MALACOLOGICAL STUDY OF RICE FIELD AGRO- ECOSYSTEM AND URINARY SCHISTOSOMIASIS AMONG RICE FARMERS IN KACHIA LOCAL GOVERNMENT AREA, KADUNA STATE, NIGERIA

BY

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APRIL 2015

DECLARATION

I declare that the work in this thesis entitled "**MALACOLOGICAL STUDY OF RICE FIELD AGRO- ECOSYSTEM AND URINARY SCHISTOSOMIASIS AMONG RICE FARMERS IN KACHIA LOCAL GOVERNMENT AREA, KADUNA STATE, NIGERIA**" was carried out by me in the Department of Biological Sciences Ahmadu Bello University, Zaria. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at this or any other institution.

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CERTIFICATION

This thesis entitled "**MALACOLOGICAL STUDYOF RICE FIELD AGRO-ECOSYSTEM AND URINARY SCHISTOSOMIASIS AMONG RICE FARMERS IN KACHIA LOCAL GOVERNMENT AREA, KADUNA STATE, NIGERIA"** by Ugochukwu OGUIKE, meets the regulations governing the award of the degree of M.Sc. Biology of the Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This work is dedicated to my friend, help and peace, the Holy Spirit; you make my Life beautiful and make me strong in weakness. I will forever chase after you.

ABSTRACT

Irrigated and rainfed wetland rice agriculture are important socioeconomic activities with direct potential bearing on the health of stakeholder rice farmers in Kachia Local Government Area of Kaduna State Nigeria. This study investigated the Malacology of rice field agro-ecosystem and urinary schistosomiasis among rice farmers across eight districts within Kachia Local Government Area. Two rice farms were randomly selected in each district and within an estimated area of $20m^2$ of rice plot per farm, available mollusc were collected, identified to species and exposed to artificial light to determine their individual infectivity with trematode cercariae. A total of 464 consenting rice farmers were recruited from the eight districts, sensitized and administered structured questionnaireto obtain demographic and schistosomiasis risk factors data. Urine samples were collected from the 464 rice farmers and analysed by centrifugation and microscopy for the presence and intensity of *Schistosomahaematobium*ova. 490 molluscconsisting of six species were encountered in rice fields which included14(2.86%) *Anodonta marginata,* 17(3.46%)*Bellamya crawshay*i, 81(16.53%*)Biomphalaria pfeifferi,* 80(16.33%*) Bulinus globosus,* 128 (26.12%) *lymnaea natalensis* and170 (34.69%) *Melanoides maculata*. *Melanoides maculata*and *lymnaeanatalensis*were dorminant on the rice fields. Three of the mollusc species *Bulinus globosus, Biomphalaria pfeifferi,* and *lymnaea natalensis* have been implicated as the snail intermediate host of medically important trematode parasite. None of the mollusc shed cercariae of parasitic trematode. Temperature, electrical conductivity and total dissolved solids correlated positively with mollusc abundance but only temperature was significantly correlated.Water pH correlated negatively with snail abundance throughout the districts. An overall urinary schistosomiasis prevalence of

60.99% and mean intensity of 41.56% eggs/10ml urine were obtained for rice farmers in the Local Government Area. Prevalence of urinary schistosomiasis differed significantly ($P<0.01; X^2 = 50.414$; df=7) amongst the districts and ranged from 28.21% in Doka to 79.55% in Ankwa district. Prevalence (80.33%) and intensity (45.96% eggs per 10ml urine) of urinary schistosomiasis amongst female rice farmers were significantly higher ($P<0.01; X^2 = 70.512$; df=1) than prevalence (40.44%) and mean intensity (32.29 eggs/10ml urine) amongst male farmers. Rice farmers lack of awareness on the importance of snail or their perception of snail as safe were significantly correlated to prevalence of urinary schistosomiasis with OR of 2.6 and 2.0 respectivelly. Farmers who felt otherwise to the presence of snails were also correlated to prevalence with OR of 1.5.The use of stream water as source of domestic water, swimming and lack of protective wears were also associated with the disease with respective ORs of 5.5,1.7 and 20.1. The study revealed very high prevalence of urinary schistosomiasis among rice farmers in Kachia Local Government Area.It is therefore recommended that mass chemotherapy be embarked upon in the area to reduce the prevalence of the disease in the population.

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ABBREVIATIONS

ANOVA Analysis of Variance

EC Electrical Conductivity

OR Odds Ratio

TDS Total Dissolved Solids

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of Urinary Schistosomiasis:

Urinary schistosomiasis or bilharziasis is a tropical parasitic disease caused by blood dwelling fluke,*Schistosoma haematobium*which is transmitted bythe snail *Bulinus* spp. (WHO, 2007). The disease is endemic in 53 countries in the Middle East and most of the African continent (Chitsulo*et al.,* 2000). Schistosomiasis is still one of the major public health problems facing humanity, with severe social and economic consequences (WHO, 1999). The global prevalence of schistosomiasis shows that over 139 million people are infected with 85% of them domiciled in Africa (WHO, 1999). Schistosomiasisis considered second only to malaria as the most devastating parasitic disease in tropical countries. In sub-Saharan Africa where it is listed among the neglected tropical diseases, more than 200,000 deaths per year are due to schistosomiasis (WHO, 2002). Urinary schistosomiasis causes renal and bladder dysfunction or liver disease, and it contributes to anemia and growth retardation in children (WHO 2002).

Nigeria is one of the countries known to be highly endemic for urinary schistosomiasis where over 100 millionpeopleare at risk and about 25 million are already infected (Chitsulo *et al.,* 2000). Although the majority of people in endemic areas have only light infections with no symptoms, the impact of urinary schistosomiasis on economic condition and the general health situation is much (Chidozie and Duniyan, 2008). The disease is known to affect the academic performances and growth patterns of school

children and the work capacity of rural inhabitants owing to the weakness and lethargy it induces(WHO,1999; Uneke *et al*., 2007).

The distribution of the disease is determined, to a large extent, by the presence or absence of *Bulinus globosus* snails, which act as the parasite's intermediate hosts (Opisa *et al*., 2011). The majority of researches on schistosomiasis lay emphasis on disease prevalence and intensity of infection among human populations, occasionally trying to identify the intermediate snail hosts within the vicinity of the areas. The World Health Organization (WHO) has emphasized the need to create predictive maps for expected *Schistosoma* species distribution (Opisa *et al*., 2011). In this regard, the Geographical Information System (GIS) can be applied to consider the spatial patterns of intermediate snails host simultaneously with those of human infection so as to improve efficiency of the allocation of resources for available transmission control interventions. Recent malacological surveys around Lake Victoria, Uganda by Standley *et al.* (2010) provide an insight on the usefulness of integrating snail surveillance with parasitologicaldata from humans. However, several knowledge gaps still exist in integrating snail distribution with human infection data. Firstly, fragmentation of infection among human populations versus snail sampling makes it difficult to indicate with certainty the occurrence and distribution of the *Schistosoma*snail host in the areas. This is further confounded by the fact that most human populations within endemic areas exhibit high illiteracy (Standley *et al*., 2010), thus complicating the pattern for locally acquired versus imported infections.Secondly, although chemotherapy plays a significant role in reducing morbidity and mortality due to schistosomiasis, the costs and logistical constraints hamper itseffectiveness on a

wider scale (Selpha *et al.,* 2011). Parallel preventive measures such as snail control, whose integration requires a thorough understanding of snail distribution, therefore, seem plausible. Thirdly, the longevity of *Schistosoma*infections in the human host makes it difficult to detect when and where transmission actually occurs, without undertaking snail surveillance. Since snails are obligatoryhosts for the larval stages of *Schistosoma* species, their examination provides important information on active transmission foci.

1.1 Statement of Research Problem

The status of urinary Schistosomiasis among rice farmers in Kachia Local Government Area of Kaduna State, Nigeriais unknown and undocumented.Likewisethe occurrence, infectivity and population density of the snail intermediate hosts of *Schistosoma* species in rice fields in the Local Government Areahave not been documented. Kachia Local Government Area of Kaduna State is well known for the cultivation of wetland rice but the associated water contact risk for schistosomiasis transmission among the farmers has not been investigated despite the extensive irrigation farming in some of its regions.

1.2 Justification

With the imminent ban on rice importation into Nigeria by Nigerian Government and consequent intensification of local rice production, it will be expedient to explore some of the health risks associated with rice cultivation especially in relation to water exposure risks for the transmission of such waterborne disease as urinary schistosomiasis among rice farmers. Assessment of the prevalence and intensity of urinary schistosomiasis among rice farmers as well as the occurrence and infection of

the snail intermediate hosts of *Schistosoma* specieson rice farms are important indices of water contact risk for Schistosomiasis (Opisa *et al*., 2011).

1.3 Aim

To conduct a malacology of rice fields and a parasitological study of urinary schistosomiasis amongst rice farmers in Kachia Local Government Area of Kaduna State, Nigeria.

1.3 Objectives

1. To determine species composition, relative abundance and distribution of snail species in rice farms in Kachia Local Government Area.
2. To evaluate the infectivity of rice field snail with *Schistosoma* parasite in Kachia Local Government Area
3. To determine some physicochemical parameters of rice fields in relation to snail abundance.
4. To determine the Distribution, prevalence and intensity of urinary schistosomiasis among rice farmers in Kachia Local Government Area.

1.4 Hypotheses

1. Mollusc species are neither present nor distributed on rice farms in Kachia Local Government Area of Kaduna State, Nigeria
2. Snails are not infected with cercariae of *Schistosoma* species in the study area.
3. Physicochemical factors of rice fields have no effect on snail abundance
4. Distribution, prevalence and intensity of urinary schistosomiasis among rice farmers in Kachia Local Government area of Kaduna state are low

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Synopsis on Urinary Schistosomiasis

Urinary schistosomiasis is an infectious disease of the tropics and sub-tropics, yet highly preventable (Ugochukwu*et al*., 2013). It is one of the most wide spread among the parasitic helminth infections that affect humans. The disease is indicated by the presence of blood in urine (haematuria) and sometimes by pains on urinating or after urinating.Other symptoms and complications associated with this disease include swimmer's itch, dysuria and supra-pubic pain (Nagi *et al.,* 1999). Humans contract the disease when physical contacts are made with infected water bodies while carrying out necessary daily activities such as farming, fishing, laundry, bathing and swimming (Wright, 1988).

2.2 Causative Agent

*Schistosoma haematobium*which is the causative agent of urinary schistosomiasis is parasitic blood-dwelling fluke belonging to the genus *Schistosoma;*Family, Schistosomatidae; Order, Digenea;Class, Trematoda; Phylum, Platyhelminths and Kingdom, Animalia. The genus *Schistosoma* contains six species that are of major health importance, including,*S. haematobium, S. mansoni, S. japonicum, S. mekongi, S. intercalatum, and S. guineensis* (Webster *et al.,* 2006). The species differ in their predilection sitesin the human host, the species of the intermediate snail host they use in their life cycle, the pathology they induce, and the number, size and shape of the eggs they produce(Webster *et al.,* 2006).

2.2.1 Morphology of *Schistosoma* species

Unlike all other medically important trematodes, schistosomes are not hermaphroditic, but have separate sexes. The adult worms are 1–2 cm long with a cylindrical body that features two terminal suckers, a complex tegument, a blind digestive tract, and reproductive organs. The male's body forms a groove or gynaecophoric canal, in which it holds the longer and slender female. As permanently embraced couples, the Schistosomes live within the perivesical (*S. haematobium*) or mesenteric (other species) venous plexus. Schistosomes feed on blood particles through anaerobic glycolysis (Rumnajek, 1987).

2.3.2 Transmission and Risk Factors

All *Schistosoma* infections follow direct contact with freshwater harbouring cercariae. There are three major factors responsible for maintaining the transmission of the infection which include, contamination of fresh water with excreta containing schistosome eggs, the presence of the snail intermediate hosts and human contact with water-infested with cercariae (Jordan and Webbe, 1993).

