



Spatial distribution of *Aedes aegypti* (Diptera: Culicidae), dengue virus vector, in Lomé, Togo

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Abstract

Mosquitoes are a major health concern due to their nuisance and the pathogens they transmit. Mosquito vector control requires knowledge of their habitats. This study aimed at presenting the results of a survey in the capital city of Lomé to assess for the first time the spatial distribution of the dengue vector *Aedes aegypti*. Between February and April 2020, which is the dry season, immature stages of *Aedes aegypti* were collected within habitations in 19 neighborhoods across Lomé, using ovitraps. The geographical coordinates of each site were taken. The sites were visited every five days for larvae collection. Collected larvae were then sorted, identified, counted, and were reared to adulthood. Pictures of potential habits were also taken. Out of 10,877 mosquito larvae collected, 9,971 (91.7%) were *Aedes aegypti*, 568 (5.2%) were *Culex* sp, and 338 (3.1%) were *Anopheles* sp. *Aedes aegypti* was the dominant species in all these neighborhoods with the highest numbers recorded at DOUMASSESE (1112), CAMPUS UL (860), and KAGOME (821) while the lowest were recorded at DJIDJOLE (182), ATTIEGOU KLOKLOVICOPE (209), and TOKOIN N'TIFAF (320). Analyses revealed that *Aedes aegypti* population increases with the altitude and reaches a peak before decreasing. Pictures of habitats showed that they mostly result from human activities. This study indicates the presence and distribution of *Aedes aegypti* mosquito in urban areas in Lomé. The proliferation of *Aedes aegypti* in urban areas, close to humans due to favorable conditions constitutes a potential risk of dengue virus transmission. The spread of this mosquito could be linked to the unhealthy environment and human activities.

Keywords: distribution, *Aedes aegypti*, habitats, dengue, Lomé, Togo

1. Introduction

Mosquitoes are a major public-health issue. They are involved in the transmission of several pathogens that cause diseases such as malaria, dengue fever, chikungunya, filariasis, encephalitis, rift valley fever, yellow fever, Zika fever [1]. Arboviruses such as dengue, transmitted by *Aedes* mosquitoes is an emerging concern worldwide, which exacerbates the overall risk and burden of disease in the world [2]. The World Health Organization (WHO) estimates that 50–100 million new dengue infections occur each year and that almost half the world's population lives in countries where dengue is endemic [3]. A study published in 2012 estimated that 3.9 billion people are at risk of dengue infection, with a risk of infection existing in 129 countries [4]. Obviously, these estimates will increase in the coming years if specific and suitable strategies are not designed to address the problem in affected countries. A systematic review by Simo *et al.* [5] reported that seroprevalence against dengue virus was around 18% in sub-Saharan Africa. To date, no treatment is known for dengue fever [2, 6, 8]. In general, the disease develops in synchrony with the spread of its vector, *Aedes aegypti*. There is a higher risk of potential spread of viral infections, especially in urban areas. In the absence of treatment or vaccination, prevention through vector targeting is the optimal approach to the treatment of the disease [2, 9, 10]. According to Scott and Morrison [11], reduction of vector populations is currently the only way to prevent dengue because there is no commercially available vaccine or clinical cure; and, it relies heavily on vector surveillance to detect the presence or absence of *Ae. Aegypti*. Addressing the issue of dengue vector proliferation requires knowledge of the vector's

habitats and its distribution for efficient geolocation. In general, *Ae. aegypti* is known to be highly adapted to the domestic environment; its abundance is therefore positively correlated with increasing urbanization [12].

In Togo, there are few information on dengue infection. Recently, a paper by Bushwal *et al.* [13] on *Aedes*-borne disease occurrence in West Africa did not mention Togo because of lack of data, whereas neighboring countries like Ghana and Burkina Faso were mentioned in terms of dengue prevalence and dengue vector presence. In addition, data reflecting the presence and the spatial distribution of dengue fever vector *Ae. aegypti* are few. The only available data on the distribution of mosquitoes of the genus *Aedes* in Togo are those of Ahadji-Dabla [14] and Thabet *et al.* [15]. The lack of data on the potential distribution of *Ae. aegypti* could impede the effective monitoring and control of the vector. In this context, the present study aims to explore the spatial distribution of *Ae. aegypti*, vector of dengue virus transmission, in Lomé, Togo.

