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Cavalcanti Correia, Juliana; Rodrigues Barbosa, Rosângela Maria; Fontes de Oliveira, Cláudia Maria; Ribeiro de Albuquerque, Cleide Maria

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Juliana Cavalcanti Correia[I]

Rosângela Maria Rodrigues Barbosa[II]

Cláudia Maria Fontes de Oliveira[II]

Cleide Maria Ribeiro de Albuquerque[III]

Residential characteristics aggravating infestation by *Culex quinquefasciatus* in a region of Northeastern Brazil

Características agravantes por infestação residencial de *Culex quinquefasciatus*, em Olinda, PE

ABSTRACT

OBJECTIVE: Analyse how basic sanitation conditions, water supply and housing conditions affect the concentration of *Culex quinquefasciatus*

METHODS: Populations of *C. quinquefasciatus* in 61 houses in the municipality of Olinda, PE, were monitored between October 2009 and October 2010. Observations were carried out in homes without the presence of preferred breeding sites in order to identify characteristics that may be aggravating factors for the development of the mosquito. Five aggravating factors were analysed: vegetation cover surrounding the home, number of residents/home, water storage, sewage drainage and water drainage. These characteristics were analysed in terms of presence or absence and as indicators of the degree of infestation, which was estimated through monitoring the concentration of eggs (oviposition traps – BR-OVT) and adults (CDC light traps).

RESULTS: Sewage drainage to a rudimentary septic tank or to the open air was the most frequent aggravating factor in the homes (91.8%), although the presence of vegetation was the only characteristic that significantly influenced the increase in the number of egg rafts ($p = 0.02$). The BR-OVT achieved positive results in 95.1% of the evaluations, with the presence of at least one egg raft per month. A total of 2,366 adults were caught, with a mosquito/room/night ratio of 32.9. No significant difference was found in the number of mosquitoes caught in the homes.

CONCLUSIONS: Although the sanitation and water supply influence the population density of *C. quinquefasciatus*, residence features that are not usually considered in control measures can be aggravating factors in sustaining the mosquito population.

DESCRIPTORS: ***Culex*. Environmental Monitoring. Insect Vectors. Oviposition traps.**

[I] Programa de Pós-Graduação em Biologia Animal. Departamento de Zoologia. Centro de Ciências Biológicas. Universidade Federal de Pernambuco. Recife, PE, Brasil

[II] Departamento de Entomologia. Centro de Pesquisas Aggeu Magalhães. Fundação Oswaldo Cruz. Recife, PE, Brasil

[III] Laboratório de Invertebrados Terrestres. Departamento de Zoologia. Centro de Ciências Biológicas. Universidade Federal de Pernambuco. Recife, PE, Brasil

Correspondence:
Juliana Cavalcanti Correia
Departamento de Zoologia. Centro de Ciências Biológicas. Universidade Federal de Pernambuco.
Av. Professor Nelson Chaves, s/n, Cidade Universitária
52011-330 Recife, PE, Brasil
E-mail: juliana.c.correia@gmail.com

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RESUMO

OBJETIVO: Analisar como as condições de saneamento básico, abastecimento de água e habitações afetam a densidade de *Culex quinquefasciatus*.

MÉTODOS: Monitorou-se a população de *C. quinquefasciatus* em 61 residências do município de Olinda, PE, de outubro de 2009 a outubro de 2010. As observações foram realizadas em residências sem a presença de criadouros preferenciais, para identificar características que contribuíssem como agravantes para o desenvolvimento do mosquito. Cinco características agravantes foram analisadas: cobertura vegetal no peridomicílio, número de moradores por residência, armazenamento de água, escoamento de esgoto, escoamento de água. Essas características foram avaliadas quanto à presença ou ausência e como indicadores de níveis de infestação, estimados por monitoramento da densidade de ovos (armadilhas de oviposição BR-OVT) e adultos (armadilhas luminosas do tipo CDC).

RESULTADOS: O escoamento de esgoto para fossa séptica/rudimentar e a céu aberto foi o mais frequente nas residências (91,8%), embora apenas a presença de vegetação tenha influenciado significativamente no aumento de jangadas (p = 0,02). As BR-OVT apresentaram-se positivas em 95,1% das avaliações, com presença de pelo menos uma jangada/mês. Foram capturados 2.366 espécimes adultos, com relação mosquito/quarto/noite de 32,9, sem diferença significativa no número de mosquitos capturados nas residências.

