Veterinary, Medical, and Urban Entomology (National Program 104) Annual Report for FY 2014

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 2014 was evidenced by following research-related activities and products:

2 new invention disclosure or patent applications;
2 patents issued;
12 active Cooperative Research and Development Agreements; and
51 incoming agreements with industry, academia, or other State and federal agencies.

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 nearly 90 of their research findings in 22 high-impact, 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, NP104 scientists participated in research collaborations with scientists in Argentina, Austria, Bolivia, Brazil, Canada, China, Colombia, Costa Rica, Denmark, Ecuador, India, Japan, Mexico, New Zealand, Oman, Pakistan, Panama, Paraguay, Peru, Saudi Arabia, Switzerland, Taiwan, United Arab Emirates, 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.

People – Awards, Events, and Recognitions:

Gary G. Clark, Research Leader (RL) of the Mosquito and Fly Research Unit (MFRU) in Gainesville, FL retired after 28 years of federal service. ***Kenneth J. Linthicum***, Director for the Center for Medical, Agricultural, & Veterinary Entomology (CMAVE), Gainesville, FL has been appointed RL of this Research Unit. We wish Gary all the best in his retirement, and congratulate Ken on his new appointment.

Xixuan Jin, Research Microbiologist in the Biological Control of Pests Research Unit in Stoneville, MS also retired in 2014. With Dr. Jin's retirement, we welcome ***Meg L. Allen*** and ***M. Guadalupe Rojas*** to the NP 104 Project "Products for Invasive Ant Control" in Stoneville, MS. Both are from another Project in the Biological Control of Pests Research Unit in Stoneville; Dr. Allen will be joining the ant project full-time, while Dr. Rojas will devote 50% of her time to the new project.

There were six retirements at the Knipling-Bushland U.S. Livestock Insects Research Laboratory in Kerrville TX. ***Alfred Siebenaler*** retired after 40 years of federal service; other retirees include ***Gordon Shelley*** (33 years), ***Steven Davis*** (29 years), ***Matt Pound*** (29 years), ***Jerome Klavons*** (25 years), and ***Gary Earl*** (21 years). That's a total of 177 years of federal service to our Nation, for which we thank them.

We congratulate the following scientists in the Agroecosystem Management Research Unit in Lincoln NE. ***Kristina Friesen*** serves as the vice-chair of the Entomological Society of America (ESA) Membership Committee, while ***David Taylor*** is the Chair of ESA's Medical, Urban, and Veterinary Entomology (MUVE) section nominating committee. David is also a member of their Executive Committee. ***Jerry Zhu*** is the president-elect of the Asia-Pacific Association of Chemical Ecologists, and serves on the council that advises the executive committee of the International Society of Chemical Ecology.

The following individuals of CMAVE in Gainesville FL were recognized in 2014. ***Bob Aldridge*** was awarded the T. Wainwright Miller, Jr. Scholarship that is managed by the FL Mosquito Control Association, while ***Don Barnard*** received the "Scientist of the Year Award" from the FL Mosquito Control Association. ***Chris Geden*** received a U.S. – Israel BARD (Binational Agricultural Research and Development) grant entitled "Development of sustainable fly management tools in an era of global warming." ***Dan Kline*** received several awards including the "Rutgers University Team Excellence Award" and the ESA– Dow Chemical Pest Management Award" for his involvement in the Area-wide Project to control the Asian tiger mosquito. Dan was also the recipient of the American Mosquito Control Association's "Meritorious Service Award. ***Ken Linthicum***, Director of CMAVE, was elected president-elect of the American Mosquito Control Association. Ken also received a grant from the U.S. – Egypt Science and Technology Joint Board.

During the VIII International Conference on Ticks and Tick-borne Pathogens, held in Cape Town South Africa, ***Felix Guerrero*** and ***Robert Miller***, both of the Livestock Insects Research Laboratory in Kerrville TX, received the Nelson Mandela Medal in recognition of their achievements in sequencing the genome of the southern cattle fever tick.

Kamal Chauhan of Invasive Insect Biocontrol and Behavior Laboratory in Beltsville MD was selected as a winner of the 2014 Mid-Atlantic Regional Federal Laboratory Consortium Award for Excellence in Technology Transfer for his submission entitled "Reduced Risk Vector Control Insecticides."

Funding

Fiscal year funding for research conducted under the auspices of NP 104 approached $18 million. 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*

Improved uniforms to protect U.S. military personnel from mosquitoes
Throughout much of the world, mosquitoes are responsible for transmitting a wide variety of disease-causing agents. While civilian travelers can avoid areas of high risk during the planning of their trips, deployed military personnel cannot, and must therefore rely upon the spraying of synthetic insecticides to kill blood-feeding pests, and/or personal protection. ARS scientists in Gainesville, FL worked with the Department of Defense to test the useful life of United States Marine Corp and Navy military uniforms that were impregnated with the insecticide permethrin. They demonstrated that after 50 washings, the treated uniforms still retained their ability to repel biting mosquitoes. This information is essential to the personnel of the United Sates military charged with protecting our deployed troops from arthropod-borne diseases.

