Variation in *Aedes aegypti* (Diptera: Culicidae) container productivity in a slum and a suburban district of Rio de Janeiro during dry and wet seasons

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Seasonal variation in container productivity and infestation levels by Aedes aegypti *were evaluated in two areas with distinct levels of urbanization degrees in Rio de Janeiro, a slum and a suburban neighborhood. The four most productive containers can generate up to 90% of total pupae. Large and open-mouthed containers, such as water tanks and metal drums, located outdoors were the most productive in both areas, with up to 47.49% of total* Ae. aegypti *pupae collected in the shaded sites in the suburban area. Water-tanks were identified as key containers in both areas during both the dry and rainy seasons. Container productivity varied according to seasons and urbanization degree. However, the mean number of pupae per house was higher in the suburban area, but not varied between seasons within each area (P > 0.05). High infestation indexes were observed for both localities, with a house index of 20.5-21.14 in the suburban and of 9.56-11.22 in the urban area. This report gives potential support to a more focused and cost-effective* Ae. aegypti *control in Rio de Janeiro.*

Key words: *Stegomyia* - container productivity - control - dengue - Rio de Janeiro

The principal urban vector of dengue and yellow fever is the mosquito *Aedes aegypti*, a species that has became closely associated with human habitation. In Rio de Janeiro, this species is generally abundant in urbanized areas, rarely invades urban forest fringes, traverses short distances, has high daily survival rates and breeds almost exclusively in artificial containers (Cunha et al. 2002, Braks et al. 2003, Lourenço-de-Oliveira et al. 2004, Maciel-de-Freitas et al. 2006a, 2007). In Rio de Janeiro, a city with intense spatial heterogeneity, efficient dengue control seems to be difficult to accomplish (Luz et al. 2003).

At present, dengue transmission can only be reduced or interrupted by mosquito control. Traditional infestation indices, such as House and Breteau Index, are currently used to monitor *Ae. aegypti* populations. However, it has some drawbacks, such as poor capacity of predicting epidemics (Focks & Chadee 1997) and the absence of addressing container productivity, i.e. the number of adult *Ae. aegypti* produced over time (Focks et al. 1981, Tun-Lin et al. 1995). Focks and Chadee (1997) formulated new infestation indices, including pupae per person (number of pupae collected over the total number of inhabitants of the households inspected) and pupae per hectare (number of pupae per hectare inspected), where entomological and epidemiological data were combined.

Previous reports have suggested that most pupae of *Ae. aegypti* were produced in few types of containers (Focks & Chadee 1997). Theoretically, the identification and subsequent elimination of the most *Ae. aegypti* producing containers in a given area may potentially reduce mosquito density below a critical threshold, what could result in more efficient and cost-effective control campaigns (Tun-Lin et al. 1995, Focks & Chadee 1997).

The principal aim of this report is to identify the most productive container types in two very distinct areas of Rio de Janeiro during dry and rainy seasons. In addition, container characteristics such as size, shape, exposure to sunlight, and location were tested to determine their influence on container productivity.

MATERIALS AND METHODS

Study areas - Two neighborhoods with distinct urbanization degree were chosen for this study: Tubiacanga (22º47’08’’S 43º13’36’’W) and Favela do Amorim (22º52’30’’S 43º14’53’’W). Tubiacanga was chosen to represent a suburban, moderate income area. It has an estimated number of 2915 residents living in 867 houses (human density of 337.36 hab./ha). This neighborhood is located in a lowland coastal area, partially surrounded by the Guanabara Bay shores and a three-meter high wall of the Tom Jobim International Airport of Rio de Janeiro and its numerous landing stripes. Houses generally have two dorm rooms and a large peridomestic area. Even with adequate sanitation and water supply, inhabitants also store water in large artificial containers.

