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SURVEILLANCE FOR THE DENGUE VECTOR *AEDES AEGYPTI* IN TOBAGO, WEST INDIES

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ABSTRACT. An island-wide house survey was conducted in January 2002 to determine the geographic distribution, container profile, and population density of the *Aedes aegypti* in Tobago, West Indies. The results showed the *Ae. aegypti* infestation levels were significantly different ($P > 0.01$) among the 4 districts, with greater infestation levels ($P > 0.01$) observed in the Northern and Windward districts than in the Central and Leeward districts. From the 50 towns in Tobago, houses were found positive in Delaford (21), Argyle (18), and Goodwood (14), representing 42.1% of the total number of positive houses in the Windward district (3,971 houses); Parlatuvier (15), Whim (14), Castara (12), and Bloody Bay (12), representing 62.3% of the total number of positive houses in the Northern district (3,087 houses); Calderhall (12), Mason Hall (11), and Government House (10), representing 46.5% of the total number of positive houses in the Central district (4,706 houses); and Lambeau (10), Bucco (6), and Bethel (6), representing 53.7% of the total number of positive houses in the Leeward district (3,175 houses). The majority (66 or 63.5%) of dengue cases occurred in the Central district where the Breteau indices ranged from 7.1 to 44.0 (mean = 16.6). These results suggest that a more systematic and sustained vector control program that uses both biological and chemical control methods should be adopted to reduce *Ae. aegypti* populations to below dengue transmission thresholds.

KEY WORDS Dengue, *Aedes aegypti*, Tobago

INTRODUCTION

In 1960, Trinidad and Tobago were declared free of *Aedes aegypti* (L.) mosquitoes, but Trinidad soon became reinfested in the period 1961–62 (Chadee 1989). However, Tobago remained virtually free of the vector until 1981 (Chadee et al. 1984, Chadee 1990) when 2 foci were discovered in Roxborough and were quickly eradicated (Chadee 1990). In 1982, the Insect Vector Control Division (IVCD) detected *Ae. aegypti* at the Scarborough Wharves and at Lambeau, a town at the periphery of the capital, Scarborough. These foci of infestations were quickly extirpated using an ultra-low volume adulticide (malathion), residual spraying (fenthion), and focal treatment (temephos).

During the period 1983–88, Tobago again became reinfested with *Ae. aegypti* mosquitoes, which started with the 1st focus being detected in water drums that were transported to Tobago from Trinidad in January 1983; this was followed by further shipments in April and June 1984 (Chadee 1990). Thereafter, the geographic spread of *Ae. aegypti* eggs was assisted by the distribution and sale of water drums to various parts of the southern half of the island. Chadee (1990) suggested methods for treating drums prior to shipment to Tobago, but no methodology was implemented. Consequently, after 1988 the *Ae. aegypti* mosquito invasion continued unabated throughout the island for the next 12 years with potentially disastrous consequences.

By November 2001, cases of dengue and dengue hemorrhagic fever were detected on the island for the 1st time, and staff members of IVCD, Trinidad, were invited to assist in the *Ae. aegypti* eradication/control program in Tobago. At this point it was discovered that the *Ae. aegypti* program in Tobago was not properly coordinated, and no systematically conducted inspection and treatment cycles of households had been done since 1998. The reasons for the Tobago program failure have been summarized by Chadee (2002) and include inadequate transportation, insufficient supply of insecticides, lack of suitable equipment, lack of training, and poor morale among workers.

The purpose of this study was to determine *Ae. aegypti* infestation levels in every town and village in Tobago by using evaluators from Trinidad and Tobago Insect Vector Control Units.

MATERIALS AND METHODS

On January 6, 2002, the Trinidad IVCD team of 8 men with 4 evaluators from the Tobago Vector Control Unit conducted an evaluation of the entire island of Tobago, which is divided into 4 vector control districts: Windward, Northern, Central, and Leeward. These districts are used for planning and administration of the program. The *Ae. aegypti* geographic distribution and density of infestation were studied, starting from Cambelton in the northeast to Plymouth in the southwest of the island (Fig. 1). The distribution of *Ae. aegypti* was assessed using a 1:10 ratio for house inspections. All containers were examined and immature mosquitoes collected according to the Pan American Health Organization (PAHO) (1968) guidelines. All data were documented with standard IVCD forms that indicated the householder's name, address, number of containers inspected and positive, and number of *Ae. aegypti* foci discovered.

