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HAS *AEDES ALBOPICTUS* ESTABLISHED IN CALIFORNIA?[1]

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ABSTRACT. Significant numbers of the Asian tiger mosquito, *Aedes albopictus,* were detected on the west coast of the USA in mid-June 2001, in containerized oceanic shipments of "lucky bamboo" (*Dracaena* spp.) originating from South China. Wholesale nurseries in California importing large quantities of lucky bamboo became the focal points of infestation. Greater Los Angeles County Vector Control District immediately implemented an adulticiding protocol at the Los Angeles/Long Beach Harbors, followed by larviciding soon after the shipment was delivered to the wholesale nursery. Intensive surveys are currently being conducted above ground and in the underground storm drain systems using battery-operated CDC/CO_2-baited light traps and ovitraps, both enhanced with an attractant (water rinse of tiger shrimps), to determine extent of infestation and perhaps establishment of *Ae. albopictus* locally.

KEY WORDS *Aedes albopictus, Dracaena* spp., introduction, maritime containers, ovitraps, establishment, invasive species

INTRODUCTION

The Asian tiger mosquito, *Aedes* (*Stegomyia*) *albopictus* (Skuse) has wide distribution throughout the Oriental region (Hawley 1988). *Ae. albopictus* mosquitoes are considered to be the most important nuisance and disease vector in the USA (Moore and Mitchell 1997; Moore 1999). It is an aggressive day-biting species and its public health significance is well documented (Rosen et al. 1983, 1985, Schroyer 1986, Boromisa et al. 1987, CDC 1987, Mitchell et al. 1987, Craven et al. 1988, Moore et al. 1988, Francy et al. 1990, Moore & Mitchell 1997, Moore 1999, Reeves 2000). The *Albopictus* Subgroup includes 12 species. The earliest records of its introduction into the continental USA date back to 1946 (Pratt et al. 1946), when small numbers of immature stages were detected in shipments of used tires imported from Asian ports. Introductions of this species into other parts of the world have been usually through the transport of used tires or other containers holding water, via transoceanic shipments from Asian countries (Reiter and Darsie 1984, Knudsen 1986, Moore 1986, Celli et al. 1994).

In mid-June 2001, another mode of introduction was discovered. "Lucky bamboo" (*Dracaena* spp.) is imported into the USA in large quantities (Madon et al. 2002). Originally, these plants were shipped dry (i.e., no free water) to the USA by air. When demand for the plant became overwhelming, air freighting large quantities became prohibitive. As a result, transoceanic shipments (from ports in South China) began arriving via refrigerated maritime containers. To survive the ~15-day oceanic voyage, the *Dracaena* were packaged in cases/crates containing 5–10 cm of water often infested with immature stages of *Ae. albopictus* (and perhaps other exotic species of mosquitoes). The possibility of *Aedes* eggs attached to the lucky bamboo stems was also considered.

The California infestation described in this article apparently was a result of shipments of *Dracaena* in ships arriving at the Los Angeles/Long Beach harbors. Maritime containers are routinely trucked to the U.S. Department of Agriculture (USDA)/Plant Protection Quarantine (PPQ) station located in west Los Angeles for inspection by the PPQ inspectors and the Centers for Disease Control and Prevention (CDC)/Division of Quarantine (DQ) officers. When one of these maritime containers was opened for inspection, the staff observed several mosquitoes flying from it. Many specimens entered the PPQ facilities and subsequently bit the staff. Five battered adult mosquitoes were collected by PPQ staff and subsequently delivered to the Greater Los Angeles County Vector Control District (GLACVCD) by CDC/DQ officers for identification. The specimens were identified as *Ae. albopictus* by one of us (M.S.M), and the identification was confirmed by Harry Savage (U.S. Centers for Disease Control and Prevention, Fort Collins, CO) and reconfirmed by Thomas Zavortink (University of San Francisco).

CONTROL PROTOCOL

Because this invasive species poses both a significant nuisance and public health problem, a control protocol was immediately implemented. The protocol involved: a) adulticiding maritime containers at port of entry; b) adulticiding, initially and periodically, the wholesale nurseries receiving the *Dracaena* shipments in preparation for retail sale and; c) applying larvicides to the inventory of cases containing *Dracaena* stored at the nurseries.

Because it was imperative to prevent adult mosquitoes that may have survived or developed during transoceanic shipment from escaping the cargo containers upon inspection at PPQ, a major facet of the

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Fig. 1. Modified Encephalitis Virus Surveillance (EVS)/CO_2-baited trap.

