
Physcia semipinnata								41	15	41
Physcia stellaris								39	34	63
Ramalina fastigiata								31	10	33
Caloplaca holocarpa									16	
Catillaria nigroclavata										11
Lecanora allophana									48	9
Lecanora argentata						10				
Lecanora meridionalis									7	
Parmelia quercina									13	40
Parmelia soredians										18
Rinodina sophodes										18

frequence/abundance of Mediterranean and subatlantic species in Abruzzo.

As a whole, the epiphytic lichen flora surveyed was characterized by sub-Mediterranean and central-European elements (Nimis, 1993), having their ecological optimum in aero-xerophytic and nitrophytic *Xanthorion* communities (Barkman, 1958). Species common along the entire altitudinal gradient (*Candelaria concolor, Phaeophyscia orbicularis, Physcia adscendens, P. aipolia, P. biziana, P. tenella, Physconia distorta, Xanthoria parietina*) are mostly photophilous, nitrophilous and xerophilous *Xanthorion* species (Barkman, 1958). Their distribution is chiefly promoted by agricul-

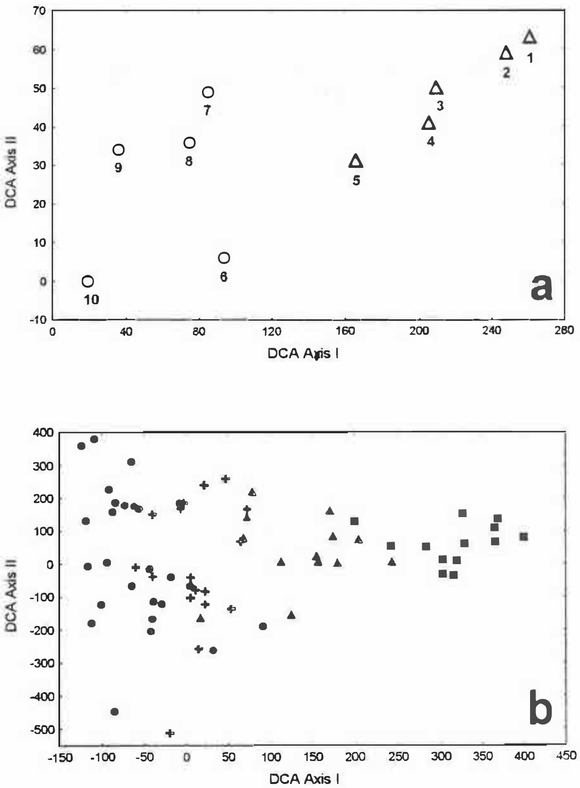

Fig. 2 - Ordination of sampling belts (a) and lichen species (b) on the plane of the first two axes of DCA and classification of both as result of TWINSPAN analysis (Δ = sampling belt group A, O = sampling belt group B; ■ = species group A, (▲ = species group B, (+ = species group C, ● = species group D).

ture, which increases eutrophication of bark and leads to neutral or basic bark pH due to nitrogen fertilizers and/or dust (Gilbert, 1976), conditions which are ideal for the development of *Xanthorion* communities.

The general response of epiphytic lichens to elevation was similar to that found on the Tyrrhenian side of Italy. As found for the same altitudinal gradient in Tuscany (Loppi *et al.*, 1997), the elevation of 500 m was identified as an ecotone. There were remarkable differences in the structure of the lichen communities along the gradient. At lower elevations, they were characterized by rather poor floristic diversity and species commonly found below the ecotone were typical of dry habitats (*Hyperphyscia adglutinata, Lecanora horiza, Physconia grisea*), others indicating more humid conditions (*Phaeophyscia hirsuta, Opegrapha varia*) determined by the vicinity to the Adriatic sea. On the contrary, at higher elevations lichen communities were more diversified, and common species above the ecotone (*Anaptychia ciliaris, Caloplaca flavorubescens, Collema flaccidum, Evernia prunastri, Lecanora carpinea, Leptogium hildebrandii, Parmelia glabratula, Parmelia subaurifera, Physcia stellaris, Ramalina fastigiata*) were typical of the montane belt and of wetter habitats.

The distribution of some species is worth noting. *Lecidella elaeochroma* and *L. euphorea* are clearly vicariant along the altitudinal gradient, the latter being much more frequent at higher elevations. According to Nimis (1993) *L. euphorea* occurs in less nutrient-enriched and more shaded situations, and is more frequent in upland areas than *L. elaeochroma*. However, it should be noted that the two species are distinguished by diagnostic characters which are problematical to detect in the field, and thus some confusion is possible. *Caloplaca haematites, Lecanora allophana, L. argentata, L. carpinea, L. meridionalis, Parmelia glabratula, Physcia semipinnata,* are species found at higher elevations in Abruzzo and at lower elevations in Tuscany. In Abruzzo *Parmelia soredians* was found only in the upper altitudinal belt (900-1000 m), whereas in Tuscany this species is found along the Tyrrhenian coast in humid situations (Nimis *et al.*, 1990; Putortì & Loppi, 1999). Some suboceanic species common in Tuscany (Loppi *et al.*, 1997) are rare (*Parmelia caperata*) or not present at all (*Normandina pulchella, Parmotrema chinense*) in the Abruzzo gradient. The fact that the Adriatic side of Italy is drier than the Tyrrhenian one has also been noted for *Quercus*-dominated forests (Biondi & Baldoni, 1991). Since lichens are more sensitive to variations in air humidity than vascular plants, they reflect these east-west differences to a greater extent.

Conclusions

In Abruzzo, despite the wide distribution of *Xanthorion* species, the effects of accumulation of nitrogen compounds and/or dust impregnation were evident only at a local level, in areas of similar elevation and climate, which were the main ecological factors influencing the distribution of the lichen communities. Except on the Abruzzo coast, the few suboceanic species present were generally found only at higher elevations, where their air humidity requirements are met. Compared to Tuscany, where the same species are much more widely distributed, this determines a sort of reverse pattern of these lichens. However, in Abruzzo the general response of epiphytic lichens to elevation was similar to that found on the Tyrrhenian side of Italy, where the altitude of 500 m was also found to be an ecotone.

To some extent, it is rather surprising that two different climatic regions have a discontinuity in lichen communities at the same altitude, without a shift between limits of contiguous bioclimatic belts. However, despite obvious differences in species composition, lichen communities are likely to be influenced by a complex of interactions between environmental variables and human activities (e.g. land use), which may make their response along an altitudinal gradient rather similar. In other words, it is well possible that in unpolluted areas, i.e. excluding air pollution as determinant, epiphytic lichens are influenced not only by climatic parameters, but also by other factors in some way related to climate, such as agricultural practices, forest type and management, etc.

However, confirmation of the existence of this altitudinal ecotone is noteworthy, since it is critically important for the use of epiphytic lichens as bioindicators of air quality. In fact, the use of lichens in this field is based on the assumption that ecological parameters other than air pollution have a constant effect on these organisms.

Finally, since variations in ecological factors induce variations in the frequencies of lichen species with given distribution patterns, and elevation is closely related to climatic parameters, the linear response of epiphytic lichen communities on *Q. pubescens* to elevation, at least in central Italy, shows that lichens themselves can be used as phytoclimatic indicators.

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