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Breeding Site Characteristics of Mosquito in Ouagadougou, Burkina Faso

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Abstract

Urban areas deal with the emergence or resurgence of transmissible and non-transmissible diseases, linked in particular to urban lifestyle and sanitation issues. Human practices create or maintain conditions that favour mosquitoes' breeding. This study investigates mosquito breeding sites characteristics in Ouagadougou, from September to November 2020. Mosquito larvae were sampled across three districts in the city, chosen based on socio-demographic and urbanization levels. The larval collection from natural breeding sites using the ladle technique and larvae transferred to can. For artificial sites, the larvae were transferred directly into can Larvae were collected from 83 breeding sites, predominantly artificial: 39% in plastic containers, 23% in clay containers, and 13% in metal, while natural sites like puddles accounted for only 25%. A total of 8352 mosquitoes were identified as six species: *Aedes aegypti*, *Aedes albopictus*, *Culex quinquefasciatus*, *Anopheles gambiae s.l.*, *Anopheles funestus*, and *Mansonia africana. Ae. aegypti* was the most prevalent, found across all breeding site types, whereas *Culex quinquefasciatus* and *Anopheles gambiae* were mainly in natural sites. Physico-chemical analysis of the breeding sites revealed that conductivity and turbidity were consistent across breeding sites. The highest median pH values were observed in ceramic and metal containers. Water temperature showed minimal variation. The presence of *Anopheles gambiae* and *Culex quinquefasciatus* correlated with higher water temperature, turbidity, and conductivity. *Anopheles funestus* preferred high pH environments. Conversely, *Aedes aegypti*, *Aedes albopictus*, and *Mansonia africana* were less influenced by these parameters. The findings underscore the need for community involvement in water and waste management to control mosquito populations, especially targeting the *Aedes aegypti* species. Raising awareness among locals about proper water storage and disposal practices is crucial for effective vector control.

Keywords

Breeding Site, Mosquito, Urbanization, Household Water, Burkina Faso

1. Introduction

Most large urban areas in the intertropical zone have high population growth rates. In addition, rural populations are increasingly migrating to the cities to meet better living conditions. We are thus witnessing the emergence of working-class neighborhoods, non-urbanized outskirts, or the creation of slums in which sanitation infrastructure is deficient or even absent [1]-[3]. This has significant repercussions on the hygiene and health of populations [4]. Indeed, this results in the development of sewage collection which constitutes breeding grounds for disease-carrying mosquitoes [5]-[7]. These urban areas will therefore have to deal with the emergence or resurgence of certain transmissible and non-transmissible diseases, linked in particular to the urban lifestyle [8]. Like most African cities, Burkina Faso's towns have the same characteristics [9]. Indeed, the urban bangs of Burkina Faso's cities are dominated by vast areas of settlement described as illegal, spontaneous, informal, or, more commonly, "non-housed", which are at once considered part of the city but present a habitat close to rural habitat [10]. In addition, these peripheral areas, most often built on the bangs of the formal and legal urbanization process, are not counted as urban areas but are generally home to the majority of urban populations [11]. These populations lead a lifestyle that straddles the gap between their village of origin and the city, taking advantage of the informal nature of their area to carry out activities that are forbidden in urban environments, notably arable farming, gardening, and livestock breeding [10]. This lifestyle creates favorable habitats for the development of mosquitoes [12]. Indeed, it is common to find in this city collections of stagnant wastewater, generated and maintained by human practices of water use, among other things badly cleaned gutters, open catch basins or simply closed by a sheet of metal [13] [14]. These stationary wastewater collections are the main source of mosquitoes that carry several pathogens, thus constituting a major public health problem [15]. Some species of mosquitoes have adapted to urban environments and preferentially lay their eggs in wastewater [3] [16]. This makes vector control ineffective despite the efforts of various control programs. For more than a decade, Burkina Faso has been subject to Dengue epidemics, especially in its capital [8] [17] and recent studies have shown that malaria in urban areas is a reality [13] [14]. Knowledge of the ecological characteristics of mosquito breeding sites in such a context would be a key element in the implementation of effective vector-borne disease control strategies and measures. This study aims to characterize mosquito breeding sites in the city of Ouagadougou, to improve strategies for the control and prevention of these infections.

