SPECIES COMPOSITION AND ABUNDANCE OF MOSQUITOES OF A TROPICAL IRRIGATION ECOSYSTEM

OGUOMA, Victor Maduabuchi and IKPEZE, Obiora Osegboka
Department of Parasitology and Entomology, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria

Corresponding Author: Ikpeze, O. O. Department of Parasitology and Entomology, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria. Email: ikpezevet@yahoo.com Phone: +2348035838255

ABSTRACT

Exophagic-anthropophilic mosquitoes were collected during the April 2007-January 2008 planting season in four designated millet and guinea-corn irrigation fields sampled in Gezawa Agro-ecological Zone of North-central Nigeria. Gezawa-1, Gezawa-2, Ketawa and Jogana irrigation fields contributed about 31.2 %, 24.8 %, 22.8 % and 21.2% respectively, to the number of mosquito species collected in the zone. There was preponderance of Anopheles gambiae complex (20.7 %) over Culex quinquefasciatus (11.8 %), C. pipiens fatigans (9.0%), A. funestus complex (7.0 %), Aedes aegypti (6.9%), A. albopictus (6.6 %), C. pipiens pipiens (5.7 %). C. tigripes (5.0%), A. pharoensis (3.7 %), A. africanus (3.6%), A. taylori (3.4%), A. coustani (3.3 %), A. luteocephalus (2.9 %), A. vittatus (2.8 %), A. rhodesiensis (2.1 %), Mansonia (2.0 %), A. simpsoni (1.9 %) and Psorophora species (1.6 %). A Shannon-Wiener and Simpson's diversity values of 1.1431 and 0.0925 were recorded for the mosquito species in Gezawa Agricultural Zone. A. gambiae had the highest Shannon-wiener diversity and Simpson's dominance indices of 0.1415 and 0.0427 respectively. There was no significant difference between species diversity for the four irrigation fields (P>0.001). Vector control must be carried out in the irrigation fields to reduce the number of these out-door biting mosquitoes, since total reliance on ACTs and ITNs could not offer full protection against malaria to farmers in Gezawa irrigation fields.

Keywords: Mosquitoes, Composition, Diversity, Dominance, Tropical ecosystem, Irrigation

INTRODUCTION

Millet (*Panicum miliaceum*) and guinea corn (*Sorghum spp*) are the major crops that are mostly grown by peasant farmers in the northern parts of Nigeria. As a result of prolonged dry season in Gezawa ecological zone in North-central Nigeria, irrigation is practiced to boost production of these crops. The demand for irrigation has led to the proliferation of mosquito fauna in the irrigation system. Despite the on-going program of artemisinin-based combination therapy (ACT) and insecticide treated bed-net (ITN) administration in Gezawa Local Government Area (LGA) of Kano State, the increasing number of malaria cases at Gezawa general Hospital prompted us to carry out this surveillance of man-biting mosquitoes in the irrigation fields where over 70% of the farmers in Gezawa work during the planting season. According to WHO (1975), such surveillance involved the collection, analysis, consolidation and evaluation of data, and its prompt dissemination which represented an overall intelligence or disease-accounting system designed to permit disease control authorities to be alerted early to the presence of disease problems and the effects of the disease on the population they serve.