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Favela do Amorim is a slum and was chosen as representative of a substandard, low income area, and has an estimated population of 2942 people living in 897 substandard houses (a human density of 901.24 hab/ha, i.e., almost three times higher than in Tubiacanga). Two paved streets surround the area, with human movements between blocks being made through narrow alleys. Houses rarely have more than one room, frequently share at least one wall and the majority of houses lack a peridomestic area. Favela do Amorim has inadequate sanitation and irregular garbage collection and water distribution. Consequently, Amorim residents have the habit of storing water in large containers. For more details concerning both areas, additional information can be found elsewhere (Maciel-de-Freitas et al. 2006b, 2007).

Survey - The climate of Rio de Janeiro is characterized by a dry winter (May-September) and a rainy summer (November-March). Air temperature and precipitation were recorded at the nearest meteorological station located approximately 5 km from both study areas.

House-to-house surveys were performed during both seasons in each area: Tubiacanga (the suburban area) in March 2005 (wet) and July 2004 (dry) and Favela do Amorim (the slum) in June 2004 (dry) and January 2005 (wet season). The main objective was to inspect all houses within each locality. In each house-to-house survey, all containers were inspected, all mosquito immatures were collected and identified following Consoli and Lourenço-de-Oliveira's (1994) identification keys and the water volume held in each container was measured.

In Tubiacanga, during wet season, temperature varied from 24.5 to 29.3ºC and month rainfall was 188.2 mm; during the dry season, temperature varied from 18.7 to 27.1ºC, with 62.6 mm of rainfall. In the slum, temperatures ranged from 20.3 to 27.8ºC during the dry season and from 24.6 to 31.4ºC during the wet season, when precipitation was 58.3 and 125.9 mm, respectively. Climate from both seasons was in accordance with the registered during ordinary years.

Container classification - Water holding containers were classified in five categories: type, size, shape, exposure to sunlight (placed in the shade or sunlight), and location (indoors or outdoors). Container size was determined by the volume of water it may potentially hold: small (holding less than 2000 ml), medium (from 2001 to 10,000 ml), and large (more than 10,000 ml). Container shape was classified as narrow-mouthed or open. Several container characters were also taken into account, such as its abundance (total number of water holding containers of one category), frequency of containers holding immature, relative productivity (the proportion of pupae collected in such a kind of container, i.e. how productive each container type was?) and total and mean ± SD of immature (larvae and pupae) collected per container type. Since the number of immatures per container has a characteristic non-normal distribution (Focks et al. 1981), the median and the interquartile distance (IQR) of pupae collected per container type was also evaluated. Since pupae mortality is low, it is generally accepted that the number of pupae per person is highly correlated with number of adult mosquitoes per person in such an area (Focks & Chadee 1997).

During the four house-to-house surveys, 18 different container types were found, and the nomenclature used herein needs some explanations. Pots, pans, and discarded glasses were called kitchen items. Plastic gallons and metal drums were large containers, generally with 25-100 l and 200 l capacity, respectively, used to store water. Covers were plastic sheets sometimes used to protect objects from rainwater, but primarily to cover large reservoirs to store water for home usage, such as water tanks and metal drums. Plant plate refers to the dish that is used under the plant vase to collect excess of water. All unusual container types that eventually were found positive, such as egg shells, chair seats, and abandoned footwear were classified as 'others'.

Data analysis - The mean number of pupae per house during the four house-to-house surveys was compared. Since each house-to-house had a different sample size, a Bartlett test was used to test variance homogeneity. If variance heterocedasticity was confirmed, a non-parametric analysis of variance (Kruskal-Wallis test) was performed with a similarity between medians as the null hypothesis. In case of rejection of the null hypothesis, a Dunn post-test was performed to determine which data series was different from others.

