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Presumed unconstrained dispersal of *Aedes aegypti* in the city of Rio de Janeiro, Brazil

Dispersão de *Aedes aegypti* em local presumidamente sem barreira limitante ao vôo na cidade do Rio de Janeiro

ABSTRACT

OBJECTIVE: To evaluate dispersal of *Aedes aegypti* females in an area with no container manipulation and no geographic barriers to constrain mosquito flight.

METHODS: A mark-release-recapture experiment was conducted in December 2006, in the dengue endemic urban district of Olaria in Rio de Janeiro, Southeastern Brazil, where there is no evident obstacle to the dispersal of *Ae. aegypti* females. Mosquito traps were installed in 192 houses (96 Adultraps and 96 MosquiTRAPs).

RESULTS: A total of 725 dust-marked gravid females were released and recapture rate was 6.3%. *Ae. aegypti* females traveled a mean distance of 288.12 m and their maximum displacement was 690 m; 50% and 90% of females flew up to 350 m and 500.2 m, respectively.

CONCLUSIONS: Dispersal of *Ae. aegypti* females in Olaria was higher than in areas with physical and geographical barriers. There was no evidence of a preferred direction during mosquito flight, which was considered random or uniform from the release point.

DESCRIPTORS: ***Aedes.*** **Disease Vectors. Mosquito Control. Culicidae. Dengue.**

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RESUMO

OBJETIVO: Avaliar a dispersão de fêmeas de *Aedes aegypt*i em uma área onde não houve nenhuma interferência quanto à redução de potenciais criadouros e não há barreira geográfica que limite o vôo dos mosquitos.

MÉTODOS: Um experimento de marcação-soltura-recaptura foi realizado em dezembro de 2006, no bairro urbano Olaria, endêmico para dengue na cidade do Rio de Janeiro (RJ), onde não há obstáculos evidentes à dispersão de fêmeas de *Ae. aegypti*. Armadilhas para captura de mosquitos foram instaladas em 192 residências (96 Adultraps e 96 MosquiTraps).

RESULTADOS: Foram soltas 725 fêmeas grávidas marcadas com pó fluorescente e a taxa de recaptura foi de 6,3%. Fêmeas de *Ae. aegypti* dispersaram em média 288,12 m do ponto de soltura e o deslocamento máximo foi de 690 m; 50% e 90% das fêmeas voaram até 350 m e 500,2 m respectivamente.

CONCLUSÕES: A dispersão de fêmeas de *Ae. aegypti* em Olaria foi maior que em áreas com barreiras físicas e/ou geográficas. Não houve evidências de preferência de direção do vôo dos mosquitos, o qual foi considerado randômico ou uniforme a partir do ponto de soltura.

DESCRITORES: ***Aedes.*** **Vetores de Doenças. Controle de Mosquitos. Culicidae. Dengue.**

INTRODUCTION

In the city of Rio de Janeiro, Brazil, the mosquito *Aedes aegypti* is essentially associated with human density, and is especially abundant in urbanized and densely populated areas.[1] *Ae. aegypti* breeds almost exclusively in artificial large containers located in the peridomestic area, such as water tanks and metal drums[15] and seldom invade the fringe of urban forests, generally not laying eggs or flying through distances exceeding 100 m from houses.[12,14]

Dispersal may have several implications on mosquito population genetics, spreading of gene pools, such as insecticide resistance and virus susceptibility, and determination of control strategies by public health authorities. The dispersal ability of *Ae. aegypti* females have already been studied.[20] However, several previous dispersal estimates might be biased. Common sources of bias in dispersal estimates seem to be site manipulation prior to mosquito release or recaptures performed in a limited area, such a small village or a single block, frequently close to the release point.[9,10,13,14,17,21,22] For example, Honório et al[10] performed a mark-release-recapture experiment in a highly endemic area of dengue with female mosquitoes with amputated proboscis to avoid ethical issues and they also eliminated or removed most small containers from the study area. These interventions may have influenced the dispersal pattern of *Ae. aegypti* females, which displaced at least 800 m from their release point. Maciel-de-Freitas et al[13] evaluated dispersal of *Ae. aegypti* females in two areas with distinct landscape and physical barriers, such as sea and extensive highways, and observed differential displacement from the release site in both areas.

The objective of the present study was to evaluate dispersal of *Ae. aegypti* females in an area with no container manipulation and no geographic barriers to constrain mosquito flight.