The study of species diversity in an ecological community takes account of the total number of species encountered in the sample, expressed as richness, and how the species abundances are distributed among the species, expressed as evenness (Fisher *et al*., 1943). A better measure known as Shannon Index or Shannon-Wiener Index of Diversity, which combines species richness and evenness in a single value is expressed as $H = (N \log N - \sum fi \log fi)/N$ where fi is the abundance and N the total number of individuals in the species (Ogbeibu, 2005). A greater number of species, as well as a more even distribution among species will therefore increase species diversity measured by Shannon-Wiener Index (Lloyd and Ghelardi, 1964). Another measure, the probability of picking two organisms at random that are different species, is known as Simpson's Dominance Index, and is expressed as $C = \sum (Pi)^2$ or $\sum (ni/N)^2$, where ni = number of individuals of the *ith* species; N being the total number of individuals for all species; Pi being the proportional abundance of *ith* species i.e., $Pi = ni/N$ (Krebs, 1972). Simpson's dominance indices is weighted towards the abundance of the commonest species and gives relatively little weight to the rare species, and ranges in value from 0 (low diversity) to a maximum of $(1-1/S)$, where S is the number of species (Fisher, 1943). The formula $\sum (ni/N)^2$ refers to a finite population where all of the members have been counted. Since ecologists work with infinite populations where it is impossible to count all members, an unbiased estimator known as Simpson's Index, denoted by $D = \sum ni\,(ni-1)/N\,(N-1)$ has been developed for sampling from infinite natural population, where ni is the total number of individuals in the *ith* species, and N is the total number of individuals (Ogbeibu, 2005). The major aim of this study was to use natural counts of the number of species, and the number of individuals in each of the species of mosquitoes sampled from four millet and guinea-corn irrigation fields in Gezawa Agricultural Zone of North-central Nigeria to determine the composition and abundance of mosquitoes in a tropical irrigation eco-system. The study will be helpful in understanding the epidemiology of mosquito-borne diseases in an endemic area, thereby aiding in vector control.

MATERIALS AND METHODS

Study Area: The study area, Gezawa irrigation system, is in Gezawa, Kano State, North-central Nigeria. Gezawa has a purely rural setting with limited health intervention. Majority of the natives cultivate millet and guinea corn. The adoption of irrigation practices has created different mosquito fauna in irrigated ditches, bed-pools, puddles and hoof-prints, which may guarantee all-year breeding of the mosquito in the area, thereby constituting a major factor in the epidemiology of malaria in Gezawa.

Mosquito Breeding Habitats: Mosquitoes larvae and adults breeding habitats in the irrigated millet and guinea corn fields were observed on weekly basis, from May to December 2007. Irrigation ditches, bed-pools, puddles, and hoof-prints were also observed from April 2007 to January 2008.

Collection of Larval Mosquitoes: Mosquito larvae observed in bed-pools and puddles were collected using ladles; those in hoof-prints were scooped with plastic spoons and those in ditches were sampled with well nets. Subsequent collections of the available larvae were made into sampling vials with rubber stoppers. The vials were appropriately labeled with place of collection and type of habitat. Each vial holds collections from only one habitat sampled. There was no attempt to exhaust all the larvae in a habitat in cases of heavy breeding but to collect representative sample as far as was possible.

Collection of Adult Mosquitoes: Adult mosquitoes were sampled by hanging a black clothe, coated with hair cream (made up of mineral oil, petroleum jelly, anhydrous lanolin, coconut oil, microcrystalline wax, collagen and fragrance) on scarecrows that acted as effective attractant to biting mosquitoes. Adult mosquitoes hovering around the baited-scarecrows were collected, especially in the evenings, using a 20cm diameter well net sampler.

Identification of Larval and Adult Mosquitoes: Adult mosquitoes collected were brought to the Department of Pathology laboratory at Gezawa General Hospital (GGH) and released into a glass jar containing chloroform. All mosquito species were observed under dissecting microscope for identification using standard morphological keys (Hopkins, 1952; Smart *et al*., 1956; Service, 1976; Gilles and Coetzee, 1987). Voucher specimens were also deposited with the pathology department at GGH, Gezawa.

Ecological Statistics: 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. Shannon-Wiener index (H) was used in calculating *t'* (Ogbeibu, 2005) to test for significant differences in diversity and dominance of mosquito species.

