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Extraordinary Insect Illustrations

Story on pages 12-14.

Agricultural Research Service • *Solving Problems for the Growing World*

FORUM

ARS Water Research: From the Headwaters to the Deltas

"We all live downstream."

It's a slogan used by cities, states, nonprofit organizations, and a whole host of other groups—even an eco-friendly troupe of musicians called the "Banana Slug String Band." Here at the USDA Agricultural Research Service, it's one of the principles guiding our research on how to protect and conserve natural resources, whether they're downstream, upstream, or right outside the window.

Since water bodies are so varied—lowland ponds, the Great Lakes, highland streams, agricultural ditches, freshwater rivers, saltwater marshes—we use a range of approaches in our work. Some of it is conducted as part of the ARS Conservation Effects Assessment Project (CEAP) Watershed Assessment Study, which involves more than 60 ARS scientists, plus additional technical support staff, working in 14 benchmark watersheds at 12 ARS locations. Our research provides additional scientific bases for the CEAP National Assessment being led by USDA's Natural Resources Conservation Service (NRCS). Findings from these investigations have been implemented in watersheds in key agro-ecological regions around the nation.

We want our assessments to provide the American people with a better understanding of the role agricultural conservation practices and programs play in achieving the nation's environmental objectives—clean air and water, healthy soils, and functioning habitat for wildlife. We also need to have a better understanding of conservation measures that can be used to improve future programs and practices.

Three of our experimental watersheds are in Mississippi. They are all part of the larger Yazoo River Basin, which in turn, is part of the Mississippi River Basin. Studies in these three watersheds help us design management strategies that mitigate runoff of agricultural pollutants from crop fields into the nearest stream or drainage ditch and ultimately into the Mississippi River and the Gulf of Mexico.

A story in this issue of the magazine discusses ARS research along Mississippi's Coldwater River, a tributary of the silty Yazoo River (story begins on page 4). ARS scientists there are investigating ways of using existing features on the delta landscape to help mitigate pollutant runoff from farm fields. This approach could help farmers reduce levels of nutrients that support hypoxia (low oxygen) in the Gulf of Mexico without sacrificing valuable farmland for riparian buffers or other controls.

Because of findings by ARS scientists, the Coldwater basin is now part of the Mississippi River Basin Healthy Watersheds Initiative. This effort, led by NRCS, supports working with producers and landowners to implement voluntary conservation practices that improve water quality, restore wetlands, enhance wildlife habitat, and sustain agricultural profitability in the Mississippi River Basin.

Additionally, the Lower Mississippi River Basin, where this research was conducted, is one of 18 nationwide locations in the USDA Long-Term Agro-ecosystem Research network. This network addresses large-scale, multi-year research; environmental management testing; and technology transfer related to the nation's agricultural ecosystems in an assortment of environments—western rangelands, midwestern prairies, the humid southeast, the temperate Mid-Atlantic—all of which face specific regional issues and challenges linked to agricultural production.

The Mississippi is the longest river in the United States, but we also work on a smaller scale. One prime example of this is is found in the sidebar on page 5. It explains that even events that we think are detrimental—like flooding—can be good in small doses, when used responsibly.

Water-quality research? We've got hip-waders, nets, maps, boats, Global Positioning System technology, sampling equipment, sediment tracers, and a lot of other paraphernalia—and we're not afraid to use them.

Mark Walbridge
ARS National Program Leader
Water Availability and
Watershed Management
Beltsville, Maryland

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CHUCK REILLY (D3261-1)

Extracts from a bacterium may be effective against pecan scab, a fungal disease of pecan that can cause blackish lesions on the plant's fruit and leaves and can reduce nut yield and quality. Story begins on page 9.

Cover: A new parasitic wasp species, *Steleucoela braziliensis,* drawn by the scientific illustrator in ARS's Systematic Entomology Laboratory, Washington, D.C. Story begins on page 12. Illustration by Taina Litwak. (D3269-2)

Delta Backwaters Can Capture Field Runoff Pollutants

In the alluvial floodplain of the Mississippi Delta, sediment accumulation can cut off segments of meandering river channels from the main channel. These isolated segments eventually become the oxbow lakes and backwater wetlands that are scattered across the Delta landscape. Agricultural Research Service ecologist Richard Lizotte believes these oxbow lakes are more than just a fisherman's retreat or an alligator's lair; he thinks they help improve water quality by trapping and removing agricultural pollutants lost from adjacent croplands.

