ARTICLES

AEDES AEGYPTI AND DENGUE IN THE CARIBBEAN[1]

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INTRODUCTION

Although most authors accepted the presence of *Aedes aegypti* (Linn.) as the vector of yellow fever and dengue in the Americas for more than two centuries, a historical note by Zinsser (1935) reported that Dutertre and Moseley described outbreaks of either disease at Guadeloupe and St. Kitts in 1635, followed by a similar epidemic in Jamaica in 1655. Thus, for at least three and one half centuries *Ae. aegypti* has co-existed with man in the Caribbean causing illness, misery and death.

The classical examples of the spread of the vector from the Old World by sailing vessels to the Caribbean were also instrumental in furthering its introduction in intra-island trade, as still seen today with small diesel-assisted windjammers plying the Antilles trade routes carrying fruit, produce and cargo. Probably equally important today is vector migration via aircraft, as rapid air travel is a modern way of life. Table 1 shows the presence and distribution of the vector during 1982; note that the vector was reported present in ovitraps in some localities in Bermuda, Cayman Islands and Tobago, where it had previously been eradicated.

DENGUE

During the past three decades, all four dengue serotypes have been isolated in the Caribbean basin, beginning in 1952 with dengue type 2 (D-2) in Trindad; dengue type 3 (D-3) in Puerto Rico (1963–64); dengue type 1 (D-1) in Jamaica (1977) becoming pandemic throughout the Caribbean (PAHO 1979) and dengue 4 (D-4) in 1981 starting in St. Barthelemy and St. Martin. Table 2 illustrates the general dengue activities during the period 1977–82. Hammon's (1969) hypothesis of the importation of different dengue serotypes to susceptible populations by air travel is now a reality.

During 1981, Cuba, the largest of the Greater Antilles islands, had a D-2 epidemic of grave proportion accompanied by dengue haemorrhagic fever (DHF) and dengue shock syndrome (DSS) with 344,203 cases; 116,143 were hospitalized and 157 deaths reported (Personal communication, G. Guzman). This is the first epidemic of the more serious form of dengue recorded anywhere in the Americas. By contrast, a clinically mild but extensive outbreak of D-4 occurred in Dominica that same year. This followed a D-1 outbreak there in 1977.

In 1982, sporadic cases of D-1, 2 and 4 occurred in the Caribbean and neighboring countries. A major outbreak was reported in Brazil at Boa Vista city located in the Amazon, where an estimated 7,000 cases of D-1 and 4 occurred during the first half of the year. Suriname had 23 isolations of D-4, but a retrospective study revealed that at least 10% of the 68,000 population of Paramaribo, the capital, had experienced dengue-like illness symptoms. Four cases were clinically diagnosed as DHF/DSS. Belize and Mexico both had outbreaks of dengue type 1. From mid-July to December, Barbados had 58 isolations of D-4, while Cayenne, French Guyana, had an estimated 5000–6000 cases of D-4. In Puerto Rico, D-4 cases occurred with DHF/DSS in two cases resulting in death; the virus being isolated in both teenage cases (Personal communication, D. Gubler, Centers for Disease Control, San Juan).

By contrast, in the United States (MMUR 1983), 144 cases of dengue-like illnesses were reported to CDC in 1982 by 28 states. Of those suspected cases, 45 were confirmed as dengue fever, all of which were imported; eight were in the southern states and the rest in eastern or midwest states. Dengue types 1, 2, and 4 were isolated and travel histories were predominantly from the Caribbean, with small numbers having travelled to Central and South America, the Pacific, India and Africa.

In 1982 no cases of D-2 were reported with DHF/DSS symptoms anywhere in the Americas.

This marked increase in dengue outbreaks in the Caribbean and the sylvatic yellow fever epidemic in Trinidad 1978–79 (CAREC 1979)[3]

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[3] CAREC (1979) Director's Report for 1979. Pan American Health Organization, CAREC SAC 80.2 pp 68 and 76. Unpublished document.

