EPIDEMIOLOGICAL STUDIES OF SCHISTOSOMIASIS IN JOS SOUTH   LOCAL GOVERNMENT AREA, PLATEAU STATE, NIGERIA

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CERTIFICATION

This is to certify that the research work for this thesis and the subsequent preparation of this thesis by Mr. Herbert Obi Okpala (PGNS/UJ/14167/O2) were carried out under our supervision.

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DECLARATION

I hereby declare that this work is the product of my own research efforts; undertaken under the supervision of Professor J.A.Ajayi and professor (Mrs.) N.N.James-Rugu and has not been presented elsewhere for the award of a degree or a ceftificate. All sources have been duly distinguished and appropriately acknowledged.

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DEDICATION

I dedicate this work to God the Father Almighty, my Wife, Mrs. Ify. Okpala and all my children.

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Abstract

Schistosomiasis is a helminthic disease that affect many people all over the world causing illnesses that prevent people from farming and performing other activities, and at times gives rise to malignancies which are fatal. Between 1999 and 2004, some aspects of the epidemiology of schistosomiasis, were studied among 3190 inhabitants of Dogon-Karfe (the boundary with Jos North Local Government Area), Gigiring, Anglo-Jos Bukuru, Vom, Zawan, Mararaba-Jama'a and Farin-Lamba, all in Jos South Local Government Area, Plateau State Nigeria. Their faeces and urine were examined microscopically for eggs of schistosomes. The faecal samples were prepared using the method described by Allen and Ridley (1970) while the urine samples were prepared using the method of Dazo and Biles (1974). Thirteen (13) (0.20%) of the entire volunteers had eggs of schistosome in their stool and 8(0.13%) recorded presence of eggs in their urine samples. The streams and irrigation systems within the area were surveyed for the intermediate hosts (snails). The snail vectors were examined for cercariae by exposure to sunshine for 30 minutes. Of the 1081 snails collected from these streams only 85(7.86%) excreted cercariae. The difference in infection of the snails by cercariae in different sites were statistically significant ($P<0.05$). Infection rates of individuals in different age groups by schistosomiasis, infection rates of individuals using different types of water supply (bore hole, pipe- borne, and stream) by schistosomiasis and infection rates of individuals using different types of toilet facilities (water closet system, pit and bush), by schistosomiasis were statistically significant ($P<0.05$). The differences in infection rates of the sexes, individuals in different religious groups, individuals in different occupational groups by schistosomiasis, infection rates of individuals within the seasons (wet and dry) by schistosomiasis and the infection rates of individuals in the different locations by schistosomiasis were not statistically significant ($P>0.05$) in all. All the infected snails were *Lymnea natalensis* while the other species, *Bulinus globosus* and *Biomphalaria pfeifferi* which were also encountered during the study were not all infected by cercariae. Water quality parameters pH, conductivity, alkalinity, temperature, and dissolved oxygen were measured in the surveyed streams. The water quality seemed to have effect on the infectivity of the snails as out of the 1081 snails collected only 85 *Lymnea* species from Vom/ National Institute for Policy and Strategic Studies, Kuru stream with lowest pH of 5.5, and dissolved

oxygen content of 5.0mg/L^{-1} were found infected while 772 snails collected from other streams with higher values of these parameters were not infected. No snail intermediate host was seen in all the irrigation systems surveyed. From the results obtained, schistosomiasis was not endemic in the study area. Of other parasites encountered during the study, *Entamoeba coli* had the highest prevalence 358 (11.22%) followed by *Entamoeba histolytica,* 266 (8.34%) and the least *Trichomonas vaginalis,* 8(0.25%) among the *Protozoa* while among the other helminthes, hookworms had the highest prevalence of 393 (12.32%) followed by *Ascaris lumbricoides,* 192 (6.02%), *Trichuris trichiura,* 8(0.25%) and the least *Enterobius vermicularis,* 6 (0.19%). From the study, there is a declining prevalence of schistosomiasis in the study area.

CHAPTER ONE

INTRODUCTION

1.1   BACKGROUND

Schistosomiasis, also known as bilharziasis, is a parasitic disease affecting about 200 million people and poses a threat to 500 to 600 million people in more than 76 countries in Asia, Africa, the Carribean and Latin America (WHO, 1993). Schistosomiasis is the most widely spread helminthic infection with very high morbidity rate – about 20 million cases, causing severe debilitating illnesses in millions of people (Bisseru, 1984; UNDP/World Bank/WHO, 1997 and   Chitsulo, Engels, Monstrsor, and Savioli, 2000). Schistosomiasis, after malaria, is the second most important tropical disease and one of the main occupational hazards encountered in rural farming populations and the most prevalent among water-based parasitic infections (Morel, 2000).