Contact with contaminated freshwater is the major risk factor for infection (Jordan and Webbe, 1993). The main risk groups are school-age children, specific occupational groups (fishermen, irrigation workers, farmers), and women and other groups using infested water for domestic purposes (WHO, 2002). Many other host-related and environmental risk factors have been identified that may affect the risk of acquiring schistosome infection or influence the distribution, prevalence, intensity, morbidity and mortality of schistosomiasis. Among these are genetic factors (Quinnell, 2003),

behaviour, household clustering (Bethony *et al.*, 2001), climate, immune response of the host, and concomitant infections (e.g. hepatitis) (IARC, 1994).

2.4 Life Cycle

The life cycle of *S. haematobium* begins with the adult female *S. haematobium* worm which produces hundreds of eggs per day throughout her life (Figure 2.1). The eggs (144x58 μm, with a characteristic terminal spine) penetrate through the bladder wall where they are excreted with urine. Each egg contains a ciliated larva (miracidium), which secretes proteolytic enzymes that help the eggs migrate into the lumen of the bladder. About half of the eggs produced do not reach the vesical lumen and are carried away with the bloodstreamor trapped in the tissues. These retained eggs provoke a granulomatous inflammatory response which is the main cause of pathology in the human host. The excreted eggs hatch if they come into contact with water and release the miracidium. These remain viable for up to 48 hours and are able to locate a suitable freshwater snail host (*Bulinus* spp.) using external stimuli such as light and snail-derived chemicals. In the snail, asexual multiplication takes place, and several generations of multiplying larvae (sporocysts) develop. Eventually, these sporocysts produce large numbers of infective larvae (cercariae) with a typical bifurcated tail. These leave the snail at a rate of thousands per day after a period of 8-9 weeks. Shedding of these cercariae can continue for months. The cercariae survive for up to 72 hours and use water turbulence and skin-derived chemicals to locate the human host. They attach to and penetrate the human skin within 3–5 minutes. They lose their tail and the young parasites (schistosomulae) migrate with the bloodstream via the lungs to the liver, where they mature into adult worms in the portal vein and mate. The paired

worms migrate against the bloodstream to the perivesicular veins, where in a total of 4–7 weeks after infection they start producing eggs throughout their adult life. The lifespan of an adult worm averages 3–5 years, but can be as long as 30 years (Wilkins, 1987). An infected person probably harbors an average of hundreds (range, 10s–1000s) of worms (Gryseels and De Vlas, 1996). Luka *etal* (2005) found a significant relationship between human activities i.e indescriminate defeactation, agriculture, swimming and schistosoma infection this is because urinating or defeacating in farms by schistosoma infected person ensures the continous contamination of the enviroment with the eggs of schistosoma which hatch as soon as they come in contact with water in the environment, the hatched miracidia soon find suitable snail host where they undergo secondary development into cercaria the cercariae emerge from snail host after about 8-9 week or less depending on the temperature (Selpha *et al*., 2011). The free swimming cercariae soon attach themselves and penetrate through the skin of human who come in contactedwith infested water, mature, pair and begin to reproduce thereby ensuring continuous infection and reinfection. selpha *et a*(201l)also reported that temperature played an important in the development of both the snail host vector and the parasite within the host snail vector, he reported that at higher temperature cyclical development of the *Schistosoma* parasite within the snail host could be shortened to 4-6 week.

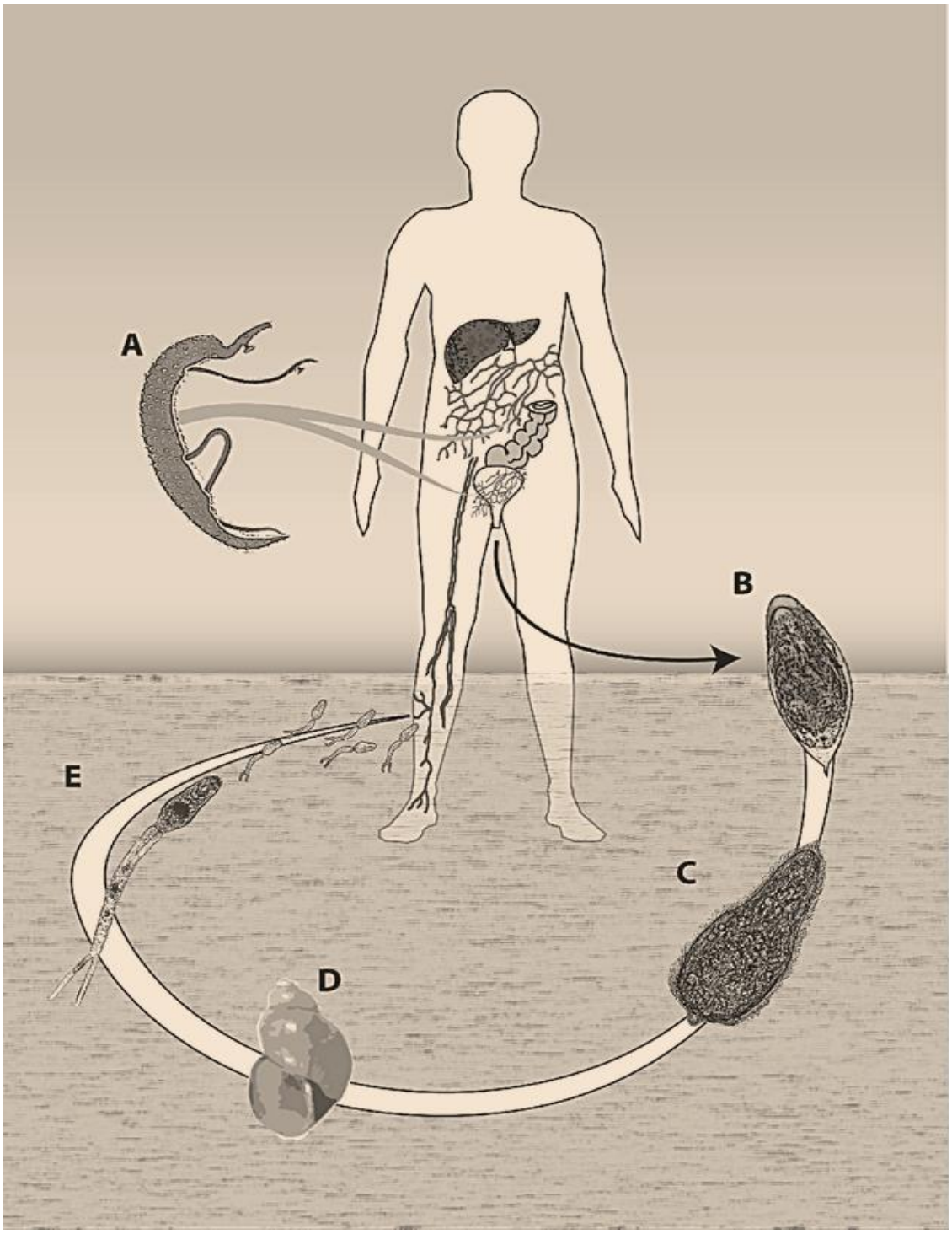


Fig: 2.1: Life cycle of *Schistsoma haematobium* **A**: paired adult worms; **B**: egg; **C**: miracidium; **D**: intermediate snail host; **E**: cercariae (Bruno*et al.*, 2006)

2.5 Pathology of Urinary Schistosomiasis

The pathology of *Schistosomahaematobium*infection is due to deposition of eggs in the tissues of bladder and ureter which elicits chronic granulomatous injury. This granulomatous inflammation causes nodules, polypoid lesions and ulcerations of the lumen of the ureter and bladder, which results clinically in urinary frequency, dysuria and terminal hematuria (Nmorsi *et al*., 2007). The disease may progress and terminate in renal failure or carcinoma of the bladder. The clinical feature and disease outcomes in persons infected with *S. haematobium* vary dramatically, ranging from mild symptoms to severe damage of the urinary tract including the kidney and bladder (Brouwer *et al.,* 2003b). In some endemic areas of Africa where facilities for diagnosis are limited, estimation of this pathological process is performed by the clinical visuals, using haematuria as the method. The use of non-invasive techniques, such as ultrasound, in investigating morbidity due to *S. haematobium* has been documented (Leutscher *et al.*, 2000; Brouwer *et al.,* 2003b). Degremont *et al* (1985) documented renal congestion and irregularity of the bladder wall. The center for disease control (CDC 2011) reports that several mechanisms have been suggested to explain the role of *S. haematobium* in bladder cancer and these include:

1. Fibrosis induced by Schistosome eggs may induce proliferation, hyperplasia and metaplasia, all of which are possible precancerous changes;
2. Chronic urinary bacterial infection and production of nitrosamines from their precursors in urine, that are well known bladder carcinogens;
3. Urinary stasis allowing concentration of endogenous carcinogens leading to their absorption from urine and exposure to the bladder epithelium;

4. Raised urinary beta-glucuronidase levels originating from miracidia and adult schistosomes liberating carcinogenic amines in urine.

2.6 Epidemiology:

Human schistosomiasis is endemic in large areas of the sub- tropics. It has been estimated that over 700 million people in 74 countries are exposed to the risk of schistosomal infection and almost 200 million were estimated to be infected in 2003 (Fenwick, 2006), of which 85% were in subSaharan Africa. About 95% of the cases are due to *S. mansoni* and *S. haematobium* infections. *S.haematobium* is endemic in 53 countries, in the Middle East and most of the African continent (Chitsulo *et al.*, 2000). Schistosomiasis is largely an infection found in rural areas, but urban schistosomiasis is an increasing problem in many countries (Mott *et al.*, 1990). Natural streams, ponds and lakes are typical sources of infection, but over the past few decades, man-made reservoirs and irrigation systems, as well as population growth and migration, have contributed to the spread of schistosomiasis (Gryseels *et al.*, 2006; McManus and Loukas, 2008). Within countries, regions and villages, the distribution of schistosomiasis can be very focal, depending on variations in snail populations and human–water contact behaviour (Gryseels and Nkulikyinka, 1988). Also, the distribution of schistosomiasis can be highly uneven across individuals. The majority of the parasites are usually present in a small fraction of the infected individuals. Prevalence and intensities of infection generally show a typical convex-shaped curve with a peak at the ages of 5–15 years, and a decrease in adults. Sex-related patterns vary in relation to behavioural, professional, cultural, and religious factors (Jordan and Webbe, 1993).

2.7 Prevention and Control of Schistosomiasis

Although preventive chemotherapy is able to temporarily reduce the prevalence in the targeted population and is thought to lower transmission by the decrease of infection intensity, and hence egg excretion into the environment, it is unlikely to interrupt reinfection. Particularly in high-transmission areas, prevalence and intensity of infection can quickly reach pretreatment levels if no other means of control are applied, even if the coverage is high.(N'Goran *et al*., 2001). To achieve a maximum impact of praziquantel treatment, it should be applied when the likelihood for re-infection is lowest, and hence be timed to the beginning of the low-transmission season, if there is any.(Augusto *et al*., 2009). To clear matured schistosomes in the body that were not targeted by the first praziquantel application due to their juvenile stage and to accelerate a more rapid reduction of infection-related disease, a second treatment, 2–8 weeks after the first treatment round is recommended.(King *et al*., 2011).

Snail control, using molluscicides, to reduce the infected intermediate host snail population at human water contact sites is an important, well-tried and effective tool to complement preventive chemotherapy against schistosomiasis.(Sturrock, 1989). The most effective time of application is shortly before or shortly after a preplanned chemotherapy campaign to avoid rapid re-infection of people.(Sturrock, 1995; Kariuki *et al*., 2013). The molluscicide niclosamide has been recommended by the WHO to control schistosomiasis in humans.(WHO, 1983; 1993). Niclosamide has been widely and effectively used for snail control in schistosomiasis control programmes in different parts of the world, most extensively in the People's Republic of China, but also in Egypt, Kenya and Morocco (Kariuki *et al*., 2013) and is currently applied and

evaluated in a randomized intervention trial that aims at elimination of urogenital schistosomiasis in Zanzibar (Knopp *et al*., 2013). It must be noted, however, that chemical molluscicides, such as niclosamide, not only kill snails but are also toxic to fish and other organisms, and hence there are significant risks for the environment and biodiversity. New molluscicidal-only formulations or products are highly desirable to remedy the negative impact on species other than snails. Alternatively, indirect snail control measures such as the destruction of the snails' natural habitat, for example, by the removal of vegetation from riverbanks, or biological control with fish, ducks, *Astacus* spp. or competitor snails have been successfully applied to reduce intermediate snail host populations (Knopp*et al*., 2012; McCullough, 1981).

