KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY,

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DEPARTMENT OF ENVIRONMENTAL SCIENCE

THE PREVALENCE AND TRANSMISSION OF ONCHOCERCIASIS IN THE BLACK VOLTA BASIN: A CASE STUDY OF SOME COMMUNITIES WITHIN THE BUI DAM ENVIRON, GHANA

A THESIS SUBMITTED TO THE DEPARTMENT OF ENVIRONMENTAL SCIENCE, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE (MSc) DEGREE IN ENVIRONMENTAL SCIENCE

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CERTIFICATION

I hereby declare that this submission is my own work towards the Master of Science in Environmental Science and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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DEDICATION

I dedicate this thesis to GOD ALMIGHTY for His Mercy, Blessings and Grace upon my life.

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LIST OF ABBREVIATIONS

ABR	Annual Biting Rate
APOC	African Programme for Onchocerciasis Control
ATP	Annual Transmission Potential
BPA	Bui Power Authority
CDTI	Community Directed Treatment with Ivermectin
CMFL	Community Microfilarial Loads
DALY	Disability Adjusted Life Years
DDT	Dichloro Diphenyl Trichloroethane
FLH	Flies with Larvae in Head
GPS	Geographic Position System
HLC	Human Landing Catches
ITCZ	Intertropical Convergence Zone
L1	First stage larvae
L2	Second stage larvae
L3	Third stage/infective larvae
MBR	Monthly Biting Rate
MDGs	Millennium Development Goals
mf	microfilariae
mf/ss	microfilariae per skin snip
MTP	Monthly Transmission Potential
OCP	Onchocerciasis Control Programme in West Africa
OEPA	Onchocerciasis Elimination Programme for the Americans
OSD	Onchocercal Skin Disease
REMO	Rapid Mapping of Onchocerciasis

s.l	sensu lato
s.s	sensu stricto
SIZ	Special Intervention Zone
spp	species
UN	United Nations
UNDP	United Nations Development Programme
WHO	World Health Organization

ABSTRACT

The constructions of dams are generally known to create ideal environmental conditions for the proliferation of the vectors of diseases and the consequent increase in parasitic infections including onchocerciasis. The Bui Hydroelectric Project by its location in an area endemic with human onchocerciasis poses a health concern related to the construction of the dam. The study was aimed at assessing the prevalence and transmission of onchocerciasis in communities around the environ of the Bui Dam, in order to provide data for appropriate interventions. Skin snips were obtained from 240 study participants in four study communities and kept in physiological saline at room temperature and the emerged microfilariae were counted under the microscope 10x microscope objective. Also, 1,490 black flies were caught by eight volunteers at the four study communities. Horizontal and cross sectional procedures were used to assess the prevalence, intensity and transmission of human onchocerciasis among selected communities in order to evaluate the risk of exposure to the working population and inhabitants around the Bui Project area. The results from the MBR, MTP and crude prevalence were used as indicators of the risk of onchocerciasis in the area. Results showed the combined prevalence of onchocerciasis in the four selected communities as 7.2%. The prevalence of the onchocerciasis in all four communities with prevalence ranged from 1.1% in Bui Village to 11.8% in Gborlekame is considerably high. The intensity of infection as measured by the community microfilarial loads (CMFL) was highest in Gborlekame (0.28 mf/ss) followed by Resettlement Part B (0.24 mf/ss) and lowest in Bui Camp (0.08 mf/ss) and Resettlement Part A (0.08 mf/ss). There were no significance differences among the CMFL at Gborlekame, Resettlement Part B as well as Bui Camp and Resettlement Part A ($P > 0.05$). Gborlekame also had the highest monthly biting rate (MBR) of 3,565 whiles Part A had the least MBR of 1,240 among the 4 communities studied. The results showed the area was endemic with onchocerciasis. These findings call for further strengthening of current onchocerciasis control campaigns that rely solely on ivermectin distribution in the Bui environ so as to achieve the set goal of elimination of onchocerciasis.

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND

In many parts of the world, particularly in developing countries water infrastructural projects and dams continue to be implemented to meet human needs especially in energy generation and water supply. In spite of the numerous benefits of hydroelectric dams, these projects sometimes have fallen short of expectations, and placed an unquantifiable environmental impact or burden on society (Moran, 2004). Although a good number of large dams are serving their purpose, they often being criticised by society due to their unconstructive environmental and public health impacts. These dams are often associated with water-related infectious diseases including onchocerciasis, malaria and schistosomiasis which are a great threat to humans.

In Ghana the construction of the Akosombo Dam in 1963, the Kpong Dam in the 1981 and the on-going Bui Dam are sustaining the energy needs of the country. However the combined effects of the Akosombo and Kpong dams have reduced flow rate of the main stream and colonization of aquatic weeds have led to increased numbers of snails, particularly those serving as intermediate hosts of various schistosomiasis (Volta Basin Research Project, 2008)

The Bui Dam is located in Ghana on the lower Black Volta River about 150km upstream of the Lake Volta. The Bui Dam catchment area has been one of the most endemic areas of the black fly *Simulium damnosum* s.l. The area has the largest continuous string of Simuliid breeding sites running from Tagadi in the north to

Tain-Aboi in the south (Boatin, 2003). The flies apart from the painful bites and nuisance especially to the working population and inhabitants around the Bui Project area are also vectors of human onchocerciasis.

Most of the flies in this area are savannah flies (*S. damnosum* and *S. sirbanum*), [Boatin, *et al*., 2003]. The Bui Dam is located within the Guinea savanna zone of Ghana and therefore falls within the catchment area of the defunct WHO Onchocerciasis Control Programme in West African countries. The basis for the formation of the OCP was based on the observation that in savannah areas, there was a blinding parasite strain transmitted by savannah members of *S. damnosum* s.l. (*S. damnosum* s.s. and *S. sirbanum*) [Boatin *et al.*, 2008] and a non-blinding forest strain, transmitted by forest members (Basáñez *et al*., 2006).

The OCP was therefore established as a partnership programme to control Onchocerciasis using anti-vectorial measures and which later incorporated parasite control as an adjunct measure following the registration and licensing of ivermectin for mass administration in human populations. Now Onchocerciasis control in Africa is supervised by the African Programme for Onchocerciasis Control (APOC) via Community Directed Treatment with Ivermectin (CDTI) and vector control in few selected river basins designated as Special Intervention Zones (Remme, 1995). After the Onchocerciasis Control Programme (OCP) in West Africa had been closed down at the end of 2002, subsequent control activities were transferred to the participating countries including Ghana. The Ghana National Onchocerciasis Control Programme basically embarks on periodic mass treatment of endemic communities with ivermectin.

Onchocerciasis is a disease of public health and socioeconomic concern in the Bui Dam catchment area as the infection is prevalent adjacent to rivers such the Black Volta where the simuliid vectors breed in fast flowing and well-oxygenated waters.

1.2 PROBLEM STATEMENT AND JUSTIFICATION

The Black Volta basin was part of the former OCP's operational area that had consistent ivermectin treatment through community volunteers (CDTI) up until when the programme was devolved to Ghana government in December 2002. Between 2002 and 2005, the Bui-Black Volta basin suffered neglect in the distribution of invermectin, and even when treatment resumed in 2005 it was erratic with reports of poor supervision and shortage of drugs (Bui Health Impact Assessment, 2010). Since Onchocerciasis is still endemic in the area and with reports of ongoing black fly breeding (Francis Veriegh, personal communication), humans living or working within the immediate environ of the Dam are a potential sources blood meal and are predisposed to the risk of infection. Currently the Bui Dam site supports intensive black fly breeding provided for by a turbulent flow of water characterised by an outlet from the turbine generating units and through an ecological pipe. This observation together with the extensive substratum and the large vegetative substrate in the Black Volta are providing fertile grounds for the breeding of the black flies and therefore gradually populating the Bui gorge catchment area with black flies.

Although, as part of the implementation of the Bui Hydroelectric Project, the Bui Power Authority commissioned a team of biomedical scientists from the Noguchi Memorial Institute for Medical Research to carry out separate entomological and hydrobiological studies of the area there is still the need to assess current prelevence and transmission levels. Data from this study will among others serve as baseline data for control of parasitic infection such as onchocerciasis prevalence and transmission in the area within the Bui Dam environs.

1.3 MAIN OBJECTIVE

The broad objective of this study was to assess the prevalence and transmission of Onchocerciasis in some communities of the Bui Dam environ.

1.4 SPECIFIC OBJECTIVES

These were to determine the;

1. Prevalence of *O. volvulus* microfilaria in the communities.
2. Intensity of microfilaridermia
3. Relative abundance of *Simulium* flies in the area
4. Infectivity rates of *Simulium* flies in the area

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Black fly (*Simulium* spp.)

Adult black flies are small (under 4 mm long) Dipteran found in all parts of the world, with the exception of a few islands. They are short, heavy-bodied flies with a well-pronounced humped thorax. They are usually black hence, the name black flies and may have black, pale or silvery hairs on the body (Bradley *et al*., 2005; Wilson *et al*., 1994). Black flies have short and broad wings, with well-developed but membranous anterior veins. Males are distinguished from females on the head where the compound eyes occupy almost all of the head and meet the anterio-dorsally (holoptic), whereas females have eyes separated on top (dichoptic). Only females feed on blood (hematophagic) and can transmit the parasite (Crosskey, 1990). The species of blackflies acting as the main vectors of onchocerciasis in Africa and Arabia belong to the *Simulium damnosum* sensu lato (s.l.) species complex.

Species complex comprises groups of closely related species that are nearly almost identical on external morphology (sibling species), but that can only be distinguished by chromosomal (cytogenetic) or molecular techniques (Rothfels, 1981). The diversity of simuliid species complexes acting as vectors of human onchocerciasis in the Americas is far greater than in Africa.

In West Africa members of the *S. damnosum* complex are the only known vectors of human Onchocerciasis and Vajime and Dunbar (1975) have identified nine species of this complex in the area covered by the OCP namely: *S. damnosum* s.s., *S. sirbanum*, *S. sanctipauli*, *S. soubrense*, *S. squamosum*, *S. leonense*, *S. dieguerense*, *S.*

yahense and *S. konkourense* albeit with varying vectorial capacities (Boakye, 1993; Boakye *et al*., 1998). However, there are some important regional species that maintain transmission in areas outside of West Africa such as *S. ethiopiense* in Ethiopia, *S. woodi* in Malawi and Tanzania, and *S. neavei* in East Africa. In Latin America, *S. ochraceum, S. metallicum,* and *S. callidum* are important vectors in Mexico, Guatemala, and Venezuela while *S. exiguum* is the primary vector in Colombia and Ecuador, with *S. amazonicum* being predominant in Brazil (WHO, 1987; Basáñez *et al*., 2006). The most likely vector in Yemen is *S. damnosum,* while the most important transmitter in Saudi Arabia remains uncertain (Awadzi, 1989).

