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Transmission dynamics of *Simulium damnosum* in rural communities of Akwa Ibom State, Nigeria

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Abstract

Background & objectives: Onchocerciasis is endemic in some parts of Akwa Ibom State, Nigeria. This study describes the entomological parameters of transmission in three rural communities of Akwa Ibom State, prior to ivermectin intervention in 2004.

Methods: Blackflies were caught using human bait and 90% of the flies were dissected for parity. All parous flies were further dissected for the presence of filaria larvae. Monthly and annual biting rate, and transmission potential were calculated using standard methods.

Results: A total of 4296 adult *Simulium damnosum* were caught on human bait, 4119 were dissected of which 208 (5.1%) were infected with *Onchocerca volvulus* larvae. Transmission parameters varied significantly ($p < 0.05$) in the three villages. Annual biting rates, ranged from 9490 to 11,218 bites per person per year. The annual transmission potential ranged from 131 to 189 infective larvae per person per year, monthly biting rate and monthly transmission potential varied significantly ($p < 0.05$) in the three villages. Transmission was highly seasonal occurring during the peak of rainy season from August to October. There was no transmission during the dry periods — November to March, and the early rainy periods — April to May. The diurnal biting activity of the fly exhibited a bimodal pattern with a morning peak (0900–1000 hrs) and a more marked evening peak (1600–1700 hrs).

Interpretation & conclusion: The results indicate that there is a temporal and spatial variation in the transmission dynamics of *S. damnosum* in the study area.

Key words Nigeria – Onchocerciasis – *Simulium damnosum* – transmission dynamics

Introduction

Onchocerciasis, also known as river blindness caused by *Onchocerca volvulus* is a chronic parasitic infection with a public health and socioeconomic problem of considerable magnitude in many sub-Saharan African countries[1,2]. The disease affects about 17 to 18 million people in 37 countries of the world, with ~123 million being at risk of infection[3]. In Nigeria, onchocerciasis is widespread and a cause of blindness in most rural communities. Of all the countries of the world, Nigeria has the largest number of persons with onchocerciasis, accounting for about a third of the global prevalence[4] with about seven million Nigerian infected, 1.5 million blind by it and about 40 million at risk of infection[5]. In Nigeria, *O. volvulus* is transmitted primarily by the *Simulium damnosum* complex[6–9]. An understanding of the transmission dynamics of onchocerciasis as in other forms of filariasis is important in advancing knowledge of how vectorial capacity (vector abundance, survival rate, feeding habit and behaviour) influence the level of infec-

tion and disease in susceptible human population[10,11]. The knowledge of vectorial capacity would be of immense value in formulating the most appropriate control strategies in a given locality.

Report by WHO[7] classified Akwa Ibom State, Nigeria as sporadic for onchocerciasis. Ever since this observation was made, the epidemiological profile of the disease in the state has undergone significant change. Recent report by Braide *et al*[12] has shown that some communities within the state are now mesoendemic. This observation prompted the African Programme for Onchocerciasis Control (APOC) to initiate control measures in the state through mass distribution of ivermectin in 2004. Presently, the state is receiving ivermectin treatment. The vector for this disease in the state is *S. damnosum s.l.* which breeds in rivers and streams in the study area[13,14]. The present study is the first longitudinal investigation of transmission dynamics of *S. damnosum* in Akwa Ibom State, Nigeria. The report describes the result of studies conducted in the year prior to mass administration of ivermectin.

Material & Methods

The study was conducted in three rural communities (Idomido, Obio Camp and Ikot Adaha) in Ini Local Government area of Akwa Ibom state, Nigeria. Akwa Ibom state is located between latitude 4°33'–5°35' N and longitude 7°35'–8°25' E in the southeastern Nigeria. The state lies within the tropical rainforest belt of southern Nigeria. It is characterized by two seasons the rainy season from April to October and the dry season from November to March with annual rainfall reaching 3000 mm. The state has uniform temperature regime with annual range of 20.4 to 35.7°C. The state is characterized by the presence of numerous ecological and zoogeographical important high gradient streams and rivers. The study area had been adequately described earlier by other workers[14,15].

Study site: The communities were chosen based on their mesoendemicity status[12].

Ethical consideration: The Akwa Ibom State Ministry of Health approved the study. Informed consent was obtained from individuals and the communities involved.

Catching method: Blackflies were caught using human bait at Idomido, Obio Camp and Ikot Adaha from January to December 2003. Each station was sampled four times a month. Fly catching was conducted between 0700–1800 hrs by two fly collectors working alternately as described by Walsh *et al*[16] and Adewale *et al*[8]. 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 exposed part of the collector's body was caught before the flies were able to bite by inverting a small glass tube over it. The caps of the tubes were then immediately replaced. All tubes containing flies were labeled to indicate time, date, and place of capture. All captured flies were packed in a cold box containing ice packs to stop further development of microfilariae in the flies before being transported to the laboratory.

