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Seasonal distribution of *Aedes aegypti* in southern Benin: a risk of dengue virus transmission to urban populations

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ABSTRACT: *Background: Aedes aegypti* is present year round in several cities of the Republic of Benin. This study aims to assess the seasonal distribution of this mosquito at Dandji, in southern Benin.
Method: A cross seasonal entomological study on larvae and adults of *Ae. aegypti* was carried out from May 2013 to April 2014 in southern Benin (Dandji). The study was based on sampling *Ae. aegypti* immature stages (larvae/pupae) from domestic, peri-domestic and natural water sources and were reared to adults. The collections were made during the dry and rainy seasons. Addional *Ae. aegypti* were collected by Human Landing Catches (HLC), Indoor Pyrethrum Spray Catches (PSC), Biogents (BG) sentinel trap and Gravid traps (GT).
Results: During the year of study, a total number of 18,658 mosquitoes were collected where 15,204 were collected by HLC; 303 with BG trap, 3,038 with PSC, 48 with the GT. Among the 18, 593 of *Ae. aegypti* collected, the female populations (13,834) was significantly higher than the male populations ($p<0.05$). From the 13,834 females, 1,380 were blood-fed.
Adult's collection was high during the two rainy seasons (June to July and October to November) but declined in the two dry seasons (December to March and August to September).
At Dandji, the average of Human Biting Rates (HBR) obtained during the rainy seasons (79.6 bites/p/n) was significantly higher than those obtained during the dry seasons (58.62 bites/p/n) ($p < 0.05$).
Conclusion: These findings showed the presence of *Aedes aegypti* year round at Dandji in southern Benin. This presence is strengthening with the trade of second hand tires which are good breeding sites for the development of *Ae. aegypti*. Data on blood feeding patterns of *Ae. aegypti* collected during this study will certainly provide valuable information about potential Dengue virus (DENV) hosts others than humans and will help to get a greater understanding about DENV ecology in Benin. It is therefore crucial for health authorities of Benin to develop a program to fight against this mosquito in order to avoid an outbreak of DENV as it was the case in many sub Saharan Africa countries recently.

KEYWORDS: *Aedes aegypti*; season; traps; tires; Benin.

1 INTRODUCTION

The incidence and distribution of dengue-related illness has grown dramatically in recent decades [**1**]. With more than 50 million cases reported to the World Health Organization (WHO) each year, Dengue virus (DENV) is now regarded as the world's most important mosquito-borne virus (mobovirus) [**1**]. It's a silent viral disease spread by the vector mosquito *Aedes aegypti* which belongs to the family *Culicidae* and order *Diptera*.

Ae. aegypti mosquitoes are the most important and the primary domestic vectors of urban dengue and yellow fever virus [**2-3**]. It can transmit Chikungunya [**4**], Murray valley encephalitis and Ross River [**5**] viruses in addition to Chandipura virus (*Rhabdoviridae*) experimentally [**6**].

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Aedes spp mosquitoes are widely distributed in Africa and can serve as vectors of DENV. When their distribution is combined with rapid population growth, unplanned urbanization, and increased international travel, extensive transmission of DENV is likely in Africa [**2**]. DENV infection is caused by one of four DENV serotypes (DENV 1, DENV 2, DENV 3, and DENV 4). All four DENV serotypes have been isolated in Africa [**2;7**]. The knowledge about DENV epidemiology and its impact on public health in Africa, is poor. Because of low awareness by health care providers and lack of diagnostic testing and systematic surveillance, the epidemiology and effect of dengue in Africa has not been defined.

Environmental factors including weather variables may play a significant role in the transmission of dengue which is a mosquito-borne disease with seasonal distribution [8-9]. Temperature, rainfall, and relative humidity are major parameters influencing the incidence of dengue fever [10]

Recently, outbreaks of dengue have been reported in many African countries. In fact, in 2009, 696 suspected cases were recorded in Senegal with 196 confirmed [11]. In Cape Verde, an estimated 210,000 clinical cases were documented of which 174 fitted the WHO definition of dengue hemorrhagic fever (DHF) and dengue shock syndrome (DSS) and six were fatal [11]. This re-emergence of dengue fever has been observed also in Mauritius [12], in Cameroon [13], and in Senegal [11]. However, in West Africa, most available data on dengue fever and *Ae. aegypti* date back more than 30-40 years [14]. In order to implement effective and sustainable arbovirus vector control measures in southern Benin, particularly at Cotonou, the economic capital, there is an urgent need to determine the prevalence and seasonal distribution of dengue mosquito, *Ae. aegypti.*

2 METHODOLOGY

2.1 STUDY AREAS

The study was carried out in southern Benin at Cotonou, the economic capital from Mai 2013 to April 2014. The choice of the study area is based on the weak level of urbanization. Additionally a lot of second hand tires from Europe and Asia, which are good breeding sites for *Ae. aegypti,* are stored and sold in this area.