2.8 Diagnosis and Treatment

For a rapid and inexpensive epidemiological assessment of *S. haematobium* infection to identify high-risk communities in need of treatment, questionnaires have been proven to be a valuable tool (Chitsulo *et al*., 1995). The proportion of schoolchildren reporting to have had blood in urine (macrohaematuria) or to have had schistosomiasis in the past showed a correlation with the *S. haematobium* prevalence in a multi country study (Lengeler*et al*., 2000).

Reagent strips to assess micro-haematuria in urine are also considered as good diagnostic indicator for heavy *S. haematobium* infections in the community and can be used for the identification of high-transmission areas (Savioli *et al*., 1990). Recent work has shown that micro-haematuria identified by reagent strips, is still a useful indicator of *S. haematobium* in a setting with a history of two decades of preventive

chemotherapy (Knopp *et al*., 2013). Haematuria levels have not been found to decrease after treatment against schistosomiasis, and hence reagent strips can also be applied as indirect measure to assess drug efficacy, with the most appropriate assessment time 6 weeks after treatment (Stete *et al*., 2012).

For the identification and mapping of *S. mansoni*endemic areas, the recently developed point-of-care circulating catholic antigen (POC-CCA) dipstick or cassette test in urine is recommended as a non- invasive, sensitive and rapid diagnostic tool (Colley *et al*., 2013). A recent multi-country study revealed that a single POC-CCA applied on urine samples, is more sensitive than multiple Kato–Katz thick smears using stool samples (Colley *et al*., 2013). The POC-CCA is particularly useful in low-infection intensity settings, without showing cross-reactivity with *S. haematobium* infections(Colley *et al*., 2013). Due to its rapid test cassette format, it is easy to apply and a single person can, after a short introduction and training, perform hundreds of tests per day without the need of an equipped laboratory. The POC-CCA assay is therefore a promising tool for rapid mapping, large-scale epidemiological surveys and individual patient management in remote health facilities without trained laboratory technicians or sophisticated equipment. The cost of the POC-CCA assay, at above US$ 1.00 per test is a disadvantage (Colley *et al*., 2013). The color grading on the haematuria reagent strips or the color intensity on the POC-CCA dipstick and cassette test band are correlated with the number of eggs excreted in urine or stool (Standley *et al*., 2010). These allow for semi-quantification of the intensity of infection. Although reagent strips for haematuria assessment have a color chart that helps to classify the intensity

of haematuria, the POC-CCA tests currently lack this useful grading option and the color intensity of the test band has to be interpreted by the reader (Knopp *et al*., 2013).

Of note, the intensity of an infection is linked with morbidity (Hotez*et al*., 2006); hence, diagnostic methods allowing a quantification of the intensity help to assess the level of morbidity.*Schistosoma haematobium* infection is quantified by means of filtering 10 ml of a vigorously shaken mid-day urine sample through a polycarbonate filter and by subsequently counting the eggs trapped on the filter using microscopy (Peters *et al*., 1976). An infection is considered as heavy, if 50 or more eggs per 10 ml of urine are counted on the filter (Montresor, 1998). The current cutoff to differentiate between low and heavy infection intensities was only set a decade ago (WHO, 2002); whereas studies conducted in the 1980s and 1990s used considerably higher egg count thresholds (Danso- Appiah*et al*., 2009). Choice drug for the treatment of schistosomiasis is Praziquantel, this drug has been found to reverse the effect of schistosomiasis up to 90% (Shadab, 2014).

2.9 Snail Vector Ecology and Distribution

Snail habitats include almost all types of freshwater bodies ranging from small temporary ponds and streams to large lakes and rivers. Within each habitat, snail distribution may be patchy and detection requires examination of different sites. Moreover, snail densities vary significantly with the season. In general, the aquatic snail hosts of schistosomes occur in shallow water near the shores of lakes, ponds, marshes, streams and irrigation channels. They live on water plants and mud that is rich in decaying organic matter. They can also be found on rocks, stones or concrete covered with algae or on various types of debris. They are most common in waters

where water plants are abundant and in water moderately polluted with organic matter, such as faeces and urine, as is often the case near human habitations. Plants serve as substrates for feeding and oviposition as well as providing protection from high water velocities and predators such as fish and birds. Most aquatic snail species die when stranded on dry land in the dry season. However, a proportion of some snail species are able to withstand desiccation for months while buried in the mud bottom by sealing their shell opening with a layer of mucus. Most species can survive outside water for short periods.

2.10 Snail Vector Life cycle

All species of *Biomphalaria* and *Bulinus* are hermaphrodite, possessing both male and female organs and being capable of self- or cross-fertilization. A single specimen can invade and populate a new habitat. The eggs are laid at intervals in batches of 5–40, each batch being enclosed in a mass of jelly-like material. The young snails hatch after 6–8 days and reach maturity in 4–7 weeks, depending on the species and environmental conditions. Temperature and food availability are among the most important limiting factors. A snail lays up to 1000 eggs during its life, which may last more than a year.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 The Study Area:

KachiaLocal Government Areas where this study was done is one of the 23 Local Government Areas in Kaduna State, Nigeria (Fig 3.1). It has it's headquarter in Kachia.It occupies an area of 4,632 km² and a population of 244,274 at the 2006 census(NPC, 2006) It is located between longitude 7^0 15′ E- $8^0$00′E and latitude $9^0$30′N -$10^0$00′N. Kachia Local Government Area comprises of thirty-two districts 10 of which were created under the leadership of Governor Namadi Sambo.Kachia Local Government Area is located at about 140 Km away from Kaduna the state capital and lies in the southern part of Kaduna State which falls within the northern Guinea savanna regions of the country with at least 6 months of rainfall annually. The well drained ferruginous soil of the LGAis capable of sustaining lush vegetation with sparsely distributed tree crops, which makes the location well suited for rice cultivation as well as the production of other cash crops. The landscape is composed of a wide variety of grasses and tall woody trees. The river Gurara forms the major focus for the drainage ofKachia Local Government area.

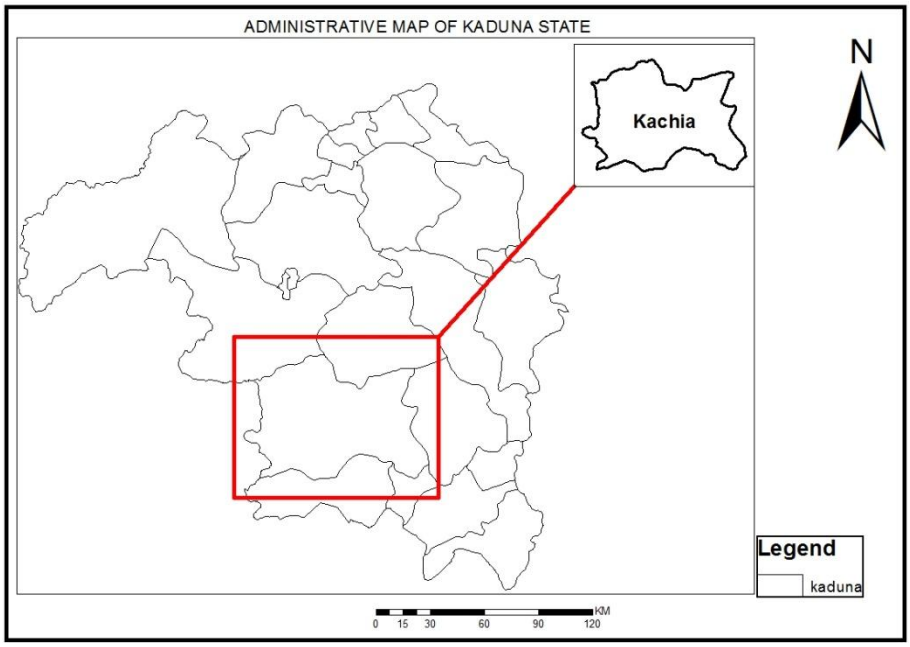


Fig 3.1: Administrative map of Kaduna State, Nigeria showing Kachia Local Government Area

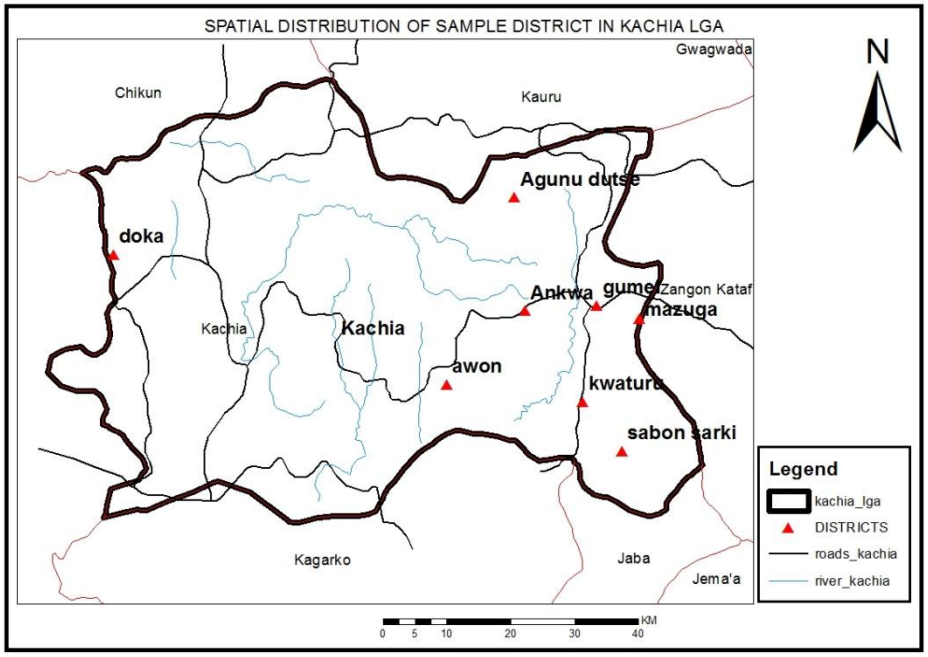


Fig 3.2: Spatial distribution of sampling sites amongst the districts in Kachia Local Government Area, Kaduna State, Nigeria

TABLE 3.1 List of sampling sites and their GPS co-ordinates

s/no	Districs	GPS co-ordinates of sites
1	Ankwa (site A)	N09^{o} 50' 42.1'' E007^{o} 52' 43.8''
2	Ankwa (site B)	N09^{o} 50'46.2'' E007 52' 27.6''
3	Awon (site A)	N09^{o} 44' 29.3'' E007^{o} 46' 06.1''
4	Awon (site B)	N09^{o} 49' 01.3'' E007^{o} 47' 03.3''
5	agunu dutse (site A)	N09^{o} 38' 03.5'' E008^{o} 03' 42.3''
6	agunu dutse (site B)	N09^{o} 38' 07.2'' E008^{o} 03' 22.3''
7	Doka (site A)	N09^{o}41' 28.4'' E008^{o} 01' 25.6''
8	Doka (site B)	N09^{o}41'33.2'' E008^{o} 01' 11.3''
9	Gumel (site A)	N09^{o} 50' 30.8'' E007^{o} 58' 42.7
10	Gumel (site B)	N09^{o} 51' 10.3'' E007^{o} 58' 46.1''
11	Mazuga (site A)	N09^{o} 50' 03.9'' E008^{o} 02' 23.5''
12	Mazuga (site B)	N09^{o} 50' 03.0'' E008^{o} 02' 24.5''
13	Kwaturu (site A)	N09^{o} 43'01.1'' E007^{o} 57' 36.2''
14	Kwaturu (site B)	N09^{o} 44' 55.8'' E007^{o} 57' 55.9''
15	sabon sarki (site A)	N09^{o} 38' 51.3'' E008^{o} 00'53.9''
16	sabon sarki (site B)	N09^{o} 38' 49.0'' E008^{o} 00'53.9''

3.2 Sample SizeDetermination:

The estimated number of individuals sampled for urinary schistosomiasis was obtained using Fisher's sampling formula (Fisher, 1935) which is $N=\frac{Z^2PQ}{d^2}$

Where Z = the critical value of standard normal distribution (1.96 at 95% confidence interval)

P= estimated prevalence of *Schistosoma haematobium* infection

Q=1-P

d=absolute precision or sampling error tolerated=5%

The minimum calculated sample size for this study was 380 participants but a total of 464 rice farmers were recruited.

