Better Communicating through Chemistry

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LIKE MOTHS TO A FLAME

When the hawkmoth *Manduca sexta* catches scent of a flower on which it can feed, it flies in a zigzag pattern as it tracks the odor to its source. Then, hovering over the bloom like a helicopter, the moth extends its long proboscis to probe the flower and dine on nectar.

As in other pollinator-plant interactions, the hawkmoth uses cues such as flower color, shape, fragrance, and texture to find and evaluate flowers as potential food sources. But recent studies suggest that floral carbon dioxide (CO_2), which is associated with nectar production and increased respiratory activity, may also play a role in interactions between flowers and their insect pollinators.

In the Sonoran Desert, the hawkmoth is the primary pollinator of the night-blooming *Datura wrightii*. *Datura*'s large white flowers open explosively at dusk, releasing CO_2 at concentrations much higher than ambient levels. *Manduca sexta* moths have a special CO_2-sensing organ, and a 2004 study showed that male hawkmoths will choose an artificial flower emitting higher than ambient CO_2 levels over one emitting ambient levels.

In a paper published online on 14 January in *Proceedings of the National Academy of Sciences,* Cornell University doctoral student Joaquín Goyret and colleagues provide new details on how floral CO_2 affects the behavior of both male and female *M. sexta* moths. Goyret, Poppy Markwell, and senior author Robert Raguso examined the behavioral responses of hawkmoths to scentless white paper flowers and to paper flowers with a floral scent, with CO_2, or with both scent and CO_2. They found that CO_2, like floral odor, attracted male and female moths from a distance and elicited the characteristic zigzag tracking behavior. But CO_2 did not trigger flower-probing behavior.

Surprisingly, when moths were given a choice between a fake flower emitting floral scent alone and an identical flower emitting scent plus CO_2, the males preferred scented flowers with high CO_2 levels, but females chose randomly. "That's when we started putting things together," Goyret says. Other researchers had observed that female hawkmoths, which lay their eggs on the underside of leaves, often feed and lay eggs on the same host plant in a single visit if the plant has nectar-rich flowers. So Goyret and coworkers added odors from host-plant leaves to the mix in their choice experiments with fake flowers. "Now the females also started choosing the flowers emitting high levels of CO_2," he says. Taken together with observations by others that female *M. sexta* lay more eggs on plants with experimentally increased amounts of nectar, the new findings suggest that female moths are using CO_2 as a distance cue to find plants that not only are a good source of nectar but also will be high-quality hosts for their eggs and larvae.

OF ANTS AND PLANTS

Flowers and leaves are not the only plant parts that produce odors attractive to insects. A paper published online on 22 January in *Proceedings of the National Academy of Sciences* provides evidence that seed scents mediate an insect-plant mutualism.

In Amazonian rainforests, *Camponotus femoratus* ants collect the seeds of specific epiphyte plants and cultivate them in nutrient-rich arboreal nests known as ant gardens. The resulting plants, which grow almost exclusively in these hanging gardens, are essential for maintaining the integrity of the nests.

Some 3000 plant species worldwide use ants to disperse their seeds, and in most cases ants are rewarded for their efforts with a nutrient-rich tidbit in the seed. But gardening ants do not eat the seeds they collect, and this and other observations led biologists to speculate that these ants use other chemical cues to recognize a select group of seeds.

Elsa Youngsteadt, a doctoral student at North Carolina State University, traveled to Peru to investigate the relationship between *C. femoratus* and the main plant it cultivates, *Peperomia macrostachya.* She coated seeds from another plant, which *C. femoratus* ants normally would ignore, with an extract made from *P. macrostachya* seeds. The ants now carried those seeds, indicating that chemicals from the gardened seeds are attractive to the ants.

A second set of experiments, in which ants could smell the extract-coated seeds but not touch them, confirmed that *C. femoratus* ants are attracted to odors from the seeds. Typically, ants that disperse seeds "just bump into seeds, and then they realize by contact cues that there's a yummy little reward on the seed," Youngsteadt says. "Ants are very good chemists. They use chemical cues to communicate with each other and navigate their world. But it's never been shown unequivocally for these seeds that it's the chemistry that the ants like, and not something else, such as the texture, size, or color of the seeds."

Youngsteadt and her colleagues identified five specific chemicals from the seeds that together attract the ants. When she used seeds coated with just those five compounds in the seed-carrying experiment, the ants would poke at the seeds but only rarely pick them up. That suggests that not odor but some other cues, which ants detect by touching the seeds, trigger the behavior of picking up seeds and carrying them back to the nest. "It's still chemistry," Youngsteadt says, "but we haven't yet identified the specific chemicals involved."

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