KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI

COLLEGE OF SCIENCE

DEPARTMENT OF THEORETICAL AND APPLIED BIOLOGY

HELMINTH AND *PLASMODIUM FALCIPARUM* INFECTIONS AMONG INHABITANTS OF THE TONO IRRIGATION CATCHMENT AREA IN THE UPPER EAST REGION

BY

CLARA A. APUUSI

JULY, 20 12

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI

COLLEGE OF SCIENCE

DEPARTMENT OF THEORETICAL AND APPLIED BIOLOGY

HELMINTH AND *PLASMODIUM FALCIPARUM* INFECTIONS AMONG INHABITANTS OF THE TONO IRRIGATION CATCHMENT AREA IN THE UPPER EAST REGION

THIS DISSERTATION IS PRESENTED TO THE DEPARTMENT OF THEORETICAL AND APPLIED BIOLOGY IN FULFILLMENT OF THE REQUIREMENTS OF MPHIL. DEGREE IN BIOLOGICAL SCIENCES (PARASITOLOGY)

BY

CLARA A. APUUSI

JULY, 2012

DECLARATION

I hereby declare that except for the references to other people's work, which has duly been acknowledged, this work has not been presented for a degree elsewhere nor is it being submitted concurrently for any other degree.

Clara .A. Apuusi (PG4997310)……….…………… ……..…………………

(Student) Signature Date

Dr. J.A. Larbi ………………………..………… ………………………

(Supervisor) Signature Date

Rev Stephen Akyeampong ………………………..………… ………………………

(Head of Department) Signature Date

DEDICATION

To Mr. John Alexander Kofi (J.A.K) Apuusi, my late father who did not live to see this lifetime wish for his daughter's education to this level come through, and above all, to our God who makes all things possible in His time. To Him be all the Glory.

ABSTRACT

In Northern Ghana the Tono Dam is one of the major irrigational facilities constructed for dry season farming, serving as water source for domestic, livestock and for other farming purposes. However, the construction of irrigational facilities has generally been documented to cause an increase in parasitic infections due to the creation of ideal environmental conditions for the proliferation of the vectors of these infections. Between May 2011 to February 2012, a total of 333 people in five communities (Bonia, Yogbania/Yigbwania, Kwarania, Gia and Gaani) within the Tono Irrigational Area of the Kassena Nankana District of the Upper East Region of Ghana were studied for parasitic infections (mainly malaria, schistosomiasis and hookworm). An overall prevalence of 10.7% was found in the study population, with *S. mansoni*, *S. haematobium*, *hookworm and Plasmodium sp* being the main types of parasites identified. Although multiple infections were recorded, none of the subjects had all four parasitic infections identified. *S. mansoni* was one of two most widespread infections (found in all the five communities studied) with a prevalence of 19.22% and mean intensity of 6.14(+/-1.35) eggs/g of stool, followed by *Plasmodium sp* , also found in all five communities, with a prevalence of 5.11% and a mean density of 299.6 (+/-115.86) parasites/uL of blood. *S. haematobium* infections followed in terms of distribution, found in four of the five study communities with a prevalence of 1.50% and a mean intensity of 4.67(+/- 2.73) eggs/10mL of urine Hookworm was the least widespread parasite, found in only two of the communities, with an overall prevalence of 0.90% and a mean intensity of 5.5(+- 2.50) eggs/g of stool. *S. mansoni* infection was of the highest prevalence (27.27%) at Yogbania/Yigbwania with Bonia recording the least of 12.31%. Malaria had the next highest prevalence, with Kwarania recording the highest prevalence of 11.7% as against 1.30% recorded in Yogbania/Yigbwania (representing the least prevalence of malaria). *S. haematobium* infection was recorded in all communities except Gia. Among the four communities in which it was found, Bonia recorded the highest prevalence of 4.62% with the least value recorded in Yugbania/Yigbwania (1.30%). Factors such as contact with the canals or the dam itself, which serve as reservoirs of infection and lack of knowledge on the causes and prevention of these parasitic infections among many others such as inadequate protective gear usage during farming were identified as the major reasons for such rates of infection as recorded in this study. Correlation analysis showed Hb levels were not affected by infection with these parasites, however a very low Hb value of 6.6 g/dl was recorded in a female infected with both malaria and *S. mansoni*. A more concerted/ health education effort is therefore necessary in order to curb these rates of infections in the communities within the irrigated area.

ACKNOWLEGEMENT

My profound gratitude goes to my supervisors Dr. J.A. Larbi and Prof. B.W.L. Lawson for their immeasurable efforts, time and guidance. May God who sees all your efforts bless you.

I am greatly indebted to Dr Koku Awonor Williams, Director of the Bolgatanga Regional Health Directorate –Bolgatanga for giving me the permission to use the hospital laboratory facilities for the laboratory analysis of my samples. For this I would not hesitate to mention the following who unquantifiably assisted me during my lab/field work : Mr Adongo Emmanuel, Mr Adolph Komla Kasu, Mr Timothy Alirah, Mr Ernest Appeau and Mr Paul Apung. I render my sincere gratitude for their assistance.

I am extremely grateful to Mr Isaac Dennis Amoah and David Komla Kessie of KNUST, who despite pursuing their MPhil Programmes offered me a helping hand with the statistical analysis of my data.

Many thanks go to my friends and family who in one way or the other contributed either morally or financially towards the completion of this project and they include: Mr Heavens Akannae (My husband), Mary Coughlan, Dr Steven Twum, Victoria Apuusi, Pastor Sackey and all whose names could not be captured due to limited space. God richly Bless you all.

Finally and most importantly to God who is the Alpha, Omega, the beginning and the end, for His faithfulness in seeing me through to the end of this project.

TABLE OF CONTENTS

Content **Pages**

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

BACKGROUND

Throughout evolutionary history humans have been infected with parasites. Today, it is estimated that over a third of the world's population, mainly individuals living in the tropics and sub-tropics, are infected by one or more parasitic helminths (worms) and protozoans (*de* Silva *et al.*, 2003; Snow *et al*., 2005).

In many developing countries, the most prevalent and important helminthes are those of the soil –transmitted nematodes. Chronic gut infection in humans commonly results from nematodes, particularly *Ascaris lumbricoides*, *Trichuris trichiura* and hookworms (*Ancylostoma duodenale and Necator americanus*) (WHO,2002), and the blood flukes (schistosomes) (Rozendel,1997). Their distribution is influenced by sanitation, population movement, availabitiy of water bodies, etc. For example high rates of malaria infections and helminthic infections such as intestinal infections eg. hookworm, ascariasis and also schistosomiasis were constantly recorded among migrant population working in irrigation schemes in Awash Valley than migrant populations employed in rain-fed agriculture in the semiarid Setit Humora area (Kloos *et al*.,1980) . It is known that irrigation and the construction of dams with poor sanitary practices results in rapid spread of *S. mansoni*, since the aqueous environment provides suitable conditions for the intermediate host snail (Markell *et al*.,1971).

Dams serve many different purposes for the community, such as domestic and agricultural water supply, irrigation and fish culture. Often yields in irrigated agriculture are higher than rain fed agriculture, thus making more food or income available to farmers. Frequently, irrigation development also implies more general infrastructural improvements: better roads, (and thus: better access to health services), rural electrification and sometimes housing improvements. The development of water projects and their operation has, however, also a history of facilitating increased transmission of vector borne diseases (Service, 1991).

Globally, more than two billion people live in areas where they are at risk of contracting malaria and the estimated annual incidence of clinical malaria is greater than 300 million cases More than one million people die every year from the direct causes of malaria, with children under the age of five years living in sub-Saharan Africa at highest risk (Breman, 2001). In 2001, the disease accounted for an estimated loss of 44.7 million disability adjusted life years (DALYs) with a DALY loss > 87% occurring in sub-Saharan Africa (WHO, 2003); in 2002 the estimated malaria burden increased to 46.5 million DALYs (WHO, 2004). An estimated 90% of this burden is related to environmental factors (WHO, 1997).

In most open canal irrigation systems, water is not only used for agricultural purposes, but also for all kinds of domestic, municipal, industrial and recreational purposes (van der Hoek *et al*., 1999). These activities may influence the water quantity, quality or both (van der Hoek *et al*., 2001).

Canals and drains may create ideal breeding sites for malaria mosquitoes or for snails, bringing both the vectors and the disease closer to the people. Many field studies have described the influence of irrigation on the spread of these water- related diseases such as malaria, schistosomiasis, liver flukes, filariasis, onchocerciasis, dengue fever, yellow fever, Rift Valley fever and encephalitis (Oomen *et al*.,1990). The distance between irrigation infrastructure and residences may determine how often and how intensely the population is exposed to vectors or infested water. In many places, the creation of small reservoirs has resulted in increased household income through productive agricultural activities upstream and downstream of the dam. However, the potential environmental (e,g., on hydrology) and health (e.g on malaria and schistosomiasis) consequences are rarely considered and the impacts of many thousands of small agro-pastoral dams has led to a rapid spread of schistosomiasis (Ripert and Raccurt 1987). Similarly results have been reported from Cote d Iviore (Le Guen, 2000; Cecchi n.d) Ghana (Hunter, 2003) and Burkina Faso (Poda and Traoré, 2000;Poda et al. 2003; Boelee and Koné n.d.).

It is estimated that a maximum of 848.3 million people live in the close vicinity of irrigation systems and 19.9 million near large dam sites worldwide. In sub-Saharan Africa, which has 87.9% of the current global malaria burden, only 9.4 million people are living near large dams and irrigation sites. In contrast, the remaining sub regions with malaria transmission concentrate of 15.3 million people near large dams and 845 million near irrigation sites but they represent only 12.1% of the global malaria burden. Whether an individual water project triggers an increase in malaria transmission largely depends on the epidemiological setting and socio-economic factors, vector management and health seeking behaviour **(** Keiser *et al*.,2005).

Malaria is a mosquito-borne infectious disease caused by the protozoan parasite of the genus *Plasmodium*. It is widespread in tropical and subtropical regions, including parts of America, Asia, and Africa. Each year, there are more than 250 million cases of malaria, killing between one and three million people, the majority of whom are young children in sub-Saharan Africa (Snow *et al*., 2005) Ninety percent of malaria-related deaths occur in sub-Saharan Africa. It is commonly associated with poverty, and can indeed be a cause of poverty and a major hindrance to economic development.
(http://www.rapidtest.ca/guides.shtml).

Schistosomiasis (also known as bilharzias or snail fever) is a parasitic disease caused by several species of trematodes ("flukes"), a parasitic worm of the genus *Schistosoma*. Although it has a low mortality rate, schistosomiasis is often a chronic illness that can damage internal organs and, in children, impair growth and cognitive development. The urinary form of schistosomiasis is associated with increased risks for bladder cancer in adults (en.wikipedia.org/wiki/schistomiasis) Schistosomiasis is a water-based disease and is the second most devastating disease next to malaria in the world. Current estimates suggest 200 million people are infested worldwide and about 131 million in sub-saharan Africa alone. The disease is found in most developing countries, especially those of the tropics and subtropics. Among these countries are Egypt, Tanzania, South Africa, Nigeria and Ghana (Damaree *et al*, 1985) . At least 1 billion people worldwide are infected, many of whom harbor multiple species concurrently. According to Jones (1967), schistosomiasis would occur wherever three conditions are satisfied. These conditions are pollution of water bodies, use of such water bodies for bathing or irrigation and the presence of snails in which the blood fluke can develop. After being infected by larvae emerging from human excreta and urine deposited in the water, freshwater snails act as intermediate hosts. They, in turn, produce larvae that enter through the skin of people who are exposed to the contaminated water. Within irrigation schemes transmission is focal and is primarily due to much localized contamination of habitats with human excreta or urine containing schistosome eggs and, also because of the high incidence of human water contact at a few points.

Schistosome transmission usually is seasonal, primarily due to the variation in temperature and the irrigation cycle. Most irrigation systems in Africa create specific conditions that may favor establishment of schistosome intermediate hosts and the subsequent transmission of schistosomiasis, especially where drainage is not always adequate (Tanji and Kielen, 2002) In countries where schistosomiasis is endemic, control is aimed at reducing morbidity and arresting symptoms of the disease. These measures are put in place either through a specific control program or through the primary healthcare system (Mott, 1984; Chippaux, 2000). Making available a vaccine to immunize people, still seems a distant prospect (Gryseels, 2000; Hagan *et al*., 2000). Luckily, safe and effective drugs such as “praziquantel” are available to treat infected people (Crompton *et al*., 2003; Hagan *et al*., 2004). Nevertheless, experience shows that re-infection following treatment can be very fast (Tchuem Tchuenté *et al*., 2001). Moreover, not all countries have adequate health systems to reach the population at risk (Chitsulo *et al*., 2000). Malaria and helminth infections are the major parasitic diseases in developing countries and their epidemiological coexistence is frequently observed, particularly in Africa (Helmby *et al*.,1998). Overlapping distribution of intestinal helminths and malaria results in a high rate of co-infection (Keiser *et al*., 2002; Adrienne *et al*.,2005) which may result both in synergism and antagonistic interaction between helminths and malaria parasites (Mathieu *et al*., 2002; Kirsten *et al.*, 2005) One of the main impacts of malaria and helminth infections is anaemia. Malaria causes anaemia, among other mechanisms through haemolysis and increased spleenic clearance of infected and uninfected red blood cells and cytokine-induced dyserythropoeisi (Crawley *et al*.,2004;McDevitt *et al*.,2004) Similarly, intestinal helminths are significant causes of anaemia as a result of direct blood loss, nutritional ‘theft’ and impairment of the appetite due to immunological factors (Stephenson *et al*.,200; Hotez *et al*.,2004). Based on the distinct mechanisms by which malaria and helminths reduce haemoglobin levels, it is probable that their combined presence might interact to enhance the risk of anaemia. Several reports in Kenya, Nigeria, Thailand and some other countries of Africa were suggestive of an additive impact of co-infection on anaemia in certain age groups (Brooker *et al*.,2006;Nacher *et al.*,2001) However such associations may be confounded by socio-economic, genetic, and nutritional factors and that the effects of co-infection may vary by malaria and helminth species and their intensities (Akhwale *et al*.,2004). The complexity of interactions between host response to helminths and malaria infection, suggests possible consequences on age-dependent malaria morbidity (Druilhe *et al.,* 2005; Briand *et al.*, 2005). Coinfection with helminthic parasites could then constitute a confusing factor in the assessment of the efficacy of malaria-control intervention, including vaccine clinical trials. An analysis, based on African studies, showed that there is a risk ratio of 2.4 and 2.6 for urinary schistosomiasis (caused by *S. hematobium*) and intestinal schistosomiasis (caused by *S. mansoni*), respectively, among persons living adjacent to dam reservoirs. The analyses also showed that persons living near land that had been irrigated for agricultural use had an estimated risk ratio of 1.1 for urinary schistosomiasis and an estimated risk ratio of 4.7 for intestinal schistosomiasis (Steinmann *et al*., 2006). In Ghana, Studies of formal irrigation schemes have shown that irrigation has increased absolute incomes as well as food supply and nutrition. For example, average annual post-project farm income at Tono, Weija and Dawhenya irrigation projects was 3, 7 and 13 times higher, respectively, than the average annual farm income before the irrigation projects (Sam, 1993). In a case study of irrigation schemes conducted for this study, health officials reported reduced cases of malnutrition (Kranjac-Berisavljevic and Cofie, 2004).

However, programmes on water resources development and the resultant population movement are known to have worsened the transmission of schistosomiasis in countries such as Nigeria, Sudan, Brazil, Philipines and Ghana (Iarotski *et al*.,1981) as well as malaria (Oomen *et al*.,1990) This has led to an increase in both prevalence and intensities of parasitic infections.

Despite the significant contribution of water resource schemes to poverty alleviation, food security, mitigation of floods and promotion of economic growth, its adverse health effects may undermine these objectives (Hunter *et al*., 1993; Jobin 1999: Keiser *et al*.,2005), if the appropriate measures are not put in place.

1.1 Rational And Justification

In irrigation systems throughout the tropics, water-related, water- based parasitic infections notably Schistosomiasis and malaria are reportedly common and affect communities living along these water courses. This is possible because most irrigated land inhabitants are involved in occupations that expose them to water contact activities with the dam and to the environment in general. Helminth and *Plasmodium* infections have similar geographical distribution and co-infection is commonplace. It has increasingly been speculated that helminth infections may alter susceptibility to clinical malaria, thus, there is now increasing interest in investigating the consequences of co-infection.

The Tono irrigation catchment area is a schistosomiasis-malaria co-endemic area with various activities around the dam, canals and its environs. These activities which include: farming (dry and wet season farming), fishing, fish migrant and immigrant trading, pito brewing, laundry, bathing among others provides a source of livelihood for the inhabitants.

The annual de-worming programme by the Ministry of Health is only for children of school going-age. Occupational risk groups which constitute the working force and non-school going children could easily bring back infection into the area (Oomen *et al*.,1988) as long as inhabitants share the same resources such as the dam and canal water in the same geographical location either for farming, domestic, industrial or constructional purposes. In the Tono irrigation system no studies have been undertaken to determine the prevalence levels of schistosomiasis and malaria and their health impact on the irrigated populace.