3.3 Study Population:

The study population was composed of 464 consenting rice farmers (239 females and 225 males).The study population was distributed as six age ranged from 1-10; 11-20; 21-30; 31-40; 41-50; and above 50 years of age.

3.4 Administration of Questionnaire:

A structured questionnairewas administered to eachfarmer to obtain personal data such as name, district, village, age, sex and risk factors such as wearing of protective clothing and shoes, disease awareness, snail perception and drinking water sources i.e stream and other sources.

3.5 Sample Collection:

Urine samples were collected from the rice farmers in Kachia Local Government Area. Sterilizedand well labeled 15ml sample bottles were distributed to the farmers for urine collection. The farmers were instructed to collect their urine as recommended by WHO (1999). Samples were obtained from participant within theeight districtrandomly selected from the LGA.Two rice farms were then selected in each district and searched for mollusc species including the snail intermediate host of *Schistosoma*. Anestimated area of $20m^2$ per rice farm was thoroughly examined for available mollusc species and placed in labeled containers. The Global Positioning SatelliteLocation of sample sites was also obtained within an accuracy range of less than ±3m using GARMIN eTrex Venture HC hand held Global Positioning Sensor (GPS). Physicochemical parameters such as temperature, pH, Total dissolved solids and electrical conductivity of water in the rice farms were determined using HANNA HI 98129 meter.

3.6 LaboratoryAnalysisof Samples:

Following the collection of urine samples, 5 ml of 10% formol saline was immediately added into the sample (Cheesbrough,1999), in order to prevent eggs of the parasite from hatching to release miracidiae.The urine samples were then placed in a cool box containing ice and transported to the Parasitology and Entomology Research laboratory, Department of Biological Sciences Ahmadu Bello University Zaria where analysis were conducted.Each urine sample was transferred into a 15ml centrifugetube and centrifuged in a centrifuge machine (Heraeus Labofuge 300)at a speed of 1000revolution per minute for 2 minutes (Cheesbrough, 2009). The supernatant was

discarded and total concentrate measured. About 0.2ml of the concentrate was then transferred to a slide and observed under the objective lenses magnification of ×10 and ×40.The egg of *Schistosoma*species were identified according to the pictorial keys of Soulsby (1982) and counted. The photomicrographs of positive slides were made using (hp cameral mode c 150w). The total number of eggs counted per 0.2 ml was estimated against the final sediment volume and expressed as number of ova per 10 ml urine sample. Molluscs collected were transported in moist plastic cups to the laboratory, placed singly in Petri dishes containing distilled water and exposed to fluorescent light for several hours (3-6 hours) to stimulate cercarial emergence. The snails were then identified; using the pictorial keys of Mandahl-Barth (1962), counted and recorded accordingly

3.5 Data Analysis:

Analysis of variancewas used to test for significance in the variation of physicochemical parameter across study districts, Pearson correlation analysis was also used to establish relationship between physicochemical parameters and snail abundance. Odd ratio was calculated for each risk factor investigated to determine association with urinary schistosomiasis in the farmers.Chi square Statistics was used to determinesignificant differences in age- specific prevalence of the disease. Unpaired student t- test and Chi- square (χ^2) were used to test for significant difference in sex-specific prevalence of urinary schistosomiasis.

CHAPTER FOUR

4.0 RESULTS

4.1 Relative Abundance, Distribution of Mollusc Species and Their Infectivity

Table 4.1 describes the relative abundance of the six species of mollusc encountered in eight districts LGA. Nigeria. The mollusc species include 14(2.86%) *Anodonta marginata,* 17(3.47%) *Bellamya crawshayi,* 81(16.53%) *Biomphalaria pfeifferi,* 80(16.33%) *Bulinus globosus,* 128(26.12%) *lymnaea natalensis* and 170(34.69%) *Melanoides maculata.* The dominant species were *Melanoides maculata* and *lymnaeanatalensis,* both of which constituted 60.81% of the collection and occurred in all the eight districts. The pair of *Biomphalariapfeifferi*and *Bulinus globosus* occurred in seven of the eight districts; being absent in Gumel district and constituted 32.86% of the collection. Both *Anodontamarginata* and *Bellamyacrawshayi* which were exclusively in Awon districts were the least abundant and constituted 6.33% of the collection. Majority (25.31%) of the 490 mollusc population, made up of all the six species were obtained from Awon district. The least proportion (6.73%) of the 490 mollusc population, made up of four of the six species were obtained from Doka district. Abundance of the mollusc species differed significantly ($P<0.05$); with that of *M. maculata* significantly higher than each of the other five specie. However, abundance of the trio of *B.pfeifferi, B.globosus* and *lymnaeanatalensis* did not differ significantly ($p>0.05$). Similarly abundance of the pair of *A.marginata* and *B.crawshayi* did not differ significantly ($p>0.05$) (Table 4.1; Appendix I). The distribution of mollusc population amongst the eight districts did not differ significantly ($P>0.05$, Appendix II). None of the 490 mollusc specimens obtained from the rice fields shedded cercaria.

Table: 4.1 Speciescomposition and abundance of molluscs in rice fields in some districts of Kachia Local Government Area, Kaduna state, Nigeria

Districts	Snail species						
	Anodonta marginata	*Belamya crawshayi*	*Biomphalaria pfeifferi*	*Bulinus globosus*	*Lymnaea natalensis*	*Melanoides maculata*	Total
Ankwa	0	0	15	14	23	21	73(14.90)
Awon	14	17	19	19	16	39	124(25.31)
Agunu Dutse	0	0	08	08	15	13	44(8.98)
Doka	0	0	09	07	12	05	33(6.73)
Gumel	0	0	0	0	26	28	54(11.02)
Mazuga	0	0	10	09	09	25	53(10.82)
Kwaturu	0	0	10	09	09	25	53(10.82)
Sabon Sarki	0	0	10	14	18	14	56(11.43)
Total	14(2.86)	17(3.47)	81(16.53)	80(16.33)	128(26.12)	170(34.69)	490(100)
	N=8	N=8	N=8	N=8	N=8	N=8	
	$\bar{x}$ = 21.25	$\bar{x}$ = 10.13	$\bar{x}$ = 10	$\bar{x}$ = 16	$\bar{x}$ = 1.75	$\bar{x}$ =2.13	
	SD= 15.51	SD= 5.49	SD= 5.71	SD= 6.19	SD= 4.95	SD= 6.01	
	95% CI= 12.46-30.04	95% CL= 5.54-14.72	95%CI= 5.23-14.77	95%CI= 2.38-5.89	95%CI= 10.83-21.18	95%CI= 2.89-7.15	

4.2 Physicochemical Parameters of Rice Field Water and Associated Mollusc Specie in Some Districts of Kachia LGA

Table 4.2 representsthe ranges (mean± standard error) of the water parameters of rice fields in Kachia Local Government Area where each of the six specie of mollusc occurred. The six species of mollusc occurred in water with same range (9.25 – 10.87) of pH. The mean pH of water supportive of the occurrence of the six species of mollusc did not differ significantly (P>0.05). Four species of mollusc found in this study, including *Biomphalaria pfeifferi*, *Bulinus globosus*, *lymnaea natalensis* and *Melanoides maculata*occurred in water with similar total dissolved solids (TDS)ranges of 13-56ppm. Similarly, the pair of *Bellamyacrawshayi* and *Anodontamarginata* occurred in water with similar TDS ranges of 17-25ppm. The mean TDS values of water where six species of mollusc occurred did not differ significantly (p>0.05, Appendix IV). The electrical conductivity (EC) values of the water where *B. pfeifferi*, *B. globosus*, *L. natalensis* and *M. maculata* occurred in the rice fields ranged between 26µs/cm and 104µs/cm. *Anodonta marginata* and *Bellamya crawshayi* occurred inwater with EC ranges of 33-52 µs/cm. the mean EC values of water where the six species of mollusc occurred did not differ significantly (P>0.05, Appendix V). The water temperature at the times of collecting *Anodontamarginata* and *Bellamyacrawshayi* from the rice fields ranged between 28.2 and 29°C.However, the quads of *B.pfeifferi*, *B.globosus*, *L. natalensis* and *M. maculata* were obtained in water at temperatures ranging between 22.10 and 29.0°C. The mean water temperatures where the six species of mollusc occurred did not differ significantly (p>0.05, Appendix VI).

Table 4.2: Range (mean±SE) of water parameter of rice fields supportive of mollusk species in Kachia Local Government of Kaduna State, Nigeria

Mollusc species	Water parameter			
	Ph	TDS (ppm)	EC (µs/cm)	Temperature (◦C)
Anodonta marginata	9.25 – 10.87 (10.06^{a} ± 0.82)	17.0 – 25.0 (21.0^{a} ± 4.01)	33 – 52 (42.5^{a} ± 9.53)	28.2 – 29 (28.6^{a} ± 0.40)
Bellamya Crawshayi	9.25 – 10.87 (10.06 ^{a} ± 0.82)	17.0 - 25.0 (21.0^{a} ± 4.01)	33 – 52 (42.5^{a} ± 9.53)	28.2 – 29 (28.6^{a} ± 0.40)
Biomphalaria pfeifferi	9.25 – 10.87 (10.43 ^{a} ± 0.10)	13 – 56 (24.64^{a} ± 2.86)	26 – 104 (48.86^{a} ± 5.22)	22.10 -29.0 (25.37^{a} ± 0.53)
Bulinus globosus	9.25 – 10.87 10.43 ^{a} ± 0.10	13 – 56 24.64^{a} ± 2.86	26 – 104 (48.86^{a} ± 5.22)	22.10 -29.0 (25.37^{a} ± 0.53)
Lymnaeanatalensis	9.25 – 10.87 (10.42 ^{a} ± 0.09)	13 – 56 (24.19^{a} ± 2.59)	26 – 104 (48.06^{a} ± 4.77)	22.10 – 29.0 (25.36^{a} ± 0.47)
Melanoidesmaculata	9.25 - 10.87 (10.42 ^{a} ± 0.09)	13 - 56 (24.19^{a} ± 2.59)	26 – 104 48.06^{a} ± 4.77)	22.10 - 29.0 25.36^{a} ± 0.47

Mean with the same superscript letter within the same column are not significantly different (P>0.05)

Table 4.3 represents the mean (±SD) of water parameter in rice field within the eight districts where the samples were obtained. The range of mean pH throughout the eight districts occurred between 10.1 – 10.7 with the highest pH occurring in Kwaturu(10.7) and the lowest occurring in Awon (10.1). The mean pH of water across the districts did not differ significantly (P>0.05). The total dissolved solidsand electrical conductivity within the districts was found to occur within a range of 15-37.5ppm and 30.5-71µs/cm respectively. Awon(37.5ppm and 71µs/cm) was found to be with highest occurrences while the lowest occurrences were found in Doka (15ppm and 30.5µs/cm). The total dissolved solids and Electrical conductivity occurring in all districts did not differ significantly (p>0.05). Temperature was found to occur in the districts between a range of 22.2°C -28.6°C with the highest and lowest occurring in Awon (28.6°C) and Doka (22.2°C) respectively. Chi square shows that temperature across the districts varied significantly (P=0.0016507), LSD shows high level of significance between the duo (Ankwa and Awon) and other districts namely Agunu dutse, Doka, Gumel, Mazuga, Kwaturu and Sabon sarkihowever, no significant difference was found between Ankwa and Awon.

Table 4.4 is depicts the correlations between water parameters of rice fields and mollusc abundance. A negative correlation was observed between pH and snail abundance however, this correlation was statistically insignificant. Positive correlations were found between snail abundance against total dissolved solids, temperature and electrical conductivity which also revealed that positive correlations between temperature and snail abundance is highly significant (P = 0.0001).

