Veterinary, Medical, and Urban Entomology (National Program 104) Annual Report for FY 2015

The mission of National Program 104 (NP 104) is to improve the protection of humans and livestock from blood-sucking arthropods, and from stinging, or otherwise damaging insects. NP 104 research is divided into three components: (1) Medical entomology for the public and military; (2) Veterinary entomology; and (3) Fire ants and other invasive ant pests. Forty permanent scientists in 13 projects conduct translational and applied research under these components to mitigate the impact of arthropods such as ticks, mosquitoes, sand flies, stable flies, biting midges, and bed bugs. Non-biting flies such as house flies, filth flies, and New World screwworms are also the targets of this research effort as are stinging, invasive ants. The ultimate goal is to protect humans and livestock from these arthropod pests, through the development of safe and effective methods of management and control.

NP 104 research is conducted in ARS laboratories located in six States; these laboratory/units and locations include:

Agroecosystem Management Research Unit, Lincoln, Nebraska;
Arthropod Borne Animal Diseases Research Unit, Manhattan, Kansas;
Biological Control of Pests Research Unit, Stoneville, Mississippi;
Invasive Insect Biocontrol and Behavior Laboratory, Beltsville, Maryland;
Imported Fire Ant and Household Insect Research Unit, Gainesville, Florida;
Mosquito and Fly Research Unit, Gainesville, Florida (2 projects);
Natural Products Utilization Research Unit, Oxford, Mississippi;
Screwworm Research Unit, Kerrville, Texas;
Tick and Biting Fly Research Unit, Kerrville, Texas (4 projects).

The quality and impact of NP 104 research in 2015 was evidenced by following research-related activities and products:

3 new invention disclosure or patent applications;
4 patents issued;
4 active Cooperative Research and Development Agreements; and
16 active Material Transfer and Material Transfer Research Agreements.

These technology transfer efforts include the development of better insecticides and insecticide formulations, traps, and repellents. NP 104 scientists work closely with the U.S. Environmental Protection Agency (EPA), as subject matter experts on bed bugs, mosquitoes, ticks, and provide input regarding repellent labeling. In addition, NP 104 personnel provide the USDA Animal and Plant Health Inspection Service (APHIS) with direct research support of their agency’s Imported Fire Ant Phorid Fly rearing and release program, Cattle Fever Tick Eradication Program, and Screwworm Eradication Program.

Scientists in NP 104 published 81 papers detailing their research findings in peer-reviewed journals such as the Archives of Virology, Insect Biochemistry & Molecular Biology, Journal of Agriculture and Food Chemistry, Journal of Medical Entomology, PLoS ONE, and Veterinary Parasitology. Research results were also communicated in numerous trade journals that target our customer/stakeholder base.

Internationally, NP 104 scientists participated in research collaborations with scientists in Argentina, Australia, Austria, Bolivia, Brazil, Canada, China, Colombia, Costa Rica, Cuba, Denmark, Ecuador, France, India, Italy, Japan, Kenya, Mexico, Morocco, New Zealand, Oman, Pakistan, Panama, Paraguay, Peru, Philippines, Saudi Arabia, South Africa, Sweden, Switzerland, Taiwan, Thailand, Tunisia, United Arab Emirates, Ukraine, United Kingdom, and Uruguay. These research collaborations allow access to places where many of our invasive species originated, and also increase the depth of our intellectual capital with original ideas from different perspectives.

Personnel in NP 104

The following scientists retired from the ranks in NP 104:
Donald R. Barnard retired from the Center for Medical, Agricultural, and Veterinary Entomology. We wish him well in new endeavors.

The following scientists in NP 104 received prominent awards in 2015:

Chris Geden, received the 2015 Lifetime Achievement Award in Veterinary Entomology at the Livestock Insect Workers Conference in Boston

Kenneth Linthicum, Gainesville, Florida, received the 2015 Annual Achievement Award for Outstanding Contributions in the Field of Medical and Veterinary Entomology from Florida Entomological Society.

Junwei (Jerry) Zhu, Lincoln, Nebraska, received the Service Award from the International Society of Chemical Ecology. He also received the Outstanding Award from the Asia-Pacific Association of Chemical Ecology. Cargill gave Dr. Zhu the Industry award for studying “Incorporation of plant essential oils into feed-through for reducing biting fly infestation on cattle”.

