Covering behavior in two intertidal anemones, *Anthopleura elegantissima* and *Anthopleura xanthogrammica*: Is it inducible in the lab?

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Introduction

Attachment of gravel and shell particles to the body walls (covering behavior) of intertidal anthozoans is a common phenomenon. An example of such a phenomenon is provided by *Anthopleura elegantissima* and *Anthopleura xanthogrammica.* Hart and Crowe (1977) demonstrated that if the gravel and bits of shell covering are removed from the animal and fresh gravel and shell particles are supplied to the denuded animal, it will within a span of a few hours cover itself with a monolayer of gravel or shell particles. The mechanism of attachment is through dermal papillae known as verrucae. It has been postulated that verrucae generate powerful suction that firmly grasp the gravel or shell particles (Parker, 1917). More recently, it has been hypothesized that verrucae secrete a mucus-type adhesive by which particles are attached (Hart & Crowe, 1977).

A. elegantissima and *A. xanthogrammica* are commonly found in the high to mid-intertidal zones of the Pacific Coast (Kozloff, 1993). Their position in the intertidal makes them vulnerable to sunlight exposure during both low and high tide. As a way to counteract exposure, it is thought that the covering behavior exhibited by these two species is a mode of protection against desiccation (Roberts, 1941). However, the adaptive significance of covering behavior has also been attributed to protection against predation (Hyman, 1940) and camouflage (Ricketts et al., 1968).

The covering behavior of *A. elegantissima* and *A. xanthogrammica* can easily be seen in the field, but can these species be induced to cover their columns in a lab setting? Lab experiments exposing various sea urchin species to ultraviolet (UV) light have been shown to increase the rate at which these animals exhibit covering behavior (Adams, 2001; Verling, 2002; Kehas, 2005). Dykens and Shick (1984) demonstrated that *A. elegantissima* will attach gravel and other debris to its column in response to elevated levels of sunlight. Based on this information, I hypothesize that both *A. elegantissima* and *A. xanthogrammica* will exhibit the covering behavior in response to increased temperature in order to inhibit desiccation or slow down the rate of desiccation

Materials and Methods

A. elegantissima and *A. xanthogrammica* were collected at North Spit, Charleston, Oregon. Both species were kept in the lab in a flow-through seawater table. The animals were left to acclimate to lab conditions for four days prior to the experiment. Anemones were divided into three groups comprising of five anemones of each species, totaling three groups of 10 anemones. Each group of 10 was placed into a large finger bowl and allowed to settle for 24 hours. After all anemones had settled (all anemones began each experiment upright and the column completely devoid of covering), a shell debris substrate was introduced into each finger bowl. Each group of 10 was subjected to three treatments in full sunlight: fully submerged in water, half submerged in water, and fully exposed (no water). The temperature of the water was taken before exposure to sunlight and monitored throughout each treatment, except for the no water treatment. The number of responses was recorded as well as the temperature of the water at the time of the response. Since no temperature could be taken in the treatment without water, the anemones response was timed, up to ten minutes. To ease analysis, two time parameters were used, < 5 minutes and > 5 minutes. The number of responses was recorded as well as a description of the response(s).

A response was defined as an anemone tipping over. In other words, an anemone that is no longer in the upright position (Fig. 1). A response was also defined as an anemone closing its oral disc, thus hiding its tentacles. Lastly, a response also included the percentage of column cover the anemone had after each experiment. To make the calculation of the percentage of column cover simple, the anemone was visually divided into quarters, so that percent cover resulted in 25, 50, 75, or 100% (Fig. 2).

Results

A. elegantissima and *A. xanthogrammica* showed no response to the treatment of fully submerged in water; the initial temperature was 13°C and the final temperature was 33°C. Neither species tipped over or closed the oral disc. Both species showed responses to the treatments of half submerged with water and fully exposed (no water). In the treatment of half submerged with water, *A. elegantissima* showed the greatest number of responses in the temperature range 22°C-23°C and 27-29°C (Table 1; Fig. 3). *A. elegantissima* displayed no response at 25°C. In the same treatment *A. xanthogrammica* demonstrated the greatest number of responses in the temperature range 23°C-28°C (Table 1; Fig. 3). *A. xanthogrammica* exhibited no response at 22°C or 29°C.

For the treatment of no water, *A. elegantissima* and *A. xanthogrammica* both displayed the greatest response at the < 5 minute parameter with 9 out of 15 *A. elegantissima* and 11 out of 15 *A. xanthogrammica* responding (Table 2). The remaining 6 *A. elegantissima* and 4 *A. xanthogrammica* responded during the > 5 minute parameter (Table 2).