"In our region, we see nitrogen and pesticide losses in runoff from corn fields. These chemicals can have a big effect on downstream water bodies, including depleting oxygen in the waters of the Gulf of Mexico," says Lizotte, who works in the ARS Water Quality and Ecology Research Unit in Oxford, Mississippi. "Farmers want to protect water quality, but when they set aside land for buffer zones to help keep chemicals and sediment out of nearby streams, they lose the profits that come from cultivating these lands."

RICHARD LIZOTTE (D3251-1)

Ecologists Richard Lizotte (left) and Scott Knight collect water samples from an upstream wetland area of the Coldwater River in northern Mississippi.

Putting a Wetland to Work

For almost a decade, Lizotte and others have been devising ways to use oxbow lakes and wetlands for cleaning up the runoff from crop fields. In his first study, Lizotte looked at how effectively an experimental wetland along Mississippi's Coldwater River trapped atrazine, *S*-metolachlor, and fipronil, which are commonly used as crop pesticides. Retired ARS hydraulic engineer Doug Shields, ecologist Scott Knight, and biologist Charles Bryant collaborated with Lizotte on the research.

The study watershed was developed in a small stretch of the Coldwater River that had been cut off from the main channel, and the resulting water body had two distinct sections. One was as deep as a small lake, and the other was a shallow wetland surrounded by natural vegetation.

The team installed small dams called "weirs" at either end of the wetland. Then they added the three pesticides to the wetland at the upstream weir at rates that would simulate typical runoff rates from a 40-acre field. They collected water samples from the upstream weir every hour within the first 24 hours after simulating the runoff. They also collected samples near both weirs at increasingly longer intervals—from 2 days to 2 weeks—for the next 8 weeks.

Lizotte and his partners found that it only took 24 hours after they added the pesticide mix for pesticide concentrations near the upstream weir to drop almost 65 percent. A week later, pesticide concentrations at the upstream weir had dropped to 20 percent of their original amount, and 21 days later, they were undetectable.

The results at the downstream weir were even more striking. One day after the pesticides were added to the wetland, water near the downstream weir contained only trace amounts of the pesticides. Four weeks later, the pesticides were completely undetectable.

Upping the Expectations

Lizotte and Knight also assessed how well the same experimental wetland reduced concentrations of pesticides, nutrients, and sediment from a "catastrophic" runoff event. This could take the form of an unexpected storm that strikes shortly after fertilizers and/or pesticides are applied, even though farmers try their best to avoid these circumstances. "They watch weather reports a lot more closely than most people do," Lizotte observes.

The scientists noted that sediment, phosphorus, nitrogen, and pesticide concentrations peaked within 3 hours after the event as far as 325 yards below the upstream weir. But within 48 hours, loads of the sediment, nutrients, and pesticides had been reduced by as much as 98 percent. At 28 days later, levels of all the pollutants had returned to—and sometimes even dropped below—pre-event levels.

"Our research indicates that these types of wetlands could become a very effective and efficient tool for reducing field runoff contaminants. By developing this technology, we don't have to take any land out of production, since the wetlands are already part of the landscape," says Lizotte. "But we'll need to engineer their design and management to accommodate potential performance differences."

RICHARD LIZOTTE (D3250-1)

A weir constructed in a natural bendway in the wetlands of the Coldwater River. The weir helps trap pesticides, nutrients, and sediment from agricultural runoff.

The Delta region where this research was conducted is located within the Lower Mississippi River Basin, which is one of 18 regions participating in the ARS Long-Term Agro-ecosystem Research (LTAR) network. ARS scientists at the National Sedimentation Laboratory are leading the LTAR work in the Lower Mississippi River Basin.

Results from this research have been published in *River Research and Applications, Science of the Total Environment,* and *Ecohydrology*.—By **Ann Perry,** ARS.

This research is part of Water Availability and Watershed Management, an ARS national program (#211) described at www.nps.ars.usda.gov.

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Biologist Charles Bryant (foreground) and Richard Lizotte measure water quality in a downstream wetland. Pesticides entering upstream degraded quickly in the wetlands before reaching the downstream areas.

RICHARD LIZOTTE (D3249-1)

A Little Flooding Helps a Lot

The fertile alluvial soils of the Mississippi Delta have been built up by repeated cycles of seasonal flooding, but current floodplain management often restricts flooding in agricultural and urban areas. Although there are many benefits to this management, it also disrupts ecosystems that have evolved in response to regular flooding, and it reduces the supply of water that helps sustain water quality in oxbow lakes and wetlands.