2.2 Life History and Distribution of Black flies

A female black fly, depending on the species, settles on partially submerged objects such as stones, wood and vegetation in fast flowing water or rapids and deposits its eggs in masses held together by sticky substances (Hadis, 2005; Petry *et al*., 2006). A single egg mass may contain 150-800 eggs which hatch within one or two days into the first larval instar which molts seven times in *S. damnosum* s.l. before changing into a pupa (Petry *et al*., 2006). The pupal and adult stages can be hidden as larval and pupal stages respectively, a condition called pharate stage (WHO, 1991). The larval stage may last between one and two weeks. The pupal stage may take from two to five days depending on a number of environmental factors such as temperature for the adult to emerge from the puparium. The period between successive molts is species and temperature dependent. After emergence, the adult either floats to the surface in a protective bubble or crawls upon submerged stones or vegetation (WHO, 1991; Hadis, 2005). The eggs of the female blackfly become fertilized when she mates with an adult male blackfly. After mating, she will seek a blood meal from a warm-blooded mammal. This blood nourishes the eggs and allows them to reach maturity. The female fly then seeks flowing water to lay her eggs and begin the cycle again. Plate 2 below, showed a black fly feeding on a human host.

Plate 1: Black fly feeding on a human host (leg)

2.3 Life cycle of the Filarial Parasite (Nematode)

The transmission cycle begins when an infective female fly takes a blood meal from an infectious human along with microfilariae. The engorged parasite undergoes different developmental processes within the fly host lasting for an average of seven days and ending in the infective stage (L3). During a subsequently blood meal the fly inoculates another human host with the larvae (L3). The microfilaria then undergoes two metamorphoses and develops into adult worms over the next one to two years which are usually enclosed as worm bundles in deep and palpable subcutaneous nodules. When matured, the female adult worms may live for as long as 10 to 15 years during which period it can produce hundreds of thousands of microfilariae per day that migrates to the skin and eyes of the host. This circulating microfilaria can be taken up by a biting adult fly, and thus the cycle of infection is completed. The adult worms seldom cause any symptoms except as subcutaneous nodules around bony prominences meanwhile the migrating microfilariae are responsible for the clinical manifestation and pathology of the disease such as severe itching, rashes, depigmentation of the lower limbs ("leopard skin"); and destruction of skin elasticity, resulting in loose, hanging folds ("hanging groin"). The most devastating effect of Onchocerciasis occurs when microfilariae which enter the eye die leading to visual impairment and eventually to blindness through a cascade of immune inflammatory responses (Basáñez *et al*., 2006).

In onchocerciasis-endemic communities with on-going transmission, the parasite's life cycle comprises the long-lived adult stages (male and female worms) located in subcutaneous palpable nodules called onchocercomata or in deeper and inaccessible bundles, with an average female reproductive life span of about ten years; the skin-dwelling embryonic microfilariae (MF) with a mean life expectancy of 15 months; immature stages (L4 and juvenile adults) that reach sexual maturity and start producing Mf within human host in roughly one year and the fly-stage larvae that attain infectivity to humans in about one week L1 to L3 (Basáñez and Boussinesq, 1999; Duke *et al.*,1991, 1993). A female adult black fly ingests microfilariae from an infected human host alongside the blood meal. The microfilariae that survive the vector’s immune system evade the intestinal lining and pass into the haemolymph where they further migrate to the thoracic muscles and undergo some morphological changes to develop into the L1 and L2 stages (Hadis, 2005). These stages of development are indicated in figure 1 below.

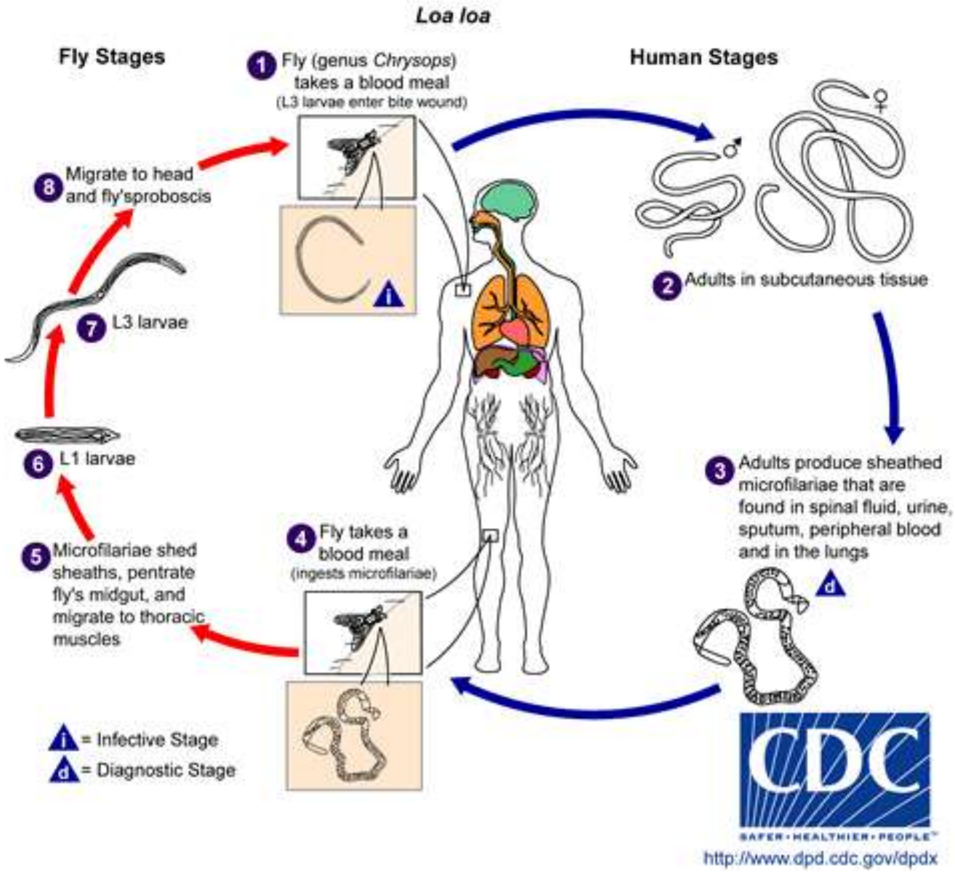


Figure 1: Life cycle of *O. volvulus* adapted from CDC

The L2 microfilariae undergo their final morphological development into the infective stage [L3] (Awadzi *et al*., 2004), move to the salivary glands of the fly and transmitted to another human host. In the human host, the larvae undergo a two stage molt to become an adult worm. It takes between 10 to 15 months for the microfilariae to develop into an adult and to produce their first microfilariae (WHO, 1991).

2.3 Distribution of onchocerciasis

Onchocerciasis, also known as river blindness is a chronic disease, considered as the world's second leading cause of preventable blindness. At present onchocerciasis is endemic in 27 sub-Saharan African countries, where over 90 % of the 37 million infected people reside and putting some 90 million people at risk (Remme, 2004). In Central and South America reports indicate that more than 400,000 have been infected (Basáñez *et al*., 2006). In all some 0.66 million are blind or visual impaired with about 50% of all infected persons showing onchocercal skin disease (Remme, 2004; TDR., 2005). The estimated burden of onchocerciasis in terms of disability-adjusted life years (DALYs) is 1,490,000.

The distribution of onchocerciasis is confined to the geographical range of the vectors which extends from Senegal in the West to Somalia in the East and from latitude 19 ^{o}N in Sudan to 34 ^{o}S in South Africa (Townson and Meredith, 1979). The distribution of members of the *Simulium damnosum* species complex in Africa is determined by the two main vegetative zones (savanna and forest), topography, river size, seasonal climatic variation, wind movement and direction and river water level (Boakye *et al*., 1998). Onchocerciasis is currently distributed in 27 sub-Saharan African countries, the Yemen on the Arabian Peninsula, and six Latin American countries including Mexico, Guatemala, Colombia, Ecuador, northern and southern Venezuela and Brazil (Bradley *et al*., 2005; Basanez *et al*., 2006; WHO, 1995; 2005). Plate 2: illustrates geographical distribution of human onchocerciasis.

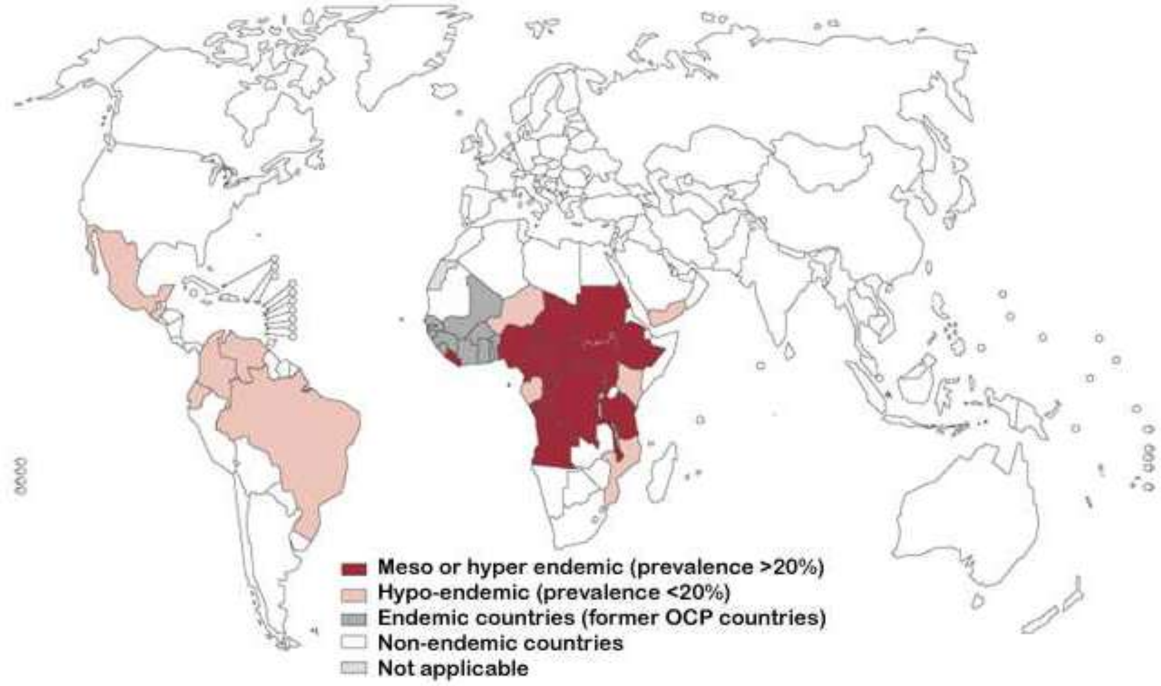


Plate 3: Geographical distribution of human Onchocerciasis (WHO factsheet-fs 374, 2013).

