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Studies on gas exchange in the meadow spittlebug, *Philaenus spumarius*: the metabolic cost of feeding on, and living in, xylem sap

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Abstract:

Spittlebugs (superfamily Cercopoidae) live within a mass of frothy, spittle-like foam that is produced as a by-product of their xylem-feeding habits. The wet spittle represents a unique respiratory environment for an insect, potentially acting either as a reserve of trapped oxygen (O_2) or as a significant barrier to O_2 diffusion from the surrounding atmosphere. Feeding on xylem sap under tension is also assumed to be energetically expensive, potentially placing further constraints on their gas exchange. To understand the respiratory strategies used by spittlebugs, this study measured the P_{O_2} within the spittle of the meadow spittlebug, *Philaenus spumarius*, as well as the non-feeding metabolic rate (RMR) and respiratory quotient (RQ) of both nymphs and adults. The metabolic rate of nymphs feeding on xylem was also measured. In separate experiments, the ability of a nymph to obtain O_2 from bubbles while submerged in foam was determined using a glass microscope slide coated in an O_2 -sensitive fluorophore. We determined that *P. spumarius* breathes atmospheric O_2 by extending the tip of its abdomen outside of its spittle, rather than respiring the O_2 trapped in air bubbles within the foam. However, spittlebugs can temporarily use these air bubbles to breathe when forcibly submerged. \dot{V}_{O_2} and \dot{V}_{CO_2} did not differ statistically within life stages, giving a RQ of 0.92 for nymphs and 0.95 for adults. Feeding on xylem was found to increase the nymphs' \dot{V}_{CO_2} by only 20 % above their RMR. From this cost of feeding, cibarial pump pressures were estimated to be between -0.05 and -0.26 MPa.

Keywords: Cibarial pump, respiratory quotient, foam, metabolic rate, xylem tension