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Agricultural Research

Good, Bad, or Ugly

We collect them all for the benefit of all, pp. 2, 4-19

Agricultural Research Service
Solving Problems for the Growing World

Systematics & Collections

Preserving Diversity, Trade, and Our Way of Life

In a government facility not too far from you, there is a carefully preserved collection that contains thousands of items. Dead or alive, the items in this collection influence your life in significant and surprising ways.

It may sound like the premise of a summer blockbuster, but it is a real scenario that occurs in federal buildings throughout the United States. The Agricultural Research Service (ARS) maintains hundreds of diverse collections of microbes and viruses, invertebrates and cell cultures, seeds and trees, and everything in-between. And every collection has major benefits for agricultural science.

Collections can be used to protect the genetic diversity of important species, to support regulation and policy decisions, and to preserve history. Some ARS collections include specimens for research, conservation, and food safety. Some preserve specimens to serve as standards or for reference purposes. Others include materials gathered for documenting diversity in nature.

Some collections house rare and historic specimens, such as the National Clonal Germplasm Repository in Corvallis, Oregon, which includes a descendant of the oldest living pear tree in the United States, or the National Animal Germplasm Program, in Fort Collins, Colorado, which maintains blood and semen samples from rare sheep breeds popular in the colonial era.

At the National Center for Genetic Resources Preservation (NCGRP) at Fort Collins, scientists maintain more than 1 million samples of genetic material from plants, animals, insects, and microbes. The materials have been used to develop new products and improve specific traits in agricultural crops. In addition, NCGRP researchers have pioneered new methods and technology for long-term preservation of genetic materials.

These materials provide a link to the past, but they are equally important for the future of food and agricultural security. When new diseases or pests appear, scientists seek out individuals with genetic resistance to these stressors. Repository collections have been used in research to improve the yields, nutritional value, and hardiness of important agricultural crops.

ARS collections have had a major influence on public health as well. In 1942, the healing properties of penicillin had already been demonstrated, but it was impossible to produce enough to treat more than a handful of patients. That changed rapidly, thanks to the culture collection maintained by the ARS National Center for Agricultural Utilization Research, in Peoria, Illinois. The collection included a strain of *Penicillium* that improved the speed of penicillin production. Within 3 years, the amount of available penicillin had increased 25,000 times.

Collections also play an important role in trade. In 1996, for example, wheat farmers in Arizona reported that their fields were infected with Karnal bunt—a fungus that makes wheat taste like spoiled fish. Similar reports followed from wheat producers around the United States, and other countries began to embargo U.S. wheat. But what looked like a disaster for the multibillion-dollar U.S. wheat industry was forestalled when ARS scientists proved that the Karnal bunt infestation was limited to a small area in Arizona. The other producers were observing a harmless look-alike fungus. The only way to differentiate between the two nearly identical fungi was to conduct DNA tests—developed with samples from USDA's National Fungus Collection in Beltsville, Maryland.

U.S. importers benefit from national collections as well. There are many subspecies of fruit fly, some of which are more harmful than others. Scientists have used the ARS fruit fly collection to develop a system for port inspectors to rapidly identify fruit flies in produce shipments. This system came into play in December 2001, when inspectors identified larvae from the destructive Mediterranean fruit fly in shipments of clementine oranges from Spain. Thanks to the system, authorities were able to halt imports before U.S. consumers started packing pests into their lunchboxes and holiday spreads along with this popular fruit.

Collections also play an integral role in protecting our nation's borders. Many of the travelers that cross U.S. borders are too small to see. Insects, fungi, and microorganisms can hitch a ride on the clothes and luggage of people traveling from one country to another. Some of these items, as well as some plants and animals that are transported intentionally, have the potential to wreak havoc in a new environment.

Every year, businesses lose millions of dollars when shipments are delayed at the border—often because inspectors cannot identify some item in the shipment. Scientists use collections of insects and microbes to identify unfamiliar items and determine whether or not they should be admitted to the country. This is a valuable service not only to the businesses that are transporting goods or awaiting shipments, but also to the general public, which relies on the government to ensure food safety.

Collections can also be used to assist foreign countries, as they did when the Iraqi *Rhizobium* collection was destroyed. ARS maintains a collection of these nitrogen-fixing bacteria in Beltsville, and this resource, which has more than 5,000 specimens, was used to help Iraqi scientists rebuild their collection.

These achievements are impressive, but hardly unique. Collections like these play a vital role in national security, public health, environmental monitoring, and scientific discovery every day, everywhere.

Kevin J. Hackett
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Agricultural Research

Solving Problems for the Growing World

Dynastes hercules

Phalacrognathus muelleri

Prosopocoilus giraffa

Megasoma occidentalis

Cover: In May 2008, postal workers in Mohnton, Pennsylvania, heard noises coming from inside a package. On the cover are just some of the foreign beetles that were found alive inside that package. By using the collections maintained by ARS's Systematic Entomology Laboratory, scientists were able to confirm the identities of the beetles, which included species native to Asia, Australia, Central and South America, and Papua New Guinea—but not to the United States. Story begins on page 16. Photo by Stephen Ausmus. (D1565-9)

IN THE NEXT ISSUE

AMAZING GRAINS—You may have grown up eating delicious hot oatmeal for breakfast. As an adult, you may enjoy beverages made with malted barley. ARS research continues to provide evidence of the health benefits of eating oats, and barley is receiving attention for its potential as a feedstock for biofuel and as a feed for fish. But like all crops, oats and barley are subject to disease, so ARS is also seeking to breed varieties with genetic resistance to stem rust and crown rust. The next issue of the magazine takes a look at the scope of ARS's work to ensure that these great grains stay healthy and thriving.

Plant Germplasm

Preserving Diversity, Insuring Our Future

PEGGY GREB (D1579-1)

Germplasm line derived from a wild African cotton species and located in College Station, Texas.

If it were a museum, chances are it would be better known. But the U.S. National Plant Germplasm System (NPGS) is a vital network of genebanks where plants from around the world are curated, propagated, analyzed, and distributed for scientific use.

Most of the 511,000 samples, or accessions, of seeds, tissues, and whole plants are not on public display. They are kept at more than 20 Agricultural Research Service genebanks (see map, page 6), many of which receive additional support from universities and state agricultural experiment stations.

The materials are available to researchers and educators globally, and as one of the most extensive collections of crop diversity in the world, NPGS plays an integral role in maintaining the U.S. and world supply of food, fiber, and other economic crops.

In addition to its vital role in today's agricultural research, NPGS serves as a kind of insurance policy for providing the resources to meet challenges to U.S. and global agriculture presented by evolving pests, pathogens, and environmental changes. It also provides producers with the crop diversity necessary to keep up with changing markets.

Maintaining diverse collections of living plant materials from around the world is a daunting task. Different crops and the wild species related to them have different storage and propagation requirements. Seeds of many species can be stored by drying and freezing, whereas seeds of other species cannot survive such treatments. Many fruit crops and other species must be maintained as whole plants in the field or in protected greenhouses or screenhouses to maintain their health, disease-free status, and unique genetic nature.

"We want to make sure we have a broad base for every important crop in the collection, from both a taxonomic and a geographic standpoint, so when the need arises, we have the necessary genetic tools available," says Gary Kinard, research leader of the National Germplasm Resources Laboratory in Beltsville, Maryland, which coordinates efforts to acquire, document, and distribute NPGS materials.

ARS shares the materials free of charge with researchers and educators around the world. NPGS mailed 183,000 samples to users in the United States and more than 75 other countries in 2008. ARS researchers are using the collection for a wide range

A sample of the range of colors, shapes, sizes, and textures of cotton leaves, bolls, and seeds in the National Cotton Germplasm Collection. Colored cottons, such as the orange and tan ones on the left, are used to make dye-free clothing and are native to Central and South America. The red-colored cotton boll, shown on the right, deters insect feeding. Sharply dissected leaves, such as those near the bottom, help keep the cotton canopy aerated and free of mold in humid climates.

PEGGY GREB (D1581-1)

PEGGY GREB (D1580-1)

In College Station, Texas, James Frelichowski, geneticist and curator of the National Cotton Germplasm Collection, inspects the variation in leaf shape and coloration among cotton lines.

TARIYEL TALIBOV, INSTITUTE OF BIORESOURCES, AZERBAIJAN (D1588-1)

Wild almonds during the flowering and early fruit stage.

of purposes, such as addressing water shortages in California's Central Valley, combating a nematode that costs U.S. cotton growers an estimated $100 million each year, and finding resistance to diseases and pests that threaten the existence of important crops.

The uses of the collection are practically infinite, so only a few examples are given here.

Scientific Value

In California, almond production is affected by water availability. In addition, newly planted almond orchards often experience replant disease, a syndrome caused by an antagonistic microbial community in the soil. Malli Aradhya, a geneticist at the National Clonal Germplasm Repository for Tree Fruit and Nut Crops and Grapes in Davis, California, is searching the ARS collection of almond species from Asia to identify new germplasm accessions with the genetic traits that help combat replant disease and improve drought tolerance.

Nematodes are microscopic worms that can sometimes destroy up to 50 percent of the cotton crop in fields from Texas to Florida. Plant pathologist Alois Bell and colleagues used an African species of cotton that resists the reniform nematode, a common pest, to help cotton growers address part of the nematode threat. By crossing and backcrossing resistance from the wild African species into specially developed hybrids, they developed lines that produce quality fiber and resist the reniform nematode. Bell and colleagues, who recently released the seed of two lines to breeders, originally obtained the African species from the National Cotton Germplasm Collection, which is part of the ARS Crop Germplasm Research Unit at College Station, Texas.

Maintaining the cotton collection isn't easy. Cotton seeds must be regrown every 10 years, and there are 9,300 different accessions of cotton. Curator James Frelichowski must keep seeds at 4˚C (39˚F) and at 20–23 percent humidity. Under those conditions, seeds remain viable for at least 10 years. New plants are propagated at nurseries in College Station and in Tecoman, Mexico (see story on page 18). The Mexican nursery provides an extended growing season and a good site for cultivation of a wide assortment of cotton.

