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Studies on some aspects of the ecology of *Culex quinquefasciatus* (Diptera: Culicidae) in relation to filarial infection in Benin City, Nigeria

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ABSTRACT

Bancroftian filariasis, caused by the filarial parasitic nematode Wuchereria bancrofti, affects about 120 million people in the tropics and subtropics. The objectives of this study were to assess the potential vector competence of Cx. quinquefasciatus and to study it's the temporal distribution and age structure in Benin City, Nigeria. This study was conducted between March and September 2006. Adults of Cx. quinquefasciatus were collected using aspirators while larvae were sampled using dippers and pipettes. Females were dissected and microscopically examined for filarial stages. No filarial parasite was detected. The bulk of the population was recorded between 0600 to 0700hrs (42.0%) and 0700hrs to 0800hrs (35.1%). The abundance of Cx quinquefasciatus adults and larvae at all sites were not significantly ($P>0.05$) different. The parous stage of Cx quinquefasciatus was significantly ($P<0.05$) higher than the nulliparous stage. This paper discusses the findings of this study and opined that the persistent occurrence of, and breeding habitat diversification by Cx. quinquefasciatus poses a serious epidemiological concern to the inhabitants of Benin City, Nigeria.

Keywords: Abundance, *Culex quinquefasciatus*, *Wuchereria bancrofti*, Benin City.

INTRODUCTION

Infection by the filarial parasite, *Wuchereria bancrofti*, is the most common cause of lymphatic filariasis, accounting globally for approximately 90% of all infections [1], Worldwide, over 120 million people are infected with lymphatic filariasis, with 20% of the global population (over 1.1 billion people) at risk for infection [2, 3, 4]. In Africa, the prevalence of lymphatic filariasis is especially striking, affecting over 40 million people in the sub-Saharan region alone [5]. Overall,

Africa is thought to account for 40% of all cases of lymphatic filariasis in the world [see 1]. *Culex* mosquitoes, especially *Cx. quinquefasciatus* and *Cx. pipiens* are the chief vectors of bancroftian filariasis caused by *Wuchereria bancrofti* in many regions of the world [6, 7, 8] including Africa [9, 10, 11]. *Culex quinquefasciatus* Say is a common urban mosquito with highly endophilic and anthropophilic behaviour. Its breeding sites are mostly located inside or near houses [12]. Thus, it benefits from anthropogenic changes in the peridomiciliary environment. In tropical areas, where environmental factors favours an abundance of breeding sites and rapid biological development, very high population densities of *Cx. quinquefasciatus* can be maintained for long periods, causing great annoyance and a strong risk of pathogen transmission to people. The abundance, behavior, population dynamics and spatial and temporal distribution of some mosquito species including *Cx. quinquefasciatus* is known to be influenced by factors such as climate, seasonality, availability of micro-habitats for breeding, physicochemical parameters of breeding sites and anthropogenic related factors (13, 14, 15, 16, 17, 18, 19, 20, 21, 22). *Culex quinquefasciatus*, the vector of *Wuchereria bancrofti*, is responsible for keeping the Niger Delta region of Nigeria endemic for lymphatic filariasis [9, 10, 23, 24, 25]. Recent studies on filariasis in the area have shown focal distribution of the disease [9, 10, 23]. Due to the rapid growth and development of urban areas in tropical rainforest, mangrove and fresh water swamp zones and the involvement of *Cx. quinquefasciatus* in the transmission of lymphatic filariasis and its potential in the transmission of other arboviruses, this mosquito has become a matter of growing concern in recent years. The development of an effective vector control programme or strategy against this species will ultimately require knowledge of some aspects of its ecology such as the age structure, time of collection, and spatial and temporal distribution. The knowledge of the physiological age is the factor with the greatest importance in vector-borne disease transmission [26, 27]. Much of the work on bancroftian filariasis in the Niger Delta however, has been carried out in the eastern and central axis of the area [23, 25, 28], probably because of the difficult ecological terrain of the central and western sections. We are not aware of any study that has attempted to investigate the ecology of *Cx. quinquefasciatus* in relation to the transmission of *W. bancrofti* in Benin City. Therefore, this study was designed to investigate the distribution and age structure of *Cx. quinquefasciatus* in Benin City, Nigeria. A further objective of this work was to assess the vector potential of *Cx. quinquefasciatus* in transmitting *W. bancrofti* in the City.

