Public Service Deficiencies and *Aedes aegypti* Breeding Sites in Venezuela[1]

R. Barrera,[2] J. C. Navarro,[2] J. D. Mora,[3] D. Domínguez,[3] & J. González[3]

♦♦♦

*The 1992 study reported here assessed relationships between potable water supply and trash collection practices and the prevalence of dengue vector mosquito (*Aedes aegypti*) breeding sites in 30 towns located along the north coast of Venezuela. Within each study town, 100 homes were chosen. At each of these homes the number of water-bearing containers and containers harboring* A. aegypti *were determined and interviews were conducted to obtain information about the local water supply, trash collection services, and excreta disposal. In general,* A. aegypti *breeding indexes were high: 55% of the residences were found to harbor* A. aegypti *immature forms; there was an average of 118 breeding sites per 100 residences; and 24% of the water-bearing receptacles were observed to contain the mosquito. The statistical method of principal component analysis was employed to rank the 30 towns in terms of variables describing public service deficiencies, and correlations existing between the variables studied were determined. Direct correlations were found between two water supply variables (frequency and duration of water supply interruptions), between the excreta disposal and trash collection variables, between the duration of water supply interruptions and the* Aedes *breeding indexes, and between the duration of water supply interruptions and the mean number of* A. aegypti *breeding sites found in water storage containers. Overall, the towns with the poorest services were found to have the highest breeding indexes and the greatest numbers of water storage containers harboring the mosquito. It is concluded that public service (water supply and waste disposal) deficiencies were largely responsible for* A. aegypti *propagation in the study towns. Accordingly, it is recommended that local programs be implemented for recycling containers, constructing water storage tanks that cannot harbor* Aedes *larvae, and conducting health education and community participation campaigns directed against the mosquito.*

The appearance of dengue hemorrhagic fever epidemics in the Caribbean has made it advisable to update information on the breeding of *Aedes aegypti* in the region, so that wide-ranging control initiatives may be adopted. In addition, the increasing spread of *Aedes albopictus* in the Americas justifies exploration of the causes behind current prevalences of its larvae in breeding containers. In this vein, it should be noted that a common characteristic of tropical countries in the Americas is accelerated urban growth without corresponding development of basic public services (*1, 2*); and so it is important to know this situation's impact upon the breeding of dengue vectors. For example, it is well known that discarded containers that catch rainwater (used tires, tin cans, scrap metal, etc.) provide aquatic habitats for imma-

[1]The work reported here was made possible through financing provided by PAHO/WHO and Venezuela's National Council for Scientific and Technological Research (Project S1-2088). Reprint requests and other correspondence should be addressed to Dr. Roberto Barrera R., Apdo. 47058, Caracas 1041-A, Venezuela. This article was also published in Spanish in the *Boletín de la Oficina Sanitaria Panamericana*, Vol. 118, No. 5, 1995.

[2]Vector Biology Laboratory, Institute of Tropical Zoology, School of Sciences, Central University of Venezuela, Caracas, Venezuela.

[3]Ministry of Health and Social Welfare, Bureau of Rural Endemias, Maracay, Venezuela.

ture forms of *A. aegypti;* and hence it is reasonable to suppose that deficiencies in trash collection services may encourage an accumulation of containers promoting *A. aegypti* propagation, dengue transmission, and increased risk of dengue hemorrhagic fever (*3*).

Also, although water storage containers (tanks, cisterns, metal drums), containers for ornamental plants and flowers, and drinking pans for animals also contribute to the breeding of *A. aegypti,* their utility makes their elimination difficult. Since such containers are used in dry as well as rainy seasons and are filled manually, *A. aegypti* is able to find breeding sites throughout the entire year regardless of rainfall patterns.

Several authors have linked poor potable water supply services to promotion of *A. aegypti* breeding-places in water storage containers (*1, 2, 4–14*). Such breeding-places appear to play a significant role in many countries (*5, 12, 14–22*). It has also been pointed out that establishment of an appropriate piped water storage system contributes to reduction of *A. aegypti* breeding levels (*23, 24*). In addition, one recent study in a coastal Venezuelan town revealed a positive correlation between the frequency of interruptions in the supply of piped water to dwellings and *A. aegypti* breeding (*25*). It was found that part of the population that experienced few water supply interruptions nevertheless continued to store water and breed *A. aegypti.* This observation, together with a finding that the entire village population was without water for periods of days or weeks on end as a result of frequent breakages in the water mains, led to a hypothesis that the presence of numerous water storage containers would depend not only on the frequency of water supply interruptions but also on the amount of time that people were without water. For this reason, it was felt important to examine the relationships involved, since their implications for *A. aegypti* breeding and dengue transmission could mean that the criterion of "a good piped water supply" should include an uninterrupted supply of water to the general public.

Preliminary observations made in various towns and in marginal areas of large cities suggest that *A. aegypti* breeding in domestic water storage containers could become widespread in Venezuela, which in turn would render control extremely difficult. The study reported here was conducted to assess the prevalence of such containers and *A. aegypti* in a sample of 30 Venezuelan towns and to test the hypothesis that the abundance of such breeding-places is related to the frequency and duration of interruptions in piped water services. The study also explored relationships between the abundance of discarded receptacles containing *A. aegypti* and deficiencies in trash collection and excreta disposal services.