RESULTS AND DISCUSSION

Five mosquito genera sampled from the four irrigated millet and guinea-corn fields were *Anopheles, Aedes, Culex, Mansonia* and *Psorophora*. The 18 species from different fauna as well as from different irrigation fields are shown in Table 1. Five species of *Anopheles*, four of *Culex*, seven of *Aedes*, each of *Mansonia* and *Psorophora* were encountered in the study area. *A. gambiae complex, A. funestus complex, A. aegypti, A. albopictus* and *A. taylori* were found in puddles; *A. albopictus* was found in hoof-prints while *A. gambiae complex, A. funestus complex, A. coustani, C. quinquefasciatus, A. aegypti, A. africanus* and *Psorophora* spp., were found in bed pools during the rainy season which lasted for a short period of time. All mosquito vector species encountered in the study were found in the irrigation ditches while only *Psorophora*, was not found in millet and guinea corn fields. Gezawa-1 contributed about 31.2 % of all the species collected, while Gezawa-2, Ketawa and Jogana contributed 24.8%, 22.8% and 21.2 % respectively. From Table 1, it could be observed that *A. gambiae complex* contributed 20.7 %, *A. funestus complex* (7.0 %), *A. pharoensis* (3.7 %), *A. rhodesiensis* (2.1 %), *A. coustani* (3.3%), *C. quinquefasciatus* (11.8 %), *C. pipiens pipiens* (5.7%), *C. pipiens fatigans* (9.0 %), *C. tigripes* (5.0%), *A. aegypti* (6.9 %), *A. albopictus* (6.65), *A. simpsoni* (1.9%), *A. africanus* (3.6 %), *A. taylori* (3.4 %), *A. luteocephalus* (2.9 %), *A. vittatus* (2.8%), *Mansonia* spp., (2.0 %) and *Psorophora* spp., (1.6 %) to the total number of mosquitoes sampled.

During the preliminary surveillance of the irrigated fields, we observed that our head region mostly attracted the mosquitoes, perhaps due to the colour of hair, fragrance of the hair cream, exhaled carbon dioxide and body temperature. This led us to conclude that a combination of visual, olfactory and physical stimuli were effective attractants to man-biting mosquitoes encountered in the irrigated field, and therefore we adopted a black clothed robot, coated with hair cream, as mosquito attractant. In the four crop fields, *A. gambiae complex* was the most frequently encountered species and this could possibly explain the cause of some malaria cases we observed at the Gezawa General Hospital, where administration of ACTs and ITNs was in progress. It has been reported that more of *A. arabiensis* (66.7%) than *A. gambiae s. s.* (6.7%) was present at Yola in the dry-savannah of north-eastern Nigeria (Umaru *et al.,* 2007). However, Service (1993) established that *A. arabiensis* s.s is a dry-savannah zoophilic and anthropophilic as well as exophagic and endophagic mosquito. The *A. gambiae complex* was recovered in the millet and guinea corn fields and water bodies but their presence in puddles, hoof-prints and bed-pools was limited, perhaps as a result of the fast drying-up of water in these artificial habitats. During the peak of the rains the presence of *A. gambiae complex* was prolonged for more than 2 weeks in puddles and bed-pools.

Table 1: Man-biting mosquitoes sampled from Gezawa irrigation Zone, North-central Nigeria

	Mosquito species	Mosquito fauna					Individuals of mosquito species collected								Total	
							Gezawa-1		Gezawa-2		Ketawa		Jogana			
		Millet and guinea-corn fields	Irrigation ditches	Puddles	Bed-pools	Hoof-prints	No.	%	No.	%	No.	%	No.	%	No.	%
1	***Anopheles gambiae***	+	+	+	+	-	83	31.1	71	26.6	62	23.2	51	19.1	267	20.7
2	***A. funestus***	+	+	+	+	-	24	26.7	15	16.7	30	33.3	21	23.3	90	7.0
3	***A. pharoensis***	+	+	-	-	-	11	22.9	5	10.4	15	31.3	17	35.4	48	3.7
4	***A. rhodesiensis***	+	+	-	-	-	8	29.6	9	33.3	4	14.8	6	22.2	27	2.1
5	***A. coustani***	+	+	-	+	-	17	40.5	11	26.2	7	16.7	7	16.7	42	3.3
6	***Culex quinqefasciatus***	+	+	-	+	-	57	37.3	40	26.1	31	20.3	25	16.3	153	11.8
7	***C. pipiens pipiens***	+	+	-	-	-	21	28.8	25	34.2	12	16.4	15	20.5	73	5.7
8	***x. pipiens fatigans***	+	+	-	-	-	44	37.9	32	27.6	19	16.4	21	18.1	116	9.0
9	***C. tigripes***	+	+				19	29.7	16	25.0	12	18.7	17	26.6	64	5.0
10	***Aedes aegypti***	+	+	+	+	-	32	35.9	15	16.9	25	28.1	17	19.1	89	6.9
11	***A. albopictus***	+	+	+	-	+	29	34.1	20	23.5	21	24.7	15	17.7	85	6.6
12	***A. simpsoni***	+	+	-	-	-	6	24.0	10	40.0	7	28.0	2	8.0	25	1.9
13	***A. africanus***	+	+	-	+	-	11	23.4	15	32.0	12	25.5	9	19.1	47	3.6
14	***A. taylori***	+	+	+	-	-	9	20.5	7	15.9	11	25.0	17	38.6	44	3.4
15	***A. luteocephalus***	+	+	-	-	-	5	13.2	8	21.0	12	31.6	13	34.2	38	2.9
16	***A. vittatus***	+	+	-	-	-	12	32.4	6	16.2	7	19.0	12	32.4	37	2.8
17	***Mansonia* spp.**	+	+	-	-	-	8	30.8	9	34.6	2	7.7	7	26.9	26	2.0
18	***Psorophora* spp.**	-	+	-	+	-	7	33.3	7	33.3	5	23.8	2	9.5	21	1.6
Σ		17	18	5	7	1	403	31.2	321	24.8	294	22.8	274	21.2	1292	100.0