MATERIALS AND METHODS

Study Area

The study was conducted in Benin City, located in latitude 6°5'N and longitude 5°8'E, the capital city of Edo state, Nigeria. It is highly populated area with approximate land area of 112km^2. Rainfall is high (1850 - 2445mm) throughout the year. The study area has a temperature of between 24°C to 30°C, with a mean temperature of 27°C. The landscape of Benin City is fairly flat with few hills to the east and northeast. The city is about 80m above sea level and is located within the rainfall zone in the Western Delta region of Nigeria. For the purpose of the study, Benin City was divided into four areas; Government Reservation Area (GRA), Sakponba, Akpakpava and Ugbowo communities. Various sampling sites were selected in each area. These were inside wall, outside wall, ceiling, floor, shelves, furniture and vegetation. Inside walls include the interior walls of the house, i.e. sitting room, bedroom, toilet, bathroom, kitchen, etc. the outside walls includes walls in the exterior of the house alongside the fence. The ceiling

refers to the ceiling and other household equipment found thereof e.g. fan, bulb, electric cables, decorations, etc. The floor is made up of the unoccupied surface of the ground. Shelves include bookshelves, cupboards, notice boards, underneath staircase etc. while furniture include chairs, tables, bed, dinning sets, wardrobes, etc. The vegetation includes trees, flowering plants and grasses found around homes.

Sampling Technique

The sampling was done with the aid of a mouth aspirator. The aspirator consists of two glass tubes (one small and one big) and a rubber tube. The small glass tube of diameter 0.6cm was inserted into the proximal end of the rubber tube of length 120cm and diameter 0.8cm. The big glass tube of diameter 0.7cm was covered with mosquito netting and inserted into the rubber tube. The mosquito netting prevents the mosquitoes from being sucked into the mouth during sampling. The collection was achieved by stretching the distal end of the mouth aspirator towards the mosquito and sucking at the proximal end. The collection was done between 0060hrs and 0900hrs from the month of March to September, 2006. An average of 20 minutes was spent in each catch location. After collection, captured insects were sent back to the laboratory in labeled cages and observed with a dissecting microscope to separate *Culex* from other mosquito species caught. The identified *Culex* mosquitoes were stored in vials containing 95% ethanol and taxonomically distinguished. The collected *Cx quinquefasciatus* adults were microscopically examined and sorted by sex. This decision was taken because females are the disease transmitters. The male mosquitoes were discarded while the females were dissected for filarial larvae [for rationale, see 29]. The dissected mosquitoes were also examined under the microscope, for follicular relics [30, 31] and were classified as nulliparous, uniparous, biparous and multiparous indicating those without relics, with one relic, with two relics, with greater than and/or equal to three ($\geq$ 3) relics respectively [for rationale, see 32, 33, 44]. Larvae were also collected and, the sampled habitats were broadly categorized into five (5) viz. containers; stagnant pools, domestic run-offs, gutters and tree-holes/leaf axils and mosquito species were sampled using dippers and pipettes [for rationale, see 20, 34] . The data was presented in frequency of occurrence and were subjected to statistical analysis by Man-Whitney U test. This test is useful when comparing independent random samples from different locations and makes no assumption regarding the frequency distribution of the data [35, 36]

RESULTS AND DISCUSSION

A total of 900 *Cx. quinquefasciatus* was collected in four human dwelling localities within Benin City and 818 were dissected, but without any observable filarial parasite (Tables 1 and 2). The numbers and percentages *of Cx. quinquefasciatus* resting in relation to time of collection and infection in Benin City is shown in Table 1. The bulk of the population was recorded between 0600hrs - 0700hrs (42.0%) and the least in 0800hrs - 0900hrs (22.9%). The abundance of *Cx quinquefasciatus* did not vary ($P>0.05$) with locations (see Table 2). The parous stage (uniparous, biparous and multiparous stages) was significantly ($P<0.05$) higher (76.68%) than the nulliparous stage. The uniparous stage was the most abundant stage at the different collection times (Table 3). Table 4 shows the abundance of parous and nulliparous *Cx quinquefasciatus* with respect to time of collection. This study showed that more *Cx. quinquefasciatus* (both parous and nulliparous stages) was recorded at Ugbowo community, while GRA recorded the least. The larval abundance of *Cx. quinquefasciatus* in relation to rainfall is shown in figure 1.

The peak population period coincided with high rainfall that is usually experienced between June and September annually in Nigeria. The breeding habitats of mosquitoes considered in this present studies were stagnant pools, containers, gutters, domestic run-offs and tree holes/leaf axils with *Cx. quinquefasciatus* showing its capacity to breed in all habitat types investigated with little or no preference for containers, stagnant pools and gutters (Figure 2).

