Breathing easy: When it comes to oxygen, a bug's life is full of it

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Because of new imaging technology, researchers are getting a better understanding of a physiological paradox: how insects, which have a respiratory system built to provide quick access to a lot of oxygen, can survive for days without it.

The insect respiratory system is so efficient that resting insects stop taking in air as they release carbon dioxide, according to research by Stefan K. Hetz of Humboldt University in Berlin, Germany. This allows them to keep oxygen and carbon dioxide levels in balance. Too great a concentration of oxygen is toxic, causing oxidative damage to the insect's tissues, just as it does in humans.

Hetz is a speakers at the upcoming symposium "Respiratory control in insects: integration from the gene to the organism." The symposium, sponsored by The American Physiological Society (APS) takes place Sunday, April 29 during the APS annual meeting at Experimental Biology 2007.

Why bugs don't pant

Bees consume large amounts of oxygen, and so it might be tempting to think they are panting – tiny inaudible pants. They are not, because they do not breathe through noses or mouths. Instead, insects draw in oxygen through holes in their bodies known as spiracles and pump the oxygen through a system of increasingly tiny tubes (tracheae) that deliver oxygen directly to tissues and muscles. Insects typically have a pair of spiracles for each thoracic and abdominal segment.

The same tubes that transport oxygen into the insect body usher out carbon dioxide. Insects use different methods to release carbon dioxide, including opening the thoracic spiracles (the ones closest to the head) to take in oxygen while exhaling carbon dioxide through the abdominal spiracles. Insects also use different mechanisms to pump the oxygen to the tissues.

This system is much more efficient than the system that vertebrates evolved. Insects deliver much greater volumes of oxygen, in proportion to their size, than do mammals. They also deliver oxygen directly to the tissues, while vertebrates dissolve oxygen in blood, transport it to tissues, and then reconvert the oxygen to usable form.

Live action footage

Because insects take in oxygen through spiracles which they open and close as needed, and because they can take in a large store of oxygen, they can live a long time without breathing by closing their spiracles and curbing their activity.

"Insects are able to survive hypoxic environments," explained Kirkton, the symposium chairman. "They can shut down and survive for hours or days. They have a low metabolic rate and can close their spiracles. If you compare Lance Armstrong, the bee and the hummingbird, the bee is the champion of oxygen delivery," he said. But at the same time, insects can survive low levels of oxygen for a comparatively long time.

Researchers have been interested in the insect tracheal respiratory system since 1911 when August Krogh researched moths and grasshoppers. Krogh's interest in oxygen delivery led him later to study blood perfusion in mammalian capillaries, for which he was awarded the Nobel Prize in 1920. But the advent of synchrotron x-rays, an advanced form of x-ray scan, has recently allowed scientists to learn much more about how insects breathe. The new imaging technology allows scientists to observe the respiration of live bugs.

This advance in technology also comes at a time when physiologists are learning more about the genes that control breathing. When physiologists gather at the symposium, they will assess these new developments and consider a roadmap for future research, said Kirkton.

Source: American Physiological Society