Rev Soc Bras Med Trop 49(4):498-501, July-August, 2016
doi:10.1590/0037-8682-0044-2016

Short Communication

Changes in infestation sites of female *Aedes aegypti* in Northeast Brazil

Luciano Pamplona de Góes Cavalcanti[1],[2], *Rhaquel de Morais Alves Barbosa Oliveira*[2],[3] *and Carlos Henrique Alencar*[1],[2]

[1]. Departamento de Saúde Comunitária, Universidade Federal do Ceará, Fortaleza, Ceará, Brasil.
[2]. Programa de Pós-Graduação em Saúde Coletiva, Universidade Federal do Ceará, Fortaleza, Ceará, Brasil.
[3]. Núcleo de Vigilância Epidemiológica, Secretaria de Saúde do Estado do Ceará, Fortaleza, Ceará, Brasil.

Abstract

Introduction: We report the behavioral changes in use of oviposition sites in *Aedes aegypti* in Fortaleza, Brazil. **Methods:** We evaluated the relationship between different types of breeding sites and changes in use from 2001 to 2012. **Results:** More than 40% of the infested breeding sites were used to store water. We observed a three-fold reduction in the infestation of water tanks ($p = 0.038$) and more than nine-fold in tires ($p = 0.035$). The proportion of infested plant pots increased six-fold ($p < 0.001$). **Conclusions:** Infested breeding sites changed over time from domestic water tanks to small-volume breeding sites.

Keywords: Oviposition. *Aedes aegypti.* Prevailing reservoir.

Aedes aegypti mosquito is an urban vector and is associated with at least three arboviruses – dengue, chikungunya, and Zika virus(1). This mosquito occurs throughout the world, especially in the tropical regions(2) (3), and is present in in different habitats and breeding sites in all 26 Brazilian states and the Federal District(4).

To enable effective control of this vector it is necessary to understand its localized behavior in each country region. Oviposition behavior is influenced by the availability of different reservoirs, local environment, water storage habits of the urban population, and historical control of vectors in the area(5). To our knowledge, this study describes for the first time, the changes in oviposition behavior in *A. aegypti* females in one of the largest cities in northeast Brazil.

We conducted a cross-sectional study of *A. aegypti* infestation in Fortaleza City in northeast Brazil. Fortaleza is the fifth largest city in Brazil with approximately 2.5 million inhabitants residing in 119 neighborhoods, which are administratively distributed in six executive regional secretaries [*Secretarias Executivas Regionais* (SER)](6).

We investigated five years that were considered epidemic disease years (>300 cases/100,000 inhabitants): 2001, 2006, 2008, 2011, and 2012(7). For analysis, we used data from the Information System of Yellow Fever and Dengue [*Sistema de Informações de Febre Amarela e Dengue* (SISFAD)] of the Brazilian Ministry of Health, and the household infestation index (HII) of Fortaleza, combined with information from the Larval Index Rapid Assay (LIRA) from the Municipal Health Secretary of Fortaleza.

According to the Brazilian Ministry of Health, water reservoirs that are potential breeding sites for *A. aegypti* are classified into five large groups: A–E. Group A includes large reservoirs of water storage, subdivided into A1: elevated (water tanks) and A2: ground reservoirs (tanks). Group B includes mobile reservoirs, such as vases/water containers, bottles, thaw containers from refrigerators, water fountains, and small ornamental fountains. Group C includes unmovable reservoirs, such as tanks in garages, gutters, disused toilets, non-treated pools, and flower vases in cemeteries. Group D includes reservoirs that can be mechanically moved, which are subdivided into D1: (tires) and D2: (trash). Finally, group E includes natural reservoirs, such as leaf axils, bromeliads, tree cavities, and rocks(4).

Statistical analysis was conducted to verify the correlation between and variation in the use of different types of oviposition sites during the epidemic years. The HII of each breeding site was the dependent variable and the epidemic years were independent variables. The analysis used the Joinpoint regression program 4.2.0.2 to calculate the APC indicator, which measures the annual percentage variation, as well as the confidence intervals (CI) in the inflection points and statistical significance.

