

Baseline Entomological Indicators of Malaria Transmission Prior to the Implementation of Indoor Residual Spraying in Malanville District, Northern of Benin.

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Abstract

Background: To assess malaria transmission in the district of Malanville in northern Benin, an entomological study was carried out in two sites from January to December 2016.

Methods: Adults mosquitoes were collected monthly by human landing catches (HLC) over two consecutive nights (8:00 PM - 6:00AM) in four compounds randomly selected from each study site. These collections were completed by indoor pyrethrum spray catches (PSC) in 10 additional compounds in each study site. The sampling method used in each compound was consistent during the study period. Head-thoraces of female mosquitoes captured by HLC were tested for the presence of *circumsporozoite protein* (CSP). Mosquitoes captured by PSC were preserved for species identification using polymerase chain reaction (PCR).

Results: i) – Overall, 9,019 female mosquitoes were caught by PSC and 21,474 by HLC; ii) – In Malanville, *Plasmodium falciparum* was mainly transmitted by *An. gambiae* s.s where malaria transmission was high from June to November during the rainy season and declined during the dry season (December-May); iii) – The average entomological inoculation rate (EIR) was significantly higher during the rainy season (0.8 infectious bites/person/night) compared to the dry season (0.1 infectious bites/person/month) ($P < 0.05$).

Conclusion: These findings showed malaria transmission is unimodal in the city of Malanville. The main malaria parasite, *Plasmodium falciparum*, was transmitted by *An. gambiae* s.s. Results from this study will be useful for National Malaria Control Program authorities in the choice of vector control strategies to prevent malaria transmission in the district of Malanville.

Keywords - Malaria; Transmission; *Anopheles gambiae*; Malanville

I. INTRODUCTION

According to the World Health Organization (WHO), malaria caused about 445 000 deaths in 2016 with an estimated 3.2 billion people living in areas at risk of malaria transmission. [1]. Over 80% of malaria deaths occur in Africa, where approximately 66% of the population live in areas at risk of malaria transmission [1].

In fact, the geographical distribution of malaria described in sub-Saharan Africa is diverse and ranged from savannah malaria to forest, highland, urban and hydro-agricultural malaria [2]. There is an urgent need to investigate on urban malaria transmission, particularly in savannah areas. Malaria incidence has recently increased in savannah areas as a result of urban expansion coupled with the development of urban agro-economic activities [2].

The initial process of urban expansion in savannah areas is accompanied by an increase in malaria prevalence on the outskirts areas [3]. This is driven by the establishment of new shanty zones with open sky pits and burrows, which offer suitable breeding sites for mosquitoes. This environmental aspect coupled with the unprecedented urbanization and declining economies may have profound implications for the epidemiology and control of malaria in savannah areas.

In Benin, there is little data available on malaria in dry savannah area. The current study was designed to assess the level of malaria transmission in Malanville, a town located in north-eastern Benin in dry savannah area. The goal of this study was to investigate the entomological aspects of malaria transmission in relation to seasonal variations in vector populations.

Specifically, the study aimed to determine (a) the distribution of *Anopheles* mosquito species throughout the year at these sites, (b) their human biting pattern, (c) the infectivity rates of malaria Vectors and (d) the entomological inoculation rates and malaria transmission in the study areas.

Results from this study will serve as baseline data on malaria vector transmission prior to the implementation of insecticide residual spraying strategy at Malanville.

II. METHODS

A. Study area

The study was carried out in the district of Malanville (11°52N, 3°23E) particularly in two villages (Guene and Madecali) in northern of Benin, from January to December 2016. The choice of this district is justified by its location in dry savannah area. In each village two collection points (A and B) were selected.

The city of Malanville is characterized by summer temperatures often exceeding 45 degrees Celsius with two seasons, one dry (December-May) and one rainy (June-November) (Figure 1). The drought is often severe, with a lot of sunshine and can last up to six months.