CONCLUSÕES: Embora as condições de saneamento e de abastecimento de água influenciem na densidade populacional de *C. quinquefasciatus*, características da residência que normalmente não são consideradas nas medidas de controle podem ser fatores agravantes na manutenção da população de mosquito.

DESCRITORES: *Culex*. Monitoramento Ambiental. Insetos Vetores. Armadilhas de oviposição.

INTRODUCTION

High population densities of the mosquito *Culex quinquefasciatus* are often associated with inadequate urban conditions.[2] The absence of basic sanitation, irregular water supply and precarious housing conditions contribute to the formation of breeding sites for this mosquito species.[9] This species preferentially lays its eggs in septic tanks and gutters with stagnant water rich in organic matter,[4,21,22] which are common in urban environments of low quality.

High densities of *C. quinquefasciatus* have also been described for areas in which preferential breeding sites are scarce, suggesting that other residential characteristics may exert a strong influence over maintaining the infestation of this mosquito, as the breeding and development needs of *C. quinquefasciatus* are normally contained within these environments.[4,13,15] According to Laporta et al,[16] the presence of vegetation surrounding the home may be a contributing factor toward the density of this mosquito, since the removal of vegetation from urban parks and consequent destruction of shelters results in the dispersion of the mosquito to other inhabited areas. The degree of colonization of breeding sites of the same nature installed in different areas is affected by the local vegetation through the availability of organic matter for the feeding and protection of immature individuals.[11] The density of the human population serving as a blood source and homes offering shelter to *C. quinquefasciatus* constitute other conditions of urban areas that favor the density and proliferation of this species.[14]

Despite information on slighter residential characteristics that favor the development of *C. quinquefasciatus* is crutial for control measures, no references on this matter were found in the revised literature. This mosquito is a vector for pathogens such as *Wuchereria bancrofti*, which causes lymphatic filariasis (commonly known as elephantiasis),[7] considered the most prevalent parasitosis in the world.[18] *C. quinquefasciatus* is also involved in the transmission of arboviruses, such as West Nile Virus.[19,24]

The present study aimed to assess how conditions of sanitation, water supply and residential characteristics can affect the density of *Culex quinquefasciatus*.

METHODS

The study was carried out in 61 houses in the neighborhood of Alto da Conquista in Olinda, Recife, Northeastern Brazil (07º58'49.09" S and 34º53'48.70" W), from October 19th 2009 to October 21th 2010. The homes are predominantly houses with yards and vegetal coverage and considerable deficiencies in basic sanitation. Only 1.77% of the homes have a bathroom or toilet connected to the general sewage system and 2.86% have bathrooms connected to septic tanks.[a] The prevalence of microfilaremic individuals is high and there is a high social-environmental risk for cases of lymphatic filariasis.[10] The houses investigated in the present study were selected based on the absence of the preferential positive breeding sites, mosquito presence and residential characteristics.

The BR-OVT oviposition trap was used for the monitoring of *C. quinquefasciatus* due to its efficient continual collection of *Culex* eggs in urban areas at high risk for the transmission of filariasis.[4,6] This trap is composed of a black polyethylene box (13 cm x 35 cm x 24 cm) with a central opening at the top (16 cm x 9 cm). A black recipient (800 ml) with water and biological larvicide containing *Bacillus thuringiensis* var. *israelensis* (Vectobac CG, Valent Biosciences, Libertyville, IL – 0.45 mg/L (Bti)) was placed inside the trap.

A total of 152 residences were monitored for the presence and variation in egg raft density using the BR-OVT traps. From these, 61 homes were monitored over a 12-month period. The remaining traps were lost along the study. The traps were installed at peridomiciliar area and examined every two to three days. The egg rafts were counted, recorded and removed. The water and larvicide were changed every month.

The density of the adult *C. quinquefasciatus* population was evaluated based on collections using Center for Disease Control (CDC) light traps placed in the bedroom or living room of 12 of the 61 homes. The traps were turned on at dusk (5 pm) and turned off the following morning (7 am). The traps remained in the homes for four nights (Monday to Friday). The CDC collection bags were removed on a daily basis and sent to the laboratory of the counts and identification of individuals, totaling 12 observations in each home. Traps were deployed in three different periods (January, May and September 2010).

The association of aggravating characteristics and the density of egg rafts was assessed in the 61 homes and the association between these characteristics and the density of adults was assessed in six randomly chosen homes. Presence/absence data were collected in and around the home regarding the following characteristics: vegetation cover surrounding the home, number of residents per home, method for storing water, forms of sewage and water drainage. Each characteristic was divided into subtypes (Table).

