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Spatio-Temporal Distribution of Two Cytospecies of Adult Host-Seeking Black Fly (*Simulium damnosum*) in Delta State, Nigeria

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Abstract: The black fly (*Simulium damnosum*) is the vector of onchocerciasis which is currently regarded as one of the neglected tropical diseases in Nigeria. Current global climate changes are being said to influence the distribution and the rate of spread of this disease vector. This research was conducted to identify the current habitat distribution of two cytospecies of the adult *Simulium* fly in Delta State, Nigeria. Adult black flies were caught using human attractants each day at the peak biting periods of morning and dusk once weekly; over a period of one year from three local government areas in Delta state. The trapped species were described and classified *in situ* using standard morphological keys and the collected data were analyzed statistically to reflect the annual population dynamics and seasonal species distributions. A marked disparity in the spatio-temporal distribution of the caught *Simulium* was noticed in the different locations. Two species: the forest dwelling species (FDS) and savannah dwelling species (SDS) were identified. The FDS were more abundant than the SDS in the three studied locations: Aganiki Camp, Oshimili North LGA (Mean 59.8: 12.3; ±47.5), Ugbodu, Aniocha North LGA (Mean 45.1: 10.7; ±34.4) and Umute, Aniocha South LGA (Mean 27: 7.9; ±19.1). Aganiki Camp has the highest number of the flies (total=867; monthly Mean=72) followed by Ugbodu (total=669; with monthly Mean=55.8) and the least Umute (total=424; with a monthly Mean of 35). The species distribution was significant $F=4.844$, $(P<0.05)$. The average monthly population was 163; the distribution peaked in August (242) and ebbed in March (110). Overall, the FDS (Mean=132.3) were more abundant than the SDS (Mean=30.9); with a range value of ±101.4. It is critical that two cytospecies of the *Simulium* fly: FDS and SDS exist in the study area with significant presence all the year round. This will predictably make the transmission occurrence and intensity of the disease an annual event and therefore has the implications for a strengthened all the year round preventive measures and sustainable intervention approaches.

Keywords: Aniocha North, Aniocha South, Oshimili North, Forest Dwelling, Savannah Dwelling, Cytospecies

1. Introduction

The black fly (*Simulium damnosum*) is the vector of onchocerciasis also known as river blindness. Due to the possibility of resurgence [1] and lack of epidemiological updates [2, 3] onchocerciasis can currently be regarded as one of the neglected tropical diseases [4] in Nigeria. There are indications that climate change, global warming and habitat destructions are presently causing increase in the rate of spread of tropical diseases and vectors to higher altitude. Onchocerciasis happens to be one of such tropical diseases. The disease vectors are known to breed in fast flowing streams and rivers which are becoming common due to climate changes. And as the epidemiology of onchocerciasis depends on availability of suitable local ecosystem for successful breeding [5]; this has predictably created more lucrative breeding grounds for this disease vector.

The population dynamics and the distribution of various species of adult *Simulium* flies are dependent on many factors. Some are influenced by climatic changes in wind

movement and river water level [6] while some are by seasonal variations [7]. A study has indicated that the construction of dams and irrigation schemes for agricultural purposes has affected black fly breeding and distribution [7, 8]. And according to Rory *et al.,* "distributional changes have been recorded as a consequence of vector control and environmental change (e.g. deforestation), with potential disease consequences" [9]. Generally speaking, the distribution of the adult black fly is primarily dependent by the geology of the country, which determines the areas of suitable breeding rivers [6]. There are however, dissensions in opinion whether altitude, vegetation and climate appear do play key roles in the population distribution of the fly except for the obvious situation in the far north. For instance, absence of the fly from the far north is more certainly attributable to the absence of suitable breeding grounds.

