ORIGINAL RESEARCH

BIOECOLOGY OF *SIMULIUM DAMNOSUM* THEOBALD COMPLEX ALONG OSUN RIVER, SOUTHWEST NIGERIA

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ABSTRACT

Objectives: A longitudinal study was carried out to investigate the adult population dynamics and the physical and chemical factors affecting the distribution of *Simulium damnosum* complex, a vector of onchocerciasis (River blindness) along Osun river in a forest zone of south-western Nigeria. Methods: Adult flies were collected on consented human baits from 7.00am to 6.00pm every fortnight at three communities; Osun Eleja, Osun Ogbere and Osun Budepo along Osun River from February 2008 to June 2009. Larval prospection was carried out in all accessible rivers around the study area and their physical-chemical parameters were determined. Results: A total of 1472 flies were caught during the study period with Osun Budepo accounting for the highest number of the flies (47.0%) followed by Osun Eleja (42.2%) and Osun Ogbere (10.8%). The fly abundance was significantly higher ($p<0.05$, respectively for the three sites) during the wet season, with a positive correlation between rainfall and fly abundance at the three sites. *S. damnosum s.l* was found breeding only in the wet season at the rivers with rocky substratum and submerged vegetations. Water velocity (p=0.050) and dissolved oxygen (p=0.042) were the only parameters showing significance with the distribution of *S. damnosum s.l* larvae at the breeding sites. The adults of *S. damnosum* s.l were found biting at the rivers hitherto scored negative for preimaginal stages showing that the presence of larvae has limitation as sole factor in determining the extent of the distribution of *S. damnosum* complex. Conclusions: The results suggest that the climatic and environmental conditions influence the distribution of *S. damnosum* s.l in the study area. The presence of the fly all year round calls for adequate control measures to curtail the transmission of onchocerciasis in particular during the wet season.

KEY WORDS: Distribution; Ecology; *Simulium damnosum* s.l; Physical; Chemical; Nigeria.

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INTRODUCTION

Black flies constitute serious public health and socio-economic problems as vectors of human onchocerciasis and biting nuisance in many rural parts of the world (Adeleke *et al*., 2010a). The flies have a wide distribution in America, Mexico, Yemen, Brazil, Venezuela, Ecuador, Colombia and Africa (WHO, 1975, Malau and James, 2006). *Simulium damnosum* s.l is the major vector of onchocerciasis in West Africa and in some countries in Eastern and Southern Africa (Mustapha *et al*., 2004). *S. damnosum* s.l is known to consist of many cytospecies and nine of these had been identified and documented in West Africa (Ibeh *et al*., 2006). These species vary in their ecological requirements and contribution to the epidemiology of onchocerciasis. Therefore, an understanding of the distribution and ecology of the local species is a prerequisite for the effective control of the *Simulium* vectors.

Nigeria has long been known as one of the most endemic countries for onchocerciasis in the world and probably accounts for one quarter of the global infection (WHO, 1995). The colossal morbidity of the infection could be attributed to the avalanche of rivers and streams abound in the country (Ibeh *et al*., 2006). Several reports emanating from the epidemiological studies after the discovery of onchocerciasis in Nigeria in 1909 showed that most rivers and fast flowing streams in the country provide conducive breeding sites for *S. damnosum complex* (Crosskey, 1981; Mafiana, 1988; Anosike and Onwuluri, 1995; Usip *et al*., 2003, Ibeh *et al*., 2007). The reports further demonstrated that although the distribution of *S. damnosum s.l* is not even in Nigeria, however, there is a relationship between the distribution and basic geology of the areas.

Despite the tremendous efforts made by earlier researchers to document the distribution of *S. damnosum* s.l in Nigeria, most of the available records were predominantly focused on the northern part of the country (Ibeh *et al*., 2007), leaving the southern part, most importantly south-western Nigeria with a paucity of information. Studies on onchocerciasis in south-western Nigeria therefore become imperative for the comprehensive understanding of the factors that are involved in the epidemiology of onchocerciasis. Investigating the temporal and spatial

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distribution of *Simulium* vectors and planning effective control measures around the area are of particular importance.The present study was carried out to determine the adult population dynamics and the physical and chemical parameters influencing the larval distribution of *S. damnosum* s.l along the river Osun and its environs in south-western Nigeria.

