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Front Cover: *Ramalina menziesii*. See article by Shrestha and St. Clair pg. 5. Photo by Kerry Heise.
The Effects of Gaseous Ozone and Nitric Acid Deposition on Two Crustose Lichen Species from Joshua Tree National Park

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My name is Elizabeth C. Hessom, and I recently completed my M.S. in Environmental Sciences at the University of California, Riverside. Towards the end of 2011, I received a student grant from CALS to support my thesis research looking at the effects of two common atmospheric pollutants on two crustose lichen species from Joshua Tree National Park. Here I present the summarized findings from this research.

When I started graduate school in 2010, I had a piqued interest in lichens; however I had little direct research experience with them, let alone with the crustose growth form. Preliminary studies helped increase my comfort level in working with crustose lichens, and I became more and more intrigued about lichens in general. At the time I was also working for the USDA Forest Service Pacific Southwest Research Station in Riverside, CA, under the supervision of Dr. Pamela Padgett. The Forest Service had used epiphytic lichens as passive bioindicators of atmospheric conditions, and was interested in expanding this use to crustose lichens. This interest shaped my research project which looked at the effects of two common atmospheric pollutants on two common crustose species within southern California, specifically Joshua Tree National Park. I wanted to see if they could be used as passive bioindicators.

In order to gain insight on what crustose lichen species were present within the park, and which ones would be ideal for collecting, I contacted Kerry Knusden, from the UC Riverside Herbarium for his input. Kerry had been working in the park at the time doing an assessment of the lichen species present, and provided me with helpful information. We took our first field trip to the park in May 2011 to assess which lichens I should collect in areas where low atmospheric deposition was occurring. This helped ensure that the lichen samples I was working with would be fairly pristine before I exposed them to their lab fumigation trials of different atmospheric pollutants. After that first trip, Kerry and I decided that I should collect two fairly prevalent species for my study, Lobothallia praeradiosa (Nyl.) Hafellner, and Acarospora socialis H. Magn.. Both
of these species also happened to have unknown sensitivities to ozone (O₃) and the nitrogen compound nitric acid (HNO₃), which are prevalent atmospheric pollutants within the Los Angeles Basin. Westerly winds often cause these pollutants to deposit within Joshua Tree National Park, so we decided that these species would be tested for their sensitivities to O₃ and HNO₃ (Allen et al. 2006; Allen et al. 2009), to see if they could be used as passive indicators for the pollutants.

Kerry and I proceeded to return to Joshua Tree National Park multiple times within the next year to set-up passive samplers (to detect current atmospheric pollutant concentrations in the field), and to collect the lichen samples themselves. Since the lichens were crustose in nature, this made them more difficult to collect than epiphytic growth forms, because they need to remain attached to their rock substrate. This resulted in hot days in Joshua Tree National Park, chipping away at rocks to get lichen samples (Fig. 1). Once collected, the samples were brought back to UC Riverside and prepped for fumigations in the CSTRs (continuously stirred tank reactors) (Fig. 2) with O₃ and HNO₃ separately.

The two lichen species underwent an O₃ fumigation, and a HNO₃ fumigation, both of which were 90 days long. Throughout the fumigations, physiological measures were taken on day 0, 30, 60, and 90 to assess the health of the lichen species in response to the pollutants. These measures included recording: 1) chlorophyll fluorescence to determine if damage occurred to photosystem II (PSII) or the algal component of the lichen, and 2) measuring ion loss to determine if thallus damage had occurred. In addition,
microscopic imaging was performed during each sampling period to register if thallus damage or color change had occurred. A novel protocol was also developed to measure the dark respiration occurring from the lichens during each sampling period to see if the fungal component of the lichens was damaged, and changing the output of CO$_2$ being released. Previous protocols used in the literature involved more destructive methods, which removed the lichen from its substrate (Larson & Kershaw 1975). However, in order to avoid this destructive step with the crustose lichen, a protocol was developed by placing the lichen/rock substrate sample into a darkened mason jar, which was then hooked up to a Licor-7000 infrared gas analyzer (LI-COR Environmental, NE, USA) to measure the total released CO$_2$ during dark respiration from the lichen sample. With the results from these measures, we were able to determine the sensitivity of Lobothallia praeradiosa (Nyl.) Hafellner, and Acarospora socialis H. Magn. to O$_3$ and HNO$_3$.

Results indicated that both species had similar sensitivities to O$_3$ and HNO$_3$. Both species registered physical damage during the O$_3$ fumigation (as captured by the imaging protocol, Fig.3), increased cation loss, as well as a decrease in dark respiration. Neither species showed major physical damage to HNO$_3$, but both manifested a decrease in chlorophyll fluorescence, suggesting damage to the photosynthetic systems of the algae symbiont. These results suggest that both species reacted negatively to the presence of O$_3$, and therefore could be used as passive bioindicators for O$_3$ in a field setting. The species however did not have a strong negative reaction to HNO$_3$ fumigation, indicating that it may not be feasible to use these species as bioindicators of HNO$_3$ pollution.

Findings from this research also suggested that the fungal component is more sensitive to the present atmospheric pollutants than the algal component. This may be due to the fact that the fungal component makes up the majority of the lichen structure, thus more of it is exposed to atmospheric deposition, whereas the algal component is more protected within the fungal structure (Purvis 2000).

Overall, this study expanded the background knowledge of these two unstudied crustose species, their susceptibilities to two different pollutants, and their potential use as passive
bioindicators for atmospheric pollution. This study also helped expand the current research on crustose lichen species, and illustrated that atmospheric deposition fumigation studies can be done on crustose lichens, despite the difficulties they present in needing to remain attached to their substrate. I hope that this research generates interest to work with crustose lichens, and use them as bioindicators in the future.

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Literature Cited