2.5 Specific Annual Transmission Potentials (ATP)

Annual transmission potential (ATP) in onchocerciasis studies represents the total number of infective larvae (L3) potentially received by a person exposed to the diurnal bites of *Simulium* flies during a whole year (Duke, 1968; Walsh *et al*., 1978). It is estimated as the product of the annual biting rate (ABR) and the mean number of L3 larvae indistinguishable from *Onchocerca volvulus* per biting fly (Duke, 1968). The ABR is expressed as the mean number of *Simulium* bites received by a person stationary at the collection point for a year. In Africa onchocerciasis transmission of occurs at different rates according to a variety of factors including habitat, vector abundance, competence of the local vector species and season.

The West African onchocerciasis habitat is characterised by the vegetative zones (either as savanna or forest), the topography of the area, the rivers size that support fly breeding and other factors which influence the distribution dynamics of transmission (Boakye *et al*., 1998). The intensity of transmission as measured by the Annual Transmission Potential (ATP) varied seasonally and Renz (1987) reported ATPs as high as 1609 to 3076 infective larvae/man/year near the breeding sites, where transmission was almost perennial. However, at distances of more than 3 km from the river, transmission will usually be restricted to the rainy season where ATPs could fall below 200, whereas low to zero levels of transmission were measured inside villages more than 3 km distant from the river. Previous works have shown that the infection rates of *S. damnosum* s.l. vectors in the Sudan-savanna of north Cameroon are low, and that they are more closely related to the prevalence of onchocerciasis and to the number of parous flies than to the mean concentrations of microfilariae in the skin or to the total number flies caught (Duke *et al.,* 1975). The human host-choice of the vectors, their rate of survival to the infective age and the mean number of infective larvae developing from one bloodmeal on a microfilarial-positive person is the main factors influencing the vectorial efficiency of a fly population (Garrett-Jones, 1964; Dietz, 1982). Seasonal variations in vectorial efficiency are likely to occur, following changes in the species composition and in the dispersal pattern of the fly population (Renz and Wenk, 1987; Renz, 1987; Duke, 1975). Thus at the same man-fly contact rate, the resulting *O. volvulus* transmission potentials may vary considerably from one place to another or from the rainy to the dry season.

In savanna regions transmission may cease in the dry season when very few vectors are present and, in general, transmission rates in the savanna are highest during rainy seasons (Renz *et al*, 1987). However, even where rivers are perennial, in forests for example, there is also seasonal variation (Denke and Cheke, 1988). In 'oil palm bush' (forest zones cleared for agricultural use) in Sierra Leone the transmission peak is in the late wet season and early dry season from October to December (Davies *et al*., 1988). In Ghana and in areas around the lower Black Volta basin, onchocerciasis constitutes a serious obstacle to socioeconomic development. Contrary to expectation, variations in transmission rates have not been satisfactorily accounted for by either changes in fly numbers or by shifts in the relative abundances of different members of the *S. damnosum* complex with contrasting vectorial efficiencies. Other factors including survival rates are also involved. Seasonal variations in fly survival rates of this sort are commonly cited as important factors influencing temporal trends in onchocerciasis transmission rates. In Nigeria, *O. volvulus* is transmitted primarily by the *Simulium damnosum* complex (Opara *et al.*, 2005). An understanding of the transmission dynamics of Onchocerciasis as in other forms of filariasis is important in advancing knowledge of how vector competence, behaviour, and abundance influence the level of infection and disease in susceptible human population. The collection and dissection of adult flies can be used as a means of following the dynamics of a *Simulium* population and vector infectivity and thus the level and magnitude of parasite transmission.

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* (Opara *et al.,* 2005). The fly-to-human ratio and the availability of microfilariae reservoirs in the human population may also affect infectivity rates (Okenu *et al*., 2005). Opara *et al.* (2005) indicated that 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 the dry season. Hence, there were greater chances of receiving a bite from an infected fly during the rainy season than in the dry season. The transmission of microfilariae via the bites of infected black flies (*Simulium* spp.) carries immature larval forms of the parasitic worms from human to human.

2.6 Prevalence of Microfilariae (MF) and Community Microfilarial Load (CMFL)

Africa is home to 99% of those infected with onchocerciasis and 99.6% of the blind where the parasite is prevalent over broadly continuous areas of savanna and forest zones in the west and over more patchy areas in the east with the West African savanna strain of the parasite being more pathogenic to the eye than the forest strains (Duke & Anderson 1972; Zimmerman *et al*., 1992). In the worst afflicted regions, the impact of the disease results in the depopulation of otherwise fertile river valleys are with serious socio-economic consequences (Evans 1995; Nwoke 1990; Prost *et al*. 1979; Remme, 2004).

Microfilarial prevalence and intensity are usually nonlinearly related such that for hyperendemic localities (≥60% of people infected) large changes in intensity are associated with slight modifications in prevalence (Anderson and May, 1985; Remme *et al*. 1986). The same relationship applies to the proportion of flies with larvae and the mean larval load per fly (Basáñez *et al*., 1994, 1995). Both are the result of highly overdispersed distributions of parasite numbers per human or vector host, which have successfully been described by the negative binomial distribution (Cheke *et al*. 1982).

In human populations where transmission regimes tend to be seasonal and less intense, mean MF intensities may be higher in males than females (but not always), increase with age in both sexes, reach a plateau in the 15 - 30 year age-group and decline in the elderly probably due to processes such as parasite-induced host mortality induced by blindness, acquired immunity, and age-dependent changes in exposure, infection rate, or parasite mortality and/or fecundity rates. Alternatively, in communities associated with heavy and virtually perennial transmissions, infection may increase steadily with age and decrease only in the oldest (50+year) age-groups (Kirkwood *et al*., 1983). This aggregation may contribute to stabilize the interaction between *O. volvulus* and its definitive and vector hosts by limiting the detrimental impact of the infection to that fraction of the host population harbouring high worm loads, and by making it possible for regulatory processes to influence the larger proportion of the parasite population concentrated in a few individuals (Anderson and May, 1978). Like most macroparasitic infections, onchocerciasis exists as an endemic, stable, resilient and usually chronic condition with high intensity of infection among affected communities where parasite prevalence may reach high levels with ongoing transmission and reinfection as most macroparasitic diseases (Anderson and May 1985; Maizels *et al*. 1993; Basáñez and Boussinesq, 1999;).

In the former Onchocerciasis Control Programme area following 8 years of vector control, the prevalence of infection in the human population did not reflect the impact of the expensive control operations as the level of endemicity of surveyed communities used to be classified using the poor indicator of MF prevalence (Remme, 2004). When analysis of model outputs and epidemiological evaluation suggested that the microfilariae prevalence was not an appropriate indicator for control evaluation, a better index of endemicity, the Community Microfilarial Load (CMFL) which reflect the intensity of infection at the community level was introduced as much more sensitive indicator of the level of endemicity and for monitoring the impact of vector control (Remme *et al*. 1995).

The CMFL, the reference index used in the OCP, is estimated as the geometric mean of individual microfilaria loads (including zero counts) in people aged 20 years or older and its evaluated as the log (x+1) transformation, where x is the individual microfilaria load (Osei-Atweneboana *et al*. 2007; Remme *et al*. 1986). Remme *et al*. (1989) tested the sensitivity of the CMFL and showed that community levels of ocular microfilarial loads, ocular lesions and blindness were linearly related to the CMFL. Subsequent CMFL analysis after correction for endemicity between savanna and forest areas of West Africa showed that the patterns in the forest zones were fundamentally different from those in the savanna: for the same level of CMFL the prevalence of ocular lesions and blindness in the forest zones were only a fraction of those in the savanna (Dadzie *et al*. 1989, 1990, 1992).

2.7 Clinical Manifestation of onchocerciasis

The long-lived adult worms (male and female) live in subcutaneous palpable nodules under the skin called onchocercomata or in deeper inaccessible worm bundles where they produce (for an average female reproductive life span of about ten years) large numbers of microfilariae. In onchocerciasis the embryonic, skin-dwelling microfilariae (MF) with a mean life expectancy of 15 months are responsible for most of the pathology associated with the disease (Basáñez and Boussinesq, 1999). Little *et al*., (2004) observed that the incidence of blindness within the OCP area was associated with past microfilarial load in individuals that were followed up after antivectorial and antiparasitic interventions confirming the progressive deterioration of onchocercal eye disease with parasite load.

Ocular lesions leading to visual impairment and blindness may be attributed to a cascade of inflammatory processes triggered by died or dying filarial products (Hall and Pearlman, 1999). Currently, it is believed that the pathogenicity of ocular disease is not only induced by the parasite itself, but also by its recently discovered endosymbiotic *Wolbachia* bacteria, when released by dying microfilariae (Saint-André *et al*., 2002; Brattig, 2004). The posterior chamber (retinal) lesions which are likely to result from autoimmune cross-reactivity processes between parasite and human host factors by contrast may continue progressing despite parasite clearance after chemotherapy (McKechnie *et al.*, 2002). Initially, in the microfilarial stage, a popular, intensely itchy rash develops and this may be the only symptom in lightly infected persons. With repeated infections characteristic subcutaneous nodules of various sizes appear.

