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SURVEY OF CONTAINER-INHABITING MOSQUITOES IN CLEMSON, SOUTH CAROLINA, WITH EMPHASIS ON *AEDES ALBOPICTUS*[1]

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ABSTRACT. A total of 530 oviposition trap samples were collected within a 10-km radius of Clemson University between March 30 and October 19, 1993. From 19,664 larvae reared from collected eggs, 7 species were identified: *Aedes albopictus* (89%), *Ae. triseriatus* (6.5%), *Culex restuans* (2.7%), *Cx. territans* (0.6%), *Cx. pipiens* complex (0.7%), *Toxorhynchites rutilus septentrionalis* (0.2%), and *Orthopodomyia signifera* (0.1%). This is the first record of *Ae. albopictus* in Clemson. *Aedes aegypti* was not found. Of the 41 ovitrap locations, 100% were positive for *Ae. albopictus.*

INTRODUCTION

Aedes albopictus (Skuse) is a container-inhabiting mosquito found in a variety of artificial and natural containers in sylvan, rural, suburban, and urban areas (Hawley 1988). The first sustained, natural population of *Ae. albopictus* in the United States was found in Houston, TX, in 1985 (Sprenger and Wuithiranyagool 1986). *Aedes albopictus* has since spread eastward to the Atlantic coast, north as far as Chicago, IL, and south into southern Florida (Sweeney et al. 1988, O'Meara et al. 1993).

In 1992 several members of the Department of Entomology at Clemson University found larval and adult *Ae. albopictus* at their residences. Simultaneously, complaints of unusually high mosquito activity were voiced by residents of the Clemson area. The potential medical importance of endemic *Ae. albopictus* populations (Knudsen 1986, Konishi 1989, Mitchell 1991), coupled with the increasing complaints, prompted an investigation of the status of *Ae. albopictus* and other container-inhabiting mosquitoes in the area around Clemson University.

Published reports on the mosquito fauna in the Clemson area are limited. The objectives of this study were to identify the container-inhabiting species in the Clemson area, determine relative abundances of the major species, track population densities as they fluctuate over time, and target foci for future mosquito control programs.

MATERIALS AND METHODS

The oviposition traps used were modifications of the black jar trap developed for use in the *Aedes aegypti* (Linn.) Eradication Program (Fay and Eliason 1966, Jakob and Bevier 1969). Each trap consisted of a 650-ml black plastic cup filled with 450 ml of tap water. A hole in the side of each cup prevented an overflow in case of heavy rain. The oviposition surface was a piece of masonite (2.5 × 12.7 × 0.32 cm) affixed vertically to the inside of the cup by a paper clip.

Forty-one sites were selected at random within a 10-km radius of Clemson University. At each location, oviposition traps were placed in preferred habitat in accordance with the "Rapid Survey Protocol for Detecting *Aedes albopictus*" (Centers for Disease Control 1987).

Samples were taken at 2-wk intervals from March 30 through October 19, 1993. The ovitraps were left out for 7 days (with the exception of the cups collected on June 1, which were exposed for 2 wk) after which each ovitrap was covered, labeled, and returned to the laboratory. The oviposition paddles from each ovitrap were transferred to white plastic cups filled with tap water, and each was labeled with the appropriate date and site number. Emerging larvae were fed a bovine liver suspension according to the procedure outlined for *Ae. aegypti* by Munstermann and Wasmuth (1985) and were reared at 25 ± 2°C, 80–85% RH, and a 16:8 L:D photoperiod. At the beginning of the rearing procedure, the cups were inspected for *Toxorhynchites rutilus septentrionalis* (Dyar and Knab) eggs and larvae, and similar inspections were made daily for approximately 1 wk. The predation effects due to the presence of immature *Tx. r. septentrionalis,* therefore, were assumed to have been minimized. Rearing cups also were inspected for heavy larval mortality (more than 4–5 dead larvae) in which case the cup would be excluded from the rest of the study.

