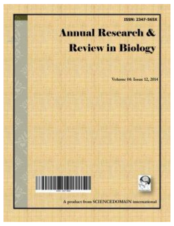

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Observations on Onchocerciasis Transmission in Parts of Middle Imo River Basin, Nigeria after Repeated Treatment with Ivermectin

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Authors' contributions

This work was carried out in collaboration between all authors. Authors AAA, JII and MN designed the study, performed the statistical analysis and wrote the protocol. Author AAA wrote the first draft of the manuscript. Authors AAA, JII and CU managed the analysis of the study. Authors FUN and JII managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Onchocerciasis is both public health hazard and socio-economic problem despite concerted efforts and high expenditure on control programme. To assist with certification of elimination, cross sectional study was conducted at Ibii and Lolo Rivers, breeding sites of *Simuluim damnosum* in the Imo River Basin from September 2015 to February 2016. *S. damnosum* were caught by human bait technique and assessed for parity, infection and infectivity status. Biting rates and transmission potentials were calculated by standard methods. Of the 591 flies caught/dissected, 0.88% (5/591) were infected with sausage (L_1) and pre infective stage (L_2) but no infective stage (L_3). The distribution of *O. volvulus* at the two sites were insignificant (P>0.05). The diurnal biting activity exhibited a bimodal pattern with morning (9.00am and 10.00am) and evening (4.00pm and 5.00pm) peaks. Monthly biting rates (MBR) of 2,581 and 1877.25 bites / persons/ months were found for Ibii

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and Lolo Rivers respectively. The monthly transmission potentials (MTP) for the two stations were zero, indicative of extremely low transmission. The public health implications of these findings are discussed in the context of the on going Community Directed Treatment with Ivermectin (CDTI) and elimination strategy of onchocerciasis in the state.

Keywords: Onchocerciasis transmission; black fly vector; ivermectin treatment.

1. INTRODUCTION

Onchocerciasis caused by filarial worm, *Onchocerca volvulus* is both public health hazard and socioeconomic problems in affected countries despite a concerted effort and high expenditure on control programmes. In Nigeria it is transmitted by *Simulium damnosum* complex [1,2]. Edungbola [3] reported that Nigeria has the largest number of persons with Onchocerciasis accounting for about a third of the global prevalence. About 7 million are infected, 1.5 million blind and 40 million at risk [4]. Mass drug administration (MDA) with ivermectin is the WHO recommended strategy for the control of Onchocerciasis [5]. Ivermectin is a microfilaricide that also has a limited effect on the viability and reproductive capacities of the adult onchocercal worms; females are able to regain their ability to produce microfilariae three to six months after ivermectin treatment [6]. Thus, repeated treatment is needed to suppress the manifestations of the infection overtime with recent evidence suggesting 5 to 15 years depending on treatment strategy [7].

In Nigeria recent efforts have been directed at establishing baseline data (on the prevalence, intensity and distribution of the disease) aimed at prioritizing control efforts. The Federal Ministry of Health through the National Onchocecasis Control Programme (NOCP) and Africa Programme for Onchocerciasis Control (APOC) are using Community Directed Treatment with Ivermectin (CDTI) approach. This establishment has led to research into the epidemiology [8-10] and transmission [1,11,12] in Nigeria. It was thought that mectizan clearance of *O. volvulus* microfilaria in human will disrupt the transmission chain and subsequently lead to gradual clearance of infective larval load by the vector. Epidemiological studies conducted prior and during the large scale distribution of Ivermectin in communities within the vicinity of some of the streams and rivers, confirmed endemicity of the disease at various levels [13,14]. However, vector activities including biting rates and transmission potentials of the disease by the fly from the endemic areas are rarely reported [11,15] especially in the Imo River Basin of South East, Nigeria.

In Imo State, Rapid Epidemiological mapping of onchocerciasis (REMO) had placed the study areas in the hyper endemic zone [10] and treatment with ivermectin had been on going from 1994 till date. However, the coverage had declined progressively in the number of eligible persons receiving mectizan each year in the endemic communities [16]. Prior to the initiation of this control, pre-control entomologic record of *O. volvulus* by the vector population was unknown. Besides there was paucity of data on the infection of black flies in the area despite prevalence of larvae and pupae report [17]. Certification of elimination by entomologic assessment to complement parasitological studies has become imperative. This study was therefore structured to obtain baseline data for evaluation of infection rates and quantify the effectiveness of drug control program in the study area.