Most studies and interventions carried out in the study area have been limited to only school children.(Amankwa, 1994) and (Anto, 2006) reported 67.7% and 48% prevalence of schistosomisis infections respectively and 55% malaria infections in school children in Tono (*www.danishwaterforum.dk/.../Impact_on_water_resources_develop...)* to the neglect of the rest of the community members who are in frequent contact with the dam and canal water by virtue of their location and occupation. Apart from the above there are no hospital records available, with any information on the types of parasitic infections prevalent in the Tono irrigated community. Also, the contribution of malaria, schistosomiasis, and other helminthic infections in the development of anaemia in individuals considering their sociodemographic characteristics, their behavioural patterns in a malaria-schistosomiasis co-endemic area is largely unreported.

The present study was undertaken to establish the prevalence and intensity of malaria, schistosomiasis and other intestinal helminth infection in relation with the Haemoglobin levels of individuals living in an irrigated community. The study also seeks to gather knowledge on their sociodemograpghic data as well as knowledge on; water contact activities, behavioural patterns, parasitic infections their control and prevention among others. As knowledge of malaria and schistosomiasis together with other helminthic infections status is necessary to help determine what preventive measures should be undertaken to protect these irrigated communities from these water related, water based parasitic infections.

1.2 Aim of Study

The aim of the present study therefore, was to determine the types and prevalence of parasitic infections in the communities served by the Tono irrigation dam and the related haemoglobin levels of the sampled human populations of the communities.

1.3 Specific Objectives

These were to determine in the study communities;

i. prevalence and intensity of malaria and schistosomiasis infections.

ii. prevalence and intensity of other intestinal helminths in the communities.

iii. prevalence of multiple infections.

iv. sex and age related prevalence and intensities of parasitic infections respectively.

v. the impact of the parasitic infections on the haemoglobin levels of infected individuals.

vi. knowledge base of the inhabitants regarding infection, prevention and control of schistosomiasis and malaria.

CHAPTER TWO

LITERATURE REVIEW

2.1 Irrigation And Health

Irrigation impacts on human health in many different ways. Often, yields in irrigated agriculture are higher than in rain fed agriculture, thus making more food or income available to farmers. This may lead to better nutrition, making people more resistant to diseases. Increased welfare may also be spent on better health care and protective measures such as vaccines and bed nets. However, irrigation canals, drains and hydraulic structures can also become breeding sites for agents of disease, such as malaria mosquitoes and snail hosts of schistosomiasis. Other diseases, such as skin and eye infections, may be reduced by the introduction of irrigation, simply because more water is available for hygiene and sanitation. In fact, water destined for irrigation of crops is often used for all kinds of domestic activities, including consumption. Though the quality of irrigation water usually does not meet the standards for drinking, it may be the only water available in remote arid regions. In some cases, seepage from irrigation canals recharges the groundwater and provides fresh water pockets in an otherwise saline aquifer or dilutes chemical pollution such as fluoride from geological origin. Consequently, investments in water resources development could be more cost-efficient if multi-purpose systems were conceived, catering for agricultural and domestic water needs. (Boelee *et al*., 2003). Higher and more diverse food production in irrigated agriculture brings health benefits to farmer families in the newly irrigated areas. People may gain access to more varied and higher quality nutrition through increased income from cash crops, though this effect is not always very clear (Benjelloun *et al.,* 2002; Parent *et al.,* 2002a). The construction or rehabilitation of irrigation systems has other positive impacts on the human environment through increased employment possibilities, which would raise income and subsequently increase access to health services and education. However, an increased income is not always spent on health care. Access to health services, water supply and sanitation can be facilitated if, with the planning of a new irrigation system, these additional services are included. Irrigation can also influence the wider physical environment in a positive way and thus increase human well-being. However, the adaptation of disease vectors and intermediate hosts to urban ecosystems has been observed, which might further enhance the negative effects associated with persistent rural lifestyles. For example, the creation of malaria vector breeding sites and contact with contaminated water and soil in areas of irrigated agriculture may increase the transmission of vector-borne, water-related and soil-transmitted parasitic diseases. Their causes are multifactorial including lack of access to clean water, improved sanitation and health services, as well as inadequate treatment, protection and prevention (http://edoc.unibas.ch/805/1/DissB_8408.pdf.).

2.1.1 Water-Related Diseases

Most of the reported impacts of irrigation development on health consist of water related diseases. Generally, four groups of diseases are distinguished based on their way of transmission (Cairncross and Feachem, 1993):

I. water-borne or faecal- orally transmitted diseases, such as cholera, typhoid and diarrhea

II. water-washed diseases, such as louse-borne infections and infectious eye and skin diseases.

III. water-based diseases with an intermediate host living in water, such as guinea worm and schistosomiasis

IV. water-related insect-borne parasitic diseases such as river blindness, filariasis and malaria.

Water-washed diseases may be reduced dramatically with the development of water resources. The availability of water, regardless of quality, enhances personal hygiene practices. This effect is especially widespread in arid and semi-arid regions, where irrigation systems may be the main source of water for all purposes. The use of irrigation water for cooking and consumption, despite its often questionable quality, may even diminish hygiene-related diarrhoeal diseases, as water quantity is believed to be more important than quality (van der Hoek *et al*., 2002). Unfortunately, water-related diseases transmitted through vectors or intermediate hosts sometimes increase with irrigation development. Canals and drains may create ideal breeding sites for malaria mosquitoes or for snails, bringing both the vectors and the disease closer to people. Many field studies have described the influence of irrigation on the spread of these water-related diseases. (Oomen *et al.*, 1988 and 1990; Bolton 1992; Hunter *et al*., 1993; Steele *et al.*,1997; Harmancioğlu *et al*.,2001). Specifically, many studies report on large-scale irrigation and malaria. Breeding sites for *Anopheles* malaria mosquitoes are found in clear surface water available in irrigation systems and an increase in vectors usually leads to an increase in malaria. Wet rice fields are ideal breeding sites and rice field breeding *Anopheles* account for a great deal of the malaria transmission in rice-growing areas of the world (Gratz, 1988). Rice field irrigation often facilitates double or even triple cropping of rice, allowing for year-round transmission of malaria. As a result mosquito abundance and density increases as the mosquitoes may live longer, allowing malaria parasites to complete their developmental cycle in the adult insect so they can be passed on to another host. Mathematical modelling has shown that these two factors (density and longevity) together with possible changes in feeding habits of these mosquitoes, determine whether epidemics break out. Or it could lead from a situation of low and irregular transmission to a situation with continuous high and regular transmission that could put a heavy toll especially on young children, who have not yet built up any resistance (Bradley, 1995). The linkages between irrigated agriculture and malaria are complex: African case studies show that malaria transmission may increase, decrease or remain largely unchanged as a consequence of irrigation (Ijumba and Lindsay, 2001). In West Africa for instance, intensified rice cultivation in the semi-arid savannah has led to an increase in *Anopheles* but with the high population densities, the life span of the mosquitoes was reduced and less mosquitoes were found infected with malaria. Moreover, mosquito abundance was high, creating a demand for bed nets, which farmers could afford through their improved income. Consequently, malaria transmission did not increase with irrigation development in several West African countries (Parent *et al*., 2002b). In Ethiopia, the construction of small dams in Tigray led to increased spread of malaria, even at higher altitudes .Seasonal transmission changed to year-round transmission because of the continuous availability of surface water. Children living near small dams had a 714 times higher risk of getting infected than children living further away (Ghebreyesus *et al*., 1999). However, such effect may be reduced over time as people benefit economically from irrigated agriculture and gain access to medication and preventive measures. The high incidence and wider spread of disease resulting from an increase in vectors or intermediate hosts is observed for several water-related infections other than malaria. Mostly, the mechanisms that play a role in increasing transmission rates are complex and dynamic. The farming system and subsequently the entire biological and human environment are often drastically changed with the introduction of irrigation.

In most open canal irrigation systems, water is used not only for agricultural purposes, but also for all kinds of; domestic, municipal, industrial and recreational purposes (van der Hoek *et al*., 1999). These activities may influence the water quantity, quality or both (van der Hoek *et al*. 2001a). At river basin level, the allocation of water resources to different sectors in an approach of integrated water management is becoming common practice ((Berkoff, 1994; Heathcote, 1998).

An analysis of data in Africa showed, that there is a risk ratio of 2.4 and 2.6 for urinary schistosomiasis (caused by *S. hematobium*) and intestinal schistosomiasis (caused by *S. mansoni*), respectively, among persons living adjacent to dam reservoirs. The analyses also showed that persons living near land that had been irrigated for agricultural use had an estimated risk ratio of 1.1 for urinary schistosomiasis and an estimated risk ratio of 4.7 for intestinal schistosomiasis (Steinmann *et al*., 2006). Their distribution is influenced by sanitation, population movement, availabitiy of water bodies, etc. For example high rates of malaria and helminthic infections such as schistosomiasis, hookworm and ascariasis, were constantly recorded among migrants from populations working in irrigation scheme in Awash Valley than migrant populations employed in rain-fed agriculture in the semiarid Setit Humora area (Kloos *et al*.,1980).

It is known that irrigation and the construction of dams with poor sanitary practices results in rapid spread of *S.mansoni*, since the aqueous environment provides suitable conditions for the intermediate host snail (Markell *et al.*, 1971) and mosquitoe breeding. Worldwide , in all endemic regions, the development of water resources play an important role in the spread of schistosomiasis. For example , the introduction of irrigated agriculture has been associated with the introduction of *S. mansoni* in both upper and middle parts of the Awash Valley (Lo *et al*.,1988) . Millions of people in Sub- Saharan Africa are infected with neglected tropical diseases (NTDs) that include schistosomiasis (200 million), hookworms (198 million), *Ascaris lumbricoides* (173 million) and *Trichuris trichiura* (182 million) among others (WHO, de Silva *et al*., 2003; Hotez *et al*., 2004). Evidence also suggests that the same continent is overwhelmed with a burden of malaria. In 2009, World Health Organisation indicated that of the global 243 million cases of malaria reported. In 2008, 208 million cases were from Africa alone (WHO, 2009; Brooker *et al*., 2009). Single helminths, *Plasmodium falciparum* and helminth –*Plasmodium falciparum* co-infections are known to cause anaemia (WHO,2009; Stoltzfus *et al*., 1997; Midzi *et al*., 2010) and reduced school attendance (Nokes *et al*.,1993; Brooker, 2000). They also impair childhood growth (Stephenson *et al*., 1993) intellectual development and school performance (Nokes, 1991; Nokes,1999; Partnership for Child Development, 2002) and reduce worker productivity (Ndamba *et al.*, 1993,). Schistosomiasis and STHs are responsible for over 415000 annual deaths and 43.5million DALYS (Hotez *et al*.,2006). Hence, malaria and the NTDs are of huge public health and economic significance (WHO, 2009; Molyneux *et al*., 2005).

2.2 Incidence Of Malaria And Schistosomiasis

Oomen *et al*., (1988) gave extensive details on the history of malaria and schistosomiasis in Sudan. Since the Gezira Irrigation System began in 1924, malaria has been closely linked to agricultural development. During the first 25 years reasonable malaria control was possible through good water management and larviciding. After 1950, when the irrigation system expanded and created more breeding sites, an intensification of cropping added water continuously to the larvae producing minor canals. At the same time, large-scale applications of chemicals both against agricultural pests and for malaria control caused pesticide resistance in malaria mosquitoes. Together, this led to severe malaria outbreaks in 1973 and 1974. Later in the 1970s the communications and control systems in the main canals broke down. Combined with heavy aquatic growth due to inadequate maintenance, all canals had to be full in order to deliver water to the crops. Without precise regulation they were prone to overflowing. Another complicating factor was the large labour force that came from malarious areas. These people were often outside health programmes and could easily bring infections into the area.

The Gezira irrigation systems have resulted in a similar increase of schistosomiasis. The same minor canals that favoured mosquito development also stimulated high snail populations most of the year. These canals with clear water and dense vegetation provided night storage and were close to villages, so water contact was high. Urinary schistosomiasis had increased from less than 1% before World War II to affecting almost a quarter of the adults and half of the children in the 1950s . Intestinal schistosomiasis rose even more from 5% in 1949 to 86% in 1973, in children of 7 to 9 years old, often the group with highest infection rates. Another vulnerable group consisted of the canal cleaners, who stayed daily for long hours in the infested water (Hunter *et al* .,1993).

A number of complex interlinking factors determine the severity of potential adverse impacts. For example, increased mosquito-breeding habitats especially in rice fields, does not necessarily result in increased prevalence of malaria or other mosquito-borne disease such as lymphatic filariasis(Erlanger *et al*.,2005) and Japanese encephalitis (Keisr *et al*.,2005b). Case studies show that malaria transmission may increase, decrease or remain largely unchanged as a consequence of irrigation. In studies in Tanzania, lower malaria prevalence in villages with irrigation, compared to those without, has been attributed to a better socioeconomic status (Ijumba and Lindsay, 2001).

The main health-related costs to households relate to increases in time spent sick and not working, as well as time spent caring for the sick. Disease incidence has also led to reduction in labour allocation to off-farm activities and a decline in non-farm income share, thus adversely affecting the households' ability to cope with risk (Senzanje *et al*., 2002). Nonetheless, because agricultural yield and farm profit significantly increased in villages close to small dams, even after accounting for health costs, the marginal benefits of investment in water outweighed the costs (Ersado, 2005). When Ghana gained independence in 1957 from British colonial rule it was envisioned that the Akosombo dam project was the most economical source of energy needed for the industrialization of the country. This led to an increase in prevalence of schistosomiasis from about 3% in 1961 to about 84% by 1967 in school children upstream: and also from about 17% in 1963 to 74% in 1981, downstream. The water development project scheme have worsened the schistosomiasis burden of the region leading to a prevalence level of about 70% among school children living along the Tono irrigation canals. The prevalence of schistosomiasis infection in school age children living in the Tono irrigation area in the Kassena- Nankana District of Northern Ghana in 2006 was recorded as 48%. Also, the seasonal prevalence of malaria in the same irrigated community was; 41.1% and 55.4% in the dry and wet seasons respectively in 2001-2002 (www.daniswater.forum.dk/.../imapct on water resource develop...).

2.3 Epidemiology Of Malaria, Schistosomiasis, Soil-transmitted Helminthiasis And Intestinal Protozoan Infections

2.3.1 Malaria

Malaria is the most important vector-borne parasitic disease worldwide. The causative agent is a one-cell parasite (*Plasmodium*), which is transmitted through the bite of a female *Anopheles* mosquito. There are four species of *Plasmodium* causing human malaria with distinct features in their life cycles and geographic distribution. *P. falciparum* occurs predominantly in sub-Saharan Africa and is responsible for the bulk of mortality and burden due to malaria. *P. vivax* is the second most important species, and its occurrence is particularly prominent in Asia. The other two species are *P. malariae* and *P. ovale*.

Figure 1.1 shows the life cycle of *P. falciparum* malaria. The malaria parasite (sporozoite) is inoculated into the human host during a blood meal of an infected female *Anopheles* mosquito. After undergoing various complex parasitic stages in the liver to evade the human immune system, the parasite multiplies asexually in erythrocytes and re-infects red blood cells. At this stage, clinical symptoms begin to manifest. A few parasites that evolved apart into sexual erythrocytic stages (gametocytes) are ingested by another *Anopheles* mosquito during a subsequent blood meal. In the mosquito's stomach, the micro- and macrogametocytes undergo another complex various-staged development. Finally, ruptured ooysts release sporozoites which move to the mosquito's salivary glands to be inoculated again into the human host (White, 2003). Recent estimates suggest that 515 million episodes of clinical malaria occurred in 2002 (Snow *et al.*, 2005) and that malaria causes between 1 and 3 million deaths every year (Guinovart *et al.,* 2006). Estimates of the disability adjusted life years (DALYs) lost due to malaria vary from 40.0 to 46.5 million (Lopez &Mathers, 2006; WHO, 2003). More than 80% of the mortality and burden of malaria are concentrated in sub-Saharan Africa, particularly in children below the age of five years (WHO & UNICEF, 2003). Malaria impedes economic growth, and hence it is closely linked with conditions of poverty. The annual loss of economic growth in malaria-endemic countries due to the disease has been estimated at 0.25-1.2% (McCarthy *et al.,* 2000; Sachs & Malaney, 2002). New research has shown that at the household level, the vulnerability of the poorest is increased by socio-economic differences in access to malaria interventions (Worrall *et al.*,2005).