METHODS

The residential district of Olaria (22°50'45''S; 43°15'39''W), located in the city of Rio de Janeiro (Southeastern Brazil), was selected to release dust-marked *Ae. aegypti* females. It has an estimated population of 62,509 inhabitants in an area of 369 hectare, nearly 169 inh./ha. Olaria is a lowland district with extensive paved streets, moderate traffic and a busy rail station. Houses generally have 2–4 rooms and large peridomestic area, with usually no more than 4–5 persons per house. There is a regular service of garbage collection and water supply. Olaria is in one of the most important dengue endemic zone in the city, which registered 49,266 dengue cases from 1986 to 2001. According to the Health Department of the City of Rio de Janeiro, during the 2001 dengue epidemic, more than 8% (2,165/26,535 cases) of the city's total cases were reported there; in 2007 there were 208 dengue cases. In July 2006, five months prior to experiment start, Olaria had a house index of 8.8.

Released *Ae. aegypti* females were derived from a laboratory colony that is renewed at least twice a year with eggs collected in ovitraps installed in Rio de Janeiro. Larvae were fed with fish food (Tetramin) and reared according to Consoli & Lourenço-de-Oliveira.[2] After emergence, females were separated from males and kept together at 25 ± 3°C and 65 ± 3% relative humidity and provided with sucrose solution up to a day before the first blood feeding.

Two blood meals were offered on 3-4 days after emergence in an artificial membrane feeder apparatus.[19] We expected all released females were gravid when released three days after blood meals. A total of 725 *Ae. aegypti* females with 6-7 days of emergence were marked with fluorescent dust (Day-Glo Color Corp., Cleveland, OH) and released outdoor in the morning (between 08:00 AM and 09:00 AM) of December 2nd, 2006, approximately one hour after dust marking.

To capture released *Ae. aegypti* females a total of 192 traps (96 Adultraps[8] and 96 MosquiTRAPs[6]) were installed in Olaria. Briefly, both traps were originally designed to capture gravid *Ae. aegypti* females. Adultrap is a black plastic jar with an external plastic screen using only water as attractant.[8] MosquiTRAP has a glued car inside a black plastic jar, using a commercial mixture as attractant.[6] Adultrap and MosquiTRAP were installed in the peridomestic area of adjacent houses and were left in the same place until the end of the experiment, covering an area of 3.14 km^2. Recaptures were carried out for 18 days. All collected mosquitoes were brought to the laboratory to be identified and checked for the presence of fluorescent mark with an UV light.

As for dispersal, the 192 houses where mosquito traps were installed were geo-referenced using a Global Position System (GPS; Garmin eTrex personal navigator) to calculate distance between releasing and capture points. The flight behavior of *Ae. aegypti* females was summarized by a set of dispersal measures: mean distance traveled (MDT), maximum distance traveled (MAX), and flight ranges of 50% (FR_{50}) and 90% (FR_{90}) of the population.[11,16] Frequency distributions of the marked mosquitoes that had traveled <100 m and >200 m from the release point were also evaluated.

We also used circular statistics to help understanding flight dynamics of *Ae. aegypti* females and most importantly, if they had an isotropic direction or a uniform distribution from the release point. For that, we calculated the angle formed between the release point and collection sites, forming a circular histogram, which shows the distribution of flight angles (to the south-north axis), with the North direction set as 0°. Flight direction tendencies were visually interpreted based on the histogram shape. The Rayleigh test of uniformity was used to calculate the probability of the null hypothesis that the data have a uniform distribution.[23] Circular histogram and data analysis were performed using Oriana program, v. 2.02.[a]

Mark-release-recapture (MRR) experiment protocols were submitted and approved by Fundação Oswaldo Cruz (Fiocruz) Research Ethics Committee (CEP/Fiocruz protocol no. 11591-2005).

RESULTS

A total of 46 (6.34%) dust-marked females were recaptured, 17 (36.9%) of them collected in Adultraps and 29 (63.1%) in MosquiTRAPs (Table 1). Dust-marked *Ae. aegypti* mosquitoes were recaptured up to nine days after release; the majority of them were recaptured up to four days (Table 1).

Ae. aegypti females had an average dispersal of 288.1 m from the release point. However, the maximum distance traveled observed was 690 m, corresponding to a single female that flew to the southeast direction. Additionally, 90% of released females flew up to 500.2 m and 69.0% displaced more than 200 m from the release point (Table 2).

Ae. aegypti flight showed an isotropic behavior from the release point, showing no evidence of a preferred direction ($z = 0.242$; $p = 0.787$). In fact, a circular histogram constructed with the angles formed by release and recapture points emphasizes the uniform distribution of flight direction (Figure).