Corresponding author: Dr. Luciano Pamplona de Góes Cavalcanti.
e-mail: pamplona.luciano@gmail.com
Received 30 January 2016
Accepted 23 June 2016

TABLE 1

Percentage of reservoirs infested with *Aedes aegypti* larvae and the annual percentage change during the epidemic years in Fortaleza.

Type of reservoir	2001	2006	2008	2011	2012	APC	CI	p-value
Water tanks (A1)	30.7	14.9	21.2	12.2	8.8	-9.4	-17.2 to -0.8	0.038
Other water storage reservoirs (A2)	40.3	45.0	48.8	46.7	44.6	2.7* -1.7**	- -	<0.050 <0.050
Flower vases and plates (B)	3.4	8.1	9.4	18.2	21.0	17.9	14.4 to 21.6	<0.001
Drains, toilets (C)	12.0	5.9	15.3	9.8	15.9	2.3	-13.1 to 20.5	0.699
Tires (D1)	5.7	5.8	1.2	0.6	0.6	-21.0	-35.7 to -3.0	0.035
Cans, packages, bottles and others (D2)	7.5	16.6	4.1	11.3	8.3	0.4	-19.1 to 24.7	0.965
Natural reservoirs (E)	0.4	3.7	0.0	1.2	0.9	5.1	-26.3 to 49.8	0.685

APC: annual percentage change; **CI**: confidence interval. *2001-2008; **2008-2012.

Fortaleza had dengue epidemics in the years 2001, 2006, 2008, 2011, and 2012 with incidences of 587, 637, 1,396, 1,387, and 1561 per 100,000 inhabitants, respectively. During the five years studied, infestation by *A. aegypti* presented indices above 1%. These indices were always elevated in Regionals I, III, V, and VI, reaching up to 14% in the second cycle of home visits in 2001. Type A2 reservoirs always represented more than 40% of the infested reservoirs in all years (**Table 1**).

A three-fold reduction in the percentage of infested water tanks (A1) was noted, as well as a nine-fold reduction in the percentage of infested tires (D1). The highest proportional reduction occurred in tires, which represented 5.7% of the infested reservoirs in 2001 and only 0.6% in 2012 ($p = 0.035$). The proportion of infested flower vases increased six-fold, from 3.4% in 2001 to 21% of the infested reservoirs in the 2012 epidemic (**Table 1**).

Reservoir types C, D2, and E all showed relative stability in infestation rates. However, a significant trend toward reductions in the proportions of infestation in water tanks [Annual percent change (APC) = -9.4; CI = -17.2 to -0.8; $p = 0.038$] and tires (APC = -21.0; CI = -35.7 to -3.0; $p = 0.035$) and increases in flower vases (APC = 17.9; CI = 14.4 to 21.6; $p < 0.001$) and other breeding sites ($p < 0.05$) was noted (**Figure 1**).

In Fortaleza, there was a significant reduction in the percentage of water tanks and tires infested by *A. aegypti* in the epidemic years studied. Considering the seven different types of reservoirs defined by LIRA, the most infested reservoirs were those used to store water for human consumption. However, in the proportional importance of infested breeding sites, water tanks declined from second to fourth place. Conversely, flower vases moved up from sixth to second place. These changes are probably a result of an intense control program that historically concentrated its efforts on water tanks with the use of nets and larvivorous fish[8] [9]. Further, the effective gathering and disposal of tires probably contributed toward this change, after it was institutionalized by the National Program of Dengue Control [*Programa Nacional de Controle da Dengue* (PNCD)][4]. Alternative breeding sites may now have more entomological importance because of the efficient control over the former types of breeding sites.

