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Measure the dynamics of malaria transmission using entomological approaches at Natitingou, Northern-East of Benin

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Abstract

To evaluate the level of malaria transmission at Natitingou Northern-East of Benin, a cross sectional entomological study was carried out from April 2016 to March 2017 in urban and rural areas of this city. Adult mosquitoes were collected in both areas by Human Landing Catch and Indoor Pyrethrum Spray Catches (PSC). Entomological parameters like the human biting rate, the *Circunsporizoite protein* (CSP) rate and the Entomological Inoculation Rate (EIR) were evaluated. A total of 21,018 mosquitoes were collected where Anopheles spp which contributed to malaria transmission represented 17.09%. The highest bites of *An. gambiae s.l.* during the rainy season was found in August at urban (33.75bites/p/n) and rural (25.83 bites/p/n) but, there is no significant different between the average HBR of *An. gambiae s.l.* in urban area (11.41 bites/p/n) and in the rural area (8.21 bites/p/n) (P>0.05). Transmission was high during the rainy season (June to November) and low during the dry season (December to May) and was vehicle by *An. gambiae Colluzzi* (65%). and *An. arabiensis* (35%). The EIR was significantly higher in the dry season in urban area (0.125bi/p/n) than in rural area (0.021 bi/p/n) (P < 0.05). However, during the rainy season, there was no significant difference between the EIR from urban and rural areas (P > 0.05). These findings showed that malaria is permanent at Natitingou both in urban and in rural area and was vehicle by *An. Coluzzi* and *An. Arabiensis*. These results will be useful to implement a strategy against malaria in this city.

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Introduction

Agricultural productivity is a priority in much of sub-Saharan Africa, where more than 70% of people live in rural areas and rely on farming. However, in 216 million cases and 445,000 malaria caused deaths worldwide, and the African Region accounts for about 90% of the cases and deaths. Furthermore, 14 sub-Saharan African countries and India carried 80% of the global malaria burden (Barber *et al.*, 2017) and agricultural development can play a role in its transmission (Deressa *et al.*, 2004; Mutuku *et al.*, 2006; Ndenga *et al.*, 2006; Lindblade *et al.*, 2000; Minakawa *et al.*, 2004).

Indeed, poverty, food insecurity and malnutrition have become urban and rural issues in sub-Saharan Africa. While meeting these challenges in cities of sub-Saharan Africa is critical, it represents a serious issue of public health (Alemu A *et al.*, 2012; Yama Y *et al.*, 2016; Mathanga DP *et al.*, 2016., Lindblade *et al.*, 2000) **.** In order to meet food security and poverty alleviation needs of growing population in sub-Sahara Africa, peri-urban and urban agriculture is rapidly becoming a major economic activity in the cities.

In general, non-used spaces (marshland, road edges, beaches etc) are turned into gardens where vegetable and different kinds of flowers are cultivated. Certain towns like Bouaké in Ivory Coast have hectares of rice cultivations. At Natitingou, a city located in North-east of Benin, vegetable farming activity consist of belts of market gardens every where in and around the city, produce local and exotic vegetables (lettuce, green beans, carrots, cabbages, cucumbers, beetroot etc.) all year round, and adopt frequent manual watering of crops.

The activity is believed to be directly responsible for the creation of almost 1,000 jobs thereby addressing urban and rural demand for food and unemployment. However, vegetable farming practices at Natitingou in urban and rural areas create numerous trenches that retain rain and irrigation water. These stagnant bodies of water provide suitable breeding site for mosquitoes, particularly of *Anophele gambiae*, the main vector of malaria in Africa. The gardeners also dig wells that are used to water irrigation.

The wells are favorable breeding habitats places for *An. gambiae.* Further more, used containers at vegetable farming sites gather bodies of water and become ideal sites for egg-laying by the malaria-transmitting mosquitoes Moreover, couple with the rapid urbanization of this city with poor hygiene practices supported by lack of sanitation facilities and poor maintenance culture, Natitingou is offering a good condition for mosquitoes development particularly *An. gambiae*, the main vector of malaria in West Africa.

The present study was conducted in order to measure the dynamics of malaria transmission at in rural and urban areas at Natitingou, Northern-East of Benin using entomological approaches.