2. Materials and Methods

2.1. Study Site

Our study was conducted from September to November 2020 in the city of Ouagadougou, Burkina Faso. It is located in the center of the country between 12˚21'58" North and 1˚31'05" West. The city extends into the Nakanbe basin and belongs to the north Soudanian zone. It harbors many rainfed reservoirs and diverse channels, most often poorly maintained which lead water to these reservoirs. These lotic water bodies promote the proliferation of mosquitoes. In addition, the appearance of slums, non-urbanized peripheral areas, and shanty towns in which sanitation infrastructures are deficient or even absent increased mosquito development. The city has a tropical savannah climate with two seasons, a rainy season from June to October and a dry season between November and May. Rainfall ranges from 750 to 900 mm per year. The average annual temperature is 33˚C. Three localities in the city were chosen for the collection of mosquito larvae, taking into account their socio-demographic characteristics and their geographical location. These were the districts of Dapoya, Zongo, and Yamtenga. Dapoya is one of Ouagadougou's formerly urbanized districts. It's a densely populated district in the center of Ouagadougou. It is characterized by a large number of households made up of modern houses built close together. Yamtenga is located to the east of the city. It is one of the new outlying districts. Yamtenga is characterized by dispersed houses, mostly built of banco. The Zongo district is a former peripheral neighborhood located to the west of the city. It is characterized by condensed houses made of mixed construction materials (Figure 1).

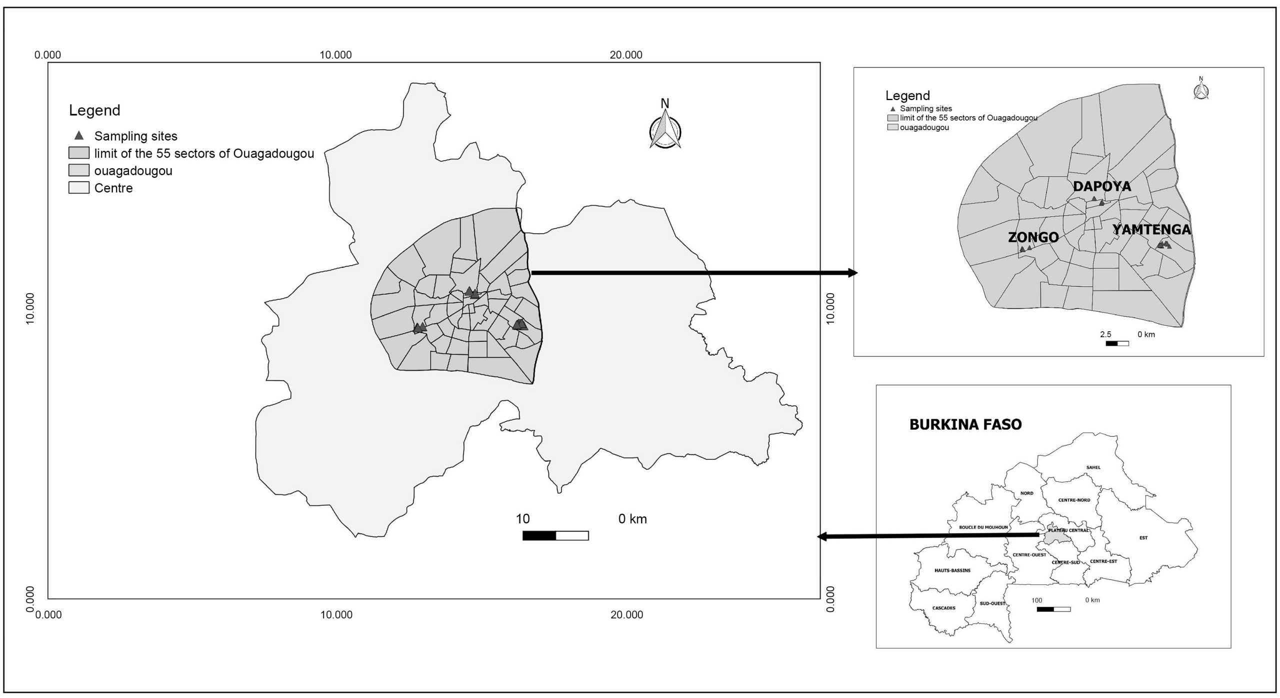

Figure 1. Map of Ouagadougou showing the sampling site.

