ARTICLES

AEDES BAHAMENSIS: ITS INVASION OF SOUTH FLORIDA AND ASSOCIATION WITH *AEDES AEGYPTI*

G. F. O'MEARA,[1] V. L. LARSON,[1] D. H. MOOK[1] AND M. D. LATHAM[2]

ABSTRACT. The exotic mosquito, *Aedes bahamensis*, is now well-established in south Florida, where it is widely distributed throughout Dade and southern Broward Counties in both urban and rural areas east of the Everglades. When discarded automobile tires were sampled in areas near human habitation, larvae and pupae of *Ae. bahamensis* were frequently found in association with immature *Ae. aegypti*. Elsewhere, however, *Ae. bahamensis* generally occurred in the absence of *Ae. aegypti*. The persistence of *Ae. bahamensis* populations at specific sites was documented in egg collections from ovitraps and in larval samples from the water retained in discarded tires.

INTRODUCTION

In the Bahamas, on Grand Bahama and New Providence islands, *Aedes bahamensis* Berlin is a common peridomestic mosquito. The larvae occur in water accumulations, not only in discarded tires and other types of artificial containers, such as those used by immature *Aedes aegypti* (Linn.), but also in tree holes and rock holes (Spielman and Weyer 1965, Belkin and Heinemann 1975). Although the immatures of *Ae. bahamensis* and *Ae. aegypti* are found together on Grand Bahama Island, *Ae. aegypti* populations tend to be restricted to the western end of the island, while *Ae. bahamensis* populations are more widely distributed. Spielman and Feinsod (1979) suggest that the presence of *Ae. bahamensis* has restricted the spread of *Ae. aegypti*.

In south Florida, *Aedes bahamensis* was discovered initially during the fall of 1986 in collections from light traps baited with dry ice and from ovitraps. Ironically, these ovitraps were being used to evaluate the spread of another exotic mosquito, *Aedes albopictus* (Skuse) (Pafume et al. 1988). The establishment of *Ae. bahamensis* in south Florida may have a significant impact on *Ae. aegypti*, which in recent years has been a very common domestic mosquito in this region. Here, *Ae. aegypti* larvae are most frequently found in scrap tires which have been stored improperly or dumped illegally (Frank 1981). In the present study, we have investigated the current distribution of *Ae. bahamensis* and its association with *Ae. aegypti* by sampling for these mosquitoes in and around areas containing discarded tires.

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[1] Florida Medical Entomology Laboratory, IFAS, University of Florida, Vero Beach, FL 32962.

[2] Dade County Mosquito Control Division, Miami, FL 33178.

MATERIALS AND METHODS

Ovitraps were used to detect the presence and the persistence of *Ae. bahamensis* and *Ae. aegypti* at several sites in Dade and Broward Counties, Florida. Each ovitrap consisted of 2, glossy black, polypropylene plastic jars equipped with red velour paper paddles (Kloter et al. 1983). To stabilize the ovitrap, the pair of jars was attached to a piece of plywood (30 cm long × 11 cm high) painted glossy white. A drain hole about two-thirds up the side of the jar limited flooding, and a wire bar at the mouth of the jar prevented animals from removing water from the trap. Once a week paddles were replaced and tap or bottled water was added to the jars if necessary. Paddles retrieved from the field were examined under a stereomicroscope, and those positive for mosquito eggs were flooded to induce hatching. Eggs that did not hatch during the first flooding episode were allowed to dry and then submerged again. Larvae so obtained were identified to determine species composition in each trap collection. On a few sample dates both the paddles and the water from the ovitraps were examined for *Aedes* mosquitoes.

Sampling with ovitraps was conducted in commercial, residential and undeveloped areas harboring artificial containers, which were usually discarded tires. The number of traps per site varied from 2 to 5 depending upon the size of the site and the relative number of water-holding containers.

To assess the distribution of *Ae. bahamensis* further, and to evaluate its associations with *Ae. aegypti*, water accumulations in tires and other types of containers were sampled for immature *Aedes* mosquitoes using siphons, strainers or dippers. Since containers differed greatly in size, shape, accessibility and amount and depth of retained water, several devices for extracting immature mosquitoes were used. Species identification of field-collected larvae and pupae was conducted in the laboratory. Young (1st- or 2nd-instar) larvae were reared to later larval stages and then identified. Wild-caught pupae were held in the laboratory until the adults emerged.

