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Mosquito Species Occurrence and Diversity in Conventional larval breeding sites in Minna metropolis, Nigeria

I. K. Olayemi, A. C. Ukubuiwe, and K. A. Oyibo-Usman

Department of Biological Sciences,
Federal University of Technology, Minna,
Minna, Niger State, Nigeria

ABSTRACT: This study was carried out to provide epidemiological information on the distribution and diversity of vector mosquito species in conventional larval breeding habitats in Minna Metropolis, Nigeria. Selected larval habitats were rice-fields, gutters, septic tanks, rain pools and streams, which were sampled weekly during the months of September through November of 2013. The results indicated the occurrence of seven vector mosquito species in the area namely, *Culex pipiens pipiens* (38.84%), *Cx. salinarius* (28.78%), *Aedes aegypti* (10.71%), *Anopheles gambiae* (7.29%), *Cx. restuans* (6.52%), *Cx. nigripalpus* (4.72%), and *An. funestus* (4.15%). *Culex p. pipiens* was the most widely distributed species, being absent only in the stream habitats, that was totally devoid of mosquitoes. *Cx. nigripalpus* and *Cx. salinarius* were encountered in three of habitat types (i.e., rice-fields, gutters and septic tanks), while *Ae. Aegypti* was encountered in the gutters and the rain pools. In addition to the rain pools, *Cx. Restuans* was also collected from gutters. The two anopheline species encountered had similar pattern of larval habitat distribution been found only in rice fields and rain pools. On the whole, the rice-fields and gutters were the most productive larval habitats, in terms of mosquito abundance (28.04% and 29.67% respectively) and diversity (diversity index=0.6940 and 0.4834 respectively). Overall mosquito species diversity for the area was 0.6985, largely contributed by *Cx. p. pipiens* and *Cx. salinarius.* The findings of this study suggest serious threat of mosquito-borne diseases to public health, in Minna Metropolis, promoted by anthropogenic alterations of the ecosystem.

KEYWORDS: *Aedes, Anopheles, Culex,* Habitat productivity, Larvae, Mosquito distribution

1 BACKGROUND

Mosquitoes are transmitters of serious human diseases including, yellow fever, malaria, filariasis, and dengue [1],[2],[3],[4],[5],[6]. More than 2,500 species of mosquitoes have been described worldwide [7]. They belong to the family Culicidae [8],[9],[10]. In Africa, Nigeria in particular, though several studies have elucidated mosquito species composition and distribution in larval breeding habitats [11],[12],[13],[14],[15],[16],[17],[18],[19],[20], the breeding ecology of the species vary considerably in different localities, thus significantly influencing mosquito-borne disease transmission in such areas [21],[22],[23],[24]. Therefore, effective mosquito vector control, in areas of high disease burdens, must be predicated on a good understanding of the occurrence of specific important vector species, their abundance, distribution and, hence, potential for disease transmission in the area. This information is scanty for many parts of Nigeria especially the North-central region, Minna inclusive. This is despite the fact that certain mosquito-borne diseases e.g. malaria, are holo-endemic in the area [10], [25], [26], [27].

Although, mosquito larval occurrence and abundance vary with species [25], [28], habitat [29], [30], [31], [32], [33], [34], [35], locality [10], [13], [36], [37], [38] and season [36], [39], [40], [41], [42], [43]; it is closely associated with the availability of suitable larval breeding habitats [25], [44], [45], [46], [47]. Important mosquito breeding habitats reported include rain pools, dams, swamps, drainage channels, wells, rivers, etc. [37], [36], [47], [48], [49], [50].

Of equally important indicator of ecological and evolutionary fitness of mosquito populations in a locality is the diversity of inherent species [16], [51]. The diversity index of mosquito vector species is positively correlated with proliferation potential, survivorship, adaptability and vectorial capacity of mosquitoes in an area. Again, species diversity of Mosquitoes has been poorly studied in Nigeria. In order to fill the existing bio-ecological information gap on mosquito vectors, especially, in North-central Nigeria, this study was carried out to evaluate the occurrence, abundance, distribution and diversity of Mosquito species in conventional larval breeding habitats in Minna Metropolis, a representative cosmopolitan ecotypesetting of North-central Nigeria.

2 Materials and Methods

2.1 Description of Study Area

The study was carried out in and around Minna area of North Central Nigeria. Minna is the Capital of Niger state, located within longitude 6^{o} 33´ E and latitude 9 ^{o} 27 ´ N; covering a land area of $88km^2$ with an estimated human population of 1.2 million. Minna is characterised by a tropical climate with mean annual temperature, relative humidity and rainfall of $30.20^{o}C$, 61.00% and 1334.00mm, respectively. The climate of the area manifests as two distinct seasons; a rainy season between May and October and dry season in November to April of the following year. The vegetation of the area is typically grass-dominated Savannah with scattered trees [52].