Material and methods

Study area

The study was carried out at Natitingou, located in North-East of Benin from March 2016 to April 2017 in urban and rural areas. Two villages were chosen separately in urban (Oubourga and Kantaborifa) and rural areas (Tigniti and de Yimporima) for mosquitoes collection (Figure. 1).

Field mosquito collection

Indoor collections of adult mosquitoes were carried out monthly for 12 months. Collections were organized in the four points chosen for mosquitoes collection. Adult mosquitoes were collected using two sampling methods.

First, indoor and outdoor Human Landing Catches (HLC) was performed monthly over two consecutive nights (8:00 PM to 6:00 AM), in 4 randomly selected compounds. Second, indoor Pyrethrum Spray Catches (PSC) in 4 other selected compounds; the same compounds in each sampling method were used throughout the study. Collectors gave prior informed consent and received anti-malaria prophylaxis and yellow fever immunization.

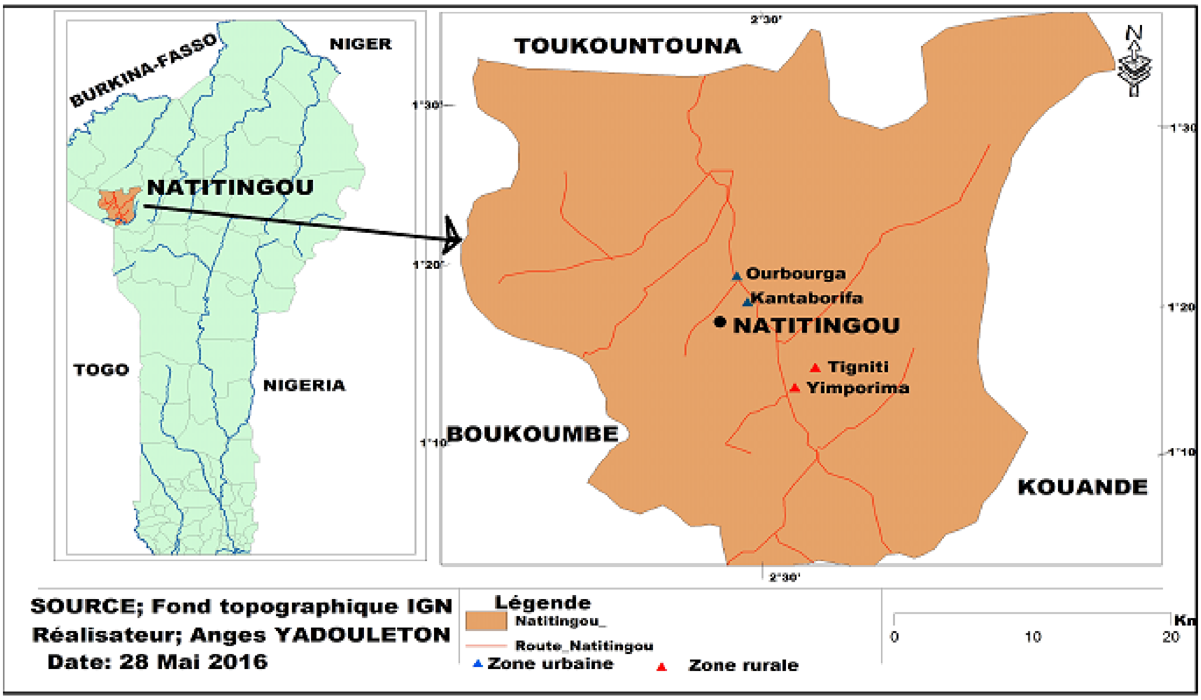

Fig. 1. Map of the study site.

They were organized in teams of two for each collection point and they were rotated between locations within houses every two hours. Mosquitoes from HLC were used to evaluate the sporozoite infection rate of each molecular form. The PSC was carried out monthly to establish the temporal dynamics of mosquito density and the molecular forms of *An. gambiae*.

Species identification and laboratory analysis

Identification of the anophelines was made using identification keys of Gillies and Meillon (1968). Female mosquitoes were grouped according to species, date, site and area and stored dry in micro tubes.

