# Veterinary, Medical, and Urban Entomology (National Program 104)
# Annual Report for FY 2017

**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 one permanent scientists in 11 projects conduct translational, fundamental 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 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;
Livestock Arthropod Pest Research Unit, Kerrville, Texas (3 projects).

**The quality and impact of NP 104 research in 2017** was evidenced by the following research-related activities and products:

- 6 new invention disclosures and 6 patents filed;
- 6 patents issued;
    - Patent No. 9,556,244 Vaccination of animals to elicit a protective immune response against tick infestations and tick-borne pathogen transmission
    - Patent No. 9,591,858 Novel *Nylanderia pubens* virus
    - Patent No. 9,617,542 Lepidopteran moth control using double-stranded RNA constructs
    - Patent No. 9,718,797 Eight diastereomers of vittatalactone and methods of attracting *Acalymma vittatum*
    - Patent No. 9,763,444 Compositions and methods for repelling blood-sucking and biting insects, ticks, and mites
    - Patent No. 9,771,393 Bioactive peptides having insecticide activity
- 3 new Cooperative Research and Development Agreements; and
- 20 new 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 U.S. Department of Agriculture (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, the Imported Fire Ant Quarantine, Cattle Fever Tick Eradication Program, and Screwworm Eradication Program. NP 104 scientists also assist the U.S. Department of Defense (DoD) with research focused upon protection of warfighters and other personnel from arthropods that cause diseases in humans.

**Scientists in NP 104 published** 86 papers detailing their research findings in peer-reviewed journals such as Advances in Entomology, Journal of Economic Entomology, Journal of Insect Science, Journal of Medical Entomology, PLoS ONE, Parasitology Research, 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, Bahrain, Bolivia, Brazil, Canada, China, Columbia, Costa Rica, Cuba, Denmark, Ecuador, Egypt, France, French Polynesia, Germany, Greece, India, Israel, Italy, Japan, Kenya, Mexico, Morocco, New Caledonia, New Zealand, Oman, Pakistan, Panama, Paraguay, Peru, Philippines, Saudi Arabia, South Africa, Spain, Sweden, Switzerland, Taiwan, Thailand, Tunisia, Ukraine, 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.

**Personnel in NP 104**

**The following scientists retired in NP104:**

**Dr. Muhammad Chaudhury**, Livestock Arthropod Research Unit, Kerrville, Texas.

**Dr. Dick Dickens**, Invasive Insect Biocontrol and Behavior Laboratory, Beltsville, Maryland.

**The following scientists in NP 104 received prominent awards in 2017:**

**Drs. Pamela Phillips and Steve Skoda**, Kerrville, Texas received the USDA-APHIS Administrator's Award as members of the New World Screwworm Response Team and for their role in eradicating screwworms in Florida during the recent outbreak.

**Dr. Junwei Zhu,** Lincoln, Nebraska, received two awards: (1) the Asia-Pacific Chemical Ecology Association Excellence in Leadership Award at the 2$^{nd}$ International Chemical Ecology Conference and (2) the Entomological Society of America Leadership Appreciation Award at the 2017 Annual Meeting of Entomology.

**Funding**

Fiscal year funding for research conducted under the auspices of NP 104 approached $22 million, of which $4.5 million of these funds were 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 Aerial Application Technology Research and Insect Control and Cotton Disease Research laboratories in College Station, Texas, the IR-4 Project (minor use pesticide registration) at Rutgers University in New Jersey, and the Navy Entomology Center of Excellence, in Jacksonville, Florida.

## ***Notable Research Accomplishments by Program Components***

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

Reducing Zika risk by improving mosquito control. Zika, yellow fever, and dengue virus are transmitted by the yellow fever mosquito (*Aedes aegypti*), and Zika virus is one of the newest viruses to be introduced into the United States. Developing a regional strategy to reduce the yellow fever mosquito population is needed to help reduce the spread of these diseases. Agriculture Research Service (ARS) researchers in Gainesville, Florida, worked with university and local government public health agency collaborators to develop a comprehensive regional program to reduce the population of vectors - insects and other arthropods that carry and transmit disease - including the yellow fever mosquito. ARS researchers led the development of a program that combined traditional vector control, community engagement, and vector surveillance solutions in a unique, innovative way to reduce the risk of Zika virus transmission by reducing or eliminating mosquito populations. This system has contributed significantly to development of new vector control strategies in the United States and partner nation agencies at local, national, and international levels.

Commercial microbial control products vary widely in effectiveness against flies. Flies are a nuisance pest. Some species have been shown to spread bacteria when landing surfaces, and other fly species feed on animals and humans. Naturally occurring fungi that are lethal to flies, primarily *Beauveria* (B.) *bassiana* and *Metarhizium* (M.) *anisopliae*, can be effective for management of house flies and stable flies. However little is known about how efficacy may be altered by commercial formulation. ARS researchers in Gainesville, Florida, and North Carolina State University evaluated four commercially available *B. bassiana* and *M. anisopliae* products for their ability to kill flies and produce spores that could infect other flies. Three products, BotaniGard® ES, Mycotrol® O, and Met52®, caused high fly mortality and produced a second generation of spores from the cadavers of infected flies. A fourth product, balEnce®, produced low mortality and spore formation. Results confirm that commercial formulation can have a substantial effect on the efficacy of microbial biocontrol agents. The results of this study are useful to industries where flies negatively impact health, well-being, and production.