2.2 Selection of Mosquito Collection Sites

The kind of mosquito breeding sites selected for larval collection were guided by earlier reports of high productivity of such habitats [29], [30], [31], [32], [33], [34], [35]. Such sites selected were rice-fields, drains, rain pools, septic tanks and streams.

2.3 Mosquito Larval Collection, Processing and Identification

Larval mosquito collection was carried out weekly in the study area, between the hours of 0700 to 1000 during the months of September through November, 2013. Dipping Method, as described by [53], [54], was employed in larval collection. Collected specimens were kept in labelled specimen bottles and transferred to the laboratory for processing prior to identification. The larvae were preserved using 10% formaldehyde solution, and identification was with the taxonomic Keys of [55], [56].

2.4 Data Analysis

Collected samples from the habitats were pooled together to show the actual numbers of mosquito species encountered. Specie relative abundance was calculated and expressed as simple percentages. Data on mosquito composition were analyzed quantitatively to determine the total abundance, percentage abundance of each species identified during the study period, as well as determining Shannon-Wiener diversity index (H) and Simpson's dominance index (C) for the area [16], [51].

3 Results

Morphological identification of collected larval instars of the mosquitoes during the period of study yielded seven species belonging to three mosquito Genera (Table 1). Four species of *Culex,* two of *Anopheles,* and one for *Aedes*; comprising of *Culex pipiens pipiens* (n=978, 38.84%)*, Cx. salinarius* (n=742, 28.78%), *Anopheles gambiae* (n=188, 7.29%), *Aedes aegypti* (n=276, 10.71%), *Cx. restuans* (n=168, 6.52%), *Cx. nigripalpus* (n=119, 4.72%)*,* and *A. funestus* (n=107, 4.15%) (Table 1). In general, the larval habitats investigated were productive for at least two of the species encountered, with the exception of the streams which was void of any species. Also, at least, one of the *Culex* species encountered was found in all the positive habitats, however, their degree of preponderance varied considerably among these habitats. Furthermore, the two Anopheline species and the only Aedine species encountered were present in only two habitats, respectively, Rice fields and Rain pools, and gutters and rain pools (Table 2). *Culex nigripalpus, Cx. salinarius, Cx. pipiens pipiens, Cx. restuans, Anopheles gambiae and A. funestus* was found in Rice fields; *Culex nigripalpus, Cx. salinarius, Cx. pipiens pipiens,* and *Aedes aegypti* were found in Gutters; *Culex nigripalpus, Cx. salinarius, Cx. pipiens pipiens* were the species found in Septic tanks; while *Cx. pipiens pipiens, Cx. restuans, Aedes aegypti, Anopheles gambiae and A. funestus* were found in Rain pools (Table 2).

Most interestingly, *Culex pipiens pipiens* was found to be catholic in distribution among the habitats (Rice fields, Gutters, Septic tanks and Rain pools) followed by *Cx. nigripalpus* and *Cx. salinarius* (Rice fields, Gutters and Septic tanks only). The other species were encountered only in two habitats; *Cx. restuans* (Rice fields and Rain pools), *Aedes aegypti* (Gutters and Rain pools), *Anopheles gambiae* and *A. funestus* (both Rice fields and Rain pools) (Table 2).

From table 3, it could be shown that there was considerable difference in the contribution of the different positive habitats, both in terms of productivity and number of species collected from each. Gutters were the most productive; although, it produced only four of the species, it accounted for 29.67% of all species encountered. This was closely followed by the Rice fields (n=6, 28.04%), Septic tanks (n=3, 22.03%) and lastly by the Rain pools (n=5, 20.25%) (Table 3). The Shannon-Wiener diversity index (*H*) and Simpson's dominance index (*C*) for the habitat was also different and are respectively, Rice field (*H*=0.69399, *C*=0.23312), Gutter (*H*=0.48335, *C*=0.38227), Septic tanks (*H*=0.31231, *C*=0.57759) and Rain pools (*H*=0.50350, *C*=0.23452) (Table 3).

Table 4 shows the computation used for diversity and dominance indices of the mosquitoes species encountered in the study area. A Shannon-Wiener diversity index (*H*) of 0.69847 and Simpson's dominance index (*C*) of 0.2516 was recorded for the study area. *Cx. pipiens pipiens* had the highest frequency of occurrence followed by *C. Salinarius.* The least occurred species was *A. funestus. Cx. pipiens pipiens* had the highest Shannon-wiener diversity and Simpson's dominance indices of 0.1596 and 0.1439 respectively.

