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The synergistic effects of increasing temperature and CO2 levels on the righting response and acid-base-balance of Hyas araneus

Zora M. C. Zittier, Timo Hirse, and Hans-Otto Pörtner
Integrative Ecophysiology, Alfred-Wegener-Institute, Am Handelshafen 12, Bremerhaven, 27570, Germany

Global climate change is causing increasing temperatures and a reduction in ocean surface pH due to the accumulation of CO2. Environmental change develops rapidly leaving insufficient time for evolutionary adaptation. Thus, the survival and distribution of species at the population level in a changing environment will depend on their ability to cope with this challenge by exploiting their physiological plasticity. Studying the synergetic effects of warming and CO2 accumulation is important to predict the future state of marine ecosystems.

In this study we investigated the impact of increasing temperature and CO2 levels on the righting response and acid –base balance of the spider crab Hyas araneus from around Svalbard. Hyas areneus is one of the most prominent brachyurian crabs in Svalbard. Animals were incubated at present-day normocapnia (390ppm) and at CO2 level expected for 2100 (750ppm) and beyond (1120 and 3000ppm). The righting response as well as the acid-base status and the content of lactate in the haemolymph were determined in animals acclimated to 1°C (winter) and 4°C (summer) water temperature. After one day of recovery the animals were transferred to 12°C at the respective CO2 levels for an additional 15min exposure to acute temperature stress and the experimental procedure was repeated.

Increasing CO2 levels caused an accumulation of total carbon (Tco2) including bicarbonate (HCO3-), and an increase in the oxygen partial pressure (Po2) in the hemolymph, whereas temperature had only a slight effect. Haemolymph pH decreased with decreasing water pH regardless of temperature. The righting response was similar in all animals acclimated to animals at 1° and 4°C. Only after inducing the additional temperature stress, was the effect of increasing CO2 levels much stronger in animals pre-acclimated to 1°C. Some individuals were not even able to respond once under high CO2 levels. In animals acclimated to 4°C the effect of CO2 at extreme temperature was reduced. Animals transferred from 1°C to 12°C displayed elevated lactate concentrations in the haemolymph with the highest values under normocapnia and the lowest at the highest CO2 level when activity capacity was largely reduced. Animals transferred from 4°C to 12°C also accumulated lactate but in this case, levels resulted higher at 3000 ppm, in line with their activity maintained.

In line with the concept of oxygen and capacity limited thermal tolerance, all animals exposed to temperature extremes suffered from reduced scope for performance which was exacerbated by increasing CO2 concentrations. Warming in combination with elevated CO2 concentrations will have negative effects on the mobility and performance of Hyas areneus with potential changes at the ecological level.
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