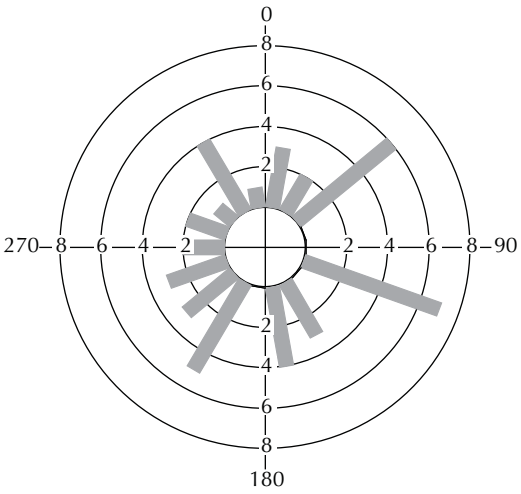
DISCUSSION

Recapture rate of *Ae. aegypti* females were in accordance with other similar studies performed in Rio de

Table 1. Number of fluorescent dust-marked *Aedes aegypti* females collected in Olaria with 192 mosquito traps (96 Adultraps and 96 MosquiTRAPs). Rio de Janeiro, Southeastern Brazil, 2006.

Day	Adultrap	MosquiTRAP
	Marked *Ae. aegypti*	Marked *Ae. aegypti*
2	7	11
4	7	10
6	2	6
9	1	2
11		
13		
16		
18		
Total	17	29
Recapture rate (%)	2.34	4.00

[a] Isle of Anglesey: Kovach Computing Services 2007 [cited 2007 May 9]. Available from: http://www.kovcomp.com/Oriana



Bars reflect the number of mosquitoes that flew in that specific direction.

Figure. Circular histogram of the distribution of flight angles of dust-marked *Ae. aegypti* females released in Olaria and recaptured with Adultraps and MosquiTRAPs. Rio de Janeiro, Southeastern Brazil, 2006.

Janeiro, even when recapture effort was confined to a smaller area.[13] As there is no evident physical or geographical obstacle in Olaria, mosquito emigration was expected to be less controlled than in other studies in areas with physical barriers.[9,13,17,21,22]

Dispersal of *Ae. aegypti* females in Olaria was higher than that seen in two other districts of the city of Rio de Janeiro and in other areas with physical and geographical barriers. [9,13,17,21,22] In Favela do Amorim, an urban area with high human density and container availability, *Ae. aegypti* females had an MDT of around 50 m and a MAX of 151 m. In Tubiacanga, a suburban area with a human density three times lower than Favela do Amorim, MDT was approximately 80 m with a maximum displacement of 363 m.[13] Since mosquito flight seems to be associated to the heterogeneity distribution of blood sources[7] and oviposition sites,[5] low availability or container elimination during dry season or control campaigns may increase mosquito dispersal rates because females would have to fly longer distances to lay their eggs.[3,4,18] Therefore, the elimination of small containers during the dry season by Honório et al[10] before *Ae. aegypti* releasing may have stimulated mosquito dispersal. These authors evaluated dispersal by collecting rubidium chloride (RbCl)-marked eggs with ovitraps set along varied distance from the release point. Several positive ovitraps were found at 800 m from the release site, the most distant collection point, suggesting that the displacement of *Ae. aegypti* females was beyond the most distant collection point.[10] Besides, Honório et al[10] amputated proboscis of released gravid *Ae. aegypti* females which may have influenced the observed dispersal range.

Dispersal is an important parameter in disease transmission dynamics and vector control. In theory, a disease vector able to displace long distances may spread pathogens to large areas. According to our results, an effective and efficient control is required that can include container elimination and insecticide spraying in a radius of at least 500 m from a reported dengue case.

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Table 2. Dispersal measures of dust-marked *Ae. aegypti* females released in Olaria and compared with similar experiments performed in residential areas worldwide. Rio de Janeiro, Southeastern Brazil, 2006.

Measure	Unconstrained dispersal	Dispersal constrained by physical and/or geographical barriers			
	Olaria	Favela do Amorim* Maciel-de-Freitas et al[13] 2007	Tubiacanga* Maciel-de-Freitas et al[13] 2007	Australia Muir & Kay[17] 1998	China Tsuda et al[22] 2001
MDT (m)	288.12	53.1;39.5	80.9;86.8	56	35;59
FR^{50} (m)	314.0	52.8;38.5	72.3;51.1	33	-
FR^{90} (m)	500.2	91.5;71.3	137.9;151.1	108	-
MAX (m)	690	151.9;99.5	363.1;248.3	150	~75
Females flying up to 100 m (%)	11.90	96.5;100.0	83.4;60.2	-	-
Females flying beyond 200 m (%)	69.04	0;0	8.7;2.3	-	-

MDT: mean distance traveled
FR^{50}: flight range of 50% of the population
FR^{90}: flight range of 90% of the population
MAX: maximum distance traveled
* Dispersal data from Favela do Amorim and Tubiacanga are presented as dry season/wet season estimates.

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