Assessment of population dynamics and biting trends of Aedes aegypti in northern Benin: Public health implications

Rock Aïkpon, Gado Dramane, Jean Robert Klotoé, Mark Brettenny, Yllias Lawani, Gorgias Aïkpon and Anges Yadouléton

Abstract

Aedes aegypti represents a major vector of arboviruses, which include Zika viruses, dengue, chikungunya, yellow fever among others. Presence and abundance of this vector is associated with the risk of arboviral diseases transmission. Little is known about biting behaviour of Aedes mosquitoes in Benin. This study aimed to assess population dynamics and biting trends of Aedes aegypti mosquito in northern Benin. Abundance and biting cycle of Aedes aegypti were determined indoors Vs outdoors through monthly human landing catches.

A total of 485 adult Aedes aegypti mosquitoes were collected. The probability of exposure to Aedes aegypti bites was highest outdoors and in afternoon hours. This is enormous risk factors for potential outbreaks of arboviral diseases.

Findings of our study serve valuable informations about potential threat of the emergence of arboviral diseases in northern Benin. Therefore, it will be important to implement urgently vector control strategies to fight against Aedes mosquitoes in order to prevent any occurrence of arbovirus.

Keywords: Aedes aegypti, population dynamics, biting, Benin

Introduction

Aedes aegypti represents a major vector of arboviruses, which include Zika viruses, dengue, chikungunya and yellow fever [1-4]. These mosquito-borne viral diseases have emerged or re-emerged in several countries in the world during the past decades [5-8].

This vector was formerly found in sub-Saharan African where it originated [9], but has now spread to over continents through trade spread to other continents through trade and currently is distributed world wide through man-made activities [10, 11]. Known as a tree-hole mosquito, its larvae breed in human made containers [10]. Therefore, habit of people of adding water to containers, which can be for drinking, bathing (Storage) and other purposes could play a role in the production and maintenance of vector population and its abundance. Moreover, several environmental factors such as weather variables may play a important role in the transmission of arboviruses [12, 13]. For instance, rainfall, relative humidity and temperature can influence the incidence of dengue fever by affecting mosquito abundance and behaviour [14].

Presence of Aedes aegypti is associated with the potential risk for the occurrence or unexpected arrival of the arboviruses diseases. Transmission of arboviruses by Ae. Aegypti occurs in many African countries. In fact, the re-emergence of dengue fever has been observed in Cameroon [15], in Senegal [16], in Mauritius [17] and even, now and then in neighboring Benin countries. Nevertheless, few cases of arbovirus transmission have been reported in Benin. For instance, the last outbreak of yellow fever has historically been reported in the department of Atacora in the north east region of Benin since 1996. The area affected is Kerou district where 48 cases and 37 deaths have been recorded. This out break has been followed by immediate vaccination of the exposed population. However, the presence of the vector remains a potential threat to the occurrence of arboviruses in Benin.

In order to implement sustainable Ae aegypti control measures to prevent any occurrence of arbovirus in northern Benin, this study aimed to document the daytime activity, especially biting habits, of Aedes aegypti mosquitoes and provide recommendations on future
management of associated public health risks. Therefore we present here the current distribution and the prevalence as well as the biting behaviors of *Ae aegypti* in the study.

**Matériels and Methods**

**Study area**

The study was carried out in Atacora region located in the Northwest of Benin and includes three districts: Kouandé, Natitingou and Toukountouna (Figure 1). Those districts covered about 6,384 km² and had an estimated population of 326,868 in 2015. Atacora region has a sub-equatorial type climate with one dry season (December-May) and only one rainy season (June to November). The annual mean rainfall is 1,300 mm and the mean monthly temperature ranges between 22° and 34 °C. The main economic activity is agriculture and it is characterized by the production of cotton and millet where various classes of pesticides are used for pest control. This area is characterized the weak level of urbanization.

![Fig 1: Map of study areas](image)

**Human landing catches (HLC)**

Adult *Ae. Aegypti* mosquitoes were collected using human baits between 3pm-8pm, and 6am-12am during the study periods. In each district, two villages were selected, and two houses were chosen per village for mosquito collection. Monthly, mosquito collections were carried inside and outside houses using a mouth aspirator, by human volunteers (adults ≥ 18 years old) who resided within the sampling area and who had previously given consent. They were all trained before they started the catching of mosquitoes. Two nights of mosquito collections a month were carried. In each village, mosquitoes were sampled indoors and outdoors (3-5 meters from the house). « Indoors » describes any place outside the doors of the house selected for sampling, round and about it but within the homestead. « Outdoors » describes the space within the door (s) of the selected house. To collect mosquitoes, the lower legs of the collectors were exposed such that when the perched to take blood meal the mosquitoes were collected using test tubes. The opening of the tube was plugged with cotton wool to prevent escape of the mosquito. Collections were recorded at intervals of 1 hour to gather more information on vector biting activities. Sampling was conducted in 2018 from January to December, from 3 pm to 8 pm in the afternoon and then from 6 am to 12 am in the morning.