Table 1. Distribution of *Aedes aegypti* in the Caribbean, 1982.

Country	Vector present	Country	Vector present
Antigua/Barbuda	Yes	St. Eustatius	Yes
Anguilla	Yes	St. Maartin	Yes
Bahamas	Yes	Saba	Yes
Bermuda*	P?	Puerto Rico	Yes
British Virgin Islands (Tortola)	Yes	St. Kitts/Nevis	Yes
Cayman Islands*	?	French Territories	
Cuba	Yes	Guadeloupe	Yes
Dominica	Yes	Martinique	Yes
Dominican Republic	Yes	St. Martin	Yes
Grenada and the Grenadines	Yes	St. Vincent and the Grenadines	Yes
Haiti	Yes	Trinidad/Tobago*	Yes/*
Jamaica	Yes	Turks and Caicos	Yes
Montserrat	Yes	U.S. Virgin Islands	Yes
Netherlands Antilles			
Aruba	Yes		
Bonaire	Yes		
Curaçao	Yes		

* *Aedes aegypti* free in early 1982, but now reported in some localities. By late 1982, *Ae. aegypti* had been eliminated from Bermuda (Mayers 1983).

Table 2. Reported dengue-like illness outbreaks and DHF/DSS in the Caribbean and neighboring countries, 1977–82.

Countries	Serotypes 1977–79	1981	1982	Reference sources
Antigua/Barbuda	D-1			CAREC[1]
Anguilla		D-4		Government
Bahamas	D-1			CAREC
Barbados	D-1		D-1,4	CAREC
Belize	D-1	D-1	D-1	CAREC
Bonaire	D-1			CAREC
British Virgin Islands (Tortola)	D-1	D-4		CDC[2]
Cuba	D-1	D-2[3]		Government
Curaçao	D-1	D-1,4		CAREC
Dominica	D-1	D-4		CAREC
French Guyana	D-2	D-1	D-4	Pasteur Institute
Grenada and the Grenadines	D-1	D-4		CAREC
Guadeloupe	D-1		D-?	Pasteur Institute
Guyana	D-1			CAREC
Haiti	D-1			CAREC
Jamaica	D-1	D-2,4		Government
Martinique	D-1	D-4?	D-?	Pasteur Institute
Mexico	D-1	D-1	D-1	Government
Montserrat	D-1			CAREC
Puerto Rico	D-1,2,3	D-1,4	D-1,4	CDC
St. Barthelemy		D-4		CAREC
St. Kitts/Nevis	D-1	D-4		CAREC
St. Lucia		D-4		CAREC
St. Martin/St. Maartin	D-1			CAREC
St. Vincent and the Grenadines	D-1	D-1	D-4	CAREC
Suriname	D-1	D-1	D-4	Government
Trinidad	D-1	D-1,4	D-2,4	CAREC
Turks and Caicos	D-1			CAREC
U.S. Virgin Islands (St. Thomas)	D-1			CAREC
Venezuela	D-1	D-1		Government

[1] Caribbean Epidemiology Centre, Port of Spain, Trinidad.
[2] Centers for Disease Control, San Juan, Puerto Rico.
[3] DHF/DSS.

and elsewhere has led to an increased awareness of the necessity for controlling and eradicating *Ae. aegypti*.

GEOGRAPHICAL DISTRIBUTION. In the region of the Caribbean basin, *Ae. aegypti* is found breeding on at least 90 islands in 24 countries, making up more than 95% of the inhabitable islands in the Greater and Lesser Antilles. These countries range from the Bahamas in the north to Trinidad and Tobago in the south, and from Cuba on the west to Barbados in the east.

The vector's northern temperate range in the Americas has been reported as far north as New York state (Bell and Benach 1973), but is usually associated with the January isotherm of 10°C (50°F) and July isotherm of 24°C (75°F); the southernmost extension in the Americas being Buenos Aires, Argentina (Christophers 1960).