MATERIALS AND METHODS

Initially, 30 northern coastal towns were selected, an effort being made to select ones with similar climatic conditions. Those selected were all large enough (>2 500 inhabitants) to be considered important population centers (most had between 5 000 and 50 000 residents) (*26*). Large cities were avoided because their heterogeneous nature would have made large sample sizes necessary in order to obtain adequate representations of the basic services supplied and *A. aegypti* breeding patterns.

To help determine the importance of water storage containers as *A. aegypti* breeding sites, an effort was made to select the sample during the north coast's season of least rainfall (November–May), the towns actually being visited in April–June 1992.

One hundred dwellings were visited in each town. In selecting this 100-residence sample, the different neighborhoods or groups of homes exhibiting relative uniformity within each town were visited. The sampling area was then divided into three or four groups, and an attempt was made to cover the greatest area possible. Strictly commercial and industrial areas were excluded. In residential neighborhoods and housing developments, one out of every three to five homes was selected. When it was not possible to obtain a response at one home, a visit was made to the next. Each dwelling was inspected in order to locate all receptacles containing water and *A. aegypti* larvae. In addition, sufficient information was obtained to determine the following variables: the domestic *A. aegypti* index (the percentage of homes having at least one *A. aegypti* breeding site), the Breteau index (the number of breeding sites per 100 dwellings), the index of positive receptacles (the percentage of receptacles containing the vector relative to the total number of water-bearing receptacles), and the number of receptacles in each of various categories containing *A. aegypti.*

At each home visited the housewife was interviewed and asked to fill out a questionnaire designed to determine the size of the home's patio or yard (site of most *A. aegypti* breeding-places) and to assess deficiencies in water supply, trash collection, and excreta disposal.

To provide a basis for estimating waste disposal and water supply deficiencies, the housewife was presented with various questions and asked to check off one of several possible answers. The matters covered and answers listed were as follows: the source of potable water (1. water pipes present inside and outside the house, 2. water pipes present only outside the house, or 3. water supplied by tank truck); the frequency of interruptions in the piped water supply (1. never, 2. sometimes, 3. every two weeks, 4. weekly, or 5. daily); the duration of the interruptions (1. hours, 2. days, 3. weeks, or 4. months); the existence of urban home trash pickup (1. yes, 2. no); the frequency of trash pickup (1. daily or thrice weekly, 2. twice weekly, or 3. weekly); the nature of the excreta disposal system (1. inside the home and connected to a sewer system, 2. inside the home and connected to a septic tank, 3. outside the home, or 4. no service); and yard size (1. no yard, 2. small patio, 3. medium-sized patio, or 4. large yard).[4]

Each response was assigned a value within a range designed to rank the degree of service deficiency. Such deficiencies ranged from none (e.g., frequency of water supply interruption: 1 = never) to extreme (e.g., frequency of interruption: 5 = daily).

The statistical methods used consisted of descriptive statistics, rank correlation analysis (nonparametric), and principal component analysis. The reason for calculating nonparametric correlations was to determine whether any degree of association existed between pairs of variables. The principal component analysis was used to rank the towns as a function of linear combinations—combinations calculated on the basis of the variables describing public service deficiencies. In addition, the principal component analysis served to determine whether the number of public service-related variables needed to explain the observed variation between the towns could be reduced, so as to get an idea of the relationship between these variables and permit ranking of the towns according to the linear combinations obtained. It was hoped, in calculating principal components, that each linear combination explaining a major portion of the total variation would have some biologic significance that would make it possible

[4]A small patio was much smaller than the home's area, a medium-sized patio was about the size of the home's area, and a large yard was larger than the home's area.

to interpret the results as relating to some specific cause (e.g., water supply deficiencies). It should also be noted that when the towns were ranked according to such causes, estimates were also made of *A. aegypti* breeding levels and the most common types of breeding-places (e.g., water storage containers).

RESULTS

Of the 3 000 homes surveyed, 98.1% had potable water hookups, most (74.8%) both inside and outside the house. Only 1.9% received their water exclusively from tank trucks. The mean water source variable scores in different towns ranged from 1.0 to 1.9, the overall mean being 1.3. Regarding the frequency of water supply interruptions, only 8.1% of those surveyed indicated that their water service was never interrupted. In 49.1% of the homes, water service interruption (for hours at a time) was said to be occasional while in 42.7% interruptions were said to occur weekly (13.7%) or daily (29.0%). The mean town scores for this variable ranged from 1.5 to 4.7, the overall mean being 3.0. Regarding the duration of interruptions, 30.6% of those interviewed said water service interruptions were a matter of hours, while 53.1% indicated that their water supply was commonly interrupted for days (36.8%) or weeks (16.3%) at a time. The mean town values for this variable ranged from 1.2 to 3.4, the overall mean being 1.9.

