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Differential response to ocean acidification in physiological traits of *Concholepas concholepas* populations

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ABSTRACT

Phenotypic adaptation to environmental fluctuations frequently occurs by preexisting plasticity and its role as a major component of variation in physiological diversity is being widely recognized. Few studies have considered the change in phenotypic flexibility among geographic populations in marine calcifiers to ocean acidification projections, despite the fact that this type of study provides understanding about how the organism may respond to this chemical change in the ocean. We examined the geographic variation in CO_2 seawater concentrations in the phenotype and in the reaction norm of physiological traits using a laboratory mesocosm approach with short-term acclimation in two contrasting populations (Antofagasta and Calfuco) of the intertidal snail *Concholepas concholepas*. Our results show that elevated pCO_2 conditions increase standard metabolic rates in both populations of the snail juveniles, likely due to the higher energy cost of homeostasis. Juveniles of *C. concholepas* in the Calfuco (southern) population showed a lower increment of metabolic rate in high-pCO_2 environments concordant with a lesser gene expression of a heat shock protein with respect to the Antofagasta (northern) population. Combined these results indicate a negative effect of ocean acidification on whole-organism functioning of *C. concholepas*. Finally, the significant Population × pCO_2 level interaction in both studied traits indicates that there is variation between populations in response to high-pCO_2 conditions.

1. Introduction

Phenotypic acclimatization to short-term environmental fluctuations should frequently occur by preexisting plasticity and underlying standing genetic variation (see Lande, 2009). Phenotypic flexibility is a particular kind of phenotypic plasticity and is defined as the possible selective advantage of those individuals that can show continuous but reversible changes in behavior, physiology and morphology in response to rapidly changing environmental conditions in timescales shorter than a lifetime (Piersma and Drent, 2003). Paleoclimate data provided evidence that wild populations rarely experienced such huge and rapid changes in environmental variables such as temperature, salinity or pH (Caldeira and Wickett, 2005; Hönisch et al., 2012). For instance, paleoclimate evidence about global warming and ocean acidification (OA) event over the past 300 MY suggest similarities with contemporaneous extinction and evolutionary turnover. However, none of these past events parallels the rapidity of the current increase of CO_2 release and chemical changes in seawater (Hönisch et al., 2012). Thus, rapid evolution of phenotypic plasticity may be necessary to prevent extinction of species subjected to sudden environmental changes such as the present event of anthropogenic OA. This may be especially threatening to calcifying organisms, given that effects on calcification may delay developmental rates at critical early life stages and could restrict opportunities in many species for larval dispersal and/or changes in geographical range (Fabry et al., 2008; Kroeker et al., 2010).

Many morphological, life-history, and metabolic traits show signs of phenotypic flexibility (Lardies et al., 2011; Pigliucci and Preston, 2004). Furthermore, geographic variations in life-history and metabolic traits among populations are ubiquitous among ectotherms (see Gilchrist and Huey, 2004; Lardies et al., 2011). Physiological variation within the life history of an individual can have profound implications for fitness (Lardies and Bozinovic, 2006; Ricklefs and Wikelski, 2002), since physiological maintenance costs are a large component of animal

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