All immature mosquitoes found were collected with strainers and dippers, placed into vials, labeled according to container types and locality, and sent

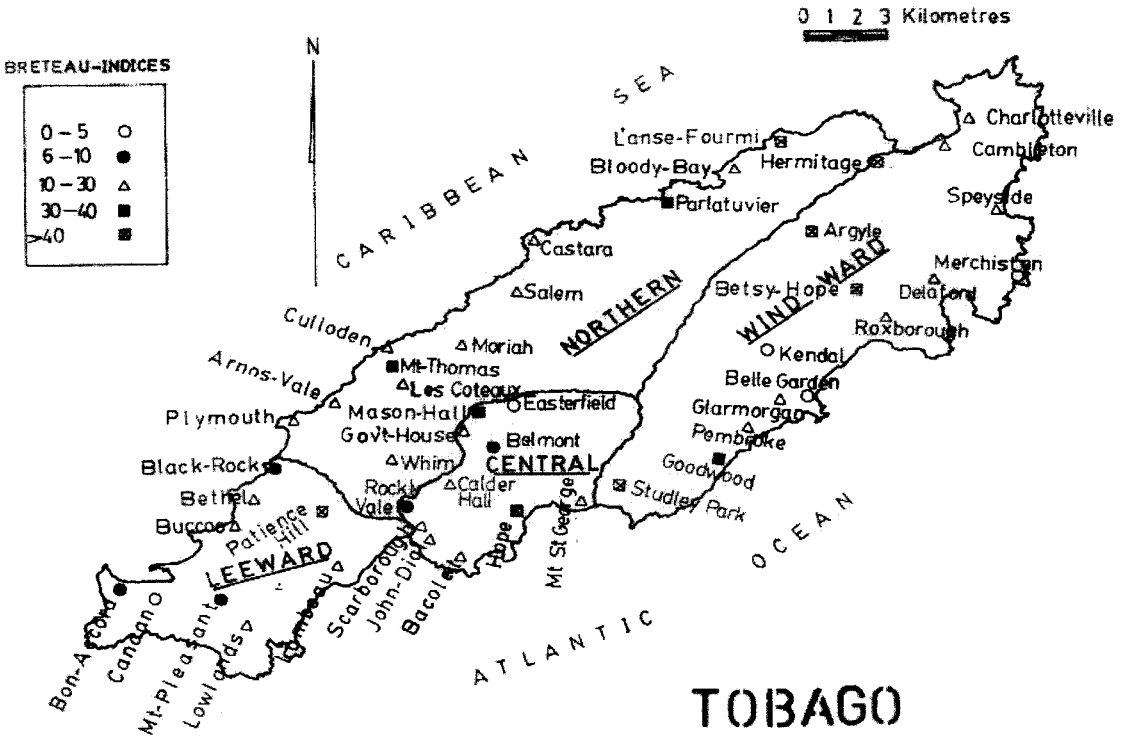

Fig. 1. Geographic distribution of *Aedes aegypti* infestations in Tobago, West Indies (2002).

to the IVCD laboratory, Trinidad, for rearing and identification.

Data were analyzed by transformation into contingency tables and subjected to a *G*-test to compare the distribution of dengue cases and *Ae. aegypti* infestation levels at the district levels (Petrie and Sabin 2000). The Breteau index (number of positive containers per 100 houses inspected) and House index (number of positive houses per number of houses inspected) were calculated to establish a relation between positive containers and positive houses, which is considered to be most informative measure (PAHO 1994).

Lehr's method (Petrie and Sabin 2000) was used to determine the sample size that would represent the population of Tobago at the 5% significance level. A sample size of 256 houses from each district was calculated to obtain a 90% chance of detecting differences in the number of positive houses and containers in each district; the 95% confidence interval around sample estimates would be about ±9% (Petrie and Sabin 2000).

