Study gives the green light to the fruit fly's color preference

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Under red light, the Department of Physics' Stanislav Lazopulo, left, and Sheyem Syed can retrieve fruit flies from an incubator without affecting the insects' internal timekeeper. Credit: TJ Lievonen/University of Miami

For more than a century, the humble and ubiquitous fruit fly has helped scientists shed light on human genetics, disease, and behavior. Now a new study by University of Miami researchers reveals that the tiny, winged insects have an innate time- and color-dependent preference for

light, raising the intriguing possibility that our own color choices depend on the time of day.

In a study published in the journal *Nature* on Wednesday, the researchers made two unexpected discoveries. First, they found that, given a choice, fruit flies are drawn to green light early in the morning and late in the afternoon, when they are most active, and to red, or dim light, in midday, when like many humans, they slow down to eat and perhaps take a siesta.

Much to the researchers' surprise, they also found that fruit flies, Drosophila melanogaster, demonstrate a "robust avoidance" for blue light throughout the day, a finding that turns a decades-long assumption on its head. Previous experiments dating back to the 1970s determined that fruit flies are attracted to blue light, the main driver for the circadian clock, or the genetic 24-hour timekeeper that controls the lives of humans and most other animals.

"If given a choice, the fact that flies would not choose blue is surprising, but the most surprising thing, which is relevant not just to flies, but to color preference in general, is the fact that color preference changes with time of day," said senior author Sheyum Syed, assistant professor of physics, who conceived and designed the study with post-doctoral student Stanislav Lazopulo. "This finding opens the possibility that human color preference also changes with the time of day, which may explain why it's been so difficult to nail down how color guides our choices."

Added study coauthor James D. Baker, research assistant professor of biology who helped supervise the study, "Stan has shown that these animals have a very clear preference for different colors of light at different times of day that's repeatable day to day, individual to individual, genotype to genotype. Our research community didn't have any idea that was happening."

Four years ago, while a graduate student in Syed's lab, Lazopulo set out to determine how Drosophila would respond to the colored light they would experience at their leisure in nature. If given a choice, what light would they choose? Would there be a pattern? Would their choices be guided by the circadian clock that guides all organisms?

With assistance from his brother, Andrey, he created an elaborate set of behavioral experiments that involved placing hundreds of single flies into tiny multicolored tubes that had a stopper on one end, food at the other end, and three distinct "rooms"—one green, one red, and one blue—that the insects could freely navigate.

Then he recorded their movements around the clock, through 12 hours of constant light and 12 hours of complete darkness, for as many as two weeks at a time. When Lazopulo reviewed the initial computer analysis of the recordings, he thought he had miscoded the computer program.

"They actually don't like blue light. They run away from blue light," he said. "It was absolutely an unexpected result. Based on all the previous knowledge we were not expecting to have such a preference for green, an avoidance for blue, and such robust patterns in this behavior."

But neither the computer program, nor the video, nor his eyes were flawed. During the day, the flies consistently avoided the blue zones, even when their food was placed in one. Under those circumstances, they would make brief incursions into a blue zone, but only to feed.

In contrast, the flies began to occupy the green zones about two hours after the lights came on in the morning. By midday, their preference for green and their activity diminished, with about half the population split between the green and red, or dim, zones. Then, about an hour before the lights turned off, the flies returned to the green zones, and their more active state. Later, during the lights-off phase, the flies randomly

distributed themselves across the three zones, indicating, the researchers said, "that light is essential for generating the observed pattern."

Lazopulo and Syed, whose lab studies fruit fly behavior to better understand animal sleep, grooming, and color preferences, attributed the disparate results from earlier studies to improvements in long-term tracking methods and to the differences in the design of the experiments, particularly the difference in the time and conditions that the flies had to choose their color preference.

Past researchers, Syed said, tested Drosophila's color preference by releasing the flies into the bottom of a T-shaped vial and giving them 30 seconds to decide which arm of the T to exit—one with a green light and the other with a blue. The UM researchers suspect the flies chose blue under duress, as "an avoidance response to a noxious stimulus."

But now they know that, at their leisure and under more natural conditions, Drosophila prefer green, like the leaves of the fruit trees where, to the frustration of many a farmer, they like to lay their eggs.

Through what Baker called a "tour de force set of experiments" that included a series of genetic manipulations, the researchers also discovered that the fruit fly's color-driven behavior doesn't depend just on its visual system, as previously documented, but also on light-sensitive cells in the insect's abdomen that sense blue. Their internal clock guides the decision to stay in green or choose dim light in the middle of the day. Delete the clock genes, and the fruit flies always stay in green, never switching to dim light in midday.

But even without the clock, they still avoid blue, thanks to those abdominal cells that signal independently of the clock genes.

What this means for humans remains to be seen. But 110 years after

embryologist Thomas Hunt Morgan began breeding fruit flies to confirm how genetic traits are inherited, UM researchers have shown there's still much to learn from the common pest that has evolved into the most studied and written about animal on the planet. In all, 10 scientists have earned six Nobel Prizes for their groundbreaking biological discoveries using fruit flies, whose genetic and physiological makeup is far simpler than humans, yet very similar.

In 1933, Morgan earned the first Nobel for discovering the role chromosomes play in heredity; in 2017, a trio of scientists earned the latest one, for isolating the circadian clock genes that control the rhythm of nearly every organism's daily life—not just in the brain, but in almost every cell in the body.

More information: Stanislav Lazopulo et al. Daytime colour preference in Drosophila depends on the circadian clock and TRP channels, *Nature* (2019). DOI: 10.1038/s41586-019-1571-y

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