MEETING ESA AND SOCIETY FOR ECOLOGICAL RESTORATION

An Ecological Oasis In the Desert

TUCSON, ARIZONA—Amid dry hills dotted with saguaro cactuses, more than 3500 ecologists gathered here from 4 to 9 August for the 87th annual meeting of the Ecological Society of America (ESA). The meeting, held jointly with the Society for Ecological Restoration, included sessions on everything from grassland restoration to the interplay of aphids, bacteria, and wasps.

A Gutsy Defense Against Killer Wasps

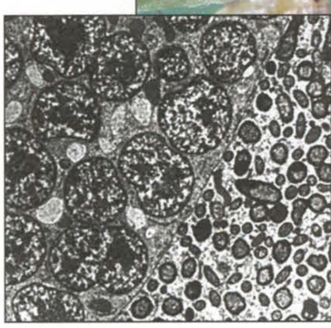
Many pea aphids suffer a grisly fate early in life. Parasitic wasps swoop down on the tiny sap-sucking insects and inject them with an egg; the larva transforms the maturing aphid into a nutrient-stocked cocoon. Some aphids, however, are able to ward off this deadly attack by using a little-known bacterium living in their cells.

The study—the first to show that symbiotic bacteria can confer resistance to an enemy—sheds light on the hidden world of bacteria that dwell inside insects. "This is one more example of how important these bacteria are in insects' lives," says Richard Stouthamer, an entomologist at the University of California, Riverside. Agricultural scientists could also translate the knowledge into better ways to control insect pests.

Over the past dozen years, scientists have used molecular techniques to uncover many bacteria that live only inside the cells of insects. For example, some *Wolbachia* bacteria manipulate their hosts' sex lives for their own benefit by forcing the host to produce only females, the sex that transmits *Wolbachia*. In other cases, there's a tangible benefit to the host. Aphids depend on *Buchnera* bacteria for nutrients such as amino acids that are lacking in their plant diet.

But another set of bacteria has long presented a mystery. Among these so-called secondary symbionts are members of the gamma proteobacteria clade—often found in female pea aphids—that inherit the microbes from their mothers. "What maintains this menagerie is a puzzle," says Charles Godfray of Imperial College at Silwood Park, U.K. Kerry Oliver and co-workers Jacob Russell, Nancy Moran, and Martha Hunter of the University of Arizona, Tucson, wondered what sustains the relationship between the aphids and the secondary symbionts.

The researchers knew that pea aphids vary in their ability to resist a major enemy, a parasitic wasp that hijacks aphids to raise its eggs. To find out if the symbionts help protect the aphids, Oliver described at the meeting how the Arizona team used a minuscule needle to inject bacteria-free aphids with three varieties of gamma proteobacteria: T-type, R-type, and U-type. Each type offered the aphids various degrees of protection. Although U-type conferred no resistance to the wasp larvae, the larvae in aphids infected with R- or T-type were up to 41% more likely to shrivel up and die.



Secret weapon. A kind of symbiotic bacteria found in pea aphids (smaller ovals at right in micrograph) help the aphids resist parasitic wasps.

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After surviving a wasp larvae attack, aphids with R- and T-type bacteria produced more offspring over their lifetimes than did uninfected aphids. The Arizona team is not sure how the bacteria protect aphids, although Oliver speculates that they might, for example, produce a toxin that poisons the wasp larvae or stimulate a deadly immune response.

Other insect labs have observed links between bacteria and host defense, says Godfray, but the new study is the first to "demonstrate unambiguously [that] the bacteria are responsible." Oliver adds that the bacterial defenders could help explain why wasps don't always control pea aphid pests in U.S. alfalfa and clover fields.

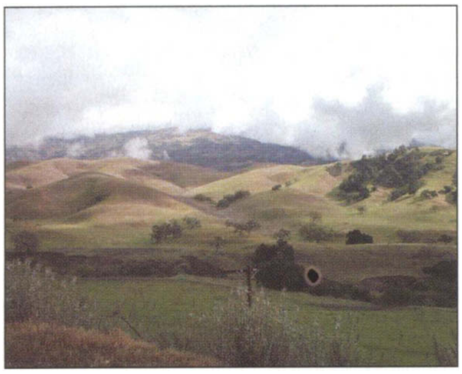
Swamping the Opposition

Exotic species are a global nightmare, second only to habitat destruction as a cause of species loss. California is a striking example: Mediterranean grasses and forbs have run riot over 9.2 million hectares of native grassland, nearly a quarter of the state. A study presented here at the meeting has uncovered the apparent secret to the California invaders' success: a dearth of native seeds.

The findings suggest that bringing back native grasslands could be as straightforward as overwhelming exotics with native seeds. "It may be possible to restore native grasslands by reversing the temporary advantage that the exotic species seem to have," says ecologist Andrew Dobson of Princeton University in New Jersey. Others caution that attempts to carry out such blanket seeding have often failed. "It's an interesting and unusual result," says Kevin Rice of the University of California (UC), Davis, "but the question is, how far can you extrapolate it."

California's grasslands became a battleground when exotic plants—hitchhiking as seeds on European settlers and their livestock—spread like wildfire in the late 1800s, probably abetted by grazing and drought that knocked down native plants. In addition to threatening to drive certain native species to extinction, the interlopers, which grow more densely and have shallower roots than the natives, increase fire risks and alter ecosystems by changing nutrient cycling.