Ability of U.S. mosquito to transmit Rift Valley fever virus
Rift Valley fever is a potentially fatal viral disease of humans that is transmitted by mosquitoes. The virus can also negatively impact livestock. Though largely constrained to the African continent, there is a concern that the Rift Valley virus could be introduced and established in the United States. In laboratory studies, ARS scientists in Gainesville, FL evaluated eight species of mosquitoes commonly found in the United States for their ability to transmit the Rift Valley fever virus. Their findings that some species of mosquitoes have a greater ability to transmit the virus than others, have a direct impact on the risk assessment of disease transmission to humans and livestock, and by allowing mosquito control assets to target those mosquito species that are most likely to be involved in disease transmission.

Mosquitoes can "taste" repellents such as DEET
Mosquitoes transmit a variety of human pathogens, including the malaria parasite as well as the viruses that cause yellow fever, Dengue fever, and West Nile. Understanding the underlying mechanisms involved in mosquito attractancy and repellency could lead to the discovery of new classes of chemicals that alter mosquito behavior. ARS scientists in Beltsville, MD discovered a taste receptor on the mouthparts of the yellow fever mosquito that is sensitive to the insect repellent DEET. Scientists were able to identify the specific hairs at the tip of the mosquito's mouthparts responsible for repellent detection. This fundamental research finding provides a new means to screen and discover novel chemicals and repellents that disrupt mosquito feeding behavior, and thereby possibly limit the transmission of human pathogens.

Fumigation efficacy of plant-based products against bed bugs
While bed bugs do not transmit disease pathogens, this blood-sucking pest of humans has become a scourge across the United States. Though chemical treatments, in the form of liquid sprays, have been developed to control bed bugs, certain household items that may become infested, such as books and electronics, are not amenable to liquid treatments. ARS scientists in Beltsville, MD, in collaboration with the University of Maryland

personnel, tested several plant-based, essential oils for their ability to control bed bugs by fumigation. Their research effort demonstrated that although several essential oils were effective under laboratory conditions, only one – rosemary oil – proved an effective fumigant under field conditions. Because rosemary oil does not require U.S. EPA registration for use as a pesticide, this information will be useful to individuals and groups interested in a safe and cost-effective treatment for bed bugs.

Component 2: *Veterinary Entomology*

Genetics of screwworm control

Infestations with immature screwworms ("maggots") devastated the U.S. livestock industry until screwworms were eradication in the 1960s, using a sterile male release technique. The use of a sterile insect technique (SIT) is still used to this day to prevent re-entry of screwworms from South America. To utilize the SIT, mass production, sterilization, and the release of millions of sterilized, adult male screwworms is employed at a cost of millions of dollars, annually. ARS scientists at Kerrville, TX, in collaboration with scientists at North Carolina State University, used genetic techniques to produce male-only screwworms, thereby making the rearing and release program more efficient and affordable. Maintaining an effective barrier against screwworms re-entering the United States ensures benefits exceeding US$1.5 billion annually for North American livestock producers.

Mass-rearing of immature screwworms

The use of the sterile insect technique (SIT) to currently prevent the re-establishment of screwworms in North America requires the mass production of millions of screwworms. Cellulose fiber, in the form of finely ground recycled paper, has been used as an additive ("bulking agent") in the food used to raise the immature screwworms. Ammonia production in the rearing facility has always been problematic, more so when cellulose fiber is used as a bulking agent. ARS scientists at Kerrville, TX and their collaborators in Panama found that ammonia emissions were reduced when a common chemical (potassium permanganate) was added to the immature screwworm diet. An added benefit was also realized when potassium permanganate was added to the diet. The anti-microbial action of this chemical eliminated the need to include formaldehyde, which was used to prevent bacterial contamination, in the diet. A lowered ammonia level in the mass-rearing facilities has improved working conditions for employees, and has also resulted in improved quality of screwworms. This research has resulted in a successful and economical means of rearing screwworms, which ultimately benefits livestock producers in the United States by preventing the re-introduction of this harmful insect pest.

Molecular method to distinguish immature screwworms from other immature flies

Guarding against the reintroduction of screwworms to North America is dependent on the rapid, reliable identification of suspected cases. Because it is very difficult to distinguish between the early immature stages ("maggots") of many fly species, ARS scientists from Kerrville, TX, collaborated with scientists in Lincoln, Nebraska, to develop a molecular

technique used to identify the earliest stages of suspected screwworm maggots. The resulting technique was demonstrated to distinguish between screwworms and other closely-related flies that often infest livestock wounds. This molecular approach provides important tools for the screwworm eradication and exclusion program, where rapid identification and verification of suspicious larval samples is needed. The technique will eliminate the unnecessary treatment of presumed, negative outbreaks, saving thousands of dollars that would have been spent each month. In the case of a real screwworm outbreak, the reliable identification will ensure a rapid response that both contains and eliminates the potentially deadly pest, protecting against millions of dollars in losses. The molecular technique developed by ARS scientists will ensure that U.S. and other North American livestock producers continue to reap the significant benefits (more than US$1.5 billion annually) resulting from the eradication of the screwworm.