Table 2: Computations for species diversity and dominance indices for mosquitoes sampled from Gezawa Irrigation Zone, North-central Nigeria

	Mosquito species (S = 18)	*fi*	*fi log fi*	*fi log* ^{2} *fi*	*Pi*	*(Pi)* ^{2} *or (ni/N)* ^{2}	*ni(n-1)/N(N-1)*	*Pi log Pi*	*Pi In Pi*	*Pi (In Pi)* ^{2}	Shannon-Wiener diversity index	Simpson's dominance index
1	***Anopheles gambiae***	267	647.88	1571.08	0.2067	0.0427	0.0426	-0.1415	-0.3259	0.5137	0.1415	0.0427
2	***A. funestus***	90	175.88	343.72	0.0697	0.0049	0.0048	-0.0806	-0.1856	0.4945	0.0806	0.0049
3	***A. pharoensis***	48	80.70	135.68	0.0372	0.0014	0.0014	-0.0532	-0.1224	0.4030	0.0532	0.0014
4	***A. rhodesiensis***	27	38.65	55.32	0.0209	0.0004	0.0004	-0.0351	-0.0808	0.3127	0.0351	0.0004
5	***A. coustani***	42	68.18	110.67	0.0325	0.0011	0.0010	-0.0484	-0.1114	0.3816	0.0484	0.0011
6	***Culex quinqefasciatus***	153	334.26	730.25	0.1184	0.0140	0.0139	-0.1097	-0.2526	0.5390	0.1097	0.0140
7	***C. pipiens pipiens***	73	136.02	253.45	0.0565	0.0032	0.0032	-0.0705	-0.1624	0.4665	0.0705	0.0032
8	***C. pipiens fatigans***	116	239.48	494.39	0.0898	0.0081	0.0080	-0.0940	-0.2164	0.5216	0.0940	0.0081
9	***C. tigripes***	64	115.60	208.79	0.0495	0.0024	0.0024	-0.0646	-0.1488	0.4472	0.0646	0.0024
10	***Aedes aegypti***	89	173.50	338.21	0.0689	0.0047	0.0047	-0.0800	-0.1843	0.4931	0.0800	0.0047
11	***A. albopictus***	85	164.00	307.67	0.0658	0.0043	0.0043	-0.0778	-0.1791	0.4872	0.0778	0.0043
12	***A. simpsoni***	25	34.95	48.86	0.0193	0.0004	0.0004	-0.0331	-0.0762	0.3008	0.0331	0.0004
13	***A. africanus***	47	78.59	131.41	0.0364	0.0013	0.0013	-0.0524	-0.1206	0.3996	0.0524	0.0013
14	***A. taylori***	44	72.31	118.84	0.0341	0.0012	0.0011	-0.0500	-0.1152	0.3892	0.0500	0.0012
15	***A. luteocephalus***	38	60.03	94.84	0.0294	0.0009	0.0008	-0.0450	-0.1037	0.3657	0.0450	0.0009
16	***A. vittatus***	37	58.02	90.99	0.0286	0.0008	0.0008	-0.0441	-0.1016	0.3613	0.0441	0.0008
17	***Mansonia* spp.**	26	36.79	52.06	0.0201	0.0004	0.0004	-0.0341	-0.0785	0.3062	0.0341	0.0004
18	***Psorophora* spp.**	21	27.77	36.71	0.0162	0.0003	0.0003	-0.0290	-0.0668	0.2753	0.0290	0.0003
Σ		N = 1292	2542.61	5122.94	1.0000	0.0925	0.0918	-1.1431	-2.6323	7.4582	1.1431	0.0925

