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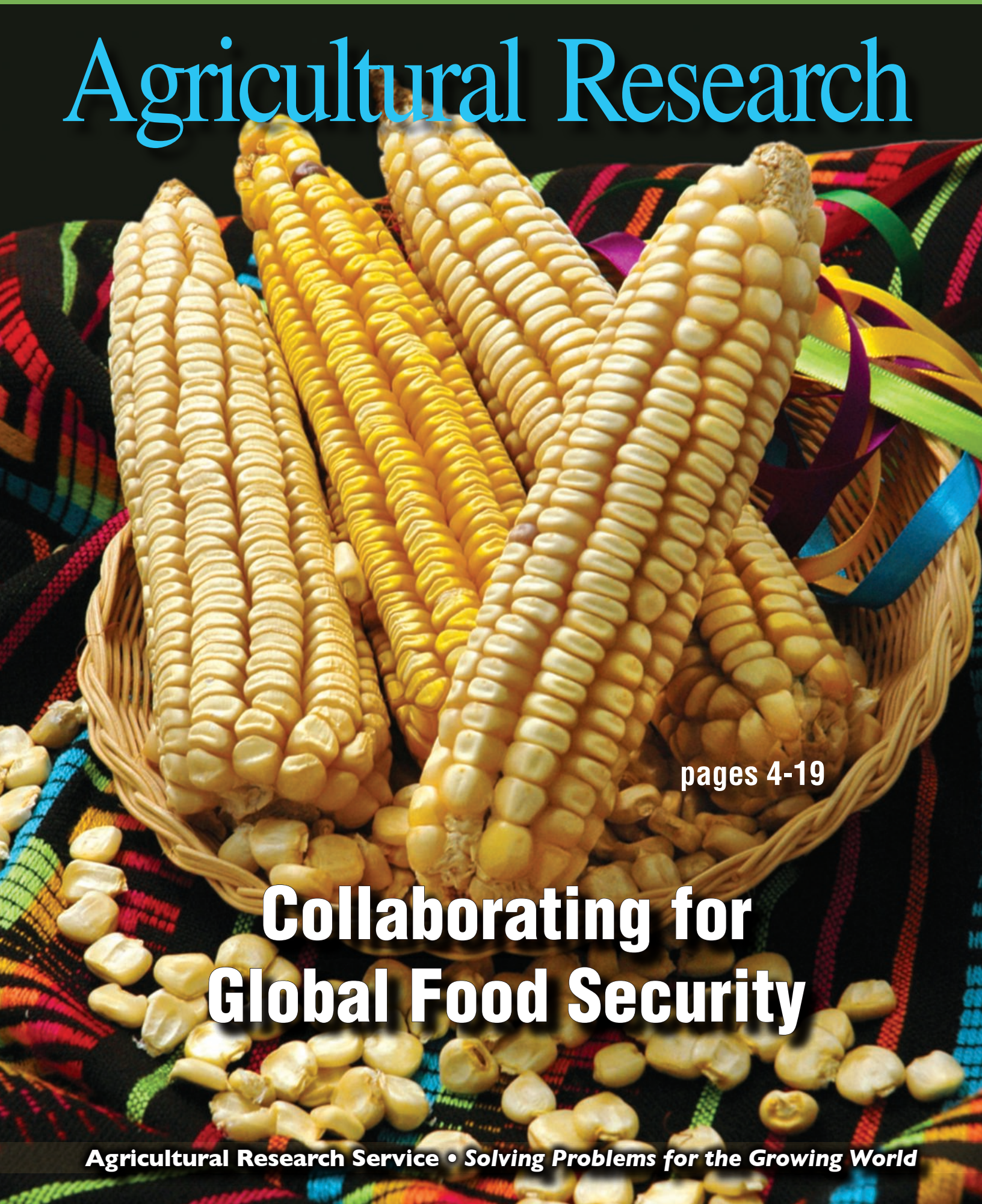

pages 4-19

Collaborating for Global Food Security

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

International Scientific Collaboration Is the Key

U.S. agriculture directly benefits from international collaboration in agricultural research through access to new ideas and technologies, global germplasm collections, and foreign research sites. Since its inception, the Agricultural Research Service has engaged in partnerships with countries that are scientifically advanced in agricultural research. Recognizing the importance of international cooperation in addressing domestic and international research priorities, ARS established the Office of International Research Programs (OIRP) in 1998.

By helping to solve worldwide agricultural problems, we can sometimes eliminate those problems or at least prevent them from spreading to other countries. International scientific collaboration is key both to ARS's primary mandate to protect and enhance U.S. agricultural production systems and to tackling global challenges, like food security and energy.

ARS's contribution to the worldwide effort to enhance agriculture starts with a sound germplasm system. Our germplasm collections are essential to preserving global biodiversity and improving agricultural productivity. Numerous ARS collections help protect the genetic base of crops, livestock, poultry, and aquatic species and provide essential genetic materials to support research and genetic improvement. The collections are available to researchers worldwide and are key to global food security.

Supporting global food security is among the top priorities of the U.S. Department of Agriculture, as the world population grows to 9 billion by 2050. ARS takes this challenge seriously by providing knowledge, technologies, and systems that improve and sustain agricultural productivity through international agricultural research cooperation and technology transfer. ARS's work is one component of the joint USDA and U.S. Agency for International Development Norman Borlaug Commemorative Research Initiative, which supports Feed the Future, the U.S. government's global hunger and food security initiative (www.feedthefuture.gov).

ARS partners with the research centers of the Consultative Group on International Agricultural Research, a network of 15 international agricultural research centers, and with national agricultural research institutions and other research organizations in many countries to help ensure that new technologies for production, livelihoods, and the environment are available for poor people and their communities. A sampling of these partnerships and the benefits of this research is found on pages 4 through 13.

As you'll read in these stories, the nature of agricultural problems is constantly evolving, and international scientific collaboration is essential to combat these challenges. Since 2005, for example, ARS has been working with several organizations that partner under the Borlaug Global Rust Initiative to find wheat that can resist the highly virulent wheat stem rust known as "Ug99." Wheat varieties around the world have essentially no resistance to the disease. A major goal, therefore, is to find wheat varieties that can resist Ug99 and get those varieties to growers—in the United States and elsewhere—before the disease arrives.

For animals, Rift Valley fever, foot-and-mouth disease (FMD), and East Coast fever are examples of diseases that require continued international alliances in order to deal with global threats to livestock, to food security, and possibly to human health. These diseases devastate livestock and could impact the livelihood of farmers in the United States and in developing nations. An example of such a global partnership that ARS has led is the Global Foot and Mouth Disease Research Alliance (GFRA). Through GFRA, ARS scientists are able to work with the international scientific community to acquire greater knowledge about FMD and develop novel tools to aid in the disease's control and eventual eradication.

In 1998, through a trust fund cooperative agreement managed by OIRP, ARS and the Brazilian agricultural research corporation named "EMBRAPA" established the LABEX program. LABEX allows ARS and Brazilian scientists to host each other's researchers for mutually beneficial efforts in areas from food safety to nanotechnology to bioenergy. The article beginning on page 14 provides a glimpse at some of the many success stories, past and present, in LABEX.

Our international efforts also include five permanent research laboratories—located in France, Greece, Australia, Argentina, and China—that have the principal mission of finding and evaluating new biological control agents. Once an invasive species has become a problem in the United States, these biological controls can help restore balance, often permanently, without the use of chemicals.

ARS-funded scientists in Pacora, Panama, perform research on rearing and distributing sterile screwworm flies. Sterile males released in eastern Panama—by the U.S.-Panamanian Commission for the Eradication and Prevention of Screwworms—keep Central and North America free of this pest that eats the living flesh of livestock, wildlife, and people.

Finally, our laboratory in Kerrville, Texas, works closely with Mexico, Brazil, and Australia to develop better methods to keep the United States free of the cattle fever tick. Eradication of this tick in America began in 1912 and was largely successful by 1943, saving the U.S. cattle industry billions of dollars.

Agriculture is a global enterprise. By maintaining effective and strategic international research partnerships, ARS will be better positioned to protect U.S. agriculture and keep it competitive. Through international research engagements, ARS is better able to combat animal and plant diseases and respond to global climate change threats.

Ibrahim Shaqir
Director of ARS's Office of International Research Programs
Beltsville, Maryland

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Solving Problems for the Growing World

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ALEJANDRO BALAGUER (K9020-20)

In all kinds of weather around the world, ARS scientists and collaborators collect germplasm to preserve the genetic diversity of our crops. These researchers are collecting potato germplasm in Lima, Peru, for national and international gene banks, which provide the backbone for international food security. Story begins on page 4.

Cover: Focusing on the biochemical pathway responsible for producing carotenoids in corn, ARS scientists have identified which corn genes increase the concentration of beta-carotene the most efficiently. The most promising of these genes came from tropical corn germplasm like the ones shown here. Details are on page 7. Photo by Marilyn Warburton. (D2300-1)

CONSUELO ESTEVEZ DE JENSEN (D2296-1)

ARS and CGIAR

Working To Provide International Food Security

At the Instituto de Investigacão Agronómica in Angola, Africa, ARS geneticist Timothy Porch (center) shows a group of technical staff and students how to hybridize common bean for improvement of resistance to common bacterial blight and angular leaf spot.

