2.c.(iii)RELEVANCE STATEMENT

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Development of Novel Application Technology for the Control of the Asian Tiger Mosquito in Urban Environments

Joint Research-Extension Project

Project Summary: This project addresses the control of the invasive vector mosquito *Aedes albopictus* (the Asian tiger mosquito) in urban residential environments. The Asian tiger mosquito is responsible for most complaints to mosquito control programs. These programs rely on area-wide applications of broad-spectrum adulticides to combat this mosquito. This controversial method is ineffective for *Ae*. *albopictus* control. Without any efficient means of control, many mosquito control programs ignore this pest. While larvicides work effectively, it is impractical if not impossible to identify and treat all sources by hand. Area-wide applications of larvicides would solve the problem, but the technology has not been developed sufficiently for use in urban residential settings. This project will develop a novel technology for the area-wide low volume application of the bacterial larvicide *Bacillus thuringiensis* ssp. *israelensis* to control *Ae. albopictus*. We will develop this new biocontrol strategy by adapting low-volume truck-mounted adulticide equipment commonly in use by mosquito control programs to apply liquid *Bti* in an outdoor urban residential setting. After application the larvicide will drift and settle in containers of water where the larvae reside, providing quick, effective control. This IPM approach will reduce the abundance of this pest, the dependence on broad-spectrum adulticides, non-target impacts, and the development of resistance through the use of novel application technology, host-targeted applications of biological larvicides, and training programs for stakeholders. Efficacy of the program will be evaluated by monitoring larval mortality, adult presence, droplet size and distribution, and pesticide persistence. We will also prepare workshops and materials to train mosquito control personnel throughout the northeast and beyond in the use of this technology.

Problem: The Asian tiger mosquito, *Aedes albopictus*, is among the most invasive of all species, and without question the most invasive of all mosquitoes. It was introduced to the U.S. in 1985 and quickly spread. Today, thirty U.S. states are infested and the species continues to expand its range. In the northeast, it has been found in seven states. Naturally found in tree holes, this mosquito has adapted to utilize artificial containers as larval habitats in urban areas. The tiger mosquito is a day-biting mosquito that prefers attacking large mammals including humans. This vicious and persistent day-biting mosquito inflicts painful bites, induces dermatological and allergic manifestations, and significantly affects the quality of life and human well-being. In the U.S., it is regarded as the most important nuisance mosquito. *Aedes albopictus* has also been found naturally infected with several serious human pathogens. It has been implicated as a bridge vector of West Nile virus as a principal vector of dengue virus, dog heartworm, and chikungunya virus. It was responsible for several major epidemics of chikungunya, constituting millions of cases and hundreds of deaths. Most recently, 166 endemic cases were reported in northeast Italy in 2007. The 2001-2002 outbreak of dengue in Hawaii,

with 95 infections, demonstrates the potential of *Ae. albopictus* to transmit this disease in the U.S. via imported cases. From 1986 to 2000, 516 confirmed and 2,128 suspected dengue cases were imported into the U.S., mostly into areas of *Ae. albopictus* activity. Unfortunately, conventional mosquito abatement methods do not affect *Ae. albopictus.* Local mosquito control agencies across the nation mount aggressive control campaigns against salt marsh, floodwater, and many other rural-based mosquito pest species, but they rarely target the urban Asian tiger mosquito. Their efforts tend to be limited to the distribution of leaflets to residents, placing the responsibility for control on unqualified citizens. Currently, there is no effective means to control *Ae. albopictus* on an area-wide basis.

