Laws of attraction: Pollinators use multiple cues to identify flowers across continents

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Hoverfly pollinators visited buttercups in Thangu Valley, North Sikkim, one of the trans-continental sites chosen. Credit: Shannon Olsson

Although at least 75% of our crop species depend on the activities of wild pollinators, little is known about their flower preferences. As global populations of domestic bee pollinators decline, it is of utmost importance for us to understand what factors attract wild pollinators such as hoverflies to flowers, and how these preferences differ in the face of environmental change. Now, a team of scientists from Uppsala and Flinders University and the National Centre for Biological Sciences (NCBS) have discovered that hoverflies, a group of generalist pollinators, use a combination of cues such as color, shape and scent to identify flowers.

You and I live in a sensory world—sight, sound, touch and taste blend to give us a sense of our surroundings. However, imagine perceiving the world as a fly, with a brain the size of a pinhead. Yet many insects with miniscule brains manage to do exactly what we do—identify objects like a flower, or a plant.

Karin Nordström's group from the University of Uppsala, Sweden, and Flinders University, Australia, and Shannon Olsson's team from the National Centre for Biological Sciences (NCBS) in Bangalore, India, have long been interested in how insects, with their "teeny-tiny" brains can recognize objects such as flowers. Now, through their collaborative work on hoverflies, the two teams have found an answer. These insects use a multimodal sensory mechanism—in other words, hoverflies require a combination of clues including shape, size, color and scent—to recognize flowers in different environments across the world.

The teams' results are especially important with respect to our scarce knowledge of what attracts wild insect pollinators to flowers. Although at least 75% of our crop species depend on the activities of wild pollinators, little is known about their flower preferences. As global populations of domestic bee pollinators decline, it is of utmost importance for us to understand the factors that attract wild pollinators

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When Olsson from NCBS contacted her long-time friend and collaborator Karin Nordström at the University of Uppsala and Flinders University for help in identifying a hoverfly species, little did they know that this would be the beginning of a major project.

"I was just amazed," says Nordström. "This hoverfly specimen collected at an altitude of 4000 meters in the Himalayas, is the same species of hoverfly, Eristalis tenax, that is also found in Sweden, Germany, USA, and Australia," she adds.

"Most studies on pollination are climate or area-specific, so it is hard to predict if pollinator preferences for flowers in, say North America, are relevant for Europe or Asia," say Olsson and Nordström. "Since we didn't just examine different environments, but actually different continents, our study directly tests this assumption," they add.

The researchers' work began with collecting observations on hoverfly behavior in three of these insects' natural habitats—tropical Bangalore, alpine Sikkim, and hemi-arboreal Uppsala. This helped them gather data on the characteristics of flowers that hoverflies found attractive and those that they found unattractive. From a "statistical soup" of all their findings, the team then extracted information about the features that hoverflies seemed to find most attractive and less attractive. Using the results of their statistical analyses, the researchers then modelled a set of hypothetical flowers, whose attractiveness to hoverflies were then tested in Bangalore, Sikkim and Uppsala.

The experiments with the artificial models indicate that hoverflies prefer certain combinations of flower characteristics in specific environments. For example, flower models of small blue models with a specific scent

were highly attractive to hoverflies in Bangalore, but not so in Sikkim or in Uppsala.

"This is really important," says V. S. Pragadeesh, a student from Olsson's lab who was involved in the study. "It means that pollinators have specific preferences in flowers in specific places. Without these cues, hoverflies may not recognize flowers as flowers," he says.

"Our models were not flower mimics or lures—they just used combinations of cues determined from our analysis. Some of our artificial flowers were attractive in all environments, despite having no reward or even resembling a real flower," says Nordström.

Robert Raguso, a behavioral ecologist from Cornell University, uninvolved in this study, is excited about the unique and creative approach taken by the authors in "interviewing" hoverflies. "I respect the multimodal approach taken in this paper and would like to see it generate similar studies, either with different focal pollinators or with multiple pollinator classes sharing the same floral market place," he adds.

Olsson and Nordström hope to continue their studies on how hoverflies and other generalist pollinators perceive flowers, and the factors affecting these pollinators' preferences.

"We would really like to investigate how network interactions can affect floral attraction. For example, if there are many other flowers in the vicinity, or many other pollinators, does this affect the attractive cues?" asks Nordström. "How does the brain code for flower objects? Are there 'flower neurons' in the brain? How do hoverflies make sense of this multimodal input? These are some of the questions we'd really like to work on," she adds.

Olsson adds that their findings can have important implications for establishing planting strategies resilient to environmental change. "We really must begin understanding pollination as a global ecological service. Many insects can be found across the globe, and understanding them across continents is essential not just for our own food security, but, I believe, for the future of this planet" she says.

The work described in this article will be published in a paper titled "In situ modeling of multimodal floral cues attracting wild pollinators across environments", in the journal *PNAS*.

More information: Karin Nordström el al., "In situ modeling of multimodal floral cues attracting wild pollinators across environments," *PNAS* (2017). www.pnas.org/cgi/doi/10.1073/pnas.1714414114

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