There is an old saying that it takes a village to raise a child. Well, it takes a planet to feed all of them. While each continent, country, and region faces unique agricultural challenges, it will take a committed global focus to meet those challenges. The Agricultural Research Service (ARS) and the Consultative Group on International Agricultural Research (CGIAR) collaborate again and again to do just that. CGIAR is a network of 15 international agricultural research centers, several of which are featured below.

Solutions for Serious Animal Diseases

Rift Valley fever, foot-and-mouth disease, and East Coast fever are some of the diseases that harm livestock and threaten the livelihood of farmers in developing nations like those of sub-Saharan Africa. The challenge of keeping these animals alive, healthy, and productive is one that's being addressed through worldwide partnerships. Scientists at ARS and CGIAR's International Livestock Research Institute (ILRI) in Nairobi, Kenya, are working together to help producers increase and sustain their livestock and farm productivity.

Laying the groundwork for an East Coast fever vaccine

Developing a vaccine that protects cattle against East Coast fever (ECF), a devastating disease in eastern and central Africa, is a team effort for scientists at ILRI and ARS's Animal Disease Research Unit (ADRU) in Pullman, Washington.

Researchers are in their fifth year of a collaborative project, "Combination Vaccines for Tick-Borne Diseases," which involves studying the tick, *Rhipicephalus appendiculatus,* that transmits *Theileria parva,* the parasite responsible for ECF.

"The focus of our work in the United States is Texas cattle fever, and in Kenya the focus is East Coast fever," says ARS entomologist Glen Scoles. "Because these parasites and the ticks that transmit them are so similar, proteins we identify in one system can also be studied in the other."

A vaccine for ECF could lead to a vaccine for Texas cattle fever, he says.

"It is important that the global community works together to control diseases that limit food and fiber production, and East Coast fever is one of those diseases," says ADRU's research leader Don Knowles. "Although we currently control most such diseases in the United States, what we learn from this collaboration will help prevent parasitic diseases here as well as in other countries."

Scoles, Knowles, and Massaro Ueti, an ADRU veterinary medical officer, teamed up with ILRI scientists to develop a polymerase chain reaction test that detects parasite DNA in ticks to quantify the level of infection. Two strains of nymphal ticks, developed at ILRI to have different *Theileria parva* susceptibilities, were allowed to feed simultaneously on infected calves and compared. The Muguga strain had a low level of parasitic infection, and the Kiambu strain was highly susceptible.

The next step will be to uncover the genetic basis for the difference between the strains and identify tick proteins that are produced in response to infection. These might be good targets for a vaccine that would help control both the parasite and the ticks that transmit them.

"A similar approach can be applied to the tick that transmits Texas cattle fever," Scoles says.

Preparing for Rift Valley fever vaccine trials

Scientists at the ARS Center for Grain and Animal Health Research (CGAHR) in Manhattan, Kansas, and international institutions in sub-Saharan Africa are developing and evaluating control strategies for diseases like Rift Valley fever (RVF), which is transmitted by mosquitoes to animals and humans.

A viral disease mainly in ruminant animals, RVF causes abortions in livestock, high mortality in young animals, and can be lethal in humans. Symptoms include fever, jaundice, and diarrhea.

CGAHR scientists at the Arthropod-Borne Animal Disease Research Unit and colleagues at Kenya Medical Research Institute (KEMRI) and Kenya Agriculture Research Institute (KARI) are teaming up with scientists at ILRI to help determine how to control RVF. At KEMRI, mosquito populations are being studied for potential RVF activity between outbreaks. At KARI, researchers are building infrastructure and developing tools to conduct large RVF vaccine trials and diagnostic evaluations.

"The next stage is to actually conduct vaccine studies using ILRI researchers' expertise in immunology," says CGAHR microbiologist William Wilson.

Testing new methods to track FMDV

A novel tool that tracks the adaptive immune response to vaccines for foot-and-mouth disease virus (FMDV) is being applied to cattle at ARS's Foreign Animal Disease Research Unit at Plum Island Animal Disease Center in Orient Point, New York, and at ILRI.

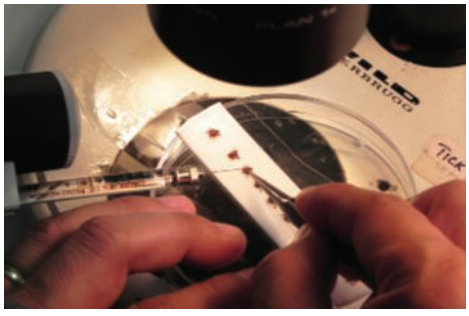
Foot-and-mouth disease is an acute, highly contagious infection that threatens the health and economic value of livestock worldwide. Though the disease hasn't been seen in the United States since the 1920s, recent outbreaks have been reported in Japan, Bulgaria, and South Korea.

The new technology, based on major histocompatibility complex (MHC) tetramers, was first developed in mice and humans and has only recently been applied to livestock, says ARS microbiologist William Golde. For the first time, scientists can follow more complicated T cell immune responses in addition to B cells.

"Antigens for virus-specific T cells are actually very small peptides of viral proteins that are present in the MHC molecules, which are the tissue molecules," Golde says. "The technology is based on typing cattle, just like you type a human for an organ transplant

GLEN SCOLES (D2297-2)

Left: Cattle at the International Livestock Research Institute (ILRI) in Nairobi, Kenya. ARS and ILRI scientists are working to develop a cattle vaccine to prevent transmission of East Coast fever (ECF), a tickborne disease. Below: At ILRI, *Rhipicephalus appendiculatus* ticks are injected in a test designed to reveal more about the tick's genes involved in infection and transmission of ECF.



GLEN SCOLES (D2298-1)

and know exactly which molecules you're working with. The combination of MHC protein and viral peptide are made into tetramers that can then identify the responding T cell."

The goal is to demonstrate that MHC tetramers can be applied to vaccine development in cattle and create tools for working with livestock diseases, says Golde, who has used the technique in pigs. In those experiments, pigs were vaccinated either with a vaccine targeting T cells or another targeting B cells and then compared. Results showed that by redesigning vaccines to target T cells, a different kind of immune response to FMDV could be induced.

Golde is working with ILRI researchers to apply these tools to other important cattle diseases in Africa, like East Coast fever. Further, he is working to import cells producing monoclonal antibodies specific for bovine proteins used for analyzing the immune response in cattle. These were prepared at ILRI.

"These reagents will be imported, tested for safety, and used in further research at Plum Island to study the response to FMD," Golde says. "Once safety tested, they will then become available to the North American research community."

Mapping the genome of sheep for parasite resistance

Identifying genes in sheep, goats, and cattle that increase tolerance to gastrointestinal (GI) parasites and improve production of grazing animals is another collaborative effort of ARS and ILRI scientists.

These parasites cause economic and production losses. Infected sheep suffer from diarrhea, weight loss, and anemia, and some die.

The team is the first to detect quantitative trait loci (QTLs) in a double-backcross population derived from native sheep adapted to the extreme conditions of East Africa.

Researchers started a breeding program at ILRI more than 10 years ago to create a resource population for mapping regions of the ovine genome that control resistance to GI nematode parasites predominant to African regions. Breeding started with creating hybrid rams by mating a GI parasite-tolerant breed—Red Maasai—to a more susceptible breed—Dorper. Six of the hybrid ram offspring were then bred to either Red Maasai or Dorper ewes to complete the backcross.

"We genotyped 20 percent of the progeny of those matings to map QTLs affecting parasite resistance traits," says Tad Sonstegard, an ARS geneticist at the Henry A. Wallace Beltsville [Maryland] Agricultural Research Center. "Some of the sheep were 75 percent Red Maasai, and some were 75 percent Dorper."

Parasite indicators—blood packed-cell volume and fecal egg count—were collected on a weekly basis for 3 months from 1,064 lambs grazing on GI-nematode-infected pastures. Average packed-cell volume, which indicates whether sheep are anemic from blood-feeding parasites, and average fecal egg count, which indicates worm load and fecundity, were used to select lambs for genotyping.

Significant QTLs for average fecal egg count and packed-cell volume were detected on chromosomes 3, 6, 14, and 22.

In a follow-up study, scientists plan to genotype the same animals again using the OvineSNP50, which interrogates more than 50,000 locations in the genome, says Sonstegard. The previous study looked at only 200 locations.

"If we can identify some of the genes that increase tolerance to parasites or figure out the best combination of Dorper and Red Maasai from a genome-composition view, we can increase production, and maintain that adaptability to parasites," Sonstegard says. "This ultimately leads to better germplasm, which leads to better global food security."

Genetics Provide the Base for Crop Production

Crops such as potatoes, corn, wheat, rice, beans, and more are the staples that feed the world. For developing nations, they are often critical for survival. The task of providing varieties of these crops that can sustainably supply the needed nutrients is a high priority for agricultural research. Several of the CGIAR centers focus on these crops and others.