All mosquitoes were transported to the laboratory, and identified on chill tables according to species using morphological characteristics [18, 19].

**Data analysis**

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), was calculated monthly. Comparisons of HBR was made by the Chi-square test between indoor and outdoor.

**Results**

**Species composition of genus *Aedes* mosquito**

As shown in figure 2, in total 485 mosquitoes were caught in the landing catches during the study period. These mosquitoes belonged to six species that are *Aedes aegypti*, *Aedes Vitatus*, *Aedes luteocephalus*, *Aedes longipalpis*, *Aedes gr. palpalis* and *Aedes gr. tarsalis*. The two most abundant species collected were *Aedes aegypti* and *Aedes vitatus* with respectively 55,46% and 20,82% of the total collected.
Fig 2: The numbers of adult Aedes species collected on human bait in study area from January to December 2018.

**Hourly activity of Aedes aegypti mosquito in the study area**

*Aedes aegypti* is known to bite diurnally. The number of *Aedes aegypti* mosquitoes collected varied among the hours. The chances of finding *Aedes aegypti* mosquitoes by HLC is higher in the afternoon hours with a major peak between 5pm and 6pm and in the morning hours with a second peak between 8am and 9am.

Fig 3: Day biting cycle of *Aedes aegypti* Mosquito in the study area

*Aedes aegypti* abundance and indoor/outdoor density

The figure 4 shows a dynamics of Human Biting Rate (expressed in number of bite/person/day) indoor Vs outdoor in the study areas. We noticed the presence of *Aedes aegypti* throughout the year. However, the monthly HBR was high during the rainy season (May to October) with a peak on July where each person received about 1.44 bites/day indoor against 1.75bites/day outdoor. In addition, the biting rate remains significantly higher outdoor during all the months of the year.
4. Discussion
This study assessed the population dynamics and biting trends of *Aedes aegypti* in northern Benin and is to our knowledge, the first documenting the day biting mosquito activity in Benin. This information on biting habits of mosquitoes active during the day in Benin, especially vector species, is primary step forward in assessing the local risks of mosquito-borne diseases.

The findings showed that *Aedes aegypti* was present all year round in the study area that may pose a potential risk of transmitting pathogens. *Aedes aegypti* is the most abundant species collected and is the species of greatest concern given its role in the transmission of dengue, chikungunya, and Zika viruses. The funding that more *Aedes aegypti* adult mosquitoes were abundant in this areas is consistent with the adaptation of this species to the domestic environment as its abundance is positively correlated with increasing urbanization [10, 20-23]. The fact that Africa’s urbanization is occurring with far less infrastructural development, notably unreliable water and disposal of solid container wastes, suggest that the spread of *Aedes aegypti* may be greatly enhanced in future years [24].

The collection of more *Aedes aegypti* adult mosquitoes outdoors than indoors during the whole year is consistent with other studies in Kenya [25, 26], in Trinidad [27], in Malaysia [28, 29] and in Brazil [30]. Moreover, significantly more *Aedes aegypti* mosquitoes were collected in the afternoon than morning hours indicating the possibility that most of the human-vector contact is occurring in the afternoon hours. This finding is consistent with the experimental results by Gouck and Smith [31] but in contrast to the findings by Strauss and others [32] who found no significant difference in the number of *Aedes aegypti* mosquitoes that fed at different times of the day.

Findings of our study give credence to the potential public health threats posed by *Aedes aegypti* mosquitoes in Benin and provide baseline informations as far as its distribution and biting behaviour are concerned in the north of the country. This study had some limitations. For instance, this study did not collect additional data about surrounding vegetation, presence of open containers, and site-specific temperatures which would have allowed for a more robust analysis of the determinants of variation in mosquito abundance across the study areas. In addition, it would be desirable to include in this study the assessment of the characteristics and distribution of larval breeding sites of *Aedes* mosquitoes in the study area.

5. Conclusion
This study documented for the first time the distribution and the biting trends of *Aedes aegypti* in the north of Benin. Most of the *Aedes aegypti* adult mosquitoes were colleted outdoors and in the afternoon hours. This is enormous risk factors and had major implications for potential outbreaks of arboviral diseases. Thus, it will be important to implement urgently vector control strategies to fight against *Aedes* mosquitoes in order to prevent emergence of arboviral diseases such as Zika, dengue, yellow fever among others.

6. Acknowledgment
The authors of this manuscript thank the Director of the Ecole Normale Superieure de Natitingou for funding this research work. We are grateful to Zika GLOBE Project for the technical assistance.

Competing interests
The authors declare that they have no competing interests.

Ethical consideration and consent to participate
Ethical approval for this study was granted by the Ethical Committee of Centre de Recherche Entomologique de Cotonou. The mosquito collectors gave prior verbal consent and they were vaccinated against yellow fever.

Authors’ contributions
RA, GD, JRK, MB, YL, GA and AY designed the study. RA, GA and JKR carried out the field activities. RA drafted the manuscript and analyzed the data. AY and RA critically revised the manuscript. RA and MB conceived and designed the study and GD revised the manuscript for intellectual content. All authors read and approved the final manuscript.
7. References


23