ASTHO Report
In-depth coverage of leading state and territorial public health issues.
March 2021

State Approaches to Insecticide Resistance Testing

State and territorial health agencies (S/THAs) play a critical role in preventing and controlling mosquito-borne diseases. Although each jurisdiction is unique, most S/THAs are either directly responsible for some component of mosquito surveillance and control or provide essential support and oversight for local and regional programs. With emerging mosquito-borne threats rising, S/THAs should prepare for these new threats while continuing to support responses to existing disease challenges, such as COVID-19. One new threat S/THAs must prepare for is the potential for mosquitoes to develop resistance to the insecticides typically used for their control.

Most S/THAs report that local mosquito control programs within their jurisdiction do not have the core capacity to conduct insecticide resistance (IR) testing. In a 2017 NACCHO survey to assess the performance of mosquito control programs, the majority (84%) were found to need improvement. Of programs that needed improvements, almost all lacked adequate capacity to conduct IR testing. Programs that met the core competency requirements use IR testing data to:

- Provide baseline data for program planning and pesticide selection before the start of control operations.
- Detect resistance at an early stage so that timely management can be implemented.
- Monitor the effect of control strategies on insecticide resistance.

IR testing capacity can ensure that the insecticides used by mosquito control programs will effectively kill mosquitoes, ensuring S/THAs can control mosquitoes in a timely fashion. Despite the need for IR testing in state mosquito control programs, funding is a major challenge. Based on the experience of IR programs developed for controlling crop pests and malaria in other parts of the world, partnering with other groups, sectors, or partners may be key to building and implementing an IR program.

Louisiana and Florida provide two examples of how states can partner with local universities to address the IR testing needs of state and local mosquito control programs. Even for these established programs, the lack of dedicated funding streams for maintaining IR testing capacity is a threat to their continued operation. Reliable funding is needed to develop and maintain staff, laboratory, and data resources needed during mosquito-borne disease outbreaks.

State Case Studies

Louisiana

Louisiana's Mosquito Control Association (LMCA) has been active since 1957, and its members include Louisiana's 28 Mosquito Abatement Districts (MADs). MADs have the resources and expertise to collect data used to develop effective mosquito control strategies. Mosquito surveillance data, including annual testing of about 30,000 mosquito pools for West Nile virus and other arboviruses, informs decisions on when and where to spray adulticides. IR testing data informs the choice, location, and timing of adulticide applications. Some MADs have conducted IR testing via CDC bottle bioassay for more than 20 years, in addition to other adulticide and larvicide bioassays. IR testing has revealed *Culex* and *Aedes* mosquitoes can be or are resistant to organophosphate and type I pyrethroid insecticides. Many areas outside of Louisiana's population centers are not served by a MAD but may have opportunities to participate in the IR program.

Louisiana State University (LSU) provides a centralized location for IR testing at the LSU Louisiana Animal Disease Diagnostic Laboratory (LADDL). MADs are responsible for collecting field samples (i.e., mosquito larvae/pupae) and raising adult mosquitoes used for IR testing at LADDL. Cooperation between LMCA members has allowed the MADs that need assistance finding resources for rearing adult mosquitoes for IR testing to participate. The Louisiana Department of Health expects all MADs to participate and makes receiving certain types of state aid contingent upon participation in the IR testing program (e.g., receiving adulticides purchased with hurricane recovery funds). In addition, LMCA conducts a training for its members, which is a conduit for IR data reaching a broader population of pest control professionals.

In addition to testing for mortality using the CDC bottle bioassay, LADDL conducts knockdown resistance (KDR) testing and research on genetic markers associated with resistance. KDR testing is used to discover possible genetic mutations attributed with resistance to pyrethroids.

Establishing MADs, building their capacity, and promoting a culture of collaboration between MADs took years. MAD activities are guided by protocols developed through a credible and transparent committee process with input from local officials, state experts, and other stakeholders. Contributing to this foundation for successful mosquito control are access to university-based laboratory services for surveillance and IR testing, and the expertise provided by the state's medical entomologist in establishing a scientific basis for the state's mosquito control activities.

Florida

Like Louisiana, mosquito control in Florida is performed primarily by independent local mosquito control programs. The state provides pass-through funding as well as technical support and guidance to Florida's 89 local mosquito programs. State support focuses on problems from disease vectors, not nuisance mosquitoes.

Florida encourages all of its mosquito control programs to conduct IR testing, but most do not have the capacity to do so. Over the last year, the University of Florida's Florida Medical Entomology Laboratory (FMEL) has provided IR testing services to fill these gaps. In addition to IR mortality testing, the Florida Department of Agriculture conducts KDR testing.

In 2016, Florida used Zika-specific funding to expand IR testing capacity to address statewide needs. Prior to this, only a few of the larger mosquito control programs conducted IR testing. Though there is increased funding for testing capacity across the state, these well-resourced local programs are encouraged to continue conducting their own IR testing. Expansion of testing to smaller programs has been facilitated by having simple, standard protocols for testing via the CDC bottle bioassay.

Florida's IR testing program focuses on the following species: *Aedes albopictus*, *Aedes aegypti*, and *Culex quinquefasciatus*. Local programs send eggs (*Aedes*) or rafts (*Culex*) to the FMEL to be raised into adults for testing. Some programs also send larvae to be raised. No larvicide testing is currently being conducted. Both pyrethroids (i.e., pyrethrin, sumethrin) and organophosphates (i.e., naled, malathion) are tested on mosquitos for resistance.

