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# SOME OBSERVATIONS ON THE ECOLOGY, BITING ACTIVITY AND PARASITE INFECTIVITY OF THE BLACKFLY (SIMULIIDAE) AND ONCHOCERCIASIS PREVALENCE IN THE RIVER BIRIM CATCHMENT

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**Abstract**

A study of the occurrence, distribution, and biting activity of the blackfly (Simuliidae) as well as the prevalence of the Onchocerciasis disease was conducted in the River Birim basin of Ghana. Four species of the blackfly: *Simulium alcocki, S. damnosum s.l., S. rufficorne* and *S. unicornutum* were identified in the area of the basin. *Simulium unicornutum* and *S. danosum s.l* were the most abundant species with *S. unicornutum* being the most widely distributed. The four species were found in 12 of the 27 locations surveyed and were relatively more abundant at the River Pam location. The occurrence of infected *S. danosum s.l.* with its bi-modal biting pattern and the prevalence of the disease neccesitate the adoption of control strategies.

**Résumé**

Opoku, A. A.: *Quelques observations sur l'écologie, l'activté piquante et l' infectivité parasitaire de le puceron noir (Simuliidae) et fréquence d'onchocerciasis dans le bassin hydrographique de la riviére Birim.* Une étude de l'apparition, la distribution et l'activité piquante de le puceron noir ainsi que la fréquence de la maladie d'onchocerciasis se déroulait dans le bassin hydrographique de la riviére Birim du Ghana. Quatre espéces du puceron noire: *Simulium alcocki, S. damnosum s.l., S. rufficorne et S. unicornutum* étaient identifiées dans la zone du bassin. *S. unicornutum* et *S. damnosum s.l.* étaient les espéces les plus abondantes avec *S. unicornutum* étant largement distribuée. Les quatre espèces étaient découvertes dans douze des vingt sept emplacements prospectés et étaient relativement plus abondantes à l' emplacement de la riviére Pam. L'événement de *S.damnosum s.l.* avec ses caractéristiques bimodales de piquer et la fréquence de la maladie nécessite l' adoption des stratégies de contrôle.

## Introduction

The blackfly (Simuliidae) which is responsible for transmission of onchocerciasis disease (River blindness) is a small, sturdy, hump-backed nematocera with the immature stages limited to fluvial ecosystems, breeding often in swiftly- running water (OCP, 1985). The vectors of human onchocerciasis in Africa are *Simulium damnosum* s.l. and *S. neavei* with *S. damnosum s.l.* being the most important vector in West Africa (Raybould, 1979; Raybould & White, 1979). The *S. damnosum* s.l is a complex of sibling species of which six are present in Ghana. They are *S. damnosum* s.s. *(sensu stricto), S. sirbanum, S. sanctipauli*, S. *soubrense, S. squamosum* and *S. yahense* (OCP, 1985). The causative agent of onchocerciasis is a nematode worm *Onchocerca volvulus* (Cheke & Garms, 1983).

Onchocerciasis, a tropical parasitic disease, poses a serious public health problem and a serious obstacle to socio-economic development in much of West Africa. As a result of this scourge, whole communes in the northern have as at 1974 abandoned their fertile riverine villages and moved interior into less fertile lands to scrape a living (OCP, 1980). It causes skin lesions, severe disabling itching, sight impairment and blindness.

Since 1974, the World Health Organization (WHO) has been executing an Onchocerciasis Control Programme (OCP) in the River Volta basin in West Africa. It is an insect control programme with the objective of reducing the risk of sight impairment by lowering the intensity of transmission to a level that cannot lead to impaired vision.

A great deal of information exists on onchocerciasis in the savaňa areas of Ghana and these have been accumulated in the past, through the activities of the OCP (OCP, 1973; 1986a; 1986b). However, scanty information exists on the blackfly and onchocerciasis in the forest zone. The erroneous impression that forest onchocerciasis is non-blinding has retarded progress in tackling the problem relating to its study and control.

In view of the immense adverse impact of the disease on the socio-economy of the riverine rural communities, it is important to focus on the importance of the fly and the disease with the view of putting their significance in their right perspective for the initiating of the appropriate control measures.