Agricultural Research Service scientists Richard Lizotte, Scott Knight, and Sam Testa explored ways of protecting these environments by comparing water quality in an oxbow lake before, during, and after artificial flooding in the late summer.

For 30 days, they pumped water from the Coldwater River into the lake, where significant improvements in water quality started almost immediately. These included lower sediment and nutrient loads and fewer swings in water temperature, dissolved oxygen levels, and pH levels. Average lake depth increased from 19 inches to 30 inches, which gave the lake—and its residents—an extra cushion of protection during drought interludes. Overall, the team concluded that artificial flooding could be used by natural-resource managers to stabilize water quality and improve habitat for fish and aquatic invertebrates.

MARK THALLMAN (D3274-1)

Tools To Identify Uncommon Beef Cattle Traits

Cattle from the germplasm evaluation project at the Roman L. Hruska U.S. Meat Animal Research Center (USMARC), Clay Center, Nebraska.

Breakthroughs in genetic research have made it possible to evaluate and routinely predict growth, calving ease, and other important, easily observable traits within beef cattle breeds. However, producers also want to be able to do the same for traits such as feed efficiency, disease resistance, meat tenderness, and reproduction, which are not easy to see or measure. These kinds of traits are typically too expensive and difficult for the cattle industry to study.

But that's just the kind of research that Agricultural Research Service scientists are equipped to do.

For many years, scientists at the Roman L. Hruska U.S. Meat Animal Research Center (USMARC) in Clay Center, Nebraska, have evaluated thousands of cattle for traits that are economically important but difficult to measure, and they have genotyped more than 15,000 of these animals.

To help producers further improve their genetic evaluations, USMARC geneticist Mark Thallman and his colleagues started the "2,000 Bulls Project" in 2007. They collaborated with the largest U.S. cattle breed associations to collect genetic profiles of 2,000 bulls from 16 different breeds. Each of the 2,000 bulls was tested for approximately 50,000 genetic markers by use of the Illumina BovineSNP50 Beadchip. The markers genotyped by that chip were discovered from a number of sources, including the germplasm evaluation project and ARS research efforts conducted at USMARC and Beltsville, Maryland.

"The 2,000 Bulls Project provided a picture of the genomic composition of prominent sires in each breed," Thallman says. "Although the project did not produce enough data to develop predictions for any individual breed, it did provide the first substantial set of high-density genotypes for each breed. Breeders have used this data as a starting point to incorporate genomic data into their breed improvement programs."

The 2,000 Bulls Project and subsequent utilization by breed associations were limited to traits that are routinely measured. However, producers want help predicting the difficult-to-measure traits, too. For example, "while growth is a routine and easily measured trait, it is also related to increased feed consumption. From the producer's standpoint, animal's feed efficiency—how much feed results in a unit of growth—is more economically important," says USMARC geneticist Larry Kuehn. "But individual feed intake is not practical to measure on large numbers of animals in an industry setting. Therefore, measurement of these traits in research herds, delivered to cattle breeders through genomic predictions, seems to be the most viable option for traits like feed efficiency."

Scientists are now sequencing the genomes of the bulls that have the most descendants in the USMARC population. They are looking at sequence variations that can alter the expression and function of the genes and ultimately affect the traits influenced by those genes.

"We hope to use sequence variants to develop predictions that are more accurate across breeds and therefore more useful to the beef industry," Kuehn says.

An Integrative Approach

Through research, published in the *Journal of Animal Science,* scientists learned that genotypes can predict performance reasonably well within breeds, but predictions based on crossbred phenotypes and genotypes do not predict performance of purebreds or unrelated crossbred cattle very well. Geneticist Warren Snelling is incorporating information about gene function and DNA sequence variation within genes to find genomic variation that predicts important traits consistently across many breeds. Integrating this information may enable more accurate predictions in broader industry populations from the USMARC data, especially for traits that are not usually measured on industry cattle.

"A lot of work has been done on biological pathways—what genes are involved in specific processes and how they interact," Snelling says. "We're trying to apply what has been learned from humans, mice, and other species to cattle, hoping this information will allow us to focus on important genes and ultimately enable accurate predictions of an animal's future performance."

Using this approach, Snelling identified genetic markers that were more predictive of meat tenderness than the markers contained on the Illumina BovineSNP50 beadchip. He first looked at the association between an animal's genes and the tenderness of its meat. That data was then used to identify a set of genes related by function. He then merged the genetic markers associated with each trait with information about genes near those markers. This allowed him to identify pathways and genes that may affect tenderness.

The same method can be applied to feed efficiency, Snelling says.