2. MATERIALS AND METHODS

2.1 Study Sites and Selection

The study was conducted on the river banks of a section of Ibii River and Lolo River in two rural communities (Umulolo and Amuro), Okigwe LGA Imo State, Nigeria from September 2015 to February 2016. The section of Ibii River is located within the National Horticultural Institute (NIHORT). These sites; Umulolo (Lat 05.85794 N and Long 007.26703 E) and Amuro (Lat 05. 85794 N and Long 007. 26703 E) are drained by the Imo River, known breeding sites of the *Simulium* vector. It falls outside the middle Imo River Basin and had earlier been placed as hyper endemic [10]. They had received yearly doses of ivermectin for over 10 years. The study area has been described in details [8]. In brief, it lies in the tropical rainforest belt of southern Nigeria characterized by 2 distinct seasons; the rainy season (from April to November) and dry season (from December to March) with rainfall and temperature between 1700 2200 mm and 20°C to 38°C (mean 29°C) respectively. The villagers are mainly Christians engaged in occupational activities such as farming, fishing, hunting, palm wine tapping and petty trading. Advocacy visits was made to the study communities and the health facilities a week before the study commenced. This enabled the research team to sensitize the stakeholders.

2.2 Ethical Consideration

As part of Carter Centre South East stop MDA decision programme, the Imo State Ministry of Health and Post Graduate Board of Zoology Department Imo State University Owerri approved the study. Informed consent was obtained from individuals and the communities involved.

2.3 Adult Black fly Collection

Biting adult females were caught by human bait along the bank of “Lolo” river from Amuro and “Ibii” river from Umulolo. Each station was sampled four times a month and fly catching was between 7.00 am and 6.00 pm by two fly collectors working alternatively [18]. Each fly collector was dressed in short-sleeved shirt, knickers and no shoes and was seated or standing in shade. Any fly perching on the uncovered body parts was caught before they probe by inverting a small glass tube over it. The caps of the tubes were then immediately replaced. All tubes containing flies were then immediately labeled to show time, date and place of capture. Each fly was caught in a different tube. All captured flies were packed in a cold box containing ice packs to stop further micofilariae development in the flies before they were taken to the laboratory.

2.4 Morphological Identification

The morphological identification was done using [19] criteria. Adult flies were identified morphologically as savanna or forest species on the basis of colour of some anatomical pats of the fly viz the wing tuft, arculus, fore coxa and basal segments of the antenna as either pale for savanna or dark for forest species.

2.5 Dissection and Assessment of Parity, Infection and Infectivity Status

Standard protocol for dissection of black flies was adopted [20]. Flies were inactivated individually with chloroform and then placed on a clean glass slides containing a drop of physiological saline. Flies were denoted as parous or nulliparous (if they had not completed at least one gonotrophic cycle). Parous flies were further dissected to determine if they haboured stages of microfilariae in different anatomical sites (head, thorax and abdomen). The number of sausage-shaped larvae (L_1) pre-infective (L_2) and infective (L_3) of *Onchocerca* species found were counted and their stages of development at these sites recorded.

2.6 Entomological Indices (Biting and Transmision)

The fly density and level of transmission of onchocerciasis were quantified by two entomologic indices; the monthly biting rates and transmission potentials. The monthly biting rates (MBR) were measured as the theoretical black fly bites received by a person stationed at a catching site during the 11 hours (7:00 am to 6.00 pm) of the daylight for one month in a given community. The monthly transmission potential (MTP) was established as a total number of infective larvae (L_3) that would be received in one month by an individual stationed at a capture point for 11hours of the daylight. Entomological indices were evaluated by established methods [18].

2.7 Data Analysis

The monthly relative density of *S. damnosum* from the two sites was subjected to two way analysis of variance (ANOVA) and the difference in infection rate evaluated by Chi Square test. Prevalence was calculated as simple percentages. Probability level of <0.05 was considered significant.

3. RESULTS

3.1 Relative Abundance and Monthly Distribution of *O. volvulus*

A total of 591 (341 at Ibii and 250 at Lolo) adult females *S. damnosum* were caught and examined for larval stages of *O. volvulus* during the 6 months study. Of this, 0.85% (5/591) were found to be infected though population of *S. damnosum* varied between the seasons, the distribution of *O. volvulus* in *S. damnosum* in the two sites showed no significant difference (P>0.05) (Table 1). The highest prevalence

(2.59%) was recorded in the month of October followed by the month of November (1.54%) while other months had no infection.