Our findings show that the reservoirs used to store water are still important, however, it is necessary to redirect actions toward the proper disposal of flower vases. Control measures for *A. aegypti* are centered in potential breeding sites, applying measures to prevent larvae proliferation. These measures can be physical (elimination, mischaracterization, or inadequate destination), chemical (larvicide), or alternatives (larvivorous fish). Implementation also includes an educational approach to highlight the responsibility of all owners of potential infestation reservoirs to maintain preventative measures[10]. Evidence suggests that integrated control measures achieve better results[11].

The synanthropic behavior of *A. aegypti* is strongly influenced by the urban and domestic environment. Cities with disorderly growth, inadequate sewerage treatment, inadequate water storage, or inadequate disposal and protection of garbage have a larger approximation of this vector to residences[12]. This causes a change in oviposition behavior with the change in supply of new potential breeding sites.

It is necessary to understand the predominant breeding sites to direct adequate control to local areas. LIRA, created by the Brazilian Health Ministry, is an informative indicator[4]; however, it has an important limitation in its application since it includes all water storage ground reservoirs in the same category (A2). The interventions for the control of *A. aegypti* in tanks, cisterns, or even pots are very different. Including all of these reservoirs in the same category (A2) reduces the accuracy of estimating the need for reservoirs to be shut, eliminated, covered, protected with nets, or treated with larvivorous fish or larvicide.

Another limiting factor is that only reservoirs that contained water when the health agent was present are recorded, rather than the potential breeding sites. Given the extremely long quiescent period of mosquito eggs[13], tanks should be regarded as potential breeding sites, irrespective of whether they are full of water at the time of inspection, as these reservoirs may be used for storing water in adverse times allowing any eggs of mosquitoes within the tank to hatch.

In São José do Rio Preto City, tires were the main infestation reservoir and were responsible for the dispersion of the vector