Onchocercal Skin Disease (OSD) which causes troublesome itching and skin changes ranges from early reactive lesions (comprises acute papular onchodermatitis, chronic papular onchodermatitis, and lichenified onchodermatitis) to late changes such as depigmentation and skin atrophy (Murdoch *et al*., 1993; Basáñez *et al*., 2006). Where the lichenified onchodermatitis is confined to one limb it is usually described as “sowda”. Onchocerciasis has also been associated with musculoskeletal pain, reduced body mass index, and decreased work productivity because the embryonic microfilarial stages may invade many tissues and organs, and are sometimes found in blood and urine (Bradley *et al*., 2005).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

The study was carried out within some communities downstream of the Bui Dam environ in the Bole district (Northern Region) and the Banda district (Brong - Ahafo Region) in north-western Ghana, approximately 150 km upstream of the Lake Volta. Communities for the study included Gborlekame, Bui Camp, Resettlement Parts A and B. The study area was located around the Bui Hydroelectric Project on the Black Volta River sharing boundaries to the Bole district (Northern Region) and former Tain, but now Banda district (Brong - Ahafo Region).

The specific location of the Bui Project is particularly suitable for a hydroelectric project because of the relatively deep gorge where the Black Volta River flows through the Banda Hills. The project includes a main dam in Bui Gorge and two smaller saddle dams in the neighbouring Banda Hills, which will create a reservoir extending roughly 40 km upstream. The project area is surrounded by an Acquired Land (Executive Instrument 70) gazette in August, 2008.

3.1.1 Climate and Rainfall

There are three major vegetation types in the area of the Bui Hydroelectric Project which comprises savannah woodland about 60%, riparian forest (10%) and grassland (30%). The dominant vegetation type, savannah woodland, is generally characterised by scattered trees of medium height (5-20 m) underlain by a dense ground cover of tall (0.5-1 m) perennial and annual grasses and forbs with some areas of exposed soil and rock. Riparian forest, the second most widespread habitat type, borders the

Black Volta River and its tributaries and is generally characterised by trees of medium and tall height (10-20 m) and dense undergrowth of woody shrubs. The climate of the project area has been classified as ‘Dry Equatorial’, a sub-classification of the Hot Equatorial-Tropical climate of the majority of West Africa (Coyne et Bellier 1995 & 2006) This is characterised by a double-peak wet season (maximum in May- June and October) or a single rainy season (maxima in July-August) depending on the yearly northernmost limit of the Inter Tropical Convergence Zone (ITCZ). The climate in the project area tends towards the latter. The average yearly rainfall in the project area is 1140 mm, based on a study by the Ghana Meteorological Agency using interpolated data from the nearest weather stations for the period 1983-2005 as attached in appendix 6.

3.1.2 Temperature Humidity and Evaporation

The equatorial air masses affecting the project area are warm and moist, and wind velocities are generally low. Data from the Coyne et Bellier (1995 & 2006) report indicates that monthly temperatures range from around 26^0 C in August to around 30^0 C in March. The project area has a mean annual relative humidity of 75%, with a maximum mean monthly value of 87% in September and a minimum of 58% in January. The Bui dam site has a mean annual pan evaporation of 1781 mm. This is considerably less than that recorded in the neighbouring Wa and Navrongo areas and is believed to be due to its more southerly position Coyne et Bellier (1995 & 2006).

3.2 Sampling Techniques

3.2.1 Selection of Communities

The four (4) communities selected for this study comprised the Bui Power Authority (BPA) Resettlement Part B (consisting of Bui, Bator/Akanyakrom and Dokakynina villages), BPA Resettlement Part A (consisting of Jama-Lucene, Dam Site, Agbezikrom and Brehodi), Bui Camp, and Gborlekame (North and South). All these communities are located downstream of the Dam construction site. The participating communities were extensively surveyed (for breeding sites) and study participants selected form the communities as illustrating the map below.

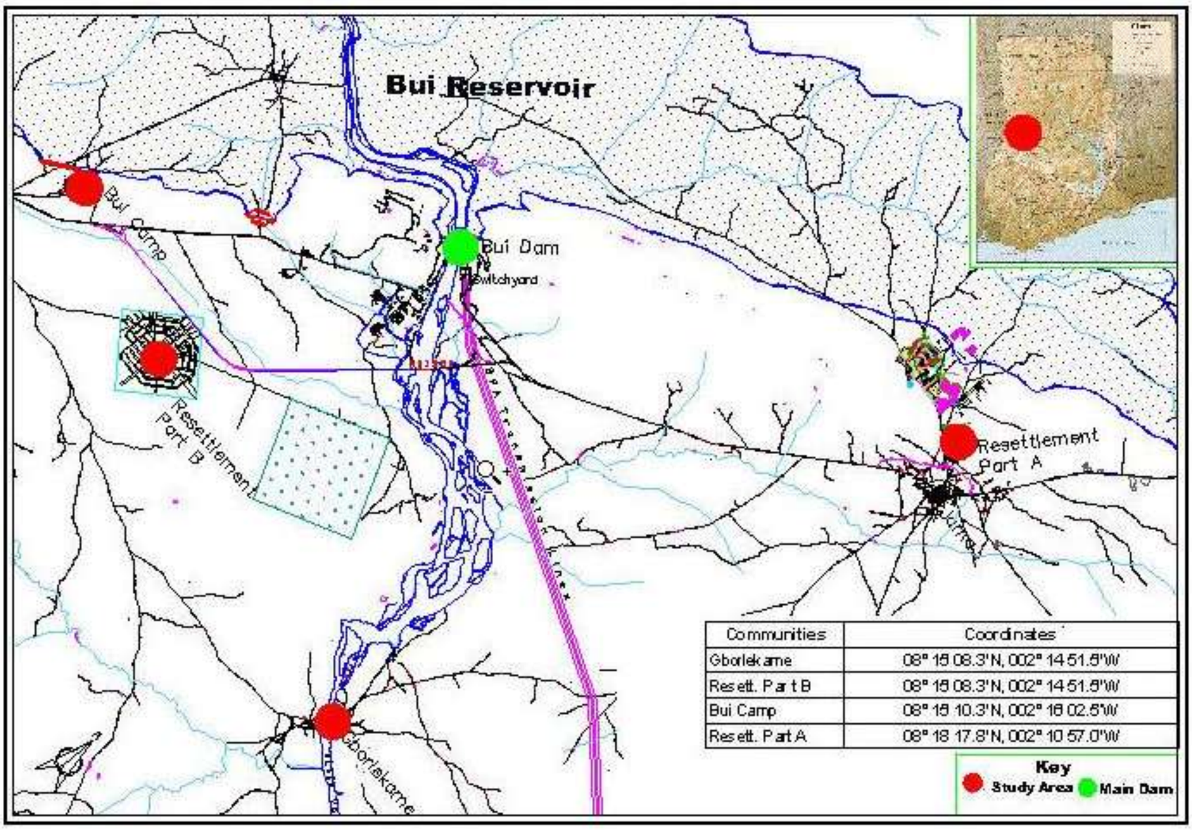


Figure 2: Map of Ghana showing the study area

3.2.2 Selection of Participants

Participants were selected from the four communities using simple random sampling technique and consisted of individuals aged 15 years and above in each community. Pieces of paper were labelled with 'yes' and 'no' and kept in a box for the participants to pick from. Sixty participants who picked yes and gave consent to participate in the study were subsequently selected for the skin snip. Each individual was registered for the study and given an identification number from 1 to 60. Plate 3 showed inhabitants gathered for the selection

Plate 3: Inhabitants gathered for random sampling

3.2.3 Skin Snipping

All 60 registered study participants from each community were skin snipped to determine individual microfilarial counts in order to evaluate the prevalence and intensity of infection in each community. A piece of cotton wool soaked in methylated spirit was used to clean both sides of iliac-crest of each person. Blood-free skin snips (approx. 2mg) were taken from each individual using a sterilized 2mm Holt corneo scleral punch (E1802, Holt storz, Germany) as carried out in plate 4 below. The biopsies were then incubated in physiological saline to detect microfilariae (mf) of *O. volvulus*.

Plate 4: Researcher in the process of snipping skin from a volunteer

3.2.4 Microscopic Examination

The skin snips from each side of the iliac crest were incubated in physiological saline (100µl) contained in a ringed well of a microtitre plate and incubated overnight at room temperature after which the number of microfilariae that emerged were countered under a light compound microscope (Olympus: X10 Objective). Each plate containing eight (8) wells takes skin biopsies from four (4) persons with an identification number that corresponds with the person's registration number as displayed in plate 5 below.

Plate 5: Snipped skins placed tray (orange colour) for biopsy studies

The number of MF that emerged from each snip was recorded on a parasitological report sheet corresponding to the prticipants' identity number. If the biopsy was positive, the MF were counted and the parasitemia collected in order to determine the intensity of infection and the prevalence of microfilariae among the study communities as denoted in plate 6.

Plate 6: Microscopic examination of skin snips for skin microfilariae

The crude prevalence rate (**P**) was calculated as;

$$P = a/b \times 100$$

Where **a** is the number of individuals in the population infected with the microfilariae and **b** as the total number of individuals sampled.

The Standard Prevalence was determined as the cumulative prevalence of all persons infected in the population (The CMFL as the geometric mean of individual microfilariae loads (including zero counts) in people aged 15 years or older.

3.3 Entomological Studies

This part of the study was conducted in the four (4) communities (Gborlekame, Bui Camp, Resettlement Parts A and B) selected for skin snip surveys. Black flies were collected from the communities downstream of the Bui Dam in order to determine fly infection rates and entomologic indices of parasite transmission.

3.3.1 Human Landing Catches

Flies were collected for four (4) days on hourly basis for all hours of diurnal activity (06:00-18:00 hrs GMT) using human landing catches (HLC). Fly collection was conducted by two well-trained and experience community volunteers working alternately totalling eight (8) fly collectors. The fly collectors sat with their legs exposed. Any fly perching on the exposed parts was caught before it fed by inverting a small tube over it as carried out on plate 7 below. The caps of the tubes were then immediately replaced. All tubes containing flies were labelled to indicate time, date and place of capture. Each fly was caught in a different tube. Hourly captures were pooled and labelled. In all a total of 1, 490 flies were collected from all the four (4) communities. The GARMIN etrex (made in Taiwan) Global Positioning System (GPS) coordinates of the collection sites in each of the community were taken and recorded.

