Irradiance Effects on Clownfish Sea Anemones: Tentacle Morphology and Physiology

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Solar irradiance impacts the daily lives of humans and animals alike. Light exposure is essential to life, providing necessary vitamins to our bodies, as well as driving primary production through photosynthesis. However, irradiance also can damage cellular structures; ultraviolet (UV) rays alter DNA proteins causing skin cells to become cancerous when overexposed to the sun.

Effects of irradiance on tentacle shape in clownfish sea anemones Entacmaea quadricolor (bulb-tentacle anemones) have been a topic of speculation for some time. This sea anemone is unique in that some individuals produce "bulbs", or extreme swellings on the tips of their tentacles. The cause of bulb formation is unknown, although some anecdotal evidence indicates a correlation with exposure to irradiance (Delbeek, 2002). It is possible these bulbs may reduce the negative effects of high irradiance on the anemones in shallow tropical seas. Sea anemones can serve as model organisms to better understand how animals respond to damage from solar irradiance, due to their simplicity and ease of experimental manipulation. Information gained from studies on anemones could teach humans how to better protect ourselves from harmful effects of the sun.

To test impacts of irradiance on these creatures, my project examined both morphological and physiological responses. Anemones initially were exposed to different light levels in a morphological experiment: controls received no alteration of light, while experimental groups were exposed to enhanced irradiance at wavelengths of 400-450 nm, which is the range of Photosynthetically Active Radiation (PAR). This range of wavelengths is utilized by the animals' zooxanthellae, which are microalgal endosymbionts living inside the anemone's endoderm and providing them with photosynthesized fuel. Changes in tentacle shape then were measured in both groups. After increasing PAR levels, a slight but not significant decrease in tentacle width was quantified. However, two specimens developed bulbous tentacles before PAR was altered, then after brief exposed to darkness, their bulbs rapidly deflated. I conclude that removing light may cause bulb dissolution, but enhanced PAR does not appear to induce bulb formation in Entacmaea quadricolor.

In the second, physiological-focused experiment, I increased emission of UV irradiance (320-290 nm) on the anemones and quantified responses of both tentacle shape and microalgal abundance. The algal populations were measured monthly for 4 months, allowing appropriate time for a physiological change. Microalgal abundance changed abundantly, but not as predicted, as the numbers spiked just after addition of UV emission then returned to their normal levels at the following collection period, and anemone tentacle shapes remained statistically constant after UV exposure.

Observations from these experiments indicate a connection between irradiance, bulb formation, and anemone microalgal populations, but more experimentation is needed to clarify that relationship. Future projects should try to isolate UV emission from visible PAR emission on these laboratory animals, to detect its sole effects on their morphology and physiology. Learning the correlation between irradiance and cnidarian responses could give the human race new ideas of how to better protect ourselves from the harmful effects of the sun, through potentially new sunscreen mechanisms that will better prevent cancer caused from sun exposure.

Figure 1: Temporary formation of tentacle bulbs on a giant sea anemone in our laboratory at Auburn University.

Statement of Research Advisor:

Anna's project addressed an important question regarding the giant sea anemones that host clownfishes on Indo-Pacific coral reefs. If we can figure out why and how tentacle bulbs form on these anemones, we can then induce bulb formation to enhance the value of anemones for the ornamental aquarium trade. As well, we may learn how they adapt morphologically and physiologically to high levels of UV or other wavelengths of solar irradiance which damage their cells. This information can help us to understand how humans also can protect ourselves from harm due to sun exposure. Although Anna's results were not definitive, they provide preliminary evidence and methods to further pursue this topic in our research laboratory.
-Dr. Nanette Chadwick, Biological Sciences

References

Delbeek, C. J. (2002). The effects of lighting on bulb-tip development in the bulb tentacle anemone, Entacmaea quadricolor (Rüppell and Leukart, 1828), with additional observations on sexual reproduction in E. quadricolor And Stichodactyla gigantea (Forsskål, 1775). Advanced Aquarist, 1. Retrieved from http://www.advancedaquarist.com/issues/nov200 2/feature.htm