RESULTS

Results of the *Ae. aegypti* evaluation program conducted in January, 2002, at the town and district levels in Tobago are summarized in Tables 1–4. When the *Ae. aegypti* infestation levels from the 4 districts were compared, significant differences (G = 32.0, df = 0.3, $P > 0.01$) were observed among the 4 districts but especially among the northern and southern halves of the island. In fact, when the Northern and Windward districts were combined and compared with the combined Central and Leeward districts, significant differences (G = 16.0, df = 0.2, $P > 0.01$) were observed. These results suggest that the *Ae. aegypti* infestations were greater in the Northern and Windward districts than in the southern part of the island, which comprised the Central and Leeward districts. In the 4 districts, the minimum sample size of 256 houses per district was exceeded by at least 100%, making the data collected representative at the 9% significance level.

Windward district

Table 1 shows a total of 3,971 houses in the Windward district, of which 865 (21%) were inspected. One hundred twenty-six (14.6%) of the houses were positive for *Ae. aegypti*. Of the 18 towns in the Windward district, the largest number of positive houses was found in Delaford (21), Argyle (18), and Goodwood (14), which represented 42.1% of the total number of positive houses. The total number of containers inspected was 11,697, of which 182 were positive for *Ae. aegypti* breeding. The container type, which represented the largest number of containers, belonged to the small miscellaneous container category found outdoors (6,020). The main breeding foci of *Ae. aegypti* were

Table 1. Towns, number of houses, number positive (in parentheses), container types, and *Aedes* indices observed in the Windward district of Tobago (January 2002).[1]

Towns	Houses	Houses inspected	Tanks	Drums	Tubs and basins	Tires	Outdoors	Indoors	*Aedes* indices			Total containers
									Breteau	House	Container	
Hermitage	16	10 (3)	0 (0)	4 (2)	17 (1)	0 (0)	219 (0)	101 (0)	40.0	30.0	1.2	348 (5)
Studley Park	45	25 (8)	17 (0)	28 (4)	25 (2)	10 (0)	91 (0)	31 (0)	40.0	32.0	4.9	202 (6)
Goodwood	397	59 (14)	44 (0)	109 (8)	193 (6)	33 (1)	390 (3)	154 (0)	30.5	23.7	1.8	976 (18)
Pembroke	338	70 (10)	97 (0)	128 (8)	385 (1)	10 (2)	914 (1)	155 (0)	17.1	14.3	0.7	1,689 (12)
Glamorgan	229	79 (18)	17 (0)	105 (9)	202 (6)	5 (0)	497 (3)	70 (1)	24.1	22.8	2.1	896 (19)
Belle Garden	531	86 (3)	47 (0)	36 (1)	207 (0)	2 (2)	179 (1)	19 (0)	4.6	3.5	1.2	335 (4)
Kendell	72	35 (1)	10 (0)	4 (0)	37 (2)	12 (0)	23 (0)	0 (0)	5.7	1.4	2.3	86 (2)
Argyle	148	50 (18)	33 (0)	219 (12)	218 (6)	2 (0)	285 (3)	130 (0)	42.0	36.0	2.7	767 (21)
Roxborough	485	61 (7)	48 (0)	80 (2)	180 (0)	10 (1)	388 (3)	115 (3)	12.9	11.5	1.2	732 (9)
Betsy Hope	183	70 (5)	45 (0)	42 (3)	259 (2)	18 (1)	1,016 (28)	30 (0)	48.6	7.1	2.4	1,415 (34)
Delaford	520	100 (21)	158 (0)	143 (12)	432 (9)	88 (1)	891 (3)	159 (1)	26.0	21.0	1.3	1,920 (26)
Speyside	461	60 (4)	23 (0)	16 (2)	191 (1)	26 (0)	440 (4)	27 (0)	11.7	6.7	0.9	723 (7)
Cambleton	117	60 (4)	43 (0)	98 (2)	144 (1)	16 (0)	122 (2)	31 (4)	15.0	6.7	2.0	454 (9)
Charlotteville	424	100 (10)	132 (0)	139 (4)	322 (4)	4 (0)	565 (4)	112 (0)	12.0	10.0	1.0	1,154 (12)
Total	3,971	865 (126)	714 (0)	1,151 (69)	2,812 (41)	236 (8)	6,020 (55)	1,134 (9)	21.5	14.6	1.6	11,697 (182)

[1] Outdoors, small miscellaneous containers; indoors, flower pots, vases, etc.