Dissection method: The percentage of blackflies dissected depended on the size of the catch, either all or 90% of the blackflies in each catch period was dissected to distinguish nulliparous and parous flies. Flies were recorded as nulliparous indicating that they had not yet taken a blood meal and could not have a parasite larvae, resulting in tightly coiled trachea systems and absence of follicular relics. Flies were identified as parous indicating that they had blood-fed and completed at least one gonotrophic cycle, resulting in the presence of follicular relics below the maturing oocyte and/or loosely stretched condition of the tracheal system[17,18]. All parous flies were further dissected minutely to search for larvae of filariae. The criteria of Porter and Collins[19] were used to distinguish and characterise all larvae of *O. volvulus*. The number of sausage-shaped larvae (L_1),

pre-infective (L_2) and infective (L_3) of *O. volvulus* found in the abdomen, thorax and head, respectively were counted and their stages of development at these sites recorded. A detailed description of the catching and dissection method of *S. damnosum* had been given elsewhere[11].

Calculation of biting rates and transmission potential: The monthly biting rate (MBR), monthly transmission potential (MTP), the annual biting rate (ABR) and annual transmission potential (ATP) were calculated by standard methods of Walsh *et al*[16].

Statistical methods: The significance of differences in *Simulium* infection rates were evaluated by the chi-square method and the monthly relative abundance of *S. damnosum* from the three sites was investigated using the two-way analysis of variance (ANOVA).

Results

Diurnal biting rate of parous flies: The diurnal biting rate of parous flies from the three stations is shown in Fig. 1. The biting cycle showed a bimodal peak of activity. There was a small peak between 0900 and 1000 hrs and a more pronounced evening peak between 1600 and 1700 hrs.

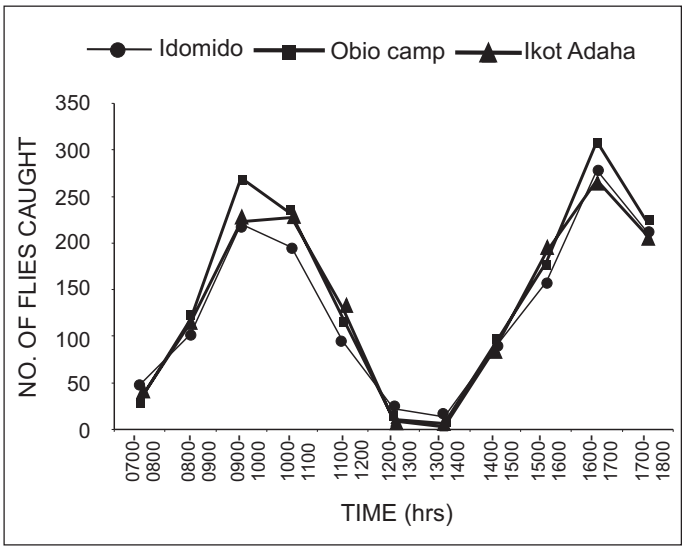

Fig. 1: Diurnal biting rate of *Simulium damnosum* at the three stations (Idomido, Obio Camp and Ikot Adah)

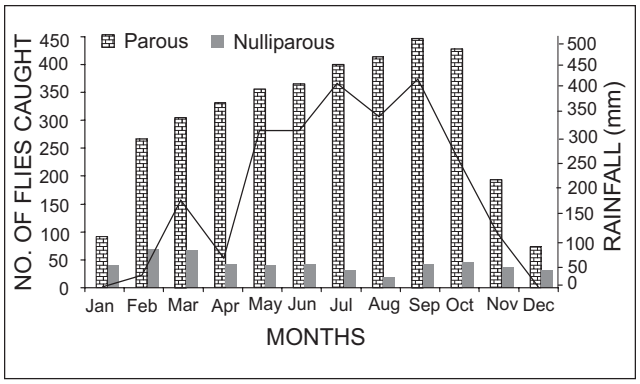

Fig. 2: Seasonal pattern of parous and nulliparous flies from January to December 2003

Fly relative abundance: A total of 4296 adult *S. damnosum* were caught, 1248 at Idomido, 1572 at Obio Camp and 1476 at Ikot Adaha. The monthly variation in the relative abundance of the flies at the three stations is shown in Fig. 2. There was a marked increase in parous fly population from January to a peak in September which corresponds to the peak of rainfall. After October, fly abundance decreased.

Vector transmission parameters: The monthly entomological parameters of transmission at Idomido are shown in Table 1. Of the 1211 (97%) flies dissected, 1041 (86%) were parous. A total of 48 (4%) of the parous flies were infected (containing L_1, L_2 and L_3 larvae) with *O. volvulus,* while 17 (1.4%) were infective (containing L_3 only). The peak MBR was recorded in October with 1286 bites per person per month, while the lowest MBR was recorded in December with 201 bites/person/month. The ABR was 9490 bites/person/year. The peak MTP was observed in August with 42.3 L_3/person/month, while the least was recorded in June with 15 L_3/person/month. There was no transmission from November to May. There was significant difference in the monthly infection rate in this station ($\chi^2 = 25.14$; $p < 0.05$).