4 DISCUSSION

Increasing population density due to rural-urban drift is one of the major characteristics of many cities in Nigeria [35]. This increase in population brings about a rapid change in the environment, which can cause the unconscious creation of man-made environment which aid the proliferation of mosquitoes. Furthermore, Agro-economic activities such as rice farming have contributed immensely in the provision of man-made habitats [14]. Meanwhile, the greatest challenge posed by mosquitoes to man is their ability to breed in any collection of stand water [23]. Though they breed everywhere, human activities and behaviour have continued to create more and renewed diversity in the occurrence and proliferation of mosquito species [57], [58].

In the present study, three genera of mosquitoes were encountered, this is similar to an earlier by [38]; a total of 2,578 mosquito species belonging to seven species were encountered, consisting of *Culex pipiens pipiens* (38.84%), *Cx. salinarius* (28.78%), *Anopheles gambiae* (7.29%), *Aedes aegypti* (10.71%), *Cx. restuans* (6.52%), *Cx. nigripalpus* (4.72%), and *A. funestus* (4.15%). Although, higher than that reported by [23], [35]; the former reported a total of eight species consisting of *Aedes aegypti*, *Ae. vittatus*, *Culex quinquefasciatus*, *Cx. tigripes*, *Cx horridus*, *Cx. cinereux*, *Cx annuliorus* and *Anopheles gambiae* in Owerri and Orlu, Nigeria while the latter reported a total of six species namely, *Aedes aegypti, Aedes albopictus, Aedes vittatus*, *Anopheles gambiae* complex, *Cx. quinquefasciatus* and *Eretmapodite chrysogaster*, it was considerably lower than that reported by [14], who reported a total of 25 species; five most common species collected during their study were *Anopheles arabiensis* Patton (52.5%), *Culex quinquefasciatus* Say (36.7%), *Anopheles pharoensis* Theobald (5.2%), *Anopheles coustani* Laveran (1.4%), and *Anopheles funestus* Giles (1.3%). Furthermore, in their study, [59] collected a total of 953 mosquitoes, which is lower than that reported in this study. Significant variations in mosquito species composition have been attributed to differences in ecotypes [14], microclimatic conditions [60] and sometimes sampling techniques [48].

In their study, [38] reported that drains were the most productive mosquito larval habitat, which is similar to the findings of the present study; we also reported an additional epidemiological contributor, the rice-fields. The reasons for this high productivity of the drains could be due to its high organic contents as most of them were clogged during larval collection. The rice field could be highly productive as a result of its water-logging attributes, high organic decay and inorganic chemical inputs by the farmers. Similarly, streams were also noted not to be epidemiologically important, as no mosquito larvae were encountered, this may be due to the fast flowing nature of the streams, which cause the washing away of the eggs and also due to the presence of large predators [61] and its apparent minimal organic content [38].

Cx. p. pipiens mosquitoes dominated the collections of larvae from the study area. The ecology of this mosquito species explains this finding, as the species is the foremost cosmopolitan mosquito thriving particularly in urban slums where anthropogenic environmental degradations result in the proliferation of polluted water receptacles preferred for breeding by the mosquito [8]. The preponderance of *Cx. p. pipiens* in Minna metropolis, therefore, pose serious public health threat, as the species is the principal vector of important human diseases especially filariasis.

Only 2 anopheline species (i.e., *An. gambiae* and *An. funestus*) were encountered during the study period in the area, and they occurred in relatively low densities. The scanty distribution of anopheline mosquitoes in the area may be due to the ongoing large-scale aggressive anti-anopheline vector control being implemented in Minna under the auspices of Roll-Back-Malaria. The campaign is particularly targeted against anopheline breeding and resting sites in the city.

Unlike the results of this study, [11] reported a higher number of mosquito Genera (five); *Anopheles, Aedes, Culex, Mansonia and Psorophora* and 18 species from four irrigated millet and guinea-corn fields in Gezawa Agricultural Zone, Kano, North-Central Nigeria. This may mean that Minna is less clement for the distribution of mosquito species and, hence, reduced transmission of mosquito-borne diseases. They also reported a Shannon-Wiener and Simpson's diversity values of 1.1431 and 0.0925 for the mosquito species encountered, this is, however, different from this study where a Shannon-Wiener and Simpson's diversity values of 0.69847 and 0.25163 respectively, was observed. Ephantus *et al.* (2006) in their study also reported mosquito species diversity (*H*) and evenness (*EH*) in non-irrigated agroecosystem as H = 1.507 and EH = 0.503 respectively, H = 0.968, EH = 0.313 for unplanned rice agroecosystem and H = 1.040, EH = 0.367 for planned rice agroecosystem, which are significantly higher than that obtained in this study.