Table 2. Towns, number of houses, number positive (in parentheses), container types, and *Aedes* indices observed in the Northern district of Tobago (January 2002).[1]

Towns	Houses	Houses inspected	Tanks	Drums	Tubs and basins	Tires	Outdoors	Indoors	*Aedes* indices			Total containers
									Breteau	House	Container	
Whim	531	79 (14)	21 (0)	49 (8)	101 (6)	23 (0)	219 (2)	12 (0)	20.3	17.7	3.0	425 (16)
Plymouth	809	110 (8)	132 (0)	112 (2)	485 (5)	18 (1)	1,052 (11)	132 (1)	18.2	7.3	1.0	1,931 (20)
Arnos Vale	56	21 (3)	6 (0)	13 (4)	29 (0)	2 (0)	71 (2)	13 (0)	28.6	14.3	4.5	134 (6)
Les Coteaux	298	70 (13)	90 (0)	73 (8)	296 (2)	25 (1)	213 (5)	23 (2)	18.6	18.6	1.9	720 (18)
Culloden	213	36 (4)	56 (0)	28 (0)	181 (4)	18 (1)	83 (0)	10 (0)	13.9	11.1	2.4	376 (5)
Mt. Thomas	244	31 (9)	24 (0)	12 (5)	51 (2)	3 (0)	54 (3)	0 (0)	32.3	29.0	6.9	144 (10)
Salem	79	17 (2)	19 (1)	15 (1)	47 (0)	25 (0)	10 (0)	1 (0)	11.8	11.8	2.0	117 (2)
Castara	198	70 (12)	18 (0)	116 (3)	106 (4)	26 (0)	404 (7)	19 (0)	20.0	17.1	2.0	689 (14)
L'anse Fourmi	82	21 (4)	12 (0)	31 (3)	49 (1)	19 (0)	201 (4)	10 (1)	42.9	19.1	2.7	322 (9)
Bloody Bay	63	70 (12)	8 (0)	88 (5)	36 (3)	0 (0)	88 (5)	0 (0)	18.6	9.4	9.4	226 (13)
Parlatuvier	131	50 (15)	43 (0)	23 (9)	82 (2)	20 (4)	227 (1)	0 (0)	32.0	17.1	4.1	395 (16)
Moriah	383	60 (10)	51 (1)	123 (8)	100 (2)	29 (1)	491 (2)	32 (0)	23.3	16.7	1.7	826 (14)
Total	3,087	635 (106)	480 (2)	683 (56)	1,563 (31)	208 (8)	3,113 (42)	252 (4)	21.7	16.7	2.5	6,305 (143)

[1] Outdoors, small miscellaneous containers; indoors, flower pots, vases, etc.

drums (69) and small miscellaneous containers (55), followed by tubs and basins (41) and tires (8).

Northern district

Table 2 shows a total of 3,087 houses in the Northern district, of which 635 (21%) were inspected. One hundred six (19.1%) of the houses were positive for *Ae. aegypti.* Of the 12 towns in the Northern district, the largest number of positive houses was found in Parlatuvier (15), Whim (14), Les Couteaux (13), Castara (12), and Bloody Bay (12), which represented 62.3% of the total number of positive houses. The total number of containers inspected was 6,305, of which 143 were positive for *Ae. aegypti* breeding. The container type, which represented the largest number of containers, belonged to the small miscellaneous container category found outdoors (3,113). The main foci of *Ae. aegypti* were drums (56) and small miscellaneous containers (42), followed by tubs and basins (31), tires (8), indoor containers (4), and water tanks (2).