Fluctuations in population density were evaluated using simple analysis of variance (ANOVA) (month x density) for the egg rafts and two-factor ANOVA (evaluations and houses x density) for the adults. Positive results in the homes were compared using the chi-square test for both egg rafts and adults. Frequency of occurrence was calculated from the number of homes positive for each group of characteristics divided by the total number of homes. The group of conditions with the greatest frequency for each characteristic was considered the main aggravating factor. The Mann-Whitney test was used for the comparative analysis of the quantitative variables, presence of aggravating characteristics and egg raft density. A generalized linear model (GLM) with the Poisson family was used to estimate density ratio, presence of aggravating characteristics and egg raft density. The chi-square test was used for the comparative analysis of the qualitative variables, presence of aggravating characteristics and density of adults. The Shapiro-Wilk test was used to test the supposition of normality of the data. Conclusions were drawn with a 5% level of significance. The analyses were made in Statistica 7.0 (StatSoft. Inc. 1984-2004) and in the statistical program R (Bivand, 2000).

The study was approved by the Ethics Committee of Centro de Pesquisas Aggeu Magalhães (CAAE: 0043.0.095.000-08).

RESULTS

Positive results in the homes ranged from 1.03 to 58.8%/event in 97 observations throughout the study period. A total of 95.1% of the homes were positive for the presence of egg rafts during at least one observation. There was no significant variation in the number of positive houses. No significant reduction occurred in the density of egg rafts in the BR-OVT traps. A mean of 3.6 (SD 7.6 rafts/home/month were removed, totaling 2,665 egg rafts, which corresponds to approximately 533,000 eggs of *C. quinquefasciatus*. The minimum and maximum number of egg rafts was one and 158/home/month, respectively.

On the three evaluations of adult density, 100.0% of the CDC traps were positive at least once, with positivity per observation ranging from 25.0 to 75.0%. A total of 2,366 mosquitoes were caught, with a mean of 131.4 (SD 189.6) mosquitoes/home/evaluation and a mosquito/room/night relation of 32.9 mosquitoes. The minimum and maximum number of mosquitoes

[a] Secretaria de Planejamento, Transporte e Meio Ambiente. Olinda em Dados. Olinda; 2000 [cited 2011 may 23]. Available from: http://portalolinda.interjornal.com.br/planejamento_meio_ambiente_olindaemdados.shtml

caught per residence was seven and 666, respectively. However, no significant differences in the number of mosquitoes caught in the homes were found in the three evaluation periods. The presence of vegetation cover was the only characteristic that significantly influenced the number of egg rafts around the homes ($p = 0.02$). Homes with yards with vegetation cover had approximately two fold more egg rafts in comparison to homes without vegetation. This aggravating characteristic occurred in approximately 56.0% of the homes analyzed (Table).

The most frequent aggravating characteristic was sewage drainage to a rudimentary septic tank and the open air (91.8%). Drainage to the general sewage system and water storage in other recipients (buckets, barrels and clay pots) were less frequent (8.2%).

Water storage in a cistern or water tank, water drainage to the street and/or puddled in yards and homes with four or more residents were recorded in more than 50.0% of the sample. Homes with up to three residents, the absence of vegetation, water drainage to a septic tank/sewage system and storage of water in other recipients were found in less than 50.0% of the homes (Table). These characteristics did not significantly affect the number of egg rafts around the homes. However, there was a tendency toward an increase in the number of egg rafts in homes with water drainage to the street and/or puddled in the yard (RR = 1.3) and sewage drained to a rudimentary septic tank and the open air (RR = 2.5) (Table). Homes with water storage in other recipients (buckets, barrels and clay pots) had a rate ratio of < 1. Homes with vegetation, sewage drainage to a rudimentary septic tank and the open air and four or more residents had a significantly greater number of adults (χ^2, $p < 0.001$), whereas homes with water storage in other recipients (buckets, barrels and clay pots) exerted no influence over the number of adults (Figure).

DISCUSSION

The present study describes physical characteristics of residences that may favor the proliferation and maintenance of high density degrees of *C. quinquefasciatus* infestation. Residential characteristics are important factors in this process, as the development and breeding needs of this mosquito are generally contained in the home environment.[4,13,15] The present study analyzed characteristics that are not commonly considered when evaluating parameters that contribute to the density of this mosquito.