Plate 7: Catching of flies by experienced volunteers in the sampling area

3.3.2 Dissection of Flies

All the 1,490 flies caught were dissected under a dissecting microscope to determine the parity and infection rates. A blackfly was placed in a drop of water on a glass slide. The slide was then placed on the stage of a dissecting microscope. With the aid of two dissecting needles, the abdomen of the fly was cut-opened on the third segment, and the ovaries carefully pulled out and examined for parity. A fly was conclusively parous if it had a retained egg, otherwise a combination of pale Malpighian tubules, absence of fat bodies and the elasticity of the ovarian follicles scored a fly parous and nulliparous on the contrary. Nulliparous flies were then discarded and all parous flies dissected on the head, thorax and abdomen. The number and developmental stages *O. volvulus* microfilariae (L1: the parasites in the abdomen. L2: parasites in the abdomen and thorax. L3: the parasites in the thorax and head) were counted and recorded. The information from the catches was used to calculate the infection, infective biting rates and the monthly transmission potential.

The Monthly Biting Rate (MBR) was calculated as:

$$\mathbf{MBR} = \frac{\text{No. of flies caught X days in the month}}{\text{No. of catching days}}$$

The Monthly Transmission Potential (MTP) was calculated as;

$$\mathbf{MTP} = \frac{\text{MBR X number of head stage L3 larvae}}{\text{Number of flies dissected}}$$

Fly infectivity rate was expressed as the number of flies with L3 larvae in the head per 1000 parous flies dissected.

3.4 Statistical Analysis

The infective stage (L3) of the *O. volvulus* in the head was used in calculating the monthly transmission potential. The data was analysed using the student t-test and differences were considered significant at 95% confidence level ($p < 0.05$).

3.5 Data Source

Some of the data was obtained from secondary source (Healthcare Centres within the Project catchment area) and through personal communications. Other data was obtained from direct field measurement and laboratory analysis.

CHAPTER FOUR

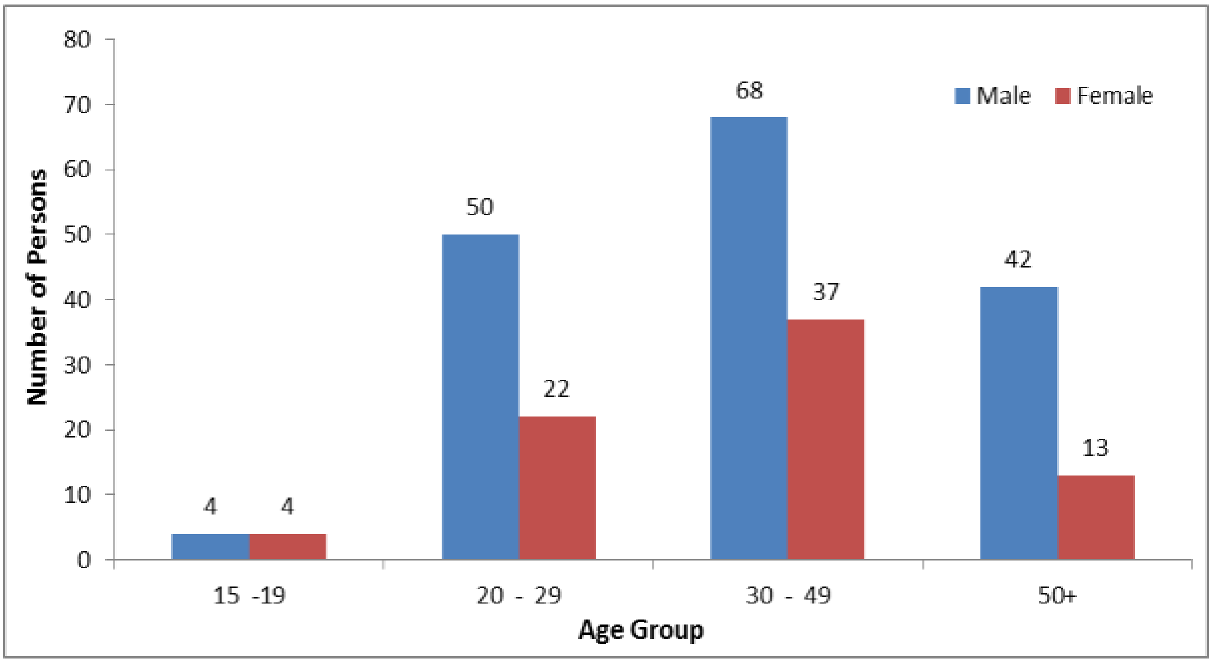
4.0 RESULTS

4.1 Study population of selected communities in the Bui Dam environ

A total of two hundred and forty (240) participants comprising 60 individuals from each of the 4 selected study communities took part in the study, out of an estimated population of one thousand four hundred and thirty (1,430) inhabitants.

4.2 Age and Sex distribution of the participants

The sample consisted of 166 males and 74 females. The subjects were grouped into four age-group categories namely, 15 – 19, 20 – 29, 30 – 49, and those who were 50+ years (Figure 3). The 30 – 49 year age group had the highest number (43.8%) of individuals while 15 – 19year age group had the lowest number (3.3%) of participants (Figure 3).



Field Survey August, 2012.

Figure 3: Age distribution of individuals screened for the Onchocerciasis survey

4.3 Prevalence of *O. volvulus* microfilaria in the Communities

The standard prevalence of microfilariae for each of the four selected communities is shown in Table 1. Gborlekame had the highest standard prevalence of 11.8% while Bui Camp had the lowest prevalence of 1.1%.

Table 1: Standard Prevalence of Onchocerciasis within the 4 Communities

Community	**No. Examined**	**No. Infected**	**Standard Prevalence (%)**
Gborlekame	60	11	11.8
Bui Camp	60	2	1.1
Resettlement Part A	60	6	3.2
Resettlement Part B	60	3	2.6

4.3 Age related prevalence of onchocerciasis in the study population

The 15-19 year age group recorded the highest prevalence (crude) of 37.5% followed by the group of individuals who were 50 years and above (9.1%). The least prevalence was the 20-29 year age group with a prevalence of 6.9% (Figure 4).

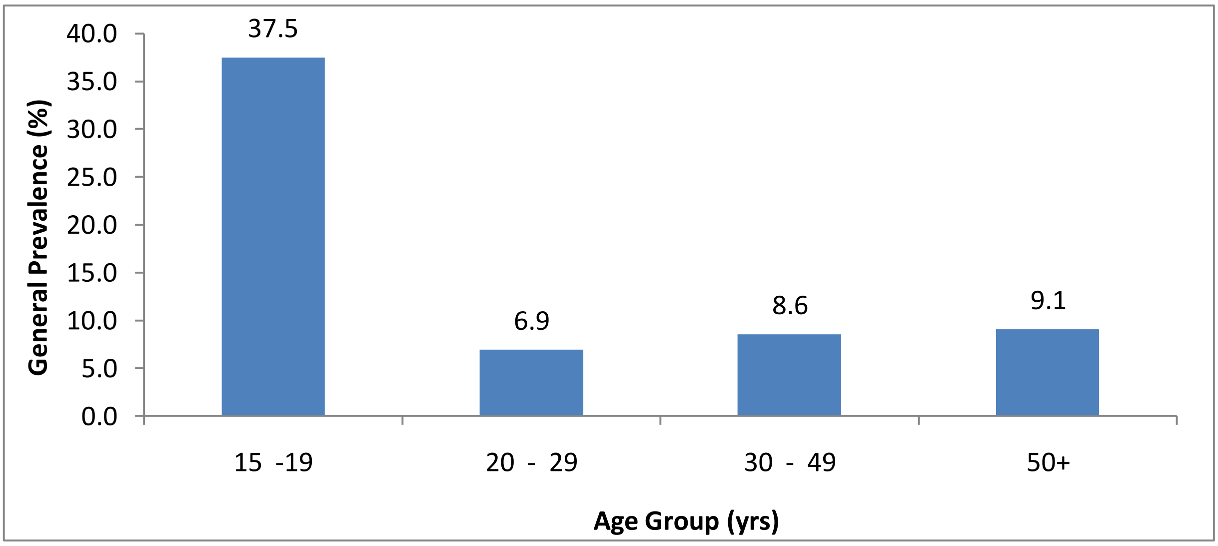


Figure 4: General prevalence by age in the study population

4.3.1 Prevalence and Intensity of *O. volvulus* Microfilariae in Resettlement Parts A and B

The prevalence and intensity of the onchocerciasis was assessed among four age group categories for the four selected communities. Resettlement Parts A and B had the least onchocerciasis prevalence among the 15 – 19 age groups and community microfilariae loads (CMFL) of 0.24 and 0.08 mf/skin snip (mf/ss) respectively. Onchocerciasis was more prevalent (12.5%) among the 30-49 age groups at Resettlement Part A as compared to Part B where the 50+ age group had the highest prevalence (14.3%). In both communities onchocerciasis was more prevalent among males than among females. The prevalence of onchocerciasis for the various age groups at Resettlement Parts A and B are shown in respective Tables 2 and 3.

Table 2: Prevalence of Onchocerciasis by Age and Sex in the Resettlement Part A Community.

Age Group	Examined			Positives			Crude Prevalence (%)			Stand. Prev. (%)	CMFL
	M	F	T	M	F	T	M	F	T		
15 – 19	0	0	0	0	0	0	0	0	0.0		
20 – 29	17	5	22	2	0	2	12	0	9.1		
30 – 49	17	7	24	3	0	3	18	0	12.5		
50+	11	3	14	1	0	1	9	0	7.1		
TOTAL	45	15	60	6	0	6	13	0	10.0	3.2	0.24

Lab. survey August, 2012

M: Male, F: Female, T: Total

Table 3: Prevalence of Onchocerciasis by Age and Sex in the Resettlement Part B Community.

Age Group	Examined			Positives			Crude Prevalence (%)			Stand. Prev. (%)	CMFL
	M	F	T	M	F	T	M	F	T		
15 – 19	0	3	3	0	0	0	0	0	0.0		
20 – 29	10	13	23	1	0	1	10	0	4.3		
30 – 49	14	6	20	0	0	0	0	0	0.0		
50+	10	4	14	1	1	2	10	25	14.3		
TOTAL	34	26	60	2	1	3	6	4	5.0	2.6	0.08

Lab. survey August, 2012

M: Male, F: Female, T: Total

4.3.2 Prevalence and Intensity of *O. volvulus* Microfilariae in Bui Camp

The prevalence and intensity of onchocerciasis at the Bui Camp; the least populated of the four selected communities was 1.1% and 0.08 mf/ss respectively. There was low prevalence of onchocerciasis in this community as compared to Resettlement Parts A and B. Only males aged between 30 and 49 were skin snip positive as shown in Table 4.

