Scientific Paper:

The Journal of Experimental Biology (2015), 218, 2201 - 2210

# Flight-motor-driven respiratory airflow increases tracheal oxygen to nearly atmospheric level in blowflies (*Calliphora vicina*)

Lutz T. Wasserthal
Department of Biology, University Erlangen-Nuremberg, Erlangen, Germany

**Abstract:**

It is widely accepted that an efficient oxygen supply and removal of $CO_2$ in small flying insects are sufficiently performed by diffusion with open spiracles. This paper shows that in the tethered flying blowfly, gas exchange occurs by autoventilation and unidirectional airflow. The air is inspired through the mesothoracic spiracles (Sp1) during the downstroke of the wings and is expired through the metathoracic spiracles (Sp2) during the upstroke. This directed airflow through the thoracic tracheal system was documented by pre-atrial pressure measurements at the Sp1 and Sp2, revealing a sub-atmospheric mean pressure at the Sp1 and an over-atmospheric mean pressure at the Sp2. In the mesothoracic air sacs, the mean pressure is sub-atmospheric, conditioned by the only slightly open spiracles. In a split flow-through chamber experiment, the $CO_2$ released through the Sp2 confirmed this unidirectional respiratory gas flow, implicating an inner tracheal valve. In the thoracic tracheal system, the $P_{02}$ during flight exceeds the high resting $P_{02}$ by 1 – 2 kPa, reaching nearly atmospheric values. In the abdominal large air sacs, the $P_{02}$ drops during flight, probably due to the accumulation of $CO_2$. Periodic heartbeat reversals continue during flight, with a higher period frequency than at rest, supporting the transport of $CO_2$ via the haemolymph towards the metathoracic tracheae and abdominal air sacs.

Keywords: Autoventilation, insect respiration, tracheal pressure, air sac, tracheae, $O_2$ supply, spiracles, haemolymph, gas exchange, $CO_2$ release, $H_2O$ emission