The number of pupae per container was log-transformed and container productivity was compared within categories by a Student's t-test, such as open shape vs narrow-mouthed shape; placed in peridomestic area vs placed inside houses; located under shaded areas vs located under sunlight; and small size vs medium size vs large size containers. We used a correspondence analysis to address the combined effects of the physical characteristics of the container on its production. This analysis is recommended when data is categorical, which is one of the properties of the four container categories evaluated (size, shape, exposure to light, and locality) (Legendre & Legendre 1998). The continuous variable (number of pupae) was categorized within five class intervals for each area (Tubiacanga: 1-2 pupas (P), 3-5 P, 6-11 P, 12-18 P, and 19-99 P; Favela do Amorim: 1-3 P, 4-7 P, 8-12 P, 13-30 P, and 31-115 P), with equitability between classes (Legendre & Legendre 1998). Tubiacanga data generated a matrix data set with 13 descriptors and 208 objects and Favela do Amorim a matrix with 13 descriptors and 86 objects. Both matrixes were analyzed with the software Statistica 6.0 (StatSoft 2001). The variable "narrow-mouth" was excluded from analysis due to its extremely low or even absence production (as shown below).

RESULTS

Numbers of houses and water-holding containers inspected - In the suburban area, a total of 546 out of 867 premises (62.9%) and 2676 (N = 9760; 27.41%) water-holding containers were inspected during the dry season. During the wet season, house-to-house inspections were made in 662 (76.3%) premises, where 3629 (N = 6076; 59.72%) water-holding containers were detected. For the slum, 401 (44.7%) and 847 (94.4%) premises and 2285 (33.6%) and 3837 (56.4%) from a total of 6803 water holding containers were inspected during the dry and wet seasons respectively. A higher number of houses could be inspected by health agents during the second house-to-house survey (wet season) probably because more house owners were confident to allow their house entrance following the well succeeded previous survey.

Species composition - In the suburban area during the dry season a total of 1282 pupae and 7060 larvae of *Ae. aegypti* were collected (Table I), resulting in a mean of 2.34 pupae per premise and 0.69 pupae per person. During the wet season 1064 pupae and 6098 larvae of *Ae. aegypti* were collected (Table II) resulting in 1.60 pupae per premise and 0.58 pupae per person. Other mosquito species found in Tubiacanga were *Ae. albopictus* (Skuse) [2 pupae (P) and 101 larvae (L)], *Ae. fluviatilis* (Lutz) (33 P and 89 L), *Culex* sp. (19 P and 48 L), and *Li. durhami* Theobald (3 L).

In the slum during the dry season, 633 pupae and 3087 larvae of *Ae. aegypti* were collected (Table III) resulting a mean number of pupae per house of 1.58 and pupae per person of 0.46. During the wet season, 959 pupae

TABLE I

Evaluation of containers abundance, frequency, and productivity for pupae and contribution to larvae collected in Tubiacanga (the suburban area), Rio de Janeiro, during the dry season. Interquartile distance (IQR) refers to the difference between upper sand lower quartiles of data distribution

Container type	Abundance (N)	Total of larvae (N)	Proportion of larvae in each container type	Containers with pupae	Total of pupae (N)	Mean ± SD	Median (IQR)	Frequency of containers with pupae (%)	Relative productivity
Boat hull	18	587	0.09	5	124	24.8 ± 23.6	31 (31)	27.78	0.10
Bottle	175	287	0.05	3	7	2.3 ± 1.2	3 (1)	1.71	0.01
Bromeliaceous	26	52	0.01	1	2	2	2 (0)	3.85	< 0.01
Bucket	282	353	0.05	6	78	13 ± 18.2	4.5 (12.75)	2.13	0.06
Drain	761	17	< 0.01	-	-	-	-	-	-
Gallon	66	362	0.06	7	38	5.4 ± 4.8	3 (6.5)	10.61	0.03
Kitchen items	162	582	0.09	5	73	14.6 ± 3.1	15 (5)	3.09	0.05
Metal drums	129	1710	0.27	24	413	17.2 ± 21.9	10 (14.5)	18.60	0.33
Plant vase	19	88	0.01	1	21	21	21 (0)	5.26	0.02
Plastic basin	19	245	0.04	2	48	24 ± 26.8	24 (19)	10.53	0.04
Plastic plate	83	233	0.04	1	2	2	2 (0)	1.20	< 0.01
Tire	39	191	0.03	7	48	6,9 ± 4.2	7 (6.5)	17.95	0.03
Water tank	413	1648	0.26	27	401	14.8 ± 21.9	8 (14.5)	6.54	0.32
Others	-	705	-	-	27	-	-	-	
Total	-	7060	1.00	94	1282	-		-	1.00