Worldwide Plant Explorations Enhance Collections

ARS has a long-running program, active since 1898, to acquire new samples for its collections. Each year, researchers conduct about 15 expeditions, coordinated by the Beltsville germplasm laboratory, to search for a range of crops and crop relatives with unique traits, such as drought tolerance and pest and pathogen resistance. Foreign explorations are conducted with collaboration from institutions in host countries. Aradhya, for instance, collected more than 145 new accessions of fruit and nut germplasm in trips to Azerbaijan in 2007 and 2008. Such trips can have long-range benefits. A peanut found in a Brazilian market in 1952 is a source for resistance to a wilt virus of U.S. peanuts. A wheat plant collected in Turkey in 1948 effectively resisted a fungal pathogen that emerged as a major threat 15 years later. Its genetics are now incorporated into virtually every wheat variety grown in the Pacific Northwest.

Tracking Requests

Most requests for materials are filed through the Germplasm Resources Information Network (GRIN), an online database (www.ars-grin.gov) that identifies and keeps track of every sample in the collection. Paul Red Elk, a Lakota Sioux youth counselor and educator, has been accessing the database for 6 years to acquire seeds of corn, beans, and onions to teach Native American children, ages 6 to 16, about their ancestral ways in Farmington, Minnesota. His program is designed to instill pride in at-risk children, in part by getting them involved in community gardening. He likes using the GRIN database because it provides accurate descriptions of the origins of the seeds and other materials in the collections.

The youth grow corn, beans, and squash in circular patterns and raise native grasses, wild onions, and wild garlic for soups and stews, as Native Americans once did.

"We try to teach them that this is the way people used to eat," he says.—By **Dennis O'Brien,** ARS.

This research is part of Plant Diseases (#303) and Plant Genetic Resources, Genomics, and Genetic Improvement (#301), two ARS national programs described at www.nps.ars.usda.gov.

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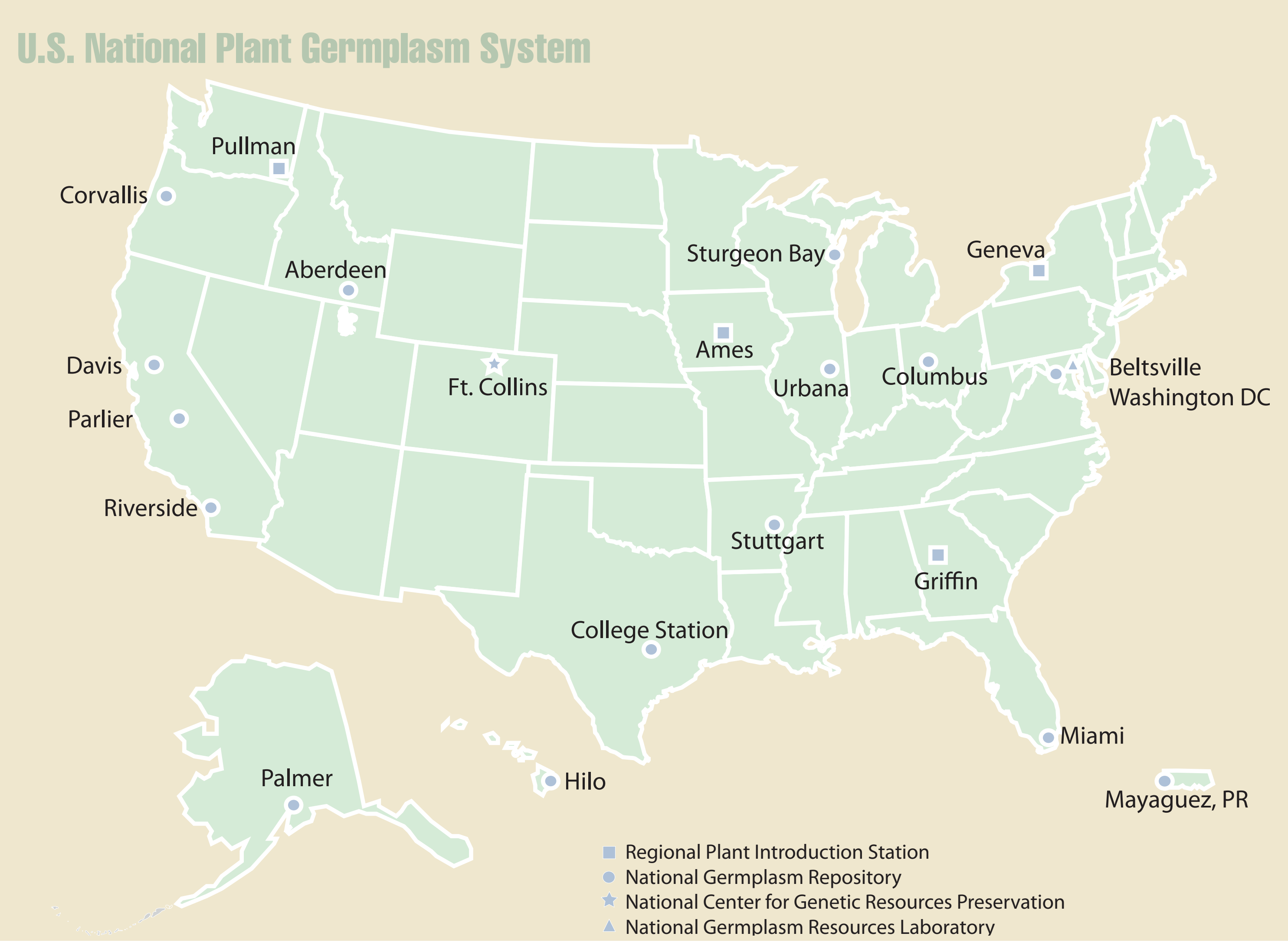

PEGGY GREB (D1575-1)

To identify a potentially destructive nematode intercepted at a U.S. port, microbiologist Zafar Handoo and plant pathologist Lynn Carta examine the head of a plant-parasitic nematode. They will compare it with specimens in the USDA Nematode Collection to make the ID.

Roundworm Repository Provides "Ag Insurance"

The USDA Nematode Collection—maintained by ARS's Nematology Laboratory in Beltsville, Maryland—contains more than 43,000 roundworm-containing microscope slides and vials, making it one of the world's largest and most treasured repositories of its kind.

Enhancing that collection's value further is the expertise of the lab's six scientists who, together with support staff, maintain the repository for systematic studies, taxonomic classifications, and training purposes and provide expert species identification for regulatory agencies such as USDA's Animal and Plant Health Inspection Service (APHIS).

Nematode specimens with requests to identify them are submitted often. In 2008, for example, ARS microbiologist Zafar A. Handoo identified nearly 700 samples, including nearly 300 sent by APHIS personnel at ports of entry or from domestic surveys.

Another use is conducting pest-control research. ARS physiologist Edward P. Masler, for example, has identified nematode signaling molecules, called "amines," that may yield new, eco-friendly controls for crop-damaging species like *Heterodera glycines,* which costs U.S. soybean farmers $1 billion annually in losses.

Besides plant-parasitic species, the collection includes nematodes that feed on microbes and insects. There is also a live collection—studied by ARS plant pathologist Lynn K. Carta—of bacterial-feeding nematodes, many of which can live in insects. Since 2000, Carta has identified seven associated species from the invasive Formosan subterranean termite as well as nematodes from various beetles and tarantulas. Some of these may prove useful in battling pests with biocontrol agents.

Preparing specimens for identification can be time consuming. Many nematodes sport similar-looking mouthparts, tail tips, and other microscopic characteristics useful for identification. "Because nematode species can overlap with respect to these characteristics, it takes an expert with years of experience and a collection of bona fide reference specimens to identify them," says David J. Chitwood, who leads the laboratory.

It helps, though, to have a resident DNA detective. Using the latest polymerase chain reaction procedures, ARS molecular biologist Andrea Skantar complements morphological identification of nematodes by "lifting" their genetic "fingerprints" from DNA samples. Even then, Skantar cautions, "Your molecular diagnosis is only as good as the information from known species used for comparison."

That attention to detail, together with the lab's extensive database of information on the collection's specimens, helps to safeguard American agriculture and ensure free trade with other countries.

A well-known example occurred in 2000, when Nematology Laboratory scientists met with a visiting Brazilian delegation in response to a ban Brazil had imposed on U.S. wheat imports for fear of introducing the seed gall nematode, *Anguina tritici.*

A turning point came when the researchers discovered a single slide of a specimen that a port inspector had submitted in 1953. A database search revealed the genus, *Anguina,* the host plant from which it had been isolated, reedgrass, and most importantly, the country of origin, Brazil. The country, in turn, lifted its ban, reopening a $50-200 million annual market for U.S. wheat.

"Had that slide not been in our collection, the market could have remained closed," Chitwood says. "That's the value of the collection."—By **Jan Suszkiw,** ARS.

This research is part of Plant Diseases (#303) and Pasture, Forage, and Range Land Systems (#215), two ARS national programs described at www.nps.ars.usda.gov.

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Overseas Collections Help Solve Domestic Problems

Many of the plants and insects that invade and harm our native ecosystems originate overseas. Therefore, it's no surprise that ARS's overseas laboratories play a vital role in our quest to prevent invasive species from completely taking over. The scientists at these laboratories have amassed collections of thousands of specimens found during expeditions. These collections—housed at the laboratories in Montpellier, France; Hurlingham, Argentina; Brisbane, Australia; and Beijing, China—serve as an important resource in identifying and evaluating potential biocontrol agents.

MICHAEL SMITH (K11033-1)

Adult Asian longhorned beetle.

From Europe, With Biocontrols

Walker Jones and colleagues at ARS's European Biological Control Laboratory (EBCL) in Montpellier, France, are true explorers.

Each year, they log thousands of miles traveling through Eastern and Western Europe, Africa, the Middle East, the Balkans, and Asia in search of natural enemies of some of North America's costliest invasive species. These include insects such as the Asian longhorned beetle, emerald ash borer, olive fruit fly, and wheat stem sawfly, as well as noxious weeds like giant reed, leafy spurge, and yellow starthistle.

