Plant toxins: A double-edged sword

Secondary plant chemicals — a wide variety of compounds, including opium, caffeine and strychnine, produced by plants but not essential to their primary metabolism — often poison or repel insects and other herbivores. However, in an ironic twist, some plant-eating insects exploit these toxins to protect *themselves* against predators. New field research in the Sierra Nevadas of California shows that production of secondary plant chemicals can actually work against plants by this circuitous route.

Salicin, a toxin produced by willows, so improves one kind of willow-eating beetle's survival that the willows that produce the most salicin end up suffering the most beetle-inflicted leaf damage, report researchers at the University of California at Irvine in the Aug. 16 SCIENCE.

"This is the first field demonstration that a plant can be harmed by the chemicals that it originally produced itself as a defense against herbivores," says insect ecologist John T. Smiley, who led the study. Although other research has shown that glutathione, an antioxidant secreted by many crop plants, attracts and invigorates Mexican bean beetles (SN: 4/20/85, p. 247), glutathione is a *primary* plant chemical and is secreted in response to stress.

The willow-leaf-eating beetle, *Chrysomela aenicollis,* belongs to a group of beetle species known to prefer plants rich in salicin, which the beetles convert to salicylaldehyde—a bitter, irritating chemical. Secreted from surface glands by the beetle larvae, salicylaldehyde deters ants and probably other arthropod predators such as wasps from attacking the larvae, say the researchers.

Smiley and two graduate students placed beetle larvae, drained of their salicylaldehyde secretions, on willow shrubs that were either high or low in salicin. (The salicin content of the willows varied 100-fold at the study site.) After 10 days, all the larvae on high-salicin willows could secrete salicylaldehyde, but none of the larvae on low-salicin willows could. Even more telling, 60 percent of the larvae on low-salicin willows had disappeared—and presumably been eaten — compared with only 10 percent of the larvae on the high-salicin willows.

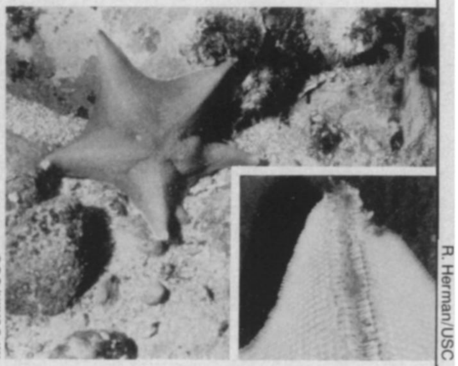
By measuring both leaf damage and salicin content in individual willow shrubs, the researchers discovered that the more salicin a willow produced, the more heavily it was damaged.

Salicin does repel herbivores less specialized than these beetles: Fewer kinds of herbivores eat salicin-rich plants than eat salicin-poor plants, says Smiley. But because *Chrysomela aenicollis* developed the ability to exploit salicin, an "evolutionarily unstable" situation has arisen, he says. To whatever extent the willows are debilitated by the beetles, the willows will experience selective pressure to not make salicin. In fact, the researchers note, most of the low-salicin willows in the study were at the lower elevations, where there are more beetles.

The researchers suggest that beetle-mediated natural selection may account for the great variation in salicin content of the willows. They also suggest that, more generally, repeated exploitation of secondary compounds by plant-eating insects may account for the great diversity of secondary chemicals that plants produce: That is, every time an insect herbivore adapts to a plant's toxins, the plant is forced to produce a new one. Some scientists have suggested that insects' remarkable capacity to develop resistance to synthetic pesticides is a knack they have evolved in response to the constant production of new pesticides by plants.

— *J. Dusheck*

Counting falling starfish in California



M. Conlin/USC

R. Herman/USC

An epidemic disease killed off hoards of starfish in southern California waters, including members of the batstar or Patiria miniata *species shown above. Inset: A lesion on the ray of a starfish marks the early stages of the disease.*

The batstar starfish is usually so abundant along the coast of California that in the northern regions it's been dubbed the "junkfish." But starting in 1978, a number of marine scientists began to notice that the batstar and other starfish species in southern California waters were dying off in droves. An epidemic disease ravaging the starfish population caused lesions to form on the animals' backs and rays, exposing the inner organs and making the bodies literally fall apart within days.

"You could swim along the bottom and just see bodies lying all over," says marine ecologist John D. Dixon. "It was kind of eerie."

Dixon and Stephen C. Schroeter, both in the Department of Biological Sciences at the University of Southern California in Los Angeles, recently documented the starfish's demise. They estimate that the batstar population density plunged from 1 to 2 per square meter in 1980 to very close to zero in May 1984 in three study areas. This year, the starfish seem to be making a comeback, but scientists don't know why and are still uncertain as to what caused the epidemic. Preliminary experiments conducted several years ago by microbiologist Kenneth H. Nealson at Scripps Institution of Oceanography in La Jolla, Calif., suggest that the villain may be a bacterium.

Whatever the cause, Dixon and Schroeter have discovered that the disease appears to work its worst in warm waters. Starfish were wiped out in the warmer coastal waters at and to the south of Santa Barbara. Moreover, the malady hit hardest during the summer and early fall, when the sea is the warmest. Fatalities were greatest between 1981 and 1983, when the El Niño episode warmed the Pacific. In a series of experiments, Dixon and Schroeter also found that a sick starfish would heal when it was placed in cold water.

The researchers observed that healthy animals became ill more rapidly when caged with a sick starfish than when caged alone. They suspect that the disease spreads faster in such close conditions because the healthy animals eat the sickly ones. Batstars, while aggressive, are normally not thought to be cannibalistic. The scientists suggest that the diseased animals are mistaken for prey when they become lethargic and are unable to protect themselves from healthy animals. Dixon hopes to test this idea by seeing what develops between two healthy starfish when one is sedated.

According to Dixon, diseases have driven a number of echinoderm species practically to extinction in the last few years. While this may be a new phenomenon, he says it's more likely that such epidemics have consumed marine populations periodically for a long time, and that researchers, who weren't able to study seafloor ecology until scuba gear was made available in the 1950s, are just now noticing them.

Dixon and Schroeter note that catastrophic epidemics provide an unusual opportunity to study the population dynamics of marine animals and the effects on an ecological system of removing one species. The researchers suspect, for example, that the drop in the number of starfish—which are known to have a taste for white sea urchins—may be related to an observed increase in urchins, which in turn have increased their grazing of kelp forests off northern San Diego County. But the link between starfish and urchin populations is still hypothetical at best. —*S. Weisburd*