2. Materials and Methods

2.1. Study sites

The study was conducted in Lomé the capital city of Togo, located within the prefecture of Gulf. Lomé comprises of seven communes and belongs to ecological zone V (Figure 1). Nineteen neighborhoods were covered by the study (see Table 1 for the geographic coordinates and latitudes). The geographic coordinates of each collection site were recorded using GPS device (portable global positioning Garmin etrex 10) and mapped using QGIS 2.18.28. All collection were done in urban areas except BAGUIDA, which is a peri-urban area characterized by the production of vegetables

along the coast. Lomé is characterized by a humid tropical climate with two dry seasons (December-March and August-September) and two rainy seasons (April-July and October-November). The average temperature is 28°C with an annual rainfall of about 1000 mm.

2.2. Sampling of mosquito larvae

Ae. aegypti eggs and larvae were collected by placing ovitraps within habitations in the 19 randomly selected neighborhoods. Consent was obtained from heads of households before placing the traps. Sample collections were done during the dry season, February through March 2020 and stopped early April which coincided with the first rain. Ovitraps consisted of 0.5-3 liters black plastic cups and small buckets half-filled with water. Habitations were visited every 5 days for mosquito larvae and eggs collection; the water in the ovitraps was renewed periodically. Each sample was labeled with the place and date of collection and brought to the insectary of the Laboratory of Ecology and of Ecotoxicology (LaEE/FDS/UL) for rearing. Larvae were sorted, identified according to Edwards [16] and Hopkins [17], and counted. Rearing conditions were T= 26±2°C and RH= 85±5%.

2.3. Data Analysis

Data were entered and percentages were calculated using Excel office professional version 2016. A quadratic regression was used to test a possible correlation between the distributions of *Ae. Aegypti*, geographic coordinates and altitude with *Ae. aegypti* as the response variable and Altitude, Longitude, and Latitude as the predictor variables. R programming software package was used for this analysis. Two-proportion Z-test was performed in R to compare the highest proportion of *Ae. aegypti* at a given neighborhood with others.

3. Results

A total of 10,877 mosquitoes larvae were collected of which 9,971 (91.7%) were *Ae. aegypti*, 338 (3.1%) *Anopheles* sp, and 568 (5.2%) were *Culex* sp. The proportion of *Ae. aegypti* was significantly higher than those of *Culex* sp and *Anopheles* sp (p<0.00001; Table 2). Out of the nineteen (19) ovitraps, mosquitoes were found and collected from eighteen (18). Regarding *Ae. aegypti*, seventeen ovitraps were positive. Figure 1 shows the spatial distribution of *Ae. Aegypti* in Lomé. Furthermore, *Ae. aegypti* was dominant at DOUMASSESE (1,112), CAMPUS UL (860), and KAGOME (821); and less abundant at DJIDJOLE (182), ATTIEGOU KLOKLOVICOPE (209), and TOKOIN N'TIFAFA (320). *Aedes aegypti* was found in all neighborhoods except ABOVE and AMADAHOME (see

Table 3). Overall, the ovitrap of AMADAHOME was negative throughout the period of collection, no mosquito was collected there. This study targeted exclusively *Ae. aegypti*; and, a comparative analysis showed a higher proportion at DOUMASSESE, with a total of 1,112 specimens, than at CAMPUS UL, with a total of 860 specimens (df=1, CI= [0.017-0.034], p<0.0001). However, the proportion of *Ae. aegypti* collected at CAMPUS UL was not different from that of KAGOME (p=0.33).

Ae. aegypti population keeps increasing until an altitude of around 27 meters before it starts decreasing. That is a specificity of a quadratic relationship, even though the p-value (i.e. p=0.055) is on the borderline (see Figure 2).

Our checks in the field showed that *Aedes* larvae breed in all kind of flower pots exhibited by landscape/garden florist, open pits such as those in car-wash bays, or water-closet, used tires, plastic pots, and cans, trash can and poly-tank lids, natural tree-holes (Figure 3).

Table 1: Geographic coordinates of the study areas in Lomé, Togo.