Table 4.3 Mean (±SD) of water parameters in rice fields within eight districts of Kachia Local Government Area, Kaduna State, Nigeria

DISTRICTS	Water parameters				
	pH	TDS(ppm)	TEMP(°C)	E.C(µs/cm)	Total Snail abundance(%)
Ankwa	10.4(±0.3)[a]	37.5(±26.2)[a]	26.5(±0.7)[a]	71(±46.7)[a]	73(14.90)
Awon	10.1(±1.1)[a]	21(±5.7)[a]	28.6(±0.6)[a]	42.5(±13)[a]	124(25.31)
Agunu Dutse	10.4(±0.0)[a]	28(±1.4)[a]	24.2(±0.2)[b]	55(±2.8)[a]	44(8.98)
Doka	10.4(±0.1)[a]	15(±2.8)[a]	22.2(±0.1)[b]	30.5(±6.4)[a]	33(6.73)
Gumel	10.3(±0.1)[a]	21(±9.9)[a]	25.3(±0.3)[b]	42.5(±20.5)[a]	54(11.02)
Mazuga	10.6(±0.2)[a]	23(±7.1)[a]	25(±0.8)[b]	46(±14.1)[a]	53(10.82)
Kwaturu	10.7(±0.1)[a]	18.5(±3.5)[a]	25.2(±0.3)[b]	38(±8.5)[a]	53(10.82)
SabonSarki	10.4(±0.0)[a]	29.5(±2.1)[a]	25.1(±1.8)[b]	59(±4.2)[a]	56(11.43)
Total	10.4(±0.4)	24.2 (± 10.4)	25.4(±1.9)	48.1(± 19.1)	490(100)

P=0.0016507

Means with the same superscript letter along same column are not significantly different (p>0.05)

Table 4.4 Comparative analysis showing the correlation between water parameters of rice fields and mollusk abundance

Parameters	pH	D.S	TEMP	E.C	SNAILAB
pH	1				
D.S	-0.30737	1			
TEMP	-0.19131	0.31113	1		
E.C	-0.34502	0.997026**	0.315898942	1	
SNAIL AB	-0.21122	0.082143	0.910992453**	0.08228542	1

** Correlation is significant at the 0.01 level

Table key:

Symbols	Meanings
pH	Hydrogen concentration
D.S	Dissolved solids
TEMP	Temperature
Snail AB	Snail abundance
E.C	Electrical conductivity

4.3 Prevalence and Intensity of Urinary Schistosomiasis Among Rice Farmers

The sex specific prevalence of urinary schistosomiasis in the eight districts is shown in Table 4.5. Female subjects who constituted 51.51% (239 persons) of the sample populationhadprevalence of urinary schistosomiasis ranged from 55.56% in Mazuga district to 100% in the single subject examined in Doka district. Overall prevalence of the infection in female subjects was 80.33%. Meanintensity (egg per 10ml of urine) of *S. haematobium* in infected female farmers ranged from 40.07in Gumel district to 52.0 in Dokadistrict (Table 4.5). Male farmers constituted 49.49 % (225 persons) of the total sample population and had Prevalence of urinary schistosomiasis ranged from 12.00% in Gumel district to 100% in the single male farmer examined in Ankwa district. Overall prevalence of the infection in male farmers was 40.44%. Mean intensity of *S.haematobium* eggs in infected male farmers ranged from 19.00 in Sabon sarkidistricts to 39.20 in Doka district (Table 4.5). Total prevalence (male and female) of urinary schistomiasis in rice farmers in districts within Kachia Local Government Area ranged from 28.21% in Doka district to 79.55% in Ankwa district; with an overall total prevalence of 60.99% for the Local Government Area (table 4.5). Prevalence of urinary schistosomiasis (80.33%) was significantly higher in females than in male rice farmers (40.44) ($P<0.01\chi^2$; = 77.512; df=1). Prevalence of urinary schistosomiasis among the district also differ significantly ($P<0.01;\chi^2$ = 50.414; df=7).

Table 4.5: Sex specific prevalence and intensity of urinary schistosomiasis amongst rice farmers in eight districts of Kachia Local Government Area of Kaduna State, Nigeria

	Female		Male		Total	Mean intensity		
District	Number examined	Number(%) infected	Number examined	Number(%) infected	Prevalence	Male	Female	Total
Ankwa	43	34(79.07)	01	01 (100)	79.55	33.00	47.41	47.00
Awon	61	50(81.97)	71	37(52.11)	65.91	37.90	48.44	43.97
Agunu dutse	23	14(60.87)	14	05(35.71)	51.35	26.20	42.14	37.95
Doka	01	01(100.00)	38	10(26.32)	28.21	39.20	52.00	40.45
Gumel	17	15(88.24)	25	03(12.00)	42.86	24.67	40.07	37.50
Mazuga	09	05(55.56)	48	21(43.75)	45.61	20.62	36.80	23.73
Kwaturu	50	45(90.00)	25	13(52.00)	77.33	34.85	48.60	45.52
Sabon sarki	35	28(80.00)	03	01(33.33)	76.32	19.00	41.93	41.14
Total	239	192(80.33)	225	91(40.44)	60.99	32.29	45.96	41.56

T value = 0.0002

Table 4.6 represents the epidemiologic association of farmers' gender with the infection of urinary schistosomiasis in Kachia Local Government Area of Kaduna State, Nigeria. Female gender had significant association (Odds ratio (OR) >1; 95CI of Odd ratio>1) with the disease but male gender was not significantly associated with the disease (OR <1;95%CI of OR<1).

Table 4.7 portrays the age specific prevalence of urinary schistosomiasis amongst rice farmers in the sampled population. A total of 239 and 225 of the 464 rice farmers were females and males respectivelly. Of these 192 females and 91 male farmers were infected. Infections ranged from 48(43.53%) in farmers that were 50 years and above to 28 (68.95%) in those aged 11-20years. With the exception of farmers 50 years and above younger age categories had more than 50% prevalence. Prevalence of urinary schistosomiasis amongst the six age categories of rice farmers did not differ significantly ($P > 0.05; \chi^2 = 6.774$; df=5) (Table 4.7)

Table 4.8 represents the intensity of infection in the sampled farmers. Majority (49.47%) of the farmers were heavily infected (> 50 eggs/ 10ml urine), while 21.20% had light infections (< 30 eggs/10ml urine) and 29.33% weremoderately infected (31-49eggs/10ml urine).

Table4.6: Sex specific prevalence of urinary schistosomiasis in farmers in eight districts of Kachia Local Government Area of Kaduna State.

Gender	Number infected	Number not infected	Odds Ratio	95% C.I
Female	192	47	6.02	4.0- 9.1
Male	91	134	0.20	0.1-0.3
Total	283	181		

Table 4.7: Age specific prevalence of urinary schistosomiasis among rice farmers in Kachia Local Government Area of Kaduna State, Nigeria

Age group Years	Number examined			Number infected		
	Female	Male	Total	Female	Male	Total (%)
1-10	2	7	9	1	4	5(55.56)
11-20	19	22	41	16	12	28(68.95
21-30	47	39	86	41	14	55(63.95
31-40	78	64	142	66	28	94(66.20)
41-50	48	53	101	37	16	53(52.48)
50 and over	45	40	85	31	17	48(43.53)
Total	239	225	464	192	91	283(60.99)

Chi-square $\chi^2 = 6.774$ df= 5

P value = 0.238

Table 4.8: Intensity of urinary schistosomiasis in rice farmers in Kachia Local Government Area of Kaduna State, Nigeria

Nature of infection	Number infected	Percent (%)
Ligtht Infection (0-30eggs)	60	21.20
moderate infection (30-49)	83	29.33
heavy infection (above 50eggs)	140	49.47
Total	283	100

Table 4.9 reflects some of the factors that could influence the farmer's risk of exposure to *S. haematobium* infection in the study area. As regards snail perception by the farmer, those who perceived snails as safe and those who had other opinions to snail presence on the rice fields were more infected (124 and 131 respectively) than those who perceived snails as harmful. Perception as safe and others to snail presence on rice field were significantly associated with urinary schistosomiasis (OR>1; 95%CI of OR>1). Rice farmers who were aware of urinary schistosomiasis as a disease (46) were less infected than those who were not aware of the disease(237). Lack of disease awareness was significantly associated with urinary schistosomiasis infection (Odds ratio/OR > 1; 95% CI of OR >1). Rice farmers who relied on stream as source of domestic water (225) were more infected than those that obtained their domestic water from other sources. Use of stream water as domestic water source was significantly associated with urinary schistosomiasis (OR >1; 95% CI of OR >1). Rice farmers who admitted to swimming as mean of water contact in the study area were more infected (230) than those who did not swim(53). Swimming as a water contact behavior was significantly associated with urinary schistosomiasis (OR >1; 95% CI of OR > 1).Rice farmers who utilized gloves and boots as protective wears on the farms (37) were less infected with S. *haematobium*infection than those who did not use these protective wears on the farm (246). None use of protective wears on farms was significantly associated with infection with urinary schistosomiasis (OR >1; 95%CI of OR >1).

Table 4.9 Relationship between some risk factors and occurrence of urinary schistosomiasis amongst rice farmers in Kachia Local Government Area, Kaduna State, Nigeria

Risk Factors	Number of infected farmers	Number of uninfected farmers	Odds ratio value	95% CI
Snail perception				
Safe	124	51	2.0	1.3-3.0
Harmful	28	65	0.2	0.1-0.3
Others	131	65	1.5	1.1-2.3
Awareness				
Aware	46	61	0.4	0.3-0.6
Not aware	237	120	2.6	1.7-4.1
Water source				
Stream	255	113	5.5	3.4-9.0
Others	28	68	0.1	0.0-0.1
Water contact				
Swimming	230	131	1.7	1.1-2.6
No swimming	53	50	0.6	0.4-0.9
Protective clothing				
Gloves and boots	37	136	0.1	0.0-0.1
No gloves and boots	246	45	20.1	12.4-32.6



A



B

Plate 4.1: Photomicrograph of *Schistosoma haematobium*eggs in urine samples under magnification ×10 and ×40 respectively.



A

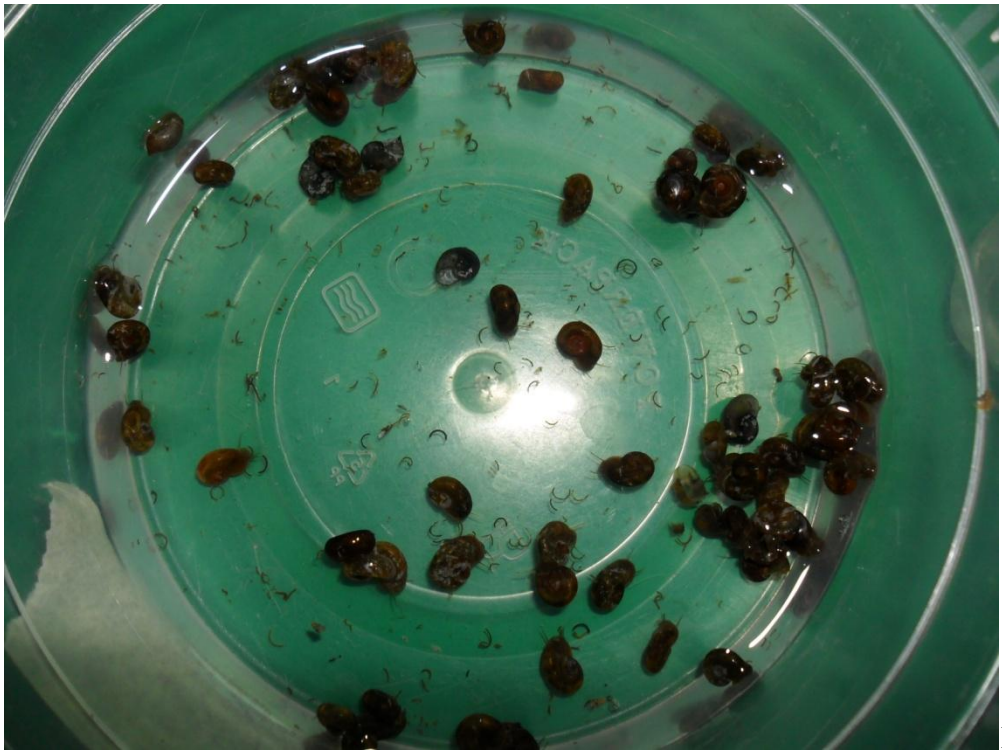


B

Plate 4.2: Photomicrograph of*Schistosoma mansoni* eggs isolated from urine sample in a mixed infection at magnification x40