Table 1: Number and percentage of *Culex quinquefasciatus* in relation to time of collection and infection between March and September 2006 in Benin City

Time of collection	% (No) caught	No. Dissected	No. Infected
0600hrs - 0700hrs	42.0(378)	341	0
0700hrs - 0800hrs	35.1(316)	295	0
0800hrs - 0900hrs	22.9(206)	182	0
Total	100 (900)	818	0

Table 2: Number and percentage of *Culex quinquefasciatus* in relation to area of collection and infection between March and September 2006 in Benin City

Area of collection	% No(caught)	No. Dissected	No Infected
Ugbowo	20.5 (232)	209	0
Akpakpava	18.7 (215)	198	0
GRA	20.7 (233)	2	0
Sokponba	19.2 (220)	200	0
Total	100 (900)	818	0

Table 3: The age composition of *Culex quinquefasciatus* caught at different times between March and September 2006 in Benin City

Time of Collection	Parity number				
	Nulliparous	Uniparous	Biparous	Multiparous	% Total
0600hr-0700hr	47	89	60	32	28.4 (228)
0700hr-0800hr	78	100	55	77	38.7 (310)
0800hr-0900hr	62	86	57	59	32.9 (264)
Total	187	275	172	168	100 (802)

Table 4: The age composition of *Culex quinquefasciatus* caught at different areas between March and September 2006 in Benin City

Area of collection	Parity number				
	Nulliparous	Uniparous	Biparous	Multiparous	% Total
Ugbowo	87	120	80	67	44.1 (228)
Sokponba	42	40	41	47	21.2 (310)
GRA	26	56	22	21	15.6 (264)
Akpakpava	32	59	29	23	19.1 (153)
Total	187	275	172	168	100 (802)

Although, *Cx quinquefasciatus* have been incriminated in the transmission of bancroftian filariasis in the various parts of Niger Delta region in Nigeria [9, 10, 23, 24, 25], we could not detect any infective stage of the filarial parasite. The results of a number of studies present contrasting views of the vectorial capacity of *Cx. quinquefasciatus*. For example, a study in Liberia showed that *Cx. quinquefasciatus* had low susceptibility to local *W. bancrofti*, but were susceptible to East African strains of *W. bancrofti* [37]. In the Pacific islands, *Cx.*

quinquefasciatus is considered a poor insect host for *W. bancrofti*, whereas the same species of mosquito seems to be a highly efficient vector in Africa [38, 39, 40]. In West Africa, this mosquito has been incriminated with low infection rate [9, 10, 23, 24, 25, 41, 42]. In Papua New Guinea infective larvae are found only in *Anopheles koliensis*, but not in *An. punctulatus* or *Cx. quinquefasciatus* [43].

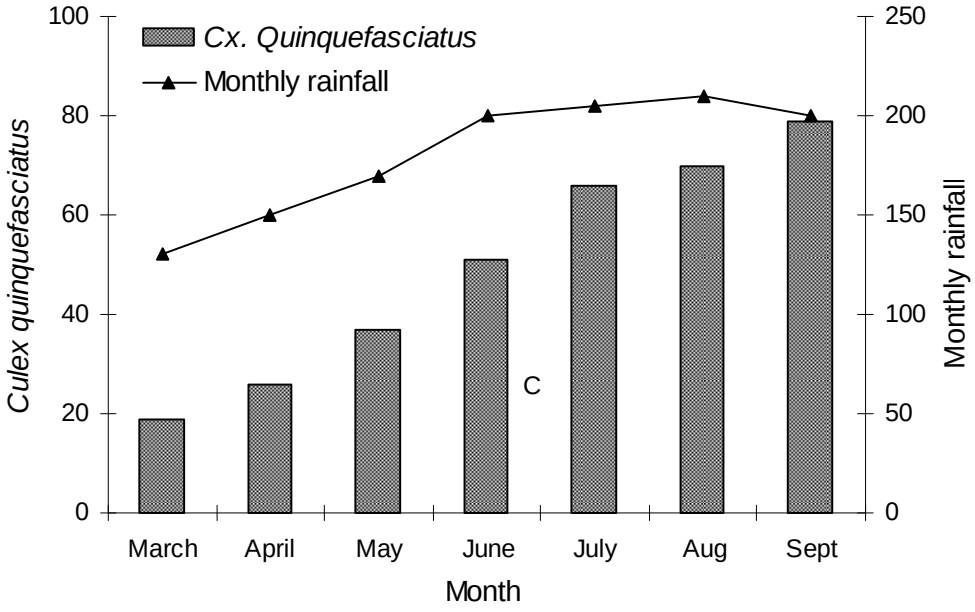

Figure 1: Temporal distribution of *Culex quinquefasciatus* in relation to rainfall between March 2006 and February 2006 in Benin City