TABLE II

Evaluation of containers abundance, frequency, and productivity for pupae and larvae collected in Tubiacanga (the suburban area), Rio de Janeiro, during the wet season. Interquartile distance (IQR) refers to the difference between upper and lower quartiles of data distribution

Container type	Abundance (N)	Total of larvae (N)	Proportion of larvae in each container type	Containers with pupae	Total of pupae (N)	Mean ± SD	Median (IQR)	Frequency of containers with pupae (%)	Relative productivity
Boat hull	9	167	0.03	2	15	8.7 ± 6.2	5 (3)	22.22	0.02
Bottle	192	29	0.01	2	3	1.5 ± 0.7	1.5 (0.5)	1.04	< 0.01
Bromeliaceous	24	4	< 0.01	-	-	-	-	-	-
Bucket	413	396	0.08	10	118	11.8 ± 8.4	10.5 (16)	2.42	0.12
Covers	11	81	0.02	3	18	4.7 ± 3.8	7 (3.5)	27.27	0.02
Drain	1202	162	0.03	1	26	26	26 (0)	0.08	0.03
Gallon	28	77	0.01	1	4	4	4 (0)	3.57	< 0.01
Kitchen items	359	731	0.14	8	126	6.8 ± 6.4	7 (12)	4.74	0.13
Metal drums	163	776	0.14	16	211	13.2 ± 10.8	14 (14)	9.82	0.21
Plant vase	29	58	0.01	2	29	14.5 ± 10.6	14.5 (7.5)	7.14	0.03
Plastic basin	59	115	0.02	2	2	1	1 (0)	3.39	< 0.01
Plastic plate	50	614	0.12	2	3	1.5 ± 0.7	1.5 (0.5)	4.00	< 0.01
Tire	28	455	0.09	8	83	10.4 ± 9.7	7 (7.2)	28.57	0.08
Water tank	634	1608	0.30	35	345	9.8 ± 9.8	7 (9)	5.52	0.35
Others	-	825	-	-	81	-	-	-	-
Total	-	6098	1.00	92	1064			-	1.00

and 7068 larvae of *Ae. aegypti* were collected (Table IV) with a mean of 1.13 pupae per house and 0.35 pupae per person. Other species collected in the slum were *Ae. albopictus* (64 pupae and 655 larvae), *Culex* spp. (8 P and 298 L), *Ae. fluviatilis* (327 P and 880 L), and *Li. durhami* (13 L).

Container productivity **-** In the dry season at the suburban area, the most productive containers were metal drums, water tanks, and boat hulls (Table I). Boat hulls presented a high number of pupae (n = 124) while not even being an abundant container type in the area. During wet season, the three most productive containers types were water tanks (35%), metal drums (21%), and kitchen items (13%) (Table II). Differentially from the observed during the dry season, boat hulls had low production and abundance in the wet season. During both surveys performed in the suburban area, bottles and drains were very low productive containers, despite of their high abundance in both areas; high productive containers also had high contribution to the total of larvae collected.