Table 4: Prevalence of Onchocerciasis by Age and Sex in the Bui Camp.

Age Group	Examined			Positives			Crude Prevalence (%)			Stand. Prev. (%)	CMFL
	M	F	T	M	F	T	M	F	T		
15 – 19	1	0	1	0	0	0	0	0	0.0		
20 – 29	15	2	17	0	0	0	0	0	0.0		
30 – 49	20	16	36	2	0	2	10	0	5.6		
50+	4	2	6	0	0	0	0	0	0.0		
TOTAL	40	20	60	2	0	2	5	0	3.3	1.1	0.08

Lab. survey August, 2012

M: Male, F: Female, T: Total

4.3.3 Prevalence and Intensity of *O. volvulus* Microfilariae at Gborlekame

Gborlekame is the immediate community downstream located about 5 km off the Bui Dam where most of the inhabitants are fishermen, dwelling on both sides of the Black Volta River. This community had the highest prevalence and intensity of *O. volvulus* infection with a standard prevalence of 11.8% and CMFL of 0.28 mf/ss. The 15 – 19 years age group was had the highest prevalence of onchocerciasis among the males' whiles the 50+ age group had the lowest since the young men were more involved with fishing activities than the old men. Among the female however, the 20 – 29 age group had the highest onchocerciasis prevalence (20%). The distribution of microfilaridermias among the various age groups is shown in Table 5.

Table 5: Prevalence of Onchocerciasis by Age and Sex in Gborlekame.

Age Group	Examined			Positives			Crude Prevalence (%)			Stand. Prev. (%)	CMFL
	M	F	T	M	F	T	M	F	T		
15 – 19	3	1	4	3	0	3	100	0	0.0		
20 – 29	8	2	10	2	0	2	25	0	20.0		
30 – 49	17	8	25	3	1	4	18	13	16.0		
50+	17	4	21	1	1	2	6	25	9.5		
TOTAL	45	15	60	9	2	11	20	13	18.3	11.8	0.28

Lab. Survey August, 2012

M: Male, F: Female, T: Total

4.3.4 Crude Prevalence and Intensity of Onchocerciasis within the four Communities

Table 6 summarises the crude prevalence and intensity of *O. volvulus* infection among the four selected communities. Out of the total of 240 inhabitants examined, 22 people (both males and females) were skin positive for *O. volvulus* parasites giving a standard prevalence of 7.2% and an overall community microfilaria load of 0.09 mf/ss. All age categories of the males were infected with *O. volvulus* whereas only a few females aged 30 and above were infected in all four study communities. There were significant variations in the standard prevalence rate among the 4 different communities with Gborlekame having the highest with 11.8%.

Table 6: Crude Prevalence and Intensity of microfilaridermia in the four communities

Community	No. Examined	No. Infected	Standard Prevalence (%)	Intensity (mf/ss)
Gborlekame	60	11	18.30	0.28
Bui Camp	60	2	3.33	0.08
Resettlement Part A	60	6	10.00	0.24
Resettlement Part B	60	3	5.00	0.08

Lab. Survey August, 2012

4.4. Relative abundance, infectivity rate, biting rate and transmission potential of *Simulium* flies in the 4 communities

The fly relative abundance, number of parous flies, fly infectivity rate, biting rate and the monthly transmission potential for the study communities are shown in Table 7 below. Two of the communities (Gborlekme and Resettlement Part B) recorded onchocerciasis transmission.

Table 7: Fly relative abundance, infection, and transmission potentials among the 4 communities selected for entomologic studies

Community	Flies Collected	Parous Flies	Infected Flies	Infective Flies	MBR	MTP	Infectivity Rates
Gborlekame	460	200	15	4(4)	3,565	31	20
Resettlement Part B	425	136	7	3(11)	3,294	85.25	22.1
Bui Camp	445	119	2	0	3,449	0	0
Resettlement Part A	160	49	1	0	1,240	0	0
Total	**1,490**	**504**	**25**	**7**			

Field Survey, 2012

* MTP is determined from the number of infective stage larvae (L3) found in the head of the fly.

4.4.1 *Simulium* flies Relative Abundance

A total of 1,490 blood seeking adult female *S. damnosum* were caught in the four communities as summarized in Table 7 above. Gborlekame had the highest fly abundance while Resettlement Part A recorded the lowest fly abundance after 4 days of vector collection. The catches were carried out simultaneously to ensure equal chance of the abundance of the flies present in the various communities.

4.4.2 Parity of *Simulium* flies.

The results from the catches and dissection of *S. damnosum* in the 4 communities indicates that, out of the total number of 1,490 flies caught, 504 representing 33.8% were parous. The proportion of parous flies (%) in the various study communities are shown in Figure 5.

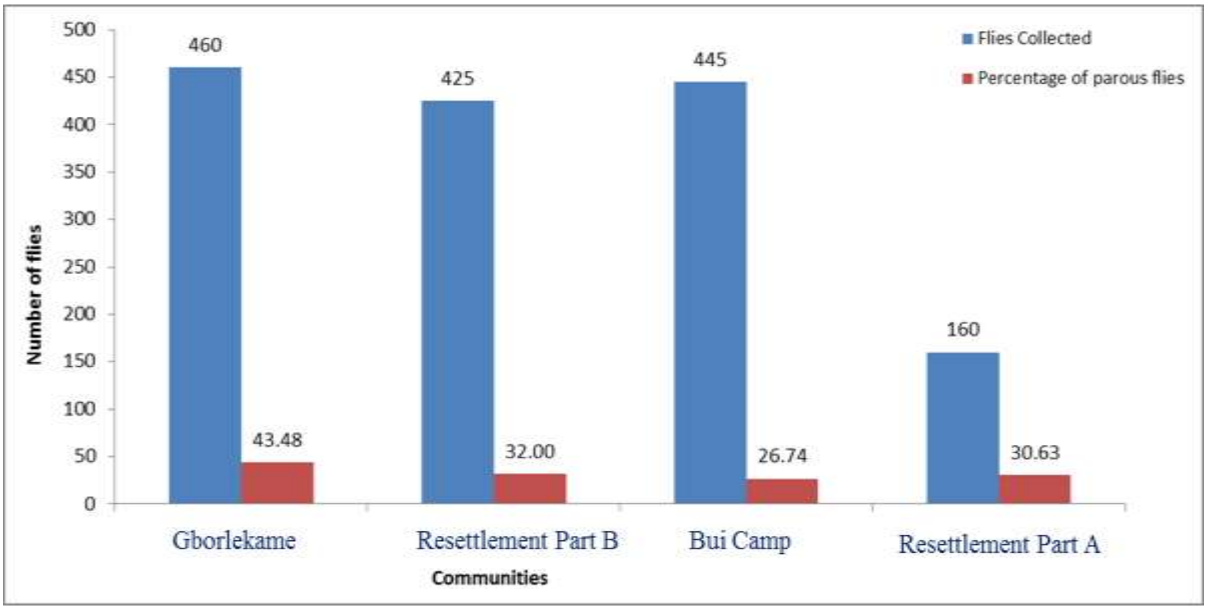


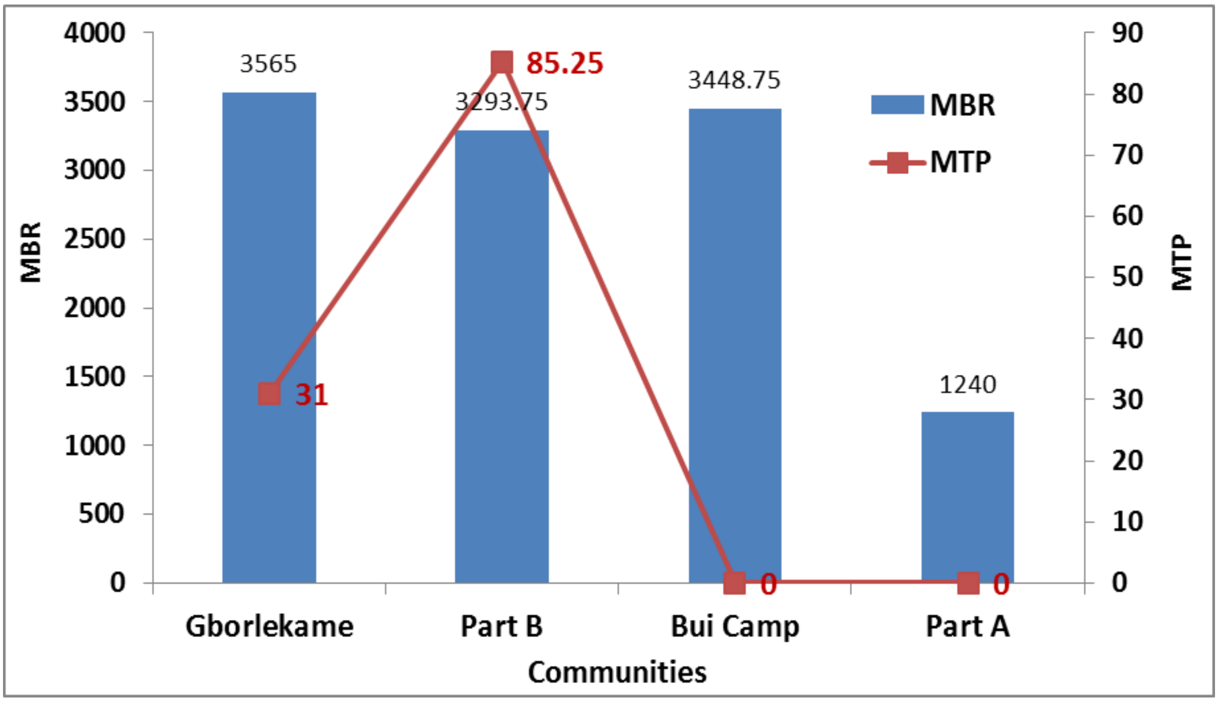
Figure 5: Comparison of *Simulium* flies collected and parous flies in the 4 communities.