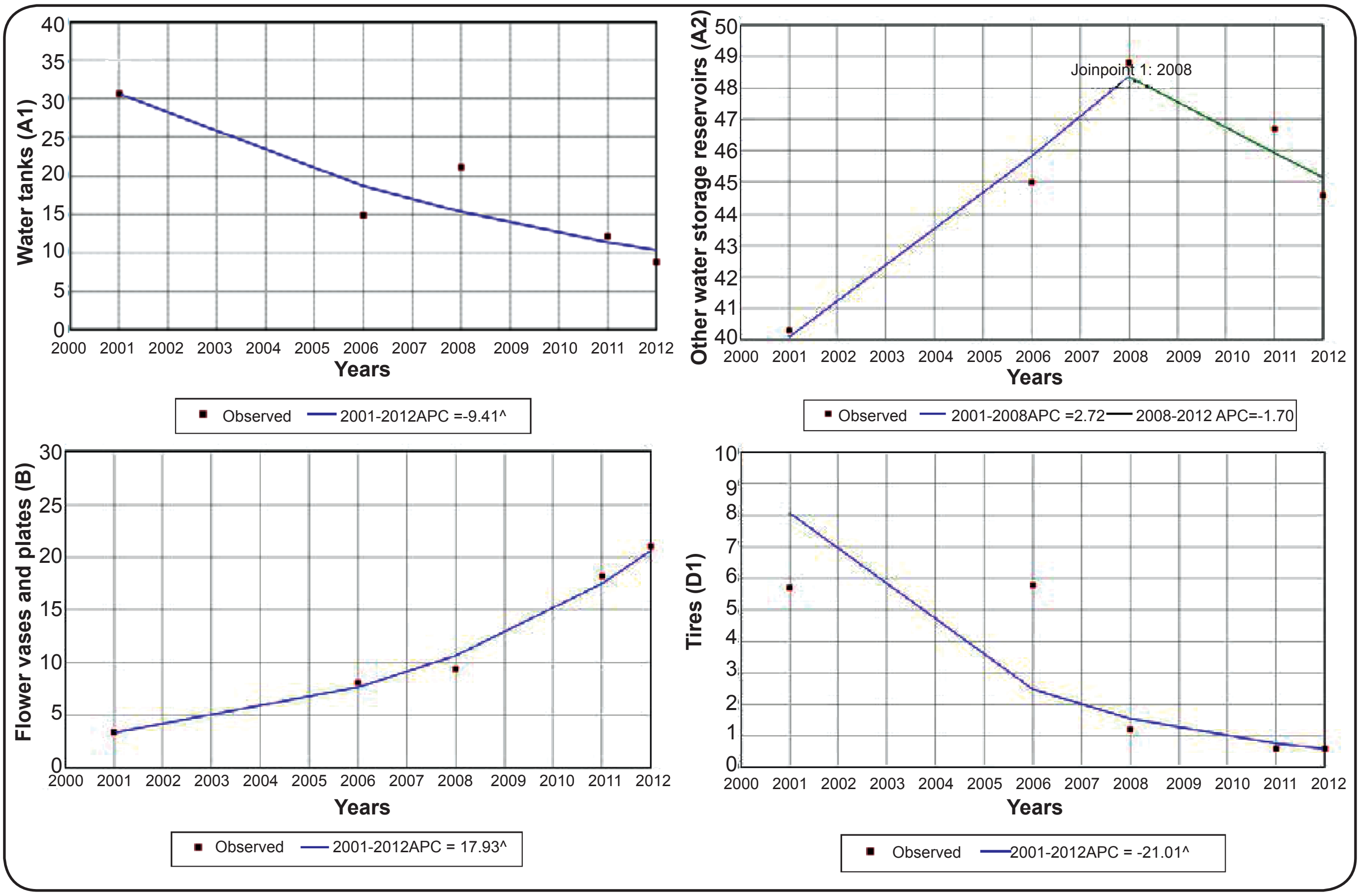

FIGURE 1. Changes in the proportion of reservoirs infested by *Aedes aegypti* in the epidemics of 2001, 2006, 2008, 2011, and 2012, Fortaleza. **A1:** water tanks; **A2:** other reservoirs; **B:** flower vases and plates; **D1:** tires.

in the region in the 1980s[14]. Changes in the rain patterns in this region in the past few years have resulted in the need for storing water, which can create significant changes in the types of predominant breeding sites, thus, requiring a change in the focus of control to new reservoirs. According to preliminary information from LIRA (not published), there is already a significant increase in the proportional infestation of water storage reservoirs in the State of São Paulo.

Regions where the control is centered in vacant lots or backyards have different needs for intervention compared to places where water tanks are the main breeding sites, where it is necessary to have stairs to access these reservoirs. In these cases, there is a need to develop policies that enable and encourage the closure of water tanks, once these large volume reservoirs reach a high infestation index. Other issues for control of infestation in water tanks include their greater capacity to generate larvae and pupae compared to that by smaller or unused reservoirs[15].

To understand the epidemics and direct efficient action, it is necessary to understand the factors that influence the density and distribution of the main vectors of dengue. This includes updating information in all affected regions to influence control programs and maintain flexibility in interventions.

There is no unique or stable pattern of predominantly infested breeding sites for *A. aegypti* mosquitoes. The timing and different interventions of the control programs, even those developed by the local communities, tend to alter mosquito behavior. Knowledge of potential breeding sites in each region over time is necessary to ensure effective and adequate interventions. The decentralization of endemic control to the counties must stimulate the use of local knowledge to increase efficacy of control measures, which are necessary despite the possibility of a dengue vaccine, as mosquitoes also carry other diseases that are not preventable by immunization.

We observed a change in the type of breeding sites used by *A. aegypti* over time, from domestic water tanks to small-volume breeding sites, such as flower vases and its plates. The entomologic vigilance performance is a fundamental strategy for the control of dengue, providing indicators and warning health services about the changes that prevention and control measurements are triggering[4]. This will help to make the programs further evidence-based and efficient.

Ethical considerations

The study was authorized by the Municipal Health Secretary of Fortaleza and approved by the Ethics in Research Committee [*Comitê de Ética em Pesquisa* (CEP)] from the Federal University of Ceará (protocol no. 20301313.6.0000.5054).