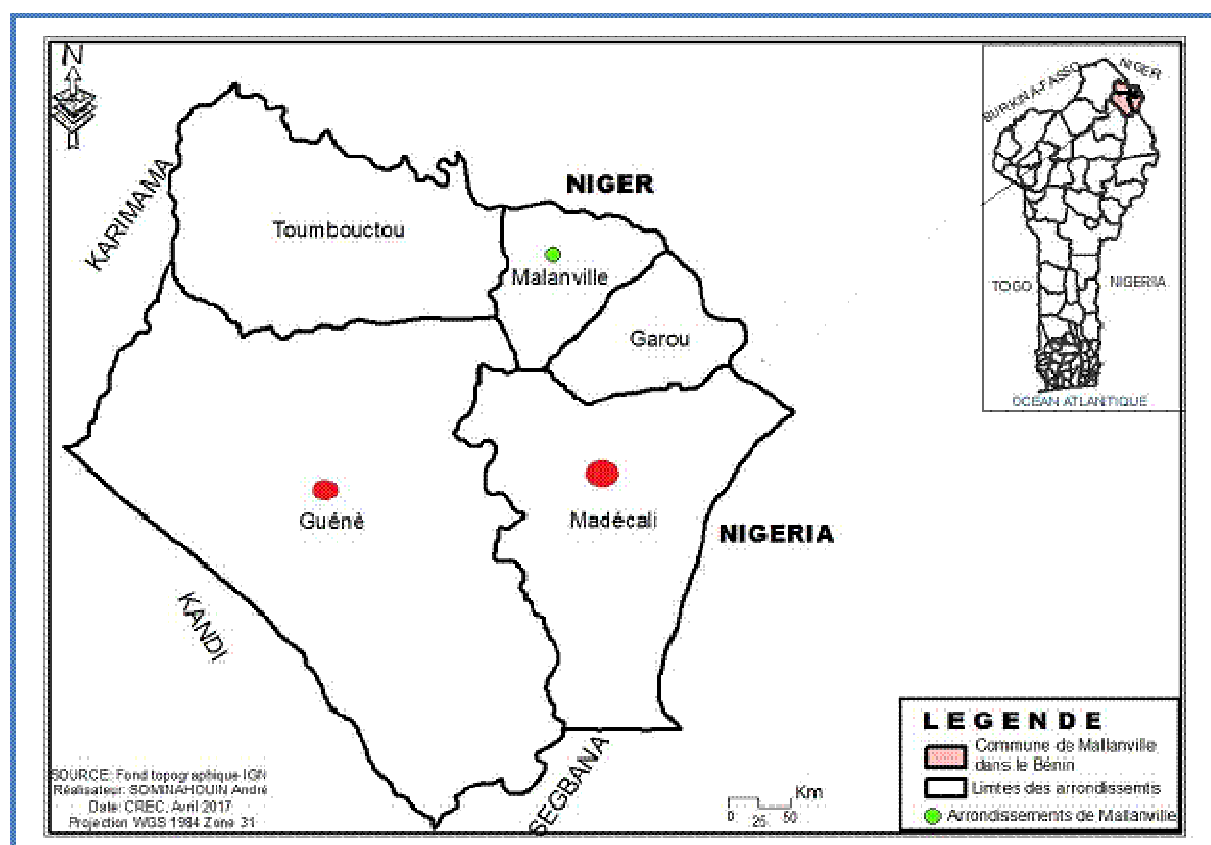


Figure 1. Map of Malanville showing the study sites

B. Field sampling methods

The seasonal trends of malaria transmission in the two villages were performed through collection of anopheles mosquitoes. Adult mosquitoes were collected using two sampling methods: (1) indoor and outdoor human landing catches (HLC) and (2) indoor pyrethrum spray catches (PSC). Four compounds were randomly selected for HLC and 10 additional compounds were chosen for PSC in each site. The same compounds were consistently used throughout the study with each sampling method.

HLC was conducted every month over two consecutive nights (8:00 PM to 6:00 AM). Two collectors were assigned to each HLC compound and they rotated between collection points within houses every two hours.