The present paper presents and discusses some studies on the distribution, biting activitiy and *Onchocerca volvulus* infectivity levels of the blackfly as well as the prevalence of the disease in the River Birim catchment. The sudy covered the period from August 1998 to November 1999.

## Experimental

*Study area*

The River Birim catchment is located between latitudes 5° 45'N and 6° 35'N and longitudes 0° 20'W and 1° 15'W. The Birim river takes its source from the Atewa range of hills in the Eastern Region of Ghana and follows a course of 175 km southwards to join the Pra river. The river drains an area of about 3,895 square km with the major tributaries being Adim, Amaw, Kade and Si.

The rainfall pattern in the drainage area varies seasonally with peaks in June and September and dry spells in December and January. It has a fairly high temperature of 25-30 °C and high relative humidity of 70-80 per cent throughout the year.

Cash-crop farming is the mainstay of the economy in the basin, major crops being cocoa, maize, cassava, cocoyam and plantain.

*Prospection for the immature stages of (Simuliidae)*

Immature forms of the Simuliidae were collected from stems, twigs and leaves in the flowing sections of watercourses, examined and identified by using the key of Freeman & De Meillon (1968), and later preserved in 80 per cent alcohol. Empty pupal cases were collected, identified and recorded as a measure of adult emergence.

At each prospected site, the *p*H and flow rate were recorded with a *p*H meter and a flowmeter, respectively. The dissoved oxygen concentrations of the sites were also determined by using the Wrinkler method of analysis (APHA, 1976).

Relative abundance of the immature forms were estimated by random sampling from the different substrata and counting the numbers of both larvae and pupae present per unit area.

*Collection of man biting adults* S. damnosum *s.l.*

Adult female flies were collected in clearings along the banks of the Birim river close to the local water pumping station and on cocoa farms at Bunso. The collection period covered both the dry and rainy seasons (January-July 1999). Two vector collectors alternating at one-hour intervals with another set of two, captured female *S. damnosum* s.l. adult into glass or plastic vials when they attempted to bite them below the knee. Collection of flies was done from 7.00 a.m. to 6.00 p.m. for three consecutive days each from January to July. Flies caught were segregated into hourly batches and the number of flies captured per hour per collector (FVH) recorded. These were placed in polyethylene bags and kept in the dark in an insulated ice chest containing ice cubes.

Flies were killed by using chloroform and dissected by teasing apart the head in a drop of sa-

TABLE 1
*pH, flow rates and type of* Simulium *spp.*

| *Location River/Town* | *Mean flow rate* ($ms^{-1}$) | *Mean* p*H* | *Species identified* |
|---|---|---|---|
| Pam/Asene | 0.25 | 7.4 | *S. alcocki* |
| | | | *S. unicornutum* |
| | | | *S. rufficorne* |
| Amaw/Tropreman | 0.5 | 7.2 | *S. unicornutum* |
| | | | *S.* spp. |
| Supon/Suponso | 0.4 | 7 | *S. unicornutum* |
| | | | *S.* spp. |
| Pram/Takyiman | 0.27 | 7.4 | *S. alcocki* |
| | | | *S. unicornutum* |
| Merepong/Akropong | 0.3 | 7.1 | *S. unicornutum* |
| Akwaa/Bunso | 0.7 | 7.2 | *S. alcocki* |
| | | | *S. unicornutum* |
| Birim/Cocoa College | 2 | 5.7 | *S. damnosum* s.l |
| Birim/Old Road | 2.3 | 5.9 | *S. damnosum* s.l |
| Birim/Osino | 1.9 | 6.2 | *S. danosum* s.l |
| Birim/Nsutam | 2.3 | 6.4 | *S. damnosum* s.l |
| Birim/Asamama | 0.8 | 7.4 | *S. unicornutum* |
| Birim/CRI | 2.4 | 5.4 | *S. danosum* s.l |

line solution and examined for *O. volvulus.*

*Epidemiological assessment*

The prevalence of the disease was determined by using data obtained from the skin snip method. This involved the cutting of skin on the buttocks or back of a person and examining it under the microscope for the presence or absence of *O. volvulus* larvae. Residents were randomly selected for the epidemiological assessment.