Discussion

The results supported my hypothesis that *A. elegantissima* and *A. xanthogrammica* will be induced to cover their column with debris in response to increased temperature. However, this is only true for the treatment with the anemones half submerged (Table 1; Fig. 3). The initial water temperature before exposure to sunlight was 13°C and as the temperature of the water increased, the number of responses by the anemones increased, with the greatest number of responses in the temperature range of 23°C-27°C. This suggests that these anemones were attempting to minimize their exposure to sunlight by shielding their columns by way of shell particles, thus reducing desiccation stress. Dykens and Shick (1984) found that both *A. elegantissima* and *A. xanthogrammica* increased column covering behavior when exposed to intense sunlight. They also found that an anemone that is in the shade will not exhibit column covering behavior and will have its oral disc open, whereas an anemone that is exposed will have its column covered and its oral disc closed. The findings for the exposed anemones are consistent with what was found in the current study. The anemones in the half submerged and fully exposed treatments responded to exposure to sunlight by covering their columns with shell particles.

In the treatment that had full exposure, or no water, both *A. elegantissima* and *A. xanthogrammica* revealed a greater response in < 5 minutes than either did in > 5 minutes (Table 2). Although the temperature of the finger bowl was not taken, I think it is fair to assume that both species were responding to an increase in exposure to sunlight, more specifically an increase in temperature. By closing the oral disc, tipping over, and covering the column, these animals were clearly attempting to slow the rate of desiccation by decreasing the amount of surface area that is exposed to sunlight.

The results for the treatment that had *A. elegantissima* and *A. xanthogrammica* completely submerged were surprising. The initial water temperature was 13°C and the final water temperature was 33°C, yet the anemones showed no response. In contrast to these findings, Dykens and Shick (1984) found that both *A. elegantissima* and *A. xanthogrammica* closed the oral disc when completely submerged and exposed to direct sunlight. It may be that the final temperature of the water for the current study, 33°C, was not high enough to invoke a response from the anemones. It would be interesting to test the response of both species at higher temperatures to see if they exhibit a response.

To further investigate the reason why *Anthopleura elegantissima* and *A. xanthogrammica* cover their column more variables need to be tested, such as wave speed and wind. By testing a greater range of variables, the factor or factors that cause the covering behavior could be deciphered and better understood. A larger number of trials should be conducted in order to gain a better understanding of what affects this behavior and why this behavior occurs. Also a greater variation in substrate should be used to see if the anemones have a preference for certain substrates or certain sizes of particles.

References

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Table 1: The temperatures at which *Anthopleura elegantissima* and *A. xanthogrammica* demonstrated a response, and the number of each species that responded while only half submerged in water (the initial temperature of the water was 13°C).

Temperature (°C)	*A. elegantissima* (15)*	*A. xanthogrammica* (15)*
20	1	1
22	3	0
23	4	3
24	1	2
25	0	3
27	2	4
28	2	2
29	2	0

* Indicates the sample size.

Table 2: The temperatures at which *Anthopleura elegantissima* and *A. xanthogrammica* demonstrated a response and the number of each species that responded while completely out of water.

Time Range (min)	*A. elegantissima* (15)*	*A. xanthogrammica* (15)*
< 5	9 responded by tipping over, completely closing oral disc, and column covering of 25%	11 responded by tipping over, completely closing oral disc and column covering of 25-50%
> 5	6 responded by tipping over, completely closing oral disc, and column covering of 50-75%	4 responded by tipping over, completely closing oral disc and column covering of 50-75%

* Indicates sample size.

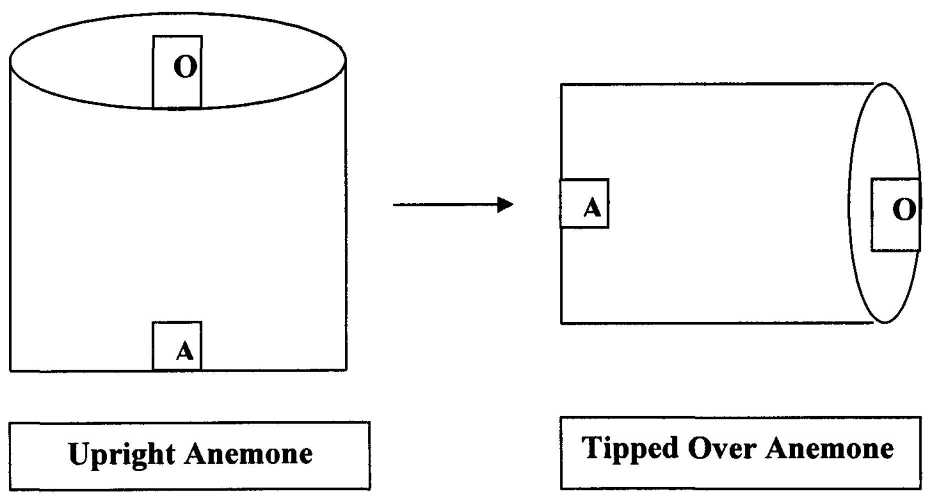

Figure 1: Representation of an upright anemone versus a tipped over anemone. "O" represents oral surface and "A" represents aboral surface.

