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First record of *Anopheles aquasalis* associated with malaria transmission in a community in Buriticupu municipality, Maranhão state, Brazil

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ABSTRACT:

Anopheles aquasalis is an important malaria vector in the northwestern coast of Brazil and is currently found in the intra continental regions. Insect studies were conducted in the Buriticupu municipality, Maranhão state, Brazil in the period of 2006 to 2011 between 6:00 h and 18:00 h comprising three environment types viz., intra, peri and extradomicile; with the objective of assessing the presence of anophelines related to malaria transmission. A total of 17 individuals of *Anopheles aquasalis* were collected in the area. We conclude that this species dispersed to the intracontinental region, in an area 300 km distant from the coastal belt.

Keywords:
Mosquito, vector, dispersion

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INTRODUCTION

Genus *Anopheles* is a group of haematophagous Diptera with a wide global distribution (Rebêlo *et al.,* 1997) commonly known worldwide as mosquitoes and as "muriçocas", "carapanãs" and "suvelas" in Brazil. The group comprises approximately 430 described species (Rabach, 2014) of which at least 30 to 40 are natural vectors of plasmodia that cause human malaria (Kiszewski *et al.,* 2004).

Of the approximately 57 anopheline species recorded in Brazil, only six are implicated as main vectors of human malaria according to the Brazilian Health Ministry Considering the subgenus *Nyssorhynchus*, *Anopheles darlingi* Root 1927, *Anopheles albitarsis Lynch-Arribálzaga* 1878 (latusenso) and *Anopheles oswaldoi* Peryassú 1922 (latusenso) are vectors in the Amazonian countryside, and *Anopheles aquasalis* Curry 1932 in the northwestern coastal area. In the subgenus *Kerteszia*, *Anopheles cruzii* Dyar and Knab 1908 and *Anopheles bellator* Dyar and Knab 1906 are vectors in Serra do Mar (Gomes *et al.,* 2008; Ministério da Saúde and Secretaria de Vigilância em Saúde, 2008). In the State of Maranhão, the main plasmodium vector species is *Anopheles darlingi*, occupying predominantly the intracontinental area, and *Anopheles aquasali*s is distributed in the coast (Rachou, 1958; Silva, 1989; Consoli and Lourenço-de-Oliveira, 1994; Forattini, 2002), although other *Anopheles* species were also been found in the region

The entomological inquiries about malaria's vectors enable the knowledge of anopheline species diversity, the analysis of those incriminated in transmission and evaluation of the environmental and biological risk factors for the epidemiology of the disease (Tadei *et al.,* 1988; 1998; 2007). According to Tadei *et al.* (1998) in Amazonia, population density of anophelines, especially *A. darlingi*, varies along the year for adult and immature forms alike. In some situations, reduced densities were found to be correlated with Amazonian winter, more evidently for adult than for immature forms (Tadei *et al.,* 2003), since in the rainy season these insects are displaced from permanent breeding grounds in the "terra firme" (upland forest) to lakes and ponds that form near river margins during the flood, as rising waters create temporary breeding grounds in the forest (Tadei *et al.,* 1998).

In Atlantic coastal regions, *A. aquasalis* are more tolerant to water bodies containing some salinity predominates (Rios-Velásquez *et al.,* 2013). *Anopheles aquasalis* commonly colonizes breeding grounds in brackish, slow-moving water, totally or partially shaded, in low-lying terrain frequently flooded by the tidal pulse, and ditches and puddles filled with rainwater in saline soils. These conditions limit the species' distribution on the coastal zone, as well as on the freshwater breeding grounds within a few kilometers from the shore (Faran, 1980; Consoli and Lourenço-de-Oliveira, 1994), with records of up to 200 km inland (Forattini, 2002).