Conflicts of Interest

The authors declare that there is no conflict of interest.

REFERENCES

1. Vasconcelos PFC. Doença pelo vírus Zika: um novo problema emergente nas Américas? Rev Pan-Amaz Saude 2015; 6:9-10.
2. Hiragi C, Simões K, Martins E, Queiroz P, Lima L, Monnerat R. Variabilidade genética em populações de *Aedes aegypti* (L.) (Diptera: Culicidae) utilizando marcadores de RAPD. Neotrop Entomol 2009; 38:542-547.
3. Veja-Rúa A, Zouache K, Girod R, Failloux AB, Lourenço-de-Oliveira R. High level of vector competence of *Aedes aegypti* and *Aedes albopictus* from ten American countries as a crucial factor in the spread of Chikungunya vírus. J Virol 2014; 88:6294-6306.
4. Ministério da Saúde. Secretaria de Vigilância em Saúde. Departamento de Vigilância das Doenças Transmissíveis. Levantamento Rápido de Índices para *Aedes Aegypti* (LIRAa) para vigilância entomológica do *Aedes aegypti* no Brasil: metodologia para avaliação dos índices de Breteau e Predial e tipo de recipientes. Brasília: 2013. 84p.
5. Barreto ML, Teixeira MG. Dengue no Brasil: situação epidemiológica e contribuições para uma agenda de pesquisa. Estud Avançados 2008; 64:53-72.
6. Instituto Brasileiro de Geografia e Estatística (IBGE). Pesquisa Nacional por Amostra de Domicílios (PNAD2010). Rio de Janeiro. Disponível em: <http://www.ibge.gov.br>. 2010. Acesso em: 03 mar. 2014.
7. Oliveira RMAB. Aspectos entomo-epidemiológicos das epidemias de dengue ocorridas entre 2001 e 2012, no município de Fortaleza, Ceará. Dissertação de Mestrado. 2014. Disponível no link: http://www.repositorio.ufc.br/handle/riufc/8211.
8. Pamplona LGC, Alencar CH, Lima JW, Heukelbach J. Reduced oviposition of *Aedes aegypti* gravid females in domestic containers with predatory fish. Trop Med Int Health 2009; 14:1347-1350.
9. Lima JWO, Cavalcanti LPG, Pontes RJ, Heukelbach J. Survival of Betta splendens fish (Regan, 1910) in domestic water containers and its effectiveness in controlling *Aedes aegypti* larvae (Linnaeus, 1762) in Northeast Brazil. Trop Med Int Health 2010; 15:1525-1532.
10. Domingos MF, Oliveira CD, Barbosa GL, Wanderley DMV. Atividades de controle de *Aedes aegypti* em municípios da Região Sul do Estado de São Paulo. J Health Biol Sci 2013; 1:122-129.
11. Lima EP, Goulart MOF, Rolim Neto ML. Meta-analysis of studies on chemical, physical and biological agents in the control of *Aedes aegypti*. BMC Public Health 2015; 15:858-871.
12. Silva Jr JB, Siqueira Jr JB, Coelho GE, Vilarinhos PT, Pimenta Jr FG. Dengue in Brazil: current situation and prevention and control activities. Epidemiol Bull 2002; 23:3-6.
13. Silva HHG, Silva IG. Influence of eggs quiescence period on the *Aedes aegypti* (Linnaeus, 1762) (Diptera, Culicidae) life cycle at laboratory conditions. Rev Soc Bras Med Trop 1999; 32: 349-355.
14. Chiaravalloti-Neto F. Descrição da colonização de *Aedes aegypti* na região de São José do Rio Preto, São Paulo. Rev Soc Bras Med Trop 1997; 30:279-285.
15. Pinheiro VCS, Tadei WP. Frequency, diversity, and productivity study on the *Aedes aegypti* most preferred containers in the city of Manaus, Amazonas Brazil. Rev Inst Med Trop Sao Paulo 2002; 44:245-250.