Funding

Fiscal year funding for research conducted under the auspices of NP 104 approached $19 million, of which $7.8 million of these funds were extramural received through extramural agreements. The Deployed War-Fighter Protection (DWFP) Program continues to provide approximately $3 million per year to support research directed at arthropod-borne diseases, and the development of products for protection of military personnel. The DWFP is funded by the Department of Defense, and administered by the

Armed Forces Pest Management Board. Some of these funds are also used to support the Area-wide Pest Management Research Unit, College Station, TX, the IR-4 Project (minor use pesticide registration) at Rutgers University in NJ, and the Navy Entomology Center of Excellence, in Jacksonville, FL.

Notable Research Accomplishments by Program Components

Component 1: ***Medical Entomology for the Public and the Military***

Next-generation arthropod-repellent military and civilian clothing. Diseases are a major cause of casualties during military operations, greatly outnumbering injuries and death from battle injuries. ARS scientists in Gainesville, Florida, conducted a Good Laboratory Practice study that generated data on etofenprox treatment of U.S. military clothing. The data were reported to the EPA in July 2015. Registration of this product, which protects the clothes wearer from arthropod bites, is expected in July 2016. Use of the product can be extended to civilian clothing, and is a safer alternative to permethrin, the only currently available arthropod repellent for clothing. Additionally, this will be the only treatment available for use on undergarments and clothing made of multiple fabric types. The protocol used for this study will become an EPA guideline for the future registration of repellent-treated clothing.

Improved insecticide-treated barrier for the U.S. military. Protection of U.S. military personnel from bites of disease-carrying arthropods is important to the success of military operations. ARS researchers in Gainesville, Florida, demonstrated that a reduction in adult mosquitoes could be achieved by aerial-applied insecticide treatment of U.S. military blast walls containing geotextile material and radar scattering camouflage netting. There was a significant improvement in adult mosquito death after release of the pesticides pallethrin and sumithrin at times of the day when adult mosquitoes were present in highest numbers. This study also provided additional evidence that existing models of spray deposition used to guide aerial applications of pesticides in the United States do not adequately represent actual spray deposition, and may be improved to reduce pesticide use and better track the fate of sprayed pesticide droplets. These findings will be integrated into future versions of the Mobile Pesticide App, http://www.ars.usda.gov/Business/docs.htm?docid=24908.

Identification of novel insecticides that inhibit insecticide-resistant variants of sand fly acetylcholinesterase. New insecticides are needed to control blood-feeding flies, especially given the rapid development of insecticide resistance in these types of flies. ARS scientists in Kerrville, Texas, supplemented with support from the Deployed War-Fighter Protection Research Program, produced mutant variants of a critical sand fly enzyme, acetylcholinesterase (PpAChE), which is the target of organophosphorous and carbamate insecticides. These variants contained mutations known to be responsible for very high levels of resistance in mosquitoes. In collaboration with researchers at the University of Florida and Virginia Tech University, an in vitro assay was used to test novel synthetic carbamates. Several novel carbamates were effective at inhibiting

PpAChE mutants that were otherwise highly resistant to available insecticides. These compounds may be used to prevent establishment of these resistant alleles in susceptible populations and for the control or remediation of resistant populations of mosquitoes and sand flies. This research is an important aid in the protection of U.S. military and civilians from the bites of arthropods when they travel abroad and to U.S. mosquito abatement and control districts that disburse insecticides to control adult mosquitoes.

Several natural compounds from *Echinops* plant species are potent mosquito larvicides. Mosquitoes transmit pathogens that cause serious human diseases such as malaria, Japanese encephalitis, yellow fever, dengue, and filariasis. Insecticides from various chemical groups are the basic tools used to manage mosquito populations. Due to continuous use of insecticides, mosquitoes have developed resistance to these chemicals and vector control has become difficult. ARS scientists in Oxford, Mississippi, isolated six known natural compounds from the globe thistle, *Echinops transiliensis*, which have been identified for the first time and found to be larvicides against the *Aedes aegypti* mosquito, which causes yellow fever. The base structure of these compounds can be used to develop new insecticides, and one of these compounds, terthiophene, appears to hold promise as a new insecticide. This research will benefit humans and other animals at risk for diseases from the bites of arthropods. This research will also benefit mosquito control and abatement districts in their task of reducing populations of biting pests.

