Gaining Insight From Probing Insects' Genes

At the start of the new millennium, the world's researchers became intimately acquainted with an insect no larger than a gnat. This organism, the common fruit fly—known in scientific circles as *Drosophila melanogaster*—was the first insect to have all its genetic material deconstructed.

Because of its simplicity, the fruit fly—which spends its 2-week lifespan surviving mostly on a diet of spoiled fruit—has served as a model research organism for nearly a century. And with its genome sequenced in 2000, the fruit fly is now providing even greater opportunities for learning, on topics ranging from insect host adaptation and evolutionary biology to human health and disease.

The fruit fly was the first insect to be sequenced in the wake of other, lower organisms, such as brewer's yeast and roundworm, and some thought it would be the last. The genetic material possessed by insects, the animal kingdom's jointed invertebrates, can't be all that different—right?

Many researchers, including those with ARS, are finding that this is hardly the case.

As the most abundant organisms on Earth, insects could be considered among the most diverse. They vary widely based on the kind of host plant or crop they're specially suited to feed on, as well as on the countless bacteria, viruses, and other pathogens they may carry and transmit.

For instance, take the aphid, one of agriculture's most costly pests. There are some 400 different aphids now known to scientists. Every one of those species has numerous subspecies or lineages, each perfectly adapted for life on a specific plant or crop species.

It's these evolutionary adaptations that make aphids and other insects so potentially destructive. Insects can pose serious challenges to the world's crop production and grain storage efforts. They also have the potential to wipe out whole stands of native forests, as invasives—like the Asian longhorned beetle and the emerald ash borer—threaten to do in the United States.

Altogether, insect pests cause around $26 billion in losses to U.S. agriculture each year, requiring new and ever-changing control measures.

But insects also serve a vital role in agriculture. For example, without honey bees, an annual $15 billion worth of fruits, vegetables, and nuts couldn't be produced in this country. Other beneficial insects, including some species of parasitic wasps, are the basis for many biological control strategies. They can be deployed to knock down pest populations, while reducing our dependence on insecticides.

By peering into the genes of these insects, ARS scientists are uncovering new clues about them—ways to control pest species and ways to bolster beneficial ones. Alternative means of combating problem insects are needed as chemical controls become ineffective or are increasingly regulated for health and environmental reasons.

Over time, many insects, with a nimble reshuffling of their genetic makeup, are able to sidestep chemical pesticides. The pea aphid, a pest known to feed on 600 different crops and plants, is a prime example. Pesticide doses that used to work against some aphids no longer do—leaving growers inclined to ramp up their chemical applications, while the insects steadily evolve ways to bypass these controls.

Wayne Hunter, an entomologist at ARS's Fort Pierce, Florida, location, is one agency scientist dedicated to demystifying the pea aphid's elusive hardiness. Contributing to a project led by researchers at Princeton University, Hunter and other ARS scientists helped get the aphid sequenced—a project that was approved earlier this year by the National Human Genome Research Institute, part of the National Institutes of Health.

With this genetic blueprint available, Hunter and others will be able to more rapidly locate aphid genes that impart its resiliency. Hunter has already uncovered genes that help the aphid produce special enzymes that act as detoxifiers when the insect is exposed to chemical pesticides.

Hunter and other ARS researchers are also studying the genes of another pest, the glassy-winged sharpshooter. The insect carries a bacterium, *Xylella fastidiosa,* that's deadly to plants, most notably grapes. One of the sharpshooter's most advantageous quirks is its ability to withstand extreme temperature changes. With more probing, the genes regulating the insect's built-in thermostat could one day be manipulated.

In addition, ARS researchers Jay Evans in Beltsville, Maryland, and Kate Aronstein at Weslaco, Texas, were part of efforts to have the honey bee and its pathogens sequenced. *Nasonia vitripennis,* a beneficial parasitic wasp, is also on the list of organisms now destined for decoding. These tiny wasps are important biological control agents of nuisance flies, such as the house fly and blowfly. Entomologist Hunter provided DNA needed for the wasp's sequencing and will help oversee the project.

And finally, the article on page 4 tells how an ARS entomologist has helped uncover genes regulating one of insects' most successful adaptations—their exoskeleton, or protective outer coat. And he did this with the help of a common pantry pest—the red flour beetle *(Tribolium castaneum)*.

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