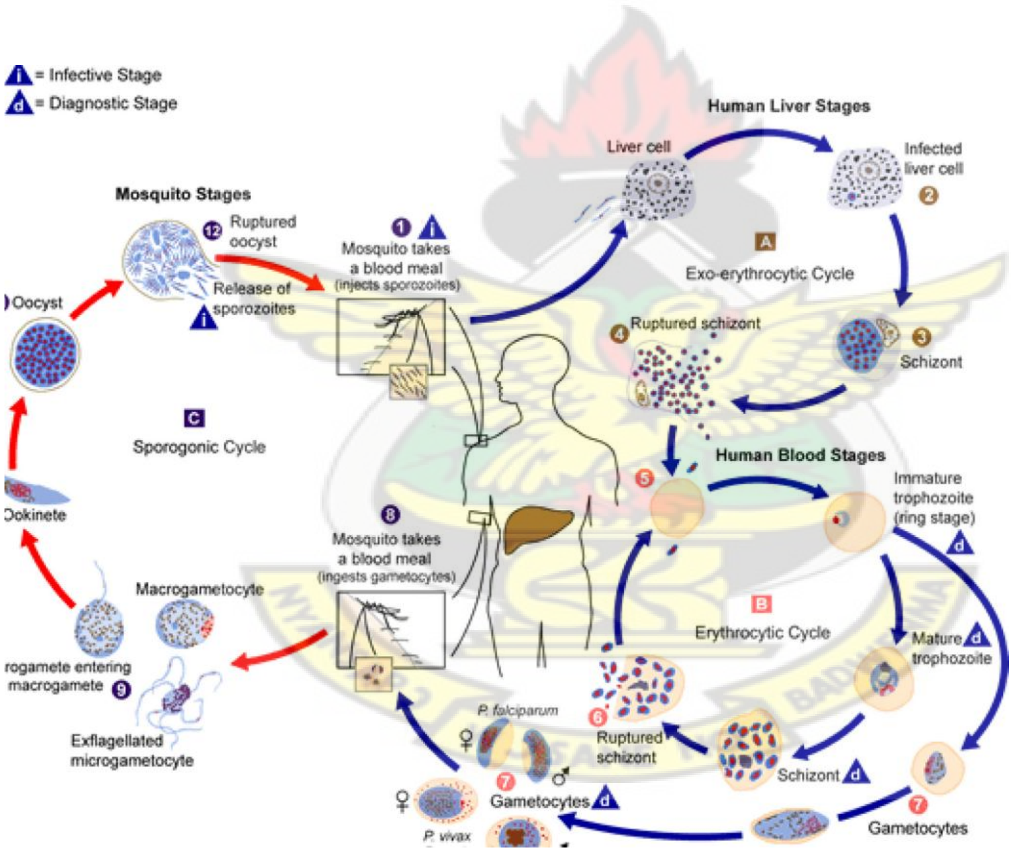


Figure 2.1 Life cycle of *P. falciparum* malaria (source: CDC, 2012)

Efforts are underway to reduce the burden of malaria. For example, the Roll Back Malaria (RBM) initiative, launched in 1998, aims at halving the global burden of malaria by 2010 by means of equitable, effective and low-cost interventions, such as the promotion of insecticide-treated nets (ITNs), and improved access to efficacious anti-malarial drugs, targeting specifically the most vulnerable groups (Binka & Akweongo, 2006; Guinovart *et al.*, 2006; Schellenberg *et al.*, 2006; WHO *et al.*, 2001).

2.3.2 Schistosomiasis

Human schistosomiasis signifies a complex of parasitic infections that are caused by a trematode the blood fluke of the genus *Schistosoma* (Davis, 2003). Specific aquatic or amphibious snails act as intermediate hosts. The three most important schistosome species parasitizing humans are *S. haematobium*, *S. japonicum* and *S. mansoni*. Both *S. mansoni* and *S. haematobium* occur in the Middle East and in Africa, with *S. mansoni* additionally found in different areas of South America and the Caribbean. The geographic distribution of *S. japonicum* is currently restricted to the Far East, namely China, Indonesia and the Philippines. The three main human schistosome species cause different pathologies. Chronic infections with *S. mansoni* and *S. japonicum* lead to intestinal schistosomiasis, whereas *S. haematobium* causes urinary schistosomiasis. In Ghana, schistosomiasis according to Bosompem *et al., (*2004) is caused mainly by *Schistosoma haematobium* and *S. mansoni*. The eggs in urine or stool, cause diarrhea, liver fibrosis, portal hypertension, obstruction uropathy, renal failure and cancer of the bladder.

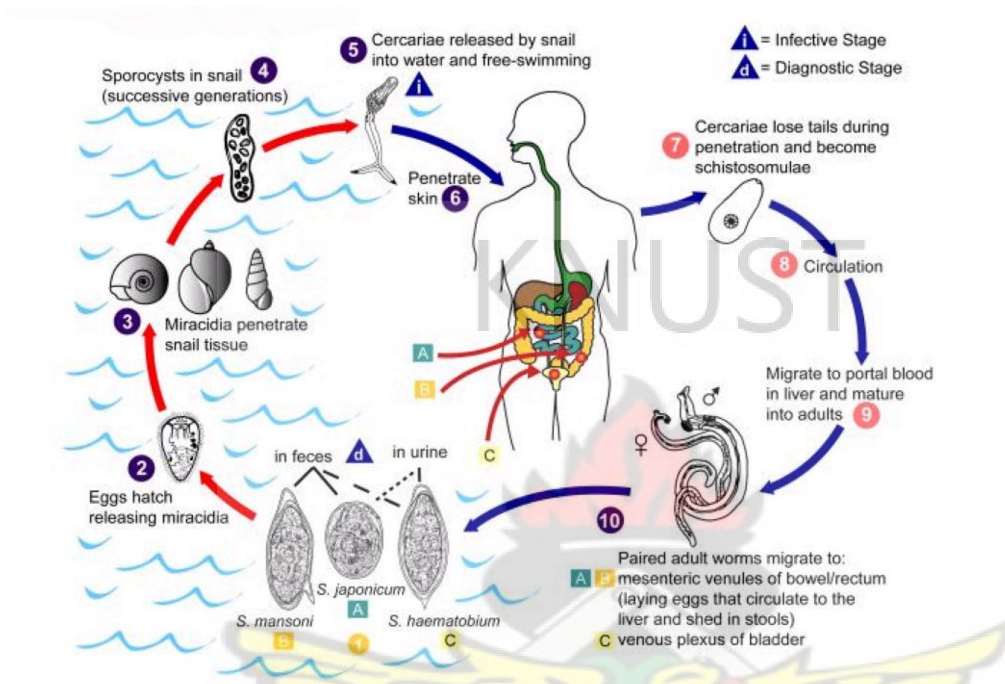


Figure 2.2 Life Cycle Of Schistosomiasis (source: CDC, 2012)

Figure 2.2 shows the life cycle of schistosomiasis. In brief, transmission occurs when humans contact freshwater sources that have been contaminated with human faeces or urine that contained *Schistosoma* eggs. These eggs hatch and release larvae (miracidia) which penetrate the intermediate snail host. Within the snail, the miracidia multiply in two cycles and produce cercariae. The infective cercariae are released by the snails and they are free-swimming. They can penetrate the skin of an immersed human host. As soon as the cercariae have penetrated the human skin, they transform into schistosomula and migrate via the heart and then the lungs to blood vessels lining the bladder or rectum. One part of the eggs is eliminated by faeces (*S. mansoni* and *S. japonicum*) or urine (*S.*

haematobium), the other part is trapped in tissues. Eggs, which migrate through the intestinal wall, cause chronic inflammation, pseudopolyposis and bleeding that are typical for intestinal schistosomiasis. Eggs stuck around the portal veins of the liver cause splenomegaly, mainly in children. Chronic hepatic schistosomiasis occludes the portal veins, resulting in hypertension (Gryseels *et al.*, 2006).

Re-infection results from contact with infested freshwater, because schistosomes do not replicate in humans. At highest risk of infection are children between 6 and 15 years who acquire the infection through swimming or bathing in snail-infected fresh water bodies and people whose occupations are water-related (e.g. women during domestic work, fishermen and farmers practicing irrigated agriculture) (Davis, 2003). Recent estimates suggest that 779 million are at risk of schistosomiasis, and 207 million people are infected, primarily in sub-Saharan Africa (Steinmann *et al.*, 2006). The global burden due to schistosomiasis is between 1.7 and 4.5 million disability-adjusted life years (DALYs) (Utzinger & Keiser, 2004). The “true” burden of schistosomiasis, however, might be considerably higher (King *et al.*, 2005). The annual mortality rate might exceed 200,000 in Africa alone, mainly due to bladder cancer or renal failure caused by urinary schistosomiasis, and liver fibrosis and portal hypertension caused by intestinal schistosomiasis (van der Werf *et al.*, 2003).

2.3.3 Soil-transmitted Helminthiasis

Soil-transmitted helminths are intestinal nematodes which develop partly in the soil and partly in the human body. The main species include the hookworms (*Ancylostoma duodenale* and *Necator americanus*), roundworm (*Ascaris lumbricoides*) and whipworm (*Trichuris trichiura*), and can be distinguished according to their life cycles.

Hookworm eggs, after they are passed via stool to the soil, develop into different larval stages. The L3 stage is infective for humans; they penetrate the skin and migrate via the respiratory tract to the small intestine, where they mature into the adult stage (see Figure 2.3). Hookworms attach to the intestinal wall, where they draw blood and hence contribute to anaemia (Gilles, 2003).

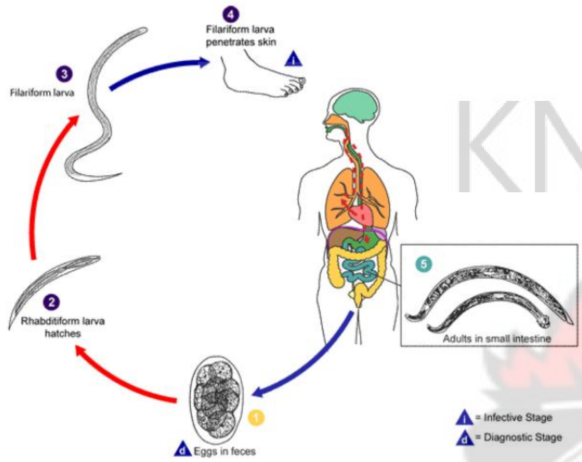


Figure 2.3 Life Cycle Of Hookworm (source :CDC, 2012)

A. lumbricoides and *T. trichiura* occur around the world with highest prevalence found in tropical and subtropical regions and areas with inadequate sanitation (de Silva *et al.*, 2003).

Hookworm infections occur in tropical and subtropical regions and transmission is highest in areas with moist and sandy soils (Gilles, 2003; Hotez *et al.*, 2004). It has been estimated that 4.5 million people are at risk of soil-transmitted helminthiasis (Horton, 2003). The latest available statistics suggest that between 807 and 1,1221 million people are infected with *A. lumbricoides*, 604-795 with *T. trichiura* and 576-795 million with hookworms (Bethony *et al.*, 2006). An estimated 300 million people suffer from resulting impairments, e.g. irreversible organ damage. Clinical manifestations caused by helminthic infections are iron-deficiency anaemia and chronic intestinal blood loss, delay in physical growth and intellectual development and reduced working capacity (Horton, 2003; Hotez *et al.*, 2004).

2.3.4 Control Of Schistosomiasis And Soil-Transmitted Helminthiasis.

In high-burden areas, the recommended strategy for the control of schistosomiasis and soil transmitted helminthiasis is morbidity control, facilitated by the administration of anti-helminthic drugs. Drugs need to be administered regularly to high-risk groups i.e. school aged children (WHO, 2002). The goal is to reduce the number of infected people harbouring high worm loads by systematic large-scale treatments in endemic areas (Bethony *et al.,* 2006). An efficient channel of regular de-worming is the school system (Hotez *et al.,* 2006; WHO, 2002; WHO, 2005). National schistosomiasis and soil-transmitted helminthiasis control programmes have been launched in several countries of West Africa (Garba *et al.,* 2006), and in East Africa (Kabatereine *et al.,* 2006). In view of chemotherapy serving as the backbone of morbidity control of schistosomiasis and soil-transmitted helminthiasis and mounting drug pressure, the development of novel antihelminthic drugs is a pressing public health issue (Horton, 2003; Utzinger & Keiser, 2004). Chemotherapy, however fails to address the root causes of infection and reinfection of schistosomiasis and soil-transmitted helminthiasis. Hence, improved water supply and sanitation, together with health education, are the key strategies to reach sustainable reductions of these parasite infections (Utzinger *et al.,* 2003).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Site

The study was carried out in the Tono irrigational catchment area in the Kassena Nankana District of the Upper East Region. Tono lies within latitude 10·45°N and longitude 1°W, The irrigation project is the largest irrigation system in Ghana and is managed by the Irrigational Company of Upper Region (ICOUR). The Tono dam sources its water mainly from runoffs and flowing streams. The dam is chiefly fed by three major tributaries coming from Chianabuga (Chiana area), Gaobuga (Po area in Burkina Faso) and Songobuga (Nabio, Kajilo areas).

3.2 Study Communities

Most people live in compounds with an average of 10 inhabitants per household. There are two main seasons: a short wet season from June to October with average rainfall of about 850mm, almost all of which occurs in the wet months and a long dry season for the rest of the year. A large reservoir (The Tono dam), in the middle of the district, provides water throughout the year, mainly for irrigation purposes. The reservoir spans over 1860 ha with maximum storage capacity of 93 × 106 m³, and serves 32 km of main canals (Binka *et al*., 1999). Due to the scattered nature of the human settlements, some houses are located near the dam and canals at a distance of 100-200m. The main reservoir is located in one of the five communities (Gia) with canals linking the dam water to the other the four communities. Fishing and irrigational farming are the activities most concentrated at Gia whereas gardens for vegetable farming and rice fields are created and served by the canal water running through the rest of the four communities (Kwarania, Yogbania/Yigbwania, and Gaani,)

An open irrigation system floods the fields during the dry seasons. There are also roughly 90 dug out wells in addition to the irrigation project that serve as water sources for the people as well as livestock during the long dry season. The average annual temperature ranges from 18-45°C (Appawu *et al*.,2004).

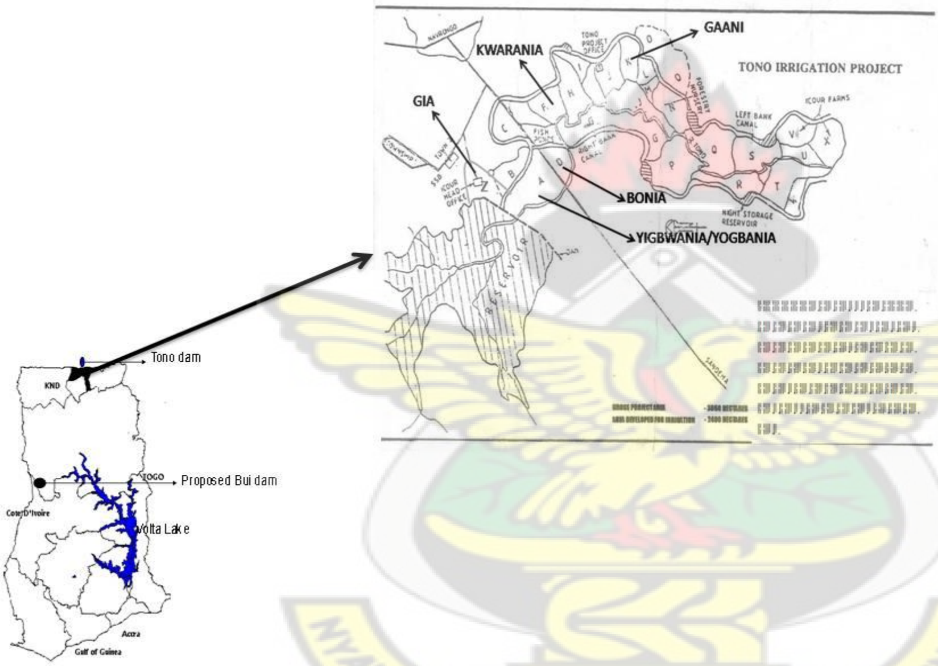


Figure 3.1 Map Of Ghana showing the Tono Dam And the Study Area

3.3 Sampling Procedure

Five communities around the Tono dam were involved in this study. Using the purposive and random sampling technique, a total of 333 participants comprising fishermen, irrigation farmers, fishmongers, school children and others, from all the selected communities were recruited after informed consent has been sought. Houses were sampled depending on whether members used the dam or canal water or not. The random sampling technique was then used to select five individuals in each household with an average house hold size of 10 inhabitants. This was achieved by folding five (5) pieces of paper with 'YES' among a number of folded pieces of paper with 'NO' making the number in particular household for members to pick, where the house hold size was above five. Those five who picked Yes in a household were included in the study. Where the number of household was five (5) or less than five all were recruited for the study. With the help of the Assembly men in each community consent was sought first from the sub chiefs from each community and then from community members. The regional and district health directorate also gave their consent for this study in area as well. The sample size was obtained using $n = (z/\Delta)^2 p(1-p)$ where:

n is the sample size required,

z is 1.96 is the z-score associated with a 95% confidence interval (CI),

Δ is the margin of error = 0.05 and

p is the prevalence of disease.(Midzi et al.,2011).

Based on previous studies in Kassena Nankana District, the prevalence of malaria, 55% and Schistosomiasis, 48% (Anto,2002&2006), were used. The prevalence of schistsomiasis (48%) was used to calculate the sample size in the rural irrigated area. The largest of the two sample sizes (n = 373) was considered optimal and it was adjusted by 30% to n = 485 considering possible loss due absenteeism.

3.4 Questionnaire Administration

Pre-tested questionnaires were administered to all recruited participants, from whom specimen samples were also collected. Recruited community members were interviewed for possible cases of schistosomiasis, malaria and water contact activities using a standardized questionnaire. Each individual was interviewed for details of age, sex, occupational status, source of water, how often one came into contact with dam or canal water, whether one had been given anti-schistosomal drug or not. They were also questioned what they do when symptoms of malaria and schistosomiasis are noticed. Health officials, herbalists, family heads, and opinion leaders were involved in focused group discussion for socio-economic indicators.