## Results and discussion

*Occurrence and distribution*

The occurrence and distribution of immature forms of the *Simulium* species are shown in Table 1. Four species of the Simuliidae, *Simulium alcocki, S. unicornutum, S. rufficorne* and *S. damnosum* complex were identified in the areas surveyed. Of the 27 locations surveyed, the simuliids were found in 12 with the epidemiologically important species *S. damnosum* s.l. occurring in five of them. *S. unicornutum* and *S. damnosum* s.l. were the most abundant species with *S. unicornutum* being the most widely distributed in the area of study. Generally, the immature forms were found on the upper surfaces of the leaves of the trailing vegetation but did occur also on both sides of the leaves in some parts of the water-way.

It was observed that objects with algal growths did not have *Simulium* attached and that could be a distribution limiting factor. Le Berre (1964) reported of a similar observation on the distribution of the *S. damnosum* s.l. in the Volta Basin. It could be that the algal substrates did not facilitate attachment.

Although samples from twigs, stems and stones reflected the size distribution of the immature forms, samples from the leaves of the vegetation gave the most reliable indication of the abundance of the larvae and pupae in the populations. This phenomenon, which has also been supported by Obeng (1967), could probably be due to the leaves of the vegetation serving as the preferred deposition site for the eggs and, therefore, the primary attachment site for the newly-hatched larvae.

The immature forms of *S. damnosum* s.l. occurred, most of the time, in the heavily-shaded parts of the river unlike the other species which were found mostly in the unshaded areas. *S. alcocki, S. unicornutum* and *S. rufficorne* were found occuring sympatrically at a location on river Pam at Asene. It is likely these species might have some common ecological characteristics which facilitate their breeding together. *S. unicornutum* and *S. alcocki* were found often associated with both slow and moderately fast-moving streams, an indication of their adaptability to both conditions of the environment.

Easily adaptable species, such as *S. adersi*, commonly found in most breeding sites in the River Volta basin of Ghana, were, however, not encountered in the Birim basin during the study period.

*Ecological factors*

The *p*H and flow rate of the river, important factors in the distribution of the Simuliidae (OCP. 1985), ranged from 5.4 to 7.4 (for the *p*H) and 0.25 $ms^{-1}$ to 2.4 $ms^{-1}$ (for the flow rate) respectively (Table 1).

During the dry season, the flow rates of the rivers and tributaries ranged from 0.25 $ms^{-1}$ to 0.4 $ms^{-1}$ and from 0.8 $ms^{-1}$ to 2.3 $ms^{-1}$ during the rains. The larvae of the vectors are knwon to prefer currents of 0.7 $ms^{-1}$ to 2 $ms^{-1}$ but have also been observed in currents ranging from 0.1 $ms^{-1}$ to 2.5 $ms^{-1}$ (OCP. 1985).

All the *S. damnosum* s.l. breeding sites had *p*H ranging from 5.4 to 6.4 whilst those of non-vectors had *p*H greater than 7. These suggest that the *p*H could be limiting factor in the distribution of the species.

It was observed that the type of species found depended on a number of ecological factors but more important was the rate of water flow, with its attendant increase in the nutritive status of the site, level of oxygenation and the presence of adequate supports.

The identified breeding sites of *S. damnosum* s.l. had little man-induced nutrient input as sewage and large-scale industrial effluent did not appear to be discharged upstream of their breeding sites. The mean dissolved oxygen concentration (DO) at each site was higher than 70 per cent saturation, though during very heavy rains the oxygen level is lowered due to increase in suspended matter. The high oxygen saturation level is an indication of the low pollution status of the breeding sites.

*Seasonal variations*

Table 2 shows the mean density of the immature stages collected per square centimetre of a leaf surface during the rainy and the dry seasons. A paired t-test treatment of the means showed that the epidemiologically significant species, *S. damnosum s.l.*, occurred in significant larger numbers during the rainy season than in the dry season ($P < 0.05$). However, there was not appreciable change in numbers of the other species namely, *S. alcocki, S. rufficorne* and *S. unicornutum* during both the dry and wet seasons ($P > 0.05$).