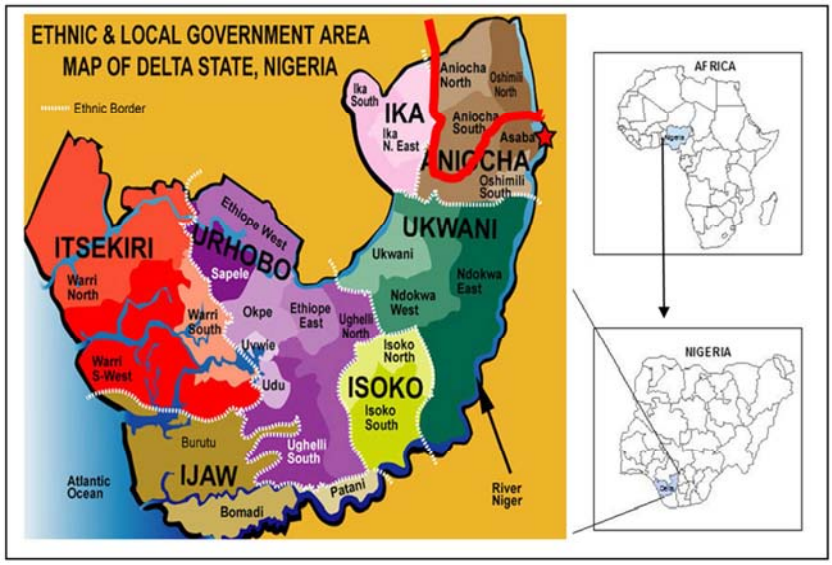
Another key area in the population dynamics of the adult *Simulium* fly is stability in the population distribution in the light of natural and human related changes over the world. A study in Ghana has indicated that the distributions of a particular species of the adult black fly have not been stable from 1971 to 2011 possibly due to vector control, migration patterns, and deforestation [9]. In a recently published Nigeria master plan for Neglected Tropical Diseases (NTDs) 2013 - 2017, onchocerciasis was one of foremost diseases sited as being neglected in this country. According to the report, climate change, global warming caused by the greenhouse effects, and the resulting increase in global temperatures are possibly causing tropical diseases and vectors to spread to higher altitudes in mountainous regions, and to higher latitudes that were previously spared. All these indicate that there is no more a regular pattern in the population distribution due to the current climatic conditions [10]. The prevalence of the disease has been inadequately documented especially in the rain forest zone [11]. In Delta State, Nigeria the presence of the black flies and availability of fast flowing water bodies have been reported; and even emerging in new areas; whereas baseline data on onchocerciasis is still considered fragmentary [2, 3] (Nmorsi *et al*, 2002 and Emina and Okaka, 2004). This research work was therefore conducted to identify and characterize current population distribution of two cytospecies of the adult *Simulium* flies in the onchocerciasis endemic areas of Delta State, Nigeria.

2. Materials and Methods

2.1. Study Area

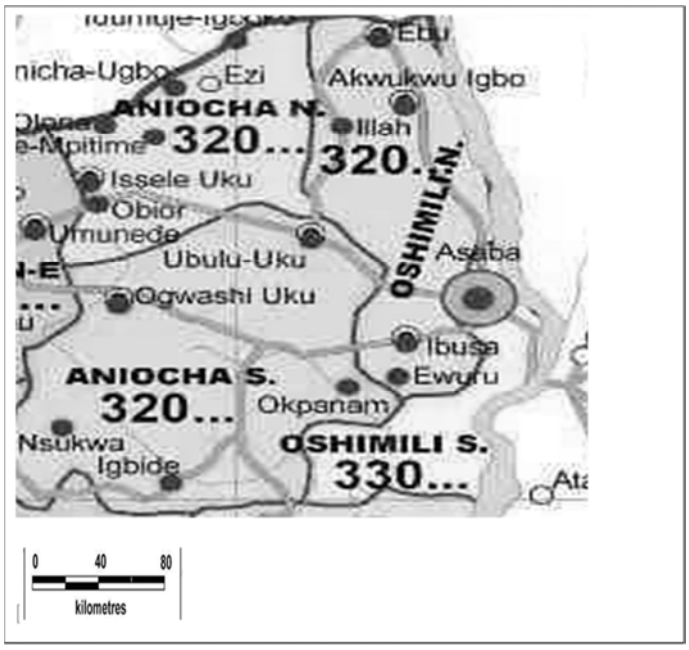
This study was carried out in the North Senatorial District of Delta State, Nigeria. The study area comprise of three contiguous local government areas namely, Oshimili North, Aniocha North and Aniocha South. The study area lies roughly between longitude 6° 10^{1} and 6°45^{1} East and Latitude 6° 5^{1} and 6° 30^{1} North and has a tropical climate marked by two distinct seasons: the dry and rainy seasons. The dry season occurs between November and March, while the rainy season begins in April and lasts till October. There exists a brief dry spell in August commonly referred to as "August break". From December to February, the dry harmattan wind blows over the area. The average annual rainfall which is mostly convectional peak in July is about 190.5cm [12].