Most of the dwellings had an excreta disposal system inside the house connected to a sewer system (51.6%) or septic tank (38.6%); less than 10% disposed of excreta in latrines outside the home (4.5%) or had no disposal facilities at all (5.3%). The mean town scores for this variable ranged from 1.0 to 2.6, the overall mean being 1.6. Most (80.7%) of those interviewed said they had home garbage pickup, while 19.3% said the residents disposed of their trash themselves (by burning, etc.). The mean town scores for this variable ranged from 1.0 to 2.0, the overall mean being 1.2. At homes where garbage was picked up, the respective percentages of interview subjects reporting weekly, twice-weekly, and daily pickups were 29.5%, 48.5%, and 22.0%. The mean town values for this variable ranged from 1.1 to 3.0, the overall mean being 2.2. Regarding yards, 7.4% of the residences surveyed had no yard, 28.4% had small yards, 12.7% had medium-sized yards, and 51.4% had large yards. The mean town scores for this variable ranged from 1.7 to 3.6, the overall mean being 3.1.

Analysis of nonparametric correlation (Spearman's correlation coefficient) between pairs of variables representing public service deficiencies (Table 1) revealed a highly significant positive correlation ($P < 0.01$) between the reported frequency of water supply interruptions and the reported duration of such interruptions. The analysis also showed positive correlations between pairs of variables relating to excreta disposal, provision of garbage collection, frequency of garbage collection, and yard size. It should be emphasized that no significant correlations were found between the water supply variables and those relating to waste disposal or yard size.

The principal component analysis, conducted in order to rank the towns surveyed as a function of the public service variables, made it possible to reduce the number of variables to five and to exclude the source of potable water and yard size variables. In addition, the analysis was able to account for 71.4% of the variation following calculation of the first two components (Table 2). The first principal component was a linear combination with important positive weights for the excreta disposal, provision of garbage collection, and frequency of garbage collection variables (Table 2). The second principal component was a linear combination with high weights for the fre-

Table 1. Spearman's nonparametric correlation coefficients among variables indicating a deficiency in public services in 30 coastal towns of Venezuela, 1992.

	Frequency of water supply interruptions	Duration of water supply interruptions	Excreta disposal	Provision of garbage collection	Frequency of garbage collection	Yard size
Frequency of water supply interruptions		+0.60*	−0.08 (NS)	−0.17 (NS)	−0.33 (NS)	−0.22 (NS)
Duration of water supply interruptions			+0.31 (NS)	+0.33 (NS)	+0.01 (NS)	+0.02 (NS)
Excreta disposal				+0.47†	+0.46†	+0.52*
Provision of garbage collection					+0.36 (NS)	+0.46†
Frequency of garbage collection						+0.58*
Yard size						

* = $P < 0.01$.
† = $P < 0.05$.
NS = not significant, $P > 0.05$.

Table 2. Analysis of principal components for 30 Venezuelan coastal towns based on variables indicating deficiencies in public services, 1992.

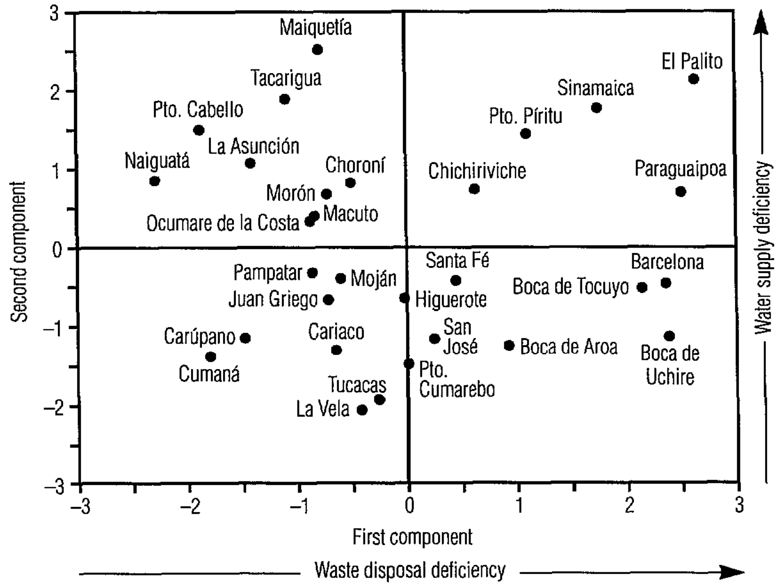
	Percentage variation explained by each principal component	
Components	%	Cumulative %
1	39.76	39.76
2	31.66	71.42
3	13.11	84.53
4	8.73	93.26
5	6.74	100.00

	Linear combinations	
Variables	First component	Second component
Frequency of interruptions	−0.13	0.69
Duration of interruptions	0.28	0.66
Excreta disposal	0.60	0.06
Garbage collection	0.57	0.01
Frequency of garbage collection	0.46	−0.28

quency of water supply interruptions and the duration of such interruptions. In this statistical method, each component is a linear combination of independent, orthogonal, noncorrelated variables with the other components. The high observed correlation (Table 1) between the two water supply deficiency variables and the absence of any correlation between them and the rest of the variables supports a conclusion that the principal component analysis has separated these two groups of variables into two independent components with no intercorrelation.