This species is distributed in almost the entire Brazilian coast, extending through Guyana, French Guyana, Surinam, Venezuela, Trinidad and Tobago, Colombia, Panama, Nicaragua, Costa Rica and even the Pacific coast of Ecuador (Conn *et al.,* 2013). It is considered quite receptive to infection and transmission of *Plasmodium vivax* (Rios-Velásquez *et al.,* 2013), and is the main species responsible for malaria transmission on the coastal belt of the Maranhão state, Brazil is (Rebêlo *et al.,* 1997). Based on this information, the objective of this work is to describe the first record of the species *Anopheles aquasalis* in the Buriticupu municipality, Maranhão state, Brazil, an area not ably of malaria transmission. Although this paper concerns only *A. aquasalis*, it is part of a larger ecological study on malaria vector species.

MATERIAL AND METHODS

Study area

Studies were conducted at the locality of

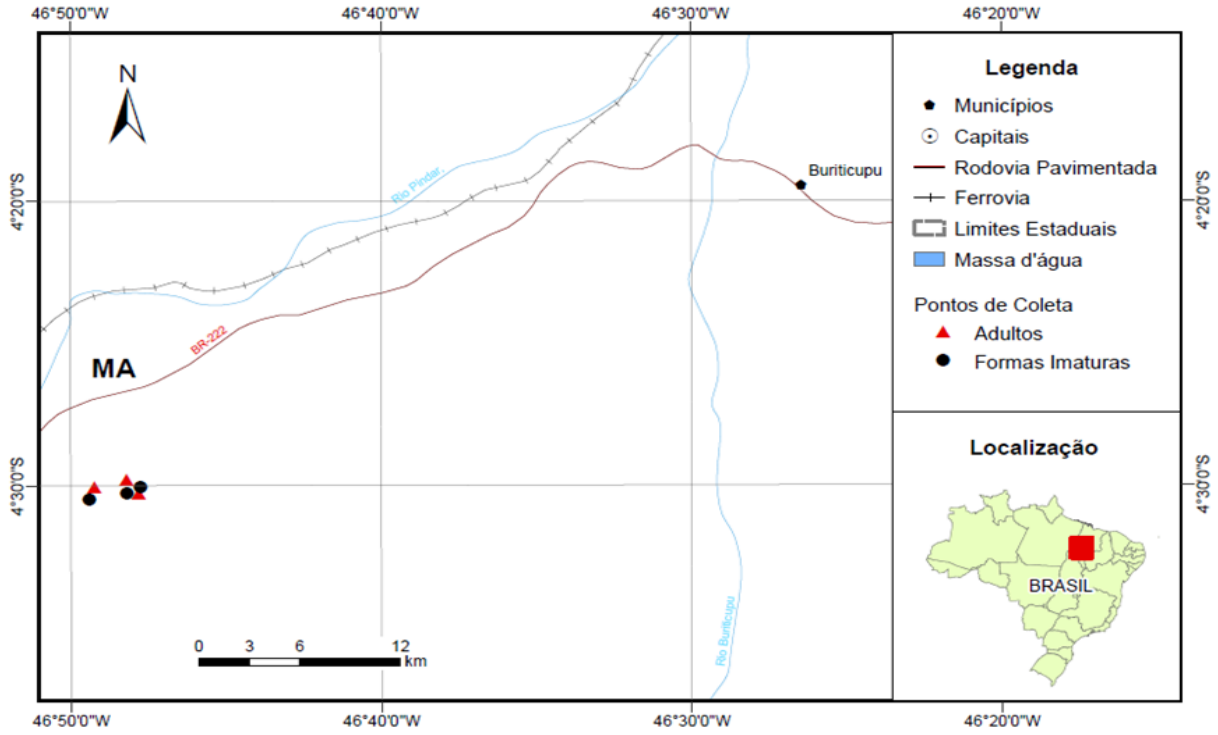

Figure 1. Geographical location of Buritizinho community, Buriticupu municipality, Maranhão State, **Brazil** **Legenda:** Legend; **Municípios:** Municipalities; **Capitais:** Capitals; **Rodovia Pavimentada**: Paved Road; **Ferrovia:** Railway; **Limites Estaduais:** Statelimits; **Massa d'água:** Waterbody; **Pontos de coleta:** Collection points; **Adultos:** Adults; **Formas Imaturas:** Immatureforms; **Localização:** Location. **MA:** Maranhão; **BR-222:** Federal Roadway BR-222.