Predicting Breed Composition

Another goal is to use genetic markers to manage cattle differently according to their genetic potential, a technique known as "marker assisted management." For instance, feedlot operators could sort cattle by the predicted amount of time they need in the feedlot to reach a specific level of fat composition.

A major factor that can affect traits is breed composition—the percentage of genes an animal has from each breed in its pedigree. Breeds generally rank differently, on average, for a variety of economically important traits such as growth, fat composition, and feed intake.

Knowing an animal's breed composition could improve how it is managed in commercial production and allow it to be targeted to the most appropriate market.

"We've used our 50K beadchip data to accurately predict breed composition of cattle produced at USMARC," Kuehn says. "Although this method is too costly to apply to commercial cattle at this time, it shows that predicting breed composition is possible, and it may be feasible in the future."—By **Sandra Avant,** ARS.

This research is part of Food Animal Production, an ARS national program (#101) described at www.nps.ars.usda.gov.

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Sixteen different breeds and combinations of breeds are represented in the USMARC cattle herd. The variability of breed composition in the herd is obvious in the varied appearance of the animals.

MARK THALLMAN (D3275-1)

Determining the Best Season for Applying Chicken Litter in the South

Mississippi farmers are increasingly using poultry litter to fertilize fields because the nitrogen in the litter boosts yields, and it cuts back on fertilizer costs. It is a particularly welcome trend in many southern states, where most of the U.S. broiler chickens—and litter—are produced.

HAILE TEWOLDE (D3248-1)

Poultry litter being incorporated into the soil during disking, a process that turns the soil and pulverizes it so that the litter will be mixed into it. Over a 3-year period, ARS scientists determined yields were cumulatively higher in plots with litter applied in the spring rather than in the fall.

Many farmers apply litter in the fall rather than at spring planting, because they are usually not as busy in the fall and because the litter is cheaper then, says Haile Tewolde, an Agricultural Research Service agronomist in the Genetics and Precision Agriculture Research Unit in Mississippi State, Mississippi.

Tewolde wanted to determine whether litter applied in the fall loses potency by the following spring. Previous studies showed that in the Midwest, fall-applied litter is just as effective as spring-applied litter. But Tewolde suspected that results could be different in the South and Southeast, where warmer temperatures could make the nitrogen in the litter dissipate more quickly.

Tewolde and his colleagues applied poultry litter in the spring and fall to experimental plots of corn planted each April for 3 years. They applied the litter at two rates: 4 tons per acre and 8 tons per acre. They incorporated it into the soil by "disking," a process that turns the soil and pulverizes it so that the litter will blend in with it. For comparison, the researchers applied nitrogen fertilizer to other test plots in the spring and fall.

The results showed that litter applications produced less corn than fertilizer applications in the first year, but those results were reversed in the second and third years. When litter was applied in the spring in the second year at the 8-ton rate, it produced 20 percent more corn than the fertilizer treatment; in the third year, it produced 9 percent more corn.

Tewolde says that in the first year, the fraction of nitrogen in the litter that became available to the crop was apparently far less than previously thought. Higher yields in the second and third years were the result of a "carryover effect," that is, nitrogen in the litter applied the first year stayed in the soil and benefited the crop in subsequent years.

The results also showed that over the 3 years, yields were cumulatively higher in plots with litter applied in the spring than in the fall, regardless of the application rate. At the 4-ton rate, spring-application yields were 16.7 percent higher, and at the 8-ton rate, they were 12.8 percent higher. Farmers are most likely to apply litter at the 4-ton rate and apply fertilizer to supply the balance of the nitrogen the corn needs, rather than apply the full 8-ton rate, Tewolde says.

The results show that, unlike in the Midwest, the South's warmer temperatures mean that nitrogen in fall-applied litter is more likely to volatilize into the atmosphere or leach deep into the soil, beyond the reach of plant roots, leaving less available the following spring, Tewolde says.

The study, published in 2013 in *Agronomy Journal,* has implications for growers who may be turned off by a single year of disappointing results with poultry litter, Tewolde says. If they stick with litter for more than a year and add some nitrogen fertilizer in that first year, their yields will improve. Yields will also be enhanced if the litter is applied in the spring rather than in the fall.—By **Dennis O'Brien,** ARS.

This research is part of Climate Change, Soils, and Emissions, an ARS national program (#212) described at www.nps.ars.usda.gov.