Figure 1 locates the study towns in terms of the values obtained for the variables having the greatest weight in each of the two principal components. For example, the second principal component (charted on the Y-axis) relates to the frequency of water service interruptions and the duration of such interruptions. It is sup-

Figure 1. Ranking of the 30 towns as a function of the first two principal components (see Table 2) describing the deficiency in public services. Reported waste disposal deficiencies increase from left to right along the horizontal (X) axis. Reported potable water supply deficiencies increase from bottom to top along the vertical (Y) axis.



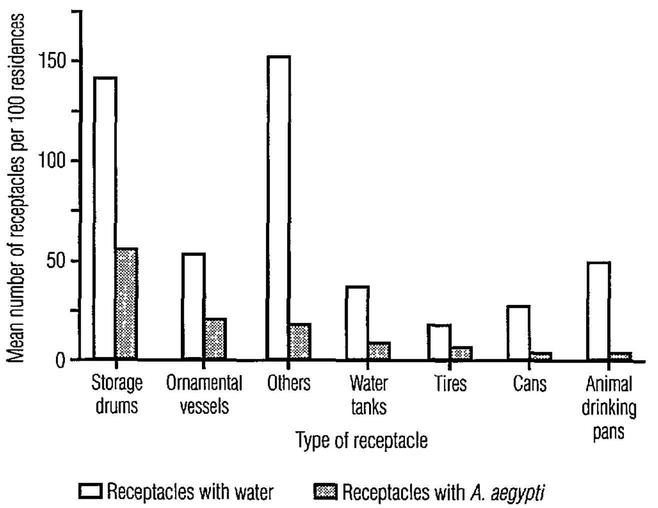
posed that the towns having the highest combined values for these variables will be ranked toward the positive end of the second principal component. Thus, the second principal component makes it possible to rank the towns from those having the lowest frequency and duration of interruptions (toward the bottom of the figure) to those having the highest scores for these variables (toward the top of the figure). The same reasoning applies to the first principal component (charted on the X-axis), which takes simultaneous account of the variables that received the highest scores with regard to excreta disposal, provision of garbage collection, and frequency of garbage collection. The resulting Figure 1 chart ranks the study towns as a function of the two groups of independent variables. At the upper right are the towns with the greatest simultaneous water supply and waste disposal deficiencies (e.g., El Palito, Paraguaipoa, Puerto Píritu, and Sinamaica). At the lower left are those with the least simultaneous water supply and waste disposal deficiencies (e.g., Cumaná, Carúpano, and La Vela). This ranking will be used later to explore relationships between these public service deficiencies and the variables used to describe *A. aegypti* breeding in each town.

The domestic *A. aegypti* indexes (the percentages of habitations with *A. aegypti*) that were found for the various towns in the course of the study ranged from 24% to 85%, with the mean for all 30 towns being 55%. The Breteau index for the towns ranged from 38 to 263 breeding sites per 100 dwellings, with an overall mean of 118 for all the towns. The index of positive receptacles (the percentage of water-bearing vessels containing *A. aegypti*) in the various towns ranged from 12% to 40%, the overall mean for the 30 towns being 24%.

The principal types of receptacles found to contain *A. aegypti* larvae or pupae were as follows: water storage containers (both water tanks and 208-liter metal drums); ornamental containers (vessels for flowers or plants that were filled with water or dirt and that had no form of drainage); watering pans for dogs, cats, chickens, and other small domestic animals; and miscellaneous receptacles that typically held water after a rain (used tires, tin cans, scrap metal, etc.). As Figure 2 indicates, the most commonly found water-bearing receptacles were miscellaneous containers, such as soft drink bottles, discarded in yards outside the homes (152 per 100 homes), followed by water storage drums (141 per 100 homes). However, *A. aegypti* larvae and pupae were found most often in the latter (57 homes per 100 had drums containing *A. aegypti*), followed by ornamental containers (20 homes per 100), other containers including bottles (19), water storage tanks (8), tires (6), cans (4), and animal drinking pans (4). The percentages of each type of container holding water that were positive for *A. aegypti* were as follows: water storage drums, 40.3%; ornamental containers, 37.4%; tires, 35.3%; water storage tanks, 21.5%; cans, 14.5%; other containers, 12.2%; and animal drinking pans, 7.8%.

The receptacles found to contain *A. aegypti* were grouped into four categories: containers for storing drinking water (tanks, drums, etc.); ornamental containers (flower pots, planters, etc.); animal watering pans; and disposable items (tires, cans, bottles, scrap metal, etc.). In 24 of the 30 towns (80%) it was observed that water storage containers (consisting primarily of metal drums) constituted the most prevalent breeding sites, while in five towns ornamental vessels were predominant and in one town disposable container breeding sites predominated. There were only two towns where one type of container accounted for virtually all the *A. aegypti* breeding sites, the types involved being water storage containers in one case and ornamental vessels in the other. In several towns, however, the number of breeding sites found in some individual category of receptacles was comparatively quite low, and water-

Figure 2. Average numbers of various types of receptacles found to contain water (light bars) and immature *Aedes aegypti* (dark bars) per 100 houses sampled in the 30 study towns.



bearing ornamental vessels were almost completely absent in nine towns.

