ScienceWatch – Stand and Fight

Now that spring is here we will witness an annual occurrence; new plant growth will appear just in time to feed hungry insects. Since they are unable to run, plants have evolved a strategy that could be called "stand and fight". This involves a form of chemical warfare by which an array of compounds is produced that can make the plants less palatable or even disable their enemies. For example, laboratory experiments show that as a result of leaf damage by caterpillars, plants will produce bitter-tasting terpenes to ward off the herbivores. They may also manufacture other substances such as hormones that prevent the caterpillars from metamorphosing into adults and laying more eggs.

Even more fascinating is the fact that other terpenes serve as "phytodistress" signals, synthesized in response to insect, but not mechanical damage because oral secretions of insect herbivores induce these volatile substances as they graze on leaves. Both damaged and undamaged leaves make the terpenes and they attract predators such as parasitoid wasps that feed on the herbivores. For example, lima beans produce volatiles that attract predatory mites when damaged by spider mites. Corn and cotton plants release volatiles, which attract wasps that inject eggs into the caterpillar host. Once the caterpillar is stung it becomes a wasp factory.

Until recently this plant defensive strategy had been documented only in the laboratory or for agricultural systems (cotton and corn). Now a paper in the March 16, 2001 issue of *Science* demonstrates that herbivore-induced release of volatile chemicals is a plant defense also occurring in nature. The researchers, Andre Kessler and Kevin Baldwin from the Max Planck Institute in Germany, conducted a series of experiments with wild tobacco plants (*Nicotinia attenuata*) growing in the Great Basin desert in southwest Utah.

By enclosing leaves on plants under insect attack in polystyrene chambers and analyzing the gases released, they showed that the plants were emitting several classes of terpenes in response to leaf damage caused by three species of naturally-occurring insect herbivores. Next they measured the effect the terpenes had on predation of the herbivores. They used four of the terpenes from the natural blend that is released as a result of insect damage, and applied lanolin mixed with one of the four per plant. They then glued eggs of one of the natural herbivores, the tobacco hornworm (*Manducca sexta*), to the treated plants. To measure predation they counted the fraction of eggs and hatching larvae eaten by a natural predator, the big-eyed bug, (*Geocoris pallens*) during the next two days. Three of the four terpenes smeared individually on plants caused significantly higher predation rates than plants smeared with lanolin alone. The application of methyl jasmonate (MeJ), a substance that induces plants to release the same blend of terpenes resulting from insect damage, also caused a higher rate of predation.

Next they tested whether release of the terpenes would affect egg-laying of native adult *Manduca* moths. They treated plants with either MeJ, or one of two terpenes, or they applied several *Manduca* larvae. Egg-laying during the next two weeks was significantly reduced on plants with applied larvae, MeJ, and one of the two terpenes. Thus, within the cocktail of volatiles released after herbivore damage, some attract predators; some reduce further egg-laying, while others do both. Kessler and Baldwin estimated that the combined effect of luring predators and repelling herbivores results in a 90% reduction in the number of herbivore eggs laid on terpene-treated tobacco leaves.

Whether or not such a decrease in herbivores can actually save a plant is open to question, but these results show that herbivore-induced plant volatiles act as a double-edged defense in the wild by attracting predators and deterring herbivores.

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