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Dispersion of carbon dioxide plumes in African woodland: implications for host-finding by tsetse flies

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Abstract. In Zimbabwe, high-resolution (10 Hz to an accuracy of ± 0.1 p.p.m.) measurements were made of atmospheric and host-produced CO_2 in tsetse habitats during the dry season. The diel structure of atmospheric CO_2 concentrations is bimodal, with a minimum at approximately 16.00 hours and maxima at approximately 05.00 hours and 20.00 hours, respectively. The background CO_2 noise is greater in densely vegetated riverine woodland than in leafless, deciduous (mopane) woodland. Variation in atmospheric CO_2 concentrations is correlated with decreasing wind speed and increasing thermal stability. Consequently, the background noise during the day is greatest in riverine woodland during early morning and late afternoon, when winds are typically light and stable, and thermal inversion conditions are developing. Measurements were made of CO_2 at 8–64 m downwind from natural (two cattle) or synthetic sources (4–20 L min^{-1} CO_2). The signal from the sources appears as fluctuations above threshold (approximately 355–362 p.p.m.), in the form of intermittent 'bursts' of CO_2. The strength, duration and intermittency of the signals attributable to these sources declines with source strength and distance from the source. In riverine woodland, approximately 50% of all bursts are 0.1 s long, and 10% are > 2.0 s long. Carbon dioxide signals from equivalent sources are stronger in riverine woodland than mopane. Carbon dioxide dispensed at rates of 4–20 L min^{-1} is detected up to 64 m downwind of the source but peaks are typically < 10 p.p.m. above threshold. Consequently, host-CO_2 signals are obscured during periods of large fluctuations in atmospheric CO_2. These results suggest that CO_2 is detectable, at least in some circumstances, at tens of metres downwind and hence dispels the notion that its action is limited to that of a short-range attractant.

Key words. Carbon dioxide, dispersion, *Glossina*, host location, odour plume, tsetse fly, turbulence, Zimbabwe.

Introduction

Carbon dioxide (CO_2) is a universal host attractant for biting flies (Gibson & Torr, 1999). For tsetse (Diptera: Glossinidae), CO_2 activates resting flies (Bursell, 1987; Torr, 1988), elicits optomotor upwind anemotactic (Colvin *et al*., 1989), klinokinetic and orthokinetic responses (Gibson & Brady, 1988; Warnes, 1990), and elicits alighting on a host animal (Vale, 1983; Vale & Hall, 1985). The role of CO_2 in host-seeking behaviour has also been documented for other diurnal biting flies such as stable flies (Diptera: Muscidae) (Warnes & Finlayson, 1985; Schofield *et al*., 1997) and horseflies (Diptera: Tabanidae) (Thornhill & Hays, 1972; French & Kline, 1989).

Carbon dioxide is the main substrate for plant photosynthesis and is released into the atmosphere through

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