MICROBIAL ECOLOGY

Bacterial volatiles give the game away

Aphids are a major crop pest, but chemical pesticides lead to the emergence of resistant organisms, and biological control can be hampered by the natural dispersal of many aphid predators. When aphids feed on plant phloem sap they excrete honeydew, a complex mixture of sugars, amino acids, lipids and organic acids that can serve as a growth medium for bacteria. Honeydew also emits volatile compounds that are thought to act as kairomones, which can attract predators to infested plants. Now, Leroy *et al.* show that, surprisingly, several of these volatiles are produced by an aphid-associated bacterium that can be isolated from honeydew.

The authors first used gas chromatography–mass spectrometry to identify the volatiles that are emitted from honeydew of the pea aphid, *Acyrtosiphon pisum*, finding 15 different molecules in total. Because bacteria can produce volatiles when metabolizing organic products, the authors

then tested the honeydew flora for the presence of bacteria.

Staphylococcus sciuri, which had previously been found in the gut of laboratory strains, was identified in honeydew of both laboratory and natural pea aphid clones. To determine whether this bacterium is the source of honeydew volatiles, the authors reinoculated sterilized honeydew with *S. sciuri*. Of the volatiles that were identified in the crude aphid honeydew, nine were found in the reinoculated sample but not in the sterile honeydew, indicating that they are produced by *S. sciuri*.

The hoverfly *Episyrphus balteatus* is considered to be one of the most abundant natural aphid predators; the adults sense volatiles to help locate prey-infested plants as sites for oviposition (egg laying), and the larvae feed on aphids. The authors carried out wind tunnel assays to test the effect of the bacterially produced volatiles on this predator: plants at one end of the tunnel were sprayed with a honeydew sample, and hoverfly movement from the other end of the tunnel towards the plants was monitored. Sterile honeydew had no effect, but crude and reinoculated honeydew

attracted hoverflies to the plants. Moreover, both samples stimulated hoverfly oviposition to a similar extent as aphid infestation. Of the individual bacterially derived honeydew volatiles, 3-methylbutanoic acid was found to be an attractant, and 3-methyl-2-butenal and 2-methylbutanoic acid were shown to be both attractants and oviposition stimulants. Similar effects on hoverfly movement were seen in the greenhouse and the field using medium from *S. sciuri* cultures as an attractant.

This insight into an unusual predator–prey relationship occurring between hoverflies and aphids, in which the prey position is betrayed by a prey-associated bacterium, could be used to greatly improve the efficacy of biological control methods. Why aphids retain their association with such a bacterium remains unclear, but one possibility is that *S. sciuri* is obtained from the plant as part of an elaborate plant defence mechanism.

Lucie Wootton

ORIGINAL RESEARCH PAPER Leroy, P. D. *et al.* Microorganisms from aphid honeydew attract and enhance the efficacy of natural enemies. *Nature Commun.* 2, 348 (2011)