It is widely accepted that the original home of *Ae. aegypti* is the Ethiopean region rather than the New World. This is supported by the numerous species, 37 there of the same *Stegomyia* subgenus as compared to 30 in the Oriental region (Personal communication, Yiau-Min Huang, Smithsonian Institution).

Three forms of *Ae. aegypti* are reported in the Americas, all of which are found in the Caribbean (Personal communication, W. Keith Hartberg):

1. *Ae. aegypti* (Linn.) sens. str.
2. *Ae. aegypti* var. *queenslandensis* (Theobald).
3. *Ae. aegypti* var. *formosus* (Walker).

Unlike the African species which can and does breed in forested areas independent of man, *Ae. aegypti* in the Caribbean is a domiciliary species, almost exclusively. However, there are exceptions as seen by the feral form breeding in coral rock holes (karst solution holes) on the island of Anguilla, and in a similar habitat on Puerto Rico and Cayman Brac (Fox et al. 1960, Nathan and Giglioli 1982). The Anguillan form is a typical *Aedes aegypti* (Linn) sens. str., with the tendency to be at the darker end of the color spectrum, (Parker, et al. 1983). In urban areas of Anguilla, the domiciliary mosquito predominantly breeds in cisterns and drums.

BIOLOGY AND OVIPOSITION PREFERENCES. In West Africa, the vector is found breeding abundantly in domestic clay water pots (Bang et al. 1981), while Macdonald (1959) related that in Malaya, both ant (formica) traps and earthen jars are favored. During the 1973 outbreak of dengue haemorrhagic fever in Malaysia (Wallace et al. 1980), *Ae. aegypti* was seen breeding prolifically in cement tubs and Shanghai water jars in houses where piped water was very dependable, but where age old water storage habits are a modern way of life. While clay pots are no longer a way of life in the Caribbean, the vector has adapted to numerous twentieth century receptacles.

Suarez and Nelson (1981) reported that in Columbia the vector has penetrated to above the 2,200 m contour level and in the French Guyana, Amazon, it is present in small river villages, being carried in the bottom of dugout canoes.

Aedes aegypti in the Caribbean has a range of breeding preferences as shown in Table 3. For example, Giglioli (1979) reported that on Anti-

Table 3. *Aedes aegypti* breeding habitat preferences in the Caribbean and neighboring countries.

Country	Principal type of habitat	Reference source
Anguilla	Drums, cisterns, rock holes	PAHO survey, Parker et al. (1983)
Antigua	Drums	PAHO survey
Bahamas	Small containers	PAHO survey
Barbados	Small containers	Program report
Belize	Vats, drums	PAHO survey
Bonaire	Cisterns, drums	PAHO survey
Caymans	Drums	Nathan
Cuba	Small containers	Personal correspondence
Curaçao	Cisterns, vases	PAHO survey
Grenada and the Grenadines	Drums, cisterns	PAHO survey
Guyana	Vats, drums	PAHO survey
Jamaica	Flower vases, small containers	Program report
Puerto Rico	Animal water pans, tires	Moore et al. (1978)
St. Kitts	Drums, large containers	PAHO survey
St. Lucia	Drums, large containers	PAHO survey
St. Vincent and the Grenadines	Drums, large containers, cisterns	PAHO survey
Suriname	Roof gutters	Tinker (1974)
British Virgin Islands (Tortola)	Drums, cisterns	PAHO survey
Trinidad	Drums, large containers	Program report, Kellett and Omardeen (1957)
Southeastern United States	Tires, large open containers	Focks et al. (1981)

gua 48% of the breeding occurs in 55 gallon drums, and an additional 41% is in cisterns. In Barbados, where piped water supply is dependable, small containers are the predominant sites. On Bonaire and Curaçao, Netherland Antilles, cisterns, drums and wells are preferred.

