Killing crop-eating pests: Compounds work by disrupting bugs' winter sleep

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(PhysOrg.com) -- The creation of compounds that disrupt a worldwide pest's winter sleep hints at the potential to develop natural and targeted controls against crop-eating insects, new research suggests.

Scientists have designed agents that interfere with the protective dormancy period of the corn earworm, a species that infests more than 100 types of plants and costs American farmers an estimated $2 billion a year in losses and control costs.

The compounds, composed of synthetic molecules that mimic the structure of a hormone in these insects, have three different effects on diapause, a hibernation-like state of arrested development that allows many types of bugs to survive through the winter. The agents can force the insects out of diapause prematurely, prevent the bugs from ever entering diapause, or block the termination of diapause.

Any of these cases could be described as "ecological suicide," said David Denlinger, professor of entomology and evolution, ecology and organismal biology at Ohio State University and senior author of the study.

"Diapause is such an important aspect of the life cycle," Denlinger said. "If we can do anything to disrupt the timing of that, make them go into diapause at the wrong time or break them out too early when there is no food available, that would be a pretty effective tool and a possible control strategy.

"And we now have tools that can do all three of those things to manipulate diapause."

The research is published online ahead of print in the Proceedings of the National Academy of Sciences.

The period of diapause in insects is controlled in part by the diapause hormone. In the corn earworm, Helicoverpa zea, and other crop pests, the hormone has been shown to break diapause, essentially waking up the bugs from their pupal state after they have been protectively burrowed underground during cold weather. In some other species, the diapause hormone initiates the hibernation instead.

Denlinger and colleagues investigated the structure of the hormone in these insects, and discovered that seven core amino acids do most of the work of terminating diapause. They then created chemical compounds based on the structure of that portion of the hormone and tested their effects on corn earworm larvae and pupae raised in a laboratory.

"By mimicking the structure of the amino acids, these compounds trick the body into responding as if the hormone is activated," said Qirui Zhang, a postdoctoral researcher in entomology and evolution, ecology and organismal biology at Ohio State and first author of the paper.

The researchers have narrowed the current crop of molecules down to three that appear to have the most potent effects at three different stages in the corn earworm's life. In at least one case, the science has improved on nature: The compound that terminates diapause prematurely is about 50 times more potent than an injection of the natural diapause hormone.

One other compound was so strong that it outright killed the larvae before there was any chance to disrupt their diapause state.

"That's not actually as interesting to us because we're looking at how to manipulate diapause," Denlinger said. "These agents wouldn't necessarily kill them right away, but interfering with diapause takes away their protection that gets them through adverse times and makes them vulnerable to environmental conditions."

Controlling these pests while they are larvae – which is when they do the most damage to plants – is desirable because once they pupate, they are underground and inaccessible, Denlinger noted.

But then again, terminating diapause early means pupae will die of exposure or starvation and won't have the chance to become adult moths that lay eggs and begin the life cycle all over again, he said.

In the experiments for this paper, the compounds were injected into the insects. Zhang is leading current experiments to deliver the agents orally in the bugs' food. Denlinger envisions the use of these compounds in some other form for insect control on a massive scale – perhaps by incorporating them into transgenic plants.

Current control measures for the corn earworm include insecticides and transgenic plants – primarily cotton, and not food crops – that contain a toxin that is deadly to the pest.

The research group will continue to work on refining the molecules and testing their effectiveness. "My guess is that these particular compounds won't be the ones that solve the world's problems, but this points us in the direction that could lead to some next-generation control agents," Denlinger said.

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