In the slum, during dry season, the most productive container types were plant vases, water tanks, metal drums, and plastic plates (Table III). Even not being abundant in the slum, plant vases had the higher productivity in the dry season. During the wet season, the most productive containers in the slum were water tanks, buck-

TABLE III

Evaluation of containers abundance, frequency, and productivity for pupae and contribution to total larvae collected in Favela do Amorim (the slum), Rio de Janeiro, during the dry season. Interquartile distance (IQR) refers to the difference between upper and lower quartiles of data distribution

Container type	Abundance (N)	Total of larvae (N)	Proportion of larvae in each container type	Containers with pupae	Total of pupae (N)	Mean ± SD	Median (IQR)	Frequency of containers with pupae (%)	Relative productivity
Bottle	323	280	0.09	1	17	17	17 (0)	0.31	0.03
Bucket	261	581	0.20	4	41	14.4 ± 13.8	5 (6.2)	1.53	0.07
Domestic filter	18	23	0.01	-	-	-	-	-	-
Drain	760	86	0.03	-	-	-	-	-	-
Gallon	45	140	0.05	1	57	57	57 (0)	2.22	0.10
Kitchen items	53	34	0.01	-	-	-	-	-	-
Metal drums	109	470	0.16	5	104	20.8 ± 16.7	12 (19)	4.59	0.18
Plant vase	26	235	0.08	3	147	41 ± 27.8	45 (36)	11.53	0.26
Plastic plate	277	535	0.18	3	76	25.3 ± 19.3	19 (18.5)	1.08	0.13
Tire	5	158	0.05	-	-	-	-	-	-
Water tank	267	413	0.14	2	133	66.5 ± 68.5	66.5 (48.5)	0.75	0.23
Others		132	-	-	58	-	-	-	-
Total	-	3087	1.00	-	633	-	-	-	1.00

TABLE IV

Evaluation of containers abundance, frequency, and productivity for pupae and larvae collected in Favela do Amorim (the slum), Rio de Janeiro, during the wet season. Interquartile distance (IQR) refers to the difference between upper and lower quartiles of data distribution

Container type	Abundance (N)	Total of larvae (N)	Proportion of larvae in each container type	Containers with pupae	Total of pupae (N)	Mean ± SD	Median (IQR)	Frequency of containers with pupae (%)	Relative productivity
Bromeliaceous	10	72	0.01	2	4	2	2 (0)	20	< 0.01
Bucket	229	948	0.14	10	304	30.4 ± 36.1		4.37	0.32
Covers	5	304	0.04	2	117	58.5 ± 49.4	58.5 (53.5)	40	0.13
Domestic filter	67	28	< 0.01	-	-	-	-	-	-
Drain	1748	82	0.01	-	-	-	-	-	-
Gallon	51	27	< 0.01	-	-	-	-	-	-
Kitchen items	189	425	0.06	8	46	5.7 ± 3.8	3.5 (6.7)	4.23	0.05
Metal drums	176	612	0.09	3	18	4.5 ± 3.0	5 (3.5)	1.70	0.02
Plant vase	47	455	0.07	2	27	13.5 ± 6.3	13.5 (4.5)	4.25	0.03
Plastic plate	449	1211	0.18	14	118	8.4 ± 8.2	5.5 (9.2)	3.11	0.13
Water tank	660	2680	0.39	19	297	15.3 ± 19.7	12 (18.2)	2.88	0.32
Others	-	224	-	-	28	-	-	-	-
Total	-	7068	1.00	60	959	-	-	-	1.00

ets, covers, and plastic plates (Table IV). Metal drums were one of the key containers in the dry season, but had a very low production during the wet season. On the other hand, covers were absent from the list of positive containers in the dry season, while they had elevated pupae production in the wet season.

Production regarding container categories - In suburban area, large and open shape containers located in the peridomestic area, but in the shade, produced 47.49% of total pupae. Moreover, 78.86% of pupae were collected in shaded containers, 84.57% in the peridomestic area, 68.07% in large containers, and 99.53% in open shape containers (Table V). Indeed, narrow-mouthed containers were significantly less productive than open containers (t = -2.405; df = 5, 202; P < 0.05) and shaded containers were more productive than those in sunlight (t = 3.517; df = 5, 202; P < 0.001). Correspondence analysis corroborated the importance of shade on pupae production, due to the close proximity of this variable to the two class intervals with higher pupae amount (12-18 P and 19-99 P). The variables "open" and "peridomestic area" seem to be important to the 12-18 P class, but not to the 19-99 P (Fig. 1).

