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Cadmium-dependent oxygen limitation affects temperature tolerance in eastern oysters (Crassostrea virginica Gmelin)

Gisela Lanning[2], Anton S. Cherkasov[1], Hans-O. Pörtner[2], Christian Bock[2] and Inna M. Sokolova[1]
[1]Biology Department, University of North Carolina at Charlotte, Charlotte North Carolina
[2]Alfred Wegener Institute for Polar and Marine Research, Marine Animal Physiology, Bremerhaven, Germany

Abstract:

Marine ectotherms, including oysters are exposed to variable environmental conditions in coastal shallow waters and estuaries. In the light of global climate change, additional stressors like pollution might pose higher risk to populations. On the basis of the concept of oxygen- and capacity-limited thermal tolerance in aquatic ectotherms (40), we show that a persistent pollutant, cadmium, can have detrimental effects on oysters (*Crassostrea virginica*). During acute warming from 20 to 28°C (4°C/48 h) standard metabolic rate (SMR) rose in control and cadmium-exposed (50 μg Cd^{2+}/l) animals, with a consistently higher SMR in Cd-exposed oysters. Additionally, Cd-exposed oysters showed a stronger temperature-dependent decrease in hemolymph oxygen partial pressures. This observation indicates that the effect of temperature on aerobic metabolism was exacerbated due to the additional Cd stress. The oxygen delivery systems could not provide enough oxygen to cover Cd-induced elevated metabolic demands at high temperatures. Interestingly, cardiac performance (measured as the heart rate and hemolymph supply to tissues) rose to a similar extent in control and Cd-exposed oysters with warming indicating that cardiac output was unable to compensate for elevated energy demand in Cd-exposed oysters. Together with the literature data on metal-induced reduction of ventilatory capacity, these findings suggest that synergistic effects of elevated temperatures and cadmium exposure led to oxygen limitation by impaired performance in oxygen supply through ventilation and circulation. Overall, cadmium exposure resulted in progressive hypoxemia in oysters at high temperatures, suggesting that the thermal tolerance window is narrowed in marine ectotherms inhabiting polluted areas compared with pristine environments.

Key-words: Metabolism, cardiac performance, magnetic resonance imaging, hemolymph Po_2, anaerobiosis