The map of Delta State and its twenty five local government areas (LGAs) and which captures the three studied LGAs; Aniocha North, Aniocha South and Oshimili North are also shown in figure 1. Figure 2 is a detailed presentation of the studied LGAs and some of their notable communities.



[13] Source: Direcrate of Lands and Surveys, Delta State Nigeria, Govemors Office, Asaba (2017).

Figure 1. *The map of Delta State showing its twenty LGAs as well as the three studied LGAs- Aniocha North, Aniocha South and Oshimili North delineated by a red line.*



[13] Source: Directorate of Lands and Surveys, Delta State Nigeria Govemors Office, Asaba (2017).

Figure 2. *A detailed view of the three studied LGAs in Delta State, Nigeria; showing some important communities.*

2.2. Data Collection

Data were collected from three communities namely Aganiki camp (Oshimili North LGA), Ugbodu (Aniocha North LGA), and Umute (Aniocha South LGA). These three communities have fast flowing streams splashing down from elevated topography which are potential breeding habitats for the *Simulium* flies [2, 3]. Ethical permit for the study was obtained from Delta State Ministry of Health, Asaba, Nigeria. Permission was also solicited from the community heads during which the purpose of the research work was explained through a local interpreter where necessary.

2.2.1. Trapping and Identification of the Adult Simulium Fly

The first phase of the work involved catching live adult blood seeking Simulium flies using human attractants. Two human attractants were stationed at a location few meters from the breeding sites of *S. damnosum*; between 700 and 1100 as well as 1500 and 1800 hours local time once a week for four weeks, making a total of four days of catching each month. The average for each month was then obtained to get monthly catches. Any fly perching on them was caught before it fed by inverting a small glass tube over it. The caps of the tube were then immediately replaced as described in line with standard methods. [14].

The second phase of the work involved the identification and classification of the adult females of *S. damnosum* flies. This was done immediately on the field with the aid of a microscope using taxonomic keys [15]. The flies caught, were classified as either forest-dwelling group or savannah dwelling group based on the color of certain morphological characteristics which include wingtuft, fore-coxa, arculus, antennae, 9th abdominal segment setae, and soutella setae as described by Rory *et al.,* and Wilson *et al.,* [8, 14]. A *Simulium damnosum* s.l. with a pale color for all the morphological characters mentioned above was classified as a member of savannah dwelling group while a fly with a dark color for any of all of the morphological characters was classified as a forest dwelling fly. Flies that were not identified in the field due to poor visibility were preserved in cotton wool soaked in fresh water and transported to the laboratory where they were later identified as described above.

2.2.2. Data Analysis

The third phase of the study is aimed at establishing the Spatio-temporal distribution of the adult flies. To do this the population dynamics of the caught *Simulium* flies were organized to reflect their seasonal or monthly distribution with respect to their local habitats using a table. Microsoft Excel 2010was used to present the Spatio-temporal variation in line graph and compute a two way ANOVA significant test to ascertain the distribution toe studied species of the Simulium flies.