Identifying genes involved in biting midges and in a virus midges transmit

Certain types of biting midges (often referred to as “no-see-ums” or “punkies”) can transmit numerous viruses that cause diseases in livestock and wildlife. Most notable is Bluetongue virus (BTV), which causes a devastating disease of sheep, cattle, and goats. Because the virus can spread across international borders, U.S. cattle and sheep producers suffer US$125 million annually in lost trade and in certifying their animals are virus-free. ARS scientists in Manhattan, KS, in collaboration with the Clemson University Genomics Institute have catalogued genes involved in midge feeding and reproduction. They have also identified genes involved in the infection of midges by virus. Taken together, this research contributes to developing new control strategies for biting midges, and to a better understanding of how to block virus transmission. The information generated by this research will be of value to scientists, livestock producers, and regulatory personnel interested in mitigating the impact of midge-borne diseases.

Occurrence of cattle fever ticks in white-tailed deer

Texas cattle fever is a devastating protozoan disease of domestic cattle transmitted by certain types of ticks, termed cattle fever ticks (CFT). By 1961, an eradication effort effectively eliminated the ticks and the disease-causing pathogen from Texas and the southeastern United States, though a tick eradication quarantine area (TEQA) is still maintained by federal personnel along the Texas-Mexico border. Originally, the CFT and the parasite it transmits was thought to infest only cattle, though recent evidence has shown that white-tailed deer can also serve as hosts for these ticks. ARS researchers at Kerrville, TX, in collaboration with scientists from Northern Arizona University, examined the genetic relationships between tick collected from cattle and ticks collected from deer. They found these ticks to be genetically similar, thereby explaining why tick populations have persisted over time in the quarantine zone. Molecular techniques were also used to determine the invasive potential of ticks into major cattle producing areas in the United States. This information will be useful to scientists and government agencies charged with maintaining tick eradication quarantine areas.

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

Specificity of virus for fire ant control

The red imported fire ant (RIFA) and the black imported fire ant (BIFA) are aggressive, stinging ants that infest over 320 million acres in the United States and Puerto Rico. These fire ants are responsible for damages exceeding US$6 billion annually, including the cost for medical treatment of stings, livestock and crop losses, and control in infested areas. ARS researchers in Gainesville, FL in cooperation with colleagues in Arizona, California, and Illinois have discovered several viruses that are being developed as natural control agents against the dominant RIFA. These scientists demonstrated that one of the most effective viruses is specific to the fire ants, and does not have a negative impact on native ants considered non-target organisms. This research will afford a new tool to personnel attempting to control this invasive ant pest.

Action of fire ant virus

The red imported fire ant (RIFA) is an invasive species, and new control methods are continually needed to combat these aggressive, stinging ants. ARS scientists in Gainesville, FL, in collaboration with a scientist in Cambridge, England conducted a laboratory study to determine the mechanism by which a fire ant-specific virus attacks a fire ant colony. They found that although the virus only attacks adult worker ants, the colony eventually perishes due to the inability of the infected worker ants to care for immature ants and fire ant queens, which are important parts of the fire ant colony. This information improves our understanding of how the virus acts, and will be used by other scientists interested in developing new control strategies for the RIFA.

Interference of gene expression can lead to fire ant control.

A novel approach to pest insect control is based on technology that "silences" the functioning of a gene critical to the survival of the pest insect. The method involves using double stranded RNA (dsRNA) to interfere with the gene's ability to function, and the general process is called RNAi (i = "interference"). ARS Scientists at Gainesville, FL characterized a specific gene in fire ants that is present in all fire ant life stages, and used RNAi to suppress this gene, which ultimately led to significant immature fire ant death, even when the dsRNA was fed first to workers who subsequently fed the larval ants. Adult worker ant mortality was also observed. This research significantly supports the use of dsRNA and RNAi as a method to control invasive ant pests, and gives scientists involved in developing ant controls a new avenue to explore.

Biological control of fire ants

The higher densities of imported fire ants found the United States compared with their native South American homelands is attributed, in part, to the lack of natural enemies. In an effort to combat the red imported fire ant, ARS scientists in Gainesville FL, in collaboration with scientists at the University of Florida and in Argentina released a fly parasite in Florida as a potential biological control agent. This fly, native to Argentina became established in Florida fire ant populations, albeit at low levels. This particular parasitic fly is being reared by the USDA- APHIS (Animal and Plant Health Inspection

Service) for release in different habitats that may prove more conducive for the fly under field conditions. This information will be used by personnel interested in developing new strategies to control imported fire ants in the United States.