Because it is a research and education center, FMEL not only provides IR testing results, but also an interpretation of these results and recommendations for addressing resistance problems. The Florida Mosquito Control Association offers educational opportunities to mosquito control professionals in both the public and private sectors. Workshops, training sessions, and short courses are widely available to address knowledge gaps at local programs.

Florida's Interagency Arboviral Task Force has been critical to program success. The active participation of numerous state agencies, universities, labs, and other non-governmental organizations is the foundation for progress. For technical guidance related to IR and other complex issues related to mosquito control, the Florida Department of Health has relied on the medical entomology expertise of its interagency partners.

Centralized IR testing allows local programs with minimal capacity to benefit from standardized IR testing data and expert consultation. In Florida, IR testing is made possible by state and federal funding, but that funding is set to end on June 30, 2021. This funding allows programs with minimal capacity to benefit from standardized IR testing data and expert consultation. The University of Florida provides a centralized hub for IR testing, but its success relies on the engagement and collaboration between partner agencies. Local program collaboration is also important as mosquitoes do not recognize geographic or political boundaries.

Additional Approaches

In Louisiana and Florida, several well-established local mosquito control districts and programs have a history of conducting routine IR testing. Other states, such as Texas, provide examples of centralized IR testing programs. The commonality in jurisdictions with centralized testing programs is their access to committed funding streams to ensure that the programs' capacity does not ebb and flow with public attention as disease threats emerge then recede.

Looking Forward

Florida and Louisiana provide examples of how laboratories at state universities can support IR testing capacity for vector-borne disease control programs. States looking to expand IR testing capacity can consider the feasibility of other models, such as centralized support from a state agency laboratory or IR testing conducted by a network of local/regional programs. As shown by the two case studies, local mosquito control programs will vary with respect to their field and IT capacities.

No matter which approach is adopted, S/THAs will need to consider the resources needed for the various components of IR testing:

- **Field.** Many states already have the capacity to collect field samples for IR bioassays through local mosquito control programs. Florida, Louisiana, and the Northeast Regional Center for Excellence in Vector-Borne Diseases have kits available for collecting and sending field samples for testing.

- **Lab.** While the CDC bottle bioassay kits simplify the laboratory component of IR testing, states will still need to find lab space, address the staffing needs for running these bioassays, and purchase reagents, supplies, and personal protective equipment. In addition, resources are needed for maintaining viable mosquitoes for use in the bioassays. Adults collected in the field need to be sorted and maintained. More often, local programs will want to collect eggs or larvae, which can be raised to adults. Keeping larvae for larvicide testing has similar space, staff, and supplies requirements.

- **IT.** While in Louisiana, local mosquito control programs are sent raw data to conduct their own analysis, in Florida, data analysis and interpretation is performed by the centralized laboratory. States must be cognizant of the data needs of their local programs.

CDC Centers of Excellence

CDC awarded funding for 2017 through 2021 to five regional centers of excellence (COE) to address issues associated with vector-borne diseases across the nation. Interest in research and sharing information on insecticide resistance is consistent with the goals of each of the COEs, based in New York state, California, Florida, Texas, and Wisconsin. The Northeast Regional Center for Excellence in Vector-Borne Diseases based in New York has already established a pesticide resistance monitoring network to support public health and mosquito control agencies in detecting pesticide resistance in mosquito populations in the northeast.

IR testing has been recognized as a core capacity of vector control programs since 2017. While IR testing is not new, it may be a new practice for many public health leaders and/or state health departments. Shifting public health priorities/changing public health culture may be necessary to advance IR testing as a more commonplace practice in health departments. Strategies for this may include adding IR information to:

- Public health officials' orientation materials.
- Mosquito control press release templates.
- Public outreach materials regarding the control of mosquitoes and mosquito-borne diseases.

S/THAs should also review and update plans to include IR testing. ASTHO's Public Health Confronts the Mosquito describes how planning is fundamental to effective mosquito control.

The call for expansion of IR testing is sound. Unfortunately, these investments compete with other emerging public health priorities. For example, the COVID-19 pandemic has changed the landscape of public health and the feasibility of expanding vector-borne disease control activities to include IR testing. The COVID-19 response has required states to shift public health staff and laboratory resources to meet the testing, surveillance, and contact tracing needs associated with controlling COVID-19 spread. Some states have temporarily suspended all laboratory activities except those related to COVID-19.

The recovery period following the pandemic may afford opportunities to improve state public health infrastructure. A recent ASTHO report can help states considering legislation to improve infrastructure for mosquito control. This analysis of the foundational legal authority for mosquito control programs in the United States includes models for sustainable, dedicated funding streams for such programs, including statutory enabling authority to establish and operate a mosquito control program or mosquito control districts.

In summary, insecticide resistance impacts S/THAs' ability to control mosquito-borne disease. States must build capacity to address IR to ensure that the insecticides used by mosquito control programs will continue to effectively kill mosquitoes. Standard protocols for local mosquito control will vary with respect to IR testing. For local programs struggling to support IR testing, Florida and Louisiana provide examples for how states can support IR testing by willing local programs. Successful adoption of IR testing can be a compelling motivation for local programs that express an unwillingness to consider the need for IR testing. While unforeseen public health emergencies, like COVID-19, can divert planned investments in core environmental public health programs, S/THAs may consider partnerships like those described above to bridge the needs gap. Part of our response to any pandemic or natural disaster needs to be investments in the continuity of operations and regular programs, including for the emergence of new and more widespread mosquito-borne disease outbreaks.