Table 1. Summary of transmission indices of *S. damnosum* in the three stations

Characteristics	Idomido	Obio Camp	Ikot Adaha
Persons days worked	48	48	48
Total flies caught	1248	1572	1476
Average daily catch per person	52	32.8	30.8
No. (%) of flies dissected	1211 (97)	1484 (94.4)	1424 (96.5)
No. (%) of parous flies	1041 (86)	1330 (89.6)	1257 (88.3)
No. (%) of nulliparous flies	170 (14)	150 (10.1)	167 (11.7)
Total No. (%) of flies infected	48 (4)	89 (5.9)	71 (5)
Flies (%) with L_1 and L_2	31 (2.6)	68 (4.5)	54 (3.8)
Flies (%) with L_3	17 (1.4)	21 (1.4)	16 (1.1)
Biting density	27.7	35.8	33.5
Annual biting rate (ABR)	9490	11,945	11,217
Minimum monthly biting rate (MBR)	201 (Dec)	317 (Dec)	232 (Dec)
Maximum monthly biting rate	1286 (Oct)	1470 (Sep)	1387 (Sep)
Annual transmission potential	137.3	178.8	131.3

The monthly entomological parameters of transmission at Obio Camp is shown in Table 1. A total of 1484 (94.4%) flies were dissected of which 1330 (89.6%) were parous, 89 (5.9%) of the parous flies were infected and 21 (1.4%) harboured infective larvae of *O. volvulus.* The peak MBR was recorded in September with 1470 bites/person/month, while the lowest MBR was observed in December with 317 bites/person/month. The ABR was 11,945 bites/person/year. An ATP of 178.8 L_3/person/year was recorded in this station. There was a significant difference in the monthly infection rate at this station (χ^2 = 128.3; $p < 0.05$).

The monthly entomological parameters of transmission at Ikot Adaha is shown in Table 1. A total of 1424 (96.5%) flies were dissected of which 1257 (88.3%) were parous, 71 (5%) of the parous flies were infected and 16 (1.1%) haboured infective larvae of *O. volvulus.* The peak MBR was observed in September with 1387 bites per person per month, the least MBR was recorded in December with 232 bites/person/month. The ABR was 11,217 bites/person/year. There was a significant difference in the monthly infection rate at this site ($\chi^2 = 42.8$; $p < 0.05$). There was a significant ($\chi^2 = 16.4$; $p < 0.05$) difference between the infection rates at these three stations.

Discussion

This study has evaluated the entomological parameters of transmission of *O. volvulus* by *S. damnosum* in three mesoendemic communities of Akwa Ibom State, Nigeria, prior to ivermectin intervention.

The biting activity of *S. damnosum* in the present study exhibited a bimodal pattern with an early morning peak (0900 to 1000 hrs) and more marked late afternoon peak (1600 to 1700 hrs). This finding is in consonance with the report of Porter and Collins[19], Adewale *et al*[8], but differs from the unimodal activity pattern observed by Barbiero and Trips[20] in

Liberia. Biting activity of *S. damnosum s.l.* is greatly influenced by illumination and temperature[8,19,21], it is possible that the bimodal peak observed in this study might be due to decreased illumination and temperature during these peak periods, which is characteristic of climatic condition in southern Nigeria. Furthermore, the peak biting periods correspond with peak human outdoor activity, depending on the prevailing day length regime, the average Nigerian small holder farmer spends an average of 6–8 h in the farm[22]. All these activities increase human-vector contact.

There was a seasonal variation in the relative abundance of flies caught at these three stations. More flies were caught during the rainy season (April–October) than the dry season (November–March). This observation is consistent with the report of Renz[23], Crosskey[24] and Opara *et al*[11]. The increased oxygen content of water during the rainy season which causes flies to emerge from pupae, coupled with the increased availability of pre-imaginal sites all of which enhance pre-imaginal development, which results in an increase in the adult population[24,25], might have accounted for this variation. The transmission of onchocerciasis varies with location and season and may also be influenced by the longevity of the fly and its ability to support the development of *O. volvulus*[26]. The fly to human ratio and the availability of microfilariae reservoirs in the human population may also affect infectivity rates. There was a significant difference in the monthly infection rate, with relatively more flies being infected during the rainy season than at the peak of dry season. This observation suggests that infection could be acquired during the rainy season, coincidentally, this season is the period of active farming in most rural communities of Nigeria. Similar findings have been reported by Renz[23], but contrast the report of Okonkwo *et al*[6] and Adewale *et al*[8].

The ABR and ATP also exhibited seasonal variation. There was no transmission during the dry season at the three stations. This observation suggests that transmission may be interrupted or abolished by initiating vector control programme during the peak biting months, from June to October. The values of ABR and ATP in the present study are greater than tolerable values of 1000 for ABR and 100/L_3/person/year for ATP suggested by WHO[7], which indicates moderate transmission of onchocerciasis. Similar findings have been recorded by Okonkwo *et al*[6] and Adewale *et al*[8] in the eastern and western parts of Nigeria respectively. The study also shows that more parous flies were caught than nulliparous flies. The large parous proportion suggests a high *Simulium* longevity or presence of migratory flies[7, 26].

This report has confirmed the active transmission of onchocerciasis in the study area. This pre-control baseline data generated would help in quantifying the effectiveness of the control programme initiated in 2004 in the study areas.

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