2.2. Breeding Habitat Characterization

To characterize the breeding habitat, a collection sheet was drawn up. It includes the nature of the breeding habitat, its position, its physicochemical parameters, and also its climatic data. The position of the habitat was defined according to whether it was located inside or outside a human habitat. The geographical coordinates of each habitat were taken by GPS. The physicochemical parameters of the habitat were measured in the field using a multi-parameter before the larvae were collected.

2.3. Mosquito Larvae Sampling and Identification

2.3.1. Mosquito Larvae Field Sampling

Larvae were collected inside the concessions, particularly in artificial breeding sites (tyres, canaries, etc.) and outside in natural breeding sites (puddles, temporary pools, etc.) scattered around the various study sites. A distance of thirty (30) metres was maintained between the natural breeding sites. All breeding sites were surveyed for the presence of mosquito larvae. If larvae were present in the natural breeding sites, approximately 500 ml of water containing larvae was collected using a ladle and filtered through a 60 µm sieve. The larvae retained were transferred, using a funnel, into containers on which we placed labels bearing the type of site, the site number, the locality, the name of the collector and the date of collection. For sites consisting of small containers (generally artificial breeding sites where there is not much water), the larvae were transferred directly into the boxes. The samples were then taken back to the laboratory for sorting and rearing. A consent form is read and signed beforehand by the head of the family or by his or her guarantor if he or she agrees to the collections (for breeding sites located inside concessions).

2.3.2. Treatment and Identification of Larvae in the Laboratory

Once in the laboratory, the larvae were first reared to adulthood for better identification. The adult mosquitoes emerging from the larvae were then put to sleep in a freezer, identified, and preserved in tubes containing a desiccant (1.5 mL Eppendorf tubes for small numbers and 15 mL Falcone tubes for large numbers of individuals). Mosquitoes were identified using the morphological identification keys of Gillies and De Meillon (1968); Gillies and Coetzee (1987); and Huang (2004).

2.4. Statistic Analysis

The data collected in the field were entered by Excel 2013 software. Statistical tests and graphs were performed by using the software "R" version R-4.1.1. Boxplots were used to visualize variations in physico-chemical parameters in the gites. The Kruskal-Wallis test was used to compare the mosquito populations in the different sites and habitat types with a significance level of 5%. We produced boxplots to show the variations in physicochemical parameters depending on the type of breeding site. An RDA was also performed to assess the effect of physico-chemical parameters on the collected mosquito populations by combining physicochemical variables with biological data.

3. Results

3.1. Typologies of Breeding Sites

A total of 83 positive larval sites were encountered during our study. These **breeding sites** included artificial **breeding sites** consisting of old abandoned objects (watering cans, motorcycle helmets, cradles, buckets, car tires, canaries, metal, and plastic cans) and natural **breeding sites** (puddles and temporary pools) (Figure 2 and Figure 3).

Figure 2. Artificial breeding sites ((a) & (b): metal box; (c), (d), (e), (f) & (h): plastic box, (g): clay).

Figure 3. Natural breeding sites ((a) & (b): ponds; (c) & (d): puddle).

3.2. Categories and Nature of the of Breeding Sites

The different **breeding sites** were classified into artificial and natural **breeding sites**. The majority of the **breeding sites** studied were artificial (n = 62; 75%). These habitats were dominated by plastic materials (n = 32; 39%), followed by ceramic materials (n = 19; 23%). The **breeding sites** composed of metallic materials were less represented (n = 11; 13%). Natural habitats accounted for 25% (n = 21) and were dominated by the puddle. The temporary ponds were 03 in number. The majority of these **breeding sites** were found in Zongo (n = 34; 41%) followed by Yamtenga (n = 23; 34%) and Dapoya (21; 25%). In terms of diversity, Yamtenga brought together the greatest number of types of **breeding sites**. Table 1 summarizes the categories and types of larval **breeding sites** encountered.