3.2 Diurnal Biting Rate of Parous Flies

The diurnal biting rate from the 2 sites is shown in Fig. 1. The biting cycle showed a bimodal peak of activity with morning (9.00 am and 10.00 am) and evening (4.00 pm and 5.00 pm) peaks.

3.3 Monthly Biting Rates

The monthly biting rates (MBR) of black flies in the sites were established for each month of the study period (Fig. 2, Table 2). The peak MBR was September (727.5 bites/person/month versus 502.5 bites/person/months) while the lowest MBR was recorded in February. A comparison of the MBRs showed that there was a significant difference between September and February MBRs ($P<0.05$). While September had no significant higher number than February, there was no significant difference in the biting rates between other months by LSD mean separation techniques.

3.4 Monthly Transmission Potential (MTP)

All the 591 flies caught were dissected to assess entomologic indices of *O. volvulus* (Table 2). At Ibii River in Umulolo 349 (57.69%) flies were dissected, 71.68% (243) were parous. A total of 3 (0.88%) of the parous flies were infected (with L_1 and L_2 larvae) with *O. volvulus* while none was infective. The monthly entomologic parameters of transmission at Lolo River in Amuro shows that, of a total of 250 flies dissected, 67.20% (168) were parous. 2 (0.88%) of the parous flies were infected and none had infective larvae (L_3 in the head) throughout the study (Table 2). Overall, in both sites, the percentage monthly black fly parity rates were high (above 50%) and MTP for the 6 months were zero.

Table 1. Monthly distribution of *O. volvulus* in *S. damnosum* in the study Area

Months	No of black flies Caught/dissected	No (%) infected	Relative percentage (%)
September	164	0(0.00)	0.00
October	116	3(2.59)	60.00
November	130	2(1.54)	40.00
December	84	0(0.00)	0.00
January	58	0(0.00)	0.00
February	39	0(0.00)	0.00
Total	**591**	**5(0.85)**	**100.00**

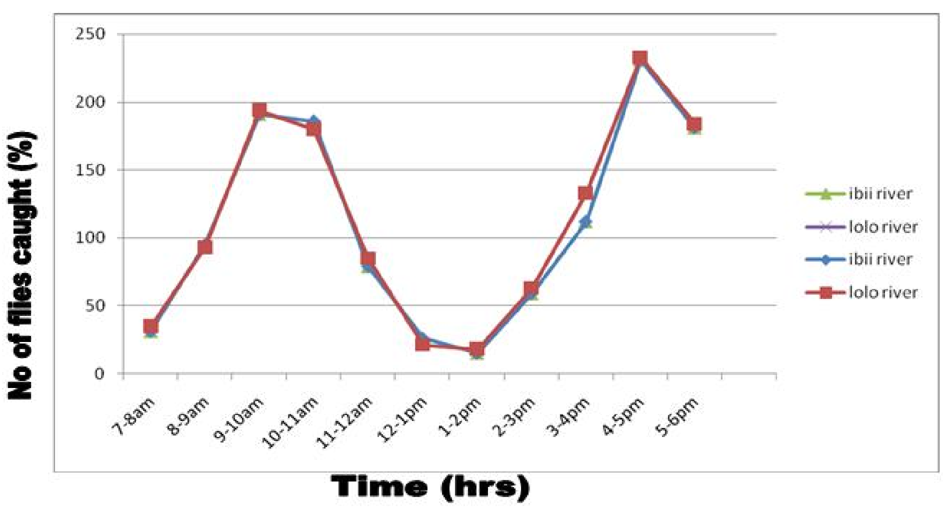

Fig. 1. Diurnnal biting rate of *S. damnosun* at the two stations (Ibii river and Lolo river)

Table 2. Summary of transmission indices of *S. damnosm* in the stations

Classification of data	Ibii river	Lolo river	Total
Persons day worked	4	4	8
Total (%) flies caught	349(57.69)	250(42.30)	591
Average daily catch per person	85	63	148
No (%) flies dissected	349(57.69)	250(42.30)	591
No (%) of parous flies	243(71.68)	168(67.20)	411
No (%) of Nulliparous flies	96(28.32)	84(33.60)	180
Total (%) of flies infected	3(0.88)	2(0.80)	5
Flies (%) with L_1 and L_2	3(0.88)	2(0.80)	5
Flies (%) with L_3	0(0.00)	0(0.00)	0
Monthly Biting Rate (MBR)	2581	1877.25	4458.25
Maximum monthly biting rate	727.5(Sept)	502.5(Sept)	1,230
Minimum monthly biting rate	131.75(Feb)	170.5(Feb)	302.25
Monthly Transmission Potential (MTP)	0	0	0

