Sugarcane pest produces foam to protect itself from heat

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Brazilian researchers found that bubbles produced by nymphs of the root spittlebug, a major sugarcane pest, act as a thermal insulator to maintain optimal body temperatures during development Credit: INCT Semiochemicals and ESALQ-USP

Tiny balls of froth can often be seen near the roots of plants in sugarcane plantations in Brazil during summer. The foam protects nymphs of the root spittlebug Mahanarva fimbriolata, a major pest of crops and pasture throughout the Neotropics.

Researchers at the University of São Paulo's Luiz de Queiroz College of Agriculture (ESALQ-USP), in collaboration with colleagues at the same university's São Carlos Physics Institute (IFSC-USP), have discovered that Mahanarva fimbriolata produces the foam to protect itself from temperature fluctuations in the external environment.

The temperature inside the ball of froth is similar to that of the soil and ideal for the insect's development, as it remains constant during the day even as the sun heats the ground. An article describing the study has been published in *Scientific Reports*.

"The theory that the foam produced by the spittlebug serves in thermoregulation [maintenance of an optimal body temperature] has been around since the 1950s, but has never been proven until now. We obtained proof by means of direct analysis," said José Maurício Simões Bento, co-author of the study.

The researchers had already observed a sharp increase in spittlebug numbers on sugarcane plantations in São Paulo State after the 2016 ban on pre-harvest sugarcane burning. The nymphs in their foam typically appear around the roots between the summer months of November and March, when atmospheric humidity is low and the soil is wet because of the rainy season.

To determine whether the foam does, indeed, confer thermal protection during this crucial stage of the insect's development before it reaches the adult stage, the researchers conducted field experiments, monitoring temperatures inside and outside of the foam and the soil on a sugarcane plantation in the Piracicaba region of São Paulo State on a warm summer's day when temperatures fluctuated significantly.

Their analysis showed that while external temperatures ranged from 24.4 degrees C to 29.2 degrees C, the temperature inside the foam remained constant throughout the day at approximately 25 degrees C, which is ideal for the nymph stage and similar to the typical soil temperature.

"We confirmed that the foam provides thermal protection for the insects during this stage of their development," said Mateus Tonelli, a Ph.D. student in entomology at ESALQ-USP and another co-author of the study.

Thermoregulatory mechanism

To gauge the foam's thermal resistance at temperatures higher than those found in the field, the FAPESP-supported research included a laboratory experiment in which foam-covered spittlebug nymphs were placed in a plant growth chamber heated to between 32 degrees C and 33 degrees C.

The analysis showed that when the temperature in the growth chamber was 32 degrees C, the temperature inside the foam was approximately 2 degrees C lower, in the range of 30 degrees C, and that the foam's structure remained intact.

"We observed that the foam acts as a thermoregulatory mechanism, keeping the temperature around the nymph below 32 degrees C, the temperature that is lethal for the insect. In sum, the foam is a sort of microhabitat or microenvironment in which the temperature is lower than that outside and remains constant regardless of external temperature fluctuations," Tonelli said.

The researchers also analyzed the chemical composition of the foam to identify the compounds related to bubble production and stability.

They found significant amounts of palmitic acid and stearic acid as well as proteins and carbohydrates. These substances act as surfactants that stabilize the foam by reducing surface tension and modulating bubble size and distribution based on viscosity and elasticity. Interactions between the carbohydrates and proteins create a stable film that stiffens and stabilizes the foam around the insect.

"The foam's chemical composition, which gives the bubbles a rigid architecture, was poorly understood until now," Bento said.

The foam comprises liquid from the sugarcane sap on which the nymphs feed, which is mixed with air, palmitic and stearic acid, and proteins and carbohydrates that reduce surface and interfacial tension to form emulsions.

To produce the foam, the spittlebug nymph uses its mouth apparatus to pierce the roots of the sugarcane plant to the xylem, the tissue that transports sap, and suck out the liquid. Part of this liquid blends with other substances present in the insect's Malpighian tubules, its main excretory organ.

The nymphs produce foam by sucking air into the ventral cavity of the abdomen. This air is mixed with the surfactant molecules and fluid in the Malpighian tubules, forming bubbles in the terminal part of the abdomen.

"Phylogenetic studies have shown that the spittlebug evolved some 200 million years ago from the cicada, which during the nymph stage, builds an underground tunnel enabling it to live for years in favorable thermal conditions. Its body temperature remains constant without any thermal insulation mechanism. The foam produced by the spittlebug nymph may serve as a 'soil extension' for the insect," Bento said.

"Unlike the cicada's legs, the spittlebug nymph's front legs are not strong enough to burrow into the soil in order to maintain a constant temperature. The spittlebug nymph has a delicate cuticle, and without the protection afforded by the foam, it would be vulnerable to environmental factors, such as high temperatures and low humidity."

According to Bento, knowledge of the foam's physical and chemical properties can be used to control the pest by developing compounds that prevent bubble formation by the spittlebug nymph.

"Currently, there aren't any commercially available compounds capable of eliminating the foam," he said.

Another possibility is the development of thermal insulators inspired by the foam.

More information: Mateus Tonelli et al, Spittlebugs produce foam as a thermoregulatory adaptation, *Scientific Reports* (2018). DOI: 10.1038/s41598-018-23031-z

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