U.S. farmers and property owners aren't the only ones who feel the economic pinch when such exotic species become established on U.S. soils; native flora and fauna also suffer. Infestations of giant reed, *Arundo donax,* for example, can rapidly take over rivers and other wetland areas, outcompeting indigenous plants for water and depriving wildlife of natural habitat.

SCOTT BAUER (K9324-1)

State-of-the-art quarantine facility located next to the European Biological Control Laboratory. Dominique Coutinot, quarantine officer and support scientist, manages the facility.

The problem is, these invaders typically arrive without their homeland's natural enemies. But it's been a stated goal of EBCL to reacquaint the invaders with their old foes—even if it means scouring the four corners of the globe. Insect, mite, and pathogen specimens acquired from such excursions are returned to EBCL under quarantine. There, they are increased in number and subjected to rigorous testing to ascertain their fitness and safety as candidate biocontrol agents that could eventually be used stateside.

Over the past several decades, for example, the lab's beneficial microorganism collection has grown to some 2,000 specimens, including isolates of *Beauveria* and other fungal species with potential to biologically battle invasive weeds and insects, such as the Formosan termite.

In the process, EBCL researchers have amassed a wealth of information about the specimens they've collected and scrutinized. The lab maintains Europe's most extensive collection of beneficial-insect specimens, housed in a climate-controlled room within 26 cabinets and dozens of individual boxes, each related to specific past projects. Many beneficial pathogens are maintained in superfreezers to sustain their viability. A large, preserved plant collection containing important voucher specimens—pressed and dried plants used for reference—has also been accumulated over many years. EBCL began operations in 1919.

Jones, EBCL director since 2005, says, "The collection is currently being identified and catalogued for eventual accessibility through an electronic database."

Discoveries From Down Under

Scientists at ARS's Australian Biological Control Laboratory (ABCL) travel throughout Australia and Southeast Asia in their search for insects that could be used as biocontrols for invasive weeds and insects in the United States.

STEPHEN AUSMUS (K11622-9)

Imported fire ants.

KRISTEN DYER (D1567-1)

In the Hunan province of China, ARS Australian Biological Control Laboratory entomologist Matthew Purcell (front) and Chinese collaborator Jianqing Ding search for potential biological control agents for the submerged aquatic weed *Hydrilla verticillata,* a pest in the United States.

"Over the past 24 years, we have accumulated an extensive collection of specimens from our expeditions and surveys," says lab director Matthew Purcell. "With excellent collaborators, we have the capability to explore countries such as Singapore, Thailand, China, Malaysia, and Indonesia to find the most promising biocontrol agents."

Stored at the laboratory in Brisbane, the collection contains tens of thousands of specimens of herbivorous and parasitic insects. Professionally preserved for permanent storage on pins or in vials of alcohol, specimens are often used in genetic characterization and by taxonomists to conduct systematic studies and identify cryptic species—new species that look identical to those already known.

"The collection benefits the scientific community, given that a large percentage of the insects we collect are unknown to science," adds Purcell. "We are increasing the knowledge of biodiversity across different habitats and ecosystems in Australia and Southeast Asia."

More than 450 insect species in the collection were identified as feeding on melaleuca alone. *Melaleuca quinquenervia,* commonly known as the "Australian broad-leaved paperbark tree," is a serious invasive plant in Florida that has caused extensive environmental and economic damage to the Everglades and surrounding areas.

Although biocontrol agents for *Melaleuca* have been released and are thriving, the Brisbane scientists continue to search for other insects to add to the arsenal being used to stop the weed's spread. Specimen data from insects in the collection help identify the host range, seasonality, and climatic restrictions of new agents—key factors in evaluating a biocontrol candidate's potential.

In addition, the collection houses samples of targeted weeds. These samples are used to help characterize and genetically match weeds in the exotic range with specimens from the native range. This has become an essential component in selecting effective, host-specific biocontrol agents.

Fighting South American Invasive Pests

Since 1962, ARS's South American Biological Control Laboratory (SABCL) in Hurlingham, Argentina, has played an invaluable role in assisting ARS scientists—both in the United States and at other international labs—with its herbarium, which now houses more than 2,200 dried specimens. This collection has been recently identified and catalogued and is available through an electronic database.

In addition, SABCL has an insect collection of about 6,000 pinned specimens, and thousands more specimens are preserved in alcohol. Many of the insects are new to science. The collection will be sorted soon.

Juan Briano, the lab's director since 2003, and the scientific team at SABCL have explored Argentina, Bolivia, Brazil, Chile, Paraguay, Peru, and Uruguay and studied the abundance, biology, efficacy, and specificity of hundreds of natural enemies of several dozen invasive pests that were introduced into the United States from South America.

Both the insect and plant collections at SABCL are continuously updated with new specimens collected during field explorations. Current projects there include work with water hyacinth, alligatorweed, Brazilian pepper-tree, fanwort, balloon vine, pompom weed, Brazilian waterweed, water primrose, *Lippia, Parkinsonia,* water lettuce, imported fire ants, glassy-winged sharpshooter, cactus moth, little fire ant, and cactus mealybug. Cooperative agreements exist between SABCL and Australia and South Africa.—By **Stephanie Yao, Jan Suszkiw,** and **Alfredo Flores,** ARS.

This research is part of Veterinary, Medical, and Urban Entomology (#104) and Crop Protection and Quarantine (#304), two ARS national programs described at www.nps.ars.usda.gov.

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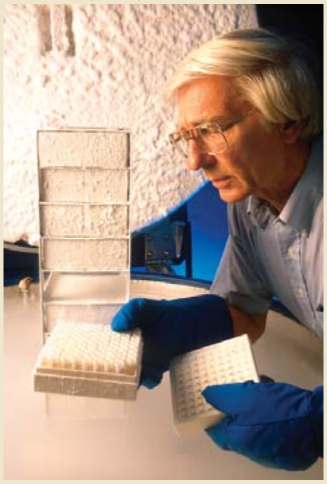
SCOTT BAUER (K9339-1)

Plant pathologist Tim Widmer sprays a fungus isolated from yellow starthistle on a seedling of the same plant species. The fungus is harmless to humans.

Marvelous Microbe Collections Accelerate Discoveries To Protect People, Plants—and More!

KEITH WELLER (K7406-3)



Microbiologist Cletus Kurtzman retrieves yeasts from the ARS Culture Collection.

PEGGY GREB (K10242-1)

Microbiologist Richard Humber identifies a fungus infecting an insect.

If you're a contact lens wearer, you probably remember headlines a few years ago about emergence of a worldwide medical problem—molds that live on contact lenses and cause debilitating eye infections.

What you may not have known: ARS experts at the National Center for Agricultural Utilization Research in Peoria, Illinois, did the detective work necessary to precisely identify these molds—which turned out to be *Fusarium* species.

These researchers derived the correct identification by working with a database of distinctive *Fusarium* genetic material that can be used to reliably differentiate among the many *Fusarium* species that cause disease.

In turn, this handy database owes part of its origin to the exemplary collection of hundreds of species of *Fusarium* housed at Peoria in the **ARS Culture Collection.**

Research leader and microbiologist Cletus Kurtzman and colleagues curate this comprehensive assemblage of living specimens of harmful and helpful bacteria, molds, actinomycetes (such as antibiotic-producing *Streptomyces*), and yeasts from around the planet.

Proximity to this genebank—the world's largest publicly accessible collection of microbes—has, not unexpectedly, hastened discoveries by Peoria scientists. Their accomplishments include innovative new ways to detect, identify, classify (put in the correct family tree), and newly use these microorganisms to make foods safer, protect plants from pests, and create new industrial products.

Of course, other scientists also benefit. Some 4,000 strains of microbes are shipped each year from this flagship collection to researchers elsewhere.

Such sharing of specimens is all in a day's work at other specialized ARS microbe collections as well, including the **U.S. National Fungus Collections** in Beltsville, Maryland.

With more than 1 million dried specimens, these collections are the largest of their kind, according to director Amy R. Rossman. Scientists worldwide use them as a reference, and specimens are loaned for research projects.

Recent additions to the collections include seven species of fungi in the chestnut blight group that were discovered and described in the past few years. These descriptions will be used by forest pathologists to determine which species of fungi occur on hardwood trees, making it easier for these specialists to figure out how best to treat infected trees.

SCOTT BAUER (K5801-14)

Microbiologist Peter van Berkum compares growth of alfalfa plants (left) inoculated with *Rhizobium* with plants that haven't been inoculated (right).

Fungi that cause plant diseases are the primary focus of the U.S. National Fungus Collections. That's in contrast to another fungal genebank, the **ARS Collection of Entomopathogenic Fungal Cultures,** which specializes in live fungi that attack or in other ways affect insects, spiders, mites, and other invertebrates. ARS microbiologist Richard Humber is curator of this Ithaca, New York-based collection. Humber and Beltsville coinvestigators Stephen Rehner, an ARS molecular biologist, and Joe Bischoff, a mycologist with USDA's Animal and Plant Health Inspection Service, have evaluated hundreds of isolates from the collection's holdings to make crucial molecular revisions of the taxonomy of two important fungal species. They are *Beauveria bassiana,* used to control termites, for instance, and *Metarhizium anisopliae,* which serves as a biological insecticide that controls termites, thrips, and grasshoppers.

There's more. ARS microbiologist Peter van Berkum, also at Beltsville, directs the **National *Rhizobium* Germplasm Resource Collection.** *Rhizobium* is the scientific term for bacteria that can form a symbiosis with alfalfa, soybean, and other legumes to provide these plants with a source of fertilizer—ammonia—for growth and reproduction. This is done by a process known as "biological nitrogen fixation"—the reduction of nitrogen gas from the atmosphere into ammonia. The collection provides a germplasm resource for industry to use in manufacturing inoculants and for researchers to use in investigating symbiosis and nitrogen fixation.

Current projects involving the collection include genetic mapping of *Rhizobium* found in association with alfalfa and other *Medicago* species from Egypt, Spain, and Tunisia. Also under way: Genetic mapping of *Bradyrhizobium* populations found in association with soybean. This investigation may determine—among other things—whether the *Bradyrhizobium* in U.S. soils are the same as those in the Far East, soybean's place of origin.

Both projects may lead to new ways to boost plants' productivity without using fertilizer.—By **Marcia Wood** and **Alfredo Flores,** ARS.