3.5 Sample Collection

3.5.1 Stool And Urine Samples

Faecal and urine samples were obtained from the participants into labeled, sterile wide mouthed screw capped container (supplied to them) with instructions on how each sample is to be taken. Thus, for urine, participants were asked to deposit midstream and terminal urine into the containers between the hours of 6am and 10:30am. In both cases, the containers were labeled with the identification numbers to correspond with that on the questionnaire for each person interviewed.

3.5.2 Blood Samples

Approximately, 1ml of each subject's venous blood was collected into labeled EDTA tubes and transported to the laboratory for Hb and malaria parasitaemia determination.

3.6 Sample Preparation And Examination

3.6 .1 Urine Examination

The appearance of urine was noted. The sedimentation method as described by Cheesbrough (2005) was used to concentrate ova from the urine samples. Ten (10ml) of well mixed urine was transferred into a conical tube and centrifuged at 2000 rpm for 1 minute and allowed to come to rest. The supernatant was discarded and sediment poured onto a microscopic slide, covered with a cover slip and examined microscopically (Cheesbrough, 2005), for detection of *Schistosoma haematobium* ova.

3.6.2 Stool Examination

The formol Ether concentration method was used to concentrate the cyst, ova and larvae from the stool samples. One gram (1g) of each stool sample was thoroughly emulsified with about 7 ml. of 10% formol-water and strained into a centrifuge tube.

Three millilitres of Ether was added and the mixture shaken vigorously and centrifuged, accelerating slowly and gradually over a period of two minutes to a speed of 2,000 r.p.m. for one minute, and then allowed to come to rest. The debris on the surface and at the interface between the two liquids was loosened from the wall of the tube with an applicator stick and the supernatant discarded. The upper part of the tube was wiped clear of fatty debris. The small deposit was shaken up and poured on to a slide. (Ridley and Hawgood, 1955). Urine and stool samples were processed within 24 hours of collection. All prepared specimens were examined microscopically first under 10x objective for good contrast and then under the 40X Objective for detail examination.

3.6.3 **Hb And Malaria Parasitaemic Determination.**

The Sysmex machine (SKX-21N), an automated system was used to determine the Hb values.

Thick blood films were made on microscopic slides from the venous blood collected from each subject. Slides were stained with Giemsa stain and read microscopically.

Parasites density was estimated by counting the number of trophozoites per 200 white blood cells (WHO,1994; Cheesbrough, 2005).

3.7: Statistical Analysis

Microsoft Office© Excel© was used for plotting all graphs. Correlation and chi-square test were all done with SPSS©.

CHAPTER FOUR

RESULTS

4.1 Demographic Characteristics Of Study Population

A total of 333 individuals were examined for between May 2011 to February 2012 in the Tono irrigational area in the Kassena Nankana District of the Upper East Region of Ghana. The overall mean age of the study population was 32.07±0.97 years. The mean ages in the five communities were : Kwarania 31.29±17.59, Bonia 32.35±18.26, Yogbania/Yigbwania 33.29±18.37, Gaani 34.64 ±18.66 and Gia 27.75±15.32. Overall, there were more females 170 (52%) than males 157(48%). The occupational groups identified and represented by the study population include: Rice farmers (11.11%), fishermen (5.11%), Fishmongers (3.60%), students (34.53%) other farmers (33.93%), Traders (10.51%) unemployed (1.20%).

4.2 Overall Prevalence Of Parasitic Infection In The Studyommunities.

Of the 333 participants, 327 samples each of urine, stool and blood were analyzed. The following parasitic infections were identified in the five communities *S. mansoni*, *S. haematobium*, Malaria and hookworm. At least 10.7% of the study population had one of the parasitic infections mentioned above. Multiparasitism was observed in some individuals, however no sample had all the four infections. The parasitic disease with the highest prevalence in all five communities was S. *mansoni* infection (19.22%) with a density of 6.14 eggs/1g of stool. Though Malaria had a lower prevalence (5.11%) than *S .mansoni*, it recorded a higher intensity (parasite density) of 299.6 *P. falciparum* parasites/µl of blood. *S. haematobium* had a prevalence of 1.50% with an intensity of 4.67

eggs/10ml of urine, this was lower than the mean intensity of 5.5 eggs/g of stool recorded for hookworm infection with a prevalence of 0.90% . Multiple infections was also recorded with a prevalence rate of 1.83% (6/327).

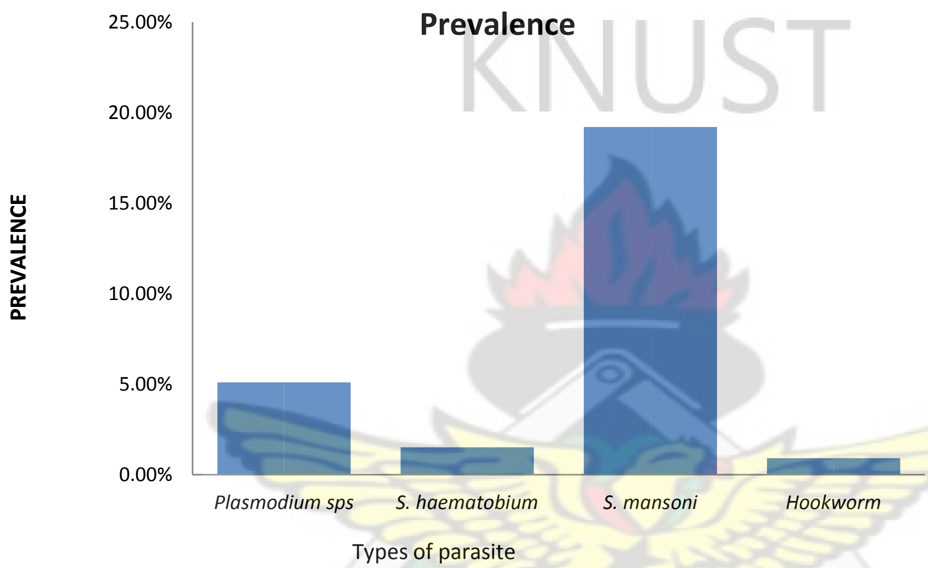


Figure 4.1 : Overall Prevalence Of Parasitic Infections In The study Communities.

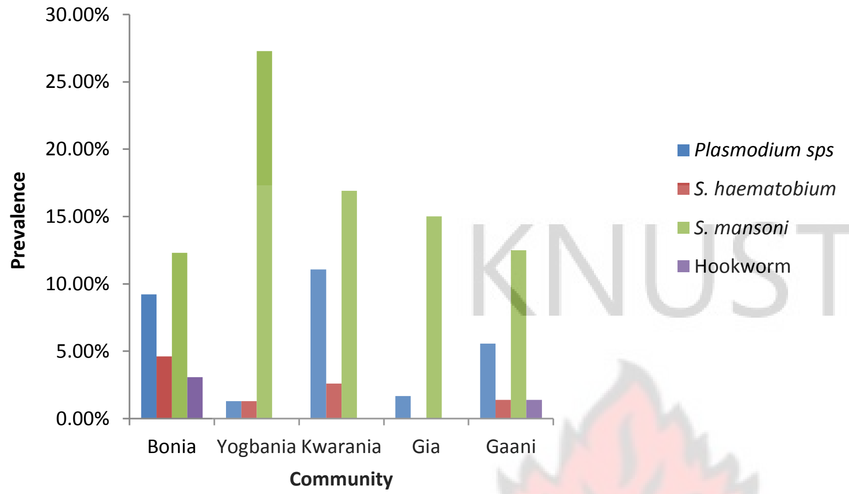


Figure 4.2. Prevalence Of Parasitic Infections In The Five Communities

4.3 Prevalence Of Parasitic Infections In The Communities

S. mansoni infection was generally wide spread in the study area with Yogbania recording the highest prevalence (27.27%) and Bonia recording the least of 12.31%. malaria had the next highest prevalence, with Kwarania recording the highest prevalence of 11.07% as against 1.30% recorded in Yogbania (representing the least prevalence of malaria). *S. haematobium* infection was present in all communities with the exception of Gia. Within the remaining four communities in which it was found, Bonia recorded the highest prevalence value of 4.62% with the least value recorded in Yogbania (1.30%). Infection with hookworm was recorded in only two out of the five communities (exception of Yubgbania, Kwarania and Gia), (correct in final work) with Bonia having a prevalence of 3.08%, representing the highest prevalence, and Gaani recording 1.39%, representing the lowest prevalence value. Statistically there was no significant difference between the communities studied (p-value= 0.0853).

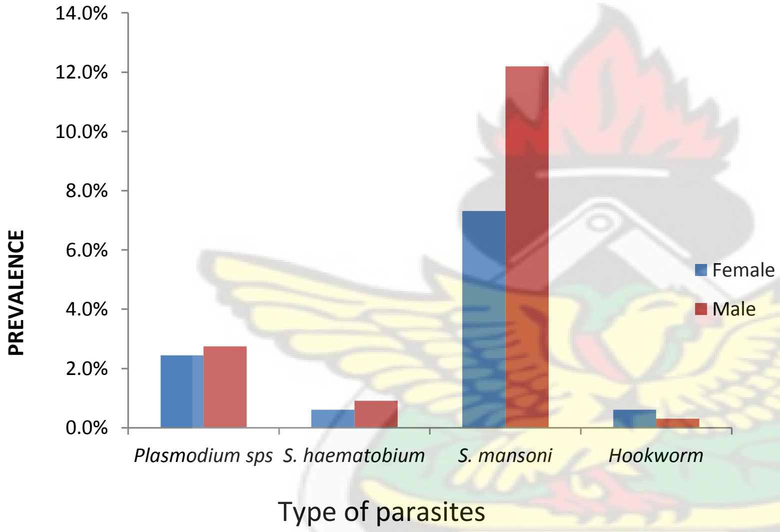


Figure 4.3. Prevalence Of Parasitic Infections By Sex In The Study Population.

4.4 Prevalence Of Infection By Gender

Sex related prevalence of the various parasitic infections studied showed that *S. mansoni*, infection was more widespread than any other infections; with this infection, males were more infected than female (12.2% as against 7.3% prevalence respectively (Fig 4.3).

Malaria parasite distribution by sex gave a higher rate in males (2.7%) than in females (2.4%). Infection with *S. heamatobium* which was the second highest helminth infection recorded, also showed that males were more likely to be infected than females with prevalence's of 0.9% and 0.6% respectively. Interestingly infection with hookworm showed a higher prevalence rate in females (0.6%) than in males (0.3%), deviating from that observed for the other three infections studied. Statistically there was a significant difference between the sexes (p-value= 0.0397).

Table 4.1 Prevalence Of Parasitic Infection By Sex In The Study Population.

Sex	**MPs**	**S. haematobium**	**S. mansoni**	**Others**
Female	2.4%	0.6%	7.3%	0.6%
Male	2.7%	0.9%	12.2%	0.3%

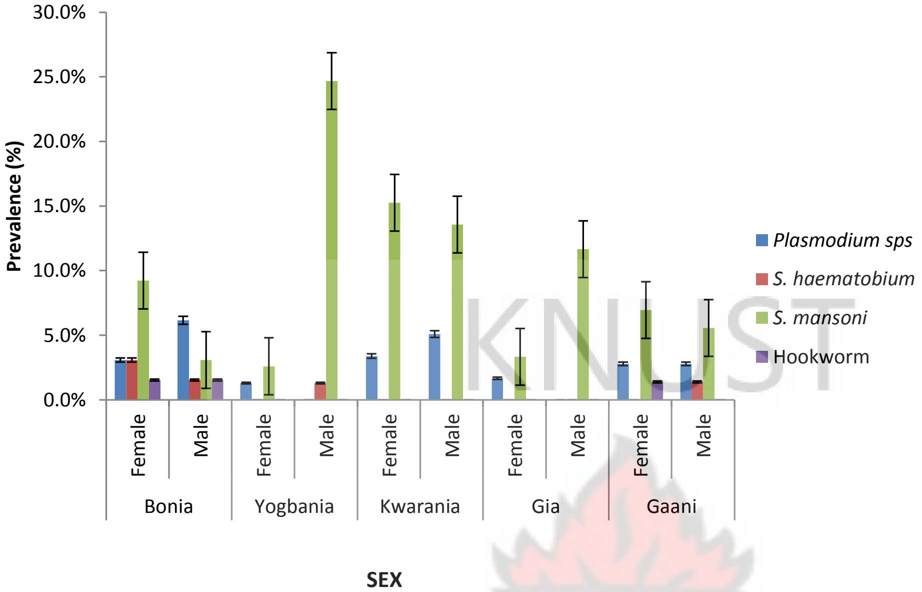


Figure 4.4. Prevalence Of Parasitic Infections By Sex In The Five Study Communities

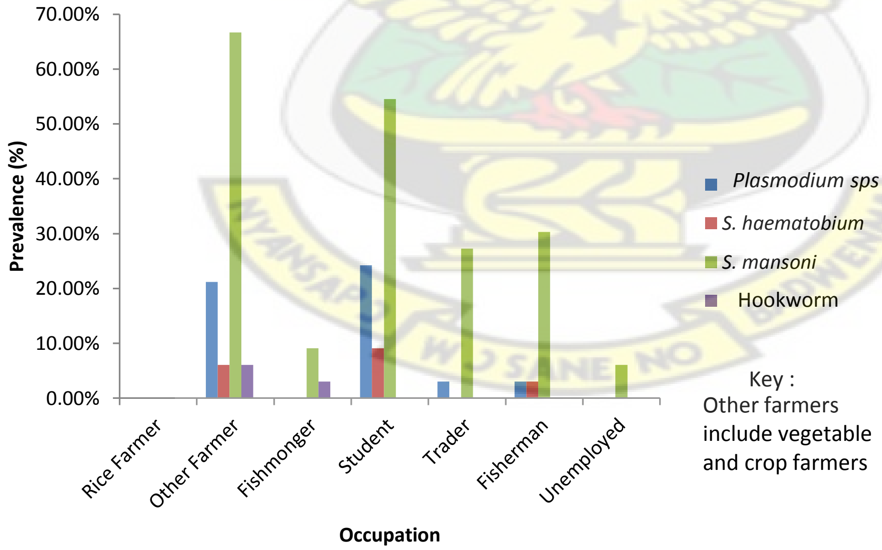
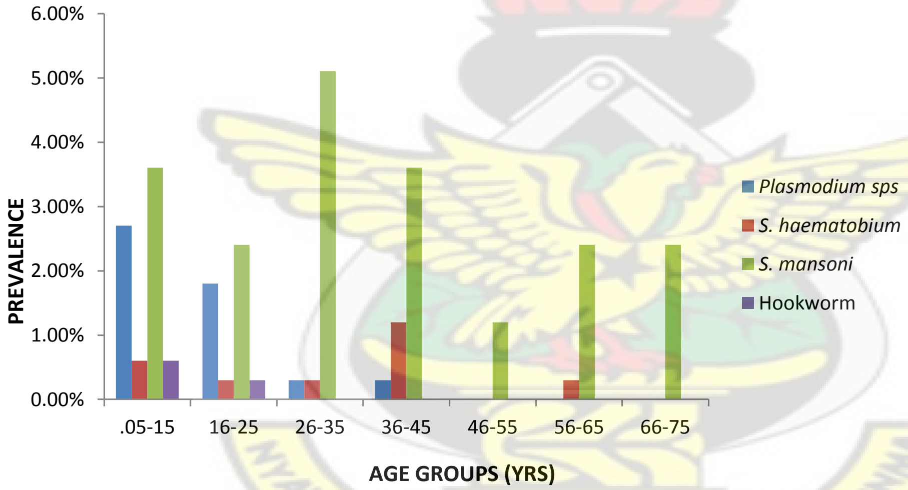


Figure 4.5. Prevalence Of Parasitic Infections In Different Occupational Groups.

4.5 Prevalence Of Parasitic Infections In The Different Occupational Groups.

Prevalence relating to occupation showed that *S. mansoni* again more widespread than the other three infections, being found in all occupational groups except rice farmers, with the highest prevalence recorded in the population under the category "other famers"(66.67%) with the unemployed members of the population giving the least prevalence of 6.06%. Infection with malaria was also widespread, present in all but three (rice farmers, fishmongers and unemployed) occupational groups. Students gave the highest prevalence of malaria (24.24%) followed by other farmers (21.21%) with both traders and fishermen recording a prevalence rate of 3.03% being the least prevalence rate. *S. heamatobium* was present in three of the occupational groups (Other farmers, Students and fishermen) with students recording the highest rate of 9.09%, followed by other farmers and fishermen respectively with values of 6.06% and 3.03%. Other infections were found in only two of the occupational groups namely: other farmers (i.e vegetable and crop farmers) and fishmongers and with the other farmers recording a prevalence of 6.06% and fishermen recording 3.03%. Statistically there are no difference between the occupational groups (p-value= 0.5323).

Figure 4.6. Prevalence Of Parasitic Infection In Different Age Groups



.