The sibling species of the *An. gambiae* complex was identified using the PCR technique of Scott *et al.* (1993). Samples from HLC were analyzed by Enzyme Linked Immunoabsorbent Assay (ELISA) to determine the presence of *P. falciparum* circumsporozoite antigens (PfCSP).

Indices of malaria parasite transmission and statistical analysis

The entomological indicators of malaria parasite transmission intensity at the sites were:

(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).

(2) The CSP rate is the proportion of mosquitoes found with *Plasmodium falciparum* CSP over the total number of mosquitoes tested.

(3) The Entomological Inoculation Rate (EIR), expressed as the number of infective bites of anopheline per person per unit of time (bi/p/t) and calculated as the product of the HBR by the CSP rate.

Data analysis

A chi square test was performed at the 5% significance level to compare the entomological outcomes within and between sites.

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 to the next household.

Results

Species composition and abundance.

A total of 21,018 mosquitoes were collected between April 2016 and March 2017. *Culex* Spp. was the dominant and represented 82.08% (Table 1). *Anopheles* spp which contributed to malaria transmission represented 17.09%.

The remaining (0.8%) were *Aedes spp* and *Mansonia spp* populations.

Table 1. Mosquitoes fauna at Natitingou collected from Human Landing Catches and Indoor Pyrethrum Spray Catches.

Species	Natitingou			
	Human Landing Catch		Capture par spray	
	Rural-area	Urban-area	Rural-area	Urban-area
Total mosquitoes caught	5.814	8.033	2.427	4.744
Total Culex Spp	4.372	6.343	2.125	4.412
Total Anopheles Spp	1.392	1.661	244	297
An. gambiae s.l	1350	1.578	213	232
An. Pharoensis	9	65	21	34
An. Ziemanni	32	61	10	31
An. Funestus	01	2	0	0
Total des *Aedes* spp	38	23	41	23
Total des *Masonia* spp	12	8	17	12

Seasonal abundance and biting rates

Results from our study showed that the highest bites of *An. gambiae s.l.* during the rainy season was found in August at urban (33.75 bites/p/n) and rural (25.83 bites/p/n) areas. Results from this study showed also that there is no significant different between the average of HBR of *An. gambiae* s.l. in urban area (11.41 bites/p/n) and in the rural area (8.21 bites/p/n) (P>0.05) (Figure. 2). During the dry season, the average of HBR from urban area (0.69) was significantly higher than what was obtained in the rural (0.25 bites/p/n) (P < 0.05) (Figure. 2). The human population living in urban area during the dry season received about two to three times higher bites of *An. gambiae s.l.* than those who lived in rural area. However, there is no significant difference between the HBRs during the rainy season in urban (10.65 bites/p/n) and in rural area (8.07 bites/p/n) (P > 0.05) (Table 2).

Table 2. Mean number of *An. gambiae* s.l. bites per person per night (Mean bi/p/n) during the seasons and annually, as determined by human landing Catches (HLC) at the study site.

Values	Dry season	Rainy season	Average_annual_ HBR
Mean bites/p/n*	0.69	10.65	11.41
Mean bites/p/n**	0.25	8.07	8.21
P value	0.035	0.212	0.195

*=Urban area

**=rural area.

Sporozoite rate and EIR

The main malaria parasite was *Plasmodium. falciparum* transmitted by *Anopheles gambiae* s.l. at Natitingou, the study site surveyed. Transmission was high during the rainy season (June to November) and low during the dry season

(December to May) (Figure. 2). At Natitingou, transmission occurred during the rainy season (June to November) with *An. gambiae Coluzzi* (65%). and *An. arabiensis* (35%) members of the complexe *An. gambiae s.l* transmitting *P. falciparum*. The EIRs were significantly higher in the dry season in urban area (0.125 bi/p/n) than in rural area (0.021 bi/p/n) (P < 0.05). However, during the rainy season, there was no significant difference between the EIRs from urban and rural areas (P > 0.05) (Table 3).

Table 3. Entomological inoculation rates (EIR) recorded at the study sites.