5 TABLES

Table 1. Mosquito Species composition and abundance in Minna Metropolis, Nigeria

Species	Species Aggregate	Percentage Abundance (%)
Culex nigripalpus	119	4.72
Cx. salinarius	742	28.78
Cx. pipiens pipiens	978	38.84
Cx. restuans	168	6.52
Aedes aegypti	276	10.71
Anopheles gambiae	188	7.29
A. funestus	107	4.15
Aggregate	2,578	100

Table 2. Relative distribution of mosquito species in conventional larval breeding habitat in Minna Metropolis, Nigeria.

Species	Habitat					
	Rice fields	Gutters	Septic Tanks	Rain Pools	Streams	**AGGREGATE**
Culex nigripalpus	52	39	28	-*	-	119
Cx. Salinarius	212	401	129	-	-	742
Cx. pipiens pipiens	236	228	411	103	-	978
Cx. Restuans	107	-	-	61	-	168
Aedes aegypti	-	97	-	179	-	276
Anopheles gambiae	71	-	-	117	-	188
A. funestus	45	-	-	62	-	107
Aggregate	723 (28.04)	765 (29.67)	568 (22.03)	522 (20.25)	-	2,578 (100)

*absence of mosquito larvae

Table 3. Relative productivity and species diversity of conventional Mosquito larval breeding habitats in Minna Metropolis, Nigeria.

Habitats	Numbers of Species encountered	Shannon-Wiener diversity index	Simpson's dominance index
Rice Fields	6 (28.04%)	0.69399	0.23312
Gutters	4 (29.67%)	0.48335	0.38227
Septic Tanks	3 (22.03%)	0.31231	0.57759
Rain Pools	6 (20.25%)	0.50350	0.23452
Streams	*- (00.00%)	* -	-

*absence of mosquito larvae

Table 4. Species diversity and dominance indices of Mosquitoes populations breeding in conventional larval breeding habitats in Minna Metropolis, Nigeria

Species	*fi*	*fi log fi*	*fi log^2 fi*	*pi*	*(pi)^2 or (ni/N)^2*	*ni (ni-1)/N (N-1)*	*Pi log Pi*	*Pi In Pi*	*Pi(In Pi)^2*	*Shannon-Wiener diversity index, H= –(Pi log Pi)*	*Simpson's dominance index, C= Σ (ni/ N)^2*
Culex nigripalpus	119	246.99	512.63	0.0461	0.00213	0.0021	-0.061	-0.1419	0.43665	0.06165	0.00213
Cx. salinarius	742	2129.84	6113.50	0.2878	0.08284	0.0827	-0.155	-0.3584	0.44642	0.15567	0.08284
Cx. pipiens pipiens	978	2924.55	8745.40	0.3793	0.14391	0.1438	-0.159	-0.3677	0.35639	0.15969	0.14391
Cx. restuans	168	373.85	831.94	0.0651	0.00424	0.0042	-0.077	-0.1779	0.48596	0.07728	0.00424
Aedes aegypti	276	673.69	1644.42	0.1070	0.01146	0.0114	-0.103	-0.2392	0.53448	0.10388	0.01146
Anopheles gambiae	188	427.54	972.27	0.0729	0.00531	0.005	-0.082	-0.1909	0.49994	0.08292	0.00531
A. funestus	107	217.14	440.67	0.0415	0.00172	0.0017	-0.057	-0.1320	0.42022	0.05735	0.00172
∑	2578	6993.61	19260.86	1	0.25163	0.2513	-0.698	-1.6083	3.18010	0.69847	0.25163

Key: fi = Abundance of species, N = total number of individuals, Pi = Proportion of individuals found in the ith species, In = the Natural (Naperian) logarithms (log_e), $(ni/N)^2 = (Pi)^2$

6 Conclusions

Vector mosquito species in Minna is dominated by the Culicines especially *Culex.* Thus, the ongoing anti-anopheline control interventions, to reduce malaria burdens, in the city should be broadened to target the breeding sites of the Culicines as well, as these mosquitoes transmit diseases of burdens that can rival malaria. The drains (Gutters) and rice-fields were the most productive mosquito larval habitats in the city. These findings further confirm the fact that anthropogenic activities are the principal drivers of mosquito proliferation in domestic and peri-domestic environments; such activities should therefore be strictly regulated. The diversity indices of the mosquito populations in Minna indicate that the established species are well adapted to the ecological conditions of the area, and will require consistent aggressive larvicidal interventions for effective control. The findings of this study will help in achieving a better understanding of the epidemiology of mosquito-borne diseases in Minna, a pre-requisite for sustainable disease control.

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