Fig. 2. Ovitrap.

control protocol involved adulticiding the maritime containers offloaded at the port. Container interiors were injected with aerosolized Scourge® (18% Resmethrin) using a special "underground storm drain larvicide applicator" (developed at GLACVCD) equipped with a Hydro-Blast® steam-cleaning tool nozzle stem. This applicator allowed the nozzle to be inserted though the double-seal doors of the container, preventing the possibility of escape of adult mosquitoes during treatment. Droplet sizes of Scourge ranging from 40 to 60 μ were achieved using an air compressor that produced 100 psi, mounted to the vehicle service unit.

In conjunction with treating the maritime containers with adulticides, the wholesale nurseries, where plants were trucked for preparation and subsequent distribution to retail outlets, were also initially adulticided with ULV applications of Scourge using hand-held Colt foggers (London Fog Inc., Long Lake, MN). Employees at the wholesale nurseries were being bitten by *Ae. albopictus* during the daytime, particularly at one nursery located in Rowland Heights (~32 km east of downtown Los Angeles). Residents in the immediate neighborhood of this nursery were also complaining of daytime-biting mosquitoes. Adulticiding the nurseries continued periodically but was eventually discontinued when data combined from CDC/CO_2-baited traps, ovitraps, and landing-biting observations indicated a lack of adult *Ae. albopictus* activity.

A final stage of the treatment protocol involved larviciding all the cases of *Dracaena* from treated containers after their contents were delivered to the nurseries. This was necessary in order to control *Ae. albopictus* immatures observed in the cases, presumably having survived shipment or resulting from hatched eggs attached to the plant stems. Larvicides used were slow-release formulations of Altosid® and/or *Bti.*

Within a short span of less than 20 days after the discovery in mid-June, on July 2nd, the CDC/Division of Global Migration & Quarantine (DGMQ), in cooperation with the USDA, enacted an Embargo pursuant to Federal Law: 42 CFR 71.32(c). The embargo specifically addressed the prohibition of importation of lucky bamboo in standing water. This expeditious and needed action resulted in effectively curbing the introduction of large numbers of exotic mosquitoes. Currently, all *Dracaena* plants are shipped dry, with stems packaged in a wetted material, such as hydrogel, but without free water capable of supporting immature development.

SURVEILLANCE

Adult *Ae. albopictus* occurrence and breeding were monitored both above- and below-ground within the immediate vicinity of the wholesale nurseries (Kluh et al. 2002). CDC/CO_2-baited traps and ovitraps were used for this purpose. The CDC/CO_2-baited traps were modified with the addition of 2 small bird-feed containers (Fig. 1) filled with a water rinse of black tiger shrimps, *Penaeus monodon* to enhance their attractiveness to *Ae. albopictus* (Thavara 2001). Clear-plastic water bottles (9–20 oz) with tops cut off, 2 holes punched ~1 in. below the top opening for attachment with an "S" hook and for overflow, painted on the outside with a flat black color, were used as ovitraps (Fig. 2). Strips of seed-germination paper (Anchor Paper Company, St. Paul, MN) were used as the oviposition medium (Steinly et al. 1991). Tiger shrimp rinse water was used in the ovitraps too as an attractant.

Attractant was prepared by rinsing 3–5 lbs of tiger shrimp with small amounts of tap water about 8–10 times until ~1–3 gal of rinse water was obtained. The rinse water was stored in a refrigerator and used as needed.

Kluh et al. (2002) and Madon et al. (2002) described the results of surveillance efforts and point-

ed out that, besides adults and immature *Ae. albopictus* being imported in standing water, eggs of this species attached to the stems of lucky bamboo also constituted a problem, as demonstrated at the nursery premises of an importer in Chinatown, just north of downtown Los Angeles. However, to date, larval or adult *Ae. albopictus* infestations have not been detected beyond the confines of this nursery or others that posed similar problems.

The extent of infestation in the Rowland Heights area was apparently localized. Above-ground surveillance indicated the presence of the Asian tiger mosquito up to ~400 m away from the focal point (wholesale nursery) of infestation. The greatest distance staff detected oviposition was ~400 m south of the wholesale nursery in Rowland Heights, and adults were trapped up to ~200 m away from the nursery. In Monterey Park ~5 mi east of downtown Los Angeles, oviposition was detected ~1,000 m from a wholesale nursery (Kenn Fujioka, personal communication). Linthicum et al. (2002) reported on the current *Ae. albopictus* infestations detected in 6 California counties at 14 nurseries/distributors. Trapping efforts in the underground storm drain systems and catch basins within GLACVCD boundaries have fortunately not yielded evidence of infestations in these environs.

