Bug breathing exposed

Powerful X-rays reveal the ins and outs of insect breath.
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Air tubes called tracheae inflate and deflate in crickets' heads.
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Researchers have spotted a new breathing mechanism in crickets, beetles and ants, using X-rays a million times more powerful than the average hospital variety[1].

Insect respiration, the study confirms, is less the passive diffusion of air, as had long been assumed, and more an active movement, like human breathing.

Most insects have a respiratory system akin to ventilation in a building. Tubes called tracheae run throughout their bodies delivering oxygen. The main airways get smaller as they branch off into their tissues. The tubes open to the outside air through vents called spiracles.

"Everybody always thought that tracheae were stiff tubes, and that they worked by plain diffusion," says Mark Westneat, associate curator of zoology at the Field Museum in Chicago, Illinois. "That idea has been dying for a while and our result puts it to death."

Until now, zoologists had observed active ventilation only in insects that were moving or flying. These insects pump their abdomens to increase airflow or fill air sacs as they fly.

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Westneat and his colleagues watched the tracheae deflate and inflate inside the head and thorax of ground beetles (*Platynus decentis*), carpenter ants (*Camponotus pennsylvanicus*) and house crickets (*Acheta domesticus*) at rest. These parts of the insect are covered in a hard outer shell and cannot pump air in by external movement.

The team saw compression and relaxation cycles of large tracheae in the head that lasted for less than a second and look similar to how mammalian lungs work. Westneat suggests that compressions that occur while the spiracles are closed may speed the diffusion of oxygen into insects' tissues by raising the internal pressure.

To answer that question you would have to look at the smaller branches where oxygen is exchanged and determine if compressions take place there too, says insect flight physiologist Robert Dudley from the University of California, Berkeley. "We still don't really know what's going on in the higher-order tracheae."

Beam time

The method used to peer at the inner workings of a live insect for the first time might resolve other mysteries that have bugged scientists for centuries. It could record wing flapping, the circulatory system of insects with multiple hearts, and genitalia during copulation.

We still don't really know what's going on in higher-order tracheae

Robert Dudley
University of California, Berkeley

It uses a synchrotron x-ray source - an intense beam of X-rays that comes from electrons travelling close to the speed of light around a 1-km circular track. The technique was discovered when physicist Wah-Keat Lee of the Advanced Photon Source at Argonne National Laboratory in Illinois placed a dead ant in the path of the beam.

The resulting images are highly detailed because of a property called edge enhancement. Edges between structures are sharpened, so that they appear outlined. Lee has also used the X-rays to look at sea-urchin teeth, fuel injection nozzles, and cracks in aluminum construction materials.

References

1. Westneat, M. W. *et al*. Tracheal respiration in insects visualized with synchrotron X-ray imaging. *Science*, **299,** 558 - 560, (2003). **|Homepage|**