4.4.3 Infection Rate

A total of 25 (1.7%) flies were infected with various developmental stages of *O. volvulus* parasites while 7 (0.5%) were infectious. Resettlement Part B had the highest transmission of *O. volvulus* parasites as compared to Bui Camp and Resettlement Part A (Part A) where there was no transmission. Fly infectivity rate analysis expressed as the number of flies with larvae in the head (FLH) for every 1000 parous flies showed that Gborlekame and Part B had 20 and 22 infective flies per 1000 parous flies respectively whereas Part A and Bui Camp recorded no transmission for 1000 parous flies analysed. There was no significant difference in the *Simulium* flies infectivity rate in the communities ($P > 0.05$).

4.4.4 Biting Rate and Vector Transmission Potential

The highest monthly biting rate (3565 bites per person per month) was recorded at Gborlekame, while Part A had the least MBR of 1240 bites per person per month. The MBR and the monthly transmission potential of flies collected varied across the all four communities as shown in Figure 6 below. There was no correlation between the MBR and the MTP (r = 0.4) and therefore parasite transmission could be linked to ivermectin treatment factors and Onchocerciasis endemicity levels in the communities.



Survey August, 2012.

Figure 6: A comparison between Monthly Biting Rate and Monthly Transmission Potential in the indicated communities

CHAPTER FIVE

5.0 DISCUSSION

The combined prevalence of Onchocerciasis in the four selected communities was 7.2% ranging from 1.1 to 11.8%. This is considerably high despite several annual ivermectin treatment programmes. Since these communities where this work was conducted were and are still part of ongoing mass ivermectin distributions, the relatively high prevalence of onchocerciasis was surprising. The high prevalence rate of onchocerciasis as recorded in this study confirms the persistence of *O. volvulus* microfilariae as reported by Osei-Atweneboana *et al*., (2007). Despite the effectiveness of ivermectin as a microfilaricide (Osei-Atweneboana *et al*. 2007) as well as the feasibility of onchocerciasis elimination with ivermectin application in parts of West Africa (Diawara *et al*., 2009) this observed prevalence of infection is particularly worrying and may give indications of possible development of resistance. The highest prevalence of onchocerciasis at Gborlekame (11.8%) could lend some credence to the observation that ivermectin-resistant populations of *O. volvulus* could be emerging in some endemic communities in Ghana (Osei-Atweneboana *et al*., 2007).

Reports from the community health volunteers indicate continuous drug distribution in all communities, thus the count per sample (36 and 221respectively) at the Resettlement Part A and B of subjects aged 20 years and above was unacceptable given that the area has been under sustained and continuous annual treatment (Awadzi *et al*., 2004: Remme, 2004). Personal interaction with some persons (especially persons who were living in old Dokakyina now resettled at Part B) showed that compliance with treatment regimens was poor and therefore the therapeutic coverage needed for ivermectin treatment to impact on mf load could be low (Awadzi *et al*., 2004; Duerr *et al*., 2005; Osei-Atweneboana *et al*., 2011). Reasons given for the noncompliance included hypersensitivity to ivermectin which is in response to heavy parasitemia and alcoholism particularly among the men. Since none of the communities had a CMFL >10 mf/ss which is characteristic of hyper-endemicity, they cannot be categorised as hyperendemic for Onchocerciasis (Diawara *et al*., 2009). In general the Mf load, which is measured by the community microfilarial load (CMFL), is considered to be roughly proportional to adult worm burden (Duke, 1993).

The results generally show that females between the ages of 15 and 29 years that were skin snip negative as compared to males of the same age group. The zero infection among these females although may reflect the low sensitivity of the diagnostic procedure agrees with other workers (Basáñez and Boussinesq, 1999; Basáñez *et al*., 2006; Duerr *et al*., 2004; Kirkwood *et al*., 1983) who reported sex-specific differences in Onchocerciasis infections between males and females in human populations. This observation is expected because male young men are mostly fishermen and farmers who work more in the field and are maximally exposed to fly bites as compared to the females. This finding also highlights the need to develop novel diagnostic test that will improved sensitivity especially during drug intervention campaigns where parasites densities are very low (Diawara *et al*., 2009).

It has been reported that the eradicability of filarial infections depend on the variations in the density-dependent processes (facilitation and limitation) between vectors, parasites and hosts which stabilizes the persistence of the parasite in the host population (Duerr *et al*., 2005). To attain APOCs goal of eliminating Onchocerciasis as a disease of public health importance, there is the need to strengthen current ivermectin distribution programmes particularly in communities with very low CMFLs because low parasite densities will require higher control efforts to achieve eradication of the infection (Duerr *et al*., 2005).

Onchocerciasis endemicity ultimately depends on the availability of the insect vector (*S. damnosum* s.l.) to maintain transmission. Of the 4 communities, transmission was reported at Gborlekame and Part B, where Part B had the highest transmission potential (Table 7). Although there was relatively high fly abundance at Bui Camp and Part A, there was no parasite transmission in these communities. Although seasonal variation in transmission was not assessed, Veriegh (personal communication) observed that dry season parameters are generally low as compared to the wet season. This study was conducted in the wet season, thus it is in agreement to that of Opara *et al*., (2005) who reported variation in Onchocerciasis transmission with respect to location and season, and that transmission may also be influenced by fly longevity and their vectorial capacities.

Biting rate is an important index in all control and elimination programmes as it introduces parasite-stage and ATP-dependent breakpoints below which the infection cannot persist in the population (Duerr *et al*., 2005). In this particular study, Gborlekame had the highest monthly biting rate (MBR) of 3565 whiles Part A had the least MBR of 1240 among the 4 communities. There was no statistically significant correlation (r = 0.42) between MBR and monthly transmission potential (MTP). This was because although Gborlekame had the highest MBR (3,565) with four larvae flies, Resettlement Part B also recorded the MBR of 3293.75 but with the MTP as 85.25(11 infective stage larvae). The non correlation between MBR and MTP is however inconclusive since there was no data saturation (Bowen, 2008). Since the CMFL in some of the communities was very low, it was not surprising that these communities (Resettlement Parts B) did not report any transmission.

Fly infectivity rates were also assessed in all 4 communities and although very high infectivity rates were recorded as compared to the WHO threshold of 1 FLH for which the risk of recrudescence was negligible, the data from this study are inconclusive (Diawara *et al*., 2009) except that it provides indications of parasite persistence at low densities.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

In conclusion, this study has shown that onchocerciasis is still persistent within the Bui Dam environ despite several years of both antivectorial and antiparasitic interventions. Thus, the working population as well as the community inhabitants may still be at risk of infection so long as the vectors and the parasite co-exist. Its therefore imperative that the community directed treatment with ivermectin (CDTI) adopted by APOC for the control and elimination of Onchocerciasis in Africa (Basáñez *et al*., 2006; Remme, 1995) be strengthened through volunteer training and motivation as the current indicators are hampering drug distribution in some communities.

The variation of fly abundance at the different communities appeared to be related to distance between vector breeding sites and fly collection sites in the communities. Gborlekame which was the community of close proximity to the breeding sites had more fly abundance (460 flies) as compared to the communities that were distant from fly breeding sites that is Bui Camp (445 flies) and Resettlement Part B (425 flies).

However, though Gborlekame recorded a higher MBR (3,565) than Resettlement Part B with MBR (3, 293.75), a comparatively higher MTP (85.25%) was recorded at later due to the number of infective stage larvae (L3) observed.

6.2 RECOMMENDATIONS

Given the findings of this study, it is recommended that:

1. More work on the study of the prevalence, intensity and transmission of onchocerciasis in the Bui Dam catchment area should be undertaken, to update existing information that will be useful to future planning of control programmes.

2. The Bui Power Authority should collaborate with other stakeholders for an integrated approach including of vector control alongside APOCs drug distribution activities particularly for downstream breeding sites when the Dam reservoir is finally impounded.

3. Public health education and awareness creation among community inhabitants on the need to participate in drug treatment should be enhanced within the Bui Dam environ.

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Appendix 1: Intensity of *O. volvulus* microfilaria in Bui Camp

Age Group (yrs)	No. of positives			Male Mf Counted			Female Mf Counted			Male mf Intensity		Female mf Intensity		Overall	
	M	F	Total	Left SS	Right SS	Total	Left SS	Right SS	Total	Intensity	CMFL	Intensity	CMFL	Mf intensity	CMFL
15 – 19	0	0	0	0	0	0	0	0	0	0		0		0	
20 – 29	0	0	0	0	0	0	0	0	0	0		0		0	
30 – 49	To	0	2	22	15	37	0	0	0	18.5		0		9.25	
50 +	0	0	0	0	0	0	0	0	0	0		0		0	
Total	To	0	2	22	15	37	0	0	0		1.1		0		

Field survey August 2012

Appendix 2: Intensity of *O. volvulus* microfilaria in Resettlement Part B

Age Group (yrs)	No. of positives			Male Mf Counted			Female Mf Counted			Male mf Intensity		Female mf Intensity		Overall	
	M	F	Total	Left SS	Right SS	Total	Left SS	Right SS	Total	Intensity	CMFL	Intensity	CMFL	Mf intensity	CMFL
15 – 19	0	0	0	0	0	0	0	0	0	0		0		0	
20 – 29	1	0	1	0	5	5	0	0	0	2.5		0		1.25	
30 – 49	0	0	0	0	0	0	0	0	0	0		0		0	
50 +	1	1	2	5	26	31	0	1	1	15.5		0.5		8	
Total	To	1	3	5	31	36	0	1	1		1.76		0.11		

Field survey August, 2012

Appendix 3: Intensity of *O. volvulus* microfilaria in Resettlement Part A

Age Group (yrs)	No. of positives			Male Mf Counted			Female Mf Counted			Male mf Intensity		Female mf Intensity		Overall	
	M	F	Total	Left SS	Right SS	Total	Left SS	Right SS	Total	Intensity	CMFL	Intensity	CMFL	Mf intensity	CMFL
15 – 19	0	0	0	0	0	0	0	0	0	0		0		0.00	
20 – 29	2	0	2	35	95	130	0	0	0	65		0		32.50	
30 – 49	3	0	3	29	60	89	0	0	0	44.5		0		22.25	
50 +	1	0	1	1	1	2	0	0	0	1		0		0.50	
Total	6	0	6	65	156	221	0	0	0		7.8		0		