In the slum, 56.91% of all pupae were collected in containers in sunlight, 80.09% in the peridomestic area, 43.28% in large containers, and 100% in open shape containers (Table VI). Indeed, shaded containers were less productive than those placed under sunlight (t = 0.26; df = 5, 202; P < 0.05). There, no variable had high proximity with the high pupae interval class (31-115 P). However, "sunlight" variable was moderately close to the 13-30 P class interval, corroborating the higher importance of containers in sunlight in comparison with the ones in the shade (Fig. 2).

Infestation indices - In Tubiacanga, the House Index was higher during wet season, whereas Container Index, Breteau Index, pupae per hectare, and pupae per person were higher in dry season (Table VII). Meanwhile, in the slum, HI, BI and pupae per person, and pupae per hectare were higher in dry season, whereas CI was higher in wet season.

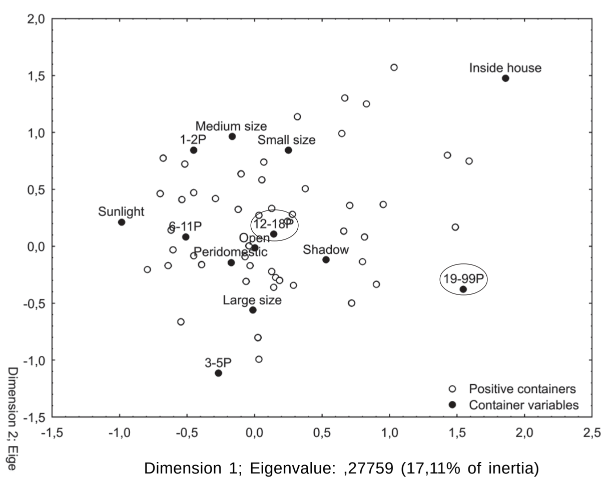

Fig. 1: correspondence analysis of positive containers (°) and its variables (•). In Tubiacanga, Rio de Janeiro, a matrix data set with 13 descriptors (variables) and 208 containers (objects) was generated and analyzed with the Statistica software. The two class intervals with high amount of pupae, i.e., the most epidemiological important intervals, are marked with a black circle.

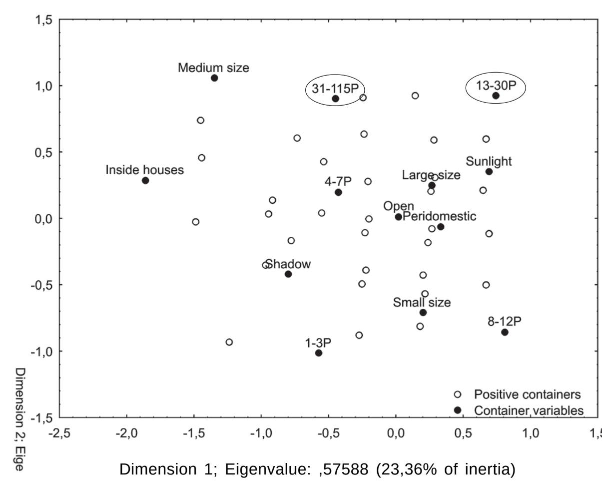

Fig. 2: correspondence analysis of positive containers (°) and its variables (•). In Favela do Amorim, Rio de Janeiro, a matrix data set with 13 descriptors (variables) and 86 containers (objects) was generated and analyzed with the Statistica software. The two class intervals with high amount of pupae, i.e., the most epidemiological important intervals, are marked with a black circle.

