

Caterpillars of the peppered moth perceive color through their skin

Twig-mimicking caterpillars change their color depending on the background and move to color-matching backgrounds

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Summary:

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Cephalopods, chameleons and some fish camouflage themselves by adapting their color to their surroundings. These animals have a system to perceive color and light independently of the eyes. Some insects, such as caterpillars of the peppered moth (*Biston betularia*), also match their body color to the twig color of their food plant; although this color change is rather slow compared to other animals. Until now, scientists have not known how insect larvae can perceive the color of their environment and how the color change occurs. Two theories dating back more than 130 years proposed that the color change could be caused by the diet or by the animal seeing the color. As some insects are known to be able to perceive light -- but not color -- by the skin, researchers from Liverpool University and the Max Planck Institute for Chemical Ecology pursued three different approaches to finally solve the riddle of how caterpillars of the peppered moth match the color of their surroundings.

First, they tested if caterpillars of the peppered moth, whose eyes were painted over with black acrylic paint, could still adjust their color to the background. The blindfolded caterpillars were raised on white, green, brown and black branches and their body color observed. Even without

being able to see, the caterpillars changed color to resemble the background to the same extent as caterpillars whose eyes were not covered. "It was completely surprising to me that blindfolded caterpillars could still change their color and match it to the background. I don't think my supervisor, Ilik Saccheri, believed me until he saw it by himself," says Amy Eacock, one of the lead authors of the new study and currently a postdoc at the Max Planck Institute for Chemical Ecology.

In behavioral experiments, blindfolded caterpillars had the choice to move to differently colored twigs. Consistently the caterpillar rested on the twig most similar to their own color.

In a third approach, the researchers examined in which parts of the body genes related to vision were expressed. They found them not only in the head of the caterpillars, where the eyes are, but also in the skin of all body segments. One visual gene was expressed even more in the skin than in the heads of the caterpillars. "We assume that this gene is involved in the perception of background color by the skin," notes Hannah Rowland, second lead author and leader of the Max Planck Research Group, Predators and Toxic Prey.

"One of the major challenges animals face is how to avoid being eaten by predators. Numerous species have evolved camouflage to avoid being detected or recognised. A considerable problem, however, is how prey animals can match the range of visual backgrounds against which they are often seen. Color change enables animals to match their surroundings and potentially reduce the risk of predation," says Hannah Rowland, highlighting the study's ecological context. Amy Eacock adds: "We constructed a computer model that can 'see' the same way birds do, so we are able to conclude that these adaptations -- color change, twig-mimicking, behavioral background-matching -- likely evolved to avoid visual detection by predators." Caterpillars with better color sensing may have been eaten less by birds, while birds with improved vision may prey more upon these larvae, continuing the evolutionary predator-prey arms race.

The study expands our understanding of how lepidopteran larvae protect themselves from predation.