

Development of a Mosquito Abatement Program in Texas: Monitoring and Predicting Insecticide Resistance

Grant Amount: \$35,169

Project Team:
Jeffery K. Tomberlin
James Olson, Ph.D.
Patricia Pietrantonio, Ph.D.

Project Leader:
Jeffrey K. Tomberlin

Lead Institution:
Texas A & M University

Source of Funding:
2004 Enhancement Grant:
Special Projects

“The primary goal is to confuse the resistance mechanism of the mosquitoes. Insects are good at doing one thing, and when they do two things, they don’t do either of them right.”

—Jimmy Olson

In 2002, Texas residents began to battle an enemy that delivered a deadly punch. In the largest insect-borne epidemic since the late 1960s, when St. Louis encephalitis ravaged through the state, the mosquito *Culex quinquefasciatus*, or the Southern house mosquito, once again claimed center stage, carrying this time the newly introduced West Nile Virus. As pest control companies and mosquito control agencies began responding to resident complaints of mosquito infestations, they soon had another problem: the insecticides that had worked for years killed less and less of the target mosquito populations. As extension specialists became involved and Texas University A & M researchers stepped in, they discovered that they were dealing with an age-old plague: insecticide resistance.

The news of mosquitoes that could resist a pesticide treatment began to concern researchers at Texas A & M University as early as 1976, when they began a project to examine mosquito resistance. In 2004, entomologist Dr. Jeffrey K. Tomberlin with Texas Cooperative Extension and fellow researchers Dr. Jim Olson and Dr. Patricia Pietrantonio from the Department of Entomology in the College of Agriculture and Life Sciences at Texas A & M University increased the scope of the project to genetic research and educational materials with funding from the Cooperative State Research, Education and Extension Service (CSREES) at USDA. After two years of research, their preliminary findings show that a specific method of alternating between the organophosphate malathion and synthetic pyrethroids currently controls most of the mosquito population. Now they are preparing to take what they have learned in Houston about this integrated approach and apply it on an area-wide basis in Texas and other regions of the United States.

West Nile virus entered the United States through New York in 1999 and spread quickly. Reports of infection grew exponentially each year, and the disease has now touched all 48 of the contiguous states. The National Institute of Allergy and Infectious Diseases has identified at least 40 mosquito species that carry West Nile virus, among them *Culex quinquefasciatus* in the southern states and *Culex pipiens* in the North. Of those, *Culex quinquefasciatus* most quickly develops resistance to insecticides. And it is the *Culex* species that carried St. Louis encephalitis in the late 1960s, with Texas being one of the states hit the hardest.

“Nothing is as scary to a mosquito control agency as having a mosquito infestation and finding out that

nothing works,” said Olson, who is the primary mosquito research specialist in Texas. “There is no part of the state that doesn’t have mosquitoes. And in Houston, we quit counting mosquitoes; we just weigh them.”

Olson and his colleagues have focused their research in Harris County, which includes Houston, a city significantly impacted by West Nile virus and the center of the St. Louis encephalitis outbreak in the 1960s. The dense mosquito population in Houston makes it particularly susceptible to mosquito-borne diseases.

Chemical control of mosquitoes involves two classes of insecticides: organophosphates and synthetic pyrethroids. Because of increasing concern about the safety of organophosphates and their persistence in the environment, the mosquito control industry began shifting over to synthetic pyrethroids. Malathion, the most commonly used organophosphate for mosquito control, received EPA scrutiny a few years ago as the agency re-examined several chemical pesticide compounds for long-term health effects and persistence in the environment. *Culex quinquefasciatus* are highly resistant to malathion, as documented in 2000 by Dr. Pietrantonio and collaborators from the Harris County Mosquito Control Division.

Texas is home to at least twelve mosquito species that carry serious diseases, including West Nile virus, St. Louis encephalitis and dog heartworm. As the fear of a possible organophosphate ban began to grow, the state found an additional problem: the *Culex* populations were beginning to survive synthetic pyrethroid treatments. By 2002, the population of synthetic pyrethroid resistant mosquitoes was rapidly increasing.

