Insulin tells young planthoppers whether to develop short or long wings

March 18 2015

One of the leading pests of rice, brown planthoppers can grow up to have either short or long wings, depending on conditions such as day length and temperature in the rice fields where they suck sap. The hormone insulin controls the switch that tells young planthoppers whether to develop into short- or long-winged adults, finds a new study. Credit: Chuan-Xi Zhang of Zhejiang University in China

Each year, rice in Asia faces a big threat from a sesame seed-sized insect called the brown planthopper. Now, a study reveals the molecular switch that enables some planthoppers to develop short wings and others

long—a major factor in their ability to invade new rice fields.

The findings will appear Mar. 18 in the journal *Nature*.

Lodged in the stalks of rice plants, planthoppers use their sucking mouthparts to siphon sap. Eventually the plants turn yellow and dry up, a condition called "hopper burn."

Each year, planthopper outbreaks destroy hundreds of thousands of acres of rice, the staple crop for roughly half the world's population.

The insects have a developmental strategy that makes them particularly effective pests. When conditions in a rice field are good, young planthoppers develop into adults with stubby wings that barely reach their middles.

Short-winged adults can't fly but they're prolific breeders. A single short-winged female can lay more than 700 eggs in her lifetime.

"The short-winged ones have great big fat abdomens. They're basically designed to stay put and reproduce," said biologist Fred Nijhout of Duke University, who co-authored the study with colleagues at Zhejiang University in China.

But in the fall as days get shorter and temperatures begin to drop—signs that the rice plants they're munching on will soon disappear—more planthopper nymphs develop into slender adults with long wings. Long-winged planthoppers lay fewer eggs but are built for travel, eventually flying away to invade new rice fields.

Until now, scientists did not know exactly how the shorter days and cooler temperatures triggered the shift between short and long wings, or which hormones were involved.

To find out, the researchers used a technique called RNA interference (RNAi) to silence the genes for two different insulin receptors—regions on the cell membrane that bind to the hormone insulin—and measured the effects on the animals' wings.

"Previously it had been assumed that all insects only had a single insulin receptor gene. We discovered that brown planthoppers have two," Nijhout said.

When the researchers silenced the first insulin receptor, short-winged adults emerged. Silencing the second receptor produced adults with long wings.

Further study revealed that long wings are the default design. But when planthoppers secrete a particular type of insulin in response to changing temperatures or day length, the second insulin receptor deactivates the first receptor in the developing wings, leading to short-winged adults.

"The second insulin receptor acts by interfering with the first one, therefore shutting down the signal," Nijhout said.

It's too early to say whether the findings could lead to techniques to treat planthopper populations so they are unable to invade new rice fields, Nijhout says.

But the researchers have found similar mechanisms in other planthopper species, and are now trying to find out if insulin plays a similar role in other insect pests with flying and flightless forms, such as aphids.

More information: "Two insulin receptors determine alternative wing morphs in planthoppers," Xu, H-J et al. *Nature*, March 18, 2015. DOI: 10.1038/nature14286

Provided by Duke University