The prevalence of water storage container breeding sites was remarkable in several towns where the Breteau indexes were quite high, a finding that reflects the importance of such containers. Analysis of the nonparametric correlation between variables indicating *A. aegypti* breeding revealed highly significant positive correlations ($P < 0.01$) between the three indexes (the domestic *A. aegypti* index, Breteau index, and positive receptacle index) (Table 3). It also revealed highly significant correlations ($P < 0.01$) or significant correlations ($P < 0.05$) between the numbers of *A. aegypti*-positive water storage containers and animal drinking pans per 100 homes and the three *A. aegypti* indexes. However, no positive correlations were found between the numbers of breeding sites detected in different container categories.

Analysis of correlations between public service deficiency variables and immature *A. aegypti* prevalences (Table 4) indicated that the reported duration of interruptions in the drinking water supply was the only variable exhibiting significant correlations with the *A. aegypti* indexes. The strongest of these correlations was found between the duration of interruptions and the Breteau index. The number of *A. aegypti* breeding sites found in water storage containers also showed a positive and highly significant correlation ($P < 0.01$) with the duration of water supply interruptions. In addition, the number of breeding sites found in ornamental vessels exhibited highly significant negative correlations ($P < 0.01$) with deficient excreta disposal systems and the frequency of garbage collection, which indicates the presence of fewer breeding sites of this type where the status of such services was poor. A noteworthy but not statistically significant relationship ($P > 0.05$) was also observed between yard size

Table 3. Spearman's nonparametric rank correlation coefficients among variables indicating the breeding of *Aedes aegypti* in 30 coastal towns of Venezuela, 1992.

	Domestic *Aedes* index	Positive receptacles index	Breteau index	*A. aegypti* in storage receptacles	*A. aegypti* in ornamental vessels	*A. aegypti* in drinking pans	*A. aegypti* in disposable containers
Domestic *Aedes* index		+0.76*	+0.87*	+0.65*	+0.21 (NS)	+0.43†	+0.45†
Positive receptacles index			+0.81*	+0.57*	+0.37†	+0.58*	+0.32 (NS)
Breteau index				+0.77*	+0.23 (NS)	+0.44†	+0.47†
A. aegypti in storage receptacles					−0.24 (NS)	+0.25 (NS)	+0.14 (NS)
A. aegypti in ornamental vessels						+0.17 (NS)	−0.05 (NS)
A. aegypti in drinking pans							+0.17 (NS)
A. aegypti in disposable containers							

* = $P < 0.01$.
† = $P < 0.05$
NS = not significant, $P > 0.05$.

Table 4. Spearman's nonparametric rank correlation coefficients among variables indicating the breeding of *Aedes aegypti* and variables indicating deficiencies in public services in 30 coastal towns of Venezuela, 1992.

	Frequency of water supply interruptions	Duration of water supply interruptions	Excreta disposal	Provision of garbage collection	Frequency of garbage collection	Yard size
Domestic *Aedes* index	+0.24 (NS)	+0.38†	−0.07 (NS)	+0.01 (NS)	−0.17 (NS)	−0.14 (NS)
Index of receptacles	+0.20 (NS)	+0.41†	+0.09 (NS)	+0.28 (NS)	−0.14 (NS)	+0.25 (NS)
Breteau index	+0.30 (NS)	+0.50*	+0.01 (NS)	+0.26 (NS)	−0.12 (NS)	+0.17 (NS)
A. aegypti in storage containers	+0.36 (NS)	+0.75*	+0.26 (NS)	+0.31 (NS)	+0.16 (NS)	+0.23 (NS)
A. aegypti in ornamental vessels	+0.11 (NS)	−0.17 (NS)	−0.50*	−0.30 (NS)	−0.51*	−0.27 (NS)
A. aegypti in drinking pans	+0.11 (NS)	+0.03 (NS)	−0.12 (NS)	+0.04 (NS)	−0.09 (NS)	+0.35 (NS)
A. aegypti in disposable containers	−0.19 (NS)	−0.03 (NS)	−0.07 (NS)	+0.20 (NS)	−0.05 (NS)	+0.25 (NS)

* = $P < 0.01$.
† = $P < 0.05$.
NS = not significant, $P > 0.05$.