Nathan and Giglioli (1982) reported that prior to eradication on the Cayman Islands although 93% of all water containers were tins, jars and bottles, only 9.2% were infested. Drums which represented only 1.9% of all water containers were infested 37.6% of the time. In Grenada and the Grenadines, preferred oviposition sites are drums and cisterns. Both Grenada and the St. Vincent Grenadines are totally dependent upon the catchment of rain water, subsequently stored in basement cisterns. In such reservoirs, larvivorous fish such as the guppy, *Poecilia reticulata,* are extensively used to control *Ae. aegypti* immatures.

By contrast,in Jamaica where it is unlawful to store water, typical breeding sites are flower vases and small containers.

In Puerto Rico, according to Moore et al. (1978) 96% of *Ae. aegypti* breeding occurs in man-made containers, with animal watering pans accounting for 18.3% of the sites, tires 14.6%, tin cans 11.4%, flower pots 11.1% and buckets 9.5%.

Tinker (1974) reports that in Suriname, roof gutters are responsible for 60% of the larval infestation. Small tins there represent only 0.4% of the oviposition sites, although they represent 16.3% of the potential breeding sites. In Belize, the vector prefers drums and vats.

In Trinidad, Kellett and Omardeen (1957) revealed that *Ae. aegypti* do breed in tree holes, 87% of which were 2 m or more above the ground. Although such tree cavity breeding is minor, it represents 8% of the positive foci which presents a problem in eradication. More commonly, drums and improperly covered gravity flow tanks are preferred. However, recently an increase in breeding in roof gutters has been recognized in Port of Spain.

In the southeastern United States, Tinker (1964) and Morlan and Tinker (1965) reported the vector present in 11 states from 639 counties and that the vector breeds prolifically in discarded tires. Focks et al. (1981) observed that in Louisiana, large open containers, such as drums, boat bottoms, bird baths, represented 74% of all breeding sites.

Thus we can see that the entire spectrum of possible sites is utilized for ovipositon by the vector in the Caribbean and neighboring countries, including natural and man-made containers, but a distinct preference is shown for drums and cisterns in 11 countries of the Caribbean.

In those Caribbean countries where potable water is not dependable or is interrupted, and or where traditional water storage habits are entrenched, large water containers used for holding or storing water constitute the major site for ovipostion selection.

In natural and artifical egg-laying sites such as tree holes, bamboo stumps, coconut husks, leaf axils, tins and jars which are rain water dependent, the oviproductivity is closely identified with rainfall. These sites are not significant breeding places in the Caribbean, nonetheless they do constitute a problem in the final stages of eradication. During the dry season such sites are no longer available for oviproduction, and the vector must entirely select man-made containers such as drums and barrels, which are periodically recharged with water by man or is present in permanent reservoirs, e.g. cisterns, holding tanks, roof tanks, etc.

RESEARCH

Data from actual research into the biology and oviposition preferences of *Ae. aegypti* in the Caribbean are rather sparse, although investigations into oviposition preference, seasonality and egg-laying periodicity at present are being undertaken in Trinidad.

In Puerto Rico, studies are being made by the CDC laboratory into a possible new vector of dengue, *Aedes mediovittatus* (Coq.), a container breeder. There, they are also conducting resistance and vector ability tests on a number of Caribbean isolates of *Ae. aegypti.*

On Anguilla, life table studies are being undertaken on the feral population of the vector, as well as research into the transmission capability and genetics of both the wild and domestic forms by laboratories in the Caribbean and United States.

Interest and capability to carry out such scientific investigations are limited in the Caribbean and the more basic, mundane needs of simply conducting control programs take precedence.

COUNTRY PROGRAMS. PAHO has been providing technical and advisory assistance in the Region for the control of mosquito vectors and has elicited information regarding individual country vector house indices and an assessment of *Aedes* campaigns. Tables 4 and 5 show the most recent information available on a country-by-country basis. House indices range from 0.09% in Cuba to more than 50% in several countries.