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Compound from Bacteria Could Be Useful Against Pecan Scab

Plant pathogens can cause disease and yield loss in many crops, including nut trees such as pecan, known scientifically as *Carya illinoinensis*. Pecan scab, caused by the plant-pathogenic fungus *Fusicladium effusum,* is the major disease currently limiting productivity and quality of pecan trees in the southeastern United States.

Researchers know that substances produced by bacteria from the guts of entomopathogenic nematodes (ones that infect insects) can suppress certain plant diseases, including pecan scab. But the specific compounds responsible for the suppression have not been previously identified.

At the Agricultural Research Service's Fruit and Tree Nut Research Laboratory in Byron, Georgia, plant pathologist Clive Bock and entomologist David Shapiro-Ilan, along with ARS chemist Charles Cantrell and plant pathologist David Wedge, examined chemical extracts of the bacteria to identify the major components responsible for suppressing pecan scab. They found that the extracts most effective against pecan scab came from the bacterium *Photorhabdus luminescens* (VS strain). Cantrell and Wedge are in ARS's Natural Products Utilization Research Unit in Oxford, Mississippi.

"We recently explored the use of naturally occurring antimicrobial compounds produced by *Xenorhabdus* and *Photorhabdus* bacteria. These bacteria live in the guts of entomopathogenic nematodes in the genera *Steinernema* and *Heterorhabditis*, respectively; the bacteria are critical in helping the beneficial nematodes kill their insect hosts," says Shapiro-Ilan. "The bacteria can be cultured in media. Extracts of the cultures contain the antimicrobial metabolites, which are active against a wide range of microbial pathogens of animals and plants, including bacteria and fungi."

CHUCK REILLY (D3261-1)

Pecan scab is a fungal disease that can cause blackish lesions on pecan fruit and leaves and can reduce nut quantity and quality.

The extract found to be most toxic to the pecan scab fungus was purified and found to contain trans-cinnamic acid. Laboratory test results showed that trans-cinnamic acid was toxic to the pecan scab fungus in tiny amounts, as low as 148-200 micrograms per milliliter in solid culture and 64 micrograms per milliliter in liquid culture.

"While some host [pecan] resistance is available to reduce the impact of pecan scab, new strains of the pathogen have been able to overcome that resistance," says Bock. "Conventional chemical fungicides have been widely used to control scab, but sometimes more than 10 sprays are required to ensure adequate control of the disease. As a result, *F. effusum* is now resistant to at least two classes of fungicides."

There is also an increasing awareness of the environmental impact of conventional pesticides. "There are important incentives to try to develop alternatives to conventional fungicides—alternatives that are of low environmental risk and that present a lower risk of fungicide resistance developing in the pathogen," says Bock. These naturally occurring antimicrobial products might offer such an alternative.

This work was published in the *Journal of Pest Science* in March 2014.—By **Sharon Durham,** ARS.

This work is part of Plant Diseases (#303) and Crop Production (#305), two ARS national programs described at www.nps.ars.usda.gov.

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DANA BERNER (D3276-1)

DANA BERNER (D3277-1)

Fungi Readied for Weed Biocontrol

Below: Spore-forming pustules of the rust fungus *Uromyces salsolae* on Russian thistle.

Above right: A stem section of Russian thistle with symptoms of *Colletotrichum salsolae* infection.

Russian thistle, *Salsola tragus* (tumbleweed), has become an icon of the American West since arriving in the 1870s as a flax seed contaminant. Make no mistake, though: The weed is a menace. It outcompetes crops, clogs irrigation ditches, spreads insect pests, and even poses a driving hazard. The latter happens when the weed's top portion breaks off the main stem and is blown onto roads, obscuring driver vision and potentially causing accidents.

Russian thistle is particularly troublesome in arid and semi-arid regions of the western United States. Large-scale infestations, especially on low-value agricultural lands, can make chemical or cultural control too costly or impractical, says Dana Berner, a plant pathologist in the Agricultural Research Service's Foreign Disease-Weed Science Research Unit (FDWSRU) in Fort Detrick, Maryland.

As an alternative, he and colleagues have been studying certain fungi with potential to biologically control the weed. The approach would involve exposing targeted thistle populations to fungal spores to cause widespread disease of the weeds.

Towards that end, Berner and colleagues Bill Bruckart and Craig Cavin examined the host range and specificity of two promising fungal candidates: *Uromyces salsolae* and *Colletotrichum salsolae*. Both were originally isolated from infected thistle plants in Russia and Hungary and exported to FDWSRU under permit for quarantine study.

In a biosafety level-3 greenhouse containment facility there, the researchers exposed specimens from 64 different plant species to *U. salsolae* and 89 species to *C. salsolae* and gauged the plants' reactions and disease symptoms, if any.