Table 3: Computations for species diversity and dominance indices for mosquitoes sampled from Gezawa 1 and Gezawa-2 irrigation fields in Gezawa Agricultural Zone, North-central Nigeria

Irrigation field	*fi*	*fi* log *fi*	*fi* log² *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 = (*N* log *N* − Σ *fi* log *fi*) /*N* or −(*Pi log Pi*)	Simpson's dominance index C = Σ (*ni*/ *N*)²
Gezawa-1											
1 ***Anopheles gambiae***	83	159.28	305.677	0.206	0.04244	0.04201	-0.1413	-0.325	0.5142	0.1413	0.04244
2 ***A. funestus***	24	33.12	45.719	0.060	0.00360	0.00341	-0.0733	-0.169	0.4750	0.0733	0.00360
3 ***A. pharoensis***	11	11.45	11.929	0.027	0.00073	0.00068	-0.0423	-0.097	0.3522	0.0423	0.00073
4 ***A. rhodesiensis***	8	7.22	6.524	0.020	0.00040	0.00035	-0.0339	-0.078	0.3061	0.0339	0.00040
5 ***A. coustani***	17	20.92	25.738	0.042	0.00176	0.00168	-0.0578	-0.133	0.4221	0.0578	0.00176
6 ***Culex quinqefasciatus***	57	100.08	175.736	0.141	0.01988	0.01970	-0.1199	-0.276	0.5411	0.1199	0.01988
7 ***C. pipiens pipiens***	21	27.77	36.713	0.052	0.00270	0.00259	-0.0668	-0.154	0.4545	0.0668	0.00270
8 ***x. pipiens fatigans***	44	72.31	118.841	0.110	0.01210	0.01167	-0.1054	-0.243	0.5359	0.1054	0.01210
9 ***C. tigripes***	19	24.30	31.069	0.047	0.00221	0.00211	-0.0624	-0.144	0.4394	0.0624	0.00221
10 ***Aedes aegypti***	32	48.16	72.495	0.080	0.00640	0.00612	-0.0877	-0.202	0.5103	0.0877	0.00640
11 ***A. albopictus***	29	42.41	62.019	0.072	0.00518	0.00501	-0.0823	-0.189	0.4984	0.0823	0.00518
12 ***A. simpsoni***	6	4.67	3.633	0.015	0.00022	0.00019	-0.0274	-0.063	0.2646	0.0274	0.00022
13 ***A. africanus***	11	11.45	11.929	0.027	0.00073	0.00068	-0.0423	-0.097	0.3522	0.0423	0.00073
14 ***A. taylori***	9	8.59	8.195	0.022	0.00048	0.00044	-0.0365	-0.084	0.3205	0.0365	0.00048
15 ***A. luteocephalus***	5	3.49	2.443	0.012	0.00014	0.00012	-0.0230	-0.053	0.2347	0.0230	0.00014
16 ***A. vittatus***	12	12.95	13.975	0.030	0.00090	0.00081	-0.0457	-0.105	0.3689	0.0457	0.00090
17 ***Mansonia* spp.**	8	7.22	6.524	0.020	0.00040	0.00035	-0.0340	-0.078	0.3061	0.0340	0.00040
18 ***Psorophora* spp.**	7	5.91	4.999	0.017	0.00029	0.00026	-0.0301	-0.069	0.2822	0.0301	0.00029