3. Results

The result showed a marked disparity in the population distribution of *Simulium* species caught in the different locations. Aganiki Camp in Oshimili North LGA has the highest number of the flies (total=867; with a monthly Mean of 72). This was followed by Ugbodu in Aniocha North LGA (total=669; with a monthly Mean of 55.8) and the least being Umute in Aniocha South LGA (total=424; with a monthly Mean of 35); (see Table 1).

The Monthly Population Distribution

The average monthly population was 163.2 (±53.2 and

±78.8 from the lowest and highest monthly population respectively). Overall, the temporal distribution was highest in the month of August (total=242) and lowest in the month of March (110); (see Table 1).

Table 1. *The monthly population distribution of two cytospecies of host seeking adult Simulium flies caught in three studied locations in three LGAs in Delta State, Nigeria.*

Location:	Species Caught	Jan	Feb	Mar	Apr	May	Jun	Jul
1. Ugbodu (Aniocha North)	Forest dwelling	32	28	21	34	42	52	71
	Savannah dwelling	14	13	15	10	11	8	8
	Monthly total	46	41	36	44	53	60	79
2. Umute (Aniocha South)	Forest dwelling	25	16	15	28	24	26	33
	Savannah dwelling	12	10	13	7	6	7	3
	Monthly total	37	26	28	35	30	33	36
3. Aganike camp (Oshimili North)	Forest dwelling	34	30	28	36	54	74	79
	Savannah dwelling	18	16	18	8	12	8	9
	Monthly total	52	46	46	44	66	82	88
Total	Forest dwelling	91	74	64	98	120	152	183
	Savannah dwelling	44	39	46	25	29	23	20
	Monthly total	135	113	110	123	149	175	202

Table 1. *Continued.*

Location:	Species Caught	Aug	Sept	Oct	Nov	Dec	Total	Mean
1. Ugbodu (Aniocha North)	Forest dwelling	68	62	41	42	48	541	45.1
	Savannah dwelling	5	7	13	10	14	128	10.7
	Monthly total	73	69	54	52	62	669	55.8
2. Umute (Aniocha South)	Forest dwelling	36	47	32	26	21	329	27
	Savannah dwelling	5	7	6	8	11	95	7.9
	Monthly total	41	54	38	34	32	424	35
3. Aganike camp (Oshimili North)	Forest dwelling	122	89	72	50	49	717	59.8
	Savannah dwelling	6	8	12	17	16	148	12.3
	Monthly total	128	97	84	67	65	867	72
Total	Forest dwelling	226	198	145	118	118	1587	132.3
	Savannah dwelling	16	22	31	35	41	371	30.9
	Monthly total	242	220	176	153	159	1958	163.2

Two species of the *Simulium* flies were identified in this work namely: the forest dwelling species and savannah dwelling species. The forest dwelling species were more abundant than the savannah species in the three studied locations: Aganiki Camp, Oshimili North LGA (Mean 59.8: 12.3; ±47.5), Ugbodu, Aniocha North LGA (Mean 45.1: 10.7; ±34.4) and Umute, Aniocha South LGA (Mean 27: 7.9; ±19.1); see Table 1. The abundance was lowest in Umute. Overall, the forest dwelling species (Mean=132.3) were more abundant than the savannah dwelling species (Mean=30.9); with a range value of ±101.4 and the distribution was significant *F=4.844, (P<0.05).*

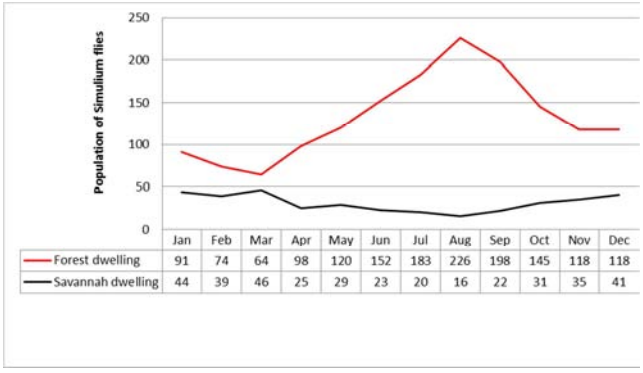


Figure 3. *Annual temporal distribution of Simulium species caught in three local government areas in Delta State, Nigeria.*

The monthly distribution pattern of both the forest and savannah species of the blackfies is represented by figure 3. The forest species abundance peaked in August and has the lowest ebb in March. On the other hand, the savannah species were more abundant in March and has the lowest ebb in August of the same year.