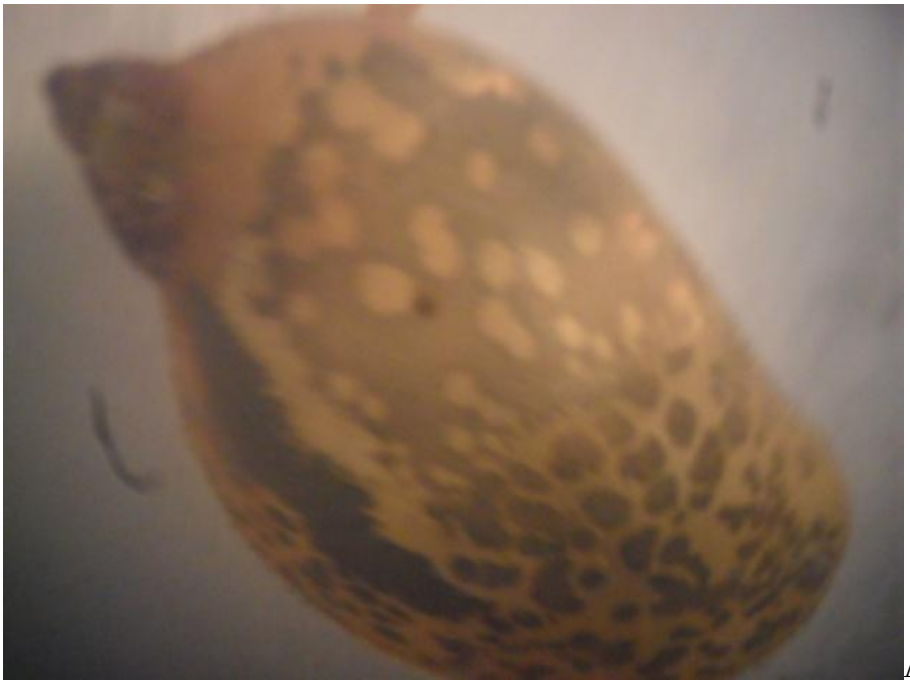


A



B

Plate 4.3 Imagesof *Biomphalaria pfeifferi* under a dissecting microscopeand at camera range respectively.



A



B

Plate 4.4 The images of *lymnaea natalensis*under magnifying lens ×10 and at camera range respectively



A

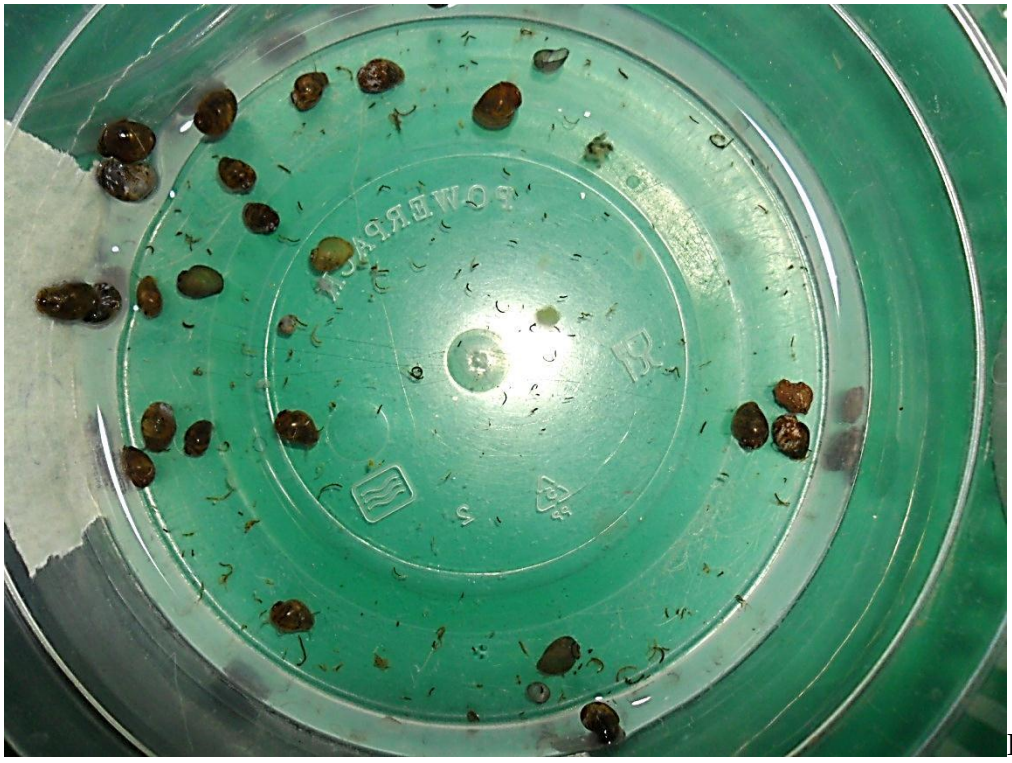


B

Plate 4.5 Images of*Melanoides maculata*at magnification ×10 and at camera range respectively



A



B

Plate 4.6 Images of *Bulinus globosus* at magnification ×10 and at camera range respectively

A

Plate 4.7 Images of *Bellamya crawshay*i at camera range


B

Plate 4.8: Image of*Anodonta marginata*at camera range

CHAPTER FIVE

5.0 DISCUSSION

5.1 Malacology and Urinary Schistosomiasis

This study reveals the occurrence of six species of mainly gastropod mollusc in rice fields within Kachia Local Government Area of Kaduna State, Nigeria. Three of the snails including *Biomphalariapfeifferi*, *Bulinusglobosus* and *Lymnaeanatalensis* are respective intermediate host of medically important trematodes which are *Schistosomamansoni*, *Schistosomahaematobium* and *Fasciolahepatica*(Ntonifor et al., 2007)that are causative agents of intestinal schistosomiasis, urinary schistosomiasis and fascioliasis respectively. Of the three medically important species, *Lymnaea natalensis*had the highest occurrence, followed by the duo of *Biomphalariapfeifferi* and *Bulinus globosus.* This could be interpreted that the three diseases associated with these snails are transmissible within rice field ecosystem in the Local Government Area of Kaduna State, Nigeria. Furthermore it proves that that the three medically important snails are well adapted to the prevailing physicochemical conditions of rice field ecosystem. The occurrence of the snails where physical rice farming activities occurred showed their association with human activities including possible human organic pollution that favorably promotes the transmission of schistosomiasis. This observation is consistent with the findings of Luka *et al*.(2005), whostated that snail intermediate hosts of*Schistosoma*are often associated with human activities with organic pollution. The three other mollusc species encountered in rice fields in this study, *Anodonta marginata*, *Bellamya crawshayi* and *Melanoides maculata* have not been previously implicated as intermediate host of disease agents and are part of the ecological diversity of rice field ecosystem. The exclusive occurrence of *Anodonta*

marginata and *Bellamya crawshayi*in Awon districts of Kachia Local Government Area could be due to itsproximity to the Gurara reservoir where sporadic flooding are known to occur in the rainy season and the possibility of these species to be carried by flood water unto the rice fields. *Bellamya crawshayi* has been classified by the International Union for Conservation of Nature as a threatened species(IUCN 2006). This could explain the rarity of the species in this study. The exclusive occurrence of *Bellamyacrawshayi* at Awon district may be as a result of the constant inflow of fresh water from the reservoir to the rice fields which ensures the constant supply of oxygenated water to the rice field which is key for the survival of this species. The highest abundance by district of mollusc species was found to occur in Awon district (25.3%) this is not unconnected with the year- round supply of water to rice fields and favorable temperatures(28.6°C) both of which has been implicated as factors for the relative high abundance of fresh water mollusc. This finding is in agreement with the report of Opisa*et al.,* (2011).Who reported from his finding that temperature was significantly positively correlated with snail abundance?

This study also revealed that six of the mollusc species obtained were found within the same pH ranges (9.25 – 10.87).With the exception of temperature no water parameter was found to vary significantly across the districts which imply that physicochemical parameters of rice fields across the districts were supportive of mollusc species with the exception of *Bellamyacrawshayi* and *Anodonta marginata* which require other special ecological conditions to thrive.

In this study, prevalence and intensity of infection were significantly higher in female rice farmers. This overt variation in gender based prevalence and intensity could be

due to the cultural practice of indigenous rice farmers in the Local Government Area. Personal interaction with the rice farmers in the districts revealed that women are often confined to the more difficult task of cultivating lowland rice under water logged conditions while their male counterparts paid occasional visits to these rice fields to join and assist in less ardous "male tasks" of farm clearing, herbicides and insecticides applications.This leaves only younger males which are coerced by the women (mostly mothers) to help out at the low land rice fields. The 60.99% overall prevalence of the disease recorded among rice farmers inthis study was higher than the 21% reported amongst nomadic Fulani resident at Dubin Dustse area of Kaduna State by Kawai *et al*.(2011). The disease prevalence obtained in this study was however slightly lower than the 68.6% recorded in Abarma village Gussau by Bala *et al*.(2012). The high prevalence of urinary schistosomiasis amongst rice farmers in Kachia Local Government Area could be due to sustained exposure to the infective parasite stage in rice field ecosystem aided by the high abundance of the *Bulinusglobosus* snail intermediate host on the farms. The high water temperatures in the rice fields (22.2^{o}C – 28.6^{o}C) could also support development of *Bulinus globosus* (snail intermediate host of *Schistosoma haematobium),* andthe intramolluscan stages of the parasite; which could translate into enhanced exposure of rice farmers that make occupational contact with rice water. Maccress and Booth (2014) reported that increasing water temperature enhanced the population dynamic of *Biomphalaria pfeifferi* and the associated transmission of *Schsitosoma mansoni.*

Results of the age specific prevalence of urinary schistosomiasis among rice farmers showed that young farmers aged group 11-20 years had the modaldisease prevalence

(68.95%) (Table 4.7). This could be attributed to the increased water contact activities commonly associated with this age group. It is plausible that farmers within this relatively younger age group make exploratory water contacts through swimming activities and washing in streams in addition to the labour times spent with adults on infested rice fields. Kanwai *et al*. (2011) and Bala *et al*. (2012) made similar submissions in their studies. The 31-40 years age group which had the next highest disease prevalence represented and produced the active farm labour force within the districts and could have been exposed to increased water contacts in infested rice fields thus increasing their chances of infection and reinfection. The age group 50 years and above showed the least disease prevalence which could be attributed to their old age and associated water contact activities capable of reducing infection and reinfection. Bala *et al*., (2012) have also associated reducedtotal worm burden to individuals within this age group.

In this study, 49.47% and 29.33% of the rice farmers examined had heavy (> 50 eggs/ 10ml urines) and moderate (31-50 eggs/10ml urine) urinary schistosomiasis infections respectively (table 4.8). These are pointers to the fact that farmers working in infested rice fields are continuously exposed to repeated infections by the infectivecercariae of *Schistosoma haematobium*. It is therefore found here that rice farming is a high risk occupation as the rice fields provide a suitable environment for survival of *Bulinus*spp. and other snail species and their infection with miracidia of *S.haematobium* and subsequent infection of exposed humans.Urinary schistosomiasis is therefore a disease that needs to be controlled in order to obtain the necessary health relief for sustainable rice production in rural communities.