Σ	*N* =403	601.30	944.158	1.000	0.10056	0.09818	-1.1121	-2.559	7.1784	1.1121	0.10056
Gezawa-2											
1 ***Anopheles gambiae***	71	131.43	248.076	0.221	0.04884	0.04838	-0.1449	-0.334	0.5036	0.1449	0.04884
2 ***A. funestus***	15	17.64	20.748	0.047	0.00221	0.00204	-0.0624	-0.144	0.4394	0.0624	0.00221
3 ***A. pharoensis***	5	3.49	2.443	0.015	0.00023	0.00019	-0.0274	-0.063	0.2646	0.0274	0.00023
4 ***A. rhodesiensis***	9	8.59	8.195	0.028	0.00078	0.00070	-0.0435	-0.100	0.3580	0.0435	0.00078
5 ***A. coustani***	11	11.45	11.929	0.034	0.00116	0.00107	-0.0499	-0.115	0.3887	0.0499	0.00116
6 ***Culex quinqefasciatus***	40	64.08	102.664	0.125	0.01563	0.01519	-0.1129	-0.260	0.5405	0.1129	0.01563
7 ***C. pipiens pipiens***	25	34.95	48.856	0.078	0.00608	0.00584	-0.0864	-0.200	0.5076	0.0864	0.00608
8 ***x. pipiens fatigans***	32	48.16	72.495	0.099	0.00980	0.00967	-0.0994	-0.229	0.5295	0.0994	0.00980
9 ***C. tigripes***	16	19.27	23.198	0.050	0.00250	0.00234	-0.0650	-0.150	0.4487	0.0650	0.00250
10 ***Aedes aegypti***	15	17.64	20.748	0.047	0.00221	0.00204	-0.0624	-0.144	0.4394	0.0624	0.00221
11 ***A. albopictus***	20	26.02	33.853	0.062	0.00384	0.00370	-0.0749	-0.172	0.4794	0.0749	0.00384
12 ***A. simpsoni***	10	10.00	10.000	0.031	0.00096	0.00087	-0.0468	-0.108	0.3740	0.0468	0.00096
13 ***A. africanus***	15	17.64	20.748	0.047	0.00221	0.00204	-0.0624	-0.144	0.4394	0.0624	0.00221
14 ***A. taylori***	7	5.91	4.999	0.022	0.00048	0.00041	-0.0365	-0.084	0.3205	0.0365	0.00048
15 ***A. luteocephalus***	8	7.22	6.524	0.025	0.00063	0.00055	-0.0400	-0.092	0.3402	0.0400	0.00063
16 ***A. vittatus***	6	4.67	3.633	0.019	0.00036	0.00029	-0.0327	-0.075	0.2984	0.0327	0.00036
17 ***Mansonia* spp.**	9	8.59	8.195	0.028	0.00078	0.00070	-0.0435	-0.100	0.3580	0.0435	0.00078
18 ***Psorophora* spp.**	7	5.91	4.999	0.022	0.00048	0.00041	-0.0365	-0.084	0.3205	0.0365	0.00048
Σ	*N* =321	442.66	652.303	1.000	0.09918	0.09643	-1.1275	-2.598	7.3504	1.1275	0.09918

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

Table 4: Computations for species diversity and dominance indices for mosquitoes sampled from Ketawa and Jogana irrigation fields in Gezawa Agricultural Zone, North-central Nigeria