Partnerships for potatoes

In developing countries, the potato is a vital source of nutrients for humans. Pinpointing a potato species' true origin can help scientists find genes needed to improve potato production.

Botanist David Spooner (right) and Alberto Salas, plant genetic resources specialist with the International Potato Center, Lima, Peru, collect potato germplasm in Peru for deposition in national and international gene banks.

ALEJANDRO BALAGUER (K9020-20)

ARS researchers and their counterparts at the International Potato Center (CIP) in Lima, Peru, are combining geographic information with computer-based tools to analyze distribution data of wild potato species, which are native to the Americas.

Until recently, wild potatoes were not known to spread outside of their native range, which is from the southwestern United States to central Chile and adjacent countries.

Botanist David Spooner at ARS's Vegetable Crops Research Unit in Madison, Wisconsin, and his CIP colleagues found that the wild potato species *Solanum chacoense* has become established in seven nonnative sites around the world, including parts of China, England, Peru, Argentina, the United States, and New Zealand. They also found that a cultivated potato, *S. tuberosum,* is now established in the wild in Hawaii and Africa.

"A technique called 'environmental modeling' was used to show other places where *S. chacoense* might spread," Spooner says. "The technology enables us to look at relationships between taxonomy and diversity and at locations and habitats where most species are found."

Boosting beta-carotene in corn

Corn and wheat are eaten in some form or another by just about everyone on the planet. Scientists affiliated with the International Maize and Wheat Improvement Center (CIMMYT) near Mexico City, Mexico, are focused on increasing the productivity of maize and wheat production systems to ensure global food security and reduce poverty.

In many developing areas of the world, corn is a staple food. In areas where most daily calories consumed come from corn, people can suffer blindness and other serious health issues because of a lack of vitamin A.

Cultivated corn does contain some carotenoids, like beta-carotene, which are converted to vitamin A in the body. Raising the concentration of beta-carotene in corn would help fight vitamin A deficiency in those areas where other sources of carotenoids in the diet are severely limited.

ARS plant geneticists Ed Buckler of the Plant, Soil, and Nutrition Research Unit in Ithaca, New York, and Marilyn Warburton of the Corn Host Plant Resistance Research Unit in Mississippi State, Mississippi, have worked to identify the genes that different corn varieties use to make beta-carotene.

Warburton and Buckler analyzed many of the high beta-carotene corn lines in the CIMMYT genebank and from CIMMYT and U.S. maize breeders. Focusing on the biochemical pathway responsible for producing carotenoids in corn, they have identified which genes would increase the concentration of beta-carotene most efficiently. The most promising type of one of these genes came from tropical corn germplasm, while the best form of another gene in the same pathway came from temperate corn. "By knowing which temperate U.S. corn variety to cross with which tropical corn variety, we could create a variety that provided much higher beta-carotene levels than would have been identified using traditional plant-breeding methods," says Warburton. (See "Boosting Vitamin A Levels in Corn To Fight Hunger," *Agricultural Research,* May/June 2010.)

Improving yield and drought resistance

Buckler has also been working on finding genetic markers for accelerating yield improvement and drought resistance. "We have a National Science Foundation/Gates Foundation funded project with the CGIAR centers to reduce the cost of genotyping and make finding the markers less expensive than growing out the varieties in field trials," says Buckler. "We are making good progress on that."

"We are about to start genotyping all the important breeding lines of corn and

STEPHEN AUSMUS (D1905-6)

At the Corn Host Plant Resistance Research Unit, in Stoneville, Mississippi, molecular geneticist Marilyn Warburton and technician Jack Hayes use gel electrophoresis and fluorescent plate readers to identify plants with markers associated with traits of interest, which will allow the most efficient selection of corn plants with the beneficial traits.

Kenyan lines of sorghum show improved growth and yield on field plots with acidic soils outside Moi University in Kenya.

SAM GUDU, MOI UNIVERSITY (D1273-1)

sorghum found throughout sub-Saharan Africa over the next few months," says Buckler. "The genotyping data will be posted on public websites, including the CGIAR public website. But the real value is for breeders to take their data on yield and performance in various environments and find out if they can apply the genotyping data to make useful outcome predictions."

Making this process faster and less expensive is important. "Imagine if every time you want to know whether or not a corn variety meets your needs, you must grow it and measure it in 10 environments. This can cost hundreds of dollars. For $10 or $20, we can genotype that line and predict whether it will serve the breeder's needs," says Buckler. This can help narrow the field of potential candidate corn varieties. "Of the thousands of potential corn lines, we can focus on the 10 percent that are likely to be the best. This saves everyone effort and time," says Buckler.

"We are also involved with CIMMYT in the survey of all the corn varieties called 'landraces'—traditional or heirloom varieties that farmers grew before modern breeding techniques were applied. These landraces have been adapted to grow in specific locations all over North and South America. For the first time, we will analyze them systematically to try to start mining out the genetic variation by genotyping them," says Buckler.

Sharing rice germplasm to help feed the world

Rice is a staple in many diets across the globe, and ARS scientists have forged collaborations with their international counterparts to help enhance rice production. That, of course, means navigating various challenges growers face, such as diseases. ARS scientists at the Dale Bumpers National Rice Research Center (DB-NRRC) in Stuttgart, Arkansas, collaborate with scientists at the International Rice Research Institute (IRRI) to evaluate rice germplasm and improve disease resistance, yield, and grain quality. IRRI is headquartered in the Philippines.

It helps to know what different rice varieties have to offer for breeders in particular geographical regions. Rice genetic resources are stored in large germplasm banks around the world, such as the Svalbard Global Seed Vault in Norway, and those in the United States and the Philippines. Germplasm is also stored and studied in smaller collections at various research locations. ARS plant geneticist Georgia Eizenga has been exploring the genetics of rice varieties housed in the IRRI germplasm bank. "IRRI has more than 112,000 rice accessions, making it the largest collection in the world," says Eizenga. By comparison, the United States has nearly 19,000 rice accessions and supplied 400 of these to develop a "rice diversity panel." The diversity panel is a set of rice varieties that that have been collected from various stages in history and from different countries. Some are wild rice types that have been collected in different environments, and others are varieties recently developed by breeders.

"We grow the diversity panel and develop genetic markers to find out which genes are responsible for particular traits," explains Eizenga. "The first complete rice genome sequence was for a Japanese cultivar, Nipponbare, which serves as the reference genome." By comparing different rice varieties against the Nipponbare sequence, researchers can determine which markers are associated with specific traits, like flowering time, seed size, leaf length, and even how sticky the grains are after cooking. These visible traits are called "phenotypic traits." Phenotypic data, along with genetic markers, can provide information about which genes govern certain traits. This enables researchers to more efficiently conduct genetic research into important agronomic traits such as disease resistance, yield, and quality.

Examining rice genes at the molecular level

ARS plant pathologist Yulin Jia, also at DB-NRRC, researches the molecular relationship between rice and the fungi responsible for the diseases rice blast and sheath blight. "I visited IRRI a few years ago and was able to bring back more than 100 lines that contained different genes that confer resistance to the

In a field of rice in Columbia, plant molecular pathologist Yulin Jia looks for typical eye-shaped lesions of rice blast disease. The inset shows a lesion on the U.S. rice cultivar Katy inoculated with *Magnaporthe grisea*.

YULIN JIA (D542-1)

FERNANDO CORREA (D542-2)

blast fungus," says Jia. "Similarly, IRRI scientists have imported rice germplasm from the ARS collection for their research. Some of this germplasm has shown some resistance to sheath blight strains that occur in their environment."

Genes are constantly changing in order to survive, and over the years the genes in rice and fungi have co-evolved. "Resistance is relative to the specific pathogens. For instance, not all humans are immune to flu viruses, because new strains of flu emerge constantly. That is also true for fungal strains and the rice varieties they infect," explains Jia. "So as time goes by, the old resistance genes may not work against the new fungal strains."

The work has certainly paid off. "We characterized the molecular mechanisms of rice blast resistance—how it works and how resistance genes evolved. We have also mapped two major blast-resistance genes from a rice cultivar from China," says Jia.

New rice varieties

Rice quality is also an area of interest to breeders, growers, and researchers. ARS scientists in Arkansas and Texas, in collaboration with researchers at Texas A&M University, University of Arkansas, Clemson University, and IRRI, developed new varieties that offer new options for U.S. growers and expanded market opportunities for the U.S. rice industry.

Although conventional long-grain varieties are grown on more than 75 percent of the rice acreage in the United States, there is interest in developing cultivars that possess specific qualities required for certain value-added markets.

The variety JES is an aromatic, soft-cooking, long-grain rice suited for the market predominantly filled by imports. A jasmine-style rice, JES has greater yield, is 5 inches shorter, and matures a week earlier than Jasmine 85, a variety currently grown for this market.

Charleston Gold, another aromatic rice, was derived from Carolina Gold (an heirloom variety that was the basis for establishing the U.S. rice industry) and genetic material from the Philippines and India. It has excellent yield, disease resistance, and cooking quality. This cultivar may lend itself well to production under organic conditions and will be used by the historically authentic cuisine market in the Carolinas.