This research is part of Plant Diseases (#303), Crop Protection and Quarantine (#304), and Plant Genetic Resources, Genomics, and Genetic Improvement (#301), three ARS national programs described at www.nps.ars.usda.gov.

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PEGGY GREB (K11058-1)

Collections manager Erin McCray and mycologist David Farr examine a fusiform rust of pine, one of more than 1 million specimens in the U.S. National Fungus Collections.

Troublesome Microbes That Resist Antimicrobials

The Antimicrobial Resistance Collection

In an effort to monitor pathogenic microbes' resistance to antimicrobials, the National Antimicrobial Resistance Monitoring System (NARMS) was established in 1996 by the U.S. Food and Drug Administration's Center for Veterinary Medicine in collaboration with the Centers for Disease Control and Prevention and the U.S. Department of Agriculture.

The animal component of NARMS focuses on zoonotic pathogens (those that can be transferred from livestock or wildlife to humans) and is housed within ARS's Bacterial Epidemiology and Antimicrobial Resistance Research Unit. Led by microbiologist Paula Cray, the unit is part of the ARS Richard B. Russell Research Center in Athens, Georgia.

The NARMS animal component tests samples, or isolates, obtained from healthy on-farm animals, animals being diagnosed for illness, and food animals at slaughter. The specimens are stored in the **Antimicrobial Resistance Collection,** maintained by Cray's team.

Resistance of *Salmonella, Campylobacter, Enterococcus,* and *Escherichia coli* to antimicrobials such as streptomycin and tetracycline is tested, monitored, and tracked in an attempt to better understand foodborne pathogens' resistance trends.

"Nontyphoid *Salmonella* was chosen as a sentinel organism of NARMS's animal component, which was launched in 1997," says Cray. A sentinel organism is one used to track changes in resistance over time. "Testing of *Campylobacter* isolates began in 1998, while *E. coli* was included in 2000. *Enterococcus* testing has also been added to the data set.

"It is vital that we track these trends of resistance and disseminate the information to animal producers, veterinarians, and consumers."—By **Sharon Durham,** ARS.

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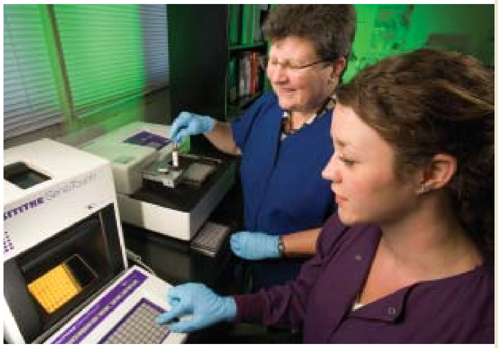
PEGGY GREB (D602-1)



Research leader Paula Cray (left) and technician Lori Ayers perform antimicrobial susceptibility testing on a bacterial culture.

Animal Gene Collections Support U.S. Research

The National Animal Germplasm Program (NAGP) opened in Fort Collins, Colorado, in 2000, with genetic material from 40 chicken lines. Since then, the collection has expanded to include dairy and beef cattle, swine, sheep, goats, bison, elk, and fish. Today, NAGP houses more than 547,000 samples of genetic material, or germplasm, from more than 12,000 animals. This collection—like all Agricultural Research Service collections of animal germplasm—preserves the genetic diversity of agriculturally important animals.

Providing genetic material for genomic studies is one of the most important functions these collections serve. NAGP, for example, has distributed samples from about 2,500 animals to ARS researchers and their university colleagues. ARS scientists have used bull semen acquired from NAGP to genotype prominent bulls that had sired dairy cattle. This information, combined with milk-production data gathered from those cows, has been used to improve dairy cattle breeding programs. Similar work has been done with beef cattle and pigs by ARS researchers in Clay Center, Nebraska.

In many cases, these collections have helped U.S. animal producers save money, but ARS animal collections aren't simply economical. They provide information for researchers and breeding material for animal producers, and they play an instrumental role in protecting and improving agricultural livestock.

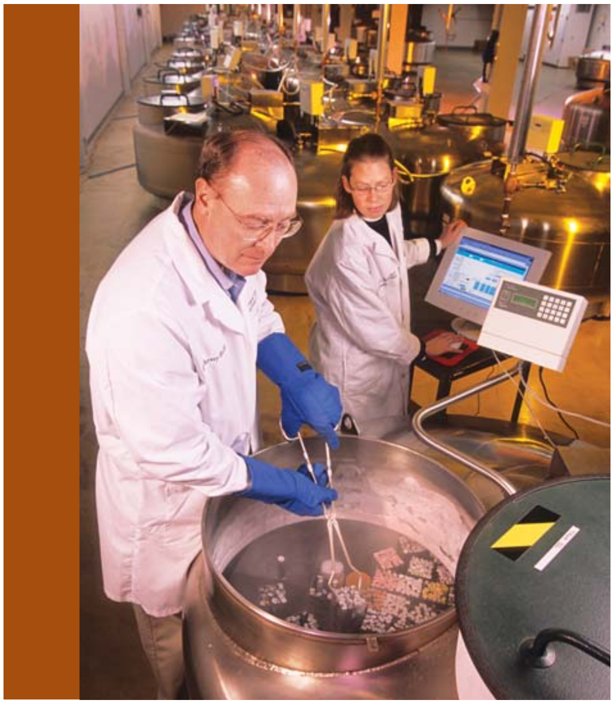
Jurassic Pork: Protecting and Promoting Rare Agricultural Breeds

Animal genetic material can't raise the dead. But it can be used to revive animal lines that have died out. Researchers at Purdue University arranged to save semen from a unique line of pigs that had two mutations that negatively influenced meat quality. Maintaining live pigs is expensive and time-consuming, so the population was terminated when the studies involving the herd concluded. At the request of Purdue researcher Terry Stewart, NAGP scientists gathered semen from three of the boars in the study and added the samples to their extensive collection of animal genetic materials.

BUCK ALBERT-USGS (D1566-1)

Grass carp or white amur, *Ctenopharyngodon idella*.

STEPHEN AUSMUS (K10187-9)



National Animal Germplasm Program coordinator Harvey Blackburn and technician Ginny Schmit place germplasm samples into a liquid nitrogen tank for long-term storage.

A few years later, Stewart and his colleagues decided to take the research in a new direction. By that point, the original herd was long gone, but the scientists were able to resurrect the line by inseminating seven sows with the saved semen. All the sows became pregnant and bore litters, indicating that in some instances, cryopreserving genetic material may be a more efficient use of time and money than maintaining a live herd.

"This is the first time a line has been cryopreserved, discontinued, and re-established using germplasm frozen and stored by NAGP," says animal geneticist and NAGP coordinator Harvey Blackburn.

The NAGP collection has also been used to prevent existing lines from dying out. For example, scientists at NAGP have collected and distributed germplasm to support a rare breed of dairy cattle.

Shorthorn cattle first came to the United States in the 19th century from the United Kingdom. Imports increased significantly after the breed was successfully crossed with the Texas Longhorn. The exact number of milking and beef Shorthorns in the United States today is unknown, but in 2000, there were about 2,800 milking Shorthorns registered. Though they have lower milk yields than Holstein or Jersey cows, Shorthorns are valued for their calm temperament and production efficiency.

Shorthorns have been successfully crossbred with many other dairy and beef cattle breeds. These crosses have performed well, but the breed's fans lobbied for the establishment of a program to identify purebred native Shorthorns.

NAGP scientists have made special efforts to collect genetic material from cattle that could be designated as native Shorthorns. In 2006, NAGP animal physiologist Phil Purdy traveled to Nebraska to collect genetic material from 15 bulls in a large Shorthorn herd.

"This herd is of particular importance because, except for one animal, no outside animals have been brought in for breeding since before World War II," Blackburn says. In addition, Shorthorn samples from the repository have been used by breeders in Utah to introduce new genetic variability into the Shorthorn breed.

Documenting Diversity

Many of the ARS animal collections document and preserve genetic diversity. For example, ARS scientists in Brooksville, Florida, worked to preserve cattle species *(Bos taurus* and *B. indicus)*—specifically those tolerant of tropical environments—by storing the germplasm needed for research on the cattle genome and phenotypic performance. The Subtropical Agricultural Research Station has played an important role in conserving beef cattle genetic resources. A unique feature of the Brooksville collection was the number of embryos collected from tropically adapted cattle—at least 100 per breed—something not done on a large scale by other collaborating repositories. The entire Brooksville collection is now stored at Fort Collins.

Germplasm from different cattle breeds is stored regardless of whether current research is under way. Preserving germplasm of cattle that are no longer being studied acts as an insurance policy in case the genetics are needed to combine with other cattle breeds for productivity under tropical conditions.

At the National Sedimentation Laboratory (NSL) in Oxford, Mississippi, 124 species of fish, amphibians, reptiles, and mammals provide a baseline sampling of animal diversity in and around the region's rivers, streams, wetlands, and ponds. Though most of the specimens

Cost-Saving Collections

Researchers at the Fort Keogh Livestock and Range Research Laboratory in Miles City, Montana, store and use cattle germplasm in their quest to develop strategies and technologies for reducing beef production costs. Cereal grains—often used as a major part of heifer diets—are becoming less abundant and more expensive due to growing demand for human food and ethanol production. According to physiologist Andrew Roberts, young female cattle developed to have lower target weights than those traditionally recommended consumed 27 percent less feed over the winter and were more efficient in weight gain throughout the postweaning period and subsequent grazing season. This strategy may reduce costs of developing each replacement heifer by more than $31—mainly from lower feed costs—and extend their life span, with important ramifications for efficiency and profitability.

ARTHUR MARIANTE (D1563-2)

In 2006, NAGP identified a unique herd of Shorthorn cattle in Broken Bow, Nebraska. With the help of the owner and breed associations, animal geneticist Harvey Blackburn and physiologist Phil Purdy collected germplasm for addition to the Shorthorn collection.

are vertebrates—like the ancient bowfin, which lives in swampy pools—some freshwater mussels and insects are also in the mix.