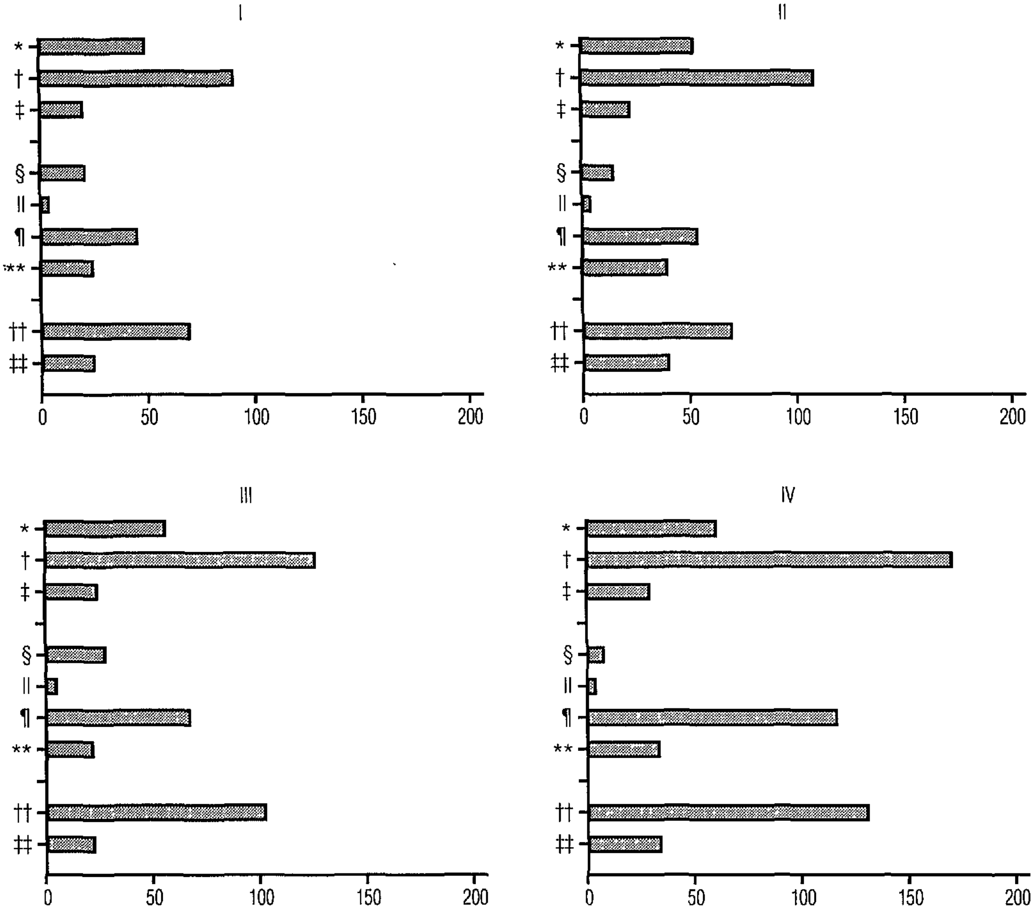
and the numbers of *A. aegypti* breeding sites found in animal drinking pans.

The ranking of the 30 towns in accordance with the two principal components calculated (see Figure 1) can be used to assess the impact of public services on the *Aedes* indices compiled. By considering each of the four quadrants into which Figure 1 is divided (Quadrant I is to the lower left, Quadrant II is to the lower right, Quadrant III is to the upper left, and Quadrant IV is to the upper right) it is possible to chart the scores of the *Aedes* breeding indices for the towns in each quadrant, as has been done in Figure 3. As may be seen, the towns with the least deficient public services (in Quadrant I) had the lowest mean *A. aegypti* indexes, while those with the most deficient services (in Quadrant IV) had the highest mean *A. aegypti* indexes. Quadrant II, which along with Quadrant IV contains the towns with the worst trash collection services, exhibits the highest average numbers of *A. aegypti* breeding sites found in disposable containers. The two upper quadrants (III and IV), which contain the towns with the worst potable water supply services, exhibit the highest average numbers of *A. aegypti* breeding sites found in water storage containers.

DISCUSSION AND CONCLUSIONS

To help assess the importance of water storage containers (e.g., receptacles that the study population typically kept filled with water) as breeding sites for *A. aegypti*, this study was conducted at the end of the dry season, thus minimizing the effect of rainfall. Still, in order to consider the effect of rainfall on generation of breeding sites and to isolate it from the effects of the public service variables, it would have been appropriate to have the analysis include rainfall data for the 30 days preceding the sampling visits in each town. This could not be done, as it

Figure 3. *A. aegypti* breeding indexes and percentages of various containers positive for the mosquito in study towns in four groups corresponding to the four quadrants of Figure 1, as follows: I. towns with relatively slight water supply and waste disposal deficiencies; II. towns with relatively great waste disposal deficiencies and relatively slight water supply deficiencies; III. towns with relatively slight waste disposal deficiencies and relatively great water supply deficiencies; and IV. towns with relatively great waste disposal and water supply deficiencies.



* Domestic *Aedes* index.

† Breteau index.

‡ Index of positive receptacles.

§ Breeding sites in ornamental vessels (No. per 100 residences)

II Breeding sites in animal drinking pans (No. per 100 residences).

¶ Breeding sites in water storage containers (No. per 100 residences).

** Breeding sites in disposable receptacles (No. per 100 residences).

†† Total breeding sites in water-bearing containers filled by people: water storage containers, ornamental vessels, animal drinking pans (No. per 100 residences).

‡‡ Total breeding sites in water-bearing containers filled by rainfall: disposable receptacles (No per 100 residences)

was not possible to obtain data from a sufficiently large number of the towns surveyed to render an appropriate statistical treatment. The existence of water-bearing receptacles that normally fill up with rainwater (e.g., discarded tires, cans, bottles, etc.) in the areas surveyed reveals that rainfall did indeed have an effect, particularly because the sampling extended up to the beginning of the rainy season. However, it is presumed that during the course and end of the rainy season the number of *A. aegypti* breeding sites in discarded receptacles is considerably greater than during the dry season, which in turn could increase *Aedes* indices in the former period.