4.7 Prevalence Of Parasitic Infections In Different Age Groups.

S. mansoni , compared with the other categories reported above had the highest age-related prevalence, with ages 26-35 years recording the highest prevalence of 5.11%, with members of the population within ages 46-55 recording the least of 1.20%. It is also worth noting that infection with *S. mansoni* was reported in all the age groups studied. Malaria was reported in almost all except age categories 46-55 yrs, 56-65 yrs and 66-75 yrs, however members of the study population within ages 5-15 yrs had the highest prevalence (2.70%) with ages 26-35 yrs and 36-45 yrs recording the least (0.30%) prevalence each. *S. haematobium* was recorded in all age categories except two (46-55 yrs and 65-75 yrs); ages between 36-45 yrs had the highest prevalence (1.20%), with three other age categories (16-25yrs, 26-35yrs and 56-65yrs) recording the least prevalence of 0.30%. Other infections were reported in only two age categories (5-15yrs and 16-25yrs), with ages 5-15yrs recording the highest prevalence (0.60%) and the least of 0.30% recorded between the ages of 16-25yrs.

4.8 Intensity of infection by Gender

As reported earlier, the intensity of infection with malaria was higher in females (367.25mps /ml of blood) than in males (232.25mps/ml of blood). For S. mansoni males recorded a higher intensity of 6.10 eggs/g of stool as against 4.45 eggs/g of stool recorded for the females. Intensity of infection with *S. haematobium* was recorded only in males with a value of 2.75 eggs/10 ml of urine, whiles intensity with other infections (mostly hookworm) was also recorded only in females with an intensity value of 2 eggs/1g of stool.

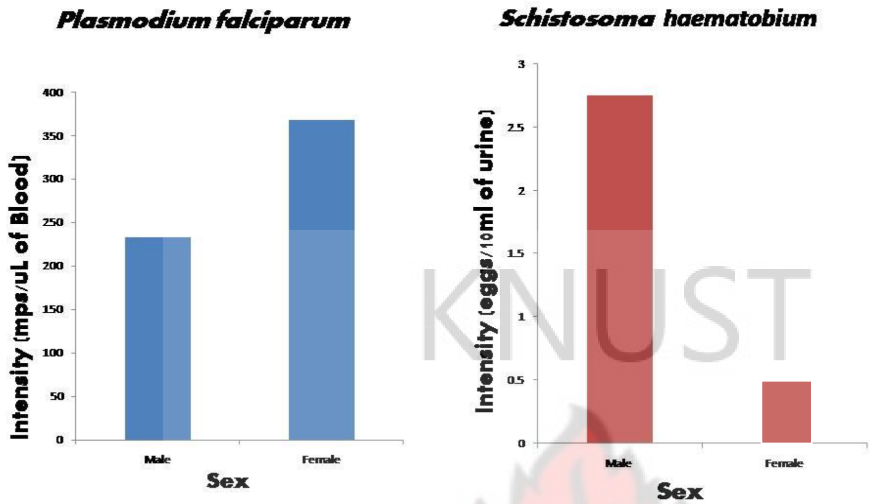


Figure 4.7 Intensity of *Plasmodium falciparum* and *Schistosoma haematobium* infections in the study area by gender.

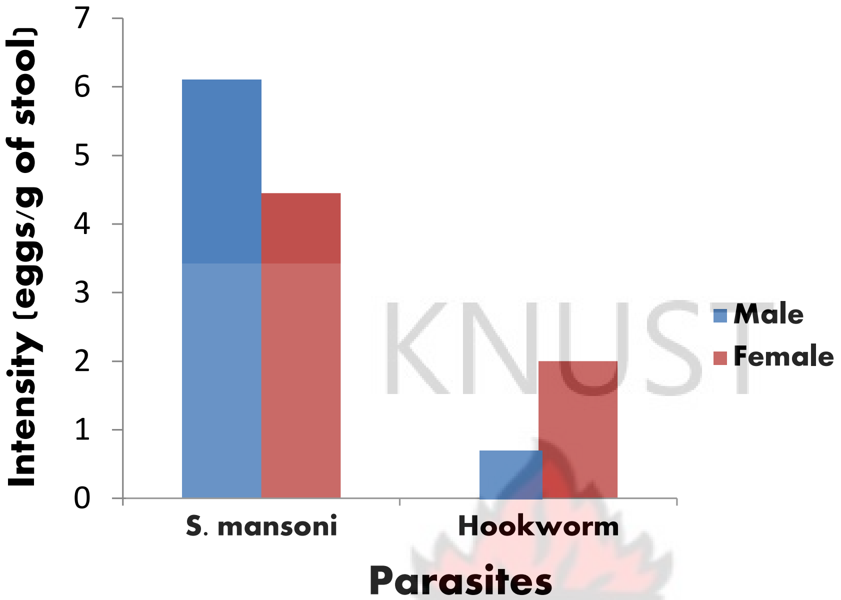


Figure 4.8 Intensity Of *Schistosoma mansoni* and Hookworm Infections In The Study Area By Gender.

4.9 Intensity Of Infections Within The Individual Communities By Age Groups

Within Gaani the highest intensity (density), of malaria (703), was found within the age groups of 5-15 yrs, followed by *S. mansoni* with an intensity of 22 eggs/g of stool within the same age group. Other age groups that recorded intensities were 36-45yrs with malaria intensity (density) of 48 and *S. mansoni* of 8 eggs/1g of stool and ages 56-65yrs and 66-75yrs recording intensity values of 3 eggs/10g of stool and 6 eggs/1g of stool respectively for *S. mansoni*. In Gia, the highest intensity of, malaria (970), was found within the age group 56-65 yrs, with *S. haematobium* of three (3 eggs/10ml of urine) and *S. mansoni* of four (4 eggs/g of stool). There were other intensities within the ages 36-45 yrs with *S.*

haematobium (1 egg/10ml of urine) and *S. mansoni* (2 eggs/g of stool), with age groups 16-25yrs reporting intensity of 1 egg/g of stool for *S. mansoni*.

In Kwarania, malaria gave a high intensity of 133mps/ul blood recorded within the age group 5-15yrs, with an intensity of 9 eggs/1g of stool for *S. mansoni*, again malaria was recorded with an intensity of 69 mps/ul blood within 26-35 years and *S. mansoni* giving intensity of 5 eggs/1g of stool. *S. mansoni* was also recorded within the ages 36-45 yrs, 46-55 yrs,56-65 yrs and 66-75 yrs with intensities 1,3,3 eggs/g of stool and respectively. As seen in the other communities, intensity with malaria was high (106 mps/ul blood) among the age group 5-15 yrs. In Yogbania, intensity of infection with parasites was low as follows for *S. mansoni* infection 36-45 yrs, 46-55 yrs, 56-65 yrs and 66-75yrs with values of 2, 4, 9 and 26 eggs/1g of stool respectively. Bonia, intensity of 544 mps/ul blood was recorded for malaria within the age group 16-25 yrs, with *S. haematobium*, *S. mansoni* and other infections recording intensity values of 10 eggs/10 ml of urine, 8 eggs/10g of stool and 3 eggs/10g of stool respectively. Other intensities of malaria, 67 mps/ul blood and 57 mps/ul blood were found in the age groups of 36-45 yrs and 46-55 yrs respectively with the only other intensity of 1 egg/1g of stool recorded for *S .mansoni* within the age group of 66-75 yrs.

4.10 Effect Of Multiparasitic Infection On Hb Levels.

Haemoglobin (Hb) levels were checked for individuals with multiple parasitism, as reported earlier only six out of the total sample size had multiple infection, with none of these six reporting incidence of all parasites studied. Hb levels ranged from 6.6 g/dl to 15.6 g/dl. The lowest Hb of 6.6 g/dl was recorded in a female infected with both malaria and *S. mansoni*, this value is far below the lower limit of 12.1 g/dl for females. The only other female with multiple parasitism had an Hb of 11 g/dl. However the highest Hb value of 15.6 g/dl was recorded in a male infected with *S. haematobium* and *S. mansoni*. It is also worth noting that the other three males with multiple infections of *S. haematobium* and *S. mansoni*, Malaria and *S. mansoni* and *S. haematobium* and *S. mansoni* respectively; recorded Hb levels of 11 g/dl, 12 g/dl and 13 g/dl, these values are below the lower limit of 13.5g/dl for males (normal hb range for male is 13.5-17.5g/dl for females it is 12.1-15.1 g/dl and for children it is 11-16.0g/dl (below 11.0g is aneamic). (www.wki.answers.com/Q/What is the normal range for hemoglobin)

Table 4.2 Hb Levels Of Individuals In The Study Population Suffering From Multiple Parasitic Infections.

HB(g/dl)	**Pf (MPs/1µl blood)**	***S.haem*** **(Eggs/10ml urine)**	***S.man*** **(Eggs/1g stool)**	**Hookworm (Eggs/1g stool)**	**Sex**
11	*0*	0	12	1	F
15.6	*0*	18	9	0	M
12	*67*	0	7	0	M
11	*0*	3	1	0	M
13	*0*	9	3	0	M
6.6	*680*	0	3	0	F

4.11 Relationship Between Subjects Hb Levels And Malaria Infection.

The results from the correlation test showed that, relationship between Hb levels and malaria is not significant (P=0.563).This implies that malaria has no impact on Hb levels of subjects in this study. This is however is not surprising as very few malaria cases were reported which goes to confirm that education on malaria and its prevention as well as the supply of mosquito bed nets in the area by the Navrongo Health Research has been addressed well.

4.12 Relationship Between Hb Levels And the Helminthic Infections.

There is a negative correlation between Hb and *S mansoni* and other helminthic infections Implying Hb decreases with an increase in *S. mansoni* and other infections respectively but the relationship is not significant (P values = 0.087). This means that other factors in the community like nutrition and general health status could have an effect on the Hb levels of the participants and not necessarily schistosomiasis.

P value for other infections(0.0164) is less than 0.05 implying a significant relationship between Hb levels and other infections such that Hb levels decreases with an increase in the incidence of other helminthic infection (i.e, Hookworm).

With a p value of 0.19 > 0.05 implied that *S haematobium* infections identified in the study had no significant impact on Hb levels in the subjects.

4.13 Relationships Established Among Malaria, Schistosomiasis And Other infections In The Study Area.

Results from the correlation test showed there is no significant relationship (p values: 0.807, 0.823) between malaria, schistosomiasis, and hookworm (Refer to Appendix Table 4.3). Thus the prevalence of one does not influence the other significantly. As such malaria infections in the communities from the t test does not precipitate the incidence of schistosomiasis or other infections and the vice versa.

There is a positive correlation between *S haematobium* and *S mansoni* infections implying *S. haematobium* infection increases with an increase in *S mansoni* infection. The relationship is thus significant as the P value = 0.0150 is less than 0.05. Reasons for this relationship could be that the intermediate host for both species of snails for *S. haematobium* and *S. mansoni* (*Bulinus* and *Biomphilaria*) respectively both reside in the same water bodies. Also their mode of infection and life cycle is the same hence their rate of infection could be the same. Also the possibility of cross infection is possible in an individual since both intestines and bladder by position lie close to each other. Hence eggs of one parasitic species e.g *S. mansoni* can leak from the intestines into the bladder. This was observed as some individual harboured both *S. haematobium* and .*S mansoni* in their urine.

The relationship between *S mansoni* and hookworm was not significant with p value =0.344.This could be due to the different modes of transmission and location both exhibit hence has nothing in common (Refer to Appendix Table 4.4).

CHAPTER FIVE

DISCUSSION

The prevalence of parasitic infections in most developing countries is still a major health issue. In the present study four parasitic infections were identified in the Tono irrigational Area namely; *S. mansoni*, *S. haematobium*, malaria (*Plasmodium sp*.) and other infections (mostly hookworm), with 10.7% of the study population infected with one or the other of the four infections identified. A similar study in the Kasena Nankana district undertaken in 2009 among pregnant women within a clinical/hospital setting found intestinal helminths overall prevalence of 20.7%, reporting of five types of intestinal helminths; *S. mansoni*, hookworm, *S. stercoralis*, *Ascaris lumbricoides* and *Trichostrongylus* (Fuseini *et al*, 2009).

The sources of these infections however could be enormous as parasites could have been transported from all manner of locations to the hospital.

In the present study, the intensity of infection with the four different parasites identified showed *S. mansoni* with the highest prevalence (19.22%) with an intensity of (6.14 eggs/g of stool) in all the five communities studied, *Schistosoma sp* infections have been shown to increase with the construction of irrigational facilities due to the creation of ideal environmental conditions for the snail intermediate host. Schistosomiasis and other water-related diseases are expected to remain as serious public health problems; these infections are expected to increase and become more acute due to population increases, and high demand for food and energy that would eventually result in the expanded and intensified exploitation of water resources (Boelee *et al*, 2006).

Malaria within the study population, had a low prevalence (5.11%) however, the few infected individuals recorded a high density (299.67 parasites/μl). The environmental conditions created by the irrigation facility provide ideal breeding grounds for the *Anopheles* female mosquito that is a vector for the transmission of this infection, therefore contributing to the higher density (Cheesbrough, 2005).

S. haematobium similar to *S. mansoni* was widespread being found in four communities except one (Gia) . Its widespread prevalence as reported for *S. mansoni* might be due to the favorable conditions created by the irrigation facility. There was a positive correlation between *S. haematobium* and *S. mansoni* infections implying that as *S. haematobium* infection increased, *S. mansoni* infection also increased. The relationship is thus significant (p value = 0.0150). Reasons for this relationship could be that the intermediate host for both species of parasites inhabit the same kind of micro-habitat and also both parasites mode of infection and life cycle are similar. Some individuals (1.20%) passed both *S. haematobium* and *S mansoni* eggs in their urine, that this could occur and may be explained by the close positions of the urinary bladder and the lower sections of the intestines and their associated blood vessels (veinules) with the possibility that a leakage in these vessels could result in the passage of eggs from one to the other. Malaria infections had no influence on the incidence of *S. heamatobium, S. mansoni* and other infections (mostly hookworm).

Ascaris lumbricoides and *Trichuris trichiura* were absent in the study population. This could be attributed to the low annual rainfall (550mm) and the high average temperatures recorded within the district (18°C-45°C). It has been reported that the eggs of these two species require an ideal temperature of about 31°C for embryo development with a temperature of 38°C being lethal to the eggs. Furthermore areas of low annual rainfall below 1400 mm, are reported to demonstrate an absence of infection (Fuseini *et al*, 2009).

Prevalence of infection by sex showed, that *S. mansoni* and *S. haematobium* were more widespread in males (12.2% and 0.9% respectively) than in females (7.3% and 0.6% respectively); this might be attributed to the higher exposure of males to infections: males are more exposed to infection because most of them are involved in activities, such as farming practices (Fuseini *et al*, 2009), that involve coming into contact with the reservoirs of infection. Likewise malaria infection was also higher in males than in females probably due to the same factors as stated above and also due to a higher night activity by men than by females. Males within the study area could be seen most of the time outdoors during the night and also, due to the provision of free insecticide treated mosquito nets to pregnant women within the district, most of them (women) sleep under insecticide treated nets.

Nevertheless, females had a high intensity of infection with malaria than males probably due to being compromised in one way or the other (i.e females on monthly basis loss blood periodically consequently resulting in haemoglobin reduction) thus this among other factors renders adolescent girls vulnerable to infections of which malaria is no exception. In many sub-Saharan African settings, adolescents are often parasitaemic and anaemic when they first become pregnant. According to data from Malawi, both non-pregnant and pregnant adolescent girls had significantly higher parasite rates than women over 19 years of age (www. WHO.int/gender/documents/gender health malaria. pdf).

On the other hand, infection with hookworm was higher prevalence in females than in males. Hookworm larvae live mostly in the upper half-inch of the soil (Cheesbrough, 2005) and women are mostly involved in activities that predispose them to infection. For instance most women in the study area were responsible for either planting or sowing (the men are responsible for clearing of the farm area and weeding, with the women active during planting and harvesting), therefore hookworm is able to infect them either through penetration of their feet by the larvae since it was observed most of them worked bare footed.

The prevalence of *S. mansoni* by community basis was highest in Yogbania/Yigbwania (27.27%) followed by Kwarania (16.90%) with the least value recorded in Bonia, however Bonia recorded the highest prevalence of *S. haematobium* followed by Kwarania (2.60%), with Gia reporting of no infection at all. These prevalence rates could be attributed to the fact that most of the inhabitants of these communities have their homes close to the canals and it was therefore observed that most of them bath in these canals especially during hot afternoons; some wash their clothes in the canals, etc. In Yigbwania/Yogbania for instance it was observed that some of the houses were less than 50m away from the canal. Gia did not report of any infection with urinary schistosomiasis but had a prevalence of 15.00% for intestinal schistosomiasis. This however, does not mean that inhabitants of Gia are free from urinary schistosomiasis with the following reasons: a very low general trend of urinary schistosomiasis prevalence across the five communities was observed, due the random sampling technique used infected persons may have not been captured at the time of this project, the main reservoir of the dam is found in this community, however, it was observed that the houses of members of this community were far away from the dam compared to that observed for Kwarania and Yogbania/Yigbwania which were very close to the canals. Members of this community were mostly fishermen and it was not common to see people bathing in the dam as reported earlier for the other communities, thus a contributing factor to the lesser rate of infection. Information gathered from the district assembly members of these communities indicated that there were no toilet facilities for members of the various communities, hence they resort to open defecation which could easily be washed into the various water bodies when it rained, contaminating waters which became sources of infection.. Hookworm infection was recorded in only two of the study communities (Bonia and Gaani). Yogbania/Yigbwania, Bonia and Gaani are all serviced by the same canal. Although hookworm infection is soil- transmitted, the pattern of infection suggested that the high hookworm load reported in Bonia (3.08%) could have been a wash off into the canal from the adjacent land upstream (Refer to Figure 3.2), and carried downstream and serving as a means of infection for the other communities that make use of the canal. This deduction is made from the fact that Yogbania/Yigbwania (upstream) did not report any infection and Bonia had the highest prevalence of hookworm infection. Majority (92.19%) of the participants reported that they use water from the dam and its canal system for most of their activities, namely, bathing, washing etc, with 97.90% of them using the water for bathing and therefore pre-disposing them to infections.