"Mississippi has an incredibly diverse assortment of freshwater fishes," ecologist Scott Knight says. Knight, who works in NSL's Water Quality and Ecology Research Unit, has been the curator of the collection's 11,000 specimens since 1986. "Our collection is maintained mostly for identification reference, but we also use it to keep tabs on the appearance of a new or exotic species, like grass carp."

The efforts of NSL scientists also help document the presence of an occasional rare species, like the Yazoo darter, which is only found near Oxford in tributaries of the Little Tallahatchie and Yocona Rivers. And in 2001, University of Southern Mississippi ichthyologist Stephen T. Ross published a 624-page book on the inland fishes of Mississippi—a guide so comprehensive that it marked the first time some of the fish in the NSL collection were included in a published reference.

In East Lansing, Michigan, more than 40 genetically unique chicken lines have been developed at the Avian Disease and Oncology Laboratory (ADOL). These lines have been critical to the successful completion of important research projects conducted at ADOL and at other research centers in the United States and around the world.

Research using these chicken lines increased knowledge about genetic resistance to disease and led to development of necessary reagents and tools used in the diagnosis, control, and prevention of virus-induced tumors of poultry. Select achievements include the first- and the next-generation Marek's disease vaccines, identification of avian leukosis virus (ALV) as the cause of lymphoid leukosis, DNA-based technology to determine ALV susceptibility of chickens, and more sensitive assays to screen live-virus vaccines for contamination with ALV.

The unique and genetically well-defined ADOL genetic resources consist of highly inbred and non-inbred lines of chickens. Two of the lines lack endogenous ALV genes, a characteristic that makes them a rare and invaluable research tool. The ADOL genetic lines comprise close to half of the chicken germplasm in the NAGP.

Because of financial constraints, genetically unique chicken lines maintained elsewhere in the United States and in other countries are rapidly diminishing. Thus, the importance and value of maintaining the ADOL genetic lines—and those like them—cannot be overemphasized.

Collections like these exist in ARS facilities throughout the United States, and they make important contributions to our nation's animal health, food security, and agricultural research.—By **Laura McGinnis,** formerly with ARS, and **Sharon Durham** and **Ann Perry,** ARS.

This research is part of Animal Health, an ARS national program (#103) described at www.nps.ars.usda.gov.

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Select Achievements from East Lansing, Michigan

- First- and second-generation Marek's disease vaccines.
- Identification of avian leukosis virus (ALV) as the cause of lymphoid leukosis.
- DNA-based technology to determine ALV susceptibility of chickens.
- More sensitive assays to screen live-virus vaccines for ALV contamination.

BRUCE FRITZ (K8129-1)

At the ARS Avian Disease and Oncology Laboratory in East Lansing, Michigan, chemist Lucy Lee (right) and technician Barry Coulson inoculate broiler chickens with an experimental recombinant vaccine against avian leukosis virus.

Archiving Parasites and Protozoa for Research, Diagnoses, and More

In the United States, parasitic infections contribute to losses of more than $2 billion annually in livestock alone. In turn, some parasites, like tapeworm, can infect humans who eat uncooked or undercooked beef or pork.

Fortunately, ARS maintains archival collections of parasites for research, identification, and diagnostic purposes, the vast majority of which are held at the U.S. National Parasite Collection (USNPC), which is curated by ARS zoologist Eric Hoberg.

Hoberg is with the Animal Parasitic Diseases Laboratory, which is part of the Henry A. Wallace Beltsville Agricultural Research Center in Beltsville, Maryland. The collection was established in 1892 and is among the largest parasite collections in the world.

Current holdings include more than 20 million catalogued specimens representing nematodes, tapeworms, flukes, spiny-headed worms, and some parasitic arthropods, such as fleas, ticks, and lice. Detailed biodiversity information about hosts and geographic distribution is maintained in an on-line database.

The USNPC contributes significantly to explorations of diversity, evolution, and distribution, furthering our understanding of the socioeconomic and ecological significance of parasites and pathogens. Archival collections serve as critical baselines to understand ecological disturbance. Archives provide a foundation to identify shifting geographic and host ranges for parasites and diseases that may emerge with accelerated global change.

Newly Reclassified Protozoa at Work

ARS researchers have also assembled and maintain invertebrate protist collections at three research locations for the purpose of in-house and joint projects.

At the Center for Medical, Agricultural, and Veterinary Entomology (CMAVE), in Gainesville, Florida, researchers are using a collection of microsporidia—formerly classified as protozoa and now considered fungi—to act as soldiers of biological warfare at the tiniest level. Species of these spore-producing parasites, such as *Kneallhazia solenopsae,* are being used to bring about declines in red imported fire ant *(Solenopsis invicta)* populations. In Argentina, these infectious soldiers are associated with localized declines of 53 percent to 100 percent in fire ant populations, according to CMAVE entomologist David Oi.

In addition, Oi and CMAVE colleagues Sanford Porter and Steven Valles were able to get *K. solenopsae* to infect phorid flies without harming them. That's important because the flies may serve as vectors to infect red imported fire ants with the microsporidia—perhaps facilitating the spread of infection to other colonies.

PEGGY GREB (K10225-1)

Entomologist David Oi collects infected fire ants from a colony decimated by the fire ant pathogen *Kneallhazia solenopsae.*

PEGGY GREB (D1578-1)

Eric Hoberg, chief curator of the U.S. National Parasite Collection, examines roundworm specimens from raccoons, which pose a potential threat for human infection.

K. solenopsae not only reduces fire ant colony size, it also reduces the number of reproducing ants, decreases the survival of queens, and increases the mortality rate of colonies, says Oi. The collection enables scientists to research the potential for using these and other microbes as biocontrol agents.

In Sidney, Montana, ARS scientists at the Northern Plains Agricultural Research Laboratory used the U.S. Rangeland Grasshopper Collection's microsporidia holdings to develop the first microbial control agent registered for use in the United States against grasshoppers. Large-scale outbreaks of grasshoppers occur about every 8 to 10 years. In 2001, such an outbreak caused an estimated $25 million of damage to crops in Utah alone.

And researchers at the Grain Marketing and Production Research Center in Manhattan, Kansas, maintain protozoa in a collection that is used to develop biocontrol agents against beetles and other bugs that burrow into stored grain products.—By **Rosalie Marion Bliss** and **Sharon Durham,** ARS.

This research is part of Animal Health, an ARS national program (#103) described at www.nps.ars.usda.gov.

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David Oi is in the USDA-ARS Center for Medical, Agricultural, and Veterinary Entomology, 1600 S.W. 23rd Dr., Gainesville, FL 32608; (352) 374-5987, david.oi@ars.usda.gov. ✷

Our Invaluable Invertebrate Collections

STEPHEN AUSMUS (D1565-23)

Left, giraffe stag beetle, *Prosopocoilus giraffa;* right, hercules beetle, *Dynastes hercules;* bottom, king stag beetle, *Phalacrognathus muelleri*.

Many people find insects annoying. But to researchers, understanding these creatures plays a significant role in protecting American agriculture. That's why the Agricultural Research Service maintains invertebrate collections all over the United States.

The invertebrate germplasm collections are unique because, unlike other ARS collections, scientists maintain them by continuously rearing live specimens. They serve as genetic resources of insects and arachnids important to agriculture. Our largest collections are located in Manhattan, Kansas; Stillwater, Oklahoma; Fort Collins, Colorado; and Fargo, North Dakota.

Scientists use the invertebrate systematics collections, which are composed of preserved dead specimens, to help identify and verify insects and mites that are of economic importance and are used in research. ARS has four major collections—each housing more than 500,000 accessions—located in Beltsville, Maryland, and Washington, D.C.; Logan, Utah; Stillwater, Oklahoma; and Newark, Delaware. The insect and mite collections at Beltsville and D.C. belong to the Smithsonian Institution as part of the U.S. National Arthropod Collection.

Taxonomy, Customs, and Contraband Beetles

It was the spring of 2008. The rhinocerus, hercules, and king stag beetles—some 6 inches in length—arrived at ARS entomologist Natalia Vandenberg's office in the National Museum of Natural History in Washington, D.C., dead (having been frozen) but impressive nonetheless for their size and beauty.

U.S. Customs and Border Protection (CBP) officials had sent the beetles after postal workers in Mohnton, Pennsylvania, heard scuttling noises inside a package from Taiwan. As an expert on the insect order Coleoptera, Vandenberg was asked to officially determine the beetles' identities, which included species native to Asia, Australia, Central and South America, and Papua New Guinea—but not the United States.

"Foreign beetles represent a potential threat to agriculture and the environment, and therefore their shipment into the United States requires special handling and permits," says Vandenberg. But no such permissions accompanied the Mohnton package. Instead of toys, gifts, and jellies as the label claimed, CBP inspectors found more than two dozen live beetles, including males and females.

Needless to say, the insects never reached the intended recipient. And while the beetles ultimately met their demise, they'll live on in posterity as a permanent part of the museum's National Entomological Collection. The 100-year-old repository, which contains 35 million insect and mite specimens, is maintained by experts from the Smithsonian Institution, U.S. Department of Defense, and ARS's Systematic Entomology Laboratory (SEL), where Vandenberg works.

STEPHEN AUSMUS (D1564-16)

Examining and identifying contraband beetles seized by Homeland Security and ARS. Smithsonian Institution collections manager and entomologist David Furth holds an elephant beetle, *Megasoma mars,* and ARS entomologist Natalia Vandenberg holds a hercules beetle, *Dynastes hercules.*

JACK DYKINGA (K4480-12)

Greenbug.

SEL research leader M. Alma Solis estimates that SEL staff identifies 35,000 specimens annually, in support of federal agencies, academia, and state agriculture departments. Located in both Washington, D.C., and Beltsville, SEL researchers also investigate the biology, taxonomy, distribution, and origins of newly detected and established species.

Thanks in great part to USDA's long-term collaboration with the Smithsonian, "The U.S. National Collection is one of the best resources in the world to support identifications and research affecting trade, quarantine issues, biological control, and other aspects of agriculture," says Solis.

Cereal Pests Preserved

At the Wheat, Peanut, and Other Field Crops Research Unit in Stillwater, Oklahoma, entomologist John Burd spends his days surrounded by insects—thousands of them. Burd manages two important collections of insects that affect cereal crops such as wheat and barley.