This part of southern Benin (Figure 1) is characterized by two rainy seasons (April- July and October- November) and two dry seasons (December-March and August-September).

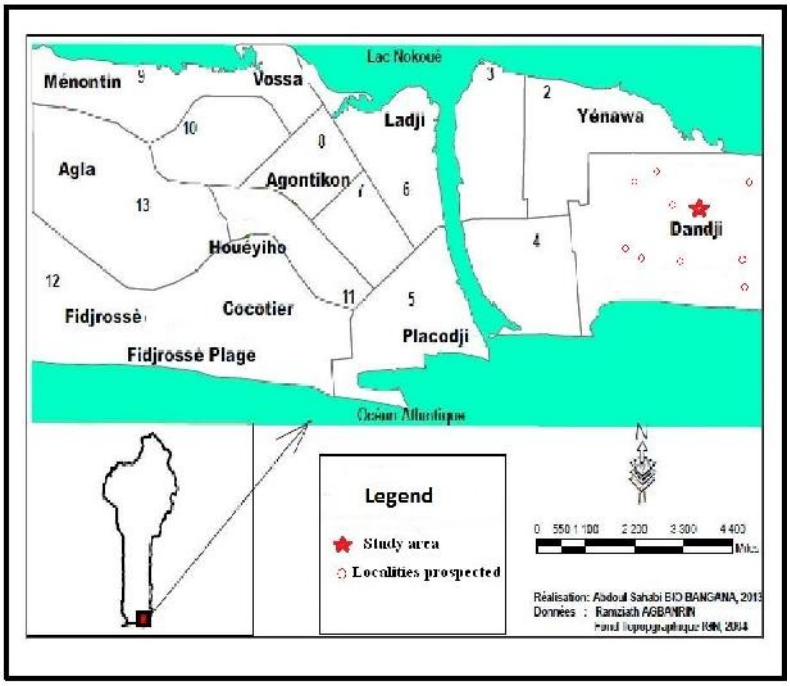

Figure 1: Map of Benin showing the study site

2.2 MATERIAL AND METHOD

MOSQUITO SAMPLING

Field mosquito collection

Indoor collections of adult mosquitoes were carried out monthly from May 2013 to April 2014. Adults collection were organized in households where old tired from Asia and Europe are stored. These mosquitoes were collected using four sampling methods:

(1) Indoor and outdoor Human Landing Catches (HLC) were performed monthly over two consecutive days (11:00 AM to 6:00 PM), in 4 randomly selected compounds;

(2) Indoor Pyrethrum Spray Catches (PSC) in 4 other selected compounds; the same compounds in each sampling method being consistently used throughout the study.

Collectors gave prior informed consent and received anti-malaria prophylaxis and yellow fever immunization. They were organized in teams of two for each collection point and they rotated between locations within houses every two hours. These mosquito populations of *Ae. aegypti* were completed with those collected from Biogents (BG) sentinel trap and Gravid traps (GT). These mosquito populations were identified base on several keys [15-16].

Moreover, *Ae. aegypti* immature stages (larvae/pupae) were sampled from domestic water sources (e.g. jars, tanks), peri-domestic (e.g. tires) and natural sources (e.g. tree holes) during the dry and rainy season. Ten points located at the study sites were chosen (Figure 1). For each sampling site, larvae or pupae from 2-6 larval breeding places were collected, stored in plastic boxes and transferred to the laboratory for rearing to adults. Once specimens are positively identified as *Ae. aegypti*, they were pooled according to location and collection source.

ENTOMOLOGICAL PARAMETERS

Entomological indicators of DENV transmission intensity at the study area were evaluated

(1) the mosquito fauna composition, which is the number of mosquitoes collected during the cross seasonal entomological study from Mai 2013-April 2014

(1) the human biting rate (HBR), which is the number of mosquitoes biting a person during a given time period (bites/p/t) (time being night, month or year)

(3) the physiology status of *Ae. aegypti* populations collected, which was evaluated by looking at the abdomen of the mosquitoes if it was blood-fed or not

ETHICAL CONSIDERATIONS

Ethical approval for this study was granted by the Ethical Committee of the Ministry of Health in Benin. Verbal consent was asked to the head of each household for the spray catches and consent of collectors was obtained prior to HLC. In case of refusal, permission was sought from the next household.