Central district

Table 3 shows a total of 4,706 houses in the Central district, of which 646 (13.7%) were inspected. Seventy-one (11%) of the houses were positive for *Ae. aegypti.* Of the 11 towns in the Central district, the largest number of positive houses was found in Calderhall (12), Government House (10), and Mason Hall (11), which represented 46.5% of the total number of positive houses. The total number of containers inspected was 10,053, of which 107 were positive for *Ae. aegypti* breeding. The container type, which represented the largest number of containers, belonged to the small miscellaneous container category found outdoors (5,039). The main foci of *Ae. aegypti* were small miscellaneous containers (37) found outdoors, followed by tubs and basins (29), drums (26), tires (9), and indoor containers (2).

Leeward district

Table 4 shows a total of 3,175 houses in the Leeward district, of which 645 (20%) were inspected. Forty-one (6.4%) of the houses were positive for *Ae. aegypti.* Of the 9 towns in the Leeward district, the largest number of positive houses was found in Lambeau (10), Bucco (6), and Bethel (6), which represented 53.7% of the total number of positive houses. The total number of containers inspected was 10,609, of which 69 were positive for *Ae. aegypti* breeding. The container type, which represented the largest number of containers, belonged to the small miscellaneous container category found outdoors (5,631). The main breeding foci of *Ae. aegypti* were drums (25) and small miscellaneous containers (22), followed by tubs and basins (13), tires (7), and water tanks (2).

Table 3. Towns, number of houses, number positive (in parentheses), container types, and *Aedes* indices observed in the Central district of Tobago (January 2002).[1]

Towns	Houses	Houses inspected	Tanks	Drums	Tubs and basins	Tires	Outdoors	Indoors	*Aedes* indices			
									Breteau	House	Container	Total containers
Bacolet	498	93 (5)	102 (0)	9 (0)	306 (8)	40 (0)	820 (5)	52 (0)	13.9	5.4	0.9	1,419 (13)
Scarborough	698	80 (6)	145 (0)	41 (2)	371 (2)	137 (1)	1,238 (4)	24 (0)	11.3	7.5	0.4	1,953 (9)
Calderhall	608	63 (12)	98 (0)	59 (1)	261 (3)	66 (0)	622 (9)	44 (0)	20.6	19.1	1.1	1,150 (13)
Government House	687	66 (10)	81 (0)	54 (2)	159 (3)	10 (0)	371 (8)	39 (0)	19.7	15.2	1.4	914 (13)
Rockley Vale	575	85 (4)	150 (0)	63 (2)	503 (2)	53 (0)	627 (2)	42 (0)	7.1	4.7	0.4	1,438 (6)
Mason Hall	263	62 (11)	33 (1)	121 (6)	171 (6)	71 (4)	356 (0)	123 (2)	30.7	17.7	2.2	875 (19)
Belmont	476	37 (3)	85 (2)	36 (0)	320 (1)	26 (0)	603 (0)	7 (0)	8.1	8.1	0.3	1,077 (3)
Easterfield	222	36 (2)	29 (1)	45 (1)	47 (0)	25 (0)	50 (0)	1 (0)	5.6	5.5	1.0	197 (2)
John Dial	111	35 (4)	19 (0)	34 (3)	59 (1)	7 (0)	49 (1)	0 (0)	14.3	11.4	3.0	168 (5)
Hope	150	25 (7)	17 (0)	14 (7)	100 (0)	3 (0)	62 (4)	4 (0)	44.0	28.0	5.6	197 (11)
Mt. St. George	418	64 (7)	55 (0)	55 (2)	252 (3)	6 (4)	241 (4)	56 (0)	20.3	10.9	2.0	655 (13)
Total	4,706	646 (71)	814 (4)	531 (26)	2,549 (29)	444 (9)	5,039 (37)	392 (2)	16.6	10.9	1.2	10,053 (107)

[1] Outdoors, small miscellaneous containers; indoors, flower pots, vases, etc.

