Photoacclimation responses of a symbiotic sea anemone reveal an important host cellular plasticity

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Introduction

The high productivity of coral reef ecosystems is largely attributed to the **mutualistic symbiosis between reef-building corals** and their intracellular dinoflagellate in the genus ***Symbiodinium*** commonly referred to as zooxanthellae. These photosynthetic algae translocate a majority of their photosynthetically fixed carbon to the host and **contribute to their metabolic needs and the calcification process**. *Symbiodinium* must maintain a balance between the energy derived from the light reactions in the chloroplast and the amount of energy used during dark reactions and other metabolic processes. Nevertheless, in the natural environment the holobiont have to cope with **daily and seasonal changes in light intensity**, upsetting that balance and creating a stress that induces a **photoacclimation response to optimize growth rates**.

Methods

Anemonia manjano
exposed to **70-100 µmol/m²s**

LL
10 days exposition to very low light intensities **0-1 µmol/m²s**

HL
10 days exposition to high light intensities **450-600 µmol/m²s**

- **Ultrastructural analysis** — TEMicroscopy
- **Photophysiological analysis** — Chlorophyll a fluorescence; HPLC; Oxymeter

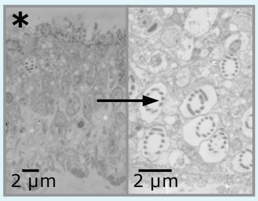
Results

Ultrastructure

LL

Ectoderm activity reorientation

1 ↑ cidocyte density

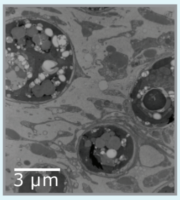


* = control healthy *A. manjano*

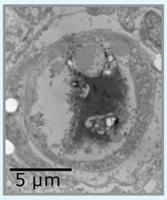
HL

Gastroderm & *Symbiodinium* are mainly affected

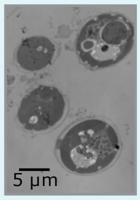
2 ↑ intercellular spaces



3 *Symbiodinium* alteration



4 release of intact algae in the gastric cavity

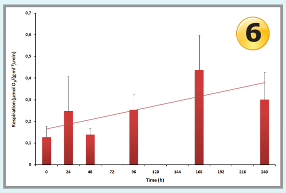


5 thylakoids desorganisation

* = control healthy *A. manjano*

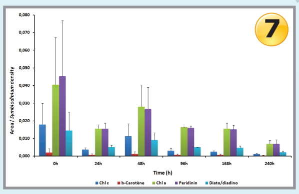
Photophysiology

LL

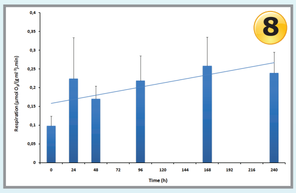


↗ respiration rate

↘ Pigment content

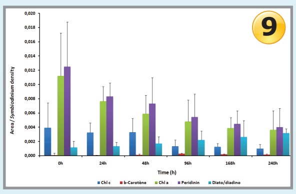


HL

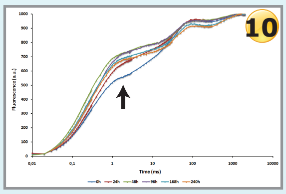


↗ respiration rate

↘ Pigment content



↗ proportion of PSII QB non reducing*



* = quinone B in the photosystem II, no more able to reduce the quinone A in the electron transport system

Conclusions

Under **low light intensity**, photosynthesis is no more occuring in *Symbiodinium* intracellularly localized in *A. manjano.* Therefore, algae will not allocate energy to the pigments synthesis and their concentration decreases (**7**). Moreover, as the **host** does not receive photosynthetically fixed carbon from *Symbiodinium*, it has to find other feeding sources and **shift to a higher level of heterotrophy** by increasing **cnidocytes density** (**1**). Consequently, its respiratory activity increases (**6**). This acclimation process may have important implications after a coral bleaching event - a phenomenon during which the animal host loses the majority of their *Symbiodinium*.

Under **high light intensity**, *Symbiodinium* in *A. manjano* experience a partial **photoinhibition** (**10**) of the electron transport system thus favoring **reactive oxygen species production**. Then, those molecules react with cellular components and damage cellular structures of the host and the *Symbiodinium* (**2**, **3**, **4**, and **5**). In order to minimize these stresses, *Symbiodinium* **reduce their light harvesting pigments** and increase their content in carotenoïds (that act immediately as ROS quenchers (**9**)). The holobiont **increases its metabolism** to repair damages and probably to synthesize enzymes playing a role against oxidative stress (**8**). This photoacclimation response occurs till **reaching a steady state** where the growth rate is optimized to the surrounding light field.

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