Breeding for disease-resistant chickpeas and lentils

Scientists at ARS's Grain Legume Genetics and Physiology Research Unit in Pullman, Washington, and the International Center for Agricultural Research in Dry Areas (ICARDA) in Aleppo, Syria, are exchanging breeding lines of germplasm to develop disease resistance and other agronomic characteristics.

"We're incorporating a lentil collection from ICARDA into our breeding program as a source of winter hardiness—cold tolerance—and virus resistance," says George Vandemark, ARS geneticist and research leader at Pullman. In turn, ARS is providing ICARDA with a special chickpea population.

"We developed a population of mutated chickpea lines, and they're really valuable genetic material," Vandemark says. "We don't have the resources to propagate the population, so our partners at ICARDA are going to increase it for us. They'll grow, harvest, clean, and store them."

Researchers at Pullman also work with colleagues at the International Crops Research Institute for the Semi-Arid Tropics in Patancheru, India, on studies that involve testing pest-resistant chickpeas. (See "Help for the Common Bean: Genetic Solutions for Legume Problems," *Agricultural Research,* May/June 2010.)

STEVE CLEMENT (D1787-1)

Entomologist Hari Sharma, of the International Crops Research Institute for the Semi-Arid Tropics, and a colleague in a chickpea research plot at the Regional Research Station, Kukumseri, in the Himalayan foothills of northern India.

Other work includes cooperative research with ICARDA that focuses on inheritance and mapping of lentil genes for resistance to rust and *Stemphylium* blight, two important diseases of lentil in Southeast Asia, says Weidong Chen, ARS plant pathologist at Pullman.

"We are trying to find DNA markers linked to genes for resistance to the diseases," Chen says. "We don't have lentil rust in the United States, but *Stemphylium* blight has been seen in North Dakota, other Northern Plains states, and adjacent Canada. So we have developed the tools to identify some of the candidate DNA markers for resistance."

Stem lesions on chickpea caused by the fungus *Ascochyta rabiei.*

GEORGE VANDEMARK (D2302-1)

PEGGY GREB (D509-1)

ARS plant pathologist Marcial Pastor-Corrales inoculates bean plants with spores of the bean rust fungus.

Finding genes to help bean growers

The International Center for Tropical Agriculture (CIAT) is headquartered in Cali, Colombia, and focuses on developing eco-friendly methods of producing crops. Plant pathologist Marcial Pastor-Corrales of the Soybean Genomics and Improvement Research Unit in Beltsville, Maryland, worked at CIAT for 17 years before coming to ARS and maintains close collaborative relationships with his former colleagues. Pastor-Corrales is working on improving common bean production, with an emphasis on discovering and incorporating genes for resistance to diseases, particularly common bean and soybean rusts. Common bean rust is a major constraint to bean production in most countries where dry and snap beans are produced, especially in eastern and southern Africa and Latin America.

"The CIAT Bean Germplasm Bank has the largest and most diverse common bean collection in the world, with some 36,000 accessions," says Pastor-Corrales. This diversity may be just what is needed to help with pathogens that are moving around the globe. "The common bean rust is a highly variable pathogen that is important worldwide. The various races of this pathogen change from one year to another, so we are always looking for new rust-resistant genes for common bean," he says.

In 2007, two new races of the common bean rust pathogen appeared in the United States, and many dry bean cultivars were susceptible to them. "We have found many new genes for resistance to several diseases, including common bean rust, from CIAT accessions. These are potentially very valuable," says Pastor-Corrales. "These collaborations can result in preventing problems in the United States and enhancing production and making it safer and more sustainable in other countries."

In the 2008-2009 growing season, the U.S. farm value of soybean production was $29.6 billion. A potential threat to this crop is the soybean rust pathogen, which arrived here in 2004. "Working with scientists from the USDA-ARS Foreign Disease-Weed Science Research Unit, we tested germplasm obtained from CIAT and found that some common dry beans were resistant to soybean rust," says Pastor-Corrales. "Because the soybean rust pathogen also infects common beans and other legumes, 16 lines of common dry beans were tested with 6 isolates of the soybean rust pathogen from Asia, Africa, and Latin America. We found 5 dry bean cultivars that were highly resistant to soybean rust. Wild accessions have more genetic diversity, so we would like to discover more resistance genes that can confer soybean rust resistance from these wild varieties to common beans and soybeans."

Meanwhile, in Puerto Rico, ARS plant geneticist Timothy Porch of the Tropical Agriculture Research Station in Mayagüez is working with CIAT scientist Rowand Chirwa and with scientists at the University of Puerto Rico and the Ministry of Agriculture in Angola on developing resistance to prevalent diseases in common bean for Angola. "The work began in 2007 and focuses on developing lines, for future cultivar release, with resistance to angular leaf spot, bean common mosaic virus, and common bacterial blight. There is a graduate student from Angola at the University of Puerto Rico performing this work on disease resistance in common bean and another graduate student studying cowpea diversity," explains Porch.

"We are using CIAT germplasm to develop and release lines with root rot

Soybean leaves infected with soybean rust.

CHRISTINE STONE (D521-1)

resistance and heat and drought tolerance that will be used to improve U.S. varieties of common bean," says Porch. "We are working on introducing novel traits and on converting tropical varieties to types that can be grown in the temperate U.S. region. This would require introducing photoperiod insensitivity to photoperiod-sensitive tropical type beans." That way, beans previously adapted to the 12-hour day-length of the Tropics will also be productive in the longer 16- to 18-hour photoperiods in the United States.

Collecting lentils from Nepal

Lentils are an important export crop for the United States and important food for the people of many nations. Geneticist Clarice Coyne of the ARS Plant Germplasm Introduction and Testing Research Unit in Pullman, Washington, manages lentil germplasm at the unit, which is also known as the Western Regional Plant Introduction Station (WRPIS). There are 3,247 lentil accessions at Pullman, but only 13 accessions are of lentil from Nepal.

In association with Ashutosh Sarker, a senior scientist with ICARDA, Coyne has developed a joint proposal to boost the number of lentil accessions in the WRPIS collection. An exploration trip is in the planning stages to collect lentil accessions from Nepal.

"We have an interest in lentil production in Nepal because they grow lentils at a high elevation. This means they will grow at a lower temperature than other lentils," says Coyne. "These plants may be adapted to colder temperatures, which would be helpful to lentil growers in the U.S. Pacific Northwest." Lentils could be grown as a fall-sown crop in Washington State. That would also help with soil erosion, which is a problem during the winter months.

It is important to collaborate with ICARDA because they have the expertise necessary to conduct a successful exploration trip in Nepal. "Their experts know where to find the lentils and they know their growing habits," says Coyne. "Also, a portion of the proposed funding would go to Nepal in order to develop their national germplasm collection."

Thwarting diseases of cacao

Cacao is the source of chocolate. Unfortunately, cacao is under attack by diseases like witches' broom, frosty pod, and black pod. ARS geneticist Raymond Schnell at the Subtropical Horticultural Research Station in Miami, Florida, is working with an international consortium to document genes and genetic markers that might lend resistance to these and, potentially, other diseases of cacao.

Working with the International Institute of Tropical Agriculture, Schnell and other international collaborators have developed 6,000 single nucleotide polymorphism (SNP) genetic markers, which are being used for marker-assisted breeding (MAB). The goal of MAB is to find SNPs or microsatellite markers associated with resistance to these diseases. Markers associated with resistance are then used to select for new cacao varieties with resistance. Using these markers greatly increases the efficiency of traditional breeding. Cacao cultivars that are resistant to these diseases will ensure that there will be a plentiful supply of cocoa beans for the confection industry.

PEGGY GREB (K9538-1)

Geneticist Raymond Schnell examines a cacao pod.

SCOTT BAUER (K8618-1)

Pathogenic fungi that cause witches' broom on cacao tree limbs and trunks also attack pods, destroying the valuable beans inside.

YUE JIN (D1797-1)

Ug99-infected wheat at a nursery in Njoro, Kenya.

In the breeding effort, Schnell and his collaborators have field trials under way in West Africa in Ghana, Cameroon, Nigeria, and Cote d'Ivoire. Field trials are also located in Ecuador, Brazil, Costa Rica, and Papua New Guinea.

The battle against Ug99 continues

The fight against a menacing strain of wheat stem rust—Ug99—is gaining momentum. The U.S. Agency for International Development is providing Feed the Future resources through the Norman Borlaug Commemorative Research Initiative for ARS to build a greenhouse at the Cereal Disease Laboratory (CDL) in St. Paul, Minnesota, as part of a collaborative effort to develop rust-resistant varieties. A groundbreaking ceremony was held in June 2011.

The greenhouse will greatly increase CDL scientists' ability to identify foreign wheat rust isolates from CGIAR centers, says CDL research leader Marty Carson. Research on Ug99 will be conducted under contained and authorized conditions.