Farmers who perceived fresh water snail as harmful (OR < 1) had no significant relationship with the disease compared to those who perceived them as safe (OR>1, OR=2.0) and indifferent (OR >1). The latter category had higher odd of acquiring the infection. This is indicative of the role knowledge plays in the prevention of schistosomiasis.Also farmers who were aware of the disease showed no significant relationship with the disease (OR <1) compared to those who were not aware of it who had greater odds (OR =2.6) of acquiring the infection. Water source was found to also play a major role in the distribution of the disease as farmers who drank from stream had higher odds (OR=5.5) for acquiring the disease compared to those who claimed to have used well and bore hole water which showed no significant relationship with the infection (OR <1). This is probably because those who drank from the stream could have been exposed to the risks of ingesting cercariae which could penetrate the mucosal lining of the mouth and cause infection and or re-infection. Water contact have again been significantly associated with the disease in this study as those who claimed to have engaged in swimming activities had higher odds (OR >1, OR=1.7) for acquiring the infection compared to those who did not swim (OR= 0.11).Swimming activities expose a large body surface to water and in infested water, make it possible for cercariae penetration, creating avenues for infection and re-infection. More than half (62.7%) of the entire study population claimed not to use protective wears during farm work while only 37.3% admittedto have usedprotective wears on rice farms. Results indicated that those who did not use protective wears had higher odds (OR = 20.1) of acquiring infections than those who used protective wears (OR = 0.11) (table 4.9). The failure of rice farmers to use protective wears could have further enhanced their infection by skin- penetrating cercariae while working on rice fields. Some of the

farmers who failed to use protective wears on the farms blamed their decision on the inconvenience such wears create during farm work. These included the excuse that farm wears hamper movement in water-logged rice fields. Even some of those who attested to using protective wears admitted to taking them off before getting into the rice fields to allow for easy movement.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 Conclusion:

The study showed that freshwater mollusc such as *Anodonta marginata, Bellamya crawshayi, Biomphalaria pfeifferi, Bulinus globosus,Lymnaea natalensis,and Melanoides maculata,occurred on* rice farms in Kachia Local Government Area of Kaduna state at 2.86%, 3.47%, 16.53%, 16.33%, 26.12% and 34.69% levels of abundance respectively. .*Anodonta marginata* and *Bellamya crawshayi* were found exclusively at Awon district. The molluscs obtained showed 0% infection ratewith cercariae of *schistosoma* species when exposed to artificial light and were presumed to be either habouring earlier stages of the species oruninfected.Molluscabundance was correlatedpositively and significantly with water temperature.With the exception of pH which had negative correlations with snail abundance, the duo of totaldissolved solid and electrical conductivity was correlated positively but insignificantly with snail abundance.The overall prevalence of urinary schistosomiasis amongst the rice farmers within the study area 60.99%,heavy infection accounted for 49.47% of the total infection, moderate infection accounted for 29.33% while light infection accounted for 21.20%.The distribution and prevalence of urinary schistosomiasis in rice farmersamong the districts ranged between 28.21% in Doka district to79.55% in Awondistrict. Prevalence of urinary schistosomiasis in Females (80.33%) was significantly higher ($P<0.01$) than males (40.44%). significant association was found between risk factors and the disease.

6.2 Recommendation:

Appropiate mass chemotherapy should be embarked upon by the state medical organisations, federal medical organization, hospitals and NGOs to halt the alarming high prevalence of urinary schistosomiasis among rice farmers in the study location.

Awareness creation and public enlightenment campaigns should be organized in rural areas to educate the people on the causes, effects and potential dangers of schistosomiasis; this will go a long way in addressing the issues of high prevalence among rural settlers engaged in rice farming occupation.

Effective mollusc species- specific molluscicides should be made available to rice farmers for the elimination of snail intermediate host of *Schistosoma*species so as to break the parasites' life cycle and halt its transmission within rice agro-ecosystem.

Focal research in relation of this should be carried out on other agrarian communities in parts of Nigeria to determine the extent of schistosomiasis problem in relation to rice cultivation.

REFERENCES

Augusto, G., Magnussen, P., Kristensen, T. K., Appleton, C. C.and Vennervald, B. J. (2009). The influence of transmission season on parasitological cure rates and intensity of infection after praziquantel treatment of *Schistosomahaematobium*-infected schoolchildren in Mozambique. *Parasitology,* 136(13): 1771–1779.

Bala, A.Y., Ladan, M. U. and Mainasara, M. (2012). Prevalence and intensity of urinary schistosomiasis in Abarma village, Gusau, Nigeria: a preliminary investigation *Science World Journal,* 7(2).

Bethony, J., Williams, J. T. and Kloos H.(2001). Exposureto *Schistosomamansoni* infection in a rural area inBrazil. II: Household risk factors. *Tropical Medicine and International Health,*6: 136‑145.

Brouwer, C. K., Ndhlovu, P. D., Wasatsuma, Y., Munatsi, A. and Shiff, C. J. (2003a). Urinary tract pathology attributed to *Schistosoma haematobium*: does parasite genetics play a role? *American Journal of Tropical Medicine and Hygiene*, 68: 456-462.

Brouwer, K. C., Ndhlovu, P. D., Wagatsuma, Y., Munatsi, A. and Shiff, C. J. (2003b). Epidemiological assessment of *Schistosoma haematobium* – induced kidney and bladder pathology in rural Zimbabwe. *Acta Tropica,* 85: 339-347.

CDC. (2011). The Burden of Schistosomiasis (Schisto, Bilhazia, snail fever). *Global health Division of parasitic disease and Malaria*.

Cheesbrough, M. (1999). *District Laboratory Practice in Tropical Countries*, Cambridge low price edition. Part 1. Cambridge University Press. Cambridge.

Cheesbrough,M. (2009).*District Laboratory Practice in Tropical Countries*. 2nd Edition updated. Cambridge University Press, Cambridge. Pp. 236-239.

Chidozie, E.U. and Duniyan, S. Y. (2008).Epidemiological survey of urinary schistosomiasis among children in selected schools: A preliminary study in Minna, Nigeria. *AfricanJournal of Biotechnology*, 7 (16): 2773-2776.

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

Chitsulo, L., Lengeler, C. and Jenkins, J. (1995). *TheSchistosomiasis Manual: A Guide for theRapid Identification of Communities with aHigh Prevalence of Urinary Schistosomiasis forDistrict Health Management Teams.* World Health Organization, Geneva, Switzerland

Colley, D. G., Binder, S.and Campbell, C.(2013). A five-country evaluation of a point-of-care circulating cathodic antigen urine assay for the prevalence of *Schistosoma mansoni*. *American Journal of Tropical Medicine and Hygiene,* 88(3): 426–432.

Danso-Appiah,A., Garner, P., Olliaro, P. L. and Utzinger, J. (2009). Treatment of urinary schistosomiasis: methodological issues and research needs identified through a Cochrane systematic review. *Parasitology*, 136(13): 1837–1849.

Degremont, A., Burki, A., Burnier, E., Schweizer, W., Meudt, R. and Tanner, M. (1985).Value of ultrasonography in investigating morbidity due to S*chistosomahaematobium* infection. *Lancet*, 1: 662- 665.

Fenwick, A. (2006). Water-borne infectious diseases–could they be consigned to history? *Science*, 313: 1077–1081.

Fisher R. A. (1935). The logic of inductive inference (with discussion). *Journal of Royal Statistical Society*, 98:39-82.

Gryseels, B. and De Vlas, S.J.(1996).Worm burdens in schistosome infections. *Parasitology Today*, 12: 115–119.

Gryseels, B. and Nkulikyinka, L. (1988). The distribution of *Schistosomamansoni* in the Rusizi plain (Burundi). *Annalsof Tropical Medicineand Parasitology*, 82: 581–590.

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

Hotez, J. P., Brindley, J. P., Bethony, M. J., King, H. C., Pearce, J. E. and Jacobson, J. (2008).Helminth infections: The great neglected tropical disease. *American Society for Clinical Investigation*, 118 (4): 1311-1321.

Hotez, P. J., Bundy, D. A. P. and Beegle, K. (2006). Helminth infections: soil-transmitted helminth infections and schistosomiasis. In: *Disease Control Priorities in DevelopingCountries*. (Jamison, D. T., Breman, J.G.and Measham, A. R.(Eds)) The World Bank Group, Washington, District of Columbia, United States of America. Pp. 467–482.

IARC. (1994). Schistosomes, liver flukes and *Helicobacterpylori*. IARC Working Group on the Evaluation ofCarcinogenic Risks to Humans. Lyon, 7‑14 June 1994.*IARC Monograph on the Evaluation of Carcinogenic Risks to Human*, 61: 1‑241.

IUCN. (2006). *The IUCN Red List of Threatened Species*. Version 2006.3. http//www.iucnredlist.org/

Jordan, P.and Webbe, G. (1963) Epidemiology. In: Humanschistosomiasis. (Jordan, P., Webbe,G. and Sturrock, R. F, (Eds)).Wallingford, UK, Pp. 87-158.

Kanwai, S., Ndams, I. S., Kogi, E., Gyem, Z. G. andHena, J. S. (2011).Urinary schistosomiasis infection in Dumbin Dutse, Igabi Local Government Area, Kaduna State, Nigeria. *Science World Journal,* 6 (2): 15-19.

Kariuki, H. C., Madsen, H. and Ouma, J. H. (2013).Long term study on the effect of mollusciciding with niclosamide in stream habitats on the transmission of *schistosoma mansoni* after community-based chemotherapy in Makueni district, Kenya. *Parasites and Vectors,* 6(1); 107.

King, C. H., Olbrych, S. K., Soon, M., Singer, M. E., Carter, J. and Colley, D. G. (2011). Utility of repeated praziquantel dosing in the treatment of schistosomiasis in high-risk communities in Africa: a systematic review. *PLoS Neglected Tropical Disease*, 5(9): e1321.

Knopp, S., Mohammed, K. A. and Ali, S. M. (2012).Study and implementation of urogenital schistosomiasis elimination in Zanzibar (Unguja and Pemba islands) using an integrated multidisciplinary approach. *BMCPublic Health,* 12(1): 930.

Knopp, S., Person, B. and Ame, S. M. (2013). Elimination of schistosomiasis transmission in Zanzibar: baseline findings before the onset of a randomized intervention trial. *PLoS Neglected Tropical Disease,* 7(10):e2474.

Lengeler, C., Makwal, J., Nqimbi, D. and Utzinger, J. (2000). Simple questionnaires can map both *Schistosomamansoni* and *Schistosomahaematobium* in the Democratic Republic of Congo. *Acta Tropica,*74(1):77-87.

Leutscher, P. D., Reimert, C. M. and Vennervald, B. J.(2000). Morbidity assessment in urinary schistosomiasis infection through ultrasonography and measurement of eosinophil catianic protein (ECP) in urine. *Tropical Medicine and International Health,* 5: 88-93.

Luka, S. A., Ajogi, I., Audu, P. A. and Umoh, J. U. (2005). Ecology of the intermediate snail host of schistosomiasis in Lere Local Government Area, Kaduna State, Nigeria. *Journal of Pest, Disease and Vector Management*, 6: 398-403.

Maccress, N. and Booth, M. (2014). The effects of increasing water temperature on *Schistosomamansoni* transmission and *Biomphalariapfeifferi* population dynamics; an agent- based modeling study. *Plos One Journal,*9;7.

McCullough, F. S. (1981). Biological control of the snail intermediate hosts of human*Schistosoma* spp.: a review of its present status and future prospects. *Acta Tropica,* 38(1): 5–13.

McManus, D. P. and Loukas, A. (2008). Current status of vaccines for schistosomiasis. *Clinical Microbiological Review,* 21: 225–242.

Montresor, A., Crompton, D. W. T., Hall, A., Bundy, D. A. P. and Savioli, L. (1998).*Guidelines for theEvaluation of Soil-Transmitted Helminthiasisand Schistosomiasis at Community Level*. World Health Organization, Geneva, Switzerland

Mott, K. E., Desjeux, P. and Moncayo, A. (1990). Parasitic diseases and urban development. *Bulletin of the World Health Organisation,* 68: 691–698.

Nagi, M. A., Mubarak, D. S. and Barmashmoos, S. A. (1999). Epidemiological, clinical and haematological profile of schistosomiasis in Yemen. *Journal of the American Medical Association,* 5(1):177-181.

N'Goran, E. K., Utzinger, J. and N'Guessan, A. N. (2001).Reinfection with *Schistosomahaematobium* following school-based chemotherapy with praziquantel in four highly endemic villages in Côte d'Ivoire. *Tropical Medicine and International Health,* 6(10): 817–825.