About seventy-nine percent (78.90%) of the inhabitants have daily contact with the water in the dam and the canal, (with 60.86% saying they often have contact with the water) thus a cycle of infection is created. Seven different occupational groups were identified as reported earlier. Of these, interestingly, rice farmers reported no infection with any of the four parasites identified. Although one would expect that since they (and fishermen) were mostly in daily contact with the dam and irrigation canals they should at least have a high infection with schistosomiasis. The absence of infection in this occupational group could, however, be attributed to the fact that the rice farmers have a higher annual income as compared to the other occupational groups, therefore with this higher economic status they are able to afford medical care or employ preventive methods, such as protective gear (eg. Wellington boots or insecticide treated mosquito nets). The category of farmers named "other farmers" who are mostly vegetable and crop farmers recorded infections the four parasites identified in the study area, with the highest prevalence of *S. mansoni* found in this occupational group (66.67%). The annual income of this group of farmers is low compared to the rice farmers; observation of their farming practices showed that the use of protective gear, such as Wellington boots, was low with these farmers. These factors probably exposed them to the infections. The highest prevalence of malaria was found among students; this could be attributed to the fact that they have more night activity than the other occupational groups for example, staying awake to study either at home or in school, the biting pattern of the female *Anopheles* mosquito is mostly in the night (Cheesbrough, 2005). The study population within the age groups 26-35 and 36-45 respectively, had the highest and second highest prevalence of *S. mansoni* probably due to the fact that most people within these age groups are farmers who therefore were highly exposed to the reservoirs of infection.

It was however observed that infection with schistosomiasis occured in all the age groups probably because they all have contact with the irrigational facility in one way or the other and for various purposes by virtue of their location and/or occupation. However, the age groups 5-15 and 16-25 gave the highest and second highest prevalence of malaria infection respectively, this could be due to the fact that malaria infection tends to be higher in children than in adults in whom there might be development of partial immunity to the infection. The precise rate and age at which immunity is acquired is exposure- dependent, but in areas of stable transmission infections in adulthood are generally low (Brooker *et al*, 2007).

Multiple parasitism was recorded in only six (1.80%) of the total study population, haemoglobin (Hb) levels for these six subjects were determined. The lowest Hb value of 6.6g/dl was recorded in a female infected with both malaria and *S. mansoni*. Haemolysis of the red blood cells is a phenomenon associated with malaria infection as well as blood loss due to schistosomiasis infection, thus, these two have a combined effect on the Hb level therefore this might be the reason for the low Hb value; which is far below the minimum value of 12.1 g/dl for females (Cheesbrough, 2005). Apart from two out of the six people with multiple parasitism, all other study subjects had Hb values below the lower limit for their respective sexes.

Multiple parasitism has multi faceted influence on a person's immunity which includes reduction in the Hb level either due to haemolysis of the RBCs or reduction in the plasma iron concentration and also direct loss of blood (Brooker *et al*, 2007). Statistically (T-test) analysis showed that there was no significant relationship between Hb levels and each single infection. Hence there could be other factors such as nutrition and general health, which could have effect on participant Hb levels as well as the multiple parasitic infections identified. P-values were all greater than 0.05; ie ;0.563, 0.0871, 0.19 with the exception 0.0164 respectively for malaria, *S. heamatobium*, *S. mansoni* and hookworm infections. Which implied that hookworm (p: 0.0164) infection in the community had an infection had a significant impact on Hb levels.

From the questionnaires administered, many of the participants (30.33%) knew about the causes of schistosomiasis infection, rightfully saying that it was acquired by coming into contact with contaminated water, but it was interesting to note that the preferred choice for reduction of infection was to boil the water before use. Twenty-nine (8.71%) of the respondents said they have had infection with the disease before and twenty-three (6.91%) said they have not had the infection. It is, however, assuring to note that forty-six (13.81%) of the study population sought medical attention from hospitals as and when they were infected; thirteen (3.90%) resorted to self-medication and ten (3.00%) of them sought help from herbalists; the use of herbal drugs have been rumored to have therapeutic effects on the infection but their efficacies and doses have not been documented and therefore is unreliable in the treatment of this disease. It came to light through the focused discussion with the health officials that the annual national pilot de-worming exercise only covered children in schools and not the entire irrigated community. Thus it was not surprising to come across these parasitic infections still persistent even in, some pupils since the adults and other non school going age children in same community were not catered for during the de-worming exercise. Hens serving as a source for re-infection to occur (Oomen *et al*.,1988).

CHAPTER SIX

CONCLUSION

Human infection with various helminth species specifically, hookworm, *Schistosoma sp and the* protozoan parasites causing malaria *Plasmodium spp,* still remain a major health issue in the Tono Irrigational area. Malaria prevalence, however, was lower than those of helminth infections identified. The incidence of multiple infections was low, with an accompanying reduction in the Hb levels of some of the individuals with this phenomenon. T-test analysis showed that sex and age had no influence on the various infections recorded in the irrigational communities. The absence of hookworm in the three communities (Yigbwania Yogbanina, Gia, and Kwarania) but present in Bonia and Gaani could be attributed to runoffs from the hookworm infested soil into the canal that links these two communities.

The levels of Hb of individuals were not affected by single infections probably due to improved income and good nutrition from the occupational activities of the irrigational facilities generated. Apart from the significant relationship that occurred between *S. mansoni* and *S. haematobium* probably due to the fact that the intermediate hosts for both species of parasites inhabit the same kind of micro-habitat as well as the similar mode of infection and life cycle by both parasites, the other parasitic infections had no significant relationship.

Factors such as proximity and occupational contact with the canal and dam water by the inhabitants and lack of knowledge and prevention of these parasitic infections (helminthes) among others may be the major reasons for such rates of infections recorded in this study.

RECOMMENDATIONS

On the basis of the persistence and widespread distribution of the helminth species due to the presence of irrigational system, it is recommended that:

1. a de-worming exercise be carried out, not only for school children but also for all the community members (adults and other children not in school) who may act as reservoirs of infection to prevent re-infection.
2. measures should be put in place to ensure sensitization and awareness creation before de-worming exercises are carried out judiciously.
3. a more detailed study be carried out to find out the snail intermediate host responsible for schistosomiasis infection in the study area and then the adoption of measures to control these vectors/intermediate hosts.

4. construction of latrine facilities and supply of safe water and inculcation of proper behavior in the use of available water facilities through education is necessary especially for those close to the irrigation facility to prevent contamination of the water with feacal matter that might act as a means of infection, and
5. to further reduce or eradicate the incidence of malaria, insecticide treated mosquito nets be made available either at a subsidized price or for free to the communities close to the irrigational facility.

REFERENCES

Adrienne, E., Edridah, M., Jennifer, K., Clarkea, K., Pascal, M., Annette, O., Narcis, B., Kabatereineb, R. and Simon, B. (2005): Epidemiology of helminth infection and their relationship to clinical malaria in Southwest Uganda**.** *Trans R Soc Trop Med Hyg*. **99:18-24**.

Akhwale, W.S., Lum, J.K., Kaneko, A., Eto, H., Obonyo, C., Bjorkman, A. and Kobayakawa, T. (2004). :Anemia and malaria at different altitudes in the western highlands of Kenya**.** *Acta Trop* **91:167-175**.

Appawu, M., Owusu-Agyei, S., Dadzie, S., Asoala, V., Anto, F., Koram, K., Rogers, W., Nkrumah, FN., Hoffman, S.L. and Fryauff, D. (2004). Malaria transmission dynamics at a site in northern Ghana. *Trop. Med. Int.Health*. **9 (1): 1-7.**

Benjelloun, S., Rogers, B.L. and Berrada M. (2002). Impacts 4conomiques, alimentaireset nutritionnels des projets de d4veloppement agricole: le cas du projet de irrigationdu Loukkos au Maroc. *Cahiers Agricultures* **11:45-50**.

Berkoff, J. (1994). A strategy for managing water in the Middle East and North Africa.Directions in Development Series. World Bank, Washington, DC, USA.

Bethony, J., Brooker, S. and Albonico, M. (2006). Soil-transmitted helminth infections: ascariasis, trichuriasis, and hookworm. *Lancet* **367, 1521-1532**.

Binka, F & Akweongo, P. (2006). Prevention of malaria using ITNs: potential for achieving the millennium development goals. *Current molecular medicine* **6, 261-267**.

Binka, F.N., Morris, S.S., Ross, D.A., Arthur, P. and Aryeetey, M.E. (1994). Patterns of malaria morbidity and mortality in children in Northern Ghana. *Transactions of the Royal Society of Tropical Medicine and Hygiene*. **88: 381-385.**

Binka, F.N., Ngom, P., Philips, J.F., Adazu, K. and Macleod, B.B. (1999). Assessing Population Dynamics in a rural African Society: The Navrongo Demographic Surveillance System. *Jour. Biosoc. Sci***. 31: 375-391.**

Boelee, E. (2003). Malaria in irrigated agriculture (Paludisme et le agriculture irrigue).*Irrigation and Drainage* **52:65-69.**

Boelee, E. and Madsen, H. (2006). Irrigation and schistosomiasis in Africa: Ecological aspects. IWMI Research Report 99. Colombo, Sri Lanka: International Water Management Institute.

Boelee, E.; Koné, A. n.d. Health impacts of small reservoirs in Burkina Faso. *IWMI Working Paper*.Forthcoming. Cited by McCartney et al 2007.

Bolton, P.(1992). Environmental and health aspects of irrigation. OD/P 116, *HydraulicsResearch*. Wallingford, UK.

Bosompem, K. M., Bentum, I. A., Otchere, J., Anyan, W. K., Brown, C. A., Osada, Y., Takeo, S., Kojima, S. and Ohta, N. (2004). Infant schistosomiasis in Ghana: a survey in an irrigation community. *Tropical Medicine and International Health* **9 (8), 917-922.**

Bosompem, K.M., Ayi, I., Anyam, W.K., Nkrumah, F.K. and Kojimas., M. (1996). Limited field evaluation of a rapid monoclonal antibody based dipstick assay for urinary schistosomiasis. *Hybridoma*. **15: 443-447**.

Bradley, D. (1995). Malaria's link with water resources development. *ODU Bulletin* **32:446**.

Breman, J. G. (2001). The ears of the hippopotamus: manifestations, determinants, andestimates of the malaria burden. *Am J Trop Med Hyg*, **64**, 1-11.

Briand, V., Watier, L., Le Hesran, J.Y., Garcia, A. and Cot, M. (2005). Coinfection withPlasmodium falciparum and Schistosoma haematobium: protective effect of schistosomiasis on malaria in senegalese children? *Am J Trop Med Hyg* **72(6): 702–7.**

Brooker, S. (2007). Spatial epidemiology of human schistosomiasis in Africa: risk models, transmission dynamics and control. *Trans R Soc Trop Med Hyg* **101: 1–8**.

Brooker, S., Clements, A.C.A., Hote, P.J., Hay, S.I., Tatem, A.J., Bundy, D.A. and Snow, R. (2006). Co-infection with hookworm and malaria is associated with lower haemoglobin levels and is common among African school children**.** *PLoS Med*.**74:258-271**.

Brooker, S., Guyatt, H., Omumbo, J., Shretta, R., Drake, L. and Ouma, J. (2000). Situation Analysis of Malaria in School-aged Children in Kenya - What Can Be Done**?** *Parasitology Today*. **16(5):183-185**.

Brooker,S., Michael, E. (2000). The potential of geographical information systems and remote sensing in the epidemiology and the control of human helminth infections. *Advances in Parasitology***. 47: 245-287**.

Bundy, D.A.P., Chan, M.S., Medley. G.F., Jamison, D. and Savioli, L. (2000). Intestinal nematode infections. In Health Priorities and Burden of Disease Analysis: Methods and Application from Global, National and Sub-National Studies. Cambridge, USA, *Harvard University Press for the WHO and World Bank (in Press).*

Cecchi, P. n.d. Des petits barrages du nord de la Côte d'Ivoire : Des milieux et des hommes. *Editions IRD.In press.*Cited by McCartney et al., 2007.

Cairncross, S. and Feachem, R.G. (1993). Environmental health engineering in the tropics. An introductory text. Second edition, Wiley and Sons, Chichester, UK.

Chan, M.S. (1997). The global burden of intestinal nematode infections- Fifty years on. *Parasitology Today* **13: 438-443**.

Cheesbrough, M. (2005). District Laboratory practice in Tropical Countries part 1. Second edition. Cambridge University press. **184-251.**

Chero., J.C., Saito., M., Bustos, J.A. *et al.* (2007). "*Hymenolepis nana* infection: symptoms and response to nitazoxanide in field conditions". *Trans R Soc Trop Med Hyg* **101 (2): 203–5.**

Chimbari, M.J., Ndhlovu, P;D., Ndlela, B.,Shamu, S., Chandiwana, S.K. and Mapira, W. (2001). Schistosomiasis control measures for small irrigation schemes in Zimbabwe. Evaluation of Mushandike Irrigation Scheme. Report 323(1). Harare, Zimbabwe: Blair Research Laboratory.

Chippaux., J. P., ed. (2000). *La lutte contre les schistosomoses en Afrique de l'Ouest*. Communications présentées à l'atelier sur les difficultées rencontrées dans la mise en oeuvre des programmes de lutte contre les schistosomoses en Afrique de l'Ouest, Niamey-Cermes, 15-18 février 2000. Éditions IRD, Institut de Recherche pour le Développement, Collection Colloques et séminaires, Paris.

Chitchang, S., Plamjinda, T., Yodmani, B., Radomyos, P. (1985). "Relationship between sverity of the symptom and the number of *Hymenolepis nana* after treatment". *J Med Assoc Thai* **68 (8): 423–26**.

Chitsulo, L., Engels, D., Montresor, A., Savioli, L. (2000). The global status of schistosomiasis and its control. *Acta Tropica* **77: 41-51.**

Crawley, J. (2004). Reducing the burden of anaemia in infants and young children in malaria-endemic countries of Africa: from evidences to action**.** *Am J Trop Med Hyg*, **71:25-34**

Crompton, D.W.T. and Nesheim, M.C. (2002). Nutritional impact of intestinal helminthiasis during the human life cycle. *Annu. Rev. Nutr.* **22: 35-59**.

Damaree Jr., R.S. and William, C. M. (1985). Parasitology. Macmillam, Publishing Company, New York**, 224-226**

Davis, A. (2003.) Schistosomiasis. In 'Manson's Tropical Diseases'. (Eds GC Cook & AI Zumla) (Elsevier Science Limited: London, UK). **1431-1463**.

De Clercq, D., Sacko, M., Behnke, J.M., Traore, M. and Vercruysse, J. (1995). *Schistosoma* and geohelminth infections in Mali, West Africa. *Annales de la societe Belge de Medicine Tropicale*. **75: 191-199.**

de Silva N.R., Brooke,r S., Hotez, P.J., Montreso,r A., Engels, D. and Savioli, L. (2003) Soil-transmitted helminth infections: updating the global picture. *Trends in Parasitology*. **19:547–551.**

Develoux, M., Mouchet, F. and Labo, R. (1986). Gastrointestinal parasites in school children in Niger, *Bulletin de la Societe de Pathologie Exotique et de ses Filiates*. **79(4): 571-575.**

Dorris, M., Viney, M.E. and Blaxter, M.L. (2002). Molecular phylogenetic analysis of the genus *Strongyloides* and related nematodes. *Int J Parasitol* **32(12):1507-17**.

Druilhe, P., Tall, A. and Sokhna, C. (2005.) Worms can worsen malaria: towards a newmeans to roll back malaria? *Trends in Parasitology* **21(8): 359–62**.

Egwunyenga, A.O., Ajayi, J.A., Nmorsi, O.P.G. and Duhlinska-Popova, D.D. (2001) *Plasmodium* intestinal helminth Co- infections among pregnant Nigerian Women**.** *Mem inst Oswaldo Cruz Rio de Janeiro.* 96(8):1055-1059.

Egwunyenga, O.A., Ajayi, J.A., Duhlinska-Popova D.D. and Nmorsi, O.P.G. (1997). Transplacental passage of *Plasmodium falciparum* and seroevaluation of newborns in Northern Nigeria. *South Eastern Asia Journal of Tropical Medicine and Public Health*. **28: 741-745**.

Egwunyenga, O.A., Ajayi, J.A., Duhlinska-Popova, D.D. and Nmorsi O.P.G (1996). Malaria infection of the cord and birth weight in Nigerians. *Afr. J. Med*. **42:265-268**.

Erlanger, T.E., Keiser, J., Caldas De Castro, M., Bos, R., Singer., B.H., Tanner, M. and Utzinger, J.(2005). Effect of water resource development and management on lymphatic filariasis, and estimates of populations at risk. *American Journal of Tropical Medicine and Hygiene* **73: 523-533.**

Ersado, L. (2005). Small-scale irrigation dams, agricultural production and health: Theory and evidence for Ethiopia. *World Bank Policy Research Working Paper 3494*. Washington, D.C.: World Bank.