Table 1. The abundance of breeding sites according to the categories, nature, and locality.

Types of breeding sites	Dapoya (n = 21)	Yamtenga (n = 23)	Zongo (n = 34)
Watering can	1	0	0
Metal box	1	1	5
Motorbike helmet	0	1	0
Metal dish	1	0	1
Metal bucket	0	0	1
Total of metal breeding sites (n = 11)			
Plastic dish	0	1	0
Battery	0	0	1
Cradle	0	1	0
Can	1	1	1
Plastic box	0	1	0
Bouillard	1	1	0
Tires	9	6	3
Plastic bucket	1	0	3
Total of plastic breeding sites (n = 32)			
Ceramics	3	5	11
Total of ceramic breeding sites (n = 19)			
Duck basins	0	0	1
Puddle	3	8	7
Ponds	0	2	0
Total of natural breeding sites (n = 21)			

3.3. Breeding Sites Physicochemical Parameters Characterization

In general, there is a significant difference between the values of physicochemical parameters according to the types of sites. Thus, the median value of pH is higher in ceramic containers and lower in plastic containers. The median water temperature value is higher in puddles and lower in ceramic containers. As for conductivity and turbidity, the median values are higher in the puddles and lower in the ceramic containers.

In general, there is a significant difference between the values of the physicochemical parameters depending on the type of site. For example, the median pH value was higher in ceramic containers and lower in plastic containers (0.019). The median water temperature was higher in the ponds and lower in the ceramic containers (p = 0.023). As for conductivity and turbidity, the median values were higher in the puddles and lower in the ceramic containers (0.019) (**Figure 4**).

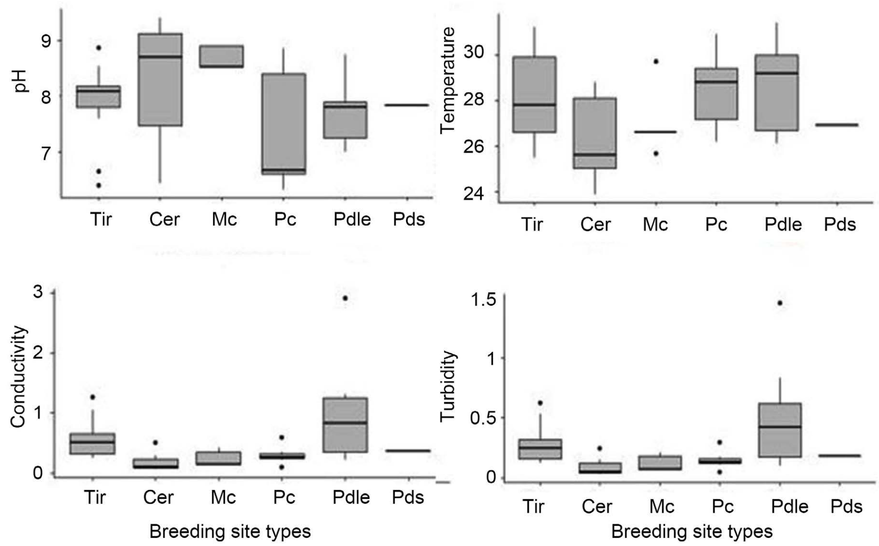

Figure 4. Variation of physicochemical parameters according to the nature of the deposits. Tir: Tires; Cer: Ceramics; MC: Metal Conteners; PC: Plastics Conteners; Pdle: Puddle; Pds: Ponds.

3.4. Mosquito Population Composition According to the Type and Category of Breeding Sites

A total of 8352 mosquitoes belonging to four genera and 06 species were collected from these different localities. The genus *Aedes* was the most dominant with a population of 5967 specimens. It is represented by 02 species namely *Aedes aegypti* and *Aedes albopictus*. Followed by the genus *Culex* represented by the species *Culex quinquefasciatus* with a population of 1373 specimens; the species *Anopheles gambiae* and *Anopheles funestus* are the species representing the genus *Anopheles* with 1009 individuals. The genus *Mansonia* is represented by the species *Mansonia africana* with only 03 specimens. The majority of larvae were collected in artificial **breeding sites** (75%) and only 25% in natural **breeding sites** (**Table 2**).