Irrigation field	*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 = (*N* log *N* − Σ *fi* log *fi*) / *N* or −(*Pi log Pi*)	Simpson's dominance index C = Σ (*ni*/ *N*)^2
Ketawa											
1 ***Anopheles gambiae***	62	111.13	199.185	0.211	0.04452	0.04390	-0.1426	-0.328	0.5108	0.1426	0.04452
2 ***A. funestus***	30	44.31	65.457	0.102	0.01040	0.01010	-0.1011	-0.233	0.5315	0.1011	0.01040
3 ***A. pharoensis***	15	17.64	20.748	0.051	0.00260	0.00234	-0.0659	-0.152	0.4517	0.0659	0.00260
4 ***A. rhodesiensis***	4	2.41	1.450	0.014	0.00020	0.00014	-0.0259	-0.060	0.2551	0.0259	0.00020
5 ***A. coustani***	7	5.91	4.999	0.024	0.00058	0.00049	-0.0389	-0.090	0.3338	0.0389	0.00058
6 ***Culex quinqefasciatus***	31	46.23	68.949	0.105	0.01103	0.01080	-0.1028	-0.237	0.5333	0.1028	0.01103
7 ***C. pipiens pipiens***	12	12.95	13.975	0.041	0.00168	0.00153	-0.0569	-0.131	0.4183	0.0569	0.00168
8 ***x. pipiens fatigans***	19	24.30	31.069	0.064	0.00450	0.00397	-0.0764	-0.176	0.4836	0.0764	0.00450
9 ***C. tigripes***	12	12.95	13.975	0.041	0.00168	0.00153	-0.0569	-0.131	0.4183	0.0569	0.00168
10 ***Aedes aegypti***	25	34.95	48.856	0.085	0.00723	0.00697	-0.0910	-0.209	0.5165	0.0910	0.00723
11 ***A. albopictus***	21	27.77	36.713	0.071	0.00504	0.00488	-0.0816	-0.188	0.4967	0.0816	0.00504
12 ***A. simpsoni***	7	5.91	4.999	0.024	0.00058	0.00049	-0.0389	-0.090	0.3338	0.0389	0.00058
13 ***A. africanus***	12	12.95	13.975	0.041	0.00168	0.00153	-0.0569	-0.131	0.4183	0.0569	0.00168
14 ***A. taylori***	11	11.45	11.929	0.037	0.00137	0.00128	-0.0530	-0.122	0.4021	0.0530	0.00137
15 ***A. luteocephalus***	12	12.95	13.975	0.041	0.00168	0.00153	-0.0569	-0.131	0.4183	0.0569	0.00168
16 ***A. vittatus***	7	5.91	4.777	0.024	0.00058	0.00049	-0.0389	-0.090	0.3338	0.0389	0.00058
17 ***Mansonia* spp.**	2	0.60	0.181	0.007	0.00005	0.00002	-0.0151	-0.035	0.1723	0.0151	0.00005
18 ***Psorophora* spp.**	5	3.49	2.443	0.017	0.00029	0.00023	-0.0310	-0.069	0.2822	0.0310	0.00029
Σ	*N* =294	393.81	557.655	1.000	0.09569	0.09222	-1.1307	-2.603	7.3104	1.1307	0.09569
Jogana											
1 ***Anopheles gambiae***	51	87.09	148.705	0.186	0.03460	0.03409	-0.1359	-0.313	0.5262	0.1359	0.03460
2 ***A. funestus***	21	27.77	36.713	0.077	0.00005	0.00561	-0.0857	-0.197	0.5062	0.0857	0.00005
3 ***A. pharoensis***	17	20.92	25.738	0.062	0.00384	0.00364	-0.0749	-0.172	0.4794	0.0749	0.00384
4 ***A. rhodesiensis***	6	4.67	3.633	0.022	0.00048	0.00040	-0.0365	-0.084	0.3204	0.0365	0.00048
5 ***A. coustani***	7	5.91	4.777	0.025	0.00063	0.00056	-0.0400	-0.092	0.3402	0.0400	0.00063
6 ***Culex quinqefasciatus***	25	34.95	48.822	0.091	0.00828	0.00802	-0.0947	-0.218	0.5228	0.0947	0.00828
7 ***C. pipiens pipiens***	15	17.64	20.748	0.055	0.00303	0.00281	-0.0693	-0.159	0.4627	0.0693	0.00303
8 ***x. pipiens fatigans***	21	27.77	36.713	0.077	0.00593	0.00561	-0.0857	-0.197	0.5062	0.0857	0.00593
9 ***C. tigripes***	17	20.92	25.738	0.062	0.00384	0.00364	-0.0749	-0.172	0.4794	0.0749	0.00384
10 ***Aedes aegypti***	17	20.92	25.738	0.062	0.00384	0.00364	-0.0749	-0.172	0.4794	0.0749	0.00384
11 ***A. albopictus***	15	17.64	20.748	0.055	0.00303	0.00281	-0.0693	-0.159	0.4627	0.0693	0.00303
12 ***A. simpsoni***	2	0.60	0.181	0.007	0.00005	0.00003	-0.0151	-0.035	0.1723	0.0151	0.00005
13 ***A. africanus***	9	8.59	8.195	0.033	0.00109	0.00096	-0.0489	-0.113	0.3840	0.0489	0.00109
14 ***A. taylori***	17	20.92	25.738	0.062	0.00384	0.00364	-0.0749	-0.172	0.4794	0.0749	0.00384
15 ***A. luteocephalus***	13	14.48	16.131	0.048	0.00230	0.00209	-0.0633	-0.146	0.4426	0.0633	0.00230
16 ***A. vittatus***	12	12.95	12.975	0.044	0.00194	0.00176	-0.0597	-0.137	0.4293	0.0597	0.00194
17 ***Mansonia* spp.**	7	5.91	4.777	0.025	0.00063	0.00056	-0.0400	-0.092	0.3402	0.0400	0.00063
18 ***Psorophora* spp.**	2	0.60	0.181	0.007	0.00005	0.00003	-0.0151	-0.035	0.1723	0.0151	0.00005
Σ	*N* =274	350.25	466.251	1.000	0.07745	0.07990	-1.1588	-2.665	7.5057	1.1588	0.07745