The PSCs were conducted the same day but from 7: 00 Am to 9: 00 AM where specimens sampled were mostly fed females resting indoor in the morning. PSCs method consisted by spraying Deltamethrin (Yotox®) for 30-45 seconds in the room. After 10 minutes, dead and immobilized mosquitoes were collected.

Mosquitoes collected by HLC were used to evaluate the human biting rate (HBR) and the sporozoite infection rate. Knocked-down mosquitoes of the *An. gambiae* complex collected by PSC were preserved for species identification at molecular level.

C. Laboratory processing of mosquitoes

* Species identification and laboratory analysis

Captured mosquitoes were identified using the Gillies key [4]. Female mosquitoes were grouped according to species, date and site and were stored dry in microtubes on silica gel. The sibling species of the *An. gambiae* complex were identified using the PCR technique of Scott et al. [5]. To search for the presence of *Plasmodium falciparum* circumsporozoite protein (CSP), heads and thoraces of the females *An. gambiae* s.l. collected by HLC were tested by ELISA using the method described by Wirtz et al. [6].

* Indicators of malaria parasite transmission and statistical analysis

The entomological indicators of malaria parasite transmission assessed in Malanville were:

- (1) the human biting rate (HBR), defined as the number of mosquitoes biting a person during a given time period (bites/person/time) (time being night, month or year);
- (2) the CSP rate, which is the proportion of mosquitoes found with *P. falciparum* CSP by ELISA over the total number of mosquitoes tested;
- (3) the entomological inoculation rate (EIR), which is the number of infectious bites per person per unit of time (infectious bites/person/time) and calculated as the product of HBR and CSP rate.

D. Ethical considerations

Ethical approval for this study was granted by the Ethical Committee of the Ministry of Health in Benin. Community leaders were briefed on the protocol and gave verbal consent before the study began. Written consent was obtained from all participating volunteers, who were vaccinated against yellow fever and provided with malaria preventive and curative treatments following the World Health Organization (WHO) protocol. In case of refusal permission will be sought to the next household.

III. RESULTS

A. Mosquito fauna composition

A total number of 21,474 mosquitoes were collected by HLC and 9,019 by PSC (Table 1). The majority of mosquitoes caught by HLC was *Culex spp* (79%). Of the remaining 21%; 94% were *Anopheles gambiae* s.l. and 0.7% were *An. pharoensis*, *Anopheles ziemanni*, and *An. funestus* all-inclusive.

Table 1: Classification of mosquitoes collected by human landing catches (HLC) and pyrethrum spray catches (PSC) in Malanville.

	Malanville			
	HLC		PSC	
	Site A	Site B	Site A	Site B
Total mosquitoes caught	10,718	10,756	4,473	4,546
Total <i>Culex</i> spp	8,532	8,483	4,013	4,090
Total <i>Anopheles</i> spp	2,063	2,156	400	389
<i>An. gambiae</i> s.l	2,012	2,105	353	332
<i>An. pharoensis</i>	15	18	22	28
<i>An. ziemanni</i>	35	33	25	29
<i>An. funestus</i>	1	0	0	0
Total <i>Aedes</i> spp	105	102	38	42
Total <i>Mansonia</i> spp	18	15	22	25

B. Species composition of *Anopheles gambiae* s.l.

Species identification showed that *Anopheles gambiae* (s.l.) samples were composed of two species; *An. gambiae arbiensis*.(2%) and *An. gambiae* s.s (98%) (Table 2)

Table 2: Species composition of *Anopheles gambiae* s.l.

Total tested	% <i>An. gambiae</i> s.s	% <i>An arabiensis</i>
360	98	2

C. Seasonal abundance and biting rates

The Human Landing Catches (HLC) results were used to estimate the seasonal Human Biting Rate (HBR). Figure 2 showed that the highest bites of *An. gambiae* was found in

August (335 bites/p/n) and the lowest in May which the driest month in this area. The average HBR was significantly higher during the rainy season (150 bites/p/n) than what was obtained during the dry season (13 bites/p/n) ($P < 0.05$).