Buritizinho, Buriticupu municipality, Maranhão State, Brazil, located in an intracontinental region, distant 300 km in a straight line, on average, from the coastal belt (Figure 1). Collection points were georeferenced; see Table 1 for geographical coordinates.

Seasonal fluctuation and density of *Anopheles aquasalis.*

Anopheline collection was performed in three environment types which are relative to the distance from houses: intra, peri and extra domicile. Captures were done monthly, between January 2006 and February 2011, one night per month, between 6:00 h and 18:00 h. On each environment type, three people systematically collected during 20 minutes every hour, 12 hours without interruption. A qualified technical team performed the captures, using the human landing catches - HLC technique with Castro type suction tubes. Collectors

Table 1. Geographical coordinates of the collection points of *Anopheles* sp. adults at the Buritizinho community, Buriticupu municipality, Maranhão state

Location	Enviroment type	Latitude	Longitude
Domicile	Intradomicile	-4º30'34.1"S	-46º49'27.3"W
Domicile	Peridomicile	-4º30'14.1"S	-46º48'0.29"W
Domicile	Extradomicile	-4º30'20.7"S	-46º47'89.0"W

Table 2. **Number of *Anopheles aquasalis* mosquitoes collected in domiciliary environments at the Buritizinho community, Buriticupu municipality, Maranhão state, 2006 to 2011**

Species	Intradomicile		Peridomicile		Total
	n	%	n	%	n
Anopheles aquasalis	4	23.5	13	76.5	17

wore personal protection equipment and followed the procedures described by Tadei *et al.* (2012).

Mosquito species identification was done at the Entomology Laboratory of the Parasitic and Infectious Diseases Reference Centre, Maranhão Federal University -UFMA (Centro de Referência do Laboratório de Entomologia do Centro de Referência em Doenças Infecciosas e Parasitárias da Universidade Federal do Maranhão) using the dichotomous keys of Consoli and Lourenço-de-Oliveira (1994) and Forattini (2002).

RESULTS AND DISCUSSION

A total of 17 specimens of *Anopheles aquasalis* was collected, all are found to be adult females. Most mosquitoes were sampled in the peridomicile environment (n=13: 76.5%), against 23.5% (n=4) in the intradomicile environment. No mosquitoes of this species were recorded in the extradomicile environment (Table 2). The species was active between 19:00 h and 21:00 h, and was limited to the period from March to May every year.

This record in the Buriticupu region is important, since the literature mentioned *A. aquasalis* within 100 km (Faran, 1980; Consoli and Lourenço-de-Oliveira, 1994) or 200 km (Forattini, 2002) of the coast. In the last decade, Rebêlo *et al.* (1997) recorded the species only in municipalities close to Maranhão State's coast. Since Buritizinho community is 300 km distant from the Atlantic Ocean's coast in a straight line, on average, this record extends the species' distribution area inland. Studies conducted in the 1980s by the National Institute of Amazonian Research - INPA (Instituto Nacional de Pesquisas da Amazônia) had recorded a few individuals in Tucuruí, Pará State, distant 240 km from the coastal zone, on average (Tadei WP personal communication). However, studies conducted in 1994 and 1995, also in Buritizinho, did not record the vector (Rebêlo, 1997), which leads us to admit that it dispersed recently. One of the factors that may have contributed to this mosquito's dispersal to the hinterland is the access ways to the region, which is connected to the coast by the Federal Roadway BR-222 and by the Carajás Railway. The vector must have found an abundant blood food source in Buritizinho, as well as breeding grounds located around the Buriticupu River, which borders the community.

Considering the species' epidemiological importance and potential to expand inland, these data constitute a finding of great relevance for entomological surveillance of malaria control in the state, since *A. darlingi*, also involved in malaria transmission, is also known to occur in the region (Rebêlo *et al.,* 1997).

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