Algal layer ratios of the pollution-tolerant lichen *Parmelia sulcata* as environmental bioindicators

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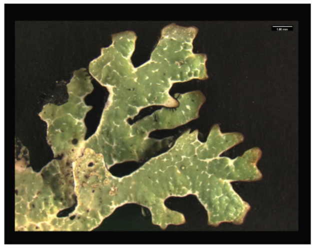
Introduction

The use of lichens as bioindicators of air quality has been applied through the observation of community composition and, more recently, ultrastructural investigation. Within the thallus of the pollution-tolerant lichen *Parmelia sulcata*, the width of the algal layer has been shown to reflect reproductive rates [1] and SO_2 pollution levels [2] . However, the effects of other environmental variables on algal layer width have not been explored.

Our objective was to describe the changing nature of the lichen symbiosis in association to anthropogenic and ecological influences. We hypothesized that algal layer ratios would increase with increases in:

- NO_2 concentration ([NO2])
- height in the canopy
- substrate pH



Lobes of *P. sulcata* thallus (10x)
(Photo-Montage by Nick Smith)

Materials and methods

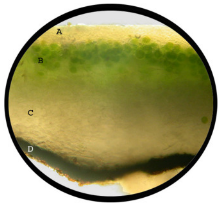
Three different studies were conducted to investigate the potential effects of environmental variables on algal layer ratios. These included:

•Collection from one rural and two urban sites along a [NO_2] pollution gradient.
- [NO_2] data were obtained from EPA monitoring stations for each site.
- Thirty samples were collected within a 2 km radius of each station.

•Collection at equal intervals along a canopy height gradient from the base to the crown of *Alnus rubra* trees.
- Thirty samples were collected at 3 m intervals according to availability.

•Collection of 10 individuals from each of 2 distinct arboreal substrates: *A. rubra* and *Psuedotsuga menziesii.*.
- Bark pH was measured using a digital pH meter with a glass electrode in a 10:1 DI water (mL) to bark (g) ratio.

Algal layer ratio measurements were recorded using light microscopy. The algal layer width and total thallus thickness were measured at 400x from five sections of each sample. Percent algal layers were calculated and compared with respective variables. The [NO_2] pollution study data were analyzed using a one-way ANOVA; the canopy stratification and substrate pH studies were analyzed using linear regression analysis.

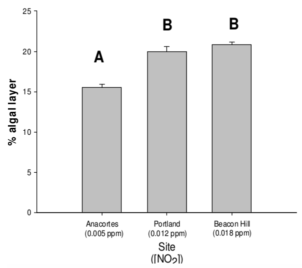


Cross section of *P. sulcata* (640x)
(Zeiss photo by Kim McNett)
A : Upper Cortex
B : Algal Layer
C : Medulla
D : Lower Cortex

Results

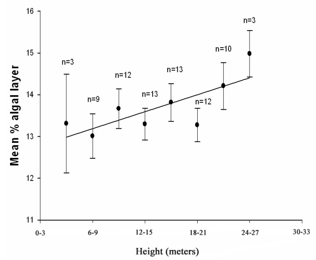
As the concentration of NO_2 increased, algal layer ratios also increased, exhibiting the fertilizing effect of NO_2.

$p < 0.001$



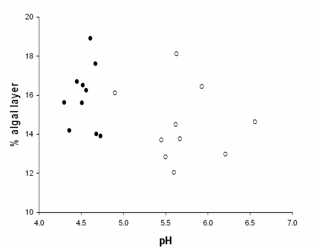
As height in the canopy increased, algal layer ratios also increased.

$p < 0.05$
$r^2 = 0.60$



As pH increased, algal layer ratios decreased, though this trend was not significant.

$p > 0.05$



Conclusions

Our hypotheses that algal layer ratios would increase with higher [NO_2] and an increase in canopy height were supported.

• **The positive relationship between algal layer ratios and [NO_2]may imply that NO_2 has a fertilizing affect on the algae in *P. sulcata*.** *Parmelia sulcata* has been characterized as a pollution-tolerant lichen [3,4] . Since *P. sulcata* is capable of withstanding the harmful effects of other pollutants present in many urban areas (SO_2, O3, CO), it may be one of the few species able to capitalize on the fertilizing benefits of excess NO_2.

• **The positive relationship between algal layer ratios and height in the canopy suggests that location on a substrate can alter symbiont proportions in *Parmelia sulcata*** This may be to an increase in light availability though other factors such as temperature, humidity, exposure, and/or competition with epiphytic bryophytes may contribute to this trend.

• **The difference in algal layer ratios corresponding with variation in [NO_2] was two-fold greater than the variation along the canopy height gradient**. This suggests that even minor pollution gradients may have a stronger effect on the nature of the lichen symbioses than ecological influences alone.

• **Fluctuations in substrate pH may contribute to shifts in the occurrences of lichen species [5], but our data are inconclusive.** Results do not show that algal layer morphology reacts to fluctuating pH in a similar manner. Further studies need to address other substrate species (including exotics) and whether intra-specific substrate pH varies with geographic locality.

Variation in the percent algal layer of *P. sulcata* cannot be unequivocally ascribed to a single environmental variable. This study provides evidence that atmospheric pollution and canopy height are more likely to influence the lichen symbiosis than substrate pH. Assessing the morphological impacts of pollution on other lichen species could lend more insight into the hyper-sensitivity of the algal layer as an indicator of air toxicity.

Literature cited

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Acknowledgments

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