All of the countries shown in these tables are

taking action to one degree or another to control *Ae. aegypti.* Many *Ae. aegypti* programs were revitalized following the dengue pandemic of 1977. However, few countries today are actually carrying out full eradication measures. Most use insecticide as the major tool to reduce the vector population, as either a larvicide (temephos) or adulticide (malathion as ULV or thermal fog). A few are using an integrated control approach, by adding a biological control component.

At present, larvivorous fish are being used principally to control *Ae. aegypti* in cisterns in five countries. The use of either *Bacillus thuringiensis* H-14 (*Bti*) or *Toxorhynchites* mosquito larvae is being considered in two other countries.

Ovitraps are being used in six countries. The

Table 4. *Aedes aegypti* larval indices in the Caribbean and selected neighboring countries.

Country	Last reported house index (%)	Estimated population (1981 CAREC)	No. of houses in country
Anguilla	22.5 (Jan. 1983)	6,500	3,454
Antigua	14.2 (April 1983)	73,000	20,758
Bahamas	60.0 (Oct. 1982)	209,595	48,532
Barbados	2.0–4.0 (Dec. 1982)	250,000	50,000
Belize	20–30 (May 1982)	150,000	33,500
Bonaire	7.9 (April 1983)	9,142	3,947
Cuba	0.09 (Jan. 1983)	9,265,000	2,058,888 est.
Curaçao	50.0 (Jan. 1982)	162,369	36,080 est.
Dominica	60–65 (Jan. 1983)	75,000	16,000
French Guyana	3.9–30 (Dec. 1982)	50,000	11,100 est.
Grenada	3.0–4.0 (Dec. 1982)	129,588	28,608
Guyana	2.8–4.2 (Nov. 1982)	221,200	38,702
Jamaica	35–50 (Mar. 1982)	2,200,000	400,000
Montserrat	9–46 (Nov. 1982)	12,034	3,727
St. Lucia	4–50 (July 1982)	120,000	24,000
St. Kitts/Nevis	58.0 (Nov. 1982)	50,000	10,000
St. Maartin	20.8 (Dec. 1982)	15,000	4,708
St. Vincent and the Grenadines	3.9 (July 1982)	140,000	27,861
Suriname	24.7 (June 1982)	352,041	109,000
Tortula (British Virgin Islands)	22.0 (Feb. 1982)	8,890	1,800
Trinidad and Tobago	5.6 (Dec. 1982)	1,100,000	241,809
Venezuela	29.0 (Dec. 1981)	15,000,000	3,500,000 est.

Table 5. An assessment of *Aedes aegypti* campaign in the Caribbean and other neighboring countries.

Country	No. of staff in program	No. of cycles in 1982	Type of program	Ovitrap monitoring	Health education program
Anguilla	7	2	Integrated	No	Yes
Antigua	29	2–3	Integrated	No	Yes
Barbados	84	2–3	Chemical	Yes	Yes
Bahamas (New Providence)	12	1	Chemical	No	Yes
Belize	8	0	Chemical	No	No
Bonaire	11	2–3	Integrated	No	No
British Virgin Islands (Tortula)	7	3	Chemical	Yes	No
Curaçao	4	0	Chemical	No	No
Dominica	4	0	Chemical	No	Yes
Grenada and the Grenadines	31	3–4	Integrated	Yes	Yes
Jamaica	238	0	Chemical	No	No
Montserrat	14	1–2	Chemical	No	No
St. Kitts/Nevis	2	0	Chemical	No	Yes
St. Lucia	61	1–2	Chemical	No	No
St. Maartin	6	1	Chemical	No	No
St. Vincent and the Grenadines	20	2–3	Integrated	No	No
Suriname	10–70	1–2	Chemical	Yes	Yes
Trinidad	6–800	3–4	Chemical	Yes	Yes

use of such traps is an excellent tool to determine the efficiency of control programs at selected monitoring sites and also serves as an indicator of possible introduction of the vector from neighboring countries at sea and air terminal ports of entry.