4. Discussion

4.1. The Abundance of the Cytospecies

This work has identified the presence of two cytospecies of *Simulium damnosum* namely: the forest dwelling and savannah dwelling species in this onchocerciasis endemic region of Delta state, Nigeria. It has also shown that the population dynamics of the adult host seeking species of the flies was influenced by some factors which include climate, topography and altitude. The abundance of forest species was influenced by rainfall as it increased with heavy rainfall and reduced with decreased precipitation [16]; see Figure 3. The population of the savannah dwelling species also fluctuated with the rains but however, decreased with high precipitation and vice versa. This showed that the study area being a rain forest bioclime is more favorable to the forest dwelling group especially during the rainy season than the savannah dwelling *Simulium* flies. The abundance of the savannah dwelling species was favoured more by dry weather while the forest dwelling by increased rainfall; (figure 3). This no doubt has the implication for the transmission intensity of different

strains of *O. volvulus* in time and space [17]; since the abundance of the different species fluctuate with the season.

The abundance of the black flies in the study areas was also influenced by topography and altitudes. The LGAs and locations with a higher altitude produced the highest number of the black flies. Aganiki Camp in Oshimili North LGA (with a monthly Mean of 72) and Ugbodu in Aniocha North LGA (with a monthly Mean of 55.8) had a higher number of the flies than Umute in Aniocha South LGA (with a monthly Mean of 35). It is worthy of note that the three locations are all in the rainforest and within the same latitude; but the fact still remains that Aganiki camp and Ugbodu are farther to the north than Umute which is south to them, (see Figures 1 and 2). This no doubt brought about the higher abundance of the *Simulium flies* in the first two than the third location.

4.2. The Seasonal Population Distribution

This study showed that the population of the *Simulium* flies was higher in the rainy season than dry season. The implications of this are that the chance of being bitten by a blackfly was higher in the rainy season than the dry season, because the fly-to-man ratio was higher. The chances of the flies picking up microfilariae from infected humans was equally higher in the rainy season, thus onchocerciasis transmission rate as revealed in a similar study will predictably be higher in the rainy season in the study area [12]. However, it is pertinent to point out that this is particularly true of non blinding strain of *O. volvulus* since it is the type mostly transmitted by the forest dwelling black flies [17], which are predominant in the study area. Although, the researchers generally encountered fewer savannah dwelling black flies in the present study, these flies appeared to be better favoured by dry season condition than the rainy season. The implication of this is that the savannah dwelling species are most likely to transmit the blinding strain of *O. volvulus* no matter how few the numbers of cases [17]. This fact will predictably make the transmission intensity of the disease an annual event since both species are present all the year round. While the forest dwelling species are very much available to bite and transmit the microfilaria in the rainy season; the savannah dwelling species will predictably continue the transmission in the dry season.

5. Conclusion

Simulium damnosum is the commonest strain of black fly that transmits the onchocerca pathogen *O. volvulus* in Delta State, Nigeria. Many communities in the Delta North have been seen to harbor these flies due to their hilly and higher altitude topographies when compared to the lower altitude Niger Delta zones. This factor together with the current global climate change has exacerbate the distribution of the black flies in this region as this study has brought out. Unpredictable rainfall and sunshine has occasioned the presence of the black flies all the year round in this studied region. This has the implications for strengthened all the year round preventive measures, sustainable intervention approaches including vector control using larvicides to reduce the fly population accompanied by the mass treatment with Ivermectin in order to minimize the risk of the disease transmission and further spread.

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