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), $(ni/N)^2 = (Pi)^2$

A. funestus complex (7.0 %) was sparse in the field, except the irrigation ditches, during the dry season. *An. funestus* had earlier been incriminated as the major malaria vector in the savannah areas in Nigeria (Service, 1963). This is in contrast with our result but we opine that the phenomenon of 'climate change' might be a common factor responsible for the observed variation. Faye (1995) reported that reduced precipitation and drought adversely affected the population dynamics of *A. funestus*. The Presence of *C. quinquefasciatus, C. fatigans, A. aegypti* and *A. albopictus* is worrisome, as these have been earlier identified as potential vectors of yellow fever in Nigeria (Bang, *et al*., 1980; Bang, *et al*., 1981). It is important to note that these mosquito vectors were recovered in both the millet and guinea corn fields and from irrigation ditches throughout the year; therefore their public health significance need not be overemphasized. The study incorporated the surveillance of irrigation ditches because each millet and guinea corn field was juxtaposed to an irrigation ditch where some other minor crops were grown. All the mosquitoes encountered in this study were found breeding in the irrigation ditches, an indication that the over 70% of farmers who carry out more than 80% of their daily activities in the fields were exposed to the risk of mosquito bites. Computations used for diversity and dominance indices for Gezawa Irrigation Zone; Gezawa-1 and Gezawa-2; Ketawa and Jogana irrigation fields are shown in Tables 2, 3 and 4 respectively. These Tables also summarized the diversity and dominance indices for Gezawa as a whole, and each of the four irrigation fields, respectively. A Shannon-Wiener and Simpson's diversity values of 1.1431 and 0.0925 were recorded for the mosquito species in Gezawa Agricultural Zone. *A. gambiae* had the highest frequency of occurrence followed by *C. quinquefasciatus*. *A. gambiae* had the highest Shannon-wiener diversity and Simpson's dominance indices of 0.1415 and 0.0427 respectively. Shannon-Wiener diversity and Simpson's dominance indices for Gezawa-1 (1.1121, 0.1006), Gezawa-2 (1.1275, 0.0992), Ketawa (1.1307, 0.0957) and Jogana (1.1588, 0.0775) were recorded in this study. There was a close similarity in the respective diversity and dominance indices in the four irrigated fields. Statistical *t*-test was used to confirmed no significant difference in the diversity and dominance indices between mosquito samples from the four irrigation fields (P>0.001). Since the presence of these vectors is of apparent danger to public health, much attention should therefore be targeted at vector control in the irrigation fields to complement the on-going provision of ACTs and ITNs in the farming communities of Gezawa LGA.

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