Scientific Paper:

The Journal of Experimental Biology (2014) 217, 3407 - 3415

A hierarchy of factors influence discontinuous gas exchange in the grasshopper *Paracinema tricolor* (Orthoptera: Acrididae)

Berlizé Groenewald[1], Steven L. Chown[2], and John S. Terblanche[1]
[1]Department of Conservation Ecology and Entomology, Centre for Invasion Biology, Faculty of AgriSciences, Stellenbosch University, Stellenbosch, South Africa
[2]School of Biological Sciences, Monash University, Melbourne, Australia

Abstract:

The evolutionary origin and maintenance of discontinuous gas exchange (DGE) in tracheate arthropods are poorly understood and highly controversial. We investigated prioritization of abiotic factors in the gas exchange control cascade by examining oxygen, water and haemolymphe pH regulation in the grasshopper *Paracinema tricolor*. Using a full-factorial design, grasshoppers were acclimated to hypoxic or hyperoxic (5% O_2, 40 % O_2) gas conditions, or dehydrated or hydrated, whereafter their CO_2 release was measured under a range of O_2, and relative humidity (RH) conditions (5 %, 21 %, 40 % O_2, and 5 %, 60 %, 90 % RH). DGE was significantly less common in grasshoppers acclimated to dehydrating conditions compared with the other acclimations (hypoxia, 98 %; hyperoxia, 100 %; hydrated, 100 %; dehydrated, 67 %). Acclimation to dehydrating conditions resulted in a significant decrease in haemolymph pH from 7.0 ± 0.3 to 6.6 ± 0.1 (means ± s. d., P = 0.018) and also significantly increased the open (O)-phase duration under 5 % O_2 treatment conditions (5 % O_2, 44.1 ± 29.3 min; 40 % O_2, 15.8 ± 8.0 min; 5 % RH, 17.8 ± 1.3 min; 60 % RH, 24.0 ± 9.7 min; 90 % RH, 20.6 ± 8.9 min). The observed acidosis could potentially explain the extension of the O-phase under low RH conditions, when it would perhaps seem more useful to reduce the O-phase to lower respiratory water loss. The results confirm that DGE occurrence and modulation are affected by multiple abiotic factors. A hierarchical framework for abiotic factors influencing DGE is proposed in which the following stressors are prioritized in decreasing order of importance: oxygen supply, CO_2 excretion and pH modulation, oxidative damage protection and water savings.

Keywords: Discontinuous gas exchange, prioritization, water regulation, oxidative damage, pH regulation.