TABLE V

Combined effects (%) of four containers parameters: shape, size, exposure to sunlight, and location on the production of pupae collected during a house-to-house survey conducted in Tubiacanga (suburban area), Rio de Janeiro

		Sunlight			Shaded			
		Small	Medium	Large	Small	Medium	Large	Total
Peridomestic area	Open	3.96	4.05	12.06	7.97	8.61	47.49	84.14
	Narrow-mouth	-	-	-	0.26	-	0.17	0.43
Inside houses	Open	-	0.72	0.34	2.09	4.22	8.01	15.39
	Narrow-mouth	-	-	-	0.04	-	-	0.04
Total		3.96	4.77	12.40	10.36	12.83	55.67	100.00

TABLE VI

Combined effects (%) of four containers parameters: shape, size, exposure to sunlight, and location on the production of pupae collected during a house-to-house survey conducted in Favela do Amorim (the slum), Rio de Janeiro

		Sunlight			Shaded			
		Small	Medium	Large	Small	Medium	Large	Total
Peridomestic area	Open	19.85	9.30	27.76	6.41	3.77	13.00	80.09
	Narrow-mouth	-	-	-	-	-	-	0.00
Inside houses	Open	-	-	-	3.96	13.44	2.51	19.91
	Narrow-mouth	-	-	-	-	-	-	0.00
Total		19.85	9.30	27.76	10.36	17.21	15.52	100.00

TABLE VII

Infestation indices observed for the four house-to-house surveys conducted in Favela do Amorim (the slum) and Tubiacanga (the suburban area), Rio de Janeiro, during dry and wet seasons

Infestation indices	Tubiacanga/Dry	Tubiacanga/Wet	Favela do Amorim/Dry	Favela do Amorim/Wet
House index	20.51	21.14	11.22	9.56
Container index	8.92	6.91	2.97	3.46
Breteau index	43.77	38.03	16.95	15.47
Pupae per person	0.69	0.58	0.46	0.35
Pupae per hectare	236.9	162.2	427.7	304.4

Influence of human habitat conditions and seasonality in productivity - The mean number of pupae collected per house during the four house-to-house surveys was compared first by a Bartlett test, which confirmed the sample heterocedasticity (χ^2 = 45.496; df = 3, P < 0.0001). Kruskal-Wallis null hypothesis was rejected (H = 14.136, df = 3, P = 0.0027), indicating that at least one of data series was different from the others. Finally, Dunn post-test indicated difference between columns. Seasonality not explained the differences in the mean number of pupae collected (slum dry vs slum wet: P > 0.05; suburban dry vs suburban wet: P > 0.05). However, significant values were obtained when the two study areas were compared within the same season (slum dry vs suburban dry: P < 0.001; slum wet vs suburban wet: P < 0.001), i.e., the mean number of pupae collected per house was higher in the suburban area, irrespective to season.

DISCUSSION

Extensive house-to-house surveys identified the most productive container types for *Ae. aegypti* in two districts with distinct urbanization degree of Rio de Janeiro during dry and wet seasons. Possibly, human urbanization and infra-structure degree may influence in some extent infestation indexes of populated areas. However, since we have chosen only two districts to be representatives of urban and suburban areas, extrapolations of the results should be avoided. Nonetheless, this report gives support to more focused and cost-effective *Ae. aegypti* control campaigns in Rio de Janeiro.

Unexpectedly, the more infra-structured district, the suburban area, had higher mean numbers of pupae collected per house than in the slum. These results contradict a previous report, which observed that in heavily infested cities in the United States, infestation indices in poorest areas were found to be 4.5 times greater than in standard areas (Von Wideguth et al. 1969). Comparisons of the number of pupae collected per house between seasons and areas suggest that the number of emerged *Ae. aegypti* per house in each neighborhood did not vary significantly over a period of few months. This result must be considered with caution as container's productivity, and consequently the infestation levels of an area is normally influenced by a series of factors that vary between seasons, such as temperature, rainfall, water evaporation, and use of water by households. The infestation stability on both areas can be due to the high production observed for permanent containers generally used to store water, such as metal drums and water tanks, and the other containers type had random and expected production between seasons and areas.