3 RESULTS

3.1 MOSQUITO FAUNA COMPOSITION

A total number of 18,593 mosquitoes were collected from Mai 2013 to April 2014. Among these populations of mosquitoes, 15,204 were collected by HLC; 303 from BG, 3,038 from PSC and 48 from the GT traps (Figure 2).

The mosquito populations collected by HLC was significantly higher than those collected from others methods of catching ($P<0.05$) (Figure 2). Among the 18,593 of *Ae. aegypti* collected, female populations (13,834) was significantly higher than male populations ($p<0.05$) (Table 1)

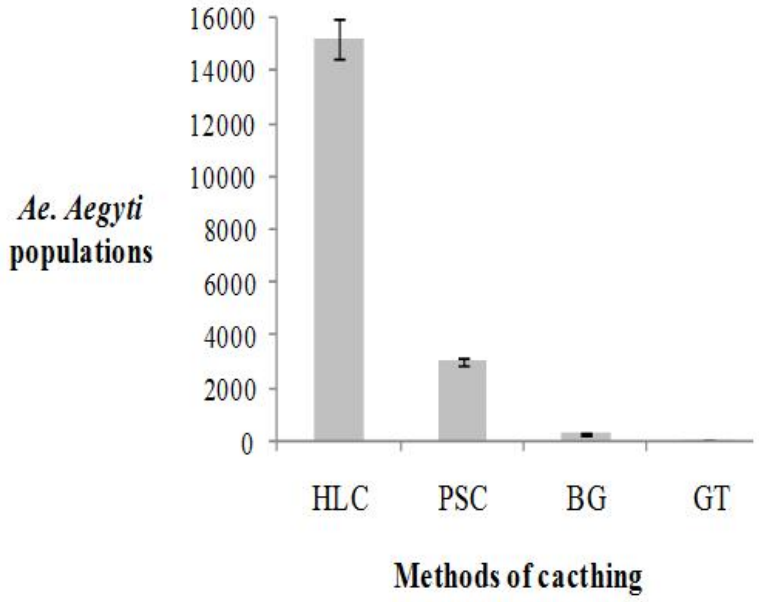

Figure 2: Number of Ae. aegypti collected from various methods of catching

Table 1: Ae. aegypti populations collected from Mai-2013 to April 2014

	Dandji												
	Mai	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Marc	Apr	Total
Female	760	1444	2395	1162	921	1412	1630	839	825	1675	206	565	13,834
Male	0	0	1028	687	701	225	778	304	0	0	592	444	4,759

3.2 SEASONAL ABUNDANCE OF *AE. AEGYPTI* POPULATION AT DANDJI

Adult's collection (Table 1) was high during the two rainy seasons (June to July and October to November) but declined in the two dry seasons (December to March and August to September). In fact, the highest bites of *Ae. aegypti* was found during the rainy seasons in July (149.69 bites/p/n) and the lowest during the dry seasons in March (12.89 bites/p/n) (Figure 3). At Dandji, from Mai 2013 to April 2014, the average of Human Biting Rates (HBR) obtained during the rainy seasons (79.6 bites/p/n) was significantly higher than those obtained during the dry seasons (58.62 bites/p/n) ($p < 0.05$).

