Genomic study ties insect evolution to the ability to detect airborne odors

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A new study from Illinois entomology professor Hugh Robertson and colleagues at the University of California, Davis reveals that all insects have odorant receptors that enable them to detect airborne chemicals. Credit: L. Brian Stauffer

A new study reveals that all insects use specialized odorant receptors that enable them to detect and pursue mates, identify enemies, find food and—unfortunately for humans—spread disease. This puts to rest a recent hypothesis that only some insects evolved the ability to detect airborne odors as an adaptation to flight, the researchers said.

The findings are reported in the journal *eLife*.

"We now know that odor detection was present at the very beginning of insect evolution and that it was probably a defining feature of insects as they became terrestrial," said University of Illinois entomology professor Hugh Robertson, who led the new research with Philipp Brand and Brian R. Johnson of the University of California, Davis. "We found odorant-receptor genes in every insect species we looked at, including some that don't fly. We did not find these genes in any other arthropods, however, including other bugs with six legs."

Although odorant receptors are found in almost all terrestrial animals and in some crustaceans and mollusks, they vary a lot between groups, Robertson said.

"In insects, odorant receptors are the most simple kind that you can imagine," he said. These proteins are embedded in the membranes of neurons and extend outward to interact with chemicals in the extracellular environment. "When they bind to a chemical, they change shape, open an ion pore and change the polarity of the neuron," he said.

Insects often have hundreds of individual odorant receptors, each of which senses a particular type of chemical, Robertson said. In almost all cases, the receptors work hand-in-glove with a single coreceptor, a protein known as Orco.

Robertson has spent much of his career studying chemoreception in insects, using genomic techniques to identify receptor and coreceptor genes.

Odorant receptors are distinct from gustatory receptors, which enable almost all animals to detect chemicals in watery environments, Robertson said. When vertebrate and invertebrate creatures began to find new niches on land, some evolved the ability to also detect airborne chemicals.

"Odorant receptors evolved from gustatory receptors," Robertson said. But why and when they evolved in insects has been the subject of debate. He hypothesized in 2003 that odorant receptors were a feature of all insects.

But in a recent study, scientists failed to find odorant-receptor proteins in two groups of flightless insects. This led them to suggest that odorant receptors occurred only in flying insects and had evolved as an adaptation to flight.

The new study revisited these flightless insects, tiny creatures known as firebrats and jumping bristletails. Instead of looking for the odorant-receptor proteins in these critters, the team scoured their genomes and the genomes of other six-legged terrestrial bugs for genes that code for the receptors and for coreceptors.

The researchers found numerous odorant-receptor genes in the wingless firebrat and jumping bristletail, but not in the genomes of six-legged bugs that are not insects.

"Unequivocally, we have a full-blown odorant-receptor family in a wingless insect," Robertson said. "That refutes the claim that the whole system evolved with flight.

"Clearly, odorant receptors evolved long before wings and were not an adaptation to flight," he said. "The evolution of odorant receptors had to be an adaptation to something else, and the most obvious thing is terrestriality."

More information: Philipp Brand et al, The origin of the odorant receptor gene family in insects, *eLife* (2018). DOI: 10.7554/eLife.38340

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