Neighborhood	Municipality	Longitude	Latitude	Altitude (m)
AMADAHOME	AFLAO GAKLI	1.23	6.15	33
AVEDJI		1.17	6.2	39
DJIDJOLE		1.19	6.18	46
CASSABLANCA		1.2	6.15	32
GBADAGO	AMOUTIVE	1.21	6.14	21
ABOVE		1.23	6.15	15
Bè-KLIKAME		1.2	6.17	27
DOUMASSESE	BE OUEST	1.21	6.16	26
CAMPUS UL		1.21	6.17	30
NUKAFU	BE CENTRE	1.23	6.16	34
FOREVER		1.23	6.15	23
TOKOIN N'TIFAFA		1.23	6.15	23
ATTIEGOU KLOKLOVICOPE	BE EST	1.26	6.19	6
Bè-KPOTA ANFAME		1.27	6.16	20
Bè-LAGUNE		1.25	6.15	9
AKODESSEWA AVELIME		1.26	6.14	13
BAGUIDA	BAGUIDA	1.31	6.16	1
KAGOME		1.3	6.17	17
ADAMAVO		1.31	6.17	23

Table 2: Proportion of each mosquito species collected

Species	Number of mosquitos	Proportion
<i>Aedes aegypti</i>	9,971	91.67 ^a
<i>Culex</i> sp	568	5.22 ^b
<i>Anopheles</i> sp	338	3.11 ^c
Total	10,877	100

Letters indicate high statistical significance between species (p<0.001)

Table 3: Distribution of mosquitoes in the nineteen neighborhoods across Lomé, Togo.

Neighborhoods	<i>Aedes aegypti</i>	%Aa	<i>Anopheles</i> sp	%An	<i>Culex</i> sp	%Cx	%Mosquitoes
ABOVE	0	0	0	0	55	9.68	0.51
ADAMAVO	727	7.29	0	0	59	10.39	7.23
AKODESSEWA AVELIME	492	4.93	18	5.33	0	0	4.69
AMADAHOME	0	0	0	0	0	0	0.00
ATTIEGOU KLOKLOVICOPE	209	2.10	0	0	0	0	1.92
AVÉDJI	456	4.57	15	4.44	55	9.68	4.84
BAGUIDA	395	3.96	187	55.33	105	18.49	6.32
BÈ-LAGUNE	558	5.60	0	0	0	0	5.13
BÈ-KLIKAME	696	6.98	0	0	0	0	6.40

BÈ-KPOTA ANFAME	538	5.40	0	0	0	0	4.95
CAMPUS UL	860	8.63	0	0	0	0	7.91
CASSABLANCA	650	6.52	0	0	0	0	5.98
DJIDJOLE	182	1.83	10	2.96	104	18.31	2.72
DOUMASSESE	1,112	11.15	96	28.40	78	13.73	11.82
FOREVER	767	7.69	0	0	0	0	7.05
GBADAGO	633	6.35	0	0	112	19.72	6.85
KAGOME	821	8.23	12	3.55	0	0	7.66
NUKAFU	555	5.57	0	0	0	0	5.10
TOKOIN N'TIFAFA	320	3.21	0	0	0	0	2.94
Total	9,971	100	338	100	568	100	100

