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Changes in hemolymph total CO_2 content during the water-to-air respiratory transition of amphibiotic dragonflies

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Abstract:

Dragonflies (Odonata, Anisoptera) are amphibiotic; the nymph is aquatic and breathes water using a rectal gill before transitioning to the winged adult that breathes air through spiracles. While the evolutionary and developmental transition from water- to air-breathing is known to be associated with a dramatic rise in internal CO_2 levels, the changes in blood-gas composition experienced by amphibiotic insects, which represent an ancestral air-to-water transition, are unknown. This study measured total CO_2 (TCO_2) in hemolymph collected from aquatic nymphs and air-breathing adults of *Anax junius*, *Aeshna multicolor* (Aeshnidae), *Libellula quadrimaculata*, and *L. forensis* (Libellulidae). Hemolymph PCO_2 was also measured *in vivo* in both Aeshnid nymphs and marbled crayfish (*Procambarus fallax*. f. *virginalis*) using a novel fiber-optic CO_2 sensor. The hemolymph TCO_2 of the pre- and early-final instar nymphs was found to be significantly lower than that of the air-breathing adults. However, the TCO_2 of the late-final instar Aeshnid nymphs was not significantly different from the air-breathing adult, despite the late-final nymph still breathing water. TCO_2 and PCO_2 were also significantly higher in the hemolymph of early-final Aeshnid nymphs compared to the water-breathing crayfish. Thus, while dragonfly nymphs show an increase in internal CO_2 as they transition from water to air, from an evolutionary standpoint, the nymph's ability to breathe water is associated with a comparatively minor decrease in hemolymph TCO_2 relative to the air-breathing adult.

Keywords: amphibiotic, insect, TCO_2, PCO_2, hemolymph, aquatic