During the rains, the mean current speed of the waterways and the area under water are increased significantly contributing to the expansion of larval habitats. There is also an increase in quantity and type of larval food carried by the water which lead to a considerable increase in numbers of

TABLE 2
*Mean density of the mature vectors collected*

| *Season* | *Flow rate* $ms^{-1}$ | *Mean density of vectors* | *Mean density of non-vectors* |
|---|---|---|---|
| Rainy | 0.8-2.3 | 1.42 | 0.85 |
| Dry | 0.25-0.4 | 0.71 | 0.91 |

larvae and, subsequently, adults. The seasonal pattern of abundance of the blackfly in the Birim basin could, therefore, be linked partly to the variations in discharge of the watercourse.

The other species had a wider distribution than the vectors (Table 1). The distribution of the non-vector species did not seem to relate to any particular stream character since they could be found in a number of streams with varying characteristics while the vectors appeared to be sensitive to certain characters such as the *p*H of the rivers which affected their distribution.

*Adult fly activity: Daily biting pattern at Bunso*

Fig. 1 and Fig. 2 show the mean biting density (number of flies caught per a vector collector per hour (FVH)), at Bunso from January to July, 1999.

Generally, the daily biting pattern observed showed a bi-modal pattern with two distinct peaks, morning and at late afternoon. Biting activity was generally vigorous during the months of May - July (rainy season). Comparatively biting activity was less vigorous during the months of January - April (dry season).

A paired t-test treatment of the mean biting peaks for January and February showed that peak biting densities in the morning were not significantly different from those of the afternoon biting peaks ($P > 0.05$). In March, the peak biting density in the afternoon was significantly greater than that

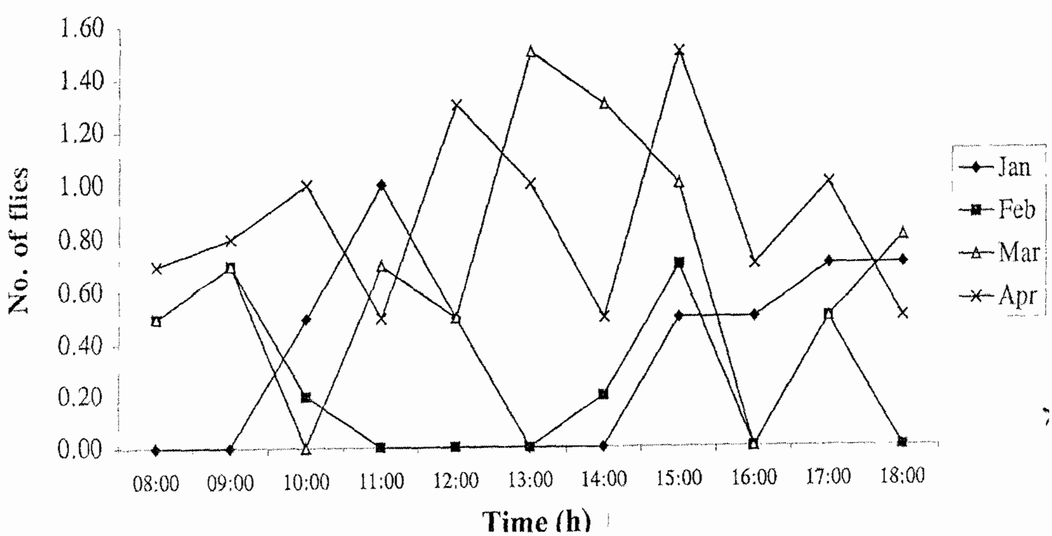


Fig. 1. The daily biting pattern of *Simulium damnosum* s.l from January-April at Bunso