Nmorsi, O. P. G., Ukwandu, N. C. D., Ogoinja, S., Blackie, H. O. T. and Odike, M. A. C. (2007). Urinary tract pathology in some *Schistosomahaematobium* infected Nigerians. *African Journal of Biotechnology*, 6(2): 123-127.

NPC (2006). National population commission's population figures for Nigeria states for 2006 population and housing census. www.june12post/national-population-commission-population-figures-for-nigeria-states-for-2006. cited 21/05/2015.

Ntonifor, H. N. and Ajayi, J. A. (2007). Studies on the Ecology and distribution of some medically important freshwater snail species in Bauchi State, Nigeria. *African Journals Online,* 3(2): 121-127

Peters, P.A., Mahmoud, A. A., Warren, K. S., Ouma, J. H. and Siongok, T. K. (1976).Field studies of a rapid, accurate means of quantifying *Schistosoma haematobium* eggs in urine samples. *Bulletin of the World Health Organisation,* 54(2): 159–162.

Quinnell, R. J. (2003). Genetics of susceptibility to human helminth infection. *International Journal of Parasitology*, 33(11):1219-1233.

Rumnajek, F. D. (1987). Biochemistry and physiology. In: *The biology of Schistosomes.* (Rollinson, D., Simpson, A. J. D. (Eds)). Academic Press,London, UK,Pp. 163-183.

Savioli, L., Hatz, C., Dixon, H., Kisumku, U. M. and Mott, K. E. (1990). Control of morbidity due to*Schistosomahaematobium* on Pemba Island: egg excretion and haematuria as indicators of infection. *American Journal of Tropical Medicine and Hygiene,* 43: 289-295.

Selpha, O., Maurice, R. O., Walter, G. Z. O. J., Karanja, D. M. S. and Mwinzi,P. N. M. (2011). Malacological survey and geographical distribution of vector snails for schistosomiasis within informal settlements of Kisumu City, western Kenya.*Parasite and Vectors*, 4(1): 226.

Shadab, H. A. (2014). Schistosomiasis treatment and management. *Med Scape.*

Soulsby, E. J. L. (1982). *Helminths, Arthropods and Protozoa of Domesticated Animals.* 7th Edition. English Language Book Society and Baillere Tindal, London. Pp. 763-772.

Standley, C. J., Adriko, M., Arinaitwe, M., Atuhaire, A., Kazibwe, F., Fenwick, A., Kabatereine, N.B. and Stothard, J. R.(2010). Epidemiology and control of intestinal schistosomiasis on the Sesse Islands, Uganda: integrating malacology and parasitology to tailor local treatment recommendations. *Parasite and Vectors,* 3:64.

Standley, C. L., Wambo, N. J. S., Lange, C., Kariuki, H., Adriko, M. and Stothard, J.(2010). Performance of circulating cathodic antigen (CCA) urine-dipsticks for rapid detection of intestinal schistosomiasis in schoolchildren from shoreline communities of Lake Victoria. *Parasite and Vectors,* 3(1): 7.

Stensgaard, A.S., Jorgensen, A., Kabatereine, N. B., Rahbek, C. and Kristensen, T. K.(2006). Modeling freshwater snail habitat suitability and areas of potential snail-borne disease transmission in Uganda. *Geospatial Health,* 1:93-104.

Stete, K., Krauth, S. J. and Coulibaly, J. T. (2012).Dynamics of *Schistosoma haematobium* egg output and associated infection parameters following treatment with praziquantel in school-aged children. *Parasite and Vectors,* 5: 298-303.

Sturrock, R. F. (1995). Current concepts of snail control. *Memorias do Instituto Oswaldo Cruz,* 90(2): 241–248.

Sturrock, R. F. (1989)Schistosomiasis: complimentary snail control in chemotherapeutic based control programmes. In: *Parasitic Diseases:Treatment and Control*. (Miller, M. J. and Love, E. S. (Eds)). CRC Press, Baton Rouge, USA, Pp. 51–60.

Ugochukwu, D. O., Onwuliri,C. O. E., Osuala, F.O.U., Dozie, I.N.S., Opara, F.N. and Nwenyi, U. C. (2013). Endemicity of schistosomaisis in some parts of Anambra State, Nigeria. *Journal of Medical Laboratory and Diagnosis*, 4(5): 54-61.

Uneke, C. J., Oyibo, P. G., Ugwuoru, C.D.C., Nwanokwai, A. P. and Iloegbunam, R. O. (2007).Urinary schistosomiasis among school age children in Ebonyi State, Nigeria. *The Internet Journal ofLaboratory Medicine*, 2(1):1.

USAID (2014). Neglected tropical diseases. www.neglected tropical disease.gov.com

Webster, B. L., Southgate, V. R. and Littlewood, D. T. (2006). A revision of the interrelationships of *Schistosoma* including the recently described *Schistosomaguineensis*. *International Journal ofParasitology*, 36: 947–955.

WHO (1983). *The role of mollusciciding Inschistosomiasis control.* World Health Organization, Geneva, Switzerland

WHO (1993). *The control of schistosomiasis. WHO Tech. Rep. Ser*. 830, 1–86.

WHO (1995).The Red Urine Study Group. Identification of High-Risk Communities for Schistosomiasis inAfrica: A Multicountry Study. *World Health Organization, Geneva, Switzerland.*

WHO (1999). Report of the WHO informal consultation on schistosomiasis control. Geneva, 2-4 December 1988. Geneva: *World Health Organization*.

WHO (2002).Prevention and control of schistosomiasis and soil-transmitted helminthiasis: report of a WHO expert committee. *WHO Tech. Rep. Ser.* 912, 1–57

WHO (2007). Microbiology notes:Schistosomiasis.*Division of Control of Tropical Disease.*WorldHealthOrganization.

WHO (2004). Assessment of the age- specific disability of chronic schistosomiasis *japonicum*. *Bulletin of the World Health Organization*, 85(6) 421-500

Wilkins, H. A. (1987). The epidemiology of schistosome infections in man. In: *The biology of Schistosomes.*(Rollinson, D. and Simpson, A. J. D.(Eds)). London, UK: Academic Press, Pp. 379-397.

Wright, C. A. (1988). A note on the ecology of some molluscan intermediate hosts of African schistosomiasis. *Annals of Tropical Medicine and Parasitology*,40:149-152.

APPENDICES

Appendix I Sample questionnaire

DEMOGRAPHIC DATA

1. Gender male( ) female ( )

2. Age 1-10 ( ) 11-20 ( ) 21-30 ( ) 31-40 ( ) 41-50 ( ) above 50 ( )

3. Farming experience 6-10 ( ) 11-15 ( ) 15-20 ( ) 21-25 ( ) 26-30 ( ) 31-35 ( ) 36-40 ( ) above 40 ( )

4. District/ village _____

RISK BEHAIVIOURS

1. Swimming activities yes ( ) No ( )

2. Do you drink from the stream or river? Yes ( ) No ( )

3. Do you urinate/ deficate in the farm? Yes ( ) No ( )

4. Do you wear protective clothing while farming yes ( ) No ( )

5. Reasons lack of finance ( ) farming convenience other reasons ( )

KNOWLEDGE AND PERCEIVED RISK

1. Have you heard about schistosomiasis? Yes ( ) No ( )

2. Do you know about water snails? Yes ( ) No ( )

3. What is your perception about them harmful ( ) safe ( ) indifferent ( )

Appendix 1I: Relative abundance of mollusc species (ANOVA)

Source of variation	Sum of square	Df	Mean of square	f-statistic	P value
Between groups	2338.51	5	467.703	10.3116	0.00000169
Within groups	1905	42	45.3572		
Total	4243.51	47			

Appendix III Distribution of mollusc populations amongst districts (ANOVA)

Source of variation	Sum of squares	Df	Mean square	F- statistic	P- value
Between groups	898.674	7	128.382	1.53472	0.183628
Within groups	3346.07	40	83.6518		
Total	4244.74	47			

Appendix IV: ANOVA table of pH/species

Source of variation	Sum of square	Df	Mean square	F- statistic	P value
Between groups	0.500175	5	0.100035	0.558742	0.731077
Within group	10.3841	58	0.179036		
Total	10.8843	63			

Appendix V: ANOVA table ofTemperature/ species

Source of variation	Sum of square	Df	Mean square	F-statistic	P value
Between group	39.2542	5	7.85083	0.068199	0.07613
Within groups	208.438	58	3.59376		
Total	247.692	63			

Appendix VI: ANOVA table of TDS/ species

Source of variation	Sum of square	Df	Mean square	F-statistic	P value
Between groups	46.374	5	9.2748	0.994187	0.95645
Within groups	6260.7	58	107.943		
Total	6307.07	63			

Appendix VII: ANOVA table of Electrical conductivity/ species

Source of variation	Sum of square	Df	Mean square	F stat	P value
Between groups	141.574	5	28.3148	0.99544	0.96422
Within group	21198.3	58	365.488		
Total	21339.9	63			

Appendix VIII: **Prevalence of haematuria in urine amongst infected rice farmers**

	Number	Percent
ABSENT	266	93.99
PRESENT	17	6.01
Total	464	100

Appendix IX: Prevalence of single and double infection among rice farmers

	SINGLE	260
	DOUBLE	23
Total		283

Appendix X: **Correlation matrix between water parameter of rice fields and mollusc abundance in Ankwa district**

Water parameters	P.H	D.s	temp	electrical conductivity	total snail abundance
P.H	1				
D.s	-1	1			
Temp	-1	1	1		
electrical conductivity	-1	1	1	1	
total snail abundance	-1	1	1	1	1

Appendix XI: **Correlation matrix between water parameter of rice fields and mollusc abundance in Awon district**

Water parameters	P.H	D.s	temp	electrical conductivity	total snail abundance
P.H	1				
D.s	-1	1			
Temp	1	-1	1		
electrical conductivity	-1	1	-1	1	
total snail abundance	1	-1	1	-1	1

Appendix XII: **Correlation matrix between water parameter of rice fields and mollusc abundance in Agunu dutse district**

Water parameters	P.H	D.s	temp	electrical conductivity	total snail abundance
P.H	1				
D.s	1	1			
Temp	-1	-1	1		
electrical conductivity	1	1	-1	1	
total snail abundance	-1	-1	1	-1	1

Appendix XIII: **Correlation matrix between water parameter of rice fields and mollusc abundance in Doka district**

Water parameters	P.H	D.s	temp	electrical conductivity	total snail abundance
P.H	1				
D.s	-1	1			
Temp	1	-1	1		
electrical conductivity	-1	1	-1	1	
total snail abundance	1	-1	1	-1	1

Appendix XIV: **Correlation matrix between water parameter of rice fields and mollusc abundance in Gumel district**

Water parameters	P.H	D.s	temp	electrical conductivity	total snail abundance
P.H	1				
D.s	-1	1			
Temp	-1	1	1		
electrical conductivity	-1	1	1	1	
total snail abundance	1	-1	-1	-1	1

Appendix XV: **Correlation matrix between water parameter of rice fields and mollusc abundance in Mazuga district**

Water parameters	P.H	D.s	temp	electrical conductivity	total snail abundance
P.H	1				
D.s	-1	1			
Temp	-1	1	1		
electrical conductivity	-1	1	1	1	
total snail abundance	-1	1	1	1	1

Appendix XVI: **Correlation matrix between water parameter of rice fields and mollusc abundance in Kwaturu district**

Water parameters	P.H	D.s	temp	electrical conductivity	total snail abundance
P.H	1				
D.s	-1	1			
Temp	-1	1	1		
electrical conductivity	-1	1	1	1	
total snail abundance	-1	1	1	1	1

Appendix XVII: **Correlation matrix between water parameter of rice fields and mollusc abundance in Sabon Sarki district**

Water parameters	P.H	D.s	temp	electrical conductivity	total snail abundance
P.H	1				
D.s	-1	1			
Temp	-1	1	1		
electrical conductivity	-1	1	1	1	
total snail abundance	-1	1	1	1	1

Appendix XVIII: Independent T-test for sex specific intensity across the district

	male	*female*
Mean	29.43	44.67375
Variance	61.25	26.84279821
Observations	8	8
Pooled Variance	44.05	
Hypothesized Mean Difference	0	
Df	14	
t Stat	-4.59	
P(T<=t) one-tail	0.0002	
t Critical one-tail	1.76	