Improved trap deployment strategies for mosquito surveillance. ARS scientists in Gainesville, Florida, developed statistical algorithms to correlate numbers of mosquitoes captured in mechanical traps to the mosquito landing rate on a human volunteer. The data were used to develop a statistical model that explains environmental effects on mosquito responses to mechanical traps. These sampling algorithms and the statistical model will enable quantitative understanding of mosquito responses to mechanical traps and are a critical first step in the development of science-based trap deployment strategies for mosquito vector detection and surveillance systems. The outcome of this study is important to local mosquito abatement and control districts, and to CDC because they all rely on accurate mosquito surveillance data for insecticide treatment and risk modeling.

Indicators for early warning of Rift Valley fever (RVF) threat to humans on the basis of weather and climate. Predicative knowledge of potential arthropod-borne disease outbreaks allows for interventions to reduce the threat and amount of disease spread by arthropods. ARS researchers in Gainesville, Florida, in conjunction with researchers at NASA with partial funding from the Department of Defense Armed Forces Health Surveillance Center, identified seasonal signals in the environment that indicate occurrences of unusually large populations of important mosquito vectors. These signals can provide weeks to months of warning to target mosquito surveillance, disease surveillance, and mosquito control. The continued monitoring of RVF activity in endemic regions in Africa is critical for enhancing awareness of U.S. public health agencies and vector control districts if RVF is found in the United States.

Component 2: *Veterinary Entomology*

Sequencing the genome of the horn fly. Horn flies bite cattle, horses, bison and other livestock, resulting in pain to the animal, decreased lactation rates in cattle, and reduction in growth for calves. The genome of an organism is a master template that guides its development, metabolism, and responses to environmental perturbations, and determines the organism's success within its ecosystem. ARS scientists in Kerrville, Texas, in collaboration with researchers at the National Center for Genome Resources in Santa Fe, New Mexico, completed the sequencing of the horn fly genome. The genome sequence will be computationally assembled and annotated to identify the full complement of genes that make up the horn fly. Knowing the gene sequences of the horn fly will facilitate the development of new fly control technologies by enabling the identification of specific gene products that can be targets for new insect specific pesticides and anti-fly vaccines.

Arundo wasp is highly effective in reducing Giant Cane (*Arundo donax*). Five years after the initial release of the arundo wasp (*Tetramesa romana*), ARS researchers in Kerrville, Texas, have shown that the wasp has thinned out the amount of Giant Cane by 22 percent along the 558 miles of river between Del Rio and Brownsville, Texas. This has resulted in significant water conservation (6,000 acre-feet per year). It has also led to better visibility of the international border for U.S. Customs and Border Protection agents, and better access and visibility for mounted patrol inspectors with the APHIS Cattle Fever Tick Eradication Program.

Annotated catalog of biting midge genes. Female biting midges transmit viruses that affect the health of the Nation's livestock and wildlife. In fiscal year 2014, ARS scientists in Manhattan, Kansas, in collaboration with scientists at Clemson University, generated and published the first catalog of expressed genes for female midges under several feeding conditions. The annotated version of this catalog, in which the genes are named and categorized by process, was released in fiscal year 2015 on the Ag Data Commons Web site hosted by the National Agriculture Library. The annotated catalog is available to collaborators and stakeholders and is being used in studies of midge biology, function, and control.

Component 3: *Fire Ants and Other Invasive Pest Ants*

Biocontrol agents released in southern California. Fire ant populations were introduced into the United States where they have no natural enemies and competitive ant species. As a result, they are a significant pest and continue to expand their range in the United States. ARS researchers in Gainesville, Florida, in collaboration with researchers at the Coachella Valley Mosquito and Vector Control District in California introduced *Solenopsis invicta* virus 3 (SINV-3), a microsporidian (*Kneallhazia solenopsae*) pathogen that infects fire ants in combination with phorid flies, a parasite to biologically control the fire ants. The evaluation was carried out in the urbanized desert habitat of the Coachella Valley in southern California. Both the SINV-3 virus and the *Kneallhazia* pathogen successfully spread throughout the fire ant population. The pathogen makes fire ant bait perform better against the ants and makes ants less able to reinfest the same area. This study demonstrates that a suite of fire ant natural enemies as biological control agents is a self-sustaining control strategy for their suppression. Further evaluations will determine the overall effect of fire ant parasites and pathogens on introduced fire ant populations in California. This research is of benefit to the protection of humans and livestock in areas where fire ant populations exist.