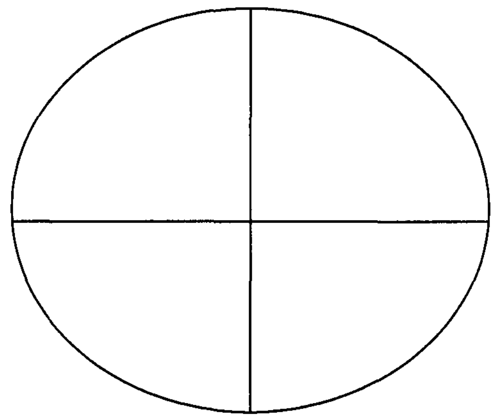

Figure 2: Oral view of an anemone divided into quarters to represent how the percent cover of the column was calculated.

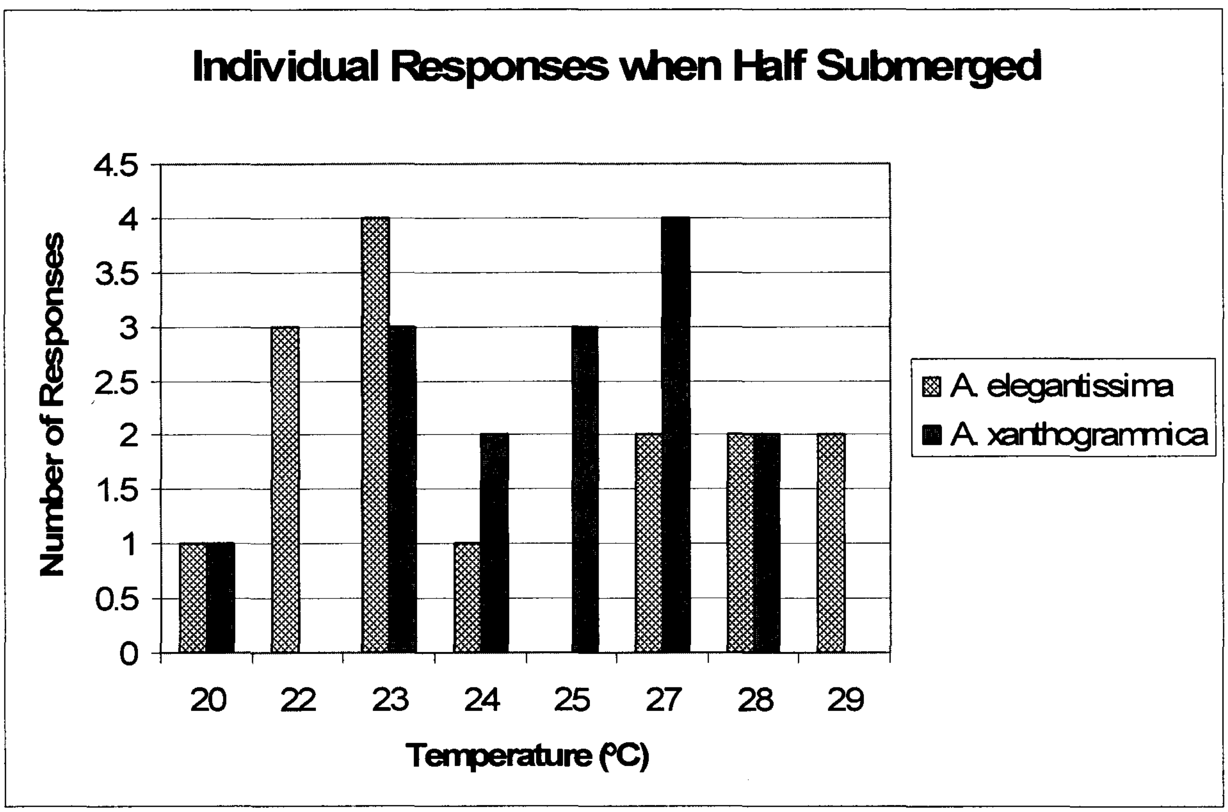

Figure 3: The number of responses at various temperatures for *Anthopleura elegantissima* and *A. xanthogrammica* when half submerged in water (the initial temperature of the water was 13°C).