Ug99 was discovered in Uganda more than a decade ago and has quickly spread throughout East Africa, Asia, and the Middle East. (See "International Wheat and Barley Screening Collaboration Helps Uncover Stem Rust-Resistant Material," *Agricultural Research,* February 2010.)

The disease now threatens food security in Pakistan and Afghanistan. ARS scientists will use the new greenhouse facility to help identify and verify unknown rust isolates and develop adapted rust-resistant varieties for Pakistan, which can also be used in Afghanistan, in partnership with CGIAR centers.

Other research on rust protection for wheat continues at ARS labs in Raleigh, North Carolina, and Pullman, Washington. (See "ARS Wheat Resistance Roundup," *Agricultural Research,* May/June 2010.)

"We need combinations of genes and more durable genes to protect wheat for years to come from these rusts," says Kay Simmons, deputy administrator of ARS's crop production and protection national programs. "That's why collaborative work between ARS wheat pathologists and geneticists with CGIAR centers is so important."

Field trials in Kenya to screen for resistance are vital to this work, according to plant pathologist Mike Bonman of the Small Grains and Potato Germplasm Research Unit in Aberdeen, Idaho.

Bonman worked at IRRI for 9 years before coming to ARS and is now working collaboratively with CIMMYT and KARI. Bonman and colleagues have screened more than 3,000 wheat landraces from the U.S. National Small Grains Collection against new races of the stem rust pathogen in the field in Kenya. A number of resistant accessions were identified and are being retested to verify their resistance. Landraces with confirmed resistance are being crossed with susceptible wheat to determine the genetic basis of the resistance.

"CIMMYT facilitates the nursery and site logistics, and ARS helps with evaluating the level of rust development in wheat varieties," says Bonman. "Without CIMMYT it would be difficult, and my team works closely with Sridhar Bhavani, the CIMMYT coordinator in Kenya, and with wheat breeder Peter Njau and plant pathologist Ruth Waynera, both from KARI."

"CIMMYT and KARI personnel have developed excellent procedures to promote rust disease in the nursery to enable us to evaluate which of our accessions are resistant to rust, but a lot depends on timing," says Bonman. "Knowing exactly when to evaluate, or rate, the disease is very important because different plant materials mature at different times, and landrace materials from the U.S. collection often mature late. A postdoctoral fellow in our lab, Maria Newcomb, was recently in Kenya to rate the off-season nursery, and we depended on Sridhar, Peter, and

PEGGY GREB (D948-1)

Plant pathologist Mike Bonman (left) and molecular biologist Eric Jackson examine wheat plants from the National Small Grains Collection in a stem rust screening plot at Aberdeen, Idaho.

Ruth to help us pinpoint the optimum time for her arrival.

"Our goal is to find new genes for resistance to Ug99, because the fungus overcomes many of the resistance genes we have been using for the past 50 years. This work will help Africa's growers now and will help suppress disease and reduce damage in developing countries. It will also prepare the United States for Ug99 should it reach our shores. This research is of great mutual benefit, and I am grateful for the outstanding assistance we receive from CIMMYT and KARI."

All of these research collaborations will help bolster food security across the globe. ARS and CGIAR will continue these endeavors for years to come.—By **Sharon Durham** and **Sandra Avant,** ARS.

This research supports the USDA priority of promoting international food security and is part of multiple ARS national programs, described at www.nps.ars.usda.gov.

To reach scientists mentioned in this article, contact Sharon Durham, USDA-ARS Information Staff, 5601 Sunnyside Ave., Beltsville, MD 20705-5129; (301) 504-1611, sharon.durham@ars.usda.gov. ✻

KEITH WELLER (K6027-9)

GRIN-Global Brings Powerful Genebank Information System to Forefront

A better system to keep track of germplasm information will soon be available worldwide, thanks to a partnership between ARS, the Global Crop Diversity Trust, and Bioversity International (a CGIAR center). The Germplasm Resources Information Network (GRIN), an online database of plant genetic resources information developed by ARS, is going global.

KEITH WELLER (K6020-1)

GRIN-Global will replace GRIN, which is used by ARS's National Plant Germplasm System to actively manage information regarding plant genetic resources at various genebank sites. This Internet-based database system enables curators throughout the world to customize it to fit their specific needs and enables public researchers to access germplasm information and material.

"GRIN software helps curators keep track of the origins of the genetic materials they manage and their traits, properties, and inventory status—which seeds, plants, and tissues are available and how much," says Peter Cyr, information technology specialist and project leader at ARS's North Central Regional Plant Introduction Station in Ames, Iowa. "It also keeps track of who requests and receives seeds or plant material."

With GRIN-Global, other nations will have the option to access a free, easy-to-use system for documenting plant germplasm and delivering that information to researchers worldwide. Each genebank will have its own local version of the GRIN-Global software, including a customizable website that can support many languages.

The system is expected to be up and running in CGIAR centers and in several national genebank systems in 2011. It will be implemented in the United States by 2012. It will enable scientists, educators, and other germplasm users to be better informed and to choose precisely the samples that best meet their needs.—By **Sandra Avant,** ARS.

STEPHEN AUSMUS (K11611-2)

Beans (above), bok choy (middle), and carrots of many different colors (left) are just a sample of the variety of specimens in the Germplasm Resources Information Network (GRIN), which will soon be available to researchers worldwide as GRIN-Global.

"Labs Without Borders" Fosters New Opportunities

In Beltsville, Maryland, Ladislau Martin Neto (center), LABEX U.S. coordinator, and Antonio Carlos Freitas (right), another EMBRAPA researcher, evaluate greenhouse gas emissions with ARS soil scientist Michel Cavigelli, from the Sustainable Agricultural Systems Laboratory.

PEGGY GREB (D2303-1)

Thanks to the international exchange program LABEX-USA, Agricultural Research Service scientists in the Bioproduct Chemistry and Engineering Research Unit in Albany, California, have enjoyed a close working relationship with visiting Brazilian researchers. Since 2005, the partnership has given rise to around 25 published papers on advances in nanotechnology and biomaterials science, 2 patents, and new microfiber-spinning procedures for creating nonwoven polymer sheets with potential medical applications.

Launched in April 1998, LABEX is a trust-fund cooperative agreement between ARS and the Brazilian Agricultural Research Corporation (EMBRAPA), an agency of Brazil's Ministry of Agriculture, Livestock, and Food Supply, headquartered in Brasilia. The "virtual laboratory" program, as LABEX is also known, operates on the principle that agricultural issues of mutual interest to the United States and Brazil are best addressed by bringing multiple points of view to bear on a research question or problem, facilitating an open exchange of scientific expertise, and pooling available resources. In the process, the limitations of any single research organization or facility become less of an impediment to success.

As two of nine EMBRAPA researchers who've worked at Albany, for example, Luiz Mattoso and Eliton Medeiros played a key role in the success of the microfiber-spinning project. They coauthored a May 2009 *Journal of Applied Polymer Science* paper on the advance with Bill Orts, the ARS lab's research leader; Greg Glenn, a plant physiologist; and Artur Klamczynski, a food technologist.

"LABEX takes the traditional parameters off so we can figure out how best to solve problems. It goes beyond conducting parallel research programs; it's more conjoined," explains Eileen Herrera, deputy director of ARS's Office of International Research Programs (OIRP), in Beltsville, Maryland.

According to Ladislau Martin Neto, the LABEX program coordinator there, ARS has hosted 20 senior scientists from EMBRAPA since 1998 at multiple locations across the country, where they've been involved in diverse projects generally lasting 2 to 3 years. Recent examples include Cesar Miranda's studies determining total energy of perennial and tropical grasses at the ARS Grain, Forage, and Bioenergy Research Unit in Lincoln, Nebraska; Janice Ciacci-Zanella's contribution to research on H1N1 swine influenza and porcine reproductive and respiratory syndrome viruses at the ARS National Animal Disease Center in Ames, Iowa; Alfredo Alves's work on germplasm preservation of vegetative material using wild cassava as a model plant at the ARS National Center for Genetic Resources Preservation in Fort Collins, Colorado; Magda Benavides's research on unraveling host genetic resistance to gastrointestinal parasite infections at the ARS Bovine Functional Genomics Laboratory in Beltsville, Maryland; and Martin Neto's research on climate change mitigation and soil carbon sequestration at the ARS Sustainable Agricultural Systems Laboratory in Beltsville.

A Two-Way Street

Now, OIRP is encouraging ARS researchers to consider doing the same—that is, to travel to any one of EMBRAPA's 46 research centers (some of which are uniquely focused on specific crops or environmental conditions) to work on projects of mutual interest to the United States and Brazil for tours of duty well beyond the standard 1- to 2-week stints.

