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Emersion Stress in Intertidal Seaweeds: Role of Active Oxygen

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Emersion Stress in Intertidal Seaweeds: Role of Active Oxygen

Project Participants

Senior Personnel

Name: Davison, Ian
Worked for more than 160 Hours: Yes
Contribution to Project:

Post-doc

Name: Collen, Jonas
Worked for more than 160 Hours: Yes
Contribution to Project:

Graduate Student

Undergraduate Student

Research Experience for Undergraduates

Organizational Partners

Other Collaborators or Contacts

Activities and Findings

Research and Education Activities:
This project was designed to test the hypothesis that the differences in the production of, or protection against, reactive oxygen species such as superoxide, hydrogen peroxide and hydroxyl radicals may explain the different abilities of intertidal seaweeds to tolerate emersion stresses such as desiccation, freezing and high light and temperature. There is a vertical gradient of stress tolerance with upper-shore species being more tolerant than lower shore species; these difference in stress tolerance are believed to play a role in controlling community structure. Our ultimate objective is to understand the mechanisms and hence the costs associated with stress tolerance and to incorporate this information into ecological models that explain competitive interactions between species across an environmental (stress) gradient. The project has supported a full-time postdoctoral research fellow, Dr. Jonas CollÚn. Dr. CollÚn has made excellent progress and most of the objectives of the study have been achieved. Four papers have been published and another is in press; in addition, our research has been presented at several National and International meetings.

Findings:
We have developed a technique to allow direct measurement of reactive oxygen (free-radical) formation in seaweeds. This technique is based upon the in vivo formation of the fluorescent compound dichlorohydrofluorescein (DCF). Together with established techniques, the DCF method has allowed us to examine the production and damage caused by active oxygen species. Using species of intertidal Fucus as a model system, we discovered that reactive oxygen production, and subsequent damage was increased by freezing, desiccation or high light stress. In general, stress-tolerant upper-shore species produced less reactive oxygen when subject to stress, and experienced less membrane lipid peroxidation than stress-susceptible lower-shore or rock pool species. There were no interspecific differences in contents of major antioxidants

such as carotenoids, ascorbate, tocopherol and glutathione. The least stress-tolerant species, Fucus distichus had the lowest activities of the reactive oxygen scavenging enzymes. However, the contents of these enzymes were similar between F. spiralis and F. evanescens when expressed on a fresh weight basis, but higher in the more stress-tolerant F. spiralis when expressed on a chlorophyll basis. These data suggest that the ratio between reactive oxygen production (represented by chlorophyll content) and protection is the major determinant of stress tolerance.

Acclimation studies with Fucus vesiculosus also support the hypothesis that reactive oxygen metabolism is involved in emersion stress tolerance. Growth at low temperature (0oC) increases freezing tolerance relative to 20oC grown controls, with the increased stress-tolerance being correlated with increases in SOD activity. Changes in stress tolerance were not associated with changes in the content of antioxidants, although our data suggest that a-tocopherol may be involved in high-temperature thermostability of thylakoid membranes. Work with a second model system also supports the hypothesis that reactive oxygen metabolism is involved in stress tolerance. Previous research in my laboratory has established that the red alga Mastocarpus stellatus is more stress-tolerant than the closely related Chondrus crispus, which grows lower on the shore. These differences were correlated with the ability to tolerate exogenous applications of rose bengal, which increases reactive oxygen production, and with the content of reactive oxygen scavenging enzymes. In contrast to Fucus spp. in which the most important enzymes appear to be SOD, ascorbate peroxidase and catalase, the key enzymes in the red algae were glutathione reductase and catalase. However, in common with Fucus species, contents of antioxidants did not appear to be involved in determining interspecific differences in stress tolerance.

Our research provides one of the first mechanistic explanations for the differences in stress tolerance between different intertidal seaweeds. Although reactive oxygen metabolism is unlikely to be the sole determinant of stress tolerance, the differences in enzymes of reactive oxygen metabolism provide an opportunity to begin to quantify the costs of stress tolerance and incorporate this information into ecological models (e.g., competitive interactions between species).

Training and Development:

The project allowed Dr. Ian Davison to gain experience in working with reactive oxygen metabolism.

Dr. Jonas Collen was able to continue his research into reactive oxygen metabolism (his thesis topic) and gain experinece in several new techniques as well as experimental design, statistics and intertidal ecology.

Outreach Activities:

Journal Publications

CollÚn, J. and I.R. Davison. In vivo measurement of active oxygen production in the brown alga Fucus evanescens using 2',7'-dichlorohydrofluorescein diacetate., "In vivo measurement of active oxygen production in the brown alga Fucus evanescens using 2',7'-dichlorohydrofluorescein diacetate.", Journal of Phycology, p. 643, vol. 33, (1997). Published

CollÚn, J. and I.R. Davison., "Reactive oxygen production and damage in intertidal Fucus spp. (Phaeophyta).", Journal of Phycology, p. 54, vol. 34, (1999). Published

CollÚn, J. and I.R. Davison., "Reactive oxygen metabolism in intertidal Fucus spp. (Phaeophyta).", Journal of Phycology, p. 62, vol. 34, (1999). Published

CollÚn, J. and I.R. Davison., "Stress Tolerance and Reactive Oxygen Metabolism in the Intertidal Red Seaweeds Mastocarpus stellatus and Chondrus crispus.", Plant Cell & Environment

, p. 1143, vol. 22, (1999). Published

CollÚn, J. and I.R. Davison., "Seasonality and thermal acclimation of reactive oxygen metabolism in the brown alga Fucus vesiculosus.", Journal of Phycology, p. , vol. 37, (2001). Accepted

Books or Other One-time Publications

CollÚn, J. and I.R. Davison. , "Diurnal changes in photosynthesis and reactive oxygen metabolismin Gracilaria tikvahiae (Rhodophyta).", (2002).

Book, Accepted
Editor(s): Davison, I.R., Anderson, R. and Vreeland V.
Collection: Proceedings of XVIIth International Seaweed Sympossium,
Bibliography: Oxford University Press

Web/Internet Site

URL(s):

Description:

Other Specific Products

Contributions

Contributions within Discipline:

Contributions to Other Disciplines:

Contributions to Human Resource Development:

Contributions to Resources for Research and Education:

Contributions Beyond Science and Engineering:

Categories for which nothing is reported:

Organizational Partners
Activities and Findings: Any Outreach Activities
Any Product
Contributions: To Any within Discipline
Contributions: To Any Other Disciplines
Contributions: To Any Human Resource Development
Contributions: To Any Resources for Research and Education
Contributions: To Any Beyond Science and Engineering