PreSens
PRECISION SENSING

Scientific Paper:

J Comp Physiol B 176, 607-621, 2006

Temperature-dependent oxygen extraction from the ventilatory current and the costs of ventilation in the cephalopod *Sepia officinalis*

Frank Melzner, Christian Bock , Hans O. Pörtner
Alfred-Wegener-Institute for Marine and Polar Research, Am Handelshafen 12, 27570 Bremerhaven, Germany; e-mail: fmelzner@awi-bremerhaven.de

Abstract:

Earlier work found cuttlefish (*Sepia officinalis*) ventilatory muscle tissue to progressively switch to an anaerobic mode of energy production at critical temperatures (T_c) of 7.0 and 26.8°C. These findings suggested that oxygen availability limits thermal tolerance. The present study was designed to elucidate whether it is the ventilatory apparatus that sets critical temperature thresholds during acute thermal stress. Routine metabolic rate (rmr) rose exponentially between 11 and 23°C, while below (8°C) and above (26°C) this temperature range, rmr was significantly depressed. Ventilation frequency (fv) and mean mantle cavity pressure (MMP) followed an exponential relationship within the entire investigated temperature range (8–26°C). Oxygen extraction from the ventilatory current (EO_2) decreased in a sigmoidal fashion with temperature, falling from > 90% at 8°C to 32% at 26°C. Consequently, ventilatory minute volume (MVV) increased by a factor of 20 from 7 to 150% body weight min^{-1} in the same temperature interval. Increases in MMP and MVV resulted in ventilatory muscle power output (Pout) increasing by a factor of > 80 from 0.03 to 2.4 mW kg^{-1} animal. Nonetheless, costs for ventilatory mechanics remain below 1.5% rmr in the natural thermal window of the population (English Channel, 9–17°C), owing to very low MMPs of < 0.05 kPa driving the ventilatory stream, and may maximally rise to 8.6% rmr at 26°C. Model calculations suggest that the ventilatory system can maintain high arterial PO_2 values of > 14 kPa over the entire temperature interval. We therefore conclude that the cuttlefish ventilation system is probably not limiting oxygen transfer during acute thermal stress. Depression of rmr, well before critical temperatures are being reached, is likely caused by circulatory capacity limitations and not by fatigue of ventilatory muscle fibres.

Key-words: Cephalopoda, ventilation, mantle cavity pressure, oxygen consumption, cuttlefish