The Aphid Biotype and Natural Enemy Collection contains more than 100,000 specimens. Biotypes occur when there is a genetic change in a pest, normally a result of sexual reproduction. This genetic change can allow the insect to damage plants that were previously resistant. Each aphid biotype has a unique phenotypic fingerprint—the way in which it damages a specific group of resistant and susceptible plants—that allows Burd to tell them apart.

There are also more than 10,000 insects in this collection that have been frozen for future use. "The saved material allows for historic comparisons to be made," says Burd. "It also ensures we have specimens necessary for future research."

Burd also maintains live colonies of all the known biotypes of two of the most economically important pests of cereal crops—the greenbug *(Schizaphis graminum)* and the Russian wheat aphid *(Diuraphis noxia)*—in the Cereal Insects Genetic Resource Library. These insects have been known to cause millions of dollars in crop losses annually.

The collection was established in 1997, but Burd began collecting specimens in 1986. "We collect and preserve living and dead insects from all over the world," says Burd. "And just as our specimens come from different countries, so do the researchers who use them."

The collection was used during a Russian wheat aphid outbreak in Colorado during the 2003-2004 growing season, which damaged many fields. Specimens in the collection allowed scientists to quickly determine that the biotype was not a new introduction to the country. This saved time and helped the scientists understand pest resistance differences and come up with solutions, including developing resistant cultivars.

SCOTT BAUER (D013-1)

In Lincoln, Nebraska, visiting entomologist Roger Leopold (from Fargo) places screwworm embryos in a liquid-nitrogen storage unit headed for Fort Collins, Colorado.

Freezing for the Future

Cryopreservation and cold-storage technologies are important tools used in long-term preservation of insect germplasm. ARS entomologist Roger Leopold at the Insect Genetics and Biochemistry Research Unit in Fargo, North Dakota, has co-written a book chapter with ARS biologist Joe Rinehart, also at Fargo, on the lab's achievements on insect cryopreservation.

Cryopreservation is the process of freezing and storing an organism in liquid nitrogen without killing it. Their lab's successful cryopreservation of the house fly led to the development of a protocol for cryopreserving screwworms, a devastating insect pest that burrows into and eats the flesh of warm-blooded animals.

An expanded screwworm cryopreservation protocol will be used to amass a large number of embryos to serve as a back-up repository for rearing facilities in Mexico and Panama.

"Insect strains" are species with special properties that either occur naturally or have been developed for a specific research project. The strain is often discarded after completion of the work. As a result, researchers must often redevelop or reisolate strains for new projects. Continuous colonization of all strains is costly. Developing technology for their cryopreservation and establishing a national repository for long-term preservation of insect germplasm would be a practical solution to this problem, says Leopold.—By **Stephanie Yao, Jan Suszkiw,** and **Alfredo Flores,** ARS.

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

To reach scientists mentioned in this article, contact Stephanie Yao, USDA-ARS Information Staff, 5601 Sunnyside Ave., Beltsville, MD 20705-5129; (301) 504-1619, stephanie.yao@ars.usda.gov. ✷

Freeze-Drying Is Key to Saving Fungal Collection

Imagine. The scientists worked for months on an experiment, and then it happened: The fungal species that was critical to the entire experiment was accidently cross-contaminated. The researchers had been working on harvesting a gene that produces a key enzyme from a very special fungus. "No problem," says taxonomist Maren Klich. She has pure inventory of exactly the fungal species needed to regroup. Experiment saved.

This is the kind of taxonomical rescue Klich conducts. She has been curator for nearly 30 years of the ARS Southern Regional Research Center's (SRRC) 1,700 strains that make up the Fungal Culture Collection.

The collection is critical to the day-to-day work of career scientists who work at SRRC and beyond. Interestingly, Klich chose a method of preserving the collection that is essentially "the closest thing to putting microbes into suspended animation," she says.

"But if we had gone that route, we would have lost the entire collection during Hurricane Katrina."—
Maren Klich

She and colleagues actually freeze-dry tiny amounts of a fungal species. In a small vacuum tube, water is removed from the frozen fungi. That suspends the life of the live organism. Fungi can stay in that condition for 50 years or more. "You end up with white pellets that can be resuspended," says Klich. "We immerse the pellet in a liquid, and place the suspension on a petri dish containing agar, and the mold grows right out—it comes back to life."

Another way the team could have chosen to preserve their live fungi was to freeze them in liquid nitrogen. "But if we had gone that route, we would have lost the entire collection during Hurricane Katrina," says Klich.

After Katrina, evacuee scientists were barred from returning to SRRC, so they would not have been able to keep cultures frozen. "You have to replenish the liquid nitrogen, and we just could not do that after Katrina," she says.

But when Klich was allowed to return, she found the collection safe and sound. She then turned her attention to helping other agencies identify potentially dangerous mold species that could occur as a result of water damage from the storm.—By **Rosalie Marion Bliss,** ARS.

Maren A. Klich is with the USDA-ARS Food and Feed Safety Laboratory, 1100 Robert. E. Lee Blvd., Bldg. 001, New Orleans, LA 70124; (504) 286-4361, maren.klich@ars.usda.gov. ✷

Tropical Treasure Turns 60

The Cotton Winter Nursery (CWN) in Tecoman, Mexico, is a vital resource for both maintenance of cotton germplasm and faster variety development. The CWN will turn 60 in 2010, making it one of the longest running cooperative facilities of its kind. Since its inception, it has been operated jointly by the Agricultural Research Service, the National Cotton Council of America, and the Mexican Institute of Forestry, Agriculture, and Livestock Research, Mexico's ARS equivalent. Government, academic, and industry scientists serve on an advisory committee.

A comprehensive collection of cotton's genetic diversity is essential for protecting and enhancing the nation's $3.8 billion cotton crop. Scientists conduct research on genetic diversity to help improve key agronomic traits for cotton. For example, cotton breeders seek to develop plants that produce long, strong fibers of uniform length and are resistant to pest, pathogens, and environmental extremes.

With more than 9,000 lines, or "accessions," the ARS Cotton Germplasm Collection in College Station, Texas, is a storehouse of unique genetic matter that could prove useful for increasing yields, improving fiber quality, and controlling future pests and pathogens. The CWN plays a major role in maintaining the viability of this collection. Cotton seeds stay viable for at least 10 years, but each accession kept at College Station must be raised from seed once every decade to maintain vigor. Many wild-collected accessions, essential for the collection's genetic diversity, require the shorter days common in the nursery's tropical location in order to reproduce. So the CWN is ARS's primary site for producing new cotton seeds and plants. Says James Frelichowski, the collection's curator, "We send between 900 and 1,000 cotton accessions to the CWN each year for seed increase."

Cotton is particularly susceptible to pests and pathogens, and some experts attribute the recent stagnation in cotton yields to the crop's narrow genetic base. But less than 1 percent of the plant's genetic base has been explored. Scientists from ARS and many universities, state agricultural experiment stations, and private companies are currently conducting more than two dozen research projects at the CWN to identify genes from exotic and wild cotton plants that may improve fiber quality, increase yields, resist pests and pathogens, and enhance drought tolerance.

The CWN's tropical location shortens the time required to study and develop new varieties, because scientists can raise two generations of cotton each year. "We can plant cotton in September in Mexico, take seeds from that crop in March or April, and plant the progeny seed in April or May of that same year in the southern United States," says Frelichowski. Thus, the nursery plays a key role not only in maintaining a vital cotton collection, but also in developing new cotton varieties.—By **Dennis O'Brien,** ARS.

James Frelichowski is in the USDA-ARS Cotton Germplasm Research Unit, 2881 F&B Rd., College Station, TX 77845; (979) 260-9209, james.frelichowski@ars.usda.gov. ✷

ARS Research Programs in Systematics and Collections

Agricultural Research Service programs for systematics and collections fall mainly under two national programs—Plant Genetic Resources, Genomics, and Genetic Improvement (#301) and Food Animal Production (#101). There are more than 15 categories of collections, including plant and animal germplasm, bacteria, fungi, nematodes, molecular reagents, parasites, and protozoa. Every day, scientists working in nearly every national program make use of collections as sources of genes, information, and reference materials for their research.

Stewardship of the ARS scientific collections is a major concern for the agency and the country. Priorities for the programs include identifying and filling gaps in germplasm collections, especially wild relatives of crops that are endangered by habitat loss; preservation of stored germplasm; improving protocols for germplasm regeneration; ensuring the accuracy of collections; and expanding the availability of germplasm information and genetic material.

ARS works with national and international committees to identify the most important gaps in germplasm collections and organize collecting expeditions and exchanges to fill them. This is helping to ensure the availability of genes that may one day fill needs that today's breeders have not even conceived of yet. The agency is also working to promote more international germplasm exchanges.