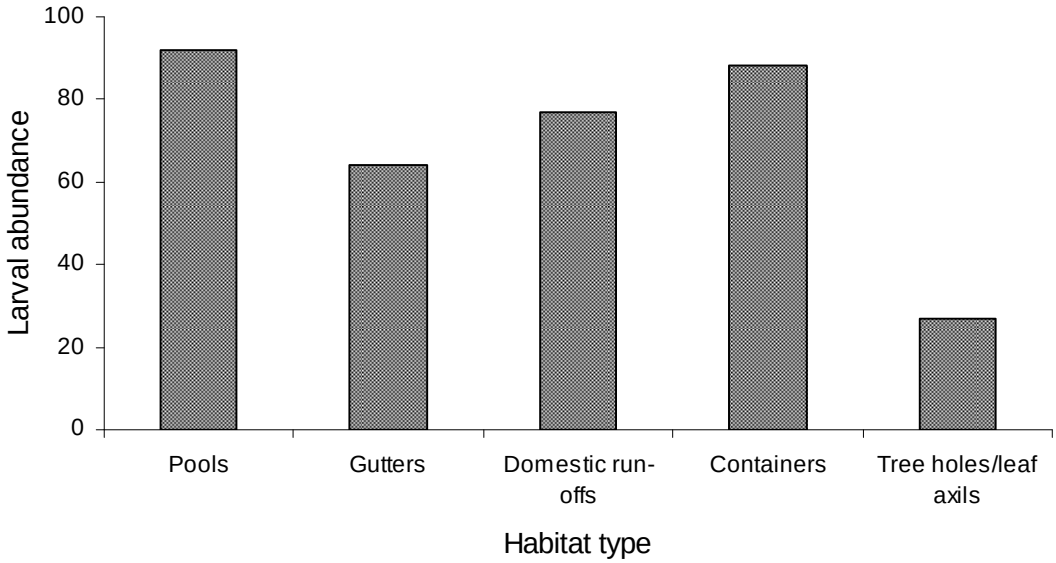

Figure 2: *Culex quinquefasciatus* and associted habitats

Aigbodion and Okaka [44] reported that catches of mosquito species from permanent dwelling in Jos metropolis in Nigeria showed no infection in spite of the large number dissected, and suggested that the parasite was scarce or absent in the area. However, regardless of geographic location, it has been suggested that *Cx. quinquefasciatus* should always be regarded as a potential vector, particularly in urban areas [45, 46]. Vector competence is determined by (1) the ability to takes up the parasite from the mammalian host; (2) the ability of the parasite to develop to the infective stage; and (3) the ability of the vector to transmit the infective stage [47]. Besides, relative humidity is important for the development of the parasite in the vector; no development with humidity below 50% [48]. One or a combination of these factors could have accounted for the absence of *W. bancrofti* infection in *Cx. quinquefasciatus* in Benin City. It has been estimated that an average of 15,500 infective *Cx. quinquefasciatus* bites are required to cause each new microftlaraemia in Rangoon [40]. However, proper adaptation may take place in future making it more susceptible to infection.

The larger numbers of *Cx. quinquefasciatus* recorded between 0600hrs and 0800hrs indicated that, with time, there were movements to more concealed areas. For the purpose of the collection of resting population this results have revealed that the best time of sampling is between 0600hrs and 0800hrs. Besides, there should be no discrimination, in sampling from various areas in Benin City since the adult population was not significantly ($P>0.05$) different comparatively in each collection locality. *Culex quinquefasciatus* occurred in all five habitats sampled in Benin City and populations were relatively abundant throughout the study period with the population peaking from April to September probably because of the high rainfall. The month of April to October is usually the rainy (wet) season in Nigeria and it's characterized with high humidity, high rainfall and average temperature of 27 ^{o}C. The increases in mosquito species populations (including *Cx. quinquefasciatus*) during the wet seasons have been reported in Nigeria [13, 27, 49, 50] and elsewhere [16, 51]. Environmental factors such as temperature, relative humidity, seasonality, and water quality have been found to be promising predicators of mosquito species distribution [17, 19, 21, 52]. The persistent occurrence of, and the breeding habitat diversification by *Cx quinquefasciatus*, pose a serious epidemiological concern to the inhabitants of Benin City. The mosquito stage (uniparous, biparous and multiparous stages) that is capable of transmitting the parasite was more than the nulliparous stage, which is an indication of the potential vector competence of *Cx quinquefasciatus* in Benin City, In conclusion, this study revealed the absence of *W. bancrofti* in *Cx quinquefasciatus* in Benin City and that, effective control of adult population of this mosquito could be achieved between 0600hrs and 0800hrs in all parts of the city. Since *Cx quinquefasciatus* is a potential vector of bancroftian filariasis, we therefore recommend that the residents of Benin City be enlightened on the environmental factors and social behaviour that support the breeding of mosquito species. The State and Local Governments should also embrace proper environmental sanitation so as to reduce the breeding sites of mosquitoes.

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