Table 4. Towns, number of houses, number positive (in parentheses), container types, and *Aedes* indices observed in the Leeward district of Tobago (January 2002).[1]

Towns	Houses	Houses inspected	Tanks	Drums	Tubs and basins	Tires	Outdoors	Indoors	*Aedes* indices			Total containers
									Breteau	House	Container	
Lowlands	456	51 (5)	57 (0)	2 (0)	171 (0)	69 (1)	333 (4)	0 (0)	15.7	9.8	1.3	632 (8)
Mt. Pleasent	419	81 (5)	149 (0)	39 (3)	364 (1)	34 (0)	570 (2)	73 (0)	7.4	6.2	2.6	1,229 (6)
Bucco	174	50 (6)	53 (0)	4 (0)	174 (2)	3 (1)	192 (5)	1 (0)	16.0	12.0	1.9	427 (8)
Canaan	252	127 (3)	132 (0)	149 (4)	495 (0)	34 (0)	1,224 (2)	171 (0)	4.7	2.4	0.3	2,205 (6)
Bon Accord	463	100 (2)	111 (0)	43 (3)	531 (3)	106 (0)	1,454 (0)	90 (0)	6.0	2.0	0.3	2,335 (6)
Bethel	439	50 (6)	92 (1)	89 (2)	92 (0)	4 (0)	680 (4)	59 (0)	14.0	12.0	0.7	1,016 (7)
Patience Hill	451	31 (2)	65 (0)	1 (0)	89 (2)	2 (1)	67 (1)	62 (0)	13.0	6.5	1.4	286 (4)
Black Rock	228	50 (2)	60 (0)	24 (4)	215 (0)	15 (0)	335 (0)	2 (0)	8.0	4.0	0.6	651 (4)
Lambeau	293	105 (10)	181 (1)	178 (9)	608 (2)	62 (4)	776 (4)	23 (0)	19.1	9.5	1.1	1,828 (20)
Total	3,175	645 (41)	900 (2)	529 (25)	2,739 (13)	329 (7)	5,631 (22)	481 (0)	11.0	6.3	0.7	10,609 (69)

[1] Outdoors, small miscellaneous containers; indoors, flower pots, vases, etc.

Breteau indices and Dengue cases in Tobago

Table 5 shows a summary of the number of dengue cases and *Ae. aegypti* Breteau indices. In all 4 districts, the Breteau indices exceeded 5, which is considered the threshold level for disease transmission (Macdonald 1956). The majority (66, or 63.5%) of dengue cases occurred in the Central district, where the Breteau indices ranged from 7.1 to 44.0 (mean = 16.6). Mason Hall (15), Scarborough (13), Signal Hill (7), and Lambeau (6) were the main towns with a large number of dengue cases. These 4 townships accounted for over 70% of the dengue cases reported from the Central and Leeward districts and 39.5% of all dengue cases reported in Tobago during 2001.

DISCUSSION

This survey represents the 1st island-wide evaluation of *Ae. aegypti* in Tobago since 1998 and provides ample evidence of the wide geographic distribution of this vector species in Tobago (Fig.1). The *Ae. aegypti* population density throughout the island was high, exceeding the Breteau index of 5, which is regarded as the disease transmission threshold (Macdonald 1956) (Table 5). The occurrence of dengue fever cases in the Central district was significantly correlated with the *Ae. aegypti* population, although the *Ae. aegypti* population density was lower in the Central district than that observed in other districts (Table 5). These results suggest that people living close to the capital and major tourist centers located in the Central and Leeward districts were at greater risk of contracting dengue by virtue of being in contact with *Ae. aegypti,* which may have taken blood meals from viremic tourists and local travelers from both Trinidad and Tobago. The large number of dengue cases in Scarborough, Mason Hall, Lambeau, and Signal Hill supports this hypothesis.

The *Ae. aegypti* population infestation levels in the Northern and Windward districts were significantly different ($P > 0.01$) from those observed in the Central and Leeward districts. These variable infestation levels were possibly due to differences in operational procedures and management practices used by vector control managers and staff. For example, Chadee (2002) showed that the districts that were far from the Central and Leeward district administrative centers were neglected (with little or no supervision, no equipment and supplies, no transportation, and lack of political will), which possibly resulted in low morale among all levels of staff.