Approximately ½ of the mosquitoes were preserved in 80% ethanol as 4th instars for later

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Table 1. Summary of the oviposition trap survey conducted in Clemson, SC, between March 30 and October 19, 1993.

			Ovitraps[1]		Sites[2]	
Species	*n*	Percent of total	No. positive	Percent positive	No. positive	Percent positive
Aedes albopictus	17,550	89.3	280	52.8	41	100.0
Aedes triseriatus	1,283	6.5	62	11.7	33	80.5
Culex restuans	530	2.7	11	2.1	7	17.1
Culex pipiens	128	0.7	1	0.2	1	2.4
Culex territans	113	0.6	4	0.8	2	4.9
Toxorhynchites rutilus septentrionalis	41	0.2	22	4.2	17	34.2
Orthopodomyia signifera	19	0.1	1	0.2	1	2.4
Total	19,664	100				

[1] 530 oviposition traps were collected.
[2] Forty-one sites were sampled.

identification. The remaining larvae were allowed to pupate, and adult identifications were made after emergence. The identification of representative specimens was confirmed by Richard F. Darsie, Jr., at the International Center for Public Health Research in McClellanville, SC.

In addition to the oviposition traps, a single survey was conducted in which 54 containers found in the ovitrap survey area were sampled. The results were compared with those of the ovitraps. A large difference in mosquito fauna or relative abundance of species between the containers and the oviposition traps would have indicated a sampling bias caused by the oviposition traps. Containers ranged in size from 55-gallon metal barrels to plastic drink cups.

RESULTS

The 29-wk survey resulted in 530 oviposition trap collections and 19,664 identified mosquitoes of 7 species. *Aedes albopictus* was the most abundant and composed 89.2% of the collection, followed by *Aedes triseriatus* (Say), which made up 6.5% of the total. *Culex restuans* Theobald, *Culex pipiens* Linn. complex, *Culex territans* Walker, *Tx. r. septentrionalis,* and *Orthopodomyia signifera* (Coq.) represented 2.7, 0.7, 0.6, 0.2, and 0.1% of the collections, respectively (Table 1).

Seasonal data for the mean number of larvae per ovitrap for each species indicated that oviposition activity was very low until late May and early June (Figs. 1 and 2). The population curves for most species were difficult to interpret. For the *Ae. albopictus* population, however, there was a consistent rate of increase and an obvious peak on July 13 (Fig. 1). Numbers of *Ae. albopictus* remained relatively high ($n \geq 24$/ovitrap) through the end of September, whereas the other species were rarely found after July 13 (Fig. 2). Samples taken on October 5 and 19 had large numbers of eggs but nearly 100% were in diapause.

The percentage of sampling locations positive for a given species for at least 1 wk was used as an index for the relative distribution of that species. *Aedes albopictus,* for example, was the most widespread species and was collected at 100% of the trap sites, whereas *Ae. triseriatus* was found at 80.5% of the sites (Table 1). Of the remaining species found, *Tx. r. septentrionalis* was fairly well distributed (34.2%), but *Cx. restuans, Cx. territans, Cx. pipiens* complex, and *Or. signifera* appeared to be very localized. The percentage of the total number of ovitraps positive for a particular species was calculated as an additional indicator of a species' distribution throughout the season (Table 1).

Nine species were collected in the container survey. In addition to the 7 species found in the ovitraps, a single *Culex salinarius* Coq. and one *Anopheles punctipennis* (Say) also were collected. As with the ovitraps, the containers surveyed indicated that *Ae. albopictus* was the most abundant species both numerically and spatially, composing 94.8% of the 1,220 larvae collected from the 54 containers (Table 2). The most abundant species were *Ae. albopictus, Cx. restuans,* and *Ae. triseriatus.* The abundance of *Ae. triseriatus* in containers was significantly lower than in the ovitraps (0.9% vs. 6.52%). Of the 2 tree holes sampled, the dominant species in each was *Ae. albopictus,* whereas only a single *Ae. triseriatus* was collected.