Table 2. Abundance and diversity of mosquitoes according to the Category and the type of breeding sites.

Type of breeding sites	*Ae. aegypti*	*Ae. albopictus*	*An. gambiae*	*An. funestus*	*Cx. quinquefasciatus*	*M. africana*
Watering can	19	22	0	0	4	0
Metal box	372	0	10	0	0	0
Motorbike helmet	78	0	0	0	0	0
Aliminum dish	30	0	0	0	0	0
Metal dish	330	0	0	0	0	0
Metal bucket	132	0	0	0	6	0
Total in the metal breeding sites (1.003)						
Plastic dish	57	0	0	0	0	0
Battery	96	0	0	0	0	0
Cradle	445	0	0	0	0	0
Can	273	0	0	0	15	0
Plastic box	13	0	0	0	0	0
Bouillard	45	0	0	0	0	0
Tires	1367	33	1	0	121	1
Plastic bucket	178	15	0	0	118	0
Total in the plastic breeding sites (2778)						
Ceramics	2260	93	2	0	94	0
Total in ceramic breeding sites (2449)						
Duck basins	30	0	0	0	0	0
Puddle	37	0	798	4	1014	2
Ponds	42	0	194	0	1	0
Total in natural breeding sites (2122)						

3.5. Mosquito Population Composition According to the Locality

In terms of abundance by locality, the mosquitoes collected were distributed as follows, 3199 mosquitoes collected in Zongo, 2604 in Dapoya and 2549 in Yamtenga (Table 3).

Table 3. Abundance and diversity of mosquitoes according to the locality.

Species	Dapoya (31.18%)	Yamtenga (30.52%)	Zongo (38.30%)
Ae. aegypti	2120 (81.41%)	2048 (80.35%)	1636 (51.14%)
Ae. albopictus	28 (1.08%)	0 (0.00%)	135 (4.22%)
An. gambiae	8 (0.31%)	382 (14.98%)	615 (19.23%)
An. funestus	0 (0.00%)	4 (0.16%)	0 (0.00%)
Cx. quinquefasciatus	448 (17.20%)	113 (4.43%)	812 (25.38%)
M. africana	0 (0.00%)	2 (0.8%)	1 (0.03%)
Over total	2604 (1.00%)	2549 (1.00%)	3199 (1.00%)

3.6. Influence of Physicochemical Parameters on Mosquito Populations

The six species of mosquitoes are distant from the center of the benchmark. They thus present a clear distribution concerning the physicochemical parameters. Thus, *An. gambiae* and *Cx. quinquefasciatus* mosquitoes are positively correlated to water temperature, turbidity and conductivity. *An. funestus* is positively correlated to the water pH. While *Ae. aegypti*, *Ae. albopictus* and *M. africana* are mosquitoes that are negative to all physico-chemical parameters (Figure 5).