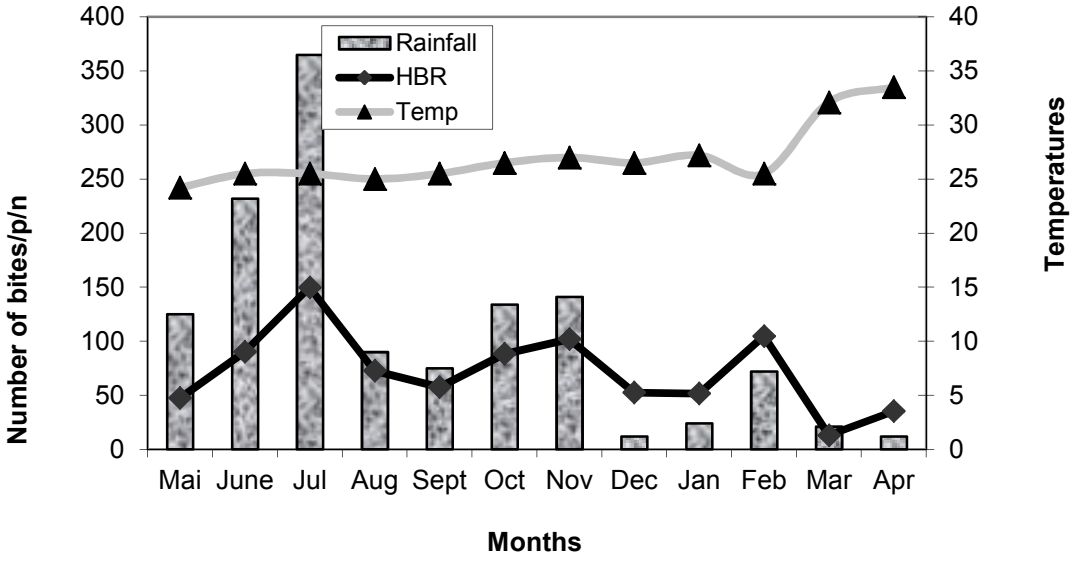

Figure 3: Seasonal variation of the number of human bites/person/night and temperature at Dandji from Mai 2013 to April 2014

3.3 PHYSIOLOGY STATUS OF *AE. AEGYPTI* POPULATIONS COLLECTED

From the 13,593 *Ae. aegypti* collected, 1,334 females were blood-fed.

The highest populations of *Ae. aegypti* blood meals were collected by human landing Catches (HLC (Table 2).

Table 2: Ae. aegypti blood meal populations collected

Dandji	
Method of catching	***Number of blood meal mosquitoes caught***
HLC	***772***
PSC	***599***
BG	***9***
Total of blood meal mosquitoes caught	***1,380***

4 DISCUSSION AND CONCLUSION

The cross seasonal entomological survey on larvae and adults of *Ae. aegypti* conducted in southern Benin has shown a presence of this mosquito year round in this part of the country. Several factors certainly contribute to it spatial distribution. Among theses factors, anthropological factors play an important role. Results from our study showed that most of adults of *Ae. aegypti* were collected from second hand tires from Europe and Asia which were kept in many stores and sold in this area. These tires were the most productive *Ae. aegypti* larvae breeding sites and this, independently of season. This result confirmed what was found in the Central African Republic [17] and in southern Cameroon [18].

In fact, the advantages of this second hand tire trade of are considerable. They contribute to the improvement of living conditions by supplying income and employment to urban populations. However, the economic and social impact of this trade is limited by a number of factors particularly these tires which are good breeding sites for *Ae. aegypti.* Despite their massive presence in the tires, some larvae were found also in abandoned peri-domestic containers and discarded tanks. This finding is in agreement with observations made in Cameroon [18], [19], [20], where peri-domestic containers represented the bulk of the containers infested by *Ae. aegypti* or *Ae. albopictus*, thus differing from the situation in other parts of the world, particularly in Asia, where domestic containers such as water storage tanks were most commonly infested with *Ae. aegypti* [21], [22].

Moreover, in many sub-Saharan towns, unplanned urbanization and lack of waste management lead to widespread water collection, thus favoring the proliferation of *Aedes* spp [7]. Dandji, our study area site, is located in a weak level of urbanization. This factor added to the presence of second hand tire trade can explain the high populations of *Ae. aegypti* in this area and can trigger the transmission of dengue and yellow fever.

Adult's collection was high during the two rainy seasons (June to July and October to November) but declined in the two dry seasons (December to March and August to September). However, the increase of the populations of *Ae. aegypti* in February 2014 (Figure 2) can be explained by the increase of the rainfall during this period of dry season; certainly an effect of climate change [23].

In Benin, there is an increasingly attention being given to malaria vector control [24-26] while *Ae. aegypti* is an important nuisance that often condition community acceptance of vector control tools [27]. Because of low awareness by health care providers and lack of diagnostic testing and systematic surveillance, DENV infections only have been reported from travelers returning to France and Japan [28-29]. These findings are supposed to be a ringing for planning vector control programs on *Ae. aegypti* in Benin. Moreover, data on blood feeding patterns of *Ae. aegypti* collected, could provide valuable information about potential DENV hosts others than humans and will help to get a greater understanding about DENV ecology in Benin.

It is therefore crucial for health authorities of Benin to develop a program to fight against this mosquito and avoid an outbreak of DENV as it was the case in many sub Saharan Africa countries cited above.

COMPETING INTERESTS

The authors declare that they have no conflict of interest.

AUTHORS' CONTRIBUTIONS

AY carried out field experiments, collected, analysed, interpreted data and wrote the first draft of the manuscript. **AR**, VC, **PG, BK, AR, UF, ZJ, HA** helped with the field activities. **AY** and **MA** conceived and designed the study, supervised fields collection, data analysis and interpretation, revised the manuscript and gave final approval for the version to be published.

All authors read and approved the final manuscript.

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