To broaden the scope of their host-range tests—critical to making sure the fungus won't harm nontarget plants or crops once released into the environment—the team adapted and validated the use of a risk-assessment approach. Dubbed "mixed model equations (MMEs) that produce best linear unbiased predictors," the approach uses a disease-ranking system and matrix information to predict susceptibility of a plant species, based on how genetically similar it is to the targeted weed—Russian thistle, for example.

Such predictions are especially useful when checking for susceptibility in plant species that are rare, endangered, or difficult to grow, says Berner. In the case of *C. salsolae,* for example, the MME risk-assessment approach enabled the team to extend plant host-range evaluations to 33 additional species.

The FDWSRU scientists have submitted petitions seeking recommendation for release of the two weed pathogens from the Technical Advisory Group for Biological Control Agents of Weeds, an advisory committee to the U.S. Department of Agriculture's Animal and Plant Health Inspection Service, consisting of other federal and state regulatory agencies and representatives of plant regulatory agencies in Canada and Mexico.

In the meantime, the search continues for other biocontrol organisms—fungal, mite, or insect—that could help turn the tide on the loathsome weed.—By **Jan Suszkiw,** ARS.

This research is part of Crop Protection and Quarantine, an ARS national program (#304) described at www.nps.ars.usda.gov.

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Weather-Tracking Tool Helps Track Migrating Insects

Corn earworms (also known as cotton bollworms) cost cotton producers an estimated $200 million a year in lost crops and control expenses, and they are notoriously hard to track because they migrate at night. Farmers worried about infestations have to make educated guesses about the pest's movement based on reports from other areas and past experience.

Agricultural Research Service scientists in College Station, Texas, have shown that signals routinely collected by the National Weather Service's (NWS) Doppler radar network could serve as an early-warning system to track the migration of corn earworms and other nighttime traveling pests.

John Westbrook and Ritchie Eyster, meteorologists in the ARS Areawide Pest Management Research Unit (and currently assigned to the Insect Control and Cotton Disease Research Unit) in College Station, focused on the surveillance capabilities of Next Generation Weather Radar, or NEXRAD. With more than 150 ground-based installations across the United States, NEXRAD monitors weather conditions by sweeping the atmosphere every 5 to 10 minutes and reading the energy reflected by rain, snow, and other precipitation. For weather assessments, algorithms normally remove energy reflected by flying organisms, but scientists have used NEXRAD and other weather radar signals to track birds, bats, and insects.

Westbrook and Eyster obtained 15 days of NEXRAD data from the NWS installation at Brownsville, Texas, to see if they could use it to detect flights of corn earworm moths during peak migration times from cornfields in the Lower Rio Grande Valley. "We wanted to use it to make aerial counts of corn earworm moths and determine their movement patterns in the atmosphere," Westbrook says.

They acquired archived NEXRAD data associated with aerial concentrations of moths at heights of up to 3,900 feet. The data had been obtained during a period of peak migration of corn earworms from fruiting corn fields. They compared it with data from the same time period previously collected by Wayne Wolf, a retired ARS agricultural engineer, using a scanning "X-band" radar system, specifically designed to track insects. Unlike NEXRAD, which operates constantly, the X-band system must be set up and monitored each time it is used. The previous research team had also launched weather balloons from a nearby airfield to calculate vertical profiles of prevailing wind speed and direction that influenced long-distance insect flights.

JACK DYKINGA (K2627-14)

Corn earworm larvae can cause great damage to cotton and corn crops. Using the NEXRAD weather monitoring system, ARS scientists have found a way to more accurately track corn earworm moths as they migrate at night. This knowledge can help farmers determine when to treat for the pest.

The results showed that NEXRAD was not only capable of tracking insect migration patterns, but it was also superior to the older scanning X-band system in offering a much larger detection range and an ability to determine the direction and speed of insect migration flights without need of weather balloons. Results were published in the *International Journal of Biometeorology* in April 2013.

More work is needed to quantify relationships between radar data and the abundance and patterns of migratory insect flights, but using NEXRAD would offer several advantages, Westbrook says. Because it must be set up each time, the X-band system is costly to operate and maintain. NEXRAD data is publicly available, so it could be used any time without the costs for positioning and monitoring equipment. Recent upgrades implemented in NEXRAD should make it easier to identify potential corn earworm infestations, and with refined algorithms, it should be able to track beet armyworms, grasshoppers, and other large-bodied insects, Westbrook says.—By **Dennis O'Brien,** ARS.

