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ORIGINAL PAPER

Metabolic responses to high pCO_2 conditions at a CO_2 vent site in juveniles of a marine isopod species assemblage

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Abstract We are starting to understand the relationship between metabolic rate responses and species' ability to respond to exposure to high pCO_2. However, most of our knowledge has come from investigations of single species. The examination of metabolic responses of closely related species with differing distributions around natural elevated CO_2 areas may be useful to inform our understanding of their adaptive significance. Furthermore, little is known about the physiological responses of marine invertebrate juveniles to high pCO_2, despite the fact they are known to be sensitive to other stressors, often acting as bottlenecks for future species success. We conducted an in situ transplant experiment using juveniles of isopods found living inside and around a high pCO_2 vent (Ischia, Italy): the CO_2 'tolerant' *Dynamene bifida* and 'sensitive' *Cymodoce truncata* and *Dynamene torelliae*. This allowed us to test for any generality of the hypothesis that pCO_2 sensitive marine invertebrates may be those that experience trade-offs between energy metabolism and cellular homoeostasis under high pCO_2 conditions. Both sensitive species were able to maintain their energy metabolism under high pCO_2 conditions, but in *C. truncata* this may occur at the expense of [carbonic anhydrase], confirming our hypothesis. By comparison, the tolerant *D. bifida* appeared metabolically well adapted to high pCO_2, being able to upregulate ATP production without recourse to anaerobiosis. These isopods are important keystone species; however, given they differ in their metabolic responses to future pCO_2, shifts in the structure of the marine ecosystems they inhabit may be expected under future ocean acidification conditions.

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Introduction

As a result of the ongoing anthropogenic increase in CO_2 emissions, the level of seawater pCO_2 is expected to increase, resulting in a decrease in oceanic pH by 0.4–0.5 pH units by the year 2100 (Caldeira and Wickett 2003; IPCC 2014); a phenomenon known as ocean acidification (OA). However, despite a plethora of recent studies, we still know relatively little about the homoeostatic metabolic responses of marine ectotherms to high pCO_2 conditions compared to other climate-driven parameters such as temperature (Somero 2005; Pörtner 2008; Gunderson and Stillman 2015; c.f. Stillman and Paganini 2015). Most previous investigations have been single species orientated and taxonomically restricted, mainly to heavily calcified marine invertebrate species (e.g. corals, sea urchins and molluscs), which have been predicted to experience the greatest negative impacts from any decrease in oceanic pH due to calcium carbonate dissolution, being adversely affected by