AEDES AEGYPTI INFESTATION CHARACTERISTICS IN SEVERAL CARIBBEAN COUNTRIES AND IMPLICATIONS FOR INTEGRATED COMMUNITY-BASED CONTROL

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ABSTRACT. Periodic larval surveys for *Aedes aegypti* were conducted in 11 Caribbean countries between 1983 and 1989. On average, there were 24 potential larval habitats per house including 4.9 which held water at the time of examination. Breteau indices for the various islands ranged from 34.7 to 121.6. In descending order of importance, water storage drums, house plants, buckets, used tires and miscellaneous small discarded containers accounted for 84% of all foci. Highest rates of infestation were found in tires (38.4%) and drums (33.8%). For the development of integrated community-based vector control programs, not only should consideration be given to the larval ecology of *Ae. aegypti*, but also to the sociological significance of the various container habitats and the selection of control strategies most appropriate for their management.

INTRODUCTION

With few exceptions Caribbean national *Aedes aegypti* (Linn.) control programs are heavily reliant upon routine house-to-house larviciding of actual and potential larval habitats of this peridomestic vector of dengue, dengue hemorrhagic fever (DHF) and yellow fever. Program objectives, essentially unchanged since the 1960s, are those of time-limited insecticidal eradication campaigns in which little regard is given to the ecology of the vector.

Despite regional political mandates to eradicate the mosquito, infestation levels remain high in almost all neotropical countries. By 1962, there were 9 Caribbean islands where *Ae. aegypti* was no longer found. Twenty-eight years later, in 1990, only the Cayman Islands reported vector-free status (PAHO, unpublished data), and this at the expense of an aggressive surveillance system to eliminate periodic introductions (J. E. Davies, unpublished data). The increasing frequency of dengue epidemics in the Caribbean and Latin America over the last 20 years and the emergence of DHF as a serious public health problem are a reflection of widespread failure to effectively control *Ae. aegypti* (Pinheiro 1989).

Although many of the Caribbean national vector control programs have accumulated considerable information on larval ecology, much of its remains unanalyzed and unpublished. Nevertheless, in Suriname, Tinker (1974) reported that roof gutters were the main larval habitats, while in Puerto Rico, Moore et al. (1978) cited, in descending order of importance, animal watering pans, tires, tin cans, flower pots and buckets. In the Cayman Islands drums used for the collection of roof catchment rainwater were found to be the primary source (Nathan and Giglioli 1982). In Anguilla, rock holes are commonly infested (Parker et al. 1983). Recent studies in Martinique by Yebakima (1989) revealed that flower vases were the main larval habitats, followed by drums, used tires and tin cans. Knudsen (1983) reviewed breeding habitat preferences in the Caribbean, citing various published and unpublished reports noting a range of man-made and natural sites including drums, cisterns, flower vases, small containers and tires.

As a basis for development of community-orientated Primary Health Care (PHC) strategies for integrated control, routine technical advisory visits to the national vector control programs of several Caribbean countries, mostly in the Lesser Antilles, incorporated a series of larval sample surveys to better understand the infestation characteristics of this mosquito. The data from these surveys, covering the period 1983–89, are presented in this paper.

MATERIALS AND METHODS

Larval surveys were conducted on an almost annual basis in the 10 English-speaking territories of the Windward and Leeward islands and on the island of New Providence in the Bahamas (Fig. 1). On each occasion a house-to-house survey was made in conjunction with national staff at whatever location they happened to be working in at the time of the visit. Interior and exterior inspections were carried out; partial or incomplete inspections were excluded from the results. For each household, the number and categorization of potential larval habitats, with and without water, were noted. Water-filled containers were examined for the presence of mosquito larvae and/or pupae. Aedine larvae were