DISCUSSION

Several workers have reported a decline in *Ae. aegypti* populations in the southeastern USA

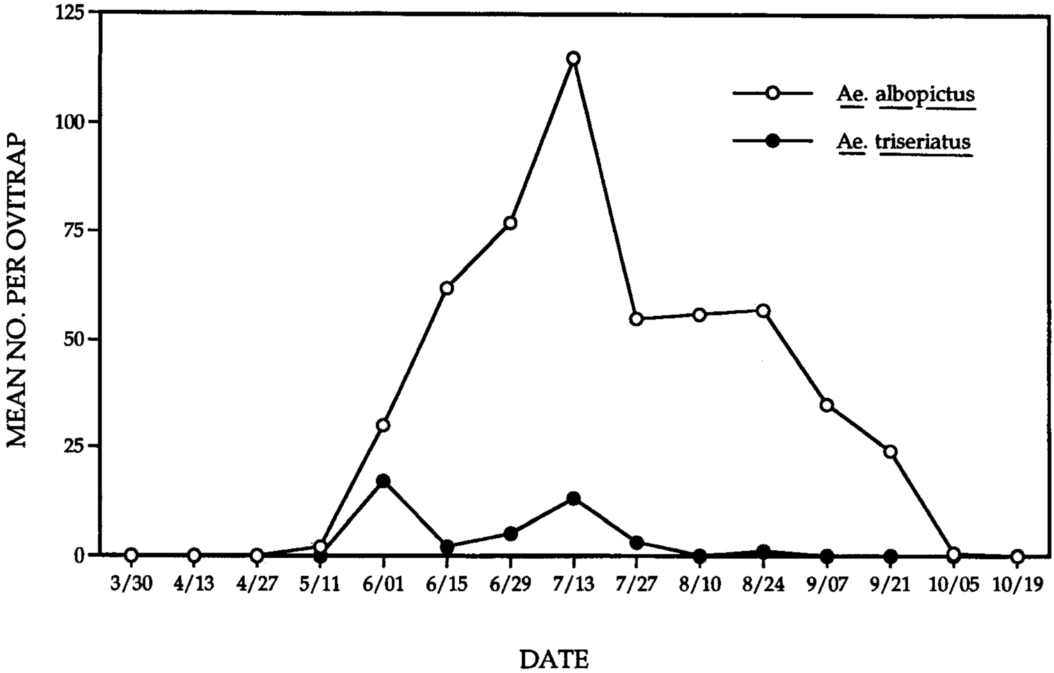

Fig. 1. Mean number of *Aedes albopictus* and *Aedes triseriatus* larvae per oviposition trap between March 30 and October 19, 1993, in Clemson, SC.