Focks and Chadee (1997), working on the epidemiological significance of the *Ae. aegypti* pupal index, showed that counties close to Port of Spain, the capital city of Trinidad, generally have a more reliable water supply and better sanitation with fewer mosquitoes than do outlying counties. The pres-

Table 5. Summary of house inspection and treatment evaluations conducted in all 4 districts in Tobago (January 2002).

District	Houses inspected (population)	Dengue cases	Houses positive	Wet containers	Containers positive	Breteau indices (range)	House indices
Windward	865 (5,208)	9	126	11,697	182	21.5 (4.6–48.6)	14.6
Northern	635 (4,445)	12	106	6,305	143	21.7 (11.8–42.9)	16.7
Central	646 (3,876)	66	71	10,053	107	16.6 (7.1–44.0)	10.9
Leeward	645 (3,225)	17	41	10,609	69	11.0 (4.7–19.1)	6.3
Total	2,791 (16,754)	104	344	38,664	501	17.9 (4.6–48.6)	12.1

ent results were consistent with these observations with a much larger number of *Ae. aegypti* breeding foci, water drums, tubs, and basins observed in the Northern and Windward districts as opposed to the Central district, where Scarborough is located.

The impact of recent infrastructural developments in the Central and Leeward districts may have resulted in improved water storage practices, with an increase in the number of water storage tanks and a decrease in the number of water drums. For example, in the Leeward district, 900 storage tanks were observed as opposed to 529 drums. Conversely, in the Northern district, 683 drums were observed as opposed to 480 tanks (Tables 2 and 4). In addition, the present results indicate a switch in the major breeding focus of *Ae. aegypti* from drums to small miscellaneous containers, especially in the Central district (Tables 1–4).

These results suggest that the water storage container types used by householders and *Ae. aegypti* in Tobago need to be closely examined before planning control programs. For example, although tanks replaced water drums in the Central district, the number positive for *Ae. aegypti* breeding was quite small (Tables 1–4). Similar results were obtained for indoor containers, such as vases and water receptacles, in the Northern and Central districts.

It is noteworthy that the frequency of container usage by *Ae. aegypti* suggests that a source reduction program for small miscellaneous containers could potentially eliminate more than 30% of the foci of breeding. The inspection and treatment of indoor containers (vases and potted plants) and water tanks should be reexamined because they represent only a modicum of the *Ae. aegypti* breeding sites (Tables 1–4). Focks and Chadee (1997) reported similar results, suggesting that these indoor containers are inconsequential because of their small numbers and lack of appreciable *Ae. aegypti* and can be best controlled by educating householders rather than by centralized control measures, which are difficult to execute because of householders' objections and "closed houses" (Chadee 1988).

In a previous study, Chadee (1990) reported that drums were the containers most frequently used by *Ae. aegypti* (35.4%) in Tobago, and 12 years later during the present study similar levels of drum infestation were observed (36%). Therefore, it is clear that a systematic approach should be adopted to prevent the proliferation of *Ae. aegypti* in water drums. For example, the provision of house connections from a central water supply, a long term objective, would not solve the water storage problem unless it is reliable, as demonstrated in Venezuela and Trinidad (Barrera et al. 1993, Chadee and Rahaman 2000). Alternatively, the physical exclusion of mosquitoes by providing protective covers for drums is another option; however, this method would be effective only if the covers are easy to use (PAHO 1994). The introduction of larvivorous fish such as *Poecilla reticulata* (L.) or other biological control agents such as copepods, bacteria, "la untadita" method of combining detergent and bleach to destroy *Ae. aegypti* eggs (Sherman et al. 1998), or use of appropriate insecticides like temephos are available options.

In conclusion, the use of the 1-in-10 house inspection and treatment sampling methodology provides a snapshot of the incidence and geographic distribution of *Ae. aegypti* in Tobago. In addition, this study also provides some of the risk factors for an epidemic outbreak of both classical dengue and dengue hemorrhagic fever, given Breteau indices in the order of 4.6 to 48.6 throughout the island. Therefore, a more systematic and sustained vector control approach should be adopted to stem the wave of dengue transmission and reduce vector populations to below epidemic transmission thresholds.

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