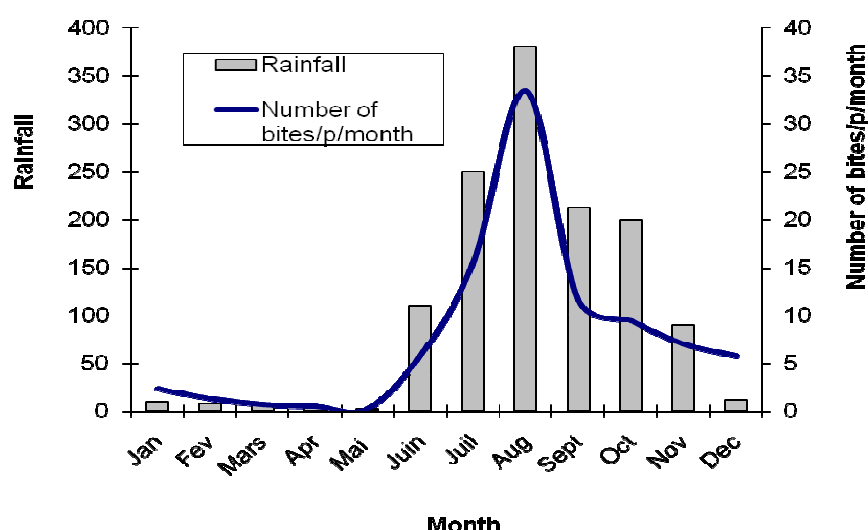


Figure 2. Seasonal variation in human biting rate of *An. gambiae* s.l. and rainfall in Malanville from January to December 2016.

D. CSPrate and EIR

P. falciparum was the main malaria parasite isolated from the *An. gambiae* complex in the the study area. Malaria transmission inMalanville was high during the rainy season (June–November) and low during the dry season (December–May), with at least two members of *An.*

gambiae complex, *An. arabiensis* and *An. gambiae* s.s transmitting *P. falciparum* (Figure 3).

The average EIRs was significantly higher during the rainy season (0.8 bi/p/n) than what was obtained during the dry season (0.1 bi/p/n) ($P < 0.05$). (Figure 3).