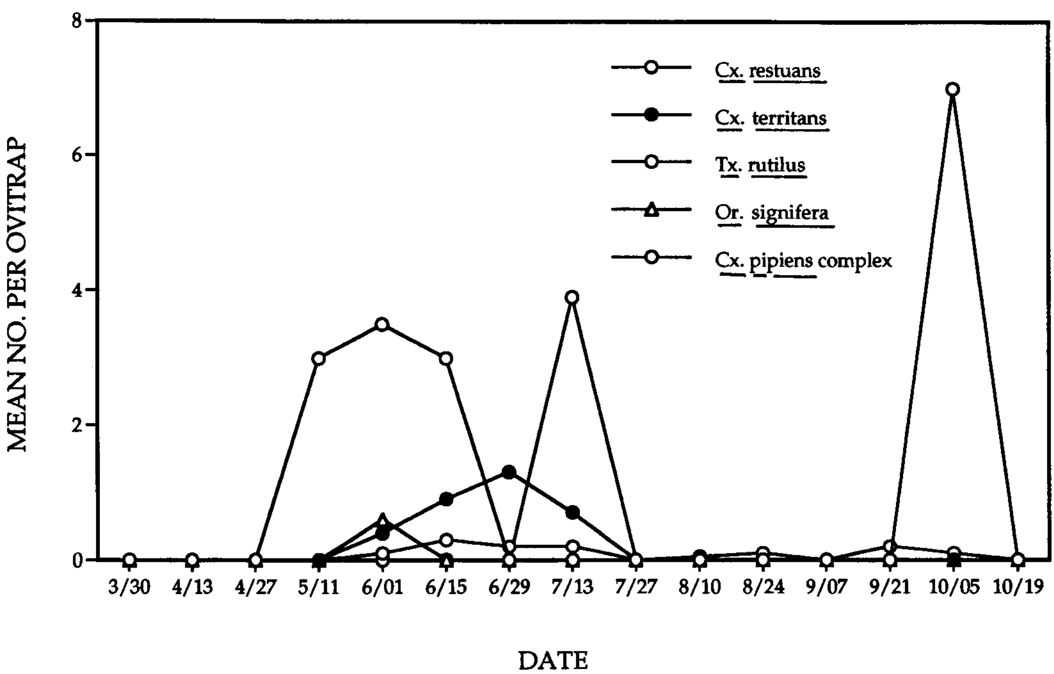

Fig. 2. Mean number of larvae per oviposition trap of several mosquito species between March 30 and October 19, 1993, Clemson, SC.

Table 2. Summary of the container survey conducted in Clemson, SC, between September 23 and 24, 1993.

Species	n[1]	Percent of total	No. of positive containers[2]	Percent positive
Aedes albopictus	1,157	94.8	38	70.4
Aedes triseriatus	11	0.9	4	7.4
Culex restuans	30	2.5	3	5.6
Culex pipiens complex	4	0.3	1	1.9
Culex territans	8	0.7	2	3.7
Culex salinarius	1	0.1	1	1.9
Toxorhynchites rutilus septentrionalis	6	0.5	3	5.6
Orthopodomyia signifera	2	0.2	1	1.9
Anopheles punctipennis	1	0.1	1	1.9

[1] Total number of larvae collected was 1,220.
[2] Total number of containers surveyed was 54.

since the introduction of *Ae. albopictus* (Hobbs et al. 1991). Our results demonstrated this trend for the Clemson area. Of the 19,664 mosquitoes identified, no *Ae. aegypti* were found. However, surveys for *Ae. aegypti* in the Clemson area (Pickens County) were positive prior to the importation of *Ae. albopictus* (Morlan and Tinker 1965, Davis et al. 1983). Numerous studies have tried to isolate a competitive mechanism to explain the displacement of *Ae. aegypti* by *Ae. albopictus* (Nasci et al. 1989, Duhrkopf and Hartberg 1992, Klowden and Chambers 1992).

The container survey indicated no significant sampling bias caused by a differential attractiveness of the ovitraps to the various species. As with the ovitraps, *Ae. aegypti* was not found in containers. Therefore, *Ae. aegypti* is no longer believed to be present at a perceptible level in Clemson, SC, or its surrounding areas. Species diversity was slightly greater in the containers, but for each of the 2 species found only in containers, only a single larva was collected.

Interestingly, *Cx. territans* was collected at 2 sampling sites on multiple sampling dates. This was unexpected because these mosquitoes are generally found in cool ponds and stream pools and seldom in containers (Carpenter and LaCasse 1955). Both collection sites were in close proximity to ponds. It is likely that the appearance of *Cx. territans* in these ovitraps was an artifact of expanding populations in other nearby areas. The 2 medically important species, *Ae. albopictus* and *Ae. triseriatus,* were evenly distributed over the area sampled. It was, therefore, unnecessary to identify foci to mosquito control personnel for future reference.

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