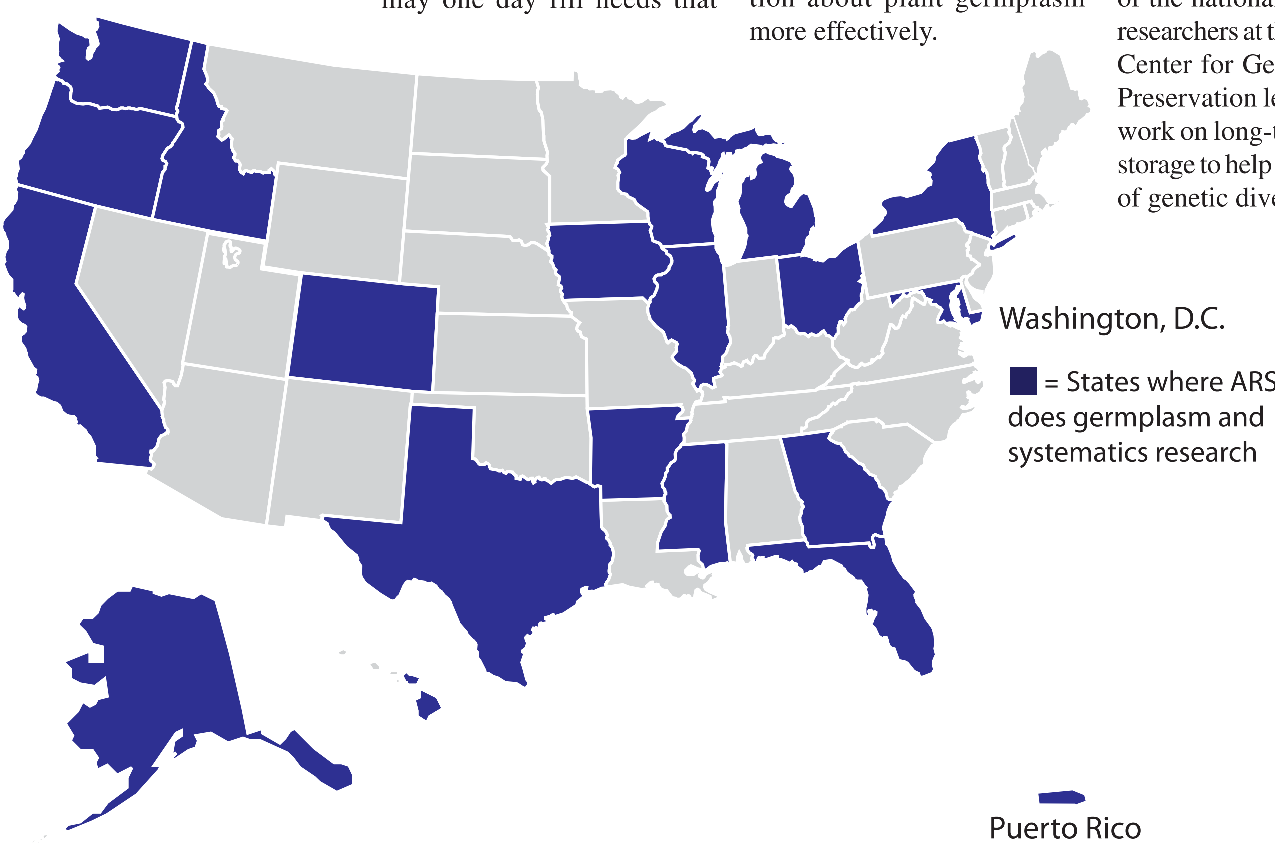
In addition, ARS is using its unique resources to mentor and train researchers and technicians around the world, which will help other countries expand their efforts to preserve and protect native germplasm.

The agency's Germplasm Resources Information Network (GRIN), currently an important source of information about ARS plant germplasm, is becoming the centerpiece of international cooperation for sharing information about plant germplasm through the GRIN-Global project. GRIN-Global will enable genebanks worldwide to manage information about plant germplasm more effectively.

Though ARS's animal germplasm collections are not as old or extensive as the plant and microbial collections, major efforts are being made to identify, preserve, characterize, and distribute animal germplasm. Research is focusing on developing ways to improve the viability of cryopreserved germplasm for some species.

Development of international databases for animal germplasm is also gaining momentum. Current livestock database-building efforts are being coordinated among ARS, Canadian, and Brazilian scientists to establish international standards and to share information.

Enhancing the security of ARS's long-term backup sites for germplasm collections is another important objective of the national programs. The researchers at the ARS National Center for Genetic Resources Preservation lead the agency's work on long-term germplasm storage to help ensure the future of genetic diversity. ✷



Preparing Peanuts for the Future

New Cultivars and Farming Strategies

Peanuts are an important crop, contributing more than $4 billion to the country's economy each year. But rapid growth in cities along with water level declines in aquifers throughout the South have resulted in fewer acres for farming and less water available for irrigation. To meet future food-supply demands, crop production will have to increase, but it must do so under the constraints of less water and, most likely, less farm land.

Agricultural Research Service scientists with the Plant Stress and Germplasm Development Research Unit in Lubbock, Texas, and the National Peanut Research Laboratory (NPRL) in Dawson, Georgia, are working with cooperators to help peanut farmers maintain and improve their production in a changing environment.

Managing Abiotic Stresses

At the Lubbock laboratory, plant physiologist Paxton Payton and postdoctoral research associate Rao Kottapalli are examining molecular mechanisms involved in peanut response to abiotic stress. Abiotic stress is the negative effect that nonliving factors, such as drought and heat, have on living organisms.

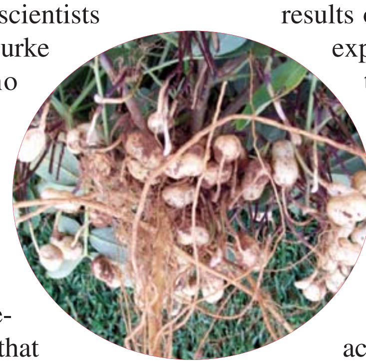
The researchers recently conducted groundbreaking work aimed at linking responses at the molecular level to the physiology and yields in peanut plants. They examined the proteins, particularly their expression, that control drought stress in peanut.

To examine diverse peanut germplasm more efficiently, Payton and Kottapalli performed greenhouse and molecular screening of 70 genotypes from the U.S. peanut mini-core collection and 7 additional cultivars representing varieties commonly grown in the southern United States and semiarid regions in Asia. The mini-core collection—developed by ARS plant breeder Corley Holbrook in Tifton, Georgia—consists of 112 peanut accessions that represent most of the variation present in the larger collection of peanut germplasm.

Field screening of the accessions was performed by New Mexico State University scientist Naveen Puppala and a team of Texas AgriLife Research and Texas Tech University scientists led by Mark Burow. Photosynthetic measurements of the field-grown plants by Payton and Kottapalli helped narrow down the group to two accessions that are highly tolerant to heat and drought and two that are highly susceptible.

This follows previous work by the AgriLife and Texas Tech scientists and ARS scientists John Burke and Gloria Burow, who demonstrated heat and drought tolerance in a smaller set of peanut germplasm. They are now examining the inheritance of abiotic stress tolerance and hope to develop molecular markers that can be useful in breeding.

PAXTON PAYTON (D1559-1)



PAXTON PAYTON (D1560-1)

"Identifying drought responses in the mini-core collection can help us determine potential genetic components involved in abiotic stress tolerance," says Payton. "Our study identifies potential targets for breeding and genetic engineering of abiotic stress tolerance in peanut crop plants."

Perhaps most importantly, the phenotypes Payton and Kottapalli identified in the screening process were confirmed by field trials under stress-inducing conditions. Puppala and Burow are using the results of this and other screening experiments to make crosses to improve abiotic stress tolerance in peanut.

Payton and the researchers are also testing peanut's response to other abiotic stresses. In recent tests, they found that the most heat-tolerant accessions were also the most drought tolerant. They also plan

Above: Drought-tolerant peanut yield from full irrigation (top) and deficit irrigation (bottom). Even with less water, drought-tolerant peanuts still yielded fairly well.

Below: Drought-sensitive peanut yield from full irrigation (left) and deficit irrigation (right). With less water, the sensitive peanuts yielded about 90 percent less.

PAXTON PAYTON (D1561-1)

PAXTON PAYTON (D1562-1)

to build on previous salt-stress work by AgriLife and Texas Tech scientists and conduct low-temperature screenings and tests in the coming year.

ARS physiologist John Burke and postdoctoral researcher Rao Kottapalli perform a chlorophyll fluorescence assay on peanut leaf samples from irrigated and drought-stressed plants. This assay is one of several that are used to screen germplasm for variability in abiotic stress tolerance. The monitor in the background shows an image of a peanut DNA microarray that is used to identify genes involved in stress response and to compare contrasting germplasm.

Developing New Farming Techniques

NPRL agronomist Wilson Faircloth and plant stress physiologist Diane Rowland (formerly with NPRL and now with Texas AgriLife Research) conducted field trials for 5 years in west Texas to determine the effects of deficit irrigation and, more recently, conservation tillage on peanut performance.

"Under deficit-irrigation management early in the season, plants appeared to reach maturity sooner than under late-season or other water deficits, and they maintained their yields," says Faircloth. "Exposure to induced early-season drought may acclimate the crop to the drought stress that commonly occurs during late-season growth."

It is also during this latter part of the growing season that growers typically experience water deficits due to reduced pumping capacity, further increasing the risk of yield loss.

"We wanted to find out whether conservation tillage with a cover crop could be used as an additional drought-mitigation tool," says Faircloth. "To do this, we did a field study to compare traditional, high-intensity tillage to conservation tillage with a rye cover crop."

To be sure the research would hold up under grower conditions, the scientists tested it in one half of a center-pivot irrigation system located in Lubbock, Texas. They subdivided it into six half-acre sections and applied varying amounts of water to peanut and cotton planted in either conservation or conventional tillage.

"We used varying amounts of water to simulate a range of conditions—from normal season-long irrigation to early-season drought to late-season drought," says Faircloth. Irrigation treatments were done in the traditional manner (meeting 100 percent of the water need) and to simulate early-season drought (50 percent of the full amount for the first 45 days after crop emergence) and late-season drought (50 percent of the full amount for the 45 days before harvest). Soil conditions and plant physiological responses were intensively monitored in the test areas. These included soil water content, plant photosynthetic rates, metabolic fitness, soil and canopy temperatures, rooting patterns, and tissue collections for genomic expression.

"Conservation tillage in the form of strip tillage was successfully demonstrated in this series of field tests, a first for peanut in this region," says Faircloth. Additionally, under deficit irrigation, strip tillage increased yield when compared to conventional tillage. "This yield increase was attributed to increased water-holding capacity of the soil and changes in peanut rooting patterns. The combination of conservation tillage and deficit irrigation promotes conservation of water during the early season, and if implemented over a large geographic area such as the Southern High Plains, it has potential to significantly affect late-season water issues by reducing the amount of water needed for peanut irrigation."

With more research, ARS will be able to help peanut farmers prepare for changes in the environment, which will help keep this delicious and nutritious legume available for generations to come.—By **Stephanie Yao** and **Sharon Durham,** ARS.

This research is part of Agricultural System Competitiveness and Sustainability (#216), Plant Biological and Molecular Processes (#302), and Quality and Utilization of Agricultural Products (#306), three ARS national programs described at www.nps.ars.usda.gov.

