New model for analyzing color vision in aphids
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Aphids are one of the least welcome garden visitors. These small insects can cause substantial damage in agriculture, but how do they actually choose their host plants? What are the basic mechanisms behind this? Researchers from the Universities of Bonn and Kassel now present two novel models that can be used to analyze aphid color vision and thus how the animals respond to plants. This opens up new possibilities for future research on this topic—but may also be relevant for agricultural applications. The study has been published in the journal *Philosophical Transactions of the Royal Society B: Biological Sciences*.

It has been known for years that aphids are particularly fond of the color yellow, which is why yellow color traps are sometimes used in agriculture to monitor the aphids in crops. For their current study, the researchers deployed a total of more than 200 color traps with about 70 different colors in the field in two consecutive springs.

Using a light spectrometer, they measured the so-called reflectance spectra of the individual colors for each wavelength. "The spectrometer allows us to objectively quantify the colors. This is important because humans perceive colors quite differently from insects—so we can't rely on our eyes for that," says study lead Prof. Dr. Thomas F. Döring from the Institute of Crop Science and Resource Conservation (INRES) at the University of Bonn.

The reflectance data and the behavioral data, that is, the number of aphids caught per trap, then formed the basis for two mathematical models. The goal was to correlate the reflectance and behavioral data, and in this way find out which wavelengths are decisive for the aphid's response.

Two models with similar results

In the first model, the scientists incorporated already known data about which photoreceptors are stimulated when aphids search for food. The second model did without the physiological data and considered only the behavior of the animals and the measured reflectance data per color. For this model, the researchers applied a special statistic method called partial least squares regression (PLSR).

Both models came to similar conclusions. Firstly, they confirmed the aphids' preference for the color yellow. Secondly, both models suggested a specific neural mechanism that controls the visual behavior of aphids. "The fact that the results of both evaluations were ultimately so similar surprised us," says Dr. Sascha M. Kirchner of the University of Kassel. "But the result is so strong that it can't be a mathematical artifact."

One conclusion of the researchers: Even for aphid species for which no physiological data are available so far, the new evaluation method, together with selected color stimuli, can help to provide more precise information on visual behavior. "In this way, we might be able to avoid costly electrophysiological studies on the animals in
the future," points out Döring, a member of the Transdisciplinary Research Area "Sustainable Futures" and the PhenoRob Cluster of Excellence at the University of Bonn.

Bridge between biology and agriculture

With their study, the researchers combine biological and agricultural research in a special way. In neurobiology, aphids do not normally serve as model organisms to study basic mechanisms. In agriculture, however, such behavioral analyses are often not applied due to their level of detail. "We tried to build a bridge between applied science and basic research in our study," says field ecologist Thomas Döring.

Specifically, the new models could help optimize existing agricultural practices, such as so-called mulching methods that can alter the visual background of crops and thus "hide" host plants from pests. The results could also be relevant for attempts to change leaf color, for example through breeding or special fertilization. The current study already provides evidence that wheat leaves are more attractive to aphids when fertilized with low levels of nitrogen than when treated more intensively with nitrogen.

Why yellow?

The question remains open as to why aphids actually have such a preference for yellow—after all, their food is green plant leaves. "We can now explain this physiologically, but the underlying benefit for the aphids is still unclear," says Thomas Döring.

In future studies, he and his colleagues would like to investigate the effect of UV light in more detail, which is interesting both for applications in crop protection and from a biological perspective.

Additionally, the study provides preliminary evidence that some aphid species respond somewhat differently than the majority. Whether this behavior is fundamentally different must also be clarified in further investigations.