Eric Seabloom of the National Center for Ecological Analysis and Synthesis in Santa Barbara, California, and his co-workers—Jim Reichman of UC Santa Barbara and Stan Harpole and David Tilman of the University of Minnesota, Twin Cities—wanted to find out how easily fields of annual exotic grasses and forbs can be converted to native perennial grasslands. They tested three possible reasons for the invaders' success. First, the exotics might dominate resources such as sunlight and water; second, they might be winning out because the sparse natives produce too few seeds to retake the fields. The third possibility was that grasses—whether native or exotic—establish a beachhead from which they aren't easily dislodged, Seabloom says.



Vanquished invaders. At this reserve dominated by exotic grasses, adding lots of native seeds to plots allowed native grasses to return.

In a 5-year series of experiments on plots in former crop fields at Sedgwick Reserve near the Southern California coast, Seabloom's team ruled out the first and third possibilities. Mixtures of exotic annuals such as black mustard, ripgut grass, and soft chess used less water, nitrogen, and sunlight than a mix of five native perennials such as California brome and purple needlegrass. And the natives were able to retake patches of exotic grasses if the researchers planted more native seeds, showing that the exotic plots weren't impregnable. Seed abundance was the crucial factor, Seabloom says.

The next step is to figure out how to parlay that knowledge into a viable restoration strategy. Californians have tried to restore grasses by adding lots of native seeds, but few seedlings survive, says Rice. Seabloom's plots were "pretty artificial," because exotics had not built up seed banks in the soil, says Carla D'Antonio of UC Berkeley. "These are not your typical grazed grasslands with tens of thousands of seeds per meter squared," she says. And the influence of seed abundance might not be as great as in locations with climates different from those tested in Southern California, Rice says.

Seabloom agrees that "we definitely need to do follow-up work in different conditions," including in fields where exotics have been growing for a long time. But even if his team hasn't found a quick fix for restoring grasslands, the experiment might lay the groundwork for more sophisticated approaches. "By understanding the mechanisms," Seabloom says, "you're always going to be better off."

—JOCELYN KAISER

MEETING PLANT TISSUE CULTURE AND BIOTECHNOLOGY

Getting Down to Bare Wood And Overcoming a Barrier

ORLANDO, FLORIDA—From 23 to 28 June, roughly 1000 scientists, half of whom came from outside the United States, gathered here to learn about the latest research on plant biotechnology. Among the new findings: a gene that might make it easier to regenerate whole plants from cultured cells and an analysis of the loblolly pine genome that might help researchers identify the genes that guide plant development.

Loblolly Pine Genome Analyzed

To the casual observer, the model plant *Arabidopsis thaliana* and the loblolly pine (*Pinus taeda* L.) have little in common. *Arabidopsis* is a tiny flowering annual with a life cycle measured in weeks; the loblolly pine, a commercially important tree that provides 58% of the timber harvested in the United States, grows as high as 50 meters and can live for centuries. Yet new results described at the meeting by Ronald Sederoff, a tree molecular geneticist at North Carolina State University (NCSU) in Raleigh, indicate that the genomes of these two species are surprisingly alike.

"We've said all along that *Arabidopsis* is a model for flowering plants," says Eliot Meyerowitz, a plant molecular biologist at the California Institute of Technology in Pasadena. "It may go further than that" and serve as a model for all seed-bearing plants, including more primitive species such as the loblolly and other conifers that don't have flowers.

Sederoff, graduate student Matias Kirst, and their colleagues, both at the NCSU Forest Biotechnology Group and the Center for Computational Genomics at the University of Minnesota, Minneapolis, came to their conclusion by producing and analyzing expressed sequence tags (ESTs) from the loblolly pine. ESTs are DNA copies of fragments of an organism's messenger RNAs and thus represent the genes active in its tissues. To better understand the gene changes that distinguish woody plants such as the loblolly from herbaceous ones such as *Arabidopsis*, the team focused primarily on ESTs from the pine's wood-forming tissue.

The researchers ultimately produced and sequenced some 60,000 ESTs, representing about 12,000 genes, roughly one-half of the total number in *Arabidopsis*. They found that 90% of the loblolly genes apparently have counterparts in *Arabidopsis*. "The closer we looked, the fewer differences we found" between the *Arabidopsis* and loblolly pine genomes, says Sederoff. Given that the last common ancestor of the two species dates back roughly 300 million years, he adds, the finding indicates that the protein-coding portions of their genomes have been highly conserved.

The finding suggests that a relatively small number of genes could determine whether a plant species grows as a tall, woody tree or a small, herbaceous plant, Sederoff notes. This difference might also be due to the influence of regulators, which can mediate between environmental factors and functional genes, turning them on and off as needed.

Indeed, there is evidence for that idea. Several years ago botanist Simcha Lev-Yadun of the University of Haifa, Israel, found that he could trigger the formation of woody roots and stems—albeit matchstick-sized ones—in *Arabidopsis* by pruning the flowers every day. Two years ago, molecular biologist Eric Beers of Virginia Polytechnic Institute and State University in Blacksburg repeated the work, using the resulting wood to build a miniature Adirondack chair.

This shows that *Arabidopsis* does in fact carry the genes for wood formation, as suggested by the Sederoff team's results. It should now be possible to track down those genes and see how they are controlled in a species much more amenable to study than the majestic loblolly pine.

Genetic cousins? Despite its normal herbaceous nature, *Arabidopsis*, like the loblolly pine, has the genetic potential to produce wood, here used to make a tiny Adirondack chair.

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