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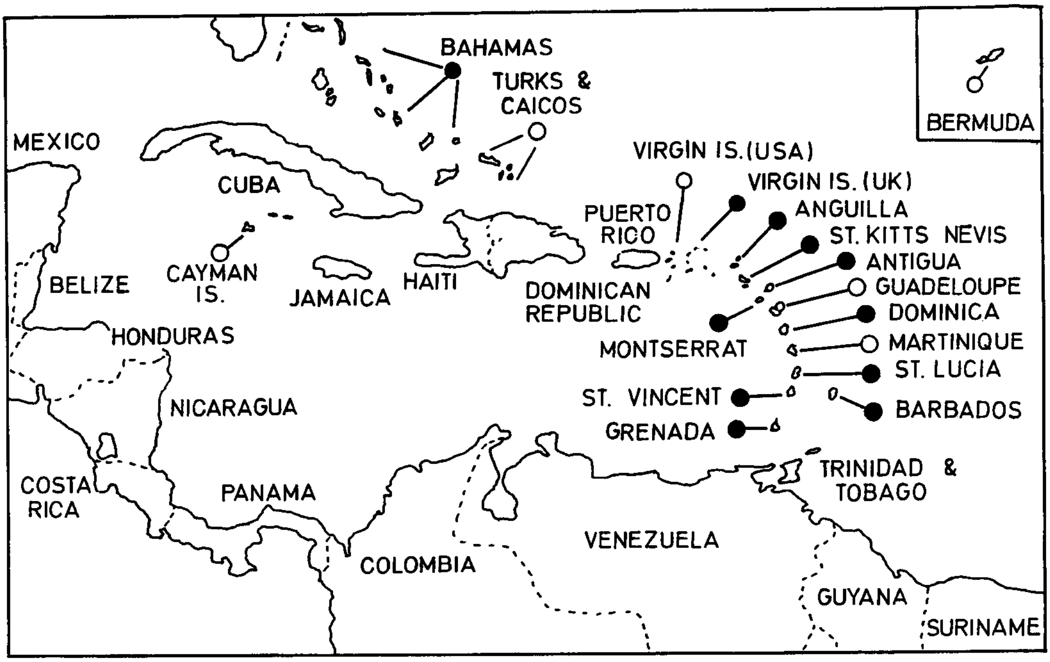

Fig. 1. Map of the Caribbean and Bermuda showing the 11 countries included in the study (closed circles).

Table 1. Abundance of potential container habitats and Breteau indices in 11 Caribbean countries.

Country	No. houses inspected	Mean no. containers/house	Mean no. wet containers/house	Breteau index
Anguilla	119	33	4.7	77.3
Antigua/Barbuda	320	17	6.1	121.6
Bahamas	244	51	6.3	98.8
Barbados	430	21	4.8	34.7
British Virgin Is.	209	26	4.0	82.8
Dominica	287	19	5.0	116.4
Grenada	274	19	4.0	57.7
Montserrat	131	26	4.5	50.4
St. Kitts/Nevis	205	20	4.0	49.3
St. Lucia	141	22	5.6	59.6
St. Vincent	294	17	4.6	67.3
Range	119–430	17–51	4.0–6.3	34.7–121.6

collected from many but not all foci, preserved in alcohol and microscopically examined for species confirmation. With few exceptions, notably in New Providence, Bahamas, where *Aedes* (*Howardina*) *bahamensis* Berlin was commonly found in container habitats, and in Dominica, where *Aedes* (*Gymnometopa*) *mediovittatus* (Coquillett) was also abundant in some areas, *Ae. aegypti* was the only aedine species encountered. Both the above-mentioned species were found, on occasion, in association with *Ae. aegypti*. Although a wide variety of man-made habitats were identified, the analysis focuses on the most common larval habitats.

RESULTS AND DISCUSSION

Potential larval habitats and infestation levels: Table 1 shows the numbers of houses surveyed in each country, the mean numbers of wet and dry containers per house and the Breteau indices (number of *Ae. aegypti* infested containers per 100 houses). Between 119 and 430 houses were inspected per country. The average number of

Table 2. Main larval habitats of *Aedes aegypti* contributing to no less than 75% of all foci in 11 Caribbean countries (ranking in parentheses).[1]