When viewed under a microscope at low magnification (25×) the 3rd- and 4th-instar larvae of the 3 *Aedes* species (*Ae. aegypti, Ae. bahamensis* and *Ae. triseriatus* (Say)) known to colonize container habitats in south Florida are distinguished by a number of morphological differences. Readily observable, diagnostic characteristics were used to separate the larvae of the 3 species. The characters used were the presence or absence of 1) stellate setal tufts on the abdomen and 2) a patch of spines on the dorsal lateral margin of the anal saddle. These setal tufts and spines are present in *Ae. bahamensis* but not in *Ae. aegypti* and *Ae. triseriatus* (Berlin 1969, Carpenter and LaCasse 1955). In *Ae. aegypti,* the 4 anal papillae are subequal and seta 7-C is simple, whereas in *Ae. triseriatus* the ventral pair of anal papillae is shorter than the dorsal pair, and seta 7-C is 6-branched (Darsie and Ward 1981). The adults of these *Aedes* mosquitoes have very different patterns of scale coloration which are readily evident without the aid of a microscope (Berlin 1969, Carpenter et al. 1946).

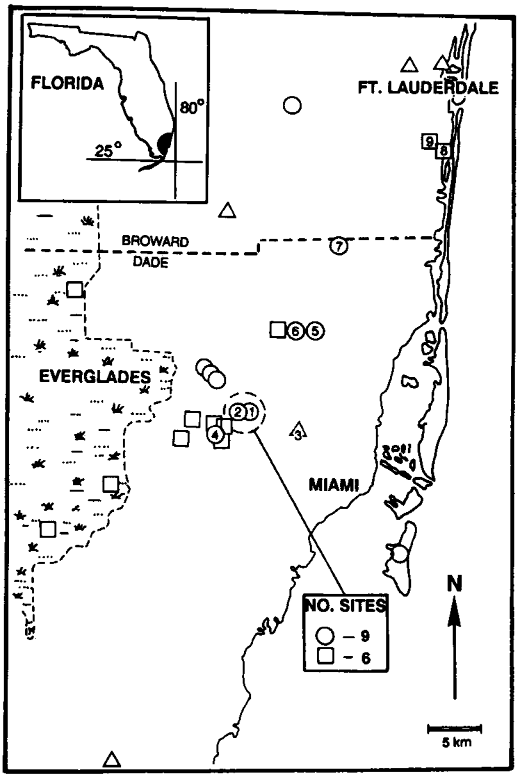

Fig. 1. Distribution of *Aedes bahamensis* and its association with *Ae. aegypti* in Dade and Broward Counties, Florida. Numbered sites (1–9) indicate ovitrap locations where both egg and larval collections were taken to assess the occurrence of *Aedes* mosquitoes. Within the circled area surrounding sites 1 and 2, there were 15 additional collecting sites. The species composition of these sites is summarized in the box in the lower right portion of the figure. Symbols: □ = *Ae. bahamensis,* △ = *Ae. aegypti,* ○ = both species.

RESULTS AND DISCUSSION

Aedes bahamensis appears to be widely distributed throughout Dade and southern Broward Counties, Florida, in both the urban and rural areas east of the Everglades (Fig. 1). Sites with discarded tires and/or occasionally other types of artificial containers were positive for immature *Ae. bahamensis* at 37 locations. At many of these sites (n = 20), *Ae. bahamensis* was found in association with *Ae. aegypti.* The 2 species occurred together over a wide range of habitats, including those in residential, commercial, and industrial zones of the city and in undeveloped or sparsely developed rural areas near human habitation. Generally, immatures of *Ae. bahamensis* were found in the absence of *Ae. aegypti* at isolated tire dump sites along rural roads and in undeveloped areas bordering the Everglades. Some exceptions to this pattern occurred where *Ae. bahamensis* was either the only or the overwhelmingly dominant *Aedes* mosquito in aquatic sites located in urban areas with considerable human activity. But, within the region of south Florida containing *Ae. bahamensis,* we did find a tire dump inhabited only by *Ae. aegypti.*

Autogeny (i.e., the ability to produce eggs without blood feeding) is a very common trait in *Ae. bahamensis* populations (Spielman and Weyer 1965, O'Meara 1985). However, with few exceptions, blood feeding is a prerequisite for all egg production in domestic-type *Ae. aegypti*—the only naturally occurring form found in Florida (Trpis 1977). Being less dependent on vertebrate blood for egg production may be a key factor that permits *Ae. bahamensis* to sustain populations at feral sites where the absence of *Ae. aegypti* is probably due to a lack of suitable hosts.

