Biological clocks of insects could lead to more effective pest control

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This image shows a 0.1 x 0.03 inch (2.5 x 0.8 mm) small Drosophila melanogaster fly. Image: Wikimedia Commons

Researchers at Oregon State University have discovered that the circadian rhythms or biological "clocks" in some insects can make them far more susceptible to pesticides at some times of the day instead of others.

With further research, the scientists said, it may be possible to tap into this genetic characteristic, identify the times that a target insect is most vulnerable to a specific pesticide, and use that information to increase the effectiveness, reduce costs and decrease the amounts of pesticide necessary for insect control.

Approaches such as this may also be highly useful in programs of "integrated pest management," the researchers said, which aim to minimize pesticide use, prevent development of resistance to pesticides, and use a broad range of physical or chemical control measures to enhance the long-term effectiveness of an insect control program in crop agriculture.

The findings were just published in PLoS ONE, a professional journal, in work supported by the U.S. Department of Agriculture, National Institutes of Health and National Science Foundation.

"We found that it took triple the dose of one pesticide to have the same lethal effect on fruit flies at the time of day their defenses were strongest, compared to when they were weakest," said Louisa Hooven, a postdoctoral fellow in the OSU Department of Zoology and lead author on the study. "A different pesticide took twice the dose. This makes it pretty clear that the time of day of an exposure to a pesticide can make a huge difference in its effectiveness."

In recent years, researchers have found that the genes which are sensitive to the natural rhythms of day and night can have a wide range of biological effects, on everything from fertility to feeding patterns, sleep, hormone production, stress, productivity, medication effectiveness and many other functions. And they operate in multiple cells in many or most plant and animal species, including humans.

In the newest work, circadian rhythms appear to coordinate "xenobiotic metabolizing" genes, or the genes responsible for breaking down and detoxifying various poisons, such as pesticides. Besides that, it's possible that circadian clocks may also affect absorption, distribution, excretion, and molecular targets of toxicity.

"This rhythmic defense mechanism may have evolved in order to disarm

the noxious compounds that plants produce to avoid being eaten by an insect," said Jadwiga Giebultowicz, a professor of zoology at OSU. Other co-authors on this work included OSU undergraduate students Katherine Sherman and Shawn Butcher.

The OSU study found that insect defenses against two commonly used pesticides, propoxur and fipronil, were strongest during mid-day, and weakest around dawn, dusk or the middle of the night. The effectiveness of two other pesticides studied - deltamethrin and malathion - did not seem to be so strongly associated with time of day, at least with fruit flies.

"For this approach to be useful in agriculture or other places pesticides are used, we will need to test specific insects against specific pesticides, and we will probably find differences in time of maximum effectiveness for various pest-pesticide configurations," Giebultowicz said. "In some cases we may be able to greatly improve the effectiveness of pesticides or allow the use of reduced doses."

Although many pesticides have a residual effect, the researchers said, the timing of the first exposure can be critical. Many pesticides are repellent to insects, and if they are not killed immediately they may simply avoid the residue, or in some cases develop resistance to the pesticide - a critical and costly problem in modern agriculture. Pesticide resistance has been a driving force behind the evolution of the field of integrated pest management, as growers realized that sustainable pest control is not as simple as using the same pesticide, year after year, which often becomes increasingly ineffective and more expensive.

The new findings, the OSU researchers said, are also another example of how circadian rhythms are important in other detoxification systems in biology. In human medicine, a field called "chronopharmacology" is already developing, based on the observation that some medications are

far more effective if administered at one time of the day instead of another.

Research into the molecular mechanisms underlying circadian rhythms was pioneered in fruit flies, but the OSU researchers hope their future research will shed light on how the biological clock influences responses to chemicals in humans.

"A fundamental understanding of the functional significance of circadian rhythms in chemical exposures may facilitate strategies to reduce adverse events in humans, promote control of pest species and reduce pesticide use," the researchers wrote in their report.

"Our study strongly suggest that time of day should be included in insect control strategies and human risk assessment of chemical exposures, including pesticides," they said. "In some cases, the clock, together with the dose, may make the poison."

Source: Oregon State University (news : web)