Indeed, Glenn, Orts, and ARS botanist De Wood are finalizing plans for 1- to 15-month-long assignments at EMBRAPA's Agricultural Instrumentation Center in São Carlos and other sites. "Greg's joint project with Luiz Mattoso will involve creating novel nanocomposites, biomaterials, and rubber-based biomaterials. De will learn new analytical techniques," says Orts. While the Albany lab undergoes a planned

PEDRO HERNANDES, EMBRAPA (D2306-1)

In Brazil, ARS plant physiologist Greg Glenn (right) and ARS botanist De Wood (center) inspect composite materials that contain plant fiber with Luiz Mattoso, director of the EMBRAPA Agricultural Instrumentation Center in São Carlos. One composite was used to make small tubes in which tree seedlings are grown and then planted in an automated process. The containers slowly degrade in the soil after planting.

renovation this year, Orts will travel to São Carlos to help organize an upcoming ARS-EMBRAPA workshop, cowrite new proposals to expand LABEX-USA, and finish several papers for publication with Brazilian coauthors.

World Centric, a Palo Alto, California, firm specializing in biodegradable single-use packaging, cups, utensils, and other items, is helping support Glenn's trip as part of an existing cooperative research and development agreement with the ARS lab.

Science Overseas

The Albany group is on the forefront of a broad realization by ARS scientists of the merits of conducting studies abroad for extended periods—excluding the multi-year tours required of those assigned to ARS's four main overseas biological control labs. These labs, which include a staff of foreign-service nationals, are in Montpellier, France; Beijing, China; Brisbane, Australia; and Buenos Aires, Argentina. ARS also has a screwworm facility in Panama City, Panama.

"The United States for many years has been the center of gravity for research," says Herrera. "That center of gravity has flattened out, and now researchers perceive they can get a lot of productivity from working overseas."

Ryan Moore, an OIRP international affairs specialist who works with Martin Neto on the LABEX program, agrees: "Traditionally, foreign scientists have come to the U.S. to conduct long-term research, not the reverse. But that attitude is changing among U.S. researchers."

Countering the threat posed by invasive species is one area where hopping a flight to Brazil or other countries for collaborative research could be especially fruitful. "Under a labs-without-borders program, scientists can go to places where problem organisms are endemic and do more effective research on them," says Herrera.

Collaborating with a host country's scientists increases the likelihood of success because of the expertise and familiarity they often possess on the target organism, its natural habitat, or its natural enemies. An example is joint research conducted by ARS scientists in Kerrville, Texas, and EMBRAPA in Campo Grande, Brazil, to develop novel vaccines against *Rhipicephalus (Boophilus) microplus* ticks. The team's members are Renato Andreotti of EMBRAPA and Felix Guerrero and Adalberto Pérez de León of ARS.

Other projects that could put ARS scientists on flights to Brazil—or to other locations where EMBRAPA also has overlapping research responsibilities—include research on animal waste management, citrus greening, orange rust of sugarcane, biological nitrogen fixation, bioenergy, animal genomics and health, water-resource management, and climate change research. All are pressing issues of relevance to the continued sustainability and productivity of not only America's agricultural system and economy, but also that of its partners.

"ARS's decision to expand and strengthen our cooperation by sending their researchers to Brazil will have a relevant impact towards obtaining new achievements of mutual interest," says Martin Neto, who is on a 2-year appointment at OIRP from EMBRAPA.

"Virtualization of the research is becoming easier to consider," adds Herrera. "It's an excellent opportunity for us, the United States, to really enhance our science."

ARS researchers interested in collaborating with EMBRAPA scientists abroad should contact Martin Neto or Moore at OIRP, using the contact information below.—By **Jan Suszkiw,** ARS.

Eileen Herrera, Ryan Moore, and Ladislau Martin Neto are with the USDA-ARS Office of International Research Programs, 5601 Sunnyside Ave., Beltsville, MD 20705-5141; (301) 504-4521 [Herrera], (301) 504-4535 [Moore], (301) 504-4556 [Martin-Neto], eileen.herrera@ars.usda.gov, ryan.moore@ars.usda.gov, ladislau.martin@ars.usda.gov.

ARS researchers from Kerrville, Texas, are concluding a bovine anti-tick vaccine test in Brazilian fields with EMBRAPA support. Shown here is a Nellore bull in Brazil.

LUIS GUSTAVO, EMBRAPA (D2309-1)

ARS in Africa

Building Trust and Fighting Poverty

The wide, open spaces of Montana might seem to have little in common with the remote villages of South Africa, but an Agricultural Research Service scientist at Miles City, Montana, has found colleagues in South Africa who share his interest in cattle breeding. Together they are working to fight poverty, reduce hunger, and improve beef production in the African nation and in the process, they may improve prospects for cattle breeders around the world.

Mike MacNeil, a geneticist at the USDA-ARS Fort Keogh Livestock and Range Research Laboratory in Miles City, has been developing fruitful relationships in South Africa since 2004 when the ARS Office of International Research Programs approached him with the idea of starting an overseas partnership. MacNeil soon began conversations with Michiel Scholtz, a scientific colleague and cattle researcher at the South African Agricultural Research Council (ARC), and the two set up an informal exchange program. Since then, MacNeil has published five papers and a book chapter with colleagues in South Africa, spoken at several scientific conferences, and forged partnerships that have led to several research collaborations.

These efforts have two goals. The first is to equip South Africa's scientists with the tools necessary to boost the economic prospects of breeders and farmers in remote and underdeveloped areas, where food security issues are paramount. The second goal is to conduct research that will lead to better cattle not only in South Africa, but also in the United States and around the world.

Much of the current research is focused on indigenous Nguni (pronounced en-GOO-nee) cattle, a breed popular among poor and emerging farmers in South Africa because of its fertility, tolerance to harsh conditions, resistance to ticks, and tolerance to tickborne diseases.

"The opportunity to lift emerging farmers out of poverty in South Africa lies with the Nguni. That's what they have in the rural areas, so that's what we are working with. It is very popular and locally adapted to the harsh South African environment, but has never been improved, intensively managed, or properly studied, and as a result, little is really known about it," MacNeil says.

One collaborative study led to a paper that documented a chronic problem in emerging areas: Nguni cattle that are too small and deposit too much fat before reaching market weight, making them undesirable to commercial feedlot operations. The paper, in the *South African Journal of Animal Science,* examined factors that breeders could consider in trying to improve progeny of their Nguni cows by mating them with larger and beefier Angus and Charolais bulls. The resulting crossbred animal ideally would retain the Nguni toughness and adaptability and take on the improved beef aspects of the Angus and Charolais sires. The research built on MacNeil's work over the years at Fort Keogh on development of crossbreeding systems and breeding objectives for U.S. domestic breeds.

Enhancing Beef Production

Olivia Mapholi, an ARC scientist who studied under MacNeil at Fort Keogh while she was earning her master's degree, continues to consult him about her research efforts. She is searching for quantitative trait loci (QTLs)—areas of the cattle genome—that confer the ability to tolerate tickborne diseases. Mapholi is crossing tick-resistant Nguni with tick-susceptible Angus and is looking for genes that confer resistance to ticks. Her research could benefit beef production in any part of the world where ticks are a problem, including the United States.

"If we can find these QTLs, that would be very big because it would not only help breeders in South Africa, but the information could also be used worldwide to reduce losses from ticks," Mapholi says. She has known MacNeil since 2006 and credits him with being instrumental in helping her develop the skills she needed to design the QTL project. "He's been an excellent mentor and partner, and I look forward to continue working with him," she says.

Norman Maiwashe, another ARC scientist who supervises Mapholi, is us-

MIKE MACNEIL (D2305-1)

Lehotlo Ephraim Matjuda, senior manager of Animal Breeding and Improvement for the Agricultural Research Council's Animal Improvement Institute, with cattle from his farm in Limpopo Province, South Africa. These cattle have body types and color patterns typical of the Nguni breed.

ing MacNeil's expertise to study cattle-breeding objectives for small farmers in remote African areas. His philosophy is best summarized in the adage that if you give a man a fish, it feeds him for a day, but if you teach him to fish, he can feed himself for life. "We're trying to build the sort of intellectual capacity for cattle breeding in South Africa that allows scientists to do research that carries the people far into the future," he says.

Maiwashe also credits MacNeil with making him a better teacher and scientist. "As a relatively young scientist, I think I learned a lot from him—subtle things that you might not learn in school. When you work with students, you have to be patient, and he taught me the importance of having patience," says Maiwashe, 37, who earned his doctorate at Colorado State University.

Genetic Diversity of Nguni

Este van Marle-Köster, a senior lecturer at the University of Pretoria, invited MacNeil to speak at a conference in South Africa 3 years ago and is now working with him on a study of the genetic architecture of Nguni. Across South Africa, there are at least five different "ecotypes" of Nguni cattle, found in different geographic regions. Each ecotype is easy to distinguish because of unique coloring patterns, body shapes, or other characteristics, according to Van Marle-Köster, who is leading the study. The rural areas are very village oriented, and each village has its own cattle population. One concern is that as Nguni are increasingly crossbred with European cattle, genetically unique lines of Nguni, with useful locally adapted genes and traits, could eventually be diluted and lost.

As part of their study, the researchers are collecting blood samples from about 600 Nguni cattle scattered throughout South Africa. They plan to study the DNA in each sample to develop a better understanding of the genetic makeup of the herds, track relationships within the population, and possibly identify the genetic basis for traits that make Nguni so adaptable. They are using MacNeil's database of microsatellite markers of the bovine genome as reference points. They could find that the entire population is one intermixed group or that there are distinct subpopulations worth preserving as sources of desirable traits.