In July 2006, fears were alleviated; the EPA reregistered malathion for mosquito control. According to Harold Coble, agronomist with the USDA Office of Pest Management Policy, the benefits of most organophosphates outweigh the risks.

“EPA is still doing a cumulative risk assessment for organophosphates,” Coble said. “But there’s no indication that they’re going anywhere.”

After a year of testing, Olson and his collaborators discovered a window of opportunity in that *Cx. quinquefasciatus* in the Houston area began to prove themselves susceptible again to malathion. In response to this, they established an insecticide resis-

Texas (continued)

Development of a Mosquito Abatement Program in Texas: Monitoring and Predicting Insecticide Resistance

tance management program involving the alternating use of organophosphate and synthetic pyrethroid insecticides.

"The primary goal is to confuse the resistance mechanisms of the mosquitoes," Olson said. "Insects are good at doing one thing, and when they do two things, they don't do either of them right."

Pietrantonio recently received funding to clone a segment of the sodium channel in *Cx. quinquefasciatus* to discover how mutations in the sodium channel are causing insecticide resistance—the first time such a study has been done on this species for Texas. Since synthetic pyrethroids target the sodium channel, learning more about it will be crucial to discovering how to better control the species with these types of insecticides.

And according to Olson, time may be running out. Although the species now continues to breed susceptibility into the remaining populations, he fears the time is near that it will develop complete resistance to both organophosphates and pyrethroids.

"Nobody has cloned the complete *Culex quinquefasciatus* sodium channel before," Pietrantonio said. "The sodium channel is very big, so we're cloning a fragment of it, and the mutation should reveal whether or not a given mosquito population is resistant to pyrethroids. However, we need to study both, the genomic DNA and the actual cDNA to confirm that resistance is associated with mutations in the sodium channel."

As Olson and Pietrantonio continue their research on resistance, Tomberlin and extension specialist Kimberly Schofield fight the battle another way—in the classroom. This past year, they introduced second and fourth graders in the Dallas and San Antonio school districts to a curriculum meeting state requirements that includes puzzles and mazes in addition to lessons on how mosquitoes develop and how to keep them out of the house. Not only did students absorb the lessons, but they had fun learning the material. And even with a tight teaching schedule, the teachers were eager to fit the lessons into their curriculum.

"The teachers felt confident enough to continue the lesson for the rest of the week after I conducted the first lesson on mosquitoes," Schofield said. "The stu-

dents seemed excited about the subject matter and the teachers really enjoyed the material as well."

The educational component has a vital goal: to teach homeowners how to prevent mosquito bites by the simplest means possible—by keeping them out of the house. Typically partial to birds, *Cx. quinquefasciatus* most often bites humans and pets when they have become trapped inside a house.

"That's why we emphasize that houses should be mosquito-proof," said Olson. "We think that most of the time humans are getting infected when mosquitoes get into the house."

Additional outreach items include a placemat that they have already shared with a few Houston restaurants and a Web site, elementaryinsects.tamu.edu, containing a news article page and educational booklets with activities for teachers to use in the classroom.

With new funding just received this year from CSREES, Tomberlin and Schofield can conduct more extensive evaluations in the next few years. In addition, they plan to make the site more dynamic and include other insect curricula as well, including fleas, spiders and "good and bad bugs."

"We'll use live video that will be directed toward agricultural agents, which they can use in their work," said Tomberlin.

While research continues, Olson and his colleagues are training mosquito control specialists to monitor the number of mosquitoes surviving each treatment, collect mosquitoes to test how they react to various levels of insecticides, and watch for the ratio of resistant mosquitoes to susceptible ones to reach a certain value before switching to another group of pesticides. One factor in their favor so far is that the susceptible mosquito strains seem to produce more offspring than the resistant ones, hence preserving susceptibility in the target mosquito population.

And to ensure that *Cx. quinquefasciatus* never gains the upper hand, Olson and his collaborators hope that they can serve as an example to the mosquito control agencies in Texas and elsewhere in the US and train them to monitor their mosquito populations before they choose an insecticide.