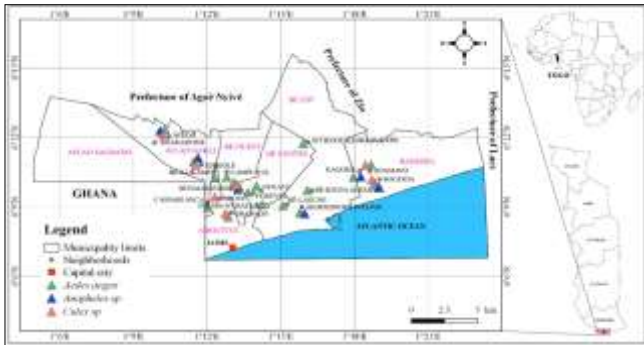


Fig 1: Map of the spatial distribution of *Aedes aegypti* in Lomé, Togo

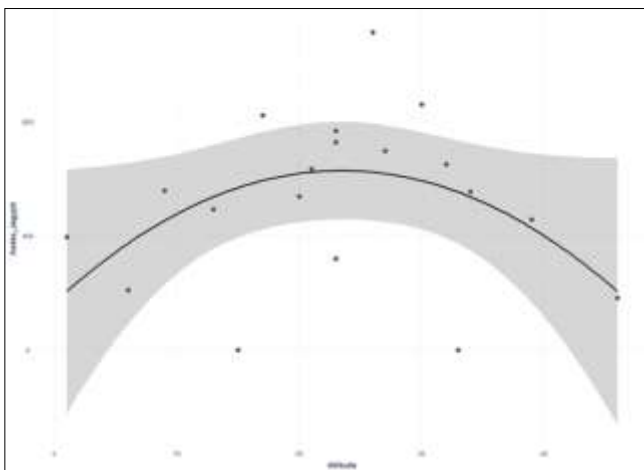


Fig 2: Quadratic variation of the number of *Aedes aegypti* during the study period



Fig 3: Types of breeding sites identified: A flower pots, B water-closet pit, C and D used tires; E used cans, F plastic pot on a garbage dump, G trash can lid, H abandoned poly-tank lids, I natural tree-hole.

4. Discussion

This study focuses on the spatial distribution of *Ae. aegypti*, vector of the dengue virus across Lomé. The collection period – dry season, was characterized by a higher number of *Ae. aegypti* than *Anopheles* and *Culex*. This could be explained by the type of trap used. In fact, *Ae. aegypti* is a container-inhabiting mosquito; hence, ovitraps are artificial well-fitted breeding sites to this mosquito. The presence of *Culex* at ABOVE could only be an indicator of a polluted environment. *Aedes aegypti* may even be a good marker of the ecology of urbanization [18]. This mosquito is commonly encountered in rapidly developing urban areas that suffer from an inadequate sanitation [19]. According to Zahouli *et al.* [20], urban areas have higher capacity to offer *Aedes* breeding sites and larvae than suburban and rural areas. The same authors stated that compared with rural areas, urban and suburban areas are characterized by high numbers of *Aedes* mosquito breeding sites; mostly it is artificial containers such as tires and discarded containers that are inhabited by the larvae of *Ae. aegypti*. Figure 3 also reveals the same profile. Five to ten years ago, a rapid urbanization was initiated in Lomé with the construction of buildings and rehabilitation of roads, starting from downtown to the outskirts. But, the urbanization process was poorly supported with inadequate draining system. In addition, mismanagement of household waste due to the lack of rigorous policy or lack of sanitation facilities in some areas of the city lead to the proliferation of artificial *Aedes* breeding sites. Besides, according to Gama *et al.* [21] there is a positive correlation between the elevation of the area and the density of *Ae. aegypti*; our study revealed a borderline p-value but in general, the density of the vector’s population increases with altitude. Lomé is almost a flat city with a few slopes therefore, altitudes between neighborhoods do not vary a lot. No mosquito was collected at AMADAHOME; this may be due to the non-recognition of the ovitrap and/or the hygiene of the house in which the trap nest was placed. The collection period could also be a contributing factor because after the first rain, our investigations revealed that there were actually *Ae. aegypti* mosquitoes at AMADAHOME. The high number of *Ae. aegypti* at DOUMASSESE, CAMPUS UL, and KAGOME could be due to human population density (i.e. human activities) and environmental factors (lack of or poor water-draining system, sanitation, and existence of garbage dumps etc.). Mellander *et al.* [22] and Ducheyne *et al.* [23] reported that human population influences the availability of dengue virus vectors. Simard *et al.* [24] and Koumba *et al.* [25] showed that the proliferation of *Aedes* mosquitoes, vectors of diseases, could be linked to the unhealthy environment and human activities that create and maintain mosquito breeding sites. Therefore, areas with high population density seem to record more dengue vectors and/or pathogens; this situation

could probably lead to an epidemic. Finally, we can hypothesize that the strong anthropophilic of *Ae. aegypti* combined with its ability to colonize urban areas could represent a high risk of introduction and transmission of dengue virus, which is evidenced by the concerns of public health services.

5. Conclusion

This study which is the first to have ever been conducted in Lomé showed that *Ae. aegypti* was the most abundant species and also the most distributed in Lomé. This distribution is more or less influenced by the altitude though our analysis did not show significant difference. Also, urbanization and mostly poor sanitation play a key role in the proliferation and distribution of the dengue virus vector *Ae. aegypti*. It is important to conduct an entomological transmission study of the dengue virus and the risks of arbovirus transmission within human population across the city.

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