Field survey August, 2012

Appendix 4: Intensity of *O. volvulus* microfilaria at Gborlekame

Age Group (yrs)	No. of positives			Male Mf Counted			Female Mf Counted			Male mf Intensity		Female mf Intensity		Overall	
	M	F	Total	Left SS	Right SS	Total	Left SS	Right SS	Total	Intensity	CMFL	Intensity	CMFL	Mf intensity	CMFL
15 – 19	4	0	4	29	48	77	0	0	0	38.5		0		19.25	
20 – 29	0	0	0	0	0	0	0	0	0	0		0		0.00	
30 – 49	3	1	4	15	13	28	4	2	6	14		3		8.50	
50 +	2	1	3	70	57	127	2	0	2	63.5		1		32.25	
Total	9	2	11	114	118	232	6	2	8		12.98		0.68		

Field survey August, 2012

Appendix 5: General intensity of the microfilaridermias by age in the 4 communities

Age Group (yrs)	No. of positives			Male Mf Counted			Female Mf Counted			Male mf Intensity		Female mf Intensity		Overall	
	M	F	Total	Left SS	Right SS	Total	Left SS	Right SS	Total	Intensity	CMFL	Intensity	CMFL	Mf intensity	CMFL
15 – 19	4	0	4	29	48	77	0	0	0	38.5		0		19.25	
20 – 29	3	0	3	35	100	135	0	0	0	67.5		0		33.75	
30 – 49	8	1	9	66	88	154	4	2	6	77		3		40.00	
50 +	4	2	6	76	84	160	2	1	3	80		1.5		40.75	
Total	19	3	22	206	320	526	6	3	9		63.3		0.78		

Field survey August 2012

Appendix 6: Rainfall data of the Bui Dam catchment area

BUI CAMP RAINFALL (1954 - 2005)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual	AVG		
1954	5.00	13.00	56.00	173.48	121.41	163.83	24.64	153.42	138.43	227.33	29.46	0.00	1106.00	92.2	1983	0.0
1955	28.45	54.36	144.78	81.03	120.40	187.96	196.09	63.75	272.80	242.32	5.84	37.85	1435.61	119.6	1984	0.0
1956	0.00	51.05	71.88	64.52	218.19	141.48	20.32	75.44	252.22	80.26	2.79	11.68	989.84	82.5	1957	206.5
1957	0.00	10.00	64.00	135.00	337.00	239.00	105.00	117.00	206.50	297.94	42.42	23.00	1576.86	131.4	1998	348.0
1958	36.32	1.27	65.53	175.51	80.01	138.94	0.00	53.85	174.50	107.44	85.85	31.75	950.98	79.2	1973	362.0
1959	5.59	18.80	101.60	128.02	91.19	220.73	72.90	55.12	258.32	146.30	43.43	22.35	1164.34	97.0	1981	363.7
1960	14.73	1.27	39.12	123.95	92.46	102.36	135.38	123.19	268.00	131.32	5.33	5.84	1042.95	86.9	1958	367.3
1961	0.00	0.00	69.34	78.23	155.19	220.47	104.65	4.83	154.69	56.39	16.51	0.00	860.30	71.7	1990	386.4
1962	0.00	4.06	50.80	156.72	194.06	178.05	57.40	53.85	190.75	93.47	112.52	16.00	1107.69	92.3	1969	392.7
1963	0.51	66.80	134.87	146.05	265.18	176.53	282.70	318.00	200.00	395.99	8.38	0.00	1995.01	166.3	1994	399.1
1964	17.53	18.03	87.88	98.04	154.18	180.09	117.60	35.31	236.98	111.51	33.00	35.00	1125.15	93.8	1982	418.4
1965	5.33	93.98	62.74	254.00	177.80	158.75	98.81	156.46	124.46	131.57	1.27	0.00	1265.17	105.4	1992	433.2

1966	0.00	1.02	93.22	113.54	148.59	253.75	126.49	50.29	243.84	212.34	0.76	16.26	1260.09
1967	0.00	22.86	61.21	105.66	98.81	123.44	87.88	185.42	95.25	134.62	36.07	3.56	954.79
1968	0.00	34.80	55.63	146.81	289.05	182.63	215.00	180.09	258.83	216.66	23.88	0.00	1603.36
1969	0.00	23.62	92.96	167.64	176.53	85.09	107.70	72.39	127.51	137.16	57.91	2.79	1051.31
1970	5.84	10.92	32.51	86.36	249.43	112.27	80.26	30.73	278.00	58.42	0.00	0.00	944.75
1971	0.00	31.24	102.11	88.39	127.51	236.73	113.03	106.17	183.39	58.42	12.45	6.86	1066.29
1972	0.00	66.29	119.89	132.59	116.08	226.06	174.75	46.74	169.67	188.21	0.00	32.77	1273.05
1973	0.00	1.78	60.45	71.12	243.08	69.60	70.36	90.68	131.32	83.82	0.00	0.00	822.20
1974	0.00	17.53	40.13	75.95	153.67	116.33	128.52	113.54	284.48	170.18	0.00	0.00	1100.33
1975	0.00	7.60	72.90	116.10	145.50	141.00	134.60	64.00	121.70	144.30	5.60	10.40	963.70
1976	0.00	51.10	41.10	68.50	107.90	195.60	104.10	84.40	169.60	218.70	53.80	0.00	1094.80
1977	2.90	0.00	44.20	114.70	180.40	80.60	47.00	115.40	256.90	111.30	0.00	0.00	953.40
1978	0.00	53.80	108.20	109.00	181.60	147.60	49.70	42.90	228.40	115.20	18.00	0.00	1054.40
1979	11.70	19.10	89.60	166.80	169.70	193.60	326.20	73.70	221.10	130.60	22.90	0.00	1425.00
1980	42.70	63.00	65.10	112.20	96.70	78.60	137.90	119.30	179.00	162.40	33.10	0.00	1090.00
1981	0.00	21.60	239.90	34.80	260.20	141.10	101.80	120.80	308.00	120.20	0.00	0.00	1348.40
1982	0.00	40.20	58.40	126.70	125.40	128.00	60.50	123.50	106.40	86.70	14.50	0.00	870.30
1983	0.00	0.00	47.40	154.50	287.60	159.00	132.00	112.00	200.00	140.00	9.00	7.00	1248.50

105.0	1975	461.3
79.6	1978	468.6
133.6	1962	480.1
87.6	1954	480.3
78.7	1997	483.1
88.9	1961	484.6
106.1	1970	487.9
68.5	1956	489.5
91.7	1967	492.0
80.3	1977	499.9
91.2	1980	514.8
79.5	1996	526.1
87.9	1965	538.5
118.8	1995	545.7
90.8	1988	549.0
112.37	1976.00	553.70
72.53	1991.00	556.20
104.04	2001.00	556.80

1984	4.00	27.00	80.00	115.00	164.00	159.00	256.00	169.00	286.00	111.00	11.00	7.00	1389.00	115.75	1999.00	568.00
1985	0.00	46.60	151.00	76.00	91.00	181.00	256.20	168.80	286.00	110.70	11.00	0.00	1378.30	114.86	1964.00	569.98
1986	0.00	7.80	151.20	76.20	91.10	181.10	150.20	139.60	185.90	142.60	7.00	0.00	1132.70	94.39	1993.00	575.90
1987	0.00	8.00	121.40	32.50	130.50	79.80	103.70	264.60	265.40	175.70	19.00	7.00	1207.60	100.63	2002.00	589.50
1988	0.00	0.00	54.10	81.60	98.10	116.80	140.50	38.30	253.40	47.90	9.20	0.00	839.90	69.99	1959.00	607.06
1989	0.00	0.00	62.40	96.20	111.10	305.80	268.80	138.60	257.10	210.00	0.00	0.00	1450.00	120.83	1972.00	617.22
1990	0.00	32.30	5.40	204.70	66.10	168.00	61.10	201.00	80.50	99.40	46.70	28.30	993.50	82.79	1960.00	618.74
1991	0.00	79.00	228.60	73.40	407.50	128.50	218.10	108.10	101.50	207.00	0.00	1.70	1553.40	129.45	1971.00	639.32
1992	5.40	2.00	33.30	135.90	121.10	208.70	77.00	42.80	149.00	96.00	57.00	0.00	928.20	77.35	2000.00	641.10
1993	0.00	7.40	144.00	50.20	123.00	125.40	84.80	77.00	308.70	48.90	24.50	19.70	1013.60	84.47	1974.00	642.87
1994	0.00	0.00	67.40	51.50	192.20	152.40	68.60	82.40	95.70	238.30	4.10	0.00	952.60		1986.00	656.80
1995	0.00	17.30	84.10	108.40	167.10	145.50	72.40	77.00	250.80	194.40	14.00	7.00	1138.00		1966.00	674.37
1996	6.30	32.70	107.30	55.00	222.60	183.60	102.60	69.10	170.80	195.10	0.00	0.00	1145.10		1985.00	711.00
1997	15.23	0.00	8.70	93.50	158.00	226.50	19.30	105.10	132.20	142.80	1.80	0.00	903.13		1987.00	713.50
1998	0.00	19.40	0.80	133.30	62.40	112.90	2.20	46.00	186.90	160.00	1.90	4.10	729.90		1955.00	720.60
1999	1.20	72.20	47.90	119.50	98.40	158.10	116.60	128.30	165.00	291.80	4.10	0.00	1203.10		1968.00	810.77
2000	76.30	0.00	13.80	102.40	142.70	245.20	43.90	97.40	254.60	54.60	4.50	0.00	1035.40		1979.00	814.60
2001	0.00	0.00	32.30	179.90	154.40	190.20	211.70	65.60	89.30	41.90	6.30	1.70	973.30		1963.00	824.99

2002	1.20	0.00	139.40	150.10	142.10	137.00	187.80	184.90	123.80	243.00	31.50	5.10	1345.90
2003	7.20	36.60	102.10	189.50	147.50	127.90	101.10	65.10	219.60	61.40	0.20	0.00	1058.20
2004	12.30	0.00	19.60	200.00	116.90	82.30	83.10	105.90	156.30	141.90	17.40	40.20	975.90
2005	27.50	15.70	34.50	125.70	165.70	118.00	293.20	66.50	196.80	201.10	0.00	0.00	1244.70

	1989.00	970.30

Min	0.00	0.00	0.80	32.50	62.40	69.60	0.00	4.83	80.50	41.90	0.00	0.00	729.90
MAX	76.30	93.98	239.90	254.00	407.50	305.80	326.20	318.00	308.70	395.99	112.52	40.20	1995.01
LTA	0.00	0.00	0.80	32.50	62.40	69.60	0.00	4.83	80.50	41.90	0.00	0.00	729.90

24.4
239.9
24.4