Analysis of the distribution of epiphytic lichens within homogeneous *Fagus sylvatica* stands along an altitudinal gradient (Mount Olympos, Greece)

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**Abstract**

Epiphytic lichen vegetation on *Fagus sylvatica* was studied in 4 sites along an altitudinal gradient from 930 to 1500 m on SE facing slopes of Mount Olympos (Greece). The crucial factor determining the spatial heterogeneity of epiphytic lichens on *F. sylvatica* is the altitude and not the height on the trunk at which lichen community is established. 17 out of 26 taxa are confined to a particular elevation range, while another three are clearly ubiquitous in their distribution. The number of lichen species at breast height is higher than at the base of the trunks. The results were compared with those gathered earlier in an analogous study on the vertical distribution of epiphytic lichens on *Pinus nigra* along an altitudinal gradient from 750 to 1510 m of the same mountain. Comparison suggests that spatial heterogeneity of epiphytic lichens on *F. sylvatica* is different from the one on *P. nigra*.

**Introduction**

The fact that epiphytic lichens show differences in vertical distribution on tree trunks is well documented (Hale 1952; Culberson 1955a, b; Hale 1955; Brodo 1968; Kalgotkar & Bird 1969; Harris 1971; Brodo 1973; Pike *et al.* 1975; James *et al.* 1977; Eversman 1982; Eversman *et al.* 1987; Pirintzos *et al.* 1993a, b). Vertical distribution of epiphytic lichen communities is probably related to the particular tree species, and differences along environmental gradients (altitudinal or pollution gradients) could provide useful information both in unpolluted and polluted regions (Eversman 1982; Pirintzos *et al.* 1993a, b).

In a previous paper (Pirintzos *et al.* 1993b), we studied the extent to which microhabitat heterogeneity influences species composition and structure of epiphytic lichen vegetation on *Pinus nigra* along an altitudinal gradient in an homogeneous forest (750–1510 m) on Mount Olympos. The critical factor for spatial distribution was the height at which the lichen community develops on the tree trunk. Changes in the community structure of the epiphytic lichen vegetation were also recorded along the altitudinal gradient, and the altitude of 1200 m was considered to be an ecotone. *Fagus sylvatica* is another important substrate for epiphytic lichen communities on Mt. Olympos. *Fagus sylvatica* forests are characterized by less xeric conditions than *P. nigra* forests (Polunin 1980). The question put forward was whether changes in the epiphytic lichens on *F. sylvatica* along the altitudinal gradient follow the same pattern as on *P. nigra*. Thus the aim of the present study was to seek for changes in the epiphytic lichen vegetation on *F. sylvatica* (Olympos-Greece) along vertical gradient on the tree trunks and the altitudinal gradient on the mountain.

**Study site**

Mount Olympos is the natural barrier between Thessaly and Macedonia (lat: 40° 00' N; 22° 00' E). It is the highest mountain of Greece (2917 m a.s.l.) and the second highest in the Balkan Peninsula.

Mount Olympos consists almost entirely of formations of limestones and marbles. In the study area, located in the Enipeas valley, the sampling plots were confined on Crystalline Triassic limestone and dolomites (IGME 1978–1983). Vegetation in this part of the mountain, consists of evergreen sclerophyl-
lous formations at low altitude, *F. sylvatica* forests in the valley, *P. nigra* forests and *P. heldreichii* (=leucodermis) forests and alpine formations of low shrubs and herbaceous plants at the alpine zone. *Fagus sylvatica* woods do not form a continuous belt around the mountain. They are found in patches in the valleys where the soil is deep and there is a fair amount of moisture (Polunin 1980). Information about the climate is given in Pirintsos et al. (1993b).

Methods

In order to select the experimental sites all existing stands with *F. sylvatica* have been explored. The most appropriate sequence of stands along the gradient was that of Enipeas valley consisting of four homogeneous *F. sylvatica* patches. Within each of them four experimental sites were chosen at 930, 1030, 1250 and 1500 m a.s.l.. Mixed forest stands of *F. sylvatica* and *P. nigra* were excluded from the investigation due to different microclimatic conditions.

Data for epiphytic lichens were taken from 40 trees (10 from each sample site) during the period 1987–90. On each tree (mean circumference at breast height 58.6 ± 5.83 cm), records were taken for each orientation. At both breast height and base two belts (26 cm width) covering the entire tree circumference were defined. The belts were subdivided into four parallelograms centered on the four points of the compass. In total, for each tree, 8 sample units were taken. Sampling method followed Green (1979) since the homogeneous sampling area was small enough as to random sampling to be possible. At each sample site the first representative tree was chosen randomly. In order to avoid spatial hazards, the first tree was as close as possible to the middle of the homogeneous forest stand (no trees other than *F. sylvatica*, in the closed continuous canopy were recorded). Then the nearest nine trees were chosen. Thus a more or less homogeneous sampling area, representative of the whole stand was defined. The number of species was recorded and their importance values (see below) were estimated. The sampling size (10 trees × 8 sampling units) was considered satisfactory since further increase of sampling size did not result in increase in the number of species, while the variance of the importance value remained stable. In total, data were taken from 320 sample units.

Data from sample units with the same orientation and the same position on the tree trunks were compiled to estimate importance values of lichen species in each sample. We preferred to estimate species importance value instead of either cover or frequency. The latter correspond to different ecological processes. Cover relates mainly to plant growth forms and is associated with local abundance, frequency relates mainly to species spatial distribution, while importance value balances the estimates of both cover and frequency. For the estimation of the species importance value, in each sample, the cover and the frequency of occurrence of each species in the sampling units were combined, according to the relationship:

\[ \text{Importance value} = \% \text{Relative cover} + \% \text{Relative frequency} \]

The maximum value of this index is 200 and refers to species displaying 100% cover in all sampling units.

For each site a data matrix was produced with 8 samples, differing in accordance to orientation (E, S, N, W) and their vertical distribution on the trunks (breast height, trunk base). The 32 samples from the four data matrices were processed by Detrended Correspondence Analysis (DCA) (Hill & Gauch 1980) for a preliminary inspection of the existing heterogeneity. Two-Way Indicator Species Analysis (TWINSPLAN) (Hill et al. 1975) was used for further grouping of samples and species.

Results

Twenty-six epiphytic lichen species were recorded in the 320 sample units. Ordination of samples by Detrended Correspondence Analysis (DCA) is depicted in Fig. 1. The first ordination axis accounts for 65% and the second one for 18% of the total data variability. Samples are ordinated on the first axis with respect to their position in the altitudinal gradient. Samples from higher altitudes are ordinated close to the left end-point of the first axis. As far as the second ordination axis is concerned, the samples tend to be ordinated according to their vertical distribution on the trunk although this tendency is not clearly depicted. Samples are not ordinated with respect to the orientation of the bark on the trees.

Ordination of species by using DCA is shown in Fig. 2. Species recorded only at higher altitudes are ordinated close to the left end-point, while species recorded only at lower altitudes are ordinated close to the right end-point of the first axis.