'Femme fatale' emerald ash borer decoy lures and kills males

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Emerald ash borer resting on leaf. Credit: Jonathan Lelito, BASF Corporation.

An international team of researchers has designed decoys that mimic female emerald ash borer beetles and successfully entice male emerald ash borers to land on them in an attempt to mate, only to be electrocuted and killed by high-voltage current.

"Our new decoy and electrocution process may be useful in managing what the U.S. Department of Agriculture Forest Service claims to be the most destructive forest pest ever seen in North America," said Michael Domingue, postdoctoral fellow in entomology, Penn State.

According to the Forest Service, the emerald ash borer was introduced to the United States from China in 2002. Since then, it has spread throughout 24 states and two Canadian provinces, and killed tens of millions of otherwise healthy native ash trees.

"Early detection of the pest in traps such as ours can help in coordinating management strategies to slow its spread and minimize its impact," said Domingue.

The researchers—including entomologists and engineers at Penn State, the Hungarian Academy of Sciences, the Forest Research Institute in Matrafured, Hungary, and the USDA—created the decoys using a bioreplication process with nanoscale fidelity.

"Specifically, we coated a dead female beetle with a vapor of nickel, and used the 'nickelized' shell to fabricate two matching molds in the shape of a resting beetle," said Akhlesh Lakhtakia, Charles Godfrey Binder professor of engineering science and mechanics, Penn State. "Pressing a structurally colored plastic sheet between the two molds while simultaneously applying heat, we cast numerous replicas or decoys. The finished bioreplicated decoys retained the surface texture of the beetle at the nanoscale.

Additionally, we painted some decoys a metallic green."

The Penn State engineers also created decoys using a 3D-printing process. In this method, they molded plastic into the size and shape of emerald ash borers, but did not attempt to duplicate the surface texture of the insects.

Next, the entomology researchers pinned the bioreplicated and 3D-printed decoys, as well as dead female emerald ash borers, onto leaves in forests in Hungary to see which of them best attracted wild males. In the same forests, the team also placed traps configured with decoys bearing a 4,000-volt charge to electrocute and trap males as they landed on the decoy females.

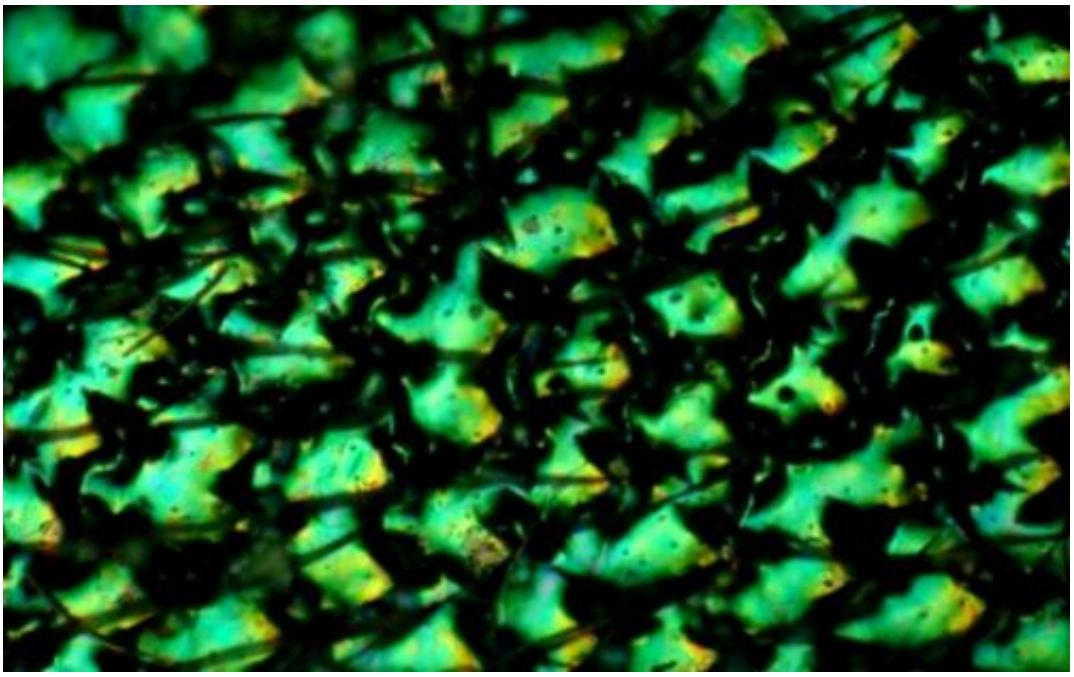
The results will appear today (Sept. 15) in the *Proceedings of the National Academy of Sciences.*

The scientists found that both types of synthetic decoys, as well as the dead pinned females, elicited initial flights by males toward them. Males nearly always chose to land on the dead females and the more realistic bioreplicated decoys. However, while the males initially flew toward the simpler 3D-printed decoys, they did not land on them. Males would normally quickly leave the bioreplicated decoys after they touched them. Yet, that brief contact was enough for them to become instantly stunned and captured by the trap if the voltage was applied to the decoys.

According to Domingue, the light-scattering properties of the beetle's shell—which the team experimentally demonstrated using a white laser—made the nano-bioreplicated decoys more lifelike and, therefore, more attractive to males than the non-textured 3D-printed decoy.

"We learned that not only do color and shape of a resting female beetle play a role in attracting males to a mate, but also the fine-scale texture of

the visible surface is important," said Domingue. "Small bumps and spines on the outer surface of their wings and heads that aren't visible to the human eye scatter light in a distinctive pattern. Beetles appear to be able to recognize this feature of the decoys and are strongly attracted to it. This insight may at least partially explain how mate-seeking males can easily detect and approach green-colored females cryptically resting on green leaves. Ultimately, we have gained new insights into how to manipulate the behavior of emerald ash borers and similar pests in ways that can help to trap them and monitor where they might be doing damage."



Pattern of spicules and spines on emerald ash borer surface. Credit: Justin George, USDA-Agricultural Research Service

According to Thomas C. Baker, distinguished professor of biology, Penn State, the findings were possible only because of the multidisciplinary

makeup of the team.

"I was able to find colleagues whose intellects, expertise, and enthusiasm matched the tasks at hand, thus enabling us to figure out how these destructive beetles find each other to mate and how we can exploit this behavior in order to help APHIS meet its goals of early detection and mitigation of invasive pests," he said.

The researchers said their next step will be to further improve the traps to maximize their potential as part of an early detection tool for emerald ash borers.

"Our laboratory has ongoing research with the USDA Animal Plant Health Inspection Service into remote-reporting, Internet-based technologies, and we will be working to couple this research with our ash-borer detection technique so that activity of the pest can be reported and assessed immediately by APHIS personnel, rather than waiting days or weeks until a trap might usually be checked," said Baker.

In addition, the team has been investigating the use of the decoys to attract other insect species, some of which are aggressive feeders on oak trees in central Europe and might threaten North American oaks in urban and forest landscapes much as the emerald ash borer destroyed ash trees.

"We have made progress in our research so far in Hungary these past few summers, and it looks like our decoys can be refined to attract and detect these other, new and potentially invasive pest species effectively," said Domingue.

More information: Bioreplicated visual features of nanofabricated buprestid beetle decoys evoke stereotypical male mating flights, *PNAS*, 2014: www.pnas.org/cgi/doi/10.1073/pnas.1412810111

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