Aedes albopictus has wide distribution in the eastern and southern USA. Sprenger and Wuithiranyagool (1986) documented the first establishment of a large population of this species in Houston, TX, in used tires shipped from Japan. Moore (1999) reported that 26 states east of the Mississippi River now have established populations. Because *Ae. albopictus* is a successful container breeder, once introduced into a new area, they appear to readily establish in their new environment. Eradication efforts following their discovery elsewhere in the USA have mainly been unsuccessful because of this mosquito's adaptability to a variety of microhabitats and/or the effort and intensity of control measures applied. However, since the discovery of *Ae. albopictus* in southern California ~1 year ago, surveillance indicates that the rapid response of our control efforts, combined with the cooperative efforts and resources of other participating agencies, including the other vector-control districts in Los Angeles County, California Department of Health Services (CDHS), CDC, and PPQ, has presumably prevented its establishment here. Resources to control mosquitoes are unique to GLACVCD and other districts within the county. Without the presence and efforts of these agencies, *Ae. albopictus* may have become established because neither other local nor state public health agencies have the resources or equipment to control the introduction of an exotic, invasive mosquito species. To date (August 2002), we have not detected the presence of adults or signs of oviposition either at the wholesale nursery or in the immediate vicinity of Rowland Heights. The success of control can be attributed to cooperation and rapid action of several agencies involved: swift action by the CDC/DGMQ and the USDA for the embargo, consultation by CDC staff, cooperation of the USDA/PPQ and CDC/DQ, statewide coordination by CDHS/VBDS, and surveillance and control by the affected local vector-control Districts.

Perhaps, by the summer of 2003, we may be able to state with confidence whether the Asian tiger mosquito has been successfully controlled and whether it's establishment has been effectively curbed in California.

ACKNOWLEDGMENTS

Rapid response to addressing this incidence was possible as a result of cooperation between several agencies and individuals implementing a proactive approach to control the spread of local infestation of the Asian tiger mosquito. Roger Nasci, Chester Moore, Harry Savage, and Duane Gubler of the Centers for Disease Control and Prevention, Fort Collins, CO, provided ongoing guidance and consultation. We also thank Clifford Smith, Dianna Bowman, and Brian Henderson, USDA/APHIS/PPQ, Long Beach, CA; Ronald Hennessey, Tony Nakamura, Nabil Armanious, Michael Bandiera, and Dave Faires, USDA/APHIS/PPQ station, West Los Angeles, CA; Officers Michael Marty and Rey Fernandez, CDC/NCID/DQ, Los Angeles Quarantine station, CA; Tony Perez and David Kim, CDC/DGMQ, Atlanta, GA; Vicki Kramer and Kenneth Linthicum, CDHS/VBDS; Tom Zavortink, University of San Francisco, CA; Kenn Fujioka, San Gabriel Valley MVCD, CA; Jeffery Beehler, West Valley MVCD, CA; and finally our GLACVCD staff, Jacqueline Spoehel, Paul O'Connor, Saeed Tabatabaeepour, Jennifer Wilson, Mark Hall, Howard Marriotta, Allan O'Connel, Tina Smith, Sylvia Lopez, Thomas Tran, and Douglass Silva.

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ERRATA

On page 298 in our paper "Has *Aedes albopictus* established in California?", *Journal of the American Mosquito Control Association* 19(4):297–300, by Minoo B. Madon, Jack E. Hazelrigg, Michael W. Shaw, Susanne Kluh and Mir S. Mulla, the legends for Figures 1 and 2 were reversed. Fig. 1 should read "Ovitrap" and Fig. 2 should read "Modified Encephalitis Virus Surveillance (EVS)/CO_2-baited trap."

Minoo B. Madon

On page 325, in the section subtitled "Species-diagnostic PCR to identify *Cx. pipiens* or *Cx. quinquefasciatus,*" in our paper "Polymerase chain reaction assay identifies North American members of the *Culex pipiens* complex based on nucleotide sequence differences in the acetylcholinesterase gene *ACE.2*," *Journal of the American Mosquito Control Association* 19(4):323–328 by Stephen Aspen and Harry M. Savage, we state that 20 ng of template DNA was used. In the current protocol that we use on a routine basis in our laboratory, the amount of template DNA is typically 300 ng.

Harry M. Savage
Stephen Aspen