Values	Dry season	Rainy season	Average_annual_ EIR
Mean bites/p/n*	0.125	0.39	0.26
Mean bites/p/n**	0.021	0.27	0.18
P value	0.018	0.32	0.21

*=number of infective bites per person per night in urban area

**=number of infective bites per person per night in rural area.

Discussion

The cross sectional entomological study carried out from April 2016 to March 2017 in urban and rural areas at Natitingou, Northen-East of Benin showed that malaria transmission is permanent through the year in the city. Regardless the areas, transmission was high during the rainy season and low during the dry season and was vehicle by *An. gambiae Coluzzi* and *An. arabiensis*. This finding showed that apart from *An. gambiae* which is the major vector of malaria transmission in West Africa (Quinones *et al.*, 2015; Mugwagwa *et al.*, 2015) other species of *An. gambiae* complex such *An. arabiensis* should also be considered as a secondary vector of malaria in this part at Natitingou. This result confirmed what were found by (Yadouléton *et al.*, 2010) in northen-West of Benin.

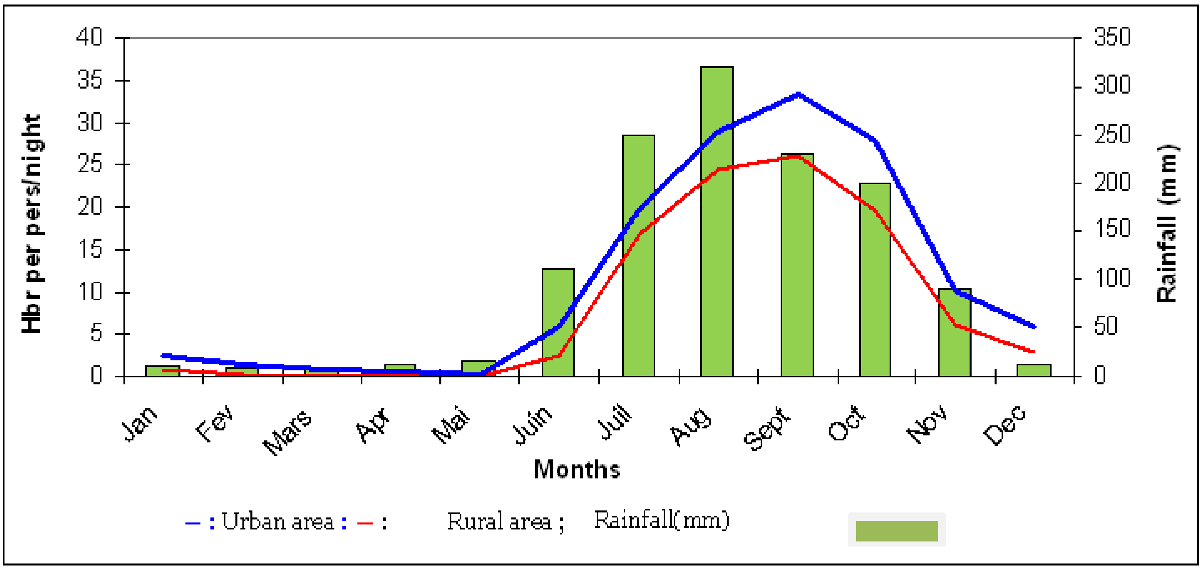

Fig. 2. Seasonal Human bite rate Number at Natitingou from April 2016 to March 2017.

Moreover, our results showed that malaria is permanent during the year both in urban or rural areas. In fact, the presence of mosquitoes bites and sporizoite in urban and in rural areas confirmed that malaria parasite transmission was permanent during the year and was reinforced by the presence of mosquitoes breeding sites in the two study areas.

This can be explained by the poor urbanization in many cities in Africa which contributes to the existence of mosquitoes breeding sites through the year (Phillips, 1993). Also, the human activities in urban and rural areas increase the level of malaria transmission. Indeed, vegetable farming activities both in urban and rural areas create numerous trenches that retain rain and irrigation water. These stagnant bodies of water provide suitable breeding sites for mosquitoes, particularly of *Anophele gambiae*, the main vector of malaria in Africa. The gardeners also dig wells that are used to water irrigation. The wells are favorable breeding habitats places for An. *gambiae*.

The present study showed that malaria transmission is permanent in the city of Natitingou and the main malaria parasite, *Plasmodium falciparum* was vehicle by *An. gambiae Coluzzi* and *An. arabiensis*. These findings will be very useful for National Malaria Control Program authorities in the choice of the method to fight against malaria in this city.

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