The presence of vegetation cover was an aggravating factor that significantly favored the proliferation and maintenance of *C. quinquefasciatus*, as showed by the high number of egg rafts recorded. The exclusive occurrence of plants is not considered a fundamental factor for the development of this species. However, the presence of plants in the area surrounding the home offers an appropriate site for shelter and consequently stimulates the maintenance of the mosquito in the home. Studies on the ecological aspects of *C. quinquefasciatus* population in the Tietê Ecological Park, São Paulo Southeastern Brazil, showed that vegetation on the margin of the canal favored the accumulation of mosquitoes.[16]

Sewage drainage to a rudimentary septic tank and the open air, water storage in a cistern and/or water tank were the most frequent aggravating characteristics. Although such characteristics may contribute for the high mosquito population density in the area, they do not significantly favor the development of *C. quinquefasciatus*. Water drainage to the street and/or puddled in the yard and homes with four or more residents were other characteristics showing similar results. These residential conditions provide a food source (human blood) and potential breeding sites (water sources for oviposition) to mosquitoes. They are important factors for the maintenance of this mosquito in homes.[3] Bonfim et al[9] report that precarious basic sanitation systems,

Table. Number of positive homes (n = 61) and frequency of occurrence of aggravating characteristics and subtypes/subdivisions. Olinda, Northeastern Brazil, 2009 to 2010.

Aggravating characteristics	Subtypes of aggravating characteristics	Homes (n)	Occurrence (%)
Vegetation surrounding home	Absence	27	44.26
	Presence	34	55.74
Number of residents/home	Up to 3 residents	29	47.54
	4 or more residents	32	52.46
Water storage	Cistern and/or water tank	51	83.6
	Other recipients (buckets, barrels and clay pots)	10	16.4
Sewage drainage	General network	5	8.2
	Rudimentary septic tank and open air	56	91.8
Water drainage	Septic tank / sewage	15	24.59
	Street and/or puddled in yard	46	75.41