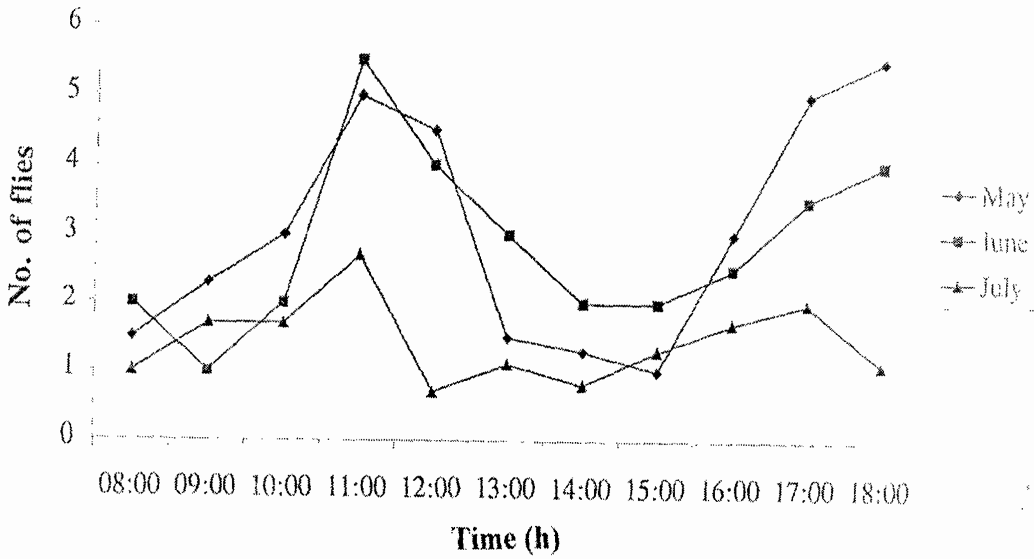


Fig. 2. The daily biting pattern of *Simulium damnosum* s.l from May-July at Bunso

in the morning ($P < 0.05$).

In April and May, the peak biting densities in the morning and in the afternoon were not significantly different from each other ($P > 0.05$). However, in June and July the morning biting peak densities were significantly greater than the afternoon biting densities ($P < 0.05$). Blackfly biting activities are known to be influenced by a host of factors such as light intensity, clouds, time of day, temperature among others (Alverson & Noblet, 1976; Underhill, 1940; Saunders, 1976), and it is likely the biting activity of the flies at Bunso were influenced by a number of such environmental factors.

The higher biting density levels in the morning could be attributed to the stimulating effects of the morning sunlight after the inactivity in the night. The general lull in activity in the afternoons could be due to the suppressive mean temperatures (32 °C) prevailing in the area.

There are no preferred resting sites of the adult blackfly (OCP, 1985) but since the catching points

TABLE 3

*The number* Simulium damnosum *s.l flies caught and dissected from January to July at Bunso*

| *Month* | *Jan* | *Feb* | *Mar* | *Apr* | *May* | *Jun* | *Jul* |
|---|---|---|---|---|---|---|---|
| No. of flies caught | 26 | 16 | 45 | 57 | 202 | 186 | 95 |
| No. dissected | 26 | 16 | 40 | 43 | 84 | 78 | 60 |
| Infectivity (%) | 11.5 | 0 | 5 | 11.6 | 9 | 6.4 | 5 |
| Parous rate (%) | 19.2 | 62.5 | 50 | 34.9 | 47.6 | 52.5 | 61.6 |
| Nulliparous rate (%) | 79.8 | 37.5 | 50 | 65.1 | 52.4 | 47.5 | 38.4 |

were bounded by vegetation, it is most likely these vegetation provide a resting place for the flies during the hotter periods of the day.

The peak periods of intense biting in the mornings and afternoons coincided with the peak period of farming activity at Bunso and could, therefore, upset the precarious local economy of the local people.

Seasonally, January - April are low biting density periods which incidentally happen to be the period when farmers prepare the land for planting of crops.

Generally, the communities are exposed to the consequent risks of contracting the disease throughout the period of land preparation, planting and harvesting in the farming season.

Onchocerca volvulus *infection and disease transmission potential*

Table 3 shows the number of *S. damnosum* s.l flies caught and dissected from January to July with parity and infectivity levels at Bunso. The proportion of parous flies caught ranged from 19.2 per cent in January to 61.6 per cent in July.

