# Got nectar? To hawkmoths, humidity is a cue

May 30 2012, By Daniel Stolte

By sensing a gradient in humidity, a hawkmoth can tell whether an evening primrose flower contains nectar without having to land and probe it. (Photo: Robert A. Raguso/Cornell University)

(Phys.org) -- Humidity emanating from a flower's nectar stores tells a moth if the flower is worth a visit, research led by a UA entomologist has discovered.

Until about 140 million years ago, dinosaurs had been munching their way through a uniformly green plant world. What happened then is one of evolution's greatest success stories, heralding a new kind of ecological relationship that would transform the planet: The first flowers appeared, competing for the attention of animals to visit them and distribute their pollen to other flowers to ensure the plant's propagation.

The myriad of ways in which flowers attract pollinators have been studied since the beginning of biology, and few ecological relationships between organisms are as well understood as those between plants and their pollinators.

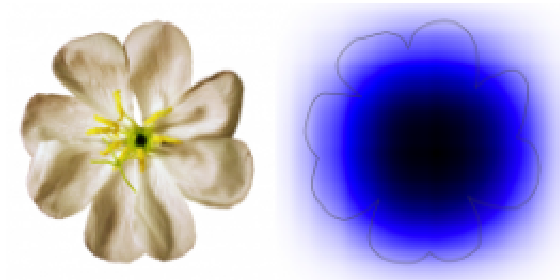
Despite decades of research, a team led by Martin von Arx, a postdoctoral fellow in the lab of Goggy Davidowitz in the University of Arizona department of entomology, now has discovered a previously unknown sensory channel that is used in plant-animal interactions.

The white-lined sphinx (Hyles lineata), the most common species of hawkmoth in North America, can detect minuscule differences in humidity when hovering near a flower that tells it if there is enough nectar inside to warrant a visit.

The findings constitute the first documented case of a pollinator using humidity as a direct cue in its foraging behavior and are published in the journal Proceedings of the National Academy of Sciences.

The study, "Floral humidity as a reliable sensory cue for profitability assessment by nectar-foraging hawkmoths," is co-authored by Davidowitz and Joaquín Goyret and Robert Raguso at the department of neurobiology and behavior at Cornell University in Ithaca, New York, where the work was carried out.

"Traditionally, most research on plant-pollinator interactions has focused on static cues like floral scent, color or shape," von Arx said. "All this time, evaporation from nectar was right under our noses, but few people ever looked. We were able to show that the insects actually perceive this cue, and it allows them to directly assess the reward that they might get from the flower."



An evening primrose flower as it appears to the human eye (left) and to a hawkmoth (right). if nectar is present, an invisible plume of humidity emanates from the flower, telling the moth if it warrants a visit. Credit: Martin von Arx

Unlike previously recognized cues used by pollinators such as flower size, shape or color, which don't necessarily reveal anything about the actual nectar levels waiting inside, the humidity evaporating from the flower's nectar provides an "honest" signal to a potential visitor. Scent, for example, is independent of nectar, which is odorless in most plants, whereas the fragrance usually is produced by the petals.

"We were always intrigued by this question," von Arx said. "Given that the known cues like flower shape and color are independent of the abundance of nectar, we were wondering if there is some other cue the insects might use. You would expect natural selection to favor an ability to sense a cue that is directly linked to the nectar reward."

To a hawkmoth setting out at dusk to search for nectar-bearing flowers of one of its favorite plants, the tufted evening primrose (Oenothera cespitosa), being able to quickly tell whether a flower is worth visiting, can make the difference between life and death.

Hovering in front of a flower while probing it with its long proboscis – the moth's "tongue" – is one of the most energetically costly modes of flight, von Arx explained. And once the insect plunges its head deep inside to reach all of the nectar, it is very vulnerable to predators such as bats.

"The metabolic cost of hovering in hawkmoths is more than 100 times that of a moth at rest," said Davidowitz. "This is the most costly mode of locomotion ever measured. An individual hawkmoth may spend 5-10 seconds evaluating whether a flower has nectar, multiply that by hundreds of flowers visited a night, and the moth is expending a huge amount of energy searching for nectar that may not be there. The energy saved by avoiding such behavior can go into making more eggs. For a moth that lives only about a week, that is a very big deal."

Add to that the "Black Friday" effect: fierce competition for limited supplies while they last.

"Imagine: As soon as the sun sets, all the hawkmoths fly around flower patches in the desert," von Arx said. "These flowers open within minutes of each other, and as soon as they do, the moths go there. A big flower patch or a plant with multiple flowers might attract many moths at the same time, so it's very important for an individual to pick the most profitable one very quickly."

A hawkmoth delving deep into a flower becomes easy prey. Being able to assess a flower's nectar content from a safer distance enhances the moth's chance of survival. Credit: Robert A. Raguso/Cornell University

The research group first measured humidity levels around a nectar-bearing flower by enclosing primrose plants in a sealed container and scanning the air inside with highly sensitive humidity measuring devices called hygrometers. They found that humidity just above the opening flower was slightly higher than ambient levels, caused partly by a plume of water vapor emanating from the flower's nectar tube.

To study whether and how moths respond to the humidity evaporating from nectar stores, the research team put artificial flowers – to exclude any other potential signal other than humidity levels – in a flight cage large enough for the moths to fly about freely.

Even though none of the artificial flowers had nectar, the moths would preferentially hover and extend their proboscis into those that had slightly elevated humidity compared with those that matched the humidity around them. The animals were able to sense if humidity near a flower was elevated as little as 4 percent above ambient humidity in the flight cage, despite of the turbulence generated by many moths hovering about.

"It was really exciting to see their high sensitivity to humidity in that they can perceive such a minute amount of difference in such a dynamic environment," von Arx said.

The results help researchers better understand the ecological relationships between flowers and their pollinators, especially in arid environments such as the Southwestern U.S.

Even though most plant-pollinator relationships are mutually beneficial – the plant rewarding the pollinator's help with food – their interests are conflicting.

"Speaking in evolutionary terms, the flower wants to be visited by a pollinator, but it doesn't want to invest too much because sacrificing resources and energy to make nectar is expensive," von Arx explained. "Often, plants are dishonest in their advertising, by presenting attractive flowers with no nectar."

But under certain circumstances, especially in desert environments, where water is scarce, it is beneficial for a flower to be honest, the researchers believe.

"If you're one of only a few flowers and there are lots of pollinators out there, you don't have to be honest about how much nectar you have because they'll visit anyway," von Arx said. "But if you want the attention of just a few, you really have to go all out. So by saying, 'Hey, come here, I have lots of nectar,' you're giving a faithful signal about an actual benefit that the pollinators can perceive and evaluate."

"I think in this case we showed that honesty makes sense in this system, because plants pollinated by hawkmoths are often pollinator-limited, and this signal, especially in the desert environment, is very potent."

According to von Arx, relative humidity plays an important role in the insect world and has been associated with choosing a suitable habitat but never was studied in the context of foraging for nectar. For example, neurobiological experiments revealed that cockroaches are able to detect humidity changes of a fraction of a percent.

"As creatures who use vision and olfaction, humans think in odors and shape, and color," von Arx said. "We are biased by what we can perceive. We know that moths have hygroreceptors on the tips of their antennae, but they remain a mystery for the most part. We know a lot about olfactory receptors, mechanoreceptors and vision. The insect eye has been studied in and out. But hygroreception? We still don't really know how that actually works."

Provided by University of Arizona

Citation: Got nectar? To hawkmoths, humidity is a cue (2012, May 30) retrieved 26 April 2024 from https://phys.org/news/2012-05-nectar-hawkmoths-humidity-cue.html