This research is part of Crop Protection and Quarantine, an ARS national program (#304) described at www.nps.ars.usda.gov.

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ILLUSTRATION BY TAINA LITWAK (D3268-1)

ILLUSTRATION BY TAINA LITWAK (D3271-1)

Taina Litwak is a scientific illustrator for the Agricultural Research Service's Systematic Entomology Laboratory (SEL) in Washington, D.C. Assigned to a SEL office located at the Smithsonian Institution's National Museum of Natural History, Litwak is ARS's "go-to" illustrator when it comes to detailed drawings and paintings of the latest insect and mite species of scientific interest—some because of the harm they could inflict to crops as invasive pests, and others for their potential to biologically control the pests.

Agricultural Research (*AR*) magazine recently caught up with Litwak to talk about her work as an ARS scientific illustrator.

AR: *How did you get your start as an illustrator?*

Litwak: I graduated from the University of Connecticut with a B.S. in Biology and a B.F.A. in printmaking in 1979. After a short period of working as a fine artist (and waitress), I realized I enjoyed the purpose and imagery of science too much to leave it. I haunted the halls of the National Museum of Natural History in Washington long enough to hear of a position opening up illustrating mosquitoes for the Walter Reed Army Institute of Research. I landed the job and stayed until 1993.

Opposite page: The wasp species shown here deposits its eggs on the female flowers of *Philodendron solimoesense*. The female wasp drags pollen from the male flower on her way to the female flower, and the developing wasp embryo releases chemicals that signal the growth of gall tissue in the plant's fruit.

Above: The finished illustration of the bark beetle created digitally by Taina Litwak from the sketch below. Below: A sketch of bark beetles, which are native to the Dominican Republic, drawn by Taina Litwak, ARS scientific illustrator.

ILLUSTRATION BY TAINA LITWAK (D3270-1)

AR: *When did you join the SEL, and what types of research do your illustrations support?*

Litwak: I joined the staff of SEL in January 2010, but I had already done a lot of contract illustration work for the entomologists there and elsewhere after I left Walter Reed. The research my work supports is systematics. Systematists, as well as taxonomists, identify, describe, and classify organisms. This is a critically important element in understanding biodiversity, wider studies of ecosystems, environmental change over time, and change brought on by human endeavors, including the introduction of invasive species.

AR: *Can you give some recent examples of the types of illustrations you have done?*

Litwak: I am just starting work illustrating a new species of beetle in the same group as the citrus root weevil. It is rather large and beautiful, a recent USDA domestic interception, and a potential pest species. I did illustrations of three new species of bark beetle from the Dominican Republic for SEL entomologist Steve Lingafelter [published in the journal *Zootaxa*]. In 2011, I did a painting of a new species of tiny parasitic wasp in the genus *Perischus*. It is involved with parasitizing a species complex of flies that lay eggs in cucurbit plants, like melons, cucumbers, and the squash family).

AR: *What's your process for tackling a specimen?*

Litwak: The illustration process starts with a pencil drawing—or series of drawings—done through the microscope. I have both dissecting and light-transmitting microscopes in my office. Positioning the specimen correctly is important and chal-

ILLUSTRATION BY TAINA LITWAK (D3269-1)

A new parasitic wasp species, *Steleucoela braziliensis.*

lenging, especially if it consists of tiny dissected parts floating around in glycerin or alcohol.

Once I have drawings, I scan the sketches and work with the now-digital images to arrive at a fully accurate, ideal view of the insect. The rendering [color painting or black "ink" line drawing] is done in a fairly traditional manner, but completely digitally, using Adobe Photoshop.

AR: *What's unique about the type of information that can be conveyed with a painted illustration versus other formats, like a photograph?*

Litwak: Insects seldom die with their head in just the right position and all their legs and wings spread out for a clear view. When I do an illustration, it can be a perfect, idealized view. In paintings of extremely small insects, I often include details only visible using a scanning electron microscope. Another thing an illustration can do which a photograph cannot is to condense information from several specimens into one image.

AR: *How long does it generally take to complete an illustration, and how many do you estimate you've done in support of SEL research?*

Litwak: A simple line drawing might take half an hour, a full-color individual species 3 days, and a complex plate with many images can take several weeks to complete. I have done thousands of insect illustrations over the past 30 years, and many were for SEL.

AR: *What do you find particularly challenging—and rewarding—about illustrating insect and mite specimens?*

Litwak: I really love the visual variety of insects, their forms and the beauty and precision of their exoskeletons. The most challenging work for me is working with very minute specimens—mites and microhymenoptera. I love what I do, because I am always learning.