Immature *Ae. aegypti* develop more rapidly than those of *Ae. bahamensis.* Laboratory studies of interspecific larval competition between the two species have shown *Ae. aegypti* to be the superior competitor, often eliminating *Ae. bahamensis* from experimental containers (Packer 1987).[3] Nevertheless, at certain field sites in south Florida, *Ae. bahamensis* populations have persisted for several months in the presence of *Ae. aegypti*. Coexistence of the two species was particularly evident in collections taken from discarded tires along a canal bank in a commercial section of Opa Locka, Florida (site 5, Fig. 1). This site was sampled on 4 occasions over a seven month period for the presence of larvae and pupae. Not only were both *Ae. bahamensis* and *Ae. aegypti* present on each sample date, but they were often found together in the same tire (Fig. 2). The proportion of *Aedes*-positive tires containing both species ranged from 38 to 74%. When similar samples were taken from tires at another illegal dump (site 7, Fig. 1) located on an undeveloped tract of land near a condominium complex, most tires positive for *Aedes* mosquitoes contained only *Ae. bahamensis*. Here, *Ae. bahamensis* was found on 4 of 4 sampling dates, whereas *Ae. aegypti* was found on only 2 of the dates (Fig. 2). At both sites 5 and 7, the invading species, *Ae. bahamensis,* has shown no signs of being eliminated by the resident, *Ae. aegypti.*

Ovitrap sampling began in late March 1988 during the dry season when competition from other ovipositional habitats was at a minimum. Once the wet season started in May, both paddles and water in the ovitrap cups were retrieved since rainfall frequently hatched some or all the eggs on many paddles. The type of ovitrap used in the present study was originally designed to assess *Ae. aegypti*; thus, the collections may have been biased towards this species. Despite these shortcomings, the ovitraps were still very useful for evaluating associations among container-inhabiting *Aedes* mosquitoes. In particular, weekly monitoring with ovitraps provided additional evidence for the persistence of *Ae. bahamensis* at sites where it occurred with or without *Ae. aegypti.*

Essentially all intact eggs retrieved from ovitrap paddles hatched in the laboratory during either the first or second flooding. The results shown in Fig. 3 were derived from the identification of larvae from ovitraps and from eggs hatched in the laboratory. Recently, J. R. Linley (personal communication) has identified morphological differences between the eggs of *Ae. bahamensis* and *Ae. aegypti* that can be observed readily with a stereomicroscope. Hence, in future studies involving ovitrap collections of these two *Aedes* mosquitoes, it should be possible to identify eggs directly.

Eggs and/or larvae of *Aedes bahamensis* were collected in ovitraps at 8 of 9 sites, and *Ae. aegypti* was also found at 5 of these *Ae. bahamensis*-positive sites (Fig. 3). At most sites, *Ae. bahamensis* was detected in many of the weekly collections taken over the course of the study. At one site only (7) did *Ae. aegypti* appear to be replacing *Ae. bahamensis*: the first 9 weekly ovitrap collections at site 7 contained only *Ae. bahamensis,* whereas the last 2 weekly collections had only *Ae. aegypti.* However, tires sampled for immature *Aedes* mosquitoes (Fig. 2) indicated that *Ae. bahamensis* was clearly the dominant mosquito at site 7 both during and after the period during which ovitraps were operated. At this site, no immature *Ae. aegypti* were found in samples taken from tires in June or July.