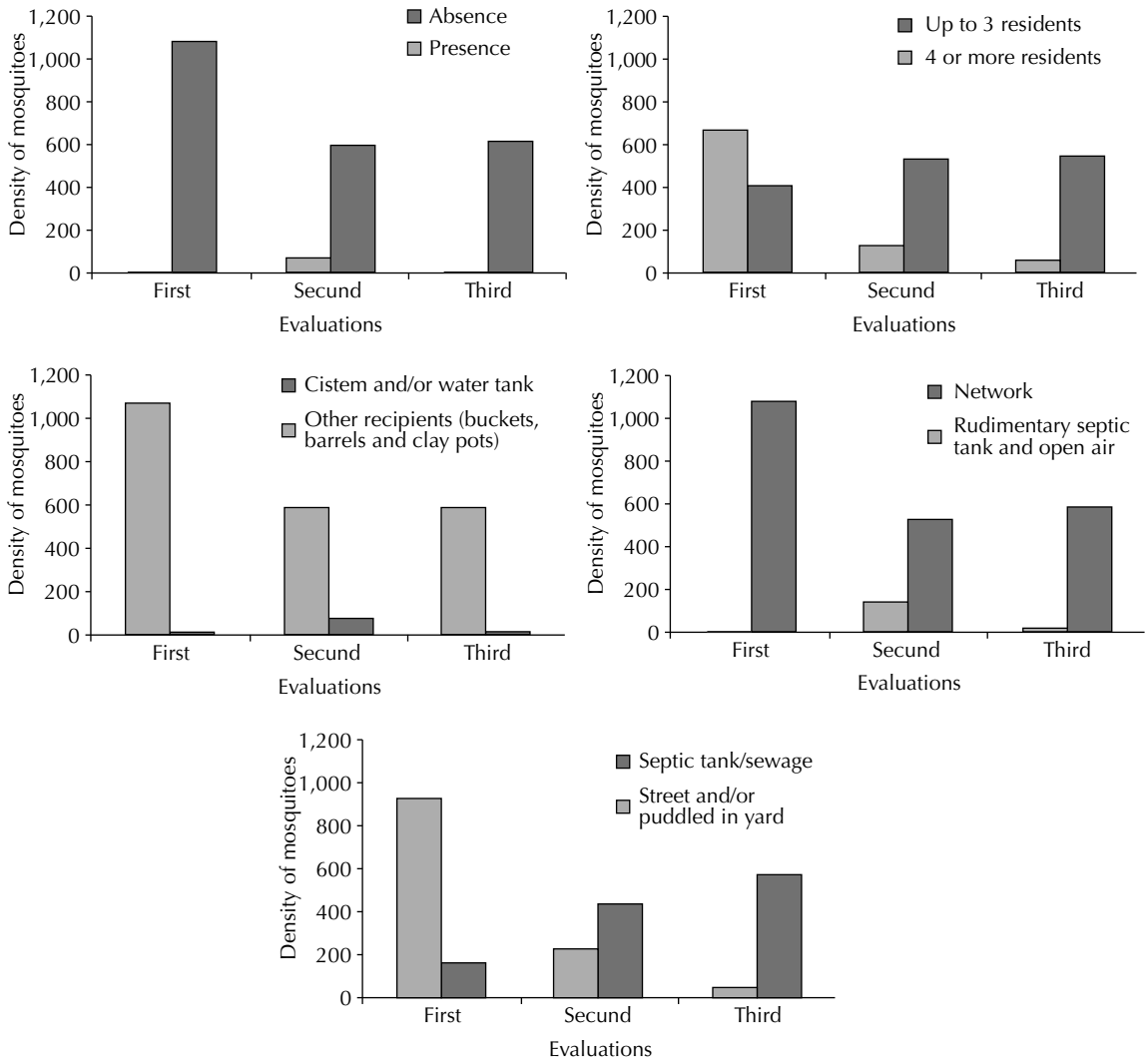

Figure. Density of mosquitoes caught with CDC traps in homes in three evaluation periods according to aggravating characteristics: A: Vegetation surrounding home; B: Number of residents/home; C: Water storage; D: Sewage drainage; E: Water drainage.

such as those found in the neighborhood studied, favor an increase in the number of breeding sites and consequently contribute to high population densities of *C. quinquefasciatus*.

The high degree of positivity in the BR-OVT traps (more than 95%) indicates that its use is a sensitive and effective strategy for the monitoring of *C. quinquefasciatus* corroboring findings described by Barbosa and Regis.[6] They clearly presented the sensitivity of the BR-OVT in the collection of eggs. The integrated use of this trap and current environmental management measures could help reduce local populations of *Culex*.[6] The positivity index for the BR-OVT traps shows that the area studied in the present investigation is highly infested with this mosquito. This was confirmed by the high density of adult individuals caught using CDC traps (32.9 mosquitoes/home/night). Barbosa et al[4] first suggested the use of the BR-OVT trap as a *C. quinquefasciatus* monitoring tool based on the high egg raft densities obtained with traps using different combinations of attractors in the neighborhood area of Caçote, Recife (Northeastern, Brazil). The use of this trap is a potential control instrument, as the larva from the egg rafts do not complete their development due to the use of the biological larvicide, thereby reducing the population of the vector.[4]

Despite the high number of egg rafts (2,665) taken from the BR-OVT traps, no effect on the population density of *C. quinquefasciatus* was observed in the study area. Characteristics inherent to the mosquito, such as high oviposition rate (192 to 225 eggs/raft),[12] short lifecycle (7 to 10 days) under favorable conditions,[20] and the high density of *C. quinquefasciatus* in the area, may have contributed to this finding. These characteristics and

the small number of traps deployed may have quickly compensated for the removal of eggs from the environment. The massive use of BR-OVT traps, reaching the majority of homes, could favor a significant reduction in the adult population of *C. quinquefasciatus*.

Anthropogenic alterations in the environment surrounding homes lead to the proliferation of potential breeding sites for *C. quinquefasciatus*.[1,13] The behavior of residents regarding home maintenance can influence the type and amount of aggravating characteristics associated with the density of egg rafts. An analysis on a worldwide scale revealed that poverty and disorganized urbanization are the basic conditions that favor the proliferation of this vector. Studies indicate that lymphatic filariasis is also related to these conditions.[9] The World Health Organization has called for the elimination of this disease by the year 2020.[19,23]

Losses in the number of traps are expected in the field. Nevertheless, the reduction in the size of the sample obtained in the present study does not invalidate the obtained data, which showed that household characteristics not usually considered in control measures can be essentially aggravating for maintaining high population density of mosquitoes. Future epidemiological research that focuses on quantifying the impact of the residence environment on mosquito density will assist in improving public health measures and mitigation actions to reduce *C. quinquefasciatus* infestation.

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