Enemy odors help flies protect their offspring

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A parasitic wasp (*Leptopilina boulardi*) lays its eggs into larvae of the vinegar fly *Drosophila melanogaster*. In nature, many *Drosophila* larvae are killed this way. However, both larvae and adult flies are able to sense and actively avoid the wasps' odor. Credit: Markus Knaden, Max Planck Institute for Chemical Ecology

Female *Drosophila* flies avoid laying eggs at sites that smell of parasitic wasps.

Females of the vinegar fly *Drosophila melanogaster* show a strong response to the odor of their most dangerous enemies, parasitic wasps of the genus *Leptopilina*. In nature, up to 80% of *Drosophila* larvae are parasitized by these wasps, who lay their eggs into the fly larvae. The wasps' larvae grow and consume the *Drosophila* larvae from within. However, an innate early warning system alerts female flies when wasps are near - female flies can then avoid laying eggs near wasps, thus increasing the likelihood of offspring survival. Research from the Max Planck Institute for Chemical Ecology, publishing in the Open Access journal *PLOS Biology* on 16th December, identified the olfactory circuit in *Drosophila* that senses if enemies are nearby by recognizing their odors. Chemical odorant compounds produced by the wasps (including their sex pheromone) trigger avoidance behavior in the flies. These scientists have described the first olfactory circuit in insects entirely dedicated to the detection of a fatal enemy.

In the course of evolution, organisms have evolved different adaptations in order to ensure their survival or to increase the survival rate of their offspring. Insects' highly sensitive and specialized sense of smell plays a crucial role in many of their complex survival strategies.

Together with international partners, scientists from the Department of Evolutionary Neuroethology led by Bill Hansson and Markus Knaden

found that the vinegar fly *Drosophila melanogaster* houses an olfactory neuron that is dedicated to detecting odors of parasitic wasps. A combination of gas-chromatographic and electrophysiological analyses as well as behavioral assays with flies and larvae led to the results. By applying these methods, the scientists could identify both the wasp odors and the olfactory receptors in *Drosophila* that detected them. They were also able to demonstrate that the detection of these odors influenced the flies' behavior - adult flies as well as fly larvae actively avoided areas that smelled of parasitic wasps.

Three components of the wasps' odor activate a single olfactory neuron on the antennae of adult *Drosophila* flies. Chemical analysis revealed that these three substances are actinidine, nepatolactol, and iridomyrmecin. Interestingly, iridomyrmecin is the sex pheromone of the female *Leptopilina* wasp. Although adult flies have two olfactory receptors and smell all three substances in the wasps' odor, *Drosophila* larvae lack one of the two receptors; they smell only the sex pheromone iridomyrmecin.

"Until recently, scientists thought that most odors were detected by several receptors and that each receptor was stimulated by numerous different smells. The activation patterns of the different receptors would tell the fly which environmental odors were present. However, the results from our lab tell a completely different story: At least parts of the olfactory system are highly specific. Odors that are of particular importance for the fly are not detected and processed by the general system; each of these odors has its own channel. Seemingly, this has the effect that the detection of dangerous bacteria (geosmin) or the best oviposition sites (limonene) cannot be interfered with by other environmental odors," says Markus Knaden.

The strength of this study is that it combines several lines of evidence—chemical and physiological analyses, and behavioral

experiments with flies and larvae. The researchers suggest that vinegar flies learned to use the odor of the parasites for their own advantage in the course of evolution. This strategy, which has evolved as a means of self-protection, is intriguing, especially since avoidance of wasp odors appears to be innate - naïve flies that had never been close to parasitic wasps and did not previously know their scent were still able to display this odor detection and avoidance behavior.

Furthermore, four *Drosophila* species demonstrated the same avoidance behavior when they encountered the scent of *Leptopilina* wasps, demonstrating evolutionary conservation. Avoiding enemies by using their own sex pheromone as an olfactory cue is a very clever move in a game called co-evolution. Counter-adaptation by the wasps may be difficult since the release of these odors—in particular the sex pheromone—is indispensable for reproduction.

More information: Shimaa A. M. Ebrahim et al. Drosophila Avoids Parasitoids by Sensing Their Semiochemicals via a Dedicated Olfactory Circuit, *PLOS Biology* (2015). DOI: 10.1371/journal.pbio.1002318

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