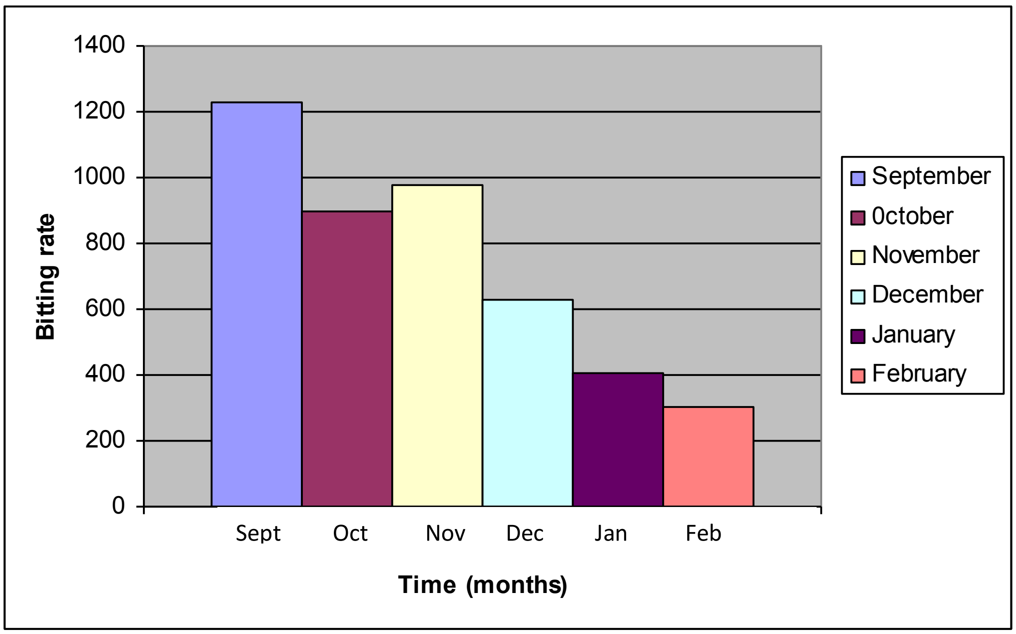

Fig. 2. Overall monthly biting rates of black flies in the study sites

4. DISCUSSION

Assessment of potential onchocerciasis vectors and their infection levels by capture and dissection is advantageous and non-insidious means of assessing the success of control measures [21]. The degrees of transmission of *O. volvulus* in the sites were measured by evaluating the entomologic indices of transmission after repeated ivermectin intervention. Although the population of adult black flies are usually difficult to estimate (due to different sampling methods), we found seasonal variation in their relative abundance at the two sites. More flies were caught during rainy season (September - November) than the dry season population (December - February) as observed by previous studies [12,22,23]. The variation could be attributed to increased oxygen content of water during the rainy season which causes flies to emerge from pupae. Also, increased availability of pre-imaginal sites which help pre-imarginal development could results in an increase in the adult population [Nwoke, pers.com]. The rainy season is known to be accompanied by flooding and phytoplankton blooms [24]. The latter forms food requirement by *S. damnosun* larvae development [22].

The biting activity which exhibited a bimodal pattern with early morning (9.00 am and 10.00 am) and evening (4.00 pm and 5.00 pm) as observed elsewhere [2,25] differs from the uni modal activity pattern reported in Liberia [26]. Although this phenomenon is poorly understood, an innate clock rhythm is indicated [22]. This activity is influenced by illumination and temperature [27,2]. Probably, the bimodal peaks was due to decreased temperature and illumination during the peak periods thus of epidemiological significance. The peak biting periods coincide with peak human outdoor activity with consequent impact on human-vector contact. For example farming, fishing, collection of wild fruits, small scale trading, palm-wine tapping etc. are the occupation of the majority of the habitants.