Our results showed that in most study towns (80%) water storage receptacles were the most prevalent *A. aegypti* breeding sites, and that 208-liter drums typically had the highest levels of infestation. Although 30 towns constitute a relatively small sample for drawing conclusions about the importance of such breeding sites throughout the entire country, the high percentage of towns in which this result was observed raises the possibility that water supply service deficiencies are common and have an important impact on the breeding of *A. aegypti* in Venezuela.

Water storage drums appear to be commonly used in several Caribbean countries, where these containers are important *A. aegypti* breeding sites (*14, 17, 19–21*). Moreover, the containers' presence has been related to potable water supply deficiencies and low socioeconomic levels (*14, 27*). Since most homes visited in our study had hookups for a piped water supply, and since the frequency and duration of interruptions in that water supply were associated with the abundance of storage container breeding sites, it is concluded that the irregularity in water supply service is to a large extent responsible for the high prevalence of *A. aegypti*. This study therefore supports the previously presented theory (*25*) that depriving the general public of water for prolonged periods is inadvisable, among other things because it promotes water storage on an individual basis in containers that make good *A. aegypti* breeding sites.

The higher prevalences of disposable containers, typically accumulated in yards outside of homes, that were found in the towns with relatively poor waste disposal services (see Figure 3) underscore the importance of this service (*3, 25*). More generally, since the *A. aegypti* breeding indexes were highest and were associated with a greater abundance of breeding sites in those towns having the worst public services (water supply, trash collection, excreta disposal, etc.), it seems reasonable to conclude that deficiencies in such services were responsible for breeding of *A. aegypti* in these areas.

One way of controlling *A. aegypti* would be to provide the entire population with adequate basic services. However, the problem in Venezuela is not a lack of broad-based basic service coverage, but rather the low quality of such services and the irregularity with which they are provided. In addition, it has been suggested (*25*) that even after providing adequate public services (such as an uninterrupted supply of potable water) to the public, it would be some time before noticeable changes occurred in the way water was stored; indeed, such changes might not occur until people were able to determine for themselves that there was nothing to be gained from maintaining individual supplies of water. Furthermore, the provision of quality public services in developing countries would appear to be an impossible short-term goal; and since dengue outbreaks will continue to occur during this period, it will be necessary to develop alternative approaches to implementing control measures. The prevailing potable water supply deficiencies and the resulting practice of storing water might be addressed over the short term by promoting construction of water storage systems in which *A. aegypti* are unable to thrive (4). In addition, elimination of solid waste (including bottles, cans, etc.) that can harbor *A. aegypti* is to a great extent a municipal responsibility. It would thus seem advisable to encourage creation of microenterprises for recycling receptacles (tires, glass, metal, plastic, etc.) and other waste such as paper, and also to teach trash collection firms how to promote regular disposal of containers accumulating in yards outside of homes. Along these same lines, health education programs (particularly those aimed at children and community leaders) will require continuing support albeit with full knowledge that such programs will be ineffective unless accompanied by concrete prospects for reconciling mosquito control efforts with basic public needs (2). Such education programs are essential for controlling *A. aegypti* breeding sites in both private areas and in public places (such as flower stands in cemeteries, for example), the environmental handling of which must consider both local customs and the need to have residents support any measures taken (*28–30*).

Acknowledgments. The authors are grateful for the support provided by Dr. Jesús Berti of the Vector Control Division of Venezuela's Ministry of Health and Social Welfare, Dr. Robert Zimmerman of the Pan American Health Organization, and Lic. Hermes Piñango of the Vector Laboratory of the Central University of Venezuela.