A paired t-test treatment of the parity rates

TABLE 4
*Monthly ochocerciasis transmission potential (MPT)*

| *Month* | *Jan* | *Feb* | *Mar* | *Apr* | *May* | *Jun* | *Jul* |
|---|---|---|---|---|---|---|---|
| MTP | 31 | 0 | 23.5 | 92.8 | 546.7 | 357.7 | 425.4 |

showed that there were significantly more parous flies than nulliparous flies in February, June and July ($P < 0.05$) but no significant differences in March. January, April and May had significantly more nulliparous flies ($P < 0.05$). The parity rate appeared to be independent of the seasonal changes. Despite significantly high proportion of parous flies from February to July, the level of onchocerca infectivity was comparatively low. The low infectivity rate could mean that the parous flies might have shed their parasites in previous bloodmeal. Alternatively, it could be that the larvae are in the developing state either in the abdomen or thorax of the fly.

TABLE 5
*Prevalence of onchocerciasis in the Birim basin*

| *No. of towns/ villages* | *No. of People skin snipped for* O. volvulus | *Prevalence (%)* | *Prevalence in children below 15 years (%)* |
|---|---|---|---|
| 11 | 829 | 16.94 | 8.2 |
| 14 | 1535 | 7.1 | 0.9 |
| 1 | 745 | 100 | 12.2 |
| 5 | 446 | 16.6 | 3.2 |
| 7 | 823 | 2.4 | 0.97 |

The monthly onchocerciasis transmission potential (MTP) of the flies, a basic index for assessing the disease transmission carried out by the fly population, was estimated by using the formula:

MTP = No. of days in month × No. of infective larvae × No. of flies caught / No. of days worked × No. of flies dissected.

The formula was proposed by Duke (1968) and applied by Garms (1973) and Duke *et al.* (1975).

The results of the MTPs obtained for the period January - July are shown in Table 4.

The MPT of the flies were higher in the rainy season than the dry season. The values obtained indicate that the level of parasite transmission poses a potential danger to man, particularly during April - July.

*Onchocerciasis prevalence*

The epidemiological data obtained (Table 5) showed that, in December 1991, out of 829 people from 11 towns and villages including Asiakwa, Asikam, Kibi, Apapam, Asafo who were examined for the presence of *O. volvulus,* 16.94 per cent were positive. The prevalence ranged from 2.1 per cent in Asafo to 100 per cent in Ahwenease with 8.2 per cent of the sample below the age of 15 years. During this period, Bunso alone registered 100 per cent onchocerciasis positive cases out of

745 people who were examined.

Again in January 1992, out of a sample of 1535 people from 15 villages and towns including Ankase, Tumfa, Anyinam, Moseaso, Odumase, and Kibi, 7.1 per cent were positive. The prevalence ranged from 1 per cent in Odumase to 42 per cent in Kibi with 0.91 per cent of the sample below the age of 15 years.

In a similar survey in February 1992, out of 446 people from five villages and towns including Akooko, Adjomoku, Anyinasin who were examined, 16.6 per cent were positive. The prevalence ranged from 4.81 per cent in Maase to 42.8 per cent in Adjomoku with 3.2 per cent of the sample below the age of 15 years.

In March of the same year, out of 823 people from seven villages and towns including Adasewase, Enyiresi, Kangkang, Abekoase, 2.4 per cent were positive with the prevalence ranging from 0 per cent in Kankang to 7.25 per cent in Monsie. Out of all the children below the age of 15 years examined, 0.97 per cent were positive.

The results of the skin sampling indicate that the catchment is onchocerciasis endemic but the level of endemicity appeared to range from low to high as evidently shown in the Bunso township. Though the endemic levels are not characterized by different blindness levels, there was clear manifestation of skin lesions (depigmentation, lizard skin etc), and nodules among the infected people. It was observed that the level of prevalence of the disease in the area was influence primarily by the location of the communities from the breeding sites and their farming practices.

## Conclusion

In the light of the findings from the study, the river Birim catchment area is onchocerciasis endemic and necessitates the alerting of the relevant authorities for the initiation of control measures.

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