Country	Total no. of foci	% of all foci						
		Drums	Plants	Buckets	Tires	Misc. small	Animal water	Old appliances
Anguilla	92	27.2 (1)	18.5 (3)	20.7 (2)	9.8 (4)	—	—	—
Antigua/Barbuda	389	51.7 (1)	11.1 (3)	14.1 (2)	—	—	—	—
Bahamas	241	8.7 (3)	20.7 (2)	45.2 (1)	8.3 (4)	—	—	—
Barbados	149	5.4 (5)	16.8 (3)	17.4 (2)	4.7 (7)	21.5 (1)	8.1 (4)	5.4 (5)
British Virgin Is.	173	26.0 (2)	29.5 (1)	12.7 (3)	7.5 (4)	—	—	
Dominica	334	25.4 (2)	30.2 (1)	—	11.7 (3)	8.1 (4)	—	—
Grenada	158	46.2 (1)	29.1 (2)	—	—	—	—	—
Montserrat	61	7.6 (4)	7.6 (4)	—	30.3 (1)	12.1 (3)	—	18.2 (2)
St. Kitts/Nevis	101	5.9 (4)	42.6 (1)	8.9 (3)	22.8 (2)	—	—	—
St. Lucia	84	28.6 (2)	29.8 (1)	15.5 (3)	15.5 (3)	—	—	—
St. Vincent	198	25.3 (2)	39.4 (1)	8.1 (4)	8.6 (3)	—	—	—

[1] Ranked in parentheses in descending order of importance.

Table 3. Potential and actual breeding sites of *Aedes aegypti* in a "typical" house based on observations in 11 Caribbean countries (number of houses inspected = 2,654).

Container type	No. examined	Mean no. per house	No. wet	Mean no. per house	No. positive	Wet container index (%)
Drums	1,995	0.75	1,605	0.60	543	33.8
Plants	17,466	6.58	2,179	0.82	484	22.2
Buckets	7,925	2.99	4,667	1.76	307	6.6
Tires	1,170	0.44	500	0.19	192	38.4
Misc. small	28,879	10.88	2,064	0.78	140	6.8
Others	5,863	2.21	2,018	0.76	314	15.6
Totals	63,298	23.85	13,033	4.91	1,980	15.2

potential larval habitats per house, i.e., both wet and dry containers, ranged from 17 to 51. The average number containing water at the time of inspection ranged from 4.0 to 6.3 while the Breteau index varied from 34.7 in Barbados to 121.6 in Antigua/Barbuda, with a median figure of 67.3.

Main larval habitats: Five major container types together accounted for 84% of all *Ae. aegypti* foci (Table 2). These were 1) drums—usually 208 liter steel drums, used for the domestic storage of roof catchment rainwater; 2) house plants—including vases of cut flowers, plants cultivated in water, e.g., *Polyanthus*, or potted plants standing in water-filled saucers or trays; 3) plastic or galvanized metal buckets, pails or bowls for domestic water usage (hereafter simply referred to as buckets); 4) used tires; and 5) miscellaneous small, discarded items such as tin cans, jars and plastic food containers.

For each of the 11 countries, Table 2 lists only the principal foci which cumulatively contributed to no less than 75% of all *Ae. aegypti* breedings, e.g., in Grenada drums and house plants alone accounted for 75.3% of the total whereas in Barbados animal watering pans and old appliances were included together with the 5 other most common sites in order to reach the 75% threshold. In 7 of the countries over three-quarters of the foci were found in only 4 container types. Uniquely, old tires were the primary source of breeding found in Montserrat followed by discarded domestic appliances such as refrigerators, stoves and washing machines.

House plants ranked as the major container habitat in 5 of the 11 countries and ranked first, second or third in all but one of them. Similarly drums ranked first in 3 countries and first, second or third in 8. Only in Barbados were miscellaneous small containers ranked as the major habitat.

Potential and actual larval habitats in a "typical" Caribbean house: In terms of potential larval habitats, the category of miscellaneous small containers contributed 46% of the total or almost 11 of the 24 containers in the "typical" Caribbean house (Table 3). In descending order of abundance, the other priority containers were house plants (27.6%), buckets (12.5%), drums (3.1%) and tires (1.8%). Other uncategorized containers accounted for the remaining 9.3%. However, when consideration is given to the frequency of occurrence of infested containers, drums were the most common, comprising 27.4% of the total, followed by house plants (24.4%), buckets (15.5%), tires (9.7%) and miscellaneous small containers (7.1%). Uncategorized containers accounted for the remaining 15.9% of foci.