Despite the observation on seasonal variation, no significant difference in the distribution of *O. volvulus* in the black flies monthly infection rate was recorded. Okonkwo et al. [28] and Adewale et al. [2] had made similar observation which contrasts that of Renz [23]. The MBR (maximum 1,230 and minimum 302.25) bites/person/month when compared with the tolerable levels of 1,000 bites/person/year is lower for hyper-endemic zone on treatment, hence biting nuisance by the flies. The results revealed that ivermectin could halt transmission to a level where infective larvae was undetectable by dissection. It is also remarkable that high parity status of the flies (access to blood meal and longevity to reproduce) did not reflect high transmission (L_3 in the head) rather L_1 and L_2 (infected flies), thus a success to the onchocerciasis control efforts. This is because transmission dynamics is a function of the mf becoming infective ((L_3) in the vector and perhaps, the mf density of the donors blood. Since assessment of infectivity rates was a standard for determining the level of transmission, it probably suggests possible interruption of transmission within the communities around the study area. Although no study was known to have been reported elsewhere, related study in Central Nigeria Community [14] has shown skin MF density reduction after 10 years ivermectin therapy. Both WHO and APOC entomologic criteria (for the Onchocerciasis stop MDA) requires results of at least 6,000 flies. Unfortunately, this demand is beyond our logistic capacity. We therefore recommend for new approaches for capturing flies if this guidelines are to be met by other programmes seeking to stop MDA for onchoceciasis in parts of Nigeria. By the on-going CDTI, it is evidenced that onchocerciasis patients in the community had low mf in the skin due to MDA ivermectin therapy [29]. This could explain low infection rates by the flies as they could only pick few or no mf in the blood. However, until verified by other studies these findings should be treated with caution. The number of flies was too few to support any statement about evidence of ivermectin control of onchocerciasis transmission. Further work will be needed including longitudinal studies to validate this result.

5. CONCLUSION

Conclusively, black flies abundance and infection status suggested that vector control should be complemented with the ongoing ivermectin therapy. The integrated control would enhance the success of Onchocerciasis Control Programme (OCP) and facilitate quick elimination of mf from the skin [30].

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Onwuliri COE, Nwoke BEB, Lawal IA, Iwuala MOE. Onchocerciasis in Plateau State Nigeria 11: The prevalence among residents around Assob River area. Ann Trop Med Parasit. 1987;8:49-52.
2. Adewale B, Mafe MA, Oyerinde JPO. Infectivity and transmission of *Simulium damnosum* sl. around Owena Dam (Ondo State). West Afri J Med. 1991;18(4):257-60.
3. Edungbola LD. Onchocerciasis control in Nigeria. Parasit Today. 1991;7(5):97-9.
4. Nwoke BEB. The socio-economic aspects of human onchocerciasis in Africa: present