AR: *Where have some of your illustrations ended up?*

Litwak: Most of my insect illustrations for the USDA end up in peer-reviewed scientific journals, but I have done other types of illustration projects that have landed my work in interesting places. For example, I was the illustrator and assisted with the development of several volumes of a series of science-and-technology textbooks for middle schools.

AR: *Any advice for aspiring science illustrators?*

Litwak: Study science! Absorb as much information about as many different things as you can. Observe things. Learn how to focus. Practice drawing what you see, not what you think you see.*

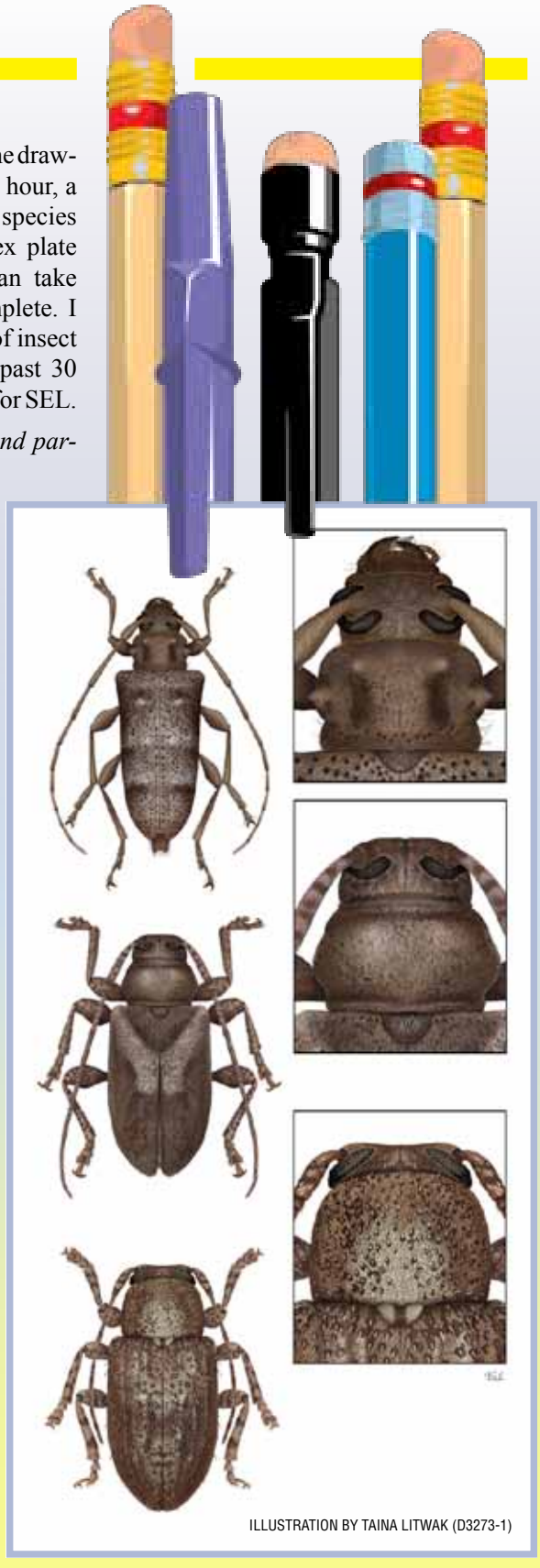

ILLUSTRATION BY TAINA LITWAK (D3273-1)

Three new species of Cerambycid beetles, all three of which are undescribed (new to science) species of longhorned woodboring beetles in the subfamily Lamiinae. They are from the island of Hispaniola. Their larvae develop in wood tissue. The top one is also from an undescribed genus.

The Agricultural Research Service has about 100 labs all over the country.

Locations Featured in This Magazine Issue

Locations listed west to east.

Map courtesy of Tom Patterson, U.S. National Park Service

Roman L. Hruska U.S. Meat Animal Research Center, Clay Center, Nebraska

4 research units ■ 118 employees

Southern Plains Agricultural Research Center, College Station, Texas

4 research units ■ 105 employees

Oxford, Mississippi

3 research units ■ 92 employees

Mississippi State, Mississippi

3 research units ■ 77 employees

Byron, Georgia

1 research unit ■ 26 employees

Fort Detrick, Maryland

1 research unit ■ 40 employees

Henry A. Wallace Beltsville Agricultural Research Center, Beltsville, Maryland

27 research units ■ 806 employees