Also shown in Table 3 are the wet container indices (the percentage of water-filled containers infested with *Ae. aegypti* larvae). The predilection for tires and drums is reflected in the high indices for these habitats, 38.4% and 33.8% respectively. Noteworthy is the low index in miscellaneous small containers (6.8%). Only 6.6% of buckets were positive, but this low infestation rate is most likely because the majority of these containers were in almost daily domestic use.

Implications for integrated community-based strategies: The realistic objectives of vector control programs in the foreseeable future must be to reduce infestation levels to an extent that the risk of dengue or yellow fever transmission is eliminated or at least minimized. Because of limited resources, Caribbean country programs are experiencing difficulty in providing an adequate and continuous "protective insecticidal shield" for their populace. Alternative strategies are needed which can be implemented through community participation and which compliment the efforts of the vector control teams. Before the advent of the insecticidal era, which began in the 1950s, integrated strategies incorporating source reduction and biological control were successfully used for *Ae. aegypti* control. In our efforts to contain the spread of dengue and yellow fever, they will again be needed, together with modern insecticides, for the suppression of vector populations.

The matter of container productivity of adult mosquitoes has not been addressed in this study. Nevertheless, the above analysis of larval habitats of *Ae. aegypti* in 11 Caribbean countries can provide some orientation for focusing control efforts on the management or elimination of the vector's most common habitats. The selection of the most appropriate and cost-efficient strategies for this management can be further guided by consideration of the main container categories in terms of their "raison d'etre." For those categories considered by the community or householder to have a functional domestic role, removal or destruction may not be an acceptable option. Drums and buckets are examples; they provide a means of storing potable water in communities where there is an inadequate pipe-borne supply or no supply at all. House plants have important social and aesthetic functions too. In dealing with rainwater drums the options include provision of house connections from a central water supply, a long-term objective; the physical exclusion of mosquitoes through the use of protective covers; the introduction of larvivorous fish such as *Poecilia reticulata* or other biological control agents such as predatory copepods; or the use of appropriate insecticides. The practice of keeping house plants in soil or sand as opposed to water, and the avoidance of overwatering would eliminate breeding in this particular habitat.

By contrast there are numerous other potential larval habitats which are the discarded products of contemporary life-styles; they no longer fulfill a useful purpose in the peridomestic environment. These can be targeted for removal or destruction. However, in managing limited resources for vector control, including the vital educational component that will provide the basis for any effective and sustainable community action, consideration should be given to the efforts and rewards of a particular action. In the case of old tires, they comprised less than 2% of all the potential habitats in this study; however, because they are "preferred oviposition sites" they accounted for almost 10% of the foci. The relative ease with which they can be removed from the peridomestic environment and their relatively slow rate of accumulation suggests that a clean-up campaign strategy would make a significant impact on vector abundance. Although miscellaneous small containers, the by-product of an increasingly materialistic, consumer- and import-oriented Caribbean society, provided only 7.1% of the foci, they constituted close to half of the potential larval habitats. In this instance, the considerable investment in time, effort and money required to conduct clean-up campaigns, and the continuing rapid accumulation of these containers, would yield short-term and minimal gains. An indirect, long-term option in this case would be to strengthen or establish solid waste disposal services.

Within each country a thorough understanding of the infestation characteristics is needed. Considerable differences exist among localities, depending on wealth, economy, basic sanitation services and various other factors. This paper describes the vector's larval habitats in a sub-regional context and is invariably biased as a result of visits to limited numbers of localities and houses in each country. In-country stratification will be needed to more accurately identify the priority larval habitats within each community or group of communities before deciding on the most appropriate means of control. As the first community-based vector control project in the Caribbean, the St. Lucia experience may be considered a useful one (Bos et al. 1988) although it must be noted that program sustainability has proven difficult.

ACKNOWLEDGMENTS

The authors are indebted to the national authorities in the various countries included in the study and especially to the managers of the vector control programs for facilitating the work. We also gratefully acknowledge the support of the Pan American Health Organization/World Health Organization and approval to publish this article.

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