METHODS

Study Area

The study was conducted along Osun river system, south-western Nigeria. The river Osun lies on the 8^{o} 20^{1} and 6^{o} 30^{1} N latitude and the $5^{o}10^{1}$ and 3^{o} 25^{1} E longitude in the forest zone of Nigeria. Both transitional forest and rain forest are found along the river course. Generally, south-western Nigeria has annual rainfall ranging from 1000 mm to 1600mm and it experiences two seasons, the wet season (April to October) and the dry season (November to March). Three fly collection sites were selected along the Osun river: Osun Eleja (derived savanna), Osun Budepo (rainforest) and Osun Ogbere (rainforest). Osun Eleja is located on latitude $7^{o}16^{1}$ N and longitude $4^{o}08^{1}$ E, Osun Budepo is located on latitude $7^{o}04^{1}$ N and longitude $4^{o}08^{1}$E, and Osun Ogbere is located on the latitude $6^{o}76^{1}$ N and longitude $4^{o}13^{1}$E.

Collection of Adult Flies

Adult flies were collected every fortnight using consenting human baits at the three catching sites in accordance with the standard protocol (Adewale *et al*., 1999) between February 2008 to January 2009 in Osun Budepo and Osun Ogbere, and between July 2008 to June 2009 in Osun Eleja. The adults used for human-landing catches were dark in complexion and they were instructed to wear black clothes to eliminate the influence of colour variation in adult catches. Two adult fly collectors were positioned near the bank of the river in each of the catching sites. The two fly capturers caught flies alternately between 7:00 am to 6:00 pm by exposing the lower portion of their legs. Any fly landing on the exposed legs was caught using catching tubes. The flies caught were pooled according to the day of catch in each location.

Prospection for *Simulium damnosum* Complex Larvae

Larval searches were carried out at the three catching sites and all the accessible tributaries of the Osun river. This was done to determine the larval distribution of Simulium damnosum s.l along the river and its immediate environs. The larval prospection was carried out between July and August 2008 and December and January, 2009. All larvae collected were fixed in freshly prepared carnoy's fluid for identification. The larvae of *S. damnosum* s.l were distinguished from other *Simuliid* by checking for the presence of dorsal tubercles as described by Crosskey (1981). The larvae of *S. damnosum* have protruding dorsal tubercle which is a feature that distinguishes them from other black fly larvae.

Physical and chemical parameters of eight of the prospected sites were determined (four positive sites and four negative sites). The four negative sites were chosen randomly from the seven negative sites investigated. Water samples were collected during larval searches to determine the physical and chemical parameters associated with the presence or absence of *S. damnosum* s.l at a study area. The parameters determined are water temperature, water velocity, water pH, oxygen content, conductivity, total calcium, total magnesium, sulphate, phosphate, nitrate, copper, iron and chromium.

Spot catching was carried out in all the rivers where larval searches were conducted. At each site, flies were caught for few hours using catching tubes. The sites were scored as "negative" or "positive" for the biting of adult humans.

Climatic Data of the Study Area

Climate data of rainfall and temperature for the study sites was provided by the Ogun-Osun River Basin Development Authority Headquarter in Abeokuta, Ogun State, Nigeria.

Statistical Analysis

The data on the fly population were subjected to t-test and correlation analysis after the data were transformed by $\sqrt{x+0.5}$ as the original data was skewed. 95%-confidence intervals were calculated and p-values less than 0.05 were considered as statistically significant.

RESULTS

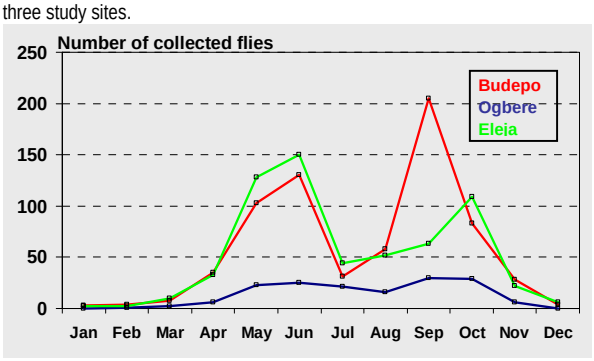
A total of 1,472 adult flies were caught at the three catching sites through normalized capture. A significantly higher number of flies was caught at Osun Budepo and Osun Eleja compared to Osun Ogbere (p=0.010)(Table 1).

Table 1: The relative abundance of *Simulium damnosum* complex caught by normalized capture during the study period.