REFERENCES

1. Halstead SB. *Aedes aegypti*: why can't we control it? *Bull Soc Vector Ecol* 1988;13:304–311.
2. Tonn RJ. Urban vector and pest control in developing countries. *Bull Soc Vector Ecol* 1988;13:291–294.
3. Winch PJ, Barrientos-Sánchez G, Puigserver-Castro E, Manzano-Cabrera L, Lloyd LS, Méndez-Galván JF. Variation in *Aedes aegypti* larval indices over a one-year period in a neighborhood of Mérida, Yucatán, Mexico. *J Am Mosquito Control Assoc* 1992;8:193–195.
4. Chan KL, Chang MS, Laird M, Phanthumachinda B. Control of *Aedes* mosquitoes by the community. In: Curtis CF, ed. *Appropriate technology in vector control.* Boca Raton, Florida: CRC Press; 1989:103–119.
5. Cheong WH. Preferred *Aedes aegypti* larval habitats in urban areas. *Bull World Health Organ* 1967;36:586–589.
6. Connor ME. Suggestions for developing a campaign to control yellow fever. *Am J Trop Med Hyg* 1924;4:277–307.
7. Elliott R. Larvicidal control of peridomestic mosquitoes. *Trans R Soc Trop Med Hyg* 1955;49:528–542.
8. Gratz NG. The control of *Aedes aegypti* in South-East Asia and the Western Pacific. *Bull World Health Organ* 1967;36:614–617.
9. Knudsen AB, Slooff R. Vector-borne disease problems in rapid urbanization: new approaches to vector control. *Bull World Health Organ* 1992;70:1–6.
10. Lumsden WHR. An epidemic of virus disease in Southern Province, Tanganyika Territory, in 1952–53. *Trans R Soc Trop Med Hyg* 1955;49:33–57.
11. Macdonald WW. *Aedes aegypti* in Malaya: II. larval and adult biology. *Ann Trop Med Parasitol* 1956;50:399–414.
12. Rao TR. Distribution, density, and seasonal prevalence of *Aedes aegypti* in the Indian Subcontinent and South-East Asia. *Bull World Health Organ* 1967;36:547–551.
13. Soper FL. Dynamics of *Aedes aegypti* distribution and density: seasonal fluctuations in the Americas. *Bull World Health Organ* 1967;36:536–538.
14. Tidwell MA, Williams DC, Carvalho-Tidwell T, et al. Baseline data on *Aedes aegypti* populations in Santo Domingo, Dominican Republic. *J Am Mosquito Control Assoc* 1990;6:514–522.
15. Camargo S. History of *Aedes aegypti* eradication in the Americas. *Bull World Health Organ* 1967;36:602–603.
16. Chadee DD. An evaluation of Temephos in water drums in Trinidad, WI. *Mosquito News* 1984;44:51–53.
17. Chadee DD. *Aedes aegypti* surveillance in Tobago, West Indies (1983–88). *J Am Mosquito Control Assoc* 1990;6:148–150.

18. Chadee DD. Seasonal incidence and vertical distribution patterns of oviposition by *Aedes aegypti* in an urban environment in Trinidad, WI. *J Am Mosquito Control Assoc* 1991;7:383–386.
19. Knudsen AB. *Aedes aegypti* and dengue in the Caribbean. *Mosquito News* 1983;43:269–275.
20. Nathan MB, Giglioli MEC. Eradication of *Aedes aegypti* on Cayman Brac and Little Cayman, West Indies, with Abate (temephos) in 1970–1972. *Bull Pan Am Health Organ* 1982;16:28–39.
21. Nathan MB, Knudsen AB. *Aedes aegypti* infestation characteristics in several Caribbean countries and implications for integrated community-based control. *J Am Mosquito Control Assoc* 1991;7:400–404.
22. Tonn RJ, Sheppard PM, Macdonald WW, Bang YH. Replicate surveys of larval habitats of *Aedes aegypti* in relation to dengue hemorrhagic fever in Bangkok, Thailand. *Bull World Health Organ* 1969;40:819–829.
23. Beeuwkes H, Mahaffy AF. The past incidence and distribution of yellow fever in West Africa as indicated by protection test surveys. *Trans R Soc Trop Med Hyg* 1934;28:39–76.
24. Holstein M. Dynamics of *Aedes aegypti* distribution, density, and seasonal prevalence in the Mediterranean area. *Bull World Health Organ* 1967;36:541–543.
25. Barrera R, Avila J, González-Téllez S. Unreliable supply of potable water and elevated *Aedes aegypti* indices: a causal relationship? *J Am Mosquito Control Assoc* 1993;9:189–195.
26. Caracas, Oficina Central de Estadística e Informática. *El Censo 90 en Venezuela.* Caracas: OCEI; 1993.
27. Gubler DJ. *Aedes aegypti* and *Aedes aegypti*-borne disease control in the 1990s: top down or bottom up. *Am J Trop Med Hyg* 1989;40:571–578.
28. Barrera R, Machado-Allison CE, Bulla LA. Criaderos, densidad larval y segregación de nicho en tres Culicidae urbanos (*Culex fatigans* Wied., *C. corniger* Theo., y *Aedes aegypti* L.) en el Cementerio de Caracas. *Acta Cient Venez* 1979;30:418–424.
29. Barrera R, Machado-Allison CE, Bulla LA. Persistencia de criaderos, sucesión y regulación poblacional en tres Culicidae urbanos (*Culex fatigans* Wied., *C. corniger* Theo., y *Aedes aegypti* L.). *Acta Cient Venez* 1981;32:386–393.
30. Barrera R, Machado-Allison CE, Bulla LA, Strong DR. Mosquitoes and mourning in the Caracas Cemetery. *Antenna* 1982;6:250–252.

♦♦♦

International Health Conference in Canada

The Second Canadian Conference on International Health (CCIH) will be held on 12–15 November 1995 in Ottawa, Ontario. The conference theme is "Health Reform around the Globe: Towards Equity and Sustainability." Sponsors of the CCIH are the Canadian Society for International Health and the Canadian University Consortium for Health in Development, with the support of the Canadian International Development Agency, the International Development Research Center, and PAHO. For more information, please contact:

CCIH Organizing Committee
170 Laurier Avenue W., Suite 902
Ottawa, Ontario K1P 5V5 Canada
phone: (613) 230-2654; fax (613) 230-8401
e-mail: csih@fox.nstn.ca