Background: *Bacillus thuringiensis* (*Bt*) is a gram-positive, spore forming, aerobic bacterium. Highly toxic to insects, many varieties of *Bt* are used for agricultural pests. The efficacy of *Bacillus thuringiensis* serovariety *israelensis* (*Bti*) has been demonstrated for many mosquito species in a variety of habitats. Today, formulations of *Bti* are the primary products used for larval mosquito control in the U.S. and other countries. Development of resistance to *Bti* is very difficult and there is almost no impact on non-target species. Normally applied as a solid directly to larval sources, several studies have demonstrated that *Bti* liquid can be applied as a low volume (LV) formulation to successfully control mosquitoes. The majority of this work was conducted in other countries where differences in the strains of *Ae. albopictus*, housing construction and condition, and accepted pest management practices confound the data. Additionally, none of the studies measured the impact on adult mosquito populations. Larval control is meaningless unless it can confer a reduction in the population of adult mosquitoes. While many of the parameters in this project have been explored before, none of the previous studies have brought all of the pieces together in one comprehensive project to determine the efficacy of the LV application of *Bti* in an outdoor urban residential setting for the control of *Ae. albopictus*. This project will evaluate what was learned in the other studies and combine it into one project specifically designed to address the unique problem that faces the public and mosquito control programs in the northeastern U.S. This study addresses several documented needs-assessment evaluations. General Priorities for the Northeast – Biocontrol; 1. Research on biological control of diseases, arthropods, and weeds; extension of this research into production systems of horticultural crops and, 2. Research/extension demonstrations of biocontrol methods for growers and private pest control operators. NEREAP-IPM; Urban pest issues including insects and rodents. Pest Management Alternatives Program; Develop IPM tactics for critical or emerging pests of regional or national magnitude. Community IPM Working Group; 1. Develop a PSMP for residential IPM particularly for suburban outdoor IPM and indoor urban IPM and, 2. Outreach: Develop and create an outreach campaign for residential IPM (radio, TV, and other creative forums). Develop material and distribute to end-users. Measure success of project.

Justification: Existing methods of *Ae. albopictus* control do not work. This project will provide environmentally responsible, efficient, cost effective, and lasting control that can be rapidly and easily implemented by mosquito control programs. Although the material and equipment already exists, this technique has not been used in the U.S. due to a lack of research demonstrating efficacy for this specific problem, and a lack of knowledge by mosquito control programs that adulticiding equipment can be used to apply larvicides on an area-wide basis. Without this project, at worst, many mosquito control programs will continue to ignore this pest and the problem will be left in the unqualified hands of the public who will continue to suffer.

At best, mosquito control programs will continue to rely on ineffective methods leading to wasted resources, the unnecessary use of pesticides with probable non-target impacts, and potential resistance problems. In either scenario, successful *Ae. albopictus* control is unlikely, people will continue to be bitten, and the risk of disease transmission from this mosquito will go unabated. This project will provide a significant benefit to the public and mosquito control programs in the northeast and beyond that are plagued by *Ae. albopictus*.

Objectives: The research component of the proposed study will develop and test the efficacy of LV applications of *Bti* to control *Ae. albopictus* in urban residential environments. First, we will conduct staged field trials where equipment is tested and optimized to deliver the *Bti* to containers of larvae at various distances. Then, we will test the method in actual mosquito control programs under real world conditions. We will demonstrate reductions in larval and adult populations of *Ae. albopictus*, a reduction in the amount of chemical adulticides applied, and an overall reduction in the cost of area-wide control for *Ae. albopictus*. The extension component of the proposed study will develop training workshops as well as printed and web-based materials to disseminate the knowledge generated in this study to the stakeholders. The extension component will begin with the training of local mosquito control agencies in NJ. These training sessions will be used to develop a formal workshop and training materials that will be made available to mosquito control agencies throughout the northeast. All of the impacts listed below will be compounded across the northeast and beyond as various stakeholders adopt this technology.

Anticipated Outcomes: There are several anticipated outcomes from this study. First will be a reduction in the larval populations of *Ae. albopictus* leading to a subsequent reduction in adult populations. The reduction in the adult populations will lower the biting frequency of this pest thereby reducing the risk of exposure to diseases transmitted by this pest. Successful suppression of *Ae. albopictus* will also help to prevent the spread of this invasive pest. The availability of a biorational larvicide will eliminate the dependence on broad-spectrum adulticides such as malathion and synthetic pyrethroids for *Ae. albopictus* control. The residual nature of *Bti* will reduce pesticide use because it can be applied less often than short-lived adulticides. This will reduce human and other non-target exposure to toxic agents. The availability of a larvicide for area-wide *Ae. albopictus* control will eliminate the repeated applications of adulticides which can lead to the development of resistance. This impact encourages the use of IPM by promoting biological control strategies. Adulticides provide very temporary control and must be reapplied to be effective. The persistence of *Bti* will accrue economic benefits by reducing the frequency of applications required for *Ae. albopictus* control resulting in lower material costs and labor expenses. These savings will free funding for other environmentally conscious mosquito control efforts such as open marsh water management. Because this technology uses existing equipment and materials it can be quickly and easily adopted by most any mosquito control program. Additionally because this method provides a cost effective solution to a difficult problem, it is likely to be adopted throughout the northeast and in other parts of the U.S. where *Ae. albopictus* is prevalent.