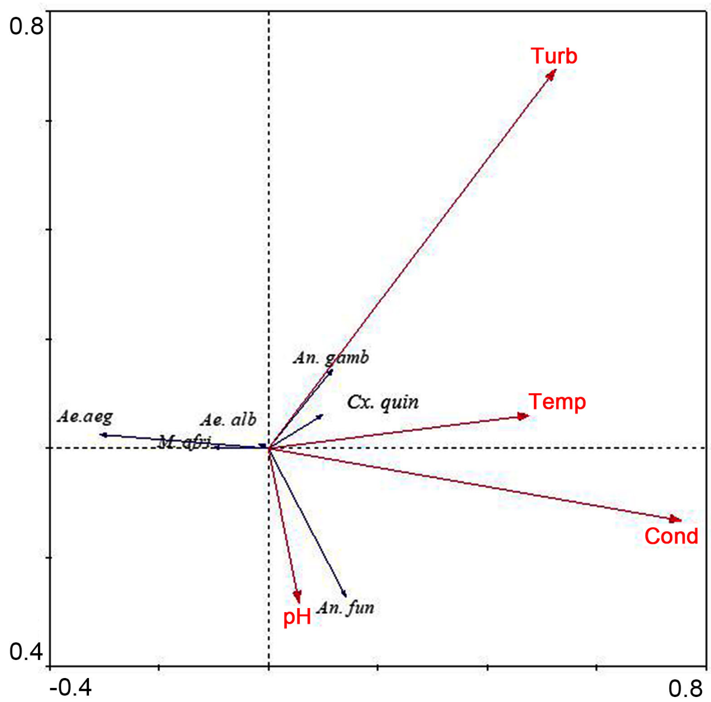

Figure 5. RDA showing the correlation between environmental parameters and collected mosquito Species (*Ae. aeg*: *Aedes aegypti*; *Ae. alb*: *Aedes albopictus*; *M. afri*: *M. africana*; *An. fun*: *Anopheles funestus*; *C. quin*: *Culex quinquefasciatus*).

4. Discussion

A total of 83 positive larval breeding sites were collected during our study. The majority of these sites were artificial breeding sites (75%), mainly from households, and the rest (25%) were natural. This high proportion of artificial breeding sites shows, on the one hand, that mosquitoes easily colonize this category of breeding sites and, on the other, the contribution made by man to the presence of mosquitoes in these different localities. Indeed, the poor management of domestic water due to the absence of sanitation infrastructure is the real cause of the presence of these habitats and therefore of the proliferation of mosquitoes in these different localities [9] [18]. Zongo is the locality with the highest number of breeding sites (35.42%), dominated by canaries. This result could be explained in part by the very physiognomy of the district, which offers a number of anthropogenic activities that provide breeding sites, and in part by the behavior of the population itself in non-urbanized areas [10]. According to him, the inhabitants of these areas generally come from the countryside and tend to transfer their original activities there (breeding, preparation of dolo, etc.), which generally contributes to the proliferation of breeding sites. Indeed, during our surveys in Zongo, we noted the presence of activities such as chicken rearing, where troughs are made of clay, and dolo preparation, where jars are most often used. These results confirm those of [18], who also found a sizeable number of larval breeding sites, including ceramics in the same locality. We also noted the presence of artificial breeding sites in all three localities and all concession types. This shows that all these localities and concessions have practically the same wastewater and household waste management, probably due to the type of urbanization experienced in most African cities, where the sanitation system is deficient [2]-[4].

The results of the analysis of the characteristics of the physicochemical parameters of the breeding sites show that sites such as buckets, tires, temporary pools, motorbike helmets, and canaries are characterized by high conductivity and turbidity values. High pH values characterized plastic boxes, metal dishes, watering cans, and jerry cans.

The inventory of Culicidae fauna shows four genera of mosquitoes encountered, namely the genera *Anopheles* composed of two species (*An. gambiae* and *An. funestus*) *Aedes* also composed of two species (*Ae. aegypti* and *Ae. albopictus*), *Culex* and *Mansonia* with each one species respectively *Cx. quinquefasciatus* and *M. africana*. This shows the risks to which the populations of these different localities are exposed, especially since these four genera of mosquitoes are vectors of diseases [19]. Indeed, the Anopheles mosquito is known for its formidable role as a vector in the transmission of malaria throughout the world and especially in sub-Saharan Africa [20]. It is also responsible for the transmission of Bancroft's filaria (*Wuchereria bancrofti*) [21]. *Culex* also plays a role in the transmission of *Wuchereria bancrofti* in East Africa and India [16]. In addition, they can transmit some arboviroses (Japanese encephalitis) and could also harbor the Zika virus [16] [22]. *Aedes* are considered important vectors of yellow fever, dengue, chikungunya, West Nile virus and Zika, as well as many other arboviruses [23]-[26]. *Mansonia* are the potential vectors of brugiosis in India, Indonesia and Malaysia. Several authors have also reported the presence of these four genera in these localities [17] [18]. The number of mosquitoes collected in Zongo was higher (3199) than those collected in Dapoya (2604) and Yamtenga (2549). This may be explained by the fact that the number of breeding sites found in Zongo was higher than those found in Dapoya and Yamtenga.