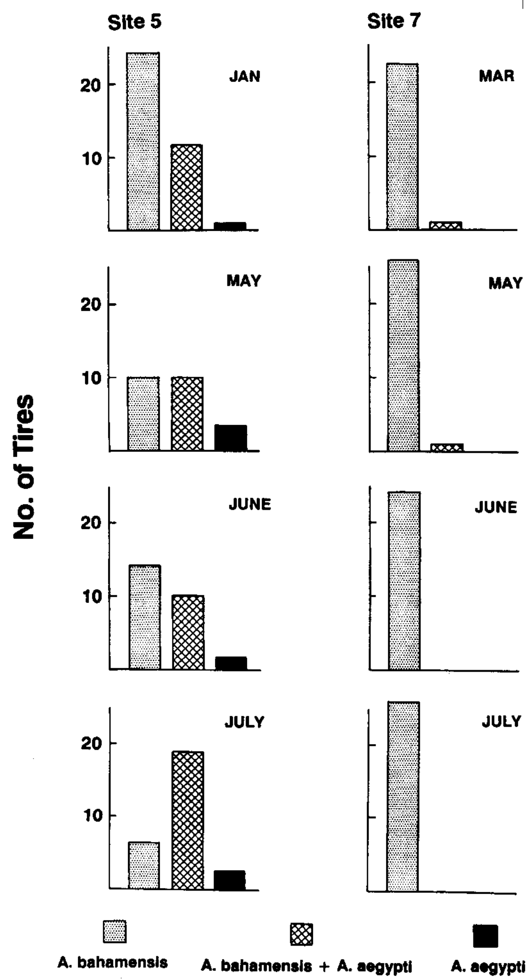

Fig. 2. The occurrence of *Aedes bahamensis* and *Ae. aegypti* larvae and/or pupae in discarded tires containing *Aedes* mosquitoes at sites 5 and 7 (see map, Fig. 1) during 1988. Collections at both sites were taken on the same date in May, June and July.

[3] Packer, M. J. 1987. Reproductive strategies of mosquitoes (Diptera: Culicidae). Ph.D. Thesis. University of Dundee.

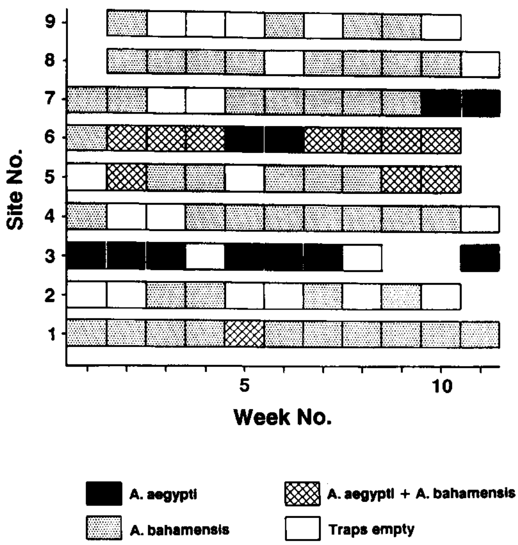

Fig. 3. Species composition in weekly ovitrap collections taken from 24 March to 9 June 1988 at nine sites.

Weekly ovitrap collections containing both *Aedes* species were most prevalent at site 6, an inner city, residential area where the yards surrounding single and multifamily housing units were littered with a variety of water-holding containers. In many ways this area represented typical *Ae. aegypti* breeding grounds. Even here, *Ae. bahamensis* persisted throughout the trapping period.

These short-term studies need to be followed up with observations over longer time periods in order to characterize more accurately associations and interactions between *Ae. bahamensis* and *Ae. aegypti* populations. The preliminary findings suggest that *Ae. bahamensis* will continue to persist in south Florida even in areas which in the past have been dominated by *Ae. aegypti.* The last 2 winters (1986-87 and 1987-88) have been very mild in south Florida, and during the past year *Aedes* species remained active throughout the year. At site 5, for example, all developmental stages of *Ae. bahamensis* and *Ae. aegypti* were found on each sample date, including the one in January 1988. The response of *Ae. bahamensis* populations to cooler winter temperatures may be an important factor affecting its future distribution. Since it is a subtropical species, *Ae. bahamensis* would probably be severely limited in its northerly spread by low winter temperatures.

