Respiratory, osmoregulatory and behavioural determinants of distribution of tropical marine hermit crabs

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Introduction

The hermit crabs *Clibanarius taeniatus* and *Clibanarius virescens* are common tropical species on the rocky intertidal shores of Queensland, Australia. This area is frequently hot and dry with temperatures in excess of 38°C. Sudden, heavy rains in river catchments and local coastal areas often result in flood events that dilute coastal waters, exposing hermit crabs to prolonged periods when salinity is as low as 14% seawater (SW), while extreme evaporation may result in tidepool concentrations of up to 125% SW. Such conditions in the intertidal area result in the combined stresses of fluctuating temperature, salinity and oxygen availability, resulting in the need for physiological tolerances and/or behavioural changes.

Method

Oxygen consumption was measured in adults of both species exposed to one of 12 factorial temperature-salinity combinations for a period of six hours to determine if differences in the distribution of *C. virescens* and *C. taeniatus* on the shore could be related to differences in metabolic costs of physiological responses to changes in environmental conditions.

To determine if there were differences in the abilities of *C. taeniatus* and *C. virescens* to osmoregulate in the range of salinities between 11% SW and 140% SW at 15°C, 25°C or 35°C crabs were exposed to one of eight salinities at one of three temperatures over a period of seven hours. Haemolymph was sampled from each crab and its osmolarity compared with that of the medium to produce a profile of osmoregulation in seawater of various salinities.

The ability of *C. taeniatus* and *C. virescens* to compete with each other for shells was investigated to determine if *C. virescens* was able to out-compete *C. taeniatus* and potentially exclude *C. taeniatus* from inhabiting open coast and island shores.

Results

The metabolic response experiments suggested that both species were significantly affected by changes in temperature and salinity. Results demonstrated a significant difference in metabolic responses between species at the acclimation salinity of 100% SW. At 100% SW *C. virescens* showed metabolic sensitivity to temperature, while *C. taeniatus* did not. This may indicate a greater tolerance of higher temperatures by *C. taeniatus*.

While both species were hyperosmoregulators over the entire range of salinities tested, no significant difference was found between them in this ability. However, both species showed a reduction in the ability to osmoregulate when exposed to dilute seawater at higher temperature, indicating an increase in physiological stress when low salinity and high temperature are combined. When a survey of rocky shores was undertaken along the coast of Queensland, results were consistent with the hypothesis that *C. virescens* is more sensitive to fresh water, and that this factor influences their distribution. Distribution of this species may also be influenced by the salinity of inshore water.

Weight for weight, when both species are without shells, *C. virescens* was not a better competitor for limited shell resources when tested in acclimation conditions. Analyses showed that body weight was an indirect, yet significant factor in acquiring resources. Results suggested that given a two-tailed hypothesis, *C. taeniatus* would acquire significantly more shells than *C. virescens*. In addition, *C. taeniatus* was shown to carry heavier shells in the field and/or in the laboratory.

Conclusion

It was hypothesised that differences in the tolerance of *C. virescens* and *C. taeniatus* to changes in environmental salinity and/or temperature may influence the geographical distribution of these species. As predicted, surveys of a large area of the Queensland rocky coast have demonstrated that there is a tendency for *C. taeniatus* to be found near areas of freshwater run-off (e.g. estuaries), while *C. virescens* is more abundant on open coasts and islands. While interspecific competition does not appear to be a main factor in the greater abundance of *C. virescens* on open coasts and islands, reasons why *C. taeniatus* is not more abundant at these sites remain unclear.

Since there is good evidence that the distribution and abundance of *C. taeniatus* and *C. virescens* is influenced by fresh water, it is proposed that these species may be used as indicators of freshwater run-off and may be a cost efficient tool for monitoring the effects of changed environmental flows on coastal ecosystems.