In approximately half of the countries, adequate numbers of vehicles are available to the *Aedes* campaigns but, even among those, repairs and maintenance remain a serious problem. Inadequate support on the part of some governments restricts program efficiency and traditional control methodologies in general need to be re-evaluated.

In general, sufficient insecticide and adequate insecticide application equipment are present in each country to only handle demands of a routine program. Very few countries have sufficient insecticide reserves on hand to mount an immediate, wide scale spraying operation, should a dengue or yellow fever outbreak occur.

The problem of resistance to some organophosporous compounds has now been reported from Puerto Rico, the Cayman Islands and Suriname, and monitoring is being done in several laboratories. Relevant health education programs, which are vital to enlist aid at community levels to assist in massive source reduction campaigns, are found in but a few countries.

PAHO INPUT. PAHO has provided consultation, training and provision of equipment, spare parts and insecticide, with the Caribbean Epidemiological Center (CAREC) assisting in surveillance, research, laboratory diagnosis and training for 19 Caribbean countries.

Since 1976, PAHO has been providing technical assistance through a single Technical Advisor and in 1981, an Area Advisor was recruited to provide additional strength to *Aedes aegypti* programs in the Caribbean.

In the WHO document *Health For All By The Year 2000,* a Plan of Action for Implementation of Regional Strategies was reviewed in 1982 by the 87th Meeting of the PAHO Executive Committee. The eradication of the vector of dengue and yellow fever was again called for. A number of excellent approaches were suggested along technical lines to carry out research, to analyze the magnitude of the problem and to resultantly resolve the threat of *Aedes aegypti*-borne diseases.

SUMMARY

In this brief overview of the presence of *Aedes aegypti* in the Caribbean, the distribution of the vector has been noted. Enjoying the salubrious climate of the Antilles, its presence extends from the Bahamas to Trinidad, and from Cuba to Barbados.

The pervasion of all four dengue serotypes in a short 30-year period from 1952–81 is clear, with resultant pandemics from 1977 onwards in the Antilles and neighboring countries and with the Cuban DHF/DSS epidemic in 1981.

Three forms of the mosquito are found breeding in either peridomestic or feral niches in the basin.

The type of breeding habit in artifical sites is extensive, ranging from drums, barrels, cisterns, wells, buckets, animal watering pans, roof gutters, tires, tins, jars, bottles, flower pots, vases, bird baths, boat bottoms to tree holes, coconut husks, leaf axils, crab holes, coral rock pockets, bamboo stumps and papaya trees in natural habitats.

The predominant breeding container most frequently choosen for oviposition is 55 gallon drums. The variation in the type of preferred egg-laying site depends upon water storage practices, source reduction pressures and local preferences exhibited by the vector. Some research into the biology and oviposition preferences is ongoing.

In the case of three areas where the vector has been previously eradicated—Bermuda, Cayman Islands and Tobago—the vector has, in late 1982, again been reported from ovitraps in some localities.

In conclusion, *Ae. aegypti* continues to survive in the New World many centuries after being introduced from Africa. Her adaptability in expanding to a greater variety of habitat types and back into previously eradicated areas offers a great challenge to the developing countries of the Caribbean which, when coupled with insufficient program support and threat of resistance, presents a problem of major magnitude.

Thus, one can predict that *Ae. aegypti* will continue to live in close association with man in the Caribbean as long as traditional water storage habits persist, lip service is given to control programs, source reduction is ignored, community participation is not applied and research is treated superficially. As a reult, we will continue to be faced with the consequences of *Ae. aegypti*-borne diseases.

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ANNOUNCEMENT

MOSQUITO ECOLOGY WORKSHOP

The Florida Medical Entomology Laboratory will sponsor an international workshop on mosquito ecology 9–12 January 1984 at the University of Florida's Welaka Research and Education Center, 65 miles SE of Gainesville. For further information write:

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