Aedes bahamensis larvae and pupae were found in discarded tires and other types of artificial containers at both heavily shaded and unshaded sites. The extent to which south Florida populations of *Ae. bahamensis* are using other types of aquatic habitats, such as phytotelmata or water retained in rock holes, remains to be determined. One of our study sites (8) is adjacent to a mangrove swamp, and burrows of land crabs are very common in and around the area containing piles of discarded tires. Here, we have sampled a few of these burrows (n = 9) for the presence of immature *Ae. bahamensis.* Although none of these burrows contained *Ae. bahamensis,* a few *Deinocerites cancer* Theobald larvae were collected from tires at this site.

The spread of *Ae. bahamensis,* especially into areas where it might displace or reduce *Ae. aegypti* populations, may have some beneficial effects. The invading species appears to be less effective as a vector of certain arboviruses (Llewellyn et al. 1970). Moreover, if female *Ae. bahamensis* forego blood feeding until after the first oviposition, then their pest or nuisance potential would probably be less than that of female *Ae. aegypti.* It should be noted, however, that around some of our study sites, numerous *Ae. bahamensis* readily attacked human hosts. Adult *Ae. bahamensis* were generally inactive during the daytime until about 1 or 2 hr before sunset. Flight and blood-seeking activity continued after sunset, at least for a few hours. By contrast, *Ae. aegypti* is diurnal with 2 peaks of activity, one in the midmorning and the other in the afternoon. These differences in daily activity patterns should be considered in any assessment of the relative pest status of *Ae. bahamensis.*

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REFERENCES CITED

Belkin, J. N. and S. J. Heinemann. 1975. Collection records of the project "Mosquitoes of Middle America" 3. Bahama Is. (BAH), Cayman Is. (CAY), Cuba (CUB), Haiti (HAC,HAR,HAT) and Lesser Antilles (LAR) Mosq. Syst. 7:367–393.

Berlin, O. G. W. 1969. Mosquito studies (Diptera: Culicidae). XII. A revision of the neotropical subgenus *Howardina* of *Aedes.* Contrib. Am. Entomol. Inst. (Ann Arbor) 4(2):1–190.

Carpenter, S. J. and W. J. LaCasse. 1955. Mosquitoes of North America (north of Mexico). University of California Press, Berkeley, CA. 360 pp.

Carpenter, S. J., W. W. Middlekauff and R. W. Chamberlain. 1946. The mosquitoes of the southern United States east of Oklahoma and Texas. Am.

Midl. Natur., Monogr. No. 3, University of Notre Dame, Notre Dame, IN. 292 pp.

Darsie, R. F., Jr. and R. A. Ward. 1981. Identification and geographical distribution of the mosquitoes of North America, north of Mexico. Mosq. Syst. (suppl.) 1:1–313.

Frank, J. H. 1981. Recycling of discarded tires for the control of *Aedes aegypti*. J. Fla. Anti-Mosq. Assoc. 52:44–48.

Kloter, K. O., D. D. Bowman and M. K. Carroll. 1983. Evaluation of some ovitrap materials used for *Aedes aegypti* surveillance. Mosq. News 43:438–441.

Llewellyn, C. H., A. Spielman and T. E. Frothingham. 1970. Survival of arboviruses in *Aedes albonotatus*, a peridomestic Bahaman mosquito. Proc. Soc. Exp. Biol. Med. 133:551–554.

O'Meara, G. F. 1985. Ecology of autogeny in mosquitoes. pp. 459–471. *In*: L. P. Lounibos, J. R. Rey and J. H. Frank (eds.), Ecology of mosquitoes: proceedings of a workshop. Florida Medical Entomology Laboratory, Vero Beach, FL.

Pafume, B. A., E. G. Campos, D. B. Francy, E. L. Peyton, A. N. Davis and M. Nelms. 1988. Discovery of *Aedes* (*Howardina*) *bahamensis* in the United States. J. Am. Mosq. Contr. Assoc. 4:380.

Spielman, A. and F. M. Feinsod. 1979. Differential distribution of peridomestic *Aedes* mosquitoes on Grand Bahama Island. Trans. R. Soc. Trop. Med. Hyg. 73:381–384.

Spielman, A. and A. E. Weyer. 1965. Description of *Aedes* (*Howardina*) *albonotatus* (Coquillett), a common domestic mosquito from the Bahamas. Mosq. News 25:339–343.

Trpis, M. 1977. Autogeny in diverse populations of *Aedes aegypti* from East Africa. Tropenmed. Parasitol. 28:77–82.