On the other hand, pupae distribution in containers types varied between dry and wet seasons, particularly in the slum. Surprisingly, only water tanks and plastic plates could be indicated as key containers in both seasons in the slum area. Meanwhile, the variation in the container productivity status was lower in the suburban area, since metal drums and water tanks were classified as key containers in both dry and wet seasons. Water tank was the unique container type classified as key container in all four house-to-house surveys. Meanwhile, abundant containers, such as bottles and drains, had low or no production during the extension of the study, which is in accordance with Focks and others in New Orleans (Focks et al. 1981).

In the dengue epidemic of 2002, public opinion pointed bromeliads as an important site for developing dengue vectors in Rio de Janeiro. Only 0.15% (6/3938) of *Ae. aegypti* pupae were collected in bromeliads in the present survey. In an extended survey conducted in the years 2000 and 2001 in Rio de Janeiro, Cunha and others observed that around 0.08% of positive containers (N = 53846) were bromeliads (Cunha et al. 2002). The frequency of *Ae. aegypti* in native bromeliads in the city of Vitória, Brazil, was not related to house infestation index in adjacent areas (Varejão et al. 2005). In Caribbean islands, was observed that even among natural habitats, bromeliads had low proportion of larvae of *Ae. aegypti* compared to other natural containers (Chadee et al. 1998).

In Rio de Janeiro, the productivity of open containers was higher when compared with narrow-mouthed ones, just like observed elsewhere (Focks & Chadee 1997, Focks et al. 1981, Tun-Lin et al. 1995). Containers placed in the shade were more productive in the suburban area, meanwhile containers in sunlight had more pupae in the slum. This unexpected outcome might be the end result of the abundance of water-holding containers exposed to sunlight or shaded in both areas (it is worth to remind that the slum is an area with scarce vegetation coverage), what is a consequence of local resident's habits of water use, environmental sanitation, mosquito cycle knowledge, and information on disease risks.

Evaluations on container productivity, key containers and infestation indices can be used as important tools to maximize cost-effectiveness in control. The elimination of some types of productive containers, e.g. water tanks and metal drums, could possibly reduce the adult population density in around 50-60%. In Rio de Janeiro, mosquito control activity faces several drawback to be surpassed, such as (a) differences in the urbanization degree and socio-economic status of adjacent neighborhoods turn Rio de Janeiro into a mosaic, where vector control in each area require specific approaches (Luz et al. 2003); (b) the high refusal of inhabitants to allow the entrance of control teams because they are afraid of urban violence; (c) the insecticide resistance of *Ae. aegypti* populations (Braga et al. 2005, Da-Cunha et al. 2005); and (d) the high genetic differentiation between *Ae. aegypti* populations within Rio de Janeiro city, what could lead to differences in mosquito ecology, behavior, and vectorial competence (Luz et al. 2003, Costa-Ribeiro et al. 2006). Indeed, despite the high infestation levels observed in the suburban area, dengue epidemics seems to be more plausible in the slum, mainly due to the high daily survival rates of *Ae. aegypti* females in this area when compared to the suburban area. For instance, in the slum, where a survival rate between 0.83-0.94 was observed, around 48.6% of females would be able to survive the extrinsic incubation period. On the other hand, in the suburban area, survival between 0.73-0.80 was detected and around 10% of females would still be alive after the period of 12 days (Maciel-de-Freitas et al. 2007). These data can be used in the construction or improvement of dengue transmission models and thresholds with entomological, epidemiological, and demographic parameters estimated, i.e. specific to Rio de Janeiro conditions (Luz et al. 2003).

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