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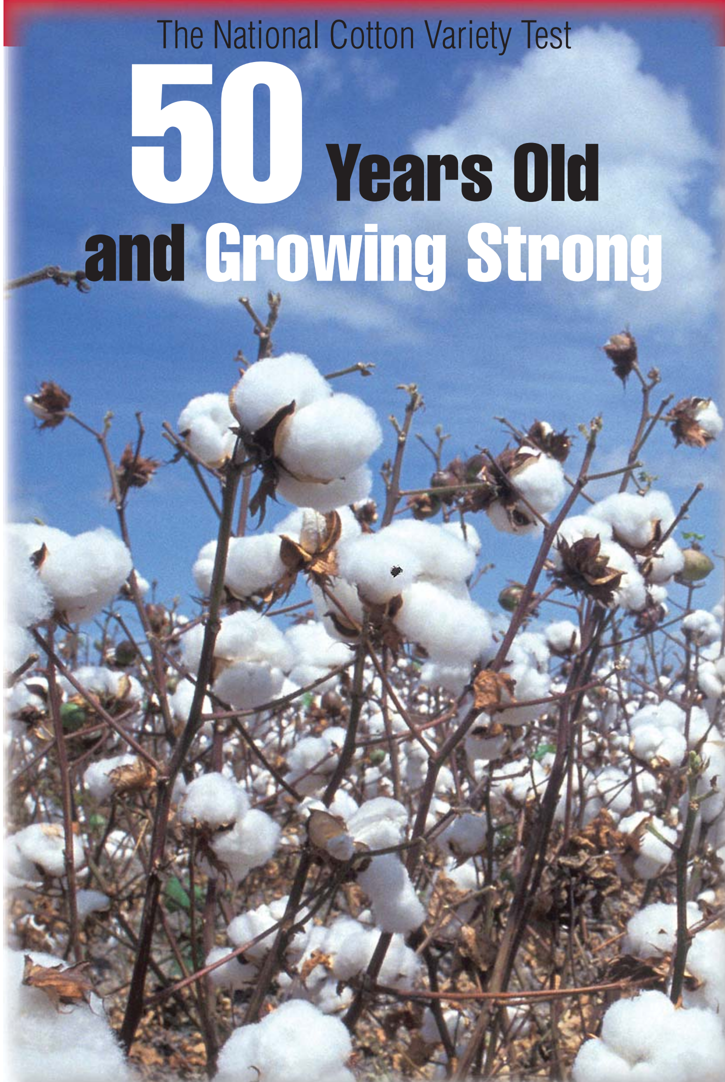
The National Cotton Variety Test

50 Years Old and Growing Strong



DAVID NANCE (K5927-22)

Quite a bit of science has gone into American cotton over the years. Take, for example, the Agricultural Research Service-led National Cotton Variety Test (NCVT). Celebrating its 50th anniversary this month, the NCVT was originally created in 1960 to standardize collection and analysis of field data necessary for objectively evaluating new upland and pima varieties.

To that end, the NCVT called for partitioning the U.S. Cotton Belt—which spans from Virginia south to Georgia and west to southern California—into six distinct growing regions, dubbed Eastern, Delta, Central, Blackland, Plains, and Western. A separate test was organized in 1961 for pima cotton species. This arrangement has allowed researchers to systematically test new, region-specific varieties and establish national standards in every test to serve as a link between regions. The four or five national standards are designated for 3-year cycles, and at the end of the cycle, two or three of these varieties will be replaced by new national standards.

ARS geneticist Charles F. Lewis was the principal organizer and motivator for the NCVT. The test was organized to encourage the sharing of exotic germplasm and breeding information. Its design also allows for appropriate statistical analysis and flexibility in the management of test locations.

To date, the NCVT program has tested more than 1,300 varieties, germplasms, and strains. In 1964, a special test called the "regional high quality" (RHQ) test was organized and extends across five of the six national regions. "Periodically, we compare the top cotton varieties of yesteryear with those of today to measure our breeding progress," says geneticist William R. Meredith, Jr., in ARS's Crop Genetics and Production Research Unit at Stoneville, Mississippi.

One of the greatest accomplishments coming out of the RHQ program was the release of variety DES 56. The parents of this variety were ARS germplasm PD 2-164 and the commercial variety Stoneville 213. DES 56 is the parent or grandparent of almost all varieties grown in the Eastern, Delta, and Central regions (encompassing South Carolina, North Carolina, Virginia, Alabama, Mississippi, Missouri, Louisiana, and Texas).

The data amassed by the program—which is analyzed by Meredith's and other labs and published annually in reports—documents notable cotton-production trends. The data also helps to determine the contributions of genetics, locations, years, and crop-management methods to fiber yield and quality.

As a result, new regions were established and others modified. A major change in variety testing occurred in the mid-1990s with the introduction of transgenic cottons that resist caterpillar feeding and tolerate glyphosate herbicides.

"Through breeding, many changes have taken place in the characteristics of cotton varieties. Seed and boll (cotton's fruit) have decreased, and the lint percentage and yield have increased," says Meredith. "Cotton today is grown in a much more eco-friendly manner than 50 years ago. Now, much less insecticide and herbicide are applied. You get a much better product and better quality cotton at a cheaper price."

ARS coordinates the program, and other key players include state experiment station personnel who conduct the tests, cotton growers and other industry members, trade groups like the National Cotton Council of America, and agricultural companies. Cooperation is especially critical as American cotton faces increasing competition from abroad, other cash crops, and the synthetic-fibers market.

As it has in the past, the NCVT will prove useful as both a chronicle of change and a guide with which to navigate it.—By **Jan Suszkiw,** ARS.

This research is part of Plant Genetic Resources, Genomics, and Genetic Improvement, an ARS national program (#301) described at www.nps.ars.usda.gov.

William R. Meredith is in the USDA-ARS Crop Genetics and Production Research Unit, 141 Experiment Station Rd, Stoneville, MS 38776; (662) 686-5322, bill.meredith@ars.usda.gov. ✷

Science Update

Know Your USDA Watersheds

Information collected over the past 40 years from large watersheds across the country is available online for the first time on a Web-based system called STEWARDS (Sustaining the Earth's Watersheds, Agricultural Research Data System). The site (http://129.186.109.10/stewards.1) allows users to download watershed data, view watershed topography, and see where monitoring instruments are located.

Users can also obtain information on pesticides, nitrogen, phosphorus, and other pollutants in streams, rivers, lakes, and drinking-water reservoirs. Data on daily stream discharge levels, air and soil temperature, and weather measurements is also posted.

STEWARDS was developed because Conservation Effects Assessment Project researchers, who study how private landowners benefit the environment when they participate in USDA conservation programs, wanted to make the watershed data available for nationwide analyses. STEWARDS data can be valuable for other hydrological analyses and to people living in these watersheds. *Jean Steiner, ARS Grazinglands Research Laboratory, El Reno, OK; (405) 262-5291, jean.steiner@ars.usda.gov.*

It Pays To Furrow Dike

Farmers who use furrow diking in their fields plow soils into ridge-like barriers that run alongside row crops. The ridges hold water and allow it to soak into the soil instead of washing away. Researchers compared the effects on runoff and erosion in southeast U.S. cotton fields with and without furrow diking. They found that furrow diking during a moderate drought saved farmers 1 inch of irrigation water per acre, reduced runoff by 28 percent, and curbed soil erosion.

The following year, when drought conditions were more severe, it saved 5 inches of irrigation water per acre. The scientists also compared crop yields, water needs, and the effects of different irrigation rates between tracts of furrow-diked cotton and traditionally tilled cotton. Results indicated that in 1 of 3 years, cotton yield and net return were higher with furrow diking over four irrigation regimes, including dryland. *Russell C. Nuti, National Peanut Research Laboratory, Dawson, GA 39842; (229) 995-7449, russell.nuti@ars.usda.gov. Clinton C. Truman, Southeast Watershed Research Unit, Tifton, GA 31793; (229) 386-7174, clint.truman@ars.usda.gov.*

Avian Bacterium More Dangerous Than Believed

Bordetella avium is a pathogenic bacterium that causes upper respiratory disease in poultry and wild birds. Until recently, *B. hinzii,* which is very similar to *B. avium,* was believed to be nonpathogenic in poultry. Scientists used highly specific, DNA-based tests to examine several *Bordetella* isolates, including some that had caused 100 percent morbidity in turkey poults. They found that the isolates were actually *B. hinzii,* even though the pathogens had initially been labeled as *B. avium*.

SCOTT BAUER (K7039-6)

In turkeys, the bacterium *Bordetella hinzii* was previously thought to be nonpathogenic, meaning it doesn't cause disease. But ARS scientists in Ames have shown that this pathogen can cause disease in turkeys.

The scientists then tested the bacterium's pathogenicity by trying to infect turkeys with six genetically distinct strains of *B. hinzii*. Four of the strains were able to grow and persist in the trachea and cause clinical disease, though none demonstrated 100 percent morbidity, and the severity of clinical signs of disease varied.

This is the first study to show that some strains of *B. hinzii* can cause disease in turkeys. *Karen B. Register and Robert A. Kunkle, National Animal Disease Center, Ames, IA 50010; (515) 337-7700 [Register], (515) 337-7190 [Kunkle], karen.register@ars.usda.gov, robert.kunkle@ars.usda.gov.*

Conservation Tillage and Cotton: The Bottom Line

From 2000 to 2004, scientists examined the economic returns for five different cotton tillage practices in the Mississippi Delta, including conventional tillage, no-till, low-till sub-soiling, no-till with a winter wheat cover crop, and low-till subsoiling with a winter wheat cover crop. The costs for each system were tracked, including all direct and fixed production expenses related to subsoiling, seed preparation, cover crop planting, and preplant herbicide application. Interest expense, labor, and the fixed costs of equipment ownership were also assessed.

Their results suggest that cotton farmers could realize the highest economic return by using no-till production. This system, which averaged a net return of $1,202 per hectare (2.471 acres), had the lowest production costs because fewer trips were needed across each field for tillage or cover crop plantings. The scientists also determined that a no-till cover crop management system had the highest mean net return of the two cover crop systems in the study. *James E. Hanks, Crop Production Systems Research Unit, Stoneville, MS 38776; (662) 686-5382, james.hanks@ars.usda.gov.*

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