Catching sites	Number of flies caught	% Flies caught
Osun Budepo	692	47.0
Osun Ogbere	159	10.8
Osun Eleja	621	42.2
Total	1472	100%

The results of monthly distribution of the flies showed significant difference in fly abundance during the months of collection at the study sites with significantly higher number of the flies in September, October and June at Osun Budepo (p=0.001), Osun Ogbere (p=0.010) and Osun Eleja (p=0.009), respectively. The fly abundance was significantly higher during the wet season (April to October) as compared with the dry season (November to March) at all the catching points visited (Osun Budepo (p=0.017); Osun Ogbere (p=0.005); Osun Eleja (p=0.030))(Figure 1).

Figure 1: The monthly distribution of *Simulium damnosum* complex at the three study sites.



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The data on rainfall and fly abundance showed a positive correlation between the rainfall and black fly abundance at the study sites (Osun Budepo: r=0.185; Osun Ogbere: r=0.391; Osun Eleja: r=0.316) but the relationships were not statistically significant. The fly abundance at the three catching sites increased as the rainfall increased and fell during the heavy rainfall (July and August) and then increased between September and October with a final decline between November and February.

Of the 11 sites prospected, only four sites were found positive for the larvae of *S.damnosum* s.l. The four sites are Ago-Iwoye (River Omi), Osun Budepo (River Osun), Osun Eleja (River Osun) and Apoje (River Omitu) (Table 2). None of the rivers were positive for the larvae of *S. damnosum* s.l. during the dry season as most of the rivers had completely dried up or broken into pools without flow. However, adult flies were caught in all the sites during the spot catching.

The topographic features of the prospected sites showed that the sites that were positive for larvae of *S.damnosum* s.l had fairly shaded vegetation, sparsely to densely rocky substrata and submerged plants as compared to the negative sites which were characterized with fairly to densely shaded vegetation with few or no rocky substrata and submerged plants. The positive sites recorded the higher mean values for all the parameters determined than the negative sites except pH, sulphate, nitrate and cupper in which the values were higher in the negative sites. However, only dissolved oxygen and water velocity showed significant relationship ($P<0.05$) with the distribution of the breeding sites of *S. damnosum* s.l among the parameters determined (Table 3).

Table 2: Results of larval sampling and spot catching at the prospected sites in the study area.

River Course	Location	Latitude (N)	Longitude (E)	Larval prospection	Spot catch
R. Ona	Odogbou	6.82	3.83	Negative	Positive
R. Omi	Ago- Iwoye	6.93	3.98	Positive	Positive
R. Osun	Budepo	7.04	4.08	Positive	Positive
R. Omitu	Apoje	6.98	4.12	Positive	Positive
R. Owa	Ijebu Ode	6.80	3.90	Negative	Positive
R. Omo	Omo reserve	6.74	4.29	Negative	Positive
R. Osun	Ogbere	6.76	4.13	Negative	Positive
R. Osun	Eleja	7.16	4.08	Positive	Positive
R. Kajola	Kajola	7.14	4.03	Negative	Positive
R. Eriju	Ogbere	6.94	4.14	Negative	Positive
R. Eri-Oru	Ijebu Oru	6.93	3.94	Negative	Positive

Table 3: Physical and chemical parameters of the prospected sites during the study period.

Parameters	Mean value (±SD) in positive sites (n=4)	Mean values (±SD) in negative sites (n=4)
Temperature (ºC)	26.2 ± 0.66	26.1 ± 0.10
Water velocity (m/sec)	2.5 ± 0.24 *	1.7 ± 0.05 *
Dissolved oxygen (mg/l)	7.2 ± 1.73 *	6.7 ± 0.70 *
Conductivity	115 ± 2.88	108.5 ± 2.80
pH	7.0 ± 0.55	7.25 ± 0.66
Calcium (mg/l)	243.4 ± 4.86	238.3 ± 6.05
Magnesium (mg/l)	72.5 ± 2.40	72.1 ± 2.25
Phosphate (mg/l)	2.0 ± 0.05	2.0 ± 0.01
Sulphate(mg/l)	11.3 ± 0.38	11.8 ± 0.50
Iron (mg/l)	2.88 ± 1.17	1.56 ± 0.25
Nitrate (mg/l)	0.12 ± 0.01	0.15 ± 0.03
Cupper (mg/l)	0.04 ± 0.05	0.47 ± 0.03
Cromium (mg/l)	0.12 ± 0.13	0.11 ± 0.14