Fuseini, G.., Edoh, D.., Kalifa, G.B. and Knight, D. (2009). Plasmodium and intestinal helminthes distribution among pregnant women in the Kassena-Nankana District of Northern Ghana. *Journal of Entomology and Nematology*.**1(2) 19-24**.

Garba, A., Toure, S., Dembele, R., Bosque-Oliva, E. and Fenwick, A. (2006). Implementation of national schistosomiasis control programmes in West Africa. *Trends in Parasitology* **22, 322-326.**

Ghebreyesus, T.A., Haile M., Witten K.H., Getachew, A., Yohannes, A.M., Yohannes, M., eklehaimanot, H.D., Lindsay, S.W. and Byass, P. (1999). Incidence of malaria among children living near dams in northern Ethiopia: Community based incidence survey. *British Medical Journal* **319:663-666**.

Gilles, H.M. (2003). Soil-transmitted helminths (geohelminths). In 'Manson's Tropical Diseases'. (Eds GC Cook & AI Zumla). (*Elsevier Science Limited: London, UK*). **1527-1553**.

Gratz, N.G. (1988). The impact of rice production on vector-borne disease problems in developing countries. In: Vector-borne disease control in humans through rice agro-ecosystem management. Proceedings of the workshop on research and training needs in the field of integrated vector-borne disease control in rice land agro-ecosystems of developing countries. *IRRI (International Rice Research Institute), Los Ba4os, The Philippines*. **7412.**

Gryseels, B. (2000). Schistosomiasis vaccines: A devils' advocate view. *Parasitology Today***. 16 (2): 46-48.**

Gryseels, B., Polman, K., Clerinx, J. and Kestens L. (2006). Human schistosomiasis. *Lancet.* **368 1106-1118.**

Guinovart, C., Navia, M.M., Tanner, M. and Alonso, P.L. (2006). Malaria: burden of disease. *Current Molecular Medicine***. 6 :137-140**.

Hagan, P., Appleton, C.C., Coles, G.C., Kusel, J.R. and Tchuem-Tchuenté, L.A.(2004). Schistosomiasis control: Keep taking the tablets. *Trends in Parasitology***. 20 (2): 92-97**.

Hagan, P.; Doenhoff, M.J.; Wilson, R.A.; Al-Sherbiny, M. and Bergquist, R.(2000). Schistosomiasis vaccines: A response to a devils' advocate's view. *Parasitology Today*. **16 (8): 322-323.**

Harmancioğlu, N., Alpaslan, N. and Boelee, E. (2001). Irrigation, health and the environment: A review of literature from Turkey. *IWMI Working Paper 6*. IWMI (International Water Management Institute), Colombo, Sri Lanka.

Hartgers, F.C., Obeng, B.B., Boakye, D. and Yazdanbakhsh, M. (2008) Immune responses during helminth-malaria co-infection: a pilot study in Ghanaian school children. *Parasitology Today* **135(7): 855–60**.

Heathcote, I.W. (1998). Integrated watershed management. Principles and practice. John Wiley and Sons Inc, New York, USA.

Helmby, H., Kullberg, M. and Troye-Blomberg, M. (1998). Altered immune responses in mice with concomitant *Schistosoma mansoni* and *Plasmodium chabaudi* infections. *Infect Immun* ***66:*****5167–5174**

Holland, C.V., Taren, D.L. and Crompton, D.W.T. (1988). Intestinal helminthiasis in relation to the socioeconomic environment of Panamanian children. *Social Science and Medicine*. **26: 209-213.**

Horton, J. (2003) Human gastrointestinal helminth infections: are they neglected diseases? *Trends in Parasitology.* **19: 527-531.**

Hotez, J.P., Molyneux, D.H., Fenwick, A., Ottesen, E., Sachs, S.E. and Sachs, J.D. (2006). Incorporating a rapid-impact package for neglected tropical diseases with programs for HIV/AIDs, Tuberculosis and Malaria**.** *PLoS Medicine.* 3**(5)**:**001-009**.

Hotez, P.J., Bethony, J., Bottazzi, M.E., Brooker. S., Diemert, D. and Loukas, A. (2006) New technologies for the control of human hookworm infection. *Trends in Parasitology***. 22: 327-331**.

Hotez, P.J., Brooker, S., Bethony, J.M., Bottazzi, M.E., Loukas, A. and Xiao, S. (2004). Hookworm infection. *New England Journal of Medicine*. **351: 799-807**.

http://edoc.unibas.ch/805/1/DissB_8408.pdf. October 2012, 11:01am.

http://en.wikipedia.org/wiki/Schistosomiasis. October 2012, 11:01am.

http://www.rapidtest.ca/guides.shtml October 2012, 11:01am.

Hunte,r J.M., Rey, L., Chu, K.Y., Adekolu-John, E.O. and Mott, K.E. (1993). Parasitic diseases in water resources development. The need for intersectoral negotiation. WHO (World Health Organization), Geneva, Switzerland.

Hunter, J.M. (2003). Inherited burden of disease: agricultural dams and the persistence of bloody urine (Schistosomiasis hematobium) in the Upper East Region of Ghana, 1959-1997. *Social Science and Medicine* **56(2): 219-234**.

Iarotski, L.S and Davis, A. (1981). The schistosomiasis problem in the world; results of a WHO questionnaire survey. *Bulletin of the World Health Organization 59*: **115-127**

Ijumba, J.N. and Lindsay, S.W. (2001). Impact of irrigation on malaria in Africa: Paddies paradox. *Medical and Veterinary Entomology*. **15:1411**.

Jilly, P. (1969). Anaemia in parturient women, with special reference to malaria infection of the placenta. *Ann. Trop. Med. Parasitol***. 63:109-116.**

Jobin, W. (1999). Dams and disease. Ecological design and health impacts of large dams, canals and irrigation systems.: E & FN Spon. London and New York.

Jones, W. J. (1967). Introduction to Parasitology. Addison-Wesley Publishing Company, Reading, Massachusetts. **2-50.**

Kabatereine, N.B., Fleming, F.M., Nyandindi, U., Mwanza, J.C. and Blair, L. (2006). The control of schistosomiasis and soil-transmitted helminths in East Africa. *Trends in Parasitology*. **22: 332-339.**

Kabatereine, N.B., Tukahebwa, E.M, Brooker, S., Alderman, H. and Hall, A. (2001). The epidemiology of intestinal helminth infections among schoolchildren in 18 districts of southern Uganda. *East Africa Medical Journal* **78:283-286**.

Keiser, J., N'Goran, E.K., Traore, M., Lohourignon, K.L., Singe, R.B.H., Lengeler, C., Tanner, M. and Utzinger, J. (2002). Polyparasitism with *Schistosoma mansoni*, geohelminths, and intestinal protozoa in rural Côte d'Ivoire**.** *J Parasitol*. **88:461-466**

Keiser, J., Utzinger, J., Tanner, M., de Castro, C.M., Singer, B.H., Maltese, M.F., Bos, R., Bartram, J. and Hall, L. (2005). The Effect Of Irrigation And Large Dams On The Burden Of Malaria On Global And Regional Scale. *American Journal of Tropical Medicine and Hygiene* ***72(4)*****: 392-406.**

Keiser, J.; Maltese, M.F.; Erlanger, T.E.; Bos, R.; Tanner, M.; Singer, B.H. and Utzinger, J. (2005). Effect of irrigated rice agriculture on Japanese encephalitis, including challenges and opportunities for integrated vector management. *Acta Tropica* **95: 40-57.**

King SE. and Mascie-Taylor, C.G. (2004). *Strongyloides fuelleborni kellyi* and other intestinal helminths in children from Papua New Guinea: associations with nutritional status and socioeconomic factors. *P N G Med J*: **47(3-4):181-91.**

King, C. (2004). Re-gauging the cost of chronic helminthic infection: meta-analysis of disability- related outcomes in endemic shistosomiasis. *Lancet*. **368: 1106-1118**.

King, C.H., Dickman, K. and Tisch, D.J. (2005). Reassessment of the cost of chronic helminthic infection: a meta-analysis of disability-related outcomes in endemic schistosomiasis. *Lancet* **365, 1561-1569.**

Kirsten, E., Alassane, D., Abdoulaye, D., Lansana, S., Abdoulaye, K., Drissa, C., Ando. G., Karim, T., Modibo, D., Issa, D., Marcelo, B., Christopher, V. and Ogobara K. (2005). Association of *Schistosoma haematobium* infection with protection against acute *Plasmodium falciparum* malaria in malaria children**.** *Am J Trop Med Hyg*. **73(6):1124-1130**

Kloos, H., Lemma, A., Kibru, B., Gebre, A., Mazengia, B., Feleke, G. and DeSole, G. (1980). Intestinal Parasitism in migrant farm labour populations in the Awash Valley, Ethiopia, and in major labour source areas. *Ethiop. Med .J*. **18: 52-61.**

Koram, K.A., Bennet, S., Adiamah, J.H. and Greenwood, B.M. (1995). Socioeconomic determinants are not major risk factors for severe malaria in Gambian children. *Transaction of the Royal Society of Tropical Medicine and Hygiene*. **89: 151-154.**

Koram, K.A., Owusu-Agyei, S. and Fryauff, D.J. (2003). Seasonal profiles of malaria infection, anemia and bed net use among age groups and communities in northern Ghana. *J. Trop. Med. Hyg***. 8(9) 793-802.**

Kranjac-Berisavljevic, G. and Cofie, O. (2004). *Comparison* of formal and informal agricultural water developmentusing selected environmental and social indicators, in Ghana. Case Study Report for Collaborative Program on Investments in Agricultural Water Management in Sub Saharan Africa: Diagnosis of Trends and Opportunities. Accra, Ghana: *International Water Management Institute.*

Le Guen, T. (2000). Aménagements hydro-agro-pastoraux dans la zone soudanienne du Nord de la Côte d'Ivoire et leur impact sur la santé: le cas des schistosomiases. *Cahiers Agriculture* **9(5): 432.**

Lo,C.T., Kloos,H. and Hailu, B. (1988). Schistosomiasis. In: *The Ecology of Health and Diseasein Ethiopia*, Zein Ahmed and Kloos, H. (editors). Addis Ababa: *EMPDA Press*:**196- 207.**

Lopez, A.D. and Mathers, C.D. (2006). Measuring the global burden of disease and epidemiological transitions: 2002-2030. *Annals of Tropical Medicine and Parasitology.* **100: 481 499.**

McCartney, M. P.; Boelee, E.; Cofie, O.; Mutero, C. M. (2007). *Minimizing the negative environmental and health impacts of agricultural water resources development in sub-Saharan Africa.* Colombo, Sri Lanka: International Water Management Institute. **41** pp. (Working Paper **117**)

Magambo, J.K., Zeyhle, E. and Wachira, T.M. (1998). Prevalence of intestinal parasites among children in Southern Sudan. *East Afr. Med. J*. **75(5): 288-290.**

Mahfouz, A.A.R., El-Morshedy, H., Farghaly, A. and Khalil A. (1997). Ecological determinants of intestinal parasitic infections among pre- school children in an urban squatter settlement of Egypt. *J. Trop. Pediatr*.**43: 341-344**.

Malaria: Disease Impacts and Long-Run Income Differences" (PDF). Institute for the Study of Labor. http://ftp.iza.org/dp2997.pdf. Retrieved 2008-12-10.ref3

Mangali, A., Sasabone, P. and Abadi, K. (1994). Prevalence of intestinal helmithic infections in Kao District, North Italmahera, Indonesia. *South East Asian Journal of Tropical Medicine and Public Health*. **25: 737- 744.**

Markell, E.K. and Voge, M.(1971). *Medical Parasitology*.3rd Ed. W.B. Sounders Company. Philadelphia London. Toronto. **171-173**.

Mathieu, N. (2002) Worms and malaria; noisy nuisances and silent benefits**.** *Parasite Immunol*. **24(7):391-401**.

Mazengia, B., Feleke, G. and DeSole, G. **(1980).** Intestinal Parasitism in migrant farm labour populations in irrigation schemes in the Awash Valley, Ethiopia, and in major labour source areas. *Ethiop. Med .J*. **18: 52-61**.

McCarthy FD, Wolf H & Wu Y (2000) Malaria and growth. World Bank. Public Economics, Washington DC, USA.

McGregor, I.A, Wilson, M.E. and Billewicz, W.Z. (1983). Malaria infection of the placenta in the Gambia, West Africa, its incidence and relationship to stillbirth, birth weights and placenta weights. *Transaction of the Royal Society of Tropical Medicine*.**77: 232-244**.

Midzi N, Mtapuri-Zinyowera, S., Sangwemec, D.,Paul.H.N., Makawre.G., Mapingure, M.P., Brouwer C.K., Mudzori, J., Hlerema, G., Chadukura.v., Mutapi. F., Kumar, N. and Mduluza, T. (2011). Efficacy of intergrated school de-worming and prompt malaria treatment on helminthes-plasmodium falciparum co-infections: A 33 months follow up study. BMC international Health and Human Rights.,11:9

Midzi N, Mtapuri-Zinyowera, S., Sangwemec, D., Chirehwa, M.T., Mapingure, M.P., Mudzori, J., Hlerema, G., Mutapi. F., Kumar, N. and Mduluza, T. (2010). Consequences of polyparasitism on anaemia among primary school children in Zimbabwe. *Acta Tropica.*

Molyneux, D.H., Hotez, P.J. and Fenwick, A. (2005). "Rapid-impact interventions": How a policy of integrated control for Africa's neglected tropical diseases could benefit the poor. *PLoS Med.* **2:336.**

Mott, K.E. (1984). Schistosomiasis: A primary health care approach. *World Health Forum* **5: 221-225.**

Nacher, M., Singhasivanon, P., Silachamroon, U., Treeprasertsuk, S., Vannaphan, S., Traore, B., Gay, F. and Looareesuwan, S. (2001). Helminth infections are associated with protection from malariarelated acute renal failure and jaundice in Thailand. *Am J Trop Med Hyg***. 65: 834–836**.

Ndamba, J., Makaza, N., Munjoma, M., Gomo, E. and Kaondera, K.C. (1993). The physical fitness and work performance of agricultural workers infected with *Schistosoma mansoni* in Zimbabwe**.** *Ann Trop Med Parasitol***. 87(6):553-61**.

Nokes, C. and Bundy, D.A.P. (1993). Compliance and absenteeism in school children: implications for helminth control**.** *Trans R Soc Trop Med Hyg* **87:148-152.**

Nokes, C., Cooper, E.S., Robinson, B.A. and Bundy, D.A.P. (1991). Geohelminth infection and academic assessment in Jamaican children**.** *Trans R Soc Trop Med Hyg* **85:272-273**

Nokes, C., Mcgarvey, S.T., Shiue, I., Wu, G., Wu, H., Bundy, D.A.P. and Olds, G.R. (1999). Evidence for an improvement in cognitive function following treatment of *Schistosoma japonicum* infection in Chinese primary school children**.** *Am J Trop Med Hyg* **60(4):556-565**.

Oomen, J.M.V., de Wolf, J. and Jobin, W.R. (1988). Health and irrigation. Incorporation of disease-control measures in irrigation, a multi-faceted task in design, construction, operation. Volume 2. ILRI Publication 45. ILRI (International Institute for Land Reclamation and Improvement), Wageningen, The Netherlands.

Oomen, J.M.V., de Wolf, J. and Jobin, W.R. (1990). Health and irrigation. Incorporation of disease-control measures in irrigation, a multi-faceted task in design, construction, operation. Volume 1. ILRI Publication 45. ILRI (International Institute for Land Reclamation and Improvement), Wageningen, The Netherlands.

Ortiz JJ, Favennec L, Chegne NL, and Gargala, G. (2002). "Comparative clinical studis of nitazoxanide, albendazole and praziquantel in the treatment of ascariasis, trichuriasis, and hymenolepiasis in children from Peru". *Trans R Soc Trop med Hyg* **96 (2): 193–96.**

Parent G., Zagr4 N-M., Ou4draogo A. and Guiguemb4 R.T. (2002a). Les grands hydroam 4nagements au Burkina Faso contribuent-ils 4 l4am4lioration des situationsnutritionelles des enfants? *Cahiers Agricultures* 11:51457.

Parent, G., Poda, J-N., Zagr4, N-M., de Plaen, R. and Courade G.(2002b). Irrigation, sant4 et s4curit4 alimentaire en Afrique: quels liens*? Cahiers Agricultures* **11:9415**.

Paris. Hunter, J.M.(2003). Inherited burden of disease: agricultural dams and the persistence of bloody urine (Schistosomiasis hematobium) in the Upper East Region of Ghana, 1959-1997**.** *Social Science and Medicine* **56(2): 219-234.**

Partnership for Child Development**:** Heavy schistosomiasis associated with poor short-term memory and slower reaction times in Tanzanian school children**.** *Trop Med Int Health* 2002, 7**(2)**:**104-117.**

Poda, J.N., Sondo, B.and Parent, G. (2003). Influence des hydro-aménagements sur la distribution des bilharzioses et de leur hôtes intermédiaires au Burkina Faso. *Cahiers Santé* **13: 49-53.** Cited by McCartney et al., 2007.