appraisal. J. Hyg. Epid. Microbiol. Immunol. 1990;59(1):37-44.
5. WHO. Preventive chemotherapy in human helminthiasis: Coordinated use of antehelminthic drugs in control interventions: A manual for health professionals and programme managers. WHO, Geneva; 2006.
6. Basanez MG, Pion SDC, Boakes E, Filipe JAN, Churcher TS, et al. Effect of single dose ivermectin on *O. volvulus* a systemic review and meta-analysis. Lanc. Infect. Dis. 2007;8:310-322.
7. Cupp EC, Cupp MS. Short report: Impact of ivermectin community-level treatments on elimination of adult *Onchocerca volvulus* when individuals receive multiple treatments per year. Am. J. Trop. Med. Hyg. 2007;73(6):1159-1161.
8. Dozie INS, Onwuliri COE, Nwoke BEB, Anosike JC, Okoli NJC. Onchocerciasis in Imo State, Nigeria 1: The prevalence and distribution in the middle Imo River Basin, Nigeria. Nig J Parasit. 2006;27:16-22.
9. Nwoke BEB, Dozie INS. Operational research and its success in onchocerciasis control in Nigeria. Nig J Parasitol. 2001;22:3-10.
10. Nwoke BEB, Edungbola LD, Mencias BS, Njoku AJ, Abanobi OC, Nkwogu FU, Nduka FO, Oguariri RM. Human onchocerciasis in the rain forest zone of south eastern Nigeria. 1: Rapid assessment for community diagnosis in the Imo River Basin. Nig J Parasit. 1994;15:46-58
11. Chikezie FM, Ezihe EK, Uzoigwe NR, Opara KN, Igbe MA, Okonkwo NJ, Nwankwo EN, Nwoke BEB. A concise entomological evaluation of onchocerciasis transmission in Ahani-Achi community in Oji River Local Government Arear of Enugu State, Nigeria. Int. J Cur Res Rev. 2015;75.
12. Opara KN, Fagbemi OE, Ekwe A and Okenu DN. Status of forest onchocerciasis in the lower Cross River Basin, Nigeria: Entomological profile after five years of Ivermectin intervention. Am J Trop Med Hyg. 2005;73(2):371-376.
13. Adeleke MA. Mafiana CE, Sam-Wobo SO, Olatunde GO, Ekpo UF, Akinwale OR. Biting behavior of *S. damnosum* infection along Osun River South West. Nigeria. Journal. Parasit and Vect. 2010;3:1-5.
14. Uzoigwe NR, Ajayi JAA. Anyanwu GA, Onyeka JOA. Changes in prevalence of parasite intensity following ivermectin therapy against river blindeness in Women community of Nasarawa State, Central Nigeria. Nig J Para. 2012;39(2):157-161.
15. Uzoigwe NR, Anuga GA, Chikezie FM, Onweluzo IE, Uzoigwe NC. Biting density and microfilariae infection of *S. damnosum* complex around the Mada River, Nasarawa State, Nigeria. Nig. Jour. Parasit. 2015;36(2):108-112.
16. Emukah EC, Osuoha E, Miri ES, Onyenema J, Amazigo U, Obiajuru C, Osuji N, Ekeanyanwu J, Amadiegwu S, Korve K, Richards FO. A longitudinal study of Impact of repeated mass ivermectin treatment on clinical manifestations of onchocerciasis in Imo State, Nigeria. Am. J. Trop. Med. Hyg. 2004;70(5):556-561.
17. Nwoke BEB, Uwazie OU. Studies on the blackflies Simulium (Diptera: Simulidae) of Imo State Nigeria: The distribution of immature stages in Isukwuato Okigwe area. Nig J Parasit. 1991;12:29-37.
18. Walsh JF, Davis JB, Le-Berre R. Standardization of criteria for assessing the effect of Simulium control in the ongoing onchocerciasis control programme. Trans. Roy. Soc. Trop. Med. Hyg. 1978;72:675-6.
19. Nwoke BEB. Practical approach on identification and dissection of Medical Important Insects (in preparation); 2012.
20. Mokrey JE. A method of estimating the age of field collected female *Simulium damnosun* (Diptera: Simulidae). Trop Med Parasitol. 1980;31:121-4.
21. Ottesen EA, Ramachandra CP. Lymphatic filariasis infection and disease control strategies. Parasit Today. 1995;11:129-131
22. Crosskey RW. The National History of Blackflies. London museum of National History; 1990.
23. Renz A. Studies on the dynamic of transmission of onchocerciasis in the Sudan Savanna area of North Cameroon 111 infection rate of the Simulium vectors and *Onchocerca volvulus* transmission potentials. Ann Trop Med Para. 1987;81: 239-252.
24. Adebisi AA. The physico-chemical hydrology of a tropical seasonal river, upper Ogun River. Hydrobiologia 1981;79:157-165.
25. Okolo CG, Akpa AU, Okonkwo PC. Studies on vectors of onchocerciasis and Simulium species in Achi, Oji River Local

Government Area, Enugu State, Nigeria. Nig J Ento. 2004;21:84-93.
26. Barbiero VK, Trips M. Transmission of onchocerciasis by local blackflies on the firestone rubber plantaion harbel, Liberia. Am J Trop Med HYg. 1984;33:586-94.
27. Nwoke BEB. Studies on the field Epidemology of human onchocerciasis on the Jos Plateau, Nigeria. The effects of climatic factors on the diurnal biting behaviours of *Simulium damnosum* (Theobald) (Diptera: Simulidae). Insect. Sci Appl. 1988;91:323-328.
28. Okonkwo P, Apka A, Ihekwaba A, Nwagbo D, Umeh R, Adibua S, Ezike V, Ogbuokiri J. Studies on onchocerciasis in forest Savannah-Mosaic areas of Nigeria 1: Investigation in Gbaragu, Oji River. Ann Trop Med Parasit. 1991;85:617-623.
29. Taylor HR, Pacque M, Munoz B, Green BM. Impact of mass treatment on onchocerciasis with Ivermectin on transmission of infection. Sci. 1990;250: 116-118.
30. Schulz-key H, Heuschkef C, Bania M. Long term efficacy of Ivermectin on *Onchocerca volvulus*. Ann Trop Med Parasit. 1989;40:493-494.

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