

Scientific Paper:

Journal of Experimental Biology, 2011, 214, 3062 - 3073

Regulation of gas exchange and haemolymph pH in the cockroach *Nauphoeta cinerea*

Philip G. D. Matthews* and Craig R. White

School of Biological Sciences, The University of Queensland, Australia

*Author for correspondence at present address: School of Earth and Environmental Sciences, The University of Adelaide, Australia

Abstract:

Ventilatory control of internal CO₂ plays an important role in regulating extracellular acid-base balance in terrestrial animals. While this phenomenon is well understood among vertebrates, the role that respiration plays in the acid-base balance of insects is in need of much further study. To measure changes in insect haemolymph pH, we implanted micro pH optodes into the haemocoel of cockroaches (*Nauphoeta cinerea*). They were then exposed to normoxic, hypoxic, hyperoxic and hypercapnic atmospheres while their haemolymph pH, V_{CO₂} and abdominal ventilation frequency were measured simultaneously. Intratracheal O₂ levels were also measured in separate experiments. It was found that cockroaches breathing continuously control their ventilation to defend a haemolymph pH of 7.3, except under conditions where hypoxia (<10 % O₂) induces hyperventilation, or where ambient hypercapnia is in excess of haemolymph (>1 % CO₂). In contrast, intratracheal O₂ levels fluctuated widely, but on average remained above 15 % in normoxic (21 % O₂) atmospheres. Decapitation caused the cockroaches to display discontinuous gas exchange cycles (DGS). The alternating periods of ventilation and apnoea during DGCs caused haemolymph pH to fluctuate by 0.11 units. Exposure to hypoxia caused haemolymph pH to increase and initiated brief bouts of spiracular opening prior to the active ventilation phase. The spontaneous occurrence of DGCs in decapitated cockroaches indicates that central pattern generators in the thoracic and abdominal ganglia generate the periodic gas exchange pattern in the absence of control from the cephalic ganglion. This pattern continues to maintain gas exchange, but with less precision.

Key-words: gas exchange, insect, haemolymph pH, DGC, hypercapnia, hypoxia