Artificial feeding system for ticks. Lone star ticks transmit several human pathogens as well as pathogens that affect livestock and other animals. ARS scientists in Beltsville, Maryland, developed an artificial feeding system for lone star ticks that was used successfully to feed adult lone star ticks in the laboratory. This artificial feeding system allowed ARS personnel test several tick control products, without the need for human or animal hosts. This information, as well as the feeding system, can be used by federal, university and pharmaceutical scientists that are interested in developing new tick control formulations.

## Component 2: *Veterinary Entomology*

Publication of the cattle fever tick genome sequence. The cattle fever tick *Rhipicephalus microplus* transmits the disease cattle fever (Babesiosis) to cattle. The genome of the cattle fever tick, which contains more than twice the amount of DNA as the human genome, is difficult to sequence. ARS scientists in Kerrville, Texas, worked with researchers at Murdoch University's Centre for Comparative Genomics, Murdoch, Australia, and published the genome sequence for this cattle fever tick. They identified genes associated with cattle fever pathogen maintenance, the cattle host immune response, pesticide resistance, tick feeding. This new comprehensive sequence information allows efficient identification of tick antigens that facilitates tick vaccine development and improves pesticide resistance monitoring, which will help protect cattle health.

Developing transgenic male-only screwworm strain. Screwworms burrow into the skin of live animals and inflict serious wounds while they feed on live tissue. ARS researchers in Kerrville, Texas, worked with researchers at North Carolina State University and the Panama-U.S. Commission for the Eradication and Prevention of Cattle Screwworm (COPEG) to complete a critical step in bioengineering a transgenic male-only strain of screwworms to mate with females in the wild. The genetically engineered male-only strains were transferred to the Methods and Development section of COPEG for further evaluation in field trials scheduled for the coming year. The ability to produce a colony consisting only of males is expected to decrease production costs and biological waste by approximately 50 percent. In related research, ARS researchers in Lincoln, Nebraska, and Kerrville, Texas, identified four volatile attractants that influence female egg laying. These results are expected to support the development of products that will increase the average number of eggs produced for creating sterile screwworm males. It will be particularly important for producing the male-only strain because fewer fertile females will be produced, which will reduce production costs.

RNAi used to manipulate gene function in the biting midge. *Culicoides* biting midges transmit viruses that cause disease in livestock and deer. Understanding the interactions between these insects and the viruses they transmit is the first step in developing methods for blocking virus transmission. ARS scientists in Manhattan, Kansas, and their collaborators at Kansas State University showed for the first time that the molecular tool RNA-interference (RNAi) can be used both to suppress, then restore specific gene(s) activity in midges. This technology will allow scientists to conduct studies that will help explain genetic components associated with the midge’s ability to transmit viruses.

Biting fly trap placement helps protect zoo animals. Stable flies bite animals to feed on their blood, and the wounds they create during feeding are stressful for those animals. A fly trap called the Knight Stick sticky fly trap is highly effective for attracting and catching stable flies and catches more stable flies when placed near the animals. However, it can be difficult to determine where to place these traps so that they are most effective. In a 21-week study, ARS scientists in Gainesville, Florida, worked with Smithsonian National Zoo researchers and found that traps located inside exhibits captured 6 to 9 times more stable flies than traps placed along exhibit perimeters, greatly improving animal health and welfare. These results indicate this strategy could be used to protect animals in other zoos and also has the potential for use in livestock production systems.

Association of salivary enzyme with the disease-spreading ability of ticks. ARS researchers at Kerrville, Texas, previously reported that the enzyme acetylcholinesterase in tick saliva may assist infectious agent transmission to the host leading to easier progression to disease. Additional studies in Kerrville, Texas, found that mosquito and sand fly saliva also contain measurable acetylcholinesterase, but that saliva from horn flies, stable flies, and house flies does not. Ticks, mosquitoes, and sand flies all transmit disease very efficiently, but horn flies, stable flies, and house flies do not. This suggests the enzyme is strongly linked to the ability to spread disease, which could help in developing new models and targets for understanding and preventing disease transmission by arthropods to cattle.

Improved cattle fever tick control. Cattle fever, which is transmitted by ticks, is lethal to naïve cattle. ARS researchers in Kerrville, Texas, and Edinburg, Texas, completed field research on controlling the southern cattle fever tick in Puerto Rico using a combination of approaches. The combined use of safer pesticides and cattle vaccination against the cattle fever tick successfully prevented outbreaks of cattle fever in dairy cattle herds. Dairy and beef cattle producers in Puerto Rico are expected to adopt integrated tick management practices based on the success of these research outcomes.

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

Finding a virus that is a natural enemy of fire ants. Fire ants inflict serious and sometimes fatal bites to animals and humans, and they cause billions of dollars of crop damage and other structural damage every year. ARS scientists in Gainesville, Florida, discovered *Solenopsis invicta* virus 4 (SINV-4) in South American fire ant populations and determined that this virus is also present in U.S. fire ant populations. *Solenopsis invicta* virus 4 (SINV-4) belongs to a new virus family, *Polycipiviridae*, and viruses within this family appear to infect only ant species. Because it is known to infect only ant species, SINV-4 may be a good biocontrol agent for controlling invasive ants, including fire ants. This research is useful to the pest control industry and other industries that are harmed by this pest.

Fire ant control improved with water resistant bait. More than two billion dollars a year is spent on fire ant control, which primarily consists of baits that contain pesticides. The bait carrier in one effective product is a form of corn grit, but the grit carrier disintegrates under wet or moist conditions. ARS researchers in Gainesville, Florida, conducted a field evaluation of a water-resistant fire ant bait under conditions where there was heavy dew on the ground and found the water-resistant bait outperformed the equivalent standard bait.  The water-resistant bait overcomes current bait use restrictions in damp environments and will be useful for controlling fire ants in wet environments, such as in Hawaii.