Poda, J.-N. and Traoré, A. (2000). Situation des schistosomoses au Burkina Fason. In: *La lutte contre lesschistosomoses en Afrique de l'Ouest*, ed. Chippaux, J.-P. Communications présentées à l'atelier sur lesdifficultés rencontrées dans la mise en oeuvre des programmes de lutte contre les schistosomoses enAfrique de l'Ouest, Niamey-Cermes, 15-18 février 2000. Éditions IRD, Institut de Recherche pour le Développement, Collection Colloques et séminaires, Paris. Cited by McCartney et al., 2007.

Ridley, D. S. and Hawgood, B.C (1956) The Value Of Formol-ether Concentration of faecal cysts and ova. *J Clin. Pathol (9)* **pp 74**

Ripert, C.L. and Raccurt, C.P. (1987). The impact of small dams on parasitic diseases in Cameroon. *Parasitology Today***. 3(9): 287-289**.

Roll Back Malaria (RBM). *Malaria Infosheet*, Geneva: Roll Back Malaria, World Health Organization. Accessed March 4, 2004 at www.rbm.who.int

Romero Cabello R, Guerrero LR, Muñóz García MR, and Geyne Cruz A (1997). "Nitazoxanide for the treatment of intestinal protozoan and helminthic infections in Mexico". *Trans. R. Soc. Trop. Med. Hyg.* **91 (6): 701–3**.

Rozendaal, J .R. (1997). Vector Control Methods for use by Individuals and Communities. Geneva, WHO. **337- 356**.

Sachs, J. and Malaney, P. (2002). The economic and social burden of malaria. *Nature* **415, 680-685.**

Safer, D., Brenes, M., Dunipace, S., and Schad, G. (2006). Urocanic acid is a major chemoattractant for the skin-penetrating parasitic nematode *Strongyloides stercoralis*. *PNAS* **104(5), 1627-1630**

Sam, E.K. (1993). *Field Survey of the impacts of water projects in Ghana.* Technical Report. CSIR. Accra,Ghana: Water Resources Research Institute.

Schantz , P.M. (1996). "Tapeworms (cestodiasis)". *Gastroenterol. Clin. North Am.* **25 (3): 637–53.**

Schellenberg, D., Abdulla, S. and Roper, C. (2006). Current issues for anti-malarial drugs to control *P. falciparum* malaria. *Current molecular medicine* **6, 253-260.**

Segarra-Newnham, M. (2007). Manifestations, diagnosis, and treatment of *Strongyloides stercoralis* infection. *Ann Pharmacother*. **41(12): 1992-2001.**

Senzanje, A., Hackenitz, E. and Chitima, M. (2002) Malaria and irrigated agriculture in Zimbabwe: impact assessment, costing and quantification under field conditions. In 'ICID 18th International Congress on Irrigation and Drainage'. Montreal. (Eds E Boelee, F Konradsen & W van der Hoek). (International Water Management Institute).

Service, M. W. (1991). Agricultural development and arthropod-borne diseases: a review. *Rev Saude Publica***, 25, 165-1**

Skerratt, L.F. (1995). *Strongyloides spearei* n. sp. (Nematoda: Strongyloididae) from the common wombat *Vombatus ursinus* (Marsupialia: Vombatidae). *Systematic Parasitology* **32:81-89.**

Smyth, J. D. and McManus, D. P. (1989). The physiology and biochemistry of cestodes. Cambridge: Cambridge University Press.

Snow, R.W., Guerra, C.A. Noor, A.M., Myint, H.Y. and Hay, S.I. (2005). The global distribution of clinical episodes of *Plasmodium falciparum* malaria. *Nature.*;**434:214–217**.

Speare, R. (1989). Identification of species of *Strongyloides*. In: Grove DI. (ed) Strongyloidiasis: a major roundworm infection of man. *Taylor & Francis: London*. **11-83**.

Steele P., Konradsen, F. and Imbulana K.A.U.S. (1997). Irrigation, health, and the environment: A literature review with examples from Sri Lanka. IIMI Discussion Paper. IIMI (International Irrigation Management Institute), Colombo, Sri Lanka.

Steinmann ,P., Keisar,J., Bos,R., Tanner, M. and Utzinger, J. (2006). Schistosomiasis and water resourses development: Systematic review,metaanalysis and Estimates of people at risk. *Lancet Infect Disease*.; **6:411-25.**

Stephenson S, Holland V, and Cooper, S. (2004): The public health significance of *Trichuris trichiura Curr Hematol Rep***. 3:97-106.**

Stephenson, L.S, Latham, M.C and Ottesen, E.A. (2000). Malnutrition and parasitic helminth infections**.** *Parasitology.* **121:23-38**.

Stephenson, L.S., Latham, M.C., Adams, E.J., Kinoti, S.N. and Pertet, A. (1993). Weight gain of Kenyan school children infected with hookworm, *Trichuris trichiura* and *Ascaris lumbricoides* is improved following once- or twice yearly treatment with albendazole**.** *J Nutr*. **123:656-665**.

Stoltzfus RJ, Chwaya HM, Tielsch JM, Schulze KJ, Albonico M. and Salvioli, L. (1997). Epidemiology of iron deficiency anaemia in Zanzibari schoolchildren: the importance of hookworms**.** *Am J Clin Nutr* **65:153-9.**

Tanji, K.K. and Kielen, N.C. (2002). Agricultural drainage water management in arid and semi-arid areas. FAO Irrigation and Drainage Paper No. 61, Rome, Italy: Food and Agricultural Organization of the United Nations (FAO). Rome.

Tchuem Tchuenté, L.A.; Southgate, V.R.; Mbaye, A.; Engels, D. and Gryseels, B. (2001). The efficacy of praziquantel against *Schistosoma mansoni* infection in Ndombo, northern Senegal. *Transactions of the Royal Society of Tropical Medicine and Hygiene*. **95: 65-66.**

Utzinger, J., Bergquist, R., Shu-Hua, X., Singer, B.H. and Tanner, M. (2003). Sustainable schistosomiasis control - the way forward. *Lancet*. **362: 1932-1934.**

Utzinger., J. and Keiser., J. (2004). Schistosomiasis and soil-transmitted helminthiasis: common drugs for treatment and control. *Expert Opinion Pharmacotherapy*. **5: 263-285**.

van der Hoek, W., Feenstra S.G. and Konradsen F.(2002). Availability of irrigation water for domestic use in Pakistan: Its impact on prevalence of diarrhoea and nutritional status of children. *Journal of Health, Population and Nutrition.* **20(1):77484**.

van der Hoek, W., Konradsen F. and Jehangir W.A. (1999). Domestic use of irrigation water: Health hazard or opportunity? *International Journal of Water Resources Development* **15:1074119**.

van der Hoek, W., Konradsen F., Ensink J.H.J., Mudasser M. and Jensen P.K.(2001). Irrigation water as a source of drinking water: Is safe use possible? *Tropical Medicine and International Health* **6:46454.**

White, N.J. (2003). Malaria. In 'Manson's Tropical Diseases'. (Eds GC Cook & AI Zumla) **pp. 1205-1295**. (Saunders: London, UK).

World Commission on Dams (2000). Tucurui Hydropower Complex Brazil, World Commission on Dams, Cape Town.

World Health Organization (WHO) (2009). World Health Organization: *World malaria report.*

World Health Organization (WHO) (2005). Deworming for health and development. WHO, Geneva, Switzerland.

World Health Organization (WHO) (2004). The world health report 2004: changing history, WHO, Geneva.

World Health Organization (WHO) (2003). The world health report 2003: shaping the future, WHO, Geneva.

World Health Organization WHO (2002). Prevention and control of schistosomiasis and soil transmitted helminthiasis. WHO Tech. Rep. Ser. No. 912, WHO, Geneva, Switzerland.

World Health Organization WHO (1997). Health and Environment in Sustainable Development, WHO, Geneva.

World Health Organization (WHO) (1994). Bench AIDS for the diagnosis of intestinal parasites. WHO, Geneva, Switzeland.

WHO & UNICEF (2003) The Africa Malaria Report 2003. WHO, Geneva, Switzerland.
World Bank & United Nations Development Programme (1990). Irrigation and Drainage Research: A Proposal, The World Bank, Washington, D.C.

Worrall, E. Basu, S. and Hanson, K. (2005) Is malaria a disease of poverty? A review of the literature. *Tropical Medicine and International Health* **10, 1047-1059**.

www.danishwaterforum.dk/.../Impact_on_water_resources_develop...Accessed October,*2012*

WWW.Whoint/gender/documents/gender-health-malaria.pdf., Accessed October, 2012

APPENDICES

APPENDIX 1

CORRELATION RESULTS

Table 4.3 Relationship between Hb levels and the parasitic infections

	Malaria	***S. haem***	***S. man***	**Other**
HB	0.0318	0.0718	-0.0939	-0.131
	0.563	0.191	0.0871	0.0164
	333	333	333	333

Table 4.4 Relationship between malaria, S. *haematobium*, *S. mansoni* and hookworm.

	S. haem	***S. man***	**Other**
Malaria	-0.0135	-0.0419	-0.0123
	0.807	0.447	0.823
	333	333	333

Table 4.5 Relationship between *S.mansoni* and hookworm.

	Other
S. mansoni	0.0520
	0.344
	333

Table 4.6 Relationship between *S. haematobium*, *S. mansoni* and hookworm

	S. mansoni	Other
S. haematobium	0.133	-0.00721
	0.0150	0.896
	333	333

APPENDIX 2

STUDIES ON MALARIA AND SCHISTOSOMIASIS CO-INFECTIONS

STD-PROJECT, KNUST

QUESTIONNAIRE

VILLAGE CODE: | | | |

Participant ID(DCHI) **Age**

- **Gender:- 1 Female 2 Male**

Residence:

1 **What is your primary occupation**

1 Farming

2 Fishing

3 Fishmonger

4 Student

5 Others (specify)

2 **Where do you get water for your daily activities?**

1} Pipe 2} Borehole 3] Well 4] Dam

3 **What do you use the water for?**

1} Washing 2}Bathing 3}Drinking 4} Fishing 5} Dry Season Farming

6 No contact at all

4 **How often do you come into contact with the water from the dam?**

1) Daily 2) Often 3) Not Often 4) Not at all

5 **How many times do you fall sick within a year?**

1) Not at all 2) Once 3) More than once 4) Countless

6 **What are some of the physical signs exhibited when you feel sick?**

1) body weakness 2) fever 3) Blood in urine 4) Others (specify)

7 **What do you do when you notice the symptom above?**

1) Self medicate 2) Herbalist 3) Hospital 4) Other(specify)

8 **Give reasons for your choice above**

1} Familiar with treatment

2}Moderate cost at the Herbalist

3}Effective treatment at hospital

4}Others(Specify)

9 **Have you been educated about malaria, its causes and control/prevent?**

1) YES

2) No

10 **Have you heard of Shistosomiasis before?** 1) YES 2) No

11 **If yes, what is Shistosomiasis (Bilharzia)**

1) Correct

2) Fairly correct

3) Wrong

12 How is the disease acquired?

1)By coming into contact with an infected person

2) By drinking contaminated water

3) By coming into contact with contaminated water

4) Don't know

13 What are the signs and symptoms of Shistosomiasis

1)fever 2)muscular and abnormal pains 3)spleen enlargement 4) urticaria 5) eosinophilia.

14. Have you been infected before? 1) YES 2) No

15 If yes how did you treat it

1) Self medication

2) Herbalist

3) Hospital

4)Choose all that apply

5) Other (please specify)

16 Reasons for choice of treatment

1) Less expensive

2)proximity

3)more reliable

4)others(specify)

17 In your own opinion how can Shistosomiasis (Bilharziasis) be controlled/prevented

1 Boiling water before use

2 Filtration of water before use

3 Avoid contact with infected persons

4 Others (Specify)

Guide for Focused Group Discussions with Herbalists

What are the most common diseases brought to you for treatment?

Do you give clients health talks on how to prevent those diseases?

Have you diagnosed and treated people suffering from malaria and bilharziasis (blood in urine or stool) before? YES/NO

If yes how was this done?

Guide for Focused Group Discussions with Health Officials

What is house hold size of these communities (irrigated community)?

Do you have hospital records of the various parasitic infections reported to your facility?

Which category of people benefit from the annual national de-worming exercise?

Is there always a public education before the commencement of the exercise?

APPENDIX 3

QUESTIONNAIRE RESPONSES.

Table 4.7 Source of water for daily activities.

Q2. **Where do you get water for your daily activities?**		
Choices	No.	
1Pipe	5	1.53%
2 Borehole	316	96.64%
3 Well	0	0.00%
4 Dam	307	93.88%

Table 4.8 Daily use of water.

Q.3 What do you use the water for?		
1 Washing	326	99.69%

2 Bathing	326	99.69%
3 Drinking	325	99.39%
4 Fishing	35	10.70%
5 Dry Season Farming	197	60.24%

Table 4.9 Frequency of contact with the dam or canal.

Q.4 How often do you come in contact with the water from dam or canal?		
1 Daily	258	78.90%
2 Often	199	60.86%
3 Not Often	16	4.89%
4 Not at all	75	22.94%

Table 4.10 Physical signs exhibited by the study population.

Q. 6 What are some of the physical signs exhibited when you feel sick?		
1	258	78.90%

2	199	60.86%
3	16	4.89%
4	75	22.94%

Table 4.11 Level of education on malaria.

Q. 9 Have you been educated about malaria, its causes , control and prevention?

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	.3	.3	.3
1 Yes	212	64.6	64.6	64.9
2 No	115	35.1	35.1	100.0
Total	328	100.0	100.0	

Table 4.12 Knowledge on schistosomiasis.

Q.11 If yes, what is schistosomiasis (Bilharziasis)?		
1 Correct	59	18.04%
2 Fairly correct	2	0.61%
3 Wrong	195	59.63%

Table 4.13 Knowledge on mode of acquisition of schistosomiasis.

Q.12. How is the disease acquired?		
1 By coming into contact with an infected person	5	1.53%

2 By drinking contaminated water	100	30.58%
3 By coming into contact with contaminated water	101	30.89%

Table 4.14 knowledge on signs and symptoms of schistosomiasis.

Q.13 What are the signs and symptoms of schistosomiasis?		
1 fever	4	1.22%
2 muscular and abnormal pains	7	2.14%
3 spleen enlargement	1	0.31%
4 urticaria	136	41.59%
5 eosinophilia		

Table 4.15 Number of respondents who have had schistosomiasis infection before.

Q. 14 Have you been infected before?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	143	43.6	43.6	43.6
	No	185	56.4	56.4	100.0
	Total	328	100.0	100.0	

Q.17 In your own opinion how can schistosomiasis (Bilharziasis) be controlled or prevented?		
1 Boiling water before use	86	26.30%
2 Filtration of water before use	80	24.46%
3 Avoid contact with	10	3.06%

infected persons		
4 Others (Specify)	2	0.61%

Table 4.16 Information on Deworming history.

Q.18 Have you ever been dewormed?

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	7	2.1	2.1	2.1
1 Yes	125	38.1	38.1	40.2
2 No	196	59.8	59.8	100.0
Total	328	100.0	100.0	

Table 4.17 Showing treatment options of inhabitants infected with schistosomiasis.

Q7 What do you do when you notice the symptom above		
1 Self medicate	112	34.25%
2 Herbalist	28	8.56%
3 Hospital	182	55.66%
4 Other(specify)	16	4.89%

Table 4.18 Showing the number of participants who have been infected with schistosomiasis.

q15 Have you been infected with schistosomiasis before		
1 Yes	23	7.03%
2 No	29	8.87%
3 Invalid	21	0.06422

APPENDIX 4

RESULTS

Table 4.19 Intensity(density) of *Plasmodium falciparum* infection by Age in the Study communities.

Plasmodium falciparum (MPs/1µl blood)

Age group	Gaani	Gia	Kwarania	Yogbania	Bonia
.05-15	703	0	133	106	0
16-25	0	0	0	0	544
26-35	0	0	69	0	0
36-45	48	0	0	0	67
46-55	0	0	0	0	57

56-65	0	970	0	0	0
66-75	0	0	0	0	0
76-85	0	0	0	0	0

4.20 Intensity of *Schistosoma haematobium* infection by Age in the Study communities.

Schistosoma haematobium (eggs/10ml of urine)

Age group	**Gaani**	**Gia**	**Kwarania**	**Yogbania**	**Bonia**
.05-15	0	0	0	0	0
16-25	0	0	0	0	10
26-35	0	0	0	0	0
36-45	0	1	0	0	0
46-55	0	0	0	0	0
56-65	0	3	0	0	0
66-75	0	0	0	0	0
76-85	0		0	0	0

4.21 Intensity of *Schistosoma mansoni* infection by Age in the Study communities.

Schistosoma mansoni (eggs/g stool)

Age group	Gaani	Gia	Kwarania	Yogbania	Bonia
.05-15	22	0	9	0	5
16-25	0	1	0	0	8
26-35	0	0	5	0	0
36-45	8	2	1	2	0
46-55	0	0	3	4	0
56-65	3	4	3	9	0
66-75	6	0	3	26	1
76-85	0	0	0	0	0

4.22 Intensity of hookworm infection by Age in the Study communities.

Age group	Hookworm (eggs/g stool) Gaani	Gia	Kwarania	Yogbania	Bonia
.05-15	0	0	0	0	0
16-25	8	0	0	0	3
26-35	0	0	0	0	0
36-45	0	0	0	0	0
46-55	0	0	0	0	0
56-65	0	0	0	0	0
66-75	0	0	0	0	0
76-85	0	0	0	0	0