"The main objective will be to evaluate the population from a genetic standpoint and provide guidance for management strategies as well as focus future conservation efforts," says Van Marle-Köster.

Dairy Ranching

In another study, MacNeil is helping Maiwashe and Scholtz determine breeding objectives for cattle in remote areas in South Africa that are used in dual-purpose dairy-ranching operations. By day, farmers allow calves and cows to graze together, but they separate the calves from their mothers at night so that the calves can't nurse. While the calves may get less total milk, they nurse enough during the day to grow and stay healthy. Such dairy-ranching operations are labor intensive, but they provide additional economic opportunity for the rancher through milk that can be sold daily.

The researchers are evaluating the costs and production levels associated with Nguni and three other breeds that are also used in dairy-ranching operations: Gir, Jersey, and Red Poll. The goal is to develop breeding objectives based on productivity, which includes milk and calf production, and costs to feed and maintain the cows.

"We want to get accurate baseline information. We're asking what kind of costs and production levels we'd see if we use these breeds in these environments and production systems," says Scholtz.

A central theme in all the work is that the ideas for projects originate with scientists in South Africa, MacNeil says. That approach ensures that African priorities are addressed and that the scientists "take ownership" of the research. Projects are designed with an awareness of the nation's cultural paradigms, such as the value placed on cattle as symbols of wealth in rural areas.

"You or I might say we should just find ways to help farmers produce cattle at low cost, sell them at the highest price, and put the money in the bank," MacNeil explains. "But in developing areas, people keep cattle as a representation of wealth and status. They view cattle as their bank, and if they sell their cattle, the source of their wealth is gone."—By **Dennis O'Brien,** ARS.

MIKE MACNEIL (D2304-1)

This Nguni bull has been evaluated with the Agricultural Research Council's Animal Improvement Institute performance testing scheme. His progeny contribute to the South African cattle evaluation system for genetic improvement of Nguni.

This research supports the USDA priority of promoting international food security and is part of Food Animal Production, an ARS national program (#101) described at www.nps.ars.usda.gov.

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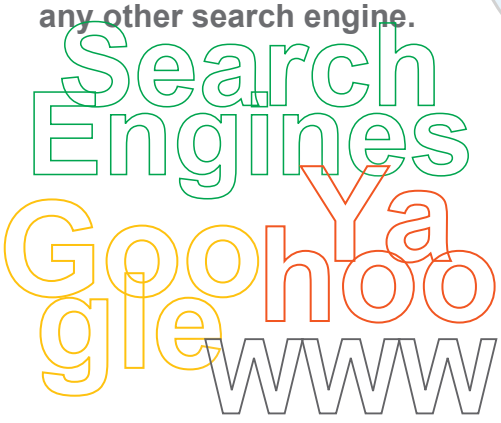
NAL & WorldW

A science-based inter

One of the major advantages of the Internet is that search engines cast a wide net when it comes to gathering up websites.

But one of the disadvantages of the Internet is that these search engines cast that wide net without any weighting for the credibility of individual sites. How many sites must a researcher or policymaker sort through to reach only those with science-based content? And how much more daunting is the task if the information is from another country and in another language?

One way to deal with this issue is to do the search through WorldWideScience.org (WWS), a global Internet portal that simultaneously and only searches nationally sponsored science websites in more than 71 countries, many of which are not readily available through any other search engine.



"WorldWideScience makes the most efficient use of search time for those who need to find data and program information from verifiably scientific sources or for those who need to know what work is being done worldwide without having to wade through a mass of irrelevant or unscientific web pages," explains National Agricultural Library (NAL) deputy director Eleanor Frierson, who serves as the principal representative for the United States to WWS.

Why worry about ensuring an agricultural search is international? "Because the problems that scientists are trying to solve don't stop at one country's borders," says Frierson. "For example, if American scientists are looking for biocontrols for the brown marmorated stink bug, which came from Asia, access to literature in China is going to be helpful. With WWS, what other countries are actually doing about the stink bugs becomes easy to find without having to go through hundreds of folk sites.

"The key is that searchers can trust that every hit they get will be science based, so it makes the most of a searcher's time," she says.

But the international search access of WWS goes much further than that, adds Frierson. "It opened a vast reservoir of previously under-accessed scientific knowledge, which promotes international scientific collaboration and interaction and can reduce duplication of research efforts."

For websites and databases to be part of WWS, they must be nominated by an authoritative agent. NAL is the designee for sponsoring most U.S. Department of Agriculture websites.

NAL sponsors its USDA nominations first to Science.gov, the Internet gateway designed to unify and simplify access and information retrieval from U.S. federal science websites. Currently, Science.gov provides cross searches of more than 45 U.S. government scientific databases and 200 million pages of science information with just one query. Science.gov, as the

ideScience.org

national search engine

U.S. national science portal, then feeds directly into WWS.

"Before NAL proposes adding a new website, we look at its potential value to the target audiences of WorldWideScience and Science.gov, which include everyone from policymakers and planners to students, from bench scientists to public interest groups," says Frierson, who also serves as co-chair of Science.gov's governing alliance.

Many of the databases searchable through WWS simply do not show up with conventional search engines such as Yahoo, Google, or even Google Scholar. These search engines essentially work by regularly sending out "crawlers" that construct an index of websites. When a user conducts a search, the search engine consults its index. But the crawlers usually cannot conduct searches of content stored within databases. This means many topics in these information repositories never make it to the index because the content remains invisible to that search engine.

Such unsearchable content resides in what is termed the "deep web." By some estimates, the deep web is more than 500 times the size of the surface web, and perhaps 99 percent of all the web-accessible scientific documents are in deep-web databases.

To access sites of the deep web, WWS automatically converts a search request into the query style needed by the affiliated websites, and then WWS produces a single list of hits, ranked by relevance.

A test of 33 typical scientist search queries chosen across a wide range of scientific disciplines was conducted in early 2011. WWS search results were uniquely different from Google and Google Scholar results 92.7 percent of the time. Within only the top 50 results from each, WWS results were 97.6 percent unique (overlap being only 2.4 percent among these top 50 results).

Search Engines

In the last year, WWS enhanced its international accessibility by adding multilingual capabilities that let users query in English, Chinese, French, German, Japanese, Korean, Portuguese, Spanish, Russian, and Arabic and automatically search websites in all of the languages. The search results are translated into the language of the searcher's choice.

"This is an important benefit to the English-speaking science community because non-English sources are growing exponentially. And of course, it benefits speakers of the other languages available in WorldWideScience who need assistance with English," Frierson says. "NAL is proud to be part of the way WorldWideScience is advancing international access to the true wealth of scientific literature and data."—By **J. Kim Kaplan, ARS**.

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Google Scholar

ARS

Cayenne Tick Responsible for Equine Piroplasmosis in Horses

Equine piroplasmosis (EP) is a tickborne disease of horses that has been largely absent from the United States for decades, thanks to cooperative federal and state efforts at eradication. Since 1978, the disease has been kept out of the country by testing horses for infection prior to importation and not allowing infected animals to enter.

While the United States has been considered free from the disease since 1978, sporadic cases have occurred in recent years. The largest of these was discovered on October 2, 2009, in Kleberg County, Texas, when a mare was presented for veterinary care with clinical signs of infection. Clinical signs of EP can include poor appetite and weight loss, and eventually the disease can cause death. EP can also affect all other equines, including donkeys, mules, and zebras.

PEGGY GREB (D2312-1)

Dermacentor variabilis tick on a horse. This tick species was implicated in the transmission of equine piroplasmosis in 2009 in Texas along with *Amblyomma cajennense* ticks (cayenne ticks).

Subsequent investigation and testing by the Texas Animal Health Commission (TAHC) and the U.S. Deparment of Agriculture's Animal and Plant Health Inspection Service (APHIS) confirmed the original case and identified more than 290 additional infected animals on the ranch.

EP is caused by the tick-transmitted microbe *Theileria equi* (also known as *"Babesia equi"*). Several tick species are capable of transmitting *T. equi,* so the first step to controlling the outbreak was to find out which tick species transmitted the disease to the mare.

Only two U.S. tick species—*Dermacentor variabilis* and *Rhipicephalus (Boophilus) microplus*—have previously been shown experimentally to be vectors of *T. equi*. Agricultural Research Service research leader Donald Knowles and his team of scientists at the Animal Diseases Research Unit in Pullman, Washington, worked with APHIS and TAHC to assess and prevent the spread of the Texas outbreak, which could have serious international trade implications if it is found to have spread beyond the original outbreak ranch. Part of their initiative was to identify the tick species responsible for the new outbreak.

"Our group identified the cayenne tick, *Amblyomma cajennense,* as the predominant tick species found on

Mare and her foal, part of the research horse herd. Horses are purpose bred at the Animal Disease Research Unit for use in *T. equi* research.