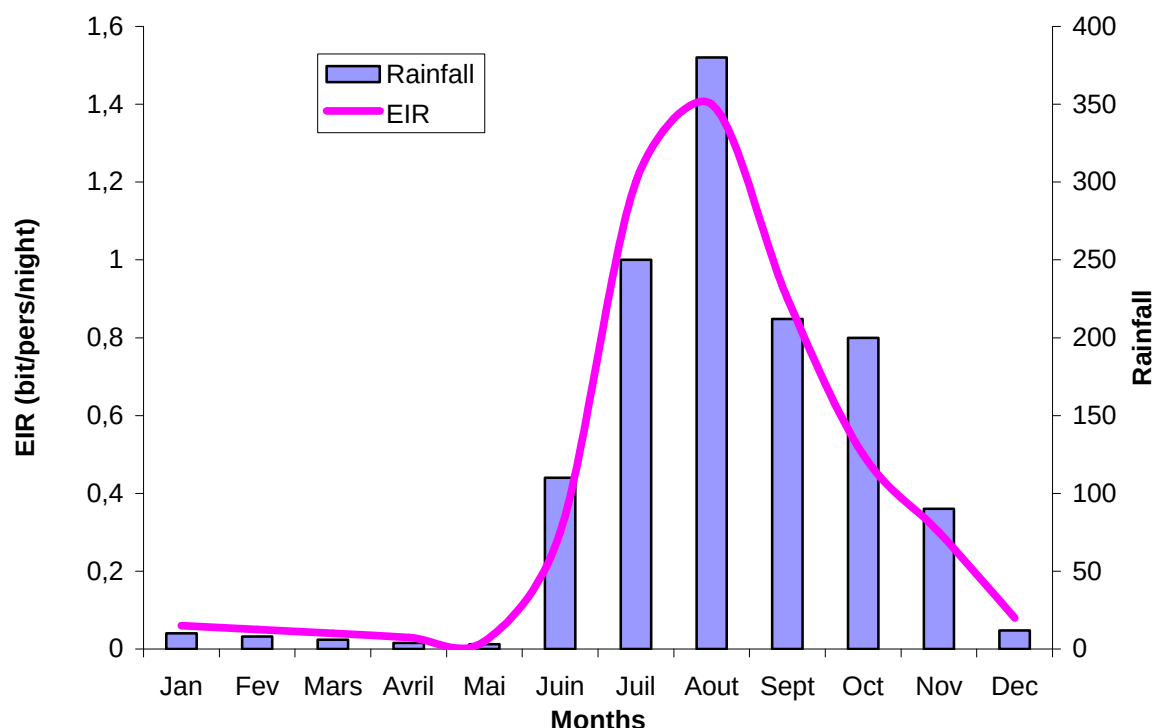


Figure 3. Entomological inoculation rate at Malanville from January to December 2016.

IV. DISCUSSION

The epidemiology of malaria is a complex interaction among host, vector and parasite factors that are specific to each location in which malaria occurs. The goal of this study carried out in Malanville in Northe-Easten of Benin was to have a baseline data on malaria vector transmission prior to the implementation of insecticide residual spraying strategy.

In fact, entomological survey conducted in many households show deferent species of anopheles responsible of malaria transmission. However, regardless of the collection area, *An. gambiae* s.l. remains the main malaria vector that ensures malaria transmission. This result confirms what was finding by Yadouleton et al [7] in northern Benin.

The poor urbanization of the city of Malanville in northern Eastern of Benin may explain the high populations of mosquitoes particularly *An. gambiae* found during our investigation. Recent studies have shown that poor urbanization in several African cities creates a suitable breeding sites for mosquitoes particularly *An. gambiae*, the main vector of malaria [8-11].

Our results show that anopheles density is higher in the rainy season than in the dry season and this confirms the result of the study conducted by Afrane *et al.* [12] in Ghana, Yadouléton *et al.* [7].

The increase number of *An. gambiae* bites recorded during the rainy season compared to the dry season can be explained by the existence of several puddles more important in the rainy season, probably induced by the lack of a good urbanization scheme for Malanville's city.

In other hand, although malaria transmission is low during the dry season, it could be explained by the presence of permanent pools and puddles maintained during watering of vegetable crops in the urban area of the city.

Moreover, this study shows an increase level of the entomological inoculation rate (EIR) during the rainy season. The increase level of EIR in malaria-endemic countries is not synonymous of higher incidence of malaria due to the infected bites saturation. Indeed, similar study conducted by Dossou-Yovo *et al.* [13], and Matthys *et al.* [14] in Côte d'Ivoire have shown that the rainy season increases the density of mosquito fauna without influencing the annual incidence of malaria. These authors conclude that the increase number of mosquitoes associated with irrigation do not necessarily lead to an increase level of malaria transmission.

The annual EIR (rainy and dry season) in Malanville is 162 bi/p/year in 2016. But in the past, Akogbeto *et al.* [15] in 1992, indicated a high annual EIR (245.78 bi/p/year) in the same area. This decrease of the EIR 24 years later could be explained by the widespread use of Long-Lasting Insecticidal Nets (LLINs) [16] as the main tool against mosquitoes bite. Indeed, vector control by widespread use of LLINs has shown that this strategy can reduce malaria morbidity and mortality in Africa [17-20].

V. CONCLUSION

The present study showed that malaria transmission is unimodal in the city of Malanville and the main malaria parasite, *P. falciparum* was primarily transmitted by *Anopheles gambiaes.s.* These findings will be useful for National Malaria Control Program authorities in the choice of vector control strategies to prevent malaria transmission at Malanville.

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