In terms of Culicidae composition, 75% of the mosquitoes collected were from artificial habitats with a high abundance of plastic habitats (2916 specimens) followed by ceramic habitats (2449 specimens), and metal habitats (865 specimens). This is a corollary of the number of artificial habitats encountered, reflecting once again the role of man as a provider of mosquitoes through his lifestyle [5] [7] [8]; and also the result of the frequency of encounter of ceramics and tires. Indeed, these types are frequently found in many studies [18].

The highest numbers of *Anopheles* and *Culex* mosquitoes were found in natural habitats (ponds and puddles) with respectively 996 specimens and 1014 specimens. This shows that *Anopheles* and *Culex* mosquitoes can use the same types of breeding sites. *Anopheles* are mosquitoes that most often use natural habitats such as puddles, ponds, rice fields, etc [18] [27].

Mosquitoes of the genus *Aedes* were present in almost every type of habitat. This shows that they are ubiquitous and can therefore colonize any type of habitat. It is therefore important to pay particular attention to these mosquitoes, as they are the source of many infections [28] and can even cause epidemics. In addition, these mosquitoes were frequently encountered in Dapoya (2148) and Yamtenga (2048), which could be explained by the type of breeding sites present in this locality. The majority of *Aedes* were found in plastic habitats (2606 or 44.90%, compared with 38.94% in ceramic habitats, 14.28% in metal habitats, and 1.88% in natural habitats), these sites were sampled much more frequently in these two localities, and these types of habitat are among those preferentially used by *Aedes* for breeding.

According to the RDA results, *Anopheles* and *Culex* mosquitoes were positively correlated with temperature and negatively correlated with water conductivity, turbidity, and pH. The development of *Anopheles* and *Culex* mosquitoes would therefore be influenced by high values of water pH, temperature, turbidity, and conductivity. On the other hand, mosquitoes of the genera *Aedes* and *Mansonia* negatively correlated to all physico-chemical parameters (conductivity, turbidity, temperature, and pH). Thus, these mosquitoes would develop in sites with low values of conductivity, turbidity, pH and water temperature. Environmental parameters would therefore be determining factors for the bioecology of Culicidae [27] [29].

5. Conclusion

Eighty-three habitats were found, including 41% in Zongo, 34% in Yamtenga, and 25% in Dapoya. These habitats were divided into natural habitats (25%) and artificial habitats (75%) made of plastic, ceramic, tires, and metal. The physico-chemical parameters of these different habitats varied from one type to another. A total of 8352 mosquitoes were collected and belonged to four genera (*Anopheles*, *Aedes*, *Culex* and *Mansonia*) and six species (*An. gambiae*, *An. funestus*, *Ae. aegypti*, *Ae. albopictus*, *C. quinquefasciatus* and *M. africana*). The genus *Aedes* was the most encountered and was found in almost all habitat types. *Culex* and *Anopheles* were found in almost the same habitats, namely natural habitats. The presence of *Aedes* and *Mansonia* was much more influenced by low values of conductivity, turbidity, temperature, and pH of the water, while that of *Anopheles* and *Culex* was influenced by high values of these different parameters. These results show that the presence of mosquitoes in urban areas is mainly due to human activities such as poor water management in homes. It is therefore necessary that for better vector control, the populations are integrated by sensitizing them to the management of wastewater and the knowledge of mosquitoes. Moreover, the genus *Aedes* is gaining ground because it can colonize several types of habitats. It therefore requires special attention because it is a vector of many arboviruses.

Authors Contributions

KJ: conducted field data collection, sample processing, and statistical data analysis and drafted the manuscript; GA and KBG: designed the study, supervised the work, edited the manuscript, and acquired funding sources; NM: participated in sample processing in the laboratory (identification); MN: supervised the work and edited the manuscript; SS: participated in field data collection and statistical data analysis

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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