* $p<0.05$

DISCUSSION

The results obtained in the present study show that adult *S. damnosum. s.l.* flies bite in all the considered catching sites but not at the same density. More flies were collected at Osun Budepo and Osun Eleja as compared with Osun Ogbere. The significant variation observed in the biting density of the flies can potentially be attributed to differences in the physical features of these catching sites. The Osun Budepo and Osun Eleja sites have rocky substrata with submerged vegetation which usually break the flow of the water and create rapids, the environment needed for the development and survival of the aquatic stages of *S. damnosum s.l.* Conversely, Osun Ogbere lacks rocky substrata but featured a few logs which create occasional rapids hence, the low number of adult flies collected at this location.

The monthly distribution of the flies at the catching points revealed that the abundance of *S .damnosum* s.l varied with season and could be potentially attributed to the seasonal pattern of the

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rainfall. At all three sites most flies were caught during the wet season (April to October). This finding is consistent with previously published reports by Crosskey (1990), Opara *et al* (2005) and Opara *et al* (2008) in Nigeria and Opoku (2006) from Ghana, but contradicts reports by Mafiana (1988) and Adewale *et al* (1999) who reported more flies during the dry season in the southern part of Nigeria. The high abundance of the flies during the wet season may be due to the high water volume with many rapids which increased the oxygen content of the water and thus, provided conducive a environment for the developmental stages of the flies.

Although, this study did not correlate the abundance of the adult flies with the physical and chemical parameters of the breeding sites, the results obtained from the sites that were positive for *Simulium* larvae had higher mean values of dissolved oxygen than the negative sites. Higher oxygen levels might support an increase in the adult fly population (Crosskey 1990., Opara *et al* 2008). In contrast, the dry season was characterized with little or no rainfall and the rivers in the catching sites broke up into pools which could not support the breeding of black flies. Notably, there was reduction in abundance of the flies between July and August which increased again in September. The marked reduction in fly population may be attributed to the heavy rainfall recorded during that period. Heavy rainfall usually caused flooding along the river course and washed away the aquatic stages of the flies as a consequence, reducing the fly population (Hashiguishi *et al.*, 1981).

It is also important to stress that, apart from the seasonal pattern of rainfall, the control of the water volume of the river by Ogun Osun River Basin Development Authority through the Oshogbo, Ede and Asejire dams (all located along Osun River) is another factor determining the abundance of the flies along Osun River. During the course of this study, frequent release of water was experienced at the peak of the wet season (July and August) and this was accompanied by downstream flooding. The flood might have flushed away the pre-imaginal stages of the flies or caused mechanical damages to their eggs and hence a reduction in fly abundance.

Physical and chemical characteristics as well as water volume of the rivers seemed to play a role in determining the breeding sites of *S. damnosum s.l* as previously suggested (Crosskey, 1981; Hashiguishi, *et al.*, 1981; Fryauff and Trips, 1986; Ibeh *et al*., 2006). Interestingly, adults of *S. damnosum s.l* were caught in all of the investigated sites including the negative sites. It is not clear whether the biting flies at the negative sites emerged from the rivers or represent migratory flies. The results of the dissection of the flies presented elsewhere showed that the majority of these flies were nulliparous (Adeleke *et al.,* 2010b). However, a intensive investigation of the entire river system will shed light on whether the biting flies at the negative sites emerged from such rivers. The absence of adequate breeding sites during the dry season could suggest that in the study area *S. damnosum s.l* breeds exclusively during the wet season.

In the past, the presence or absence of *Simulium* larvae and "white water" had been used to explain the distribution of *S. damnosum s.l* in Nigeria (Braide *et al.,* 1980; Iwuala and Ezike 1980; Crosskey, 1981). The results of this study showed that the use of breeding sites to describe the extent of the distribution of *S. damnosum* s.l may be misleading as adult *S. damnosum s.l* flies may be transmitting diseases in many areas hitherto believed to be negative for *Simulium* larvae. There is therefore a need for reviewing past records on the distribution of *S. damnosum s.l* in Nigeria if an effective national eradication programme is to be accomplished.

In conclusion, this study has reported the spatial and temporal distributions of *S. damnosum* s.l along the river Osun and the possible contribution of physical and chemical parameters to the distribution of the larvae. Further studies are recommended for south-western Nigeria in order to establish comprehensive data on the distribution of *S. damnosum* s.l in this area and to allow adequate planning for the control of onchocerciasis.

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