PEGGY GREB (D2315-1)

Entomologist Kathy Mason and technician Ralph Horn check ticks feeding on a horse infected with *T. equi.*

PEGGY GREB (D2311-1)

(D2316-1) (D2316-2) (D2316-3) (D2316-4) (D2316-5)

Ticks are dissected to test for *T. equi*. Presence of this microbe in the gut proves the tick was exposed to the parasite while feeding on an infected horse. Presence in the salivary glands confirms that it can complete its lifecycle and be transmitted by the tick. Above, left to right: whole tick before dissection; dissected tick with internal organs showing; dissected tick with internal organs but appendages removed; tick gut separated from other tissues and organs and ready for testing; salivary glands separated and ready for testing. Photos by Sara Davis.

horses at the ranch," says Knowles. "Although this species had not previously been shown to be a competent vector, adult cayenne ticks were collected from positive horses and allowed to attach and feed on a noninfected horse, and the ticks successfully transmitted *T. equi*."

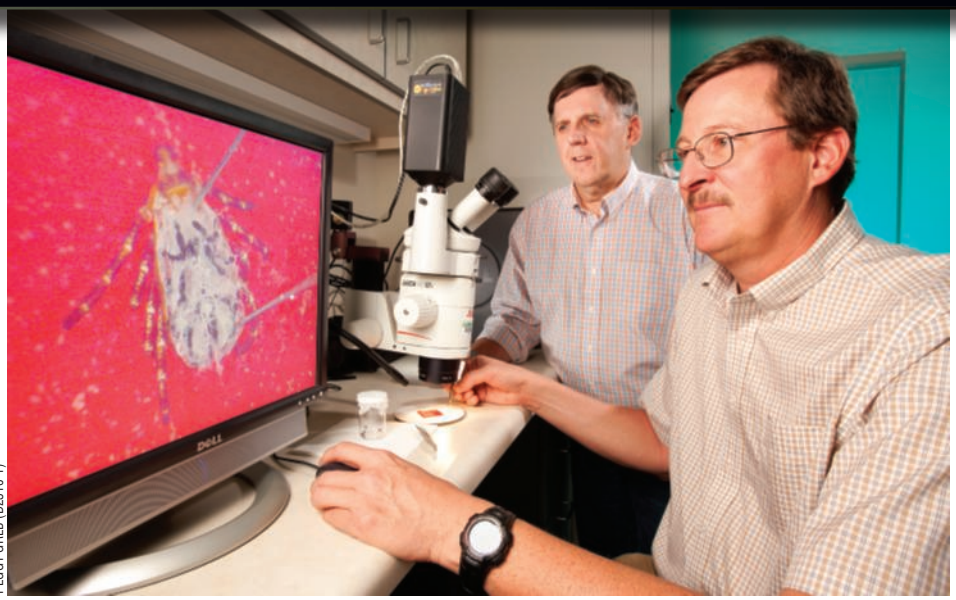
But how did the horses in a geographical area that was free of the disease become infected?

"One of the diagnostic tests previously used widely to screen horses being moved internationally has likely allowed for the entrance of infected horses into countries considered free of infection," says Knowles. That test, says Knowles, is called the "complement fixation test."

"A more recently developed test, cELISA, has enhanced detection of clinically silent, persistently infected horses and could have prevented the spread of the disease."

Knowles and his team are treating some of the South Texas horses with imidocarb dipropionate. Knowles and his team have shown in laboratory tests that this drug not only cures the infected animal, but also renders it incapable of being a carrier that can infect other horses. So far, 14 horses have been successfully treated with the drug, but trials are still ongoing.

"Discovering that this tick species is present in the United States and is capable of spreading piroplasmosis is a crucial development in helping horse ranchers and traders in their quest to keep the United States free of this debilitating disease," says Knowles.—By **Sharon Durham,** ARS.



PEGGY GREB (D2310-1)

Entomologist Glen Scoles (foreground) dissects a tick while research leader Don Knowles observes.

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

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Technician James Allison (left) and veterinary medical officer Massaro Ueti collect a blood sample from a horse infected with *T. equi.*

PEGGY GREB (D2313-1)

James Allison prepares a horse for use in research. Horses must be well acclimated to handling before inclusion in research projects.

PEGGY GREB (D2314-1)

A Mississippi Graveyard

The Perfect Place for a Plant Mystery

Some plants stay put. Others wander all over the globe. And the journey of one restless plant—an Old World native that now thrives in several cemeteries in Meridian, Mississippi—could well be linked to the final resting places of several members of a royal Gypsy family.

Graveyards can be a good place to scout for plant species, which is what Mississippi State University graduate student Lucas Majure was doing in 2007 when he found an unknown sedge. He asked botanist Charles Bryson, who works at the Agricultural Research Service's Crop Production Systems Research Unit, in Stoneville, Mississippi, to help identify the mystery plant.

Bryson always keeps an eye out for the appearance of new and potentially invasive plants. After several months of searching, he was able to confirm that the plant was blue sedge *(Carex breviculmis),* a native of Asia and Australia and previously unknown from North America.

Bryson checked out three possible routes of introduction—planes, trains, and automobiles. He didn't find the sedge along highways or around military airfields in the area. He found it growing along the railroad tracks, but only around campgrounds used by vagrants and other transients. And he found it in or around four cemeteries in Meridian, including Rose Hill Cemetery, where the Queen of the Gypsies was buried in 1915. The King of the Gypsies was later buried alongside his queen, and the cemetery became a draw for visitors from all over the world.

Given the plant's restricted and distinctive distribution in the region, Bryson thinks that global travelers introduced the sedge into Mississippi, possibly via seeds trapped in clothing or by leaving plants or soil at the gravesites of the Gypsy royalty. Then cemetery caretakers may have spread plant material from the first introduction site to the other cemeteries via contaminated clothing and lawn care equipment.

Blue sedge is clearly a survivor, since it can even grow in sidewalk cracks. At two sites where it is established, it now exhibits "weedy" characteristics and reproduces and spreads profusely. Bryson collected leaf samples and preserved them in silica gel for DNA fingerprinting and is looking for a cooperator who can supply Old World leaf material for comparison. "With a diverse sample from the native range, fingerprinting could provide the origin of the introduction," he says.

Bryson and Majure published their findings in the *Journal of the Botanical Research Institute of Texas,* and Bryson is keeping an eye on the plant. "It's considered a weed in Asia, and I think it has the potential to become problematic in fruit and nut crops," Bryson says. "So we could be looking at another headache for the lawn and turf world."—By **Ann Perry,** ARS.

This research is part of Crop Protection and Quarantine (#304) and Crop Production (#305), two ARS national programs described at www.nps.ars.usda.gov.

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In Stoneville, Mississippi, botanist Charles Bryson uses a dissecting microscope and some herbarium specimens to identify the blue sedge, *Carex breviculmis,* discovered at a cemetery in Meridian, Mississippi.

STEPHEN AUSMUS (D2295-13)

Blue sedge, *Carex breviculmis,* near a tombstone at a cemetery in Meridian, Mississippi.

CHARLES BRYSON (D2301-1)

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

Locations Featured in This Magazine Issue

Not shown on map

Tropical Agriculture Research Station, Mayagüez, Puerto Rico
1 research unit ■ 45 employees

European Biological Control Laboratory, Montpellier, France
18 employees

South American Biological Control Laboratory, Buenos Aires, Argentina
12 employees

Australian Biological Control Laboratory, Indooroopilly, Australia
6 employees

Sino-American Biological Control Laboratory, Beijing, China
8 employees

Western Regional Research Center, Albany, California
8 research units ■ 243 employees

Pullman, Washington
6 research units ■ 155 employees

Aberdeen, Idaho
1 research unit ■ 66 employees

Fort Collins, Colorado
5 research units ■ 157 employees

Fort Keogh Livestock and Range Research Laboratory, Miles City, Montana
1 research unit ■ 29 employees

Knipling-Bushland U.S. Livestock Insects Research Laboratory, Kerrville, Texas
2 research units ■ 52 employees

Center for Grain and Animal Health Research, Manhattan, Kansas
5 research units ■ 127 employees

Lincoln, Nebraska
2 research units ■ 94 employees

Ames, Iowa
8 research units ■ 535 employees

St. Paul, Minnesota
3 research units ■ 93 employees

Stuttgart, Arkansas
2 research units ■ 64 employees

Jamie Whitten Delta States Research Center, Stoneville, Mississippi
7 research units ■ 323 employees

Madison, Wisconsin
5 research units ■ 167 employees

Mississippi State, Mississippi
3 research units ■ 80 employees

Raleigh, North Carolina
4 research units ■ 110 employees

Robert W. Holley Center for Agriculture and Health, Ithaca, New York
3 research units ■ 60 employees

Subtropical Horticulture Research Station, Miami, Florida
1 research unit ■ 53 employees

Henry A. Wallace Beltsville Agricultural Research Center, Beltsville, Maryland
30 research units ■ 953 employees

Foreign Disease-Weed Science Research Unit, Fort Detrick, Maryland
1 research unit ■ 52 employees

Plum Island Animal Disease Center, Orient Point, New York
1 research unit ■ 32 employees

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

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