The transmission of schistosomiasis is associated with water development projects such as dams for irrigation systems and fish-farming, as the snail intermediate hosts of the parasites breed in them and human water contact (Klump and Webbe, 1987 ; WHO, 1989). Schistosomiasis, being a water-based disease is spread through contact with water in which snails harbouring and shedding the infective stage (cercariae) of the parasite (schistosome) are present (Costa de Limae, Pocha, Filhocoura, and Katz (1993).   The role played by various epidemiological factors in the transmission and level of infection has been studied in various locations using a variety of methods. Among such factors are distance from the transmission site, migration and emergence of new foci, urbanisation, socio-economic status, sanitation, water supply patterns and level of disposal of human wastes – faeces and urine (Feachen, 1983).

According to Dorland (1968), epidemiology may be viewed as based on two fundamental assumptions; first that human disease does not occur at random and second that human disease has causal and preventive factors that can be identified through systematic investigation of different populations or sub-groups of individuals within a population in different places or at different times. This leads to a useful and comprehensive definition of epidemiology as the study of the relationships of various factors determining the frequency and distribution of diseases in the human community (Dorland,1968) or the field of medicine dealing with the determination of specific causes of localised outbreaks of infection, toxic poisoning or other diseases of recognised aetiology (Dorland,1968).

1.2   STATEMENT OF THE PROBLEM

Schistosomiasis affects many communities especially the local farmers in Jos South Local Government Area causing illnesses and lithargy that prevent people from farming, attendance to schools and performing other activities, and at times gives rise to malignancies which are fatal.

1.3   AIM AND OBJECTIVES

The streams surveyed in the study area harboured the snail hosts of schistosomes and most of the inhabitants of the area dispose their urine and stool indiscrimately on the environment including the vicinities of the water bodies. Children, farmers and some other inhabitants visit the streams for one water contact activity or the other. These epidemiological factors were supposed to bring about increase in the prevalence of the disease in the Local Government Area, but the reverse was the case as reported in patients who attended surrounding hospitals and clinics.

Aim

To determine the true picture of the disease – schistosomiasis in the Local Government Area and the factors contributing to its spread.

Specific Objectives

1.   To determine the prevalence of schistosomiasis in the inhabitants.

2.   To assess the relationship between physico-chemical factors and occurrence and distribution of snail intermediate hosts of schistosomes.

3.   To determine some factors influencing the transmission and spread of schistosomiasis in the study area.

4.   To assess the effect of water contact activities on the infection rate of schistosomiasis.

1.4   HYPOTHESIS

Null hypothesis (Ho): There is marginal (Meso-endemic) increase in the Prevalence of schistosomiasis in Jos South Local Government Area.

1.5   SIGNIFICANCE OF THE STUDY

Several factors, such as cultural, social, environmental and behavioural, directly influence the prevalence and intensity of schistosomiasis. It is important that these factors be identified to aid designing control programmes. In several areas in Nigeria, there is complete lack of knowledge on the factors associated with schistosomiasis transmission. Environmental conditions and sewage disposal are deplorable, indiscriminate defaecation and urination is very common, the literacy level is low, and safe/portable water is greatly inadequate with consequent effects on the community health. Jos South Local Government Area is a victim of most of the above, if not all. These conditions were supposed to cause increase in the prevalence of schistosomiasis in the study area but instead there was decrease in

the prevalence of the disease, as observed from results in some hospitals and clinics in the Local Government Area from 1985 to 1998. Some of the streams in the Local Government surveyed before the study harboured snail hosts of schistosomes. In view of the above, we decided to go into this study, epidemiological studies of the disease, schistosomiasis, to ascertain the true picture of the disease in the Local Government Area, presently.

1.6   HISTORY OF SCHISTOSOMIASIS

Schistosomiasis, caused by a trematode helminth, is present in different parts of the world and variously distributed. The causative agent has however only relatively been identified but the symptoms of the disease have been recognised a very long time ago. The most obvious sign of urinary schistosome is blood in urine. This attracted the ancient Egyptians who described the disease as 'a-a-a' disease (Belding ,1965). *Schistosoma haematobium* was the first to be described by a German Pathologist, Theodore Maximilian Bilharz in 1851 during an autopsy in an Egyptian patient and the popular name for all forms of schistosomiasis is 'bilharziasis' in honour of his discovery. Until 1906 it was assumed that *Schistosoma mansoni* was represented by the two species *Schistosoma haematobium* and *Schistosoma japonicum*. It had however been noted by Sir Patrick Manson, a Physician to the Seamen's Hospital in Greenwich that the eggs passed in the urine from schistosomiasis patients were all terminally spined while only those found in the faeces had the lateral spine Belding,1965). He then speculated that possibly there are two species of bilharzia, one with lateral spined ova depositing its eggs in the rectum only, the other haunting the rectum and bladder differently. The presence of the two types of spined eggs, and of two clinical forms of the disease, the vesical and the intestinal, caused considerable confusion until Sambon, in 1907 demonstrated

the existence of two species, *Schistosoma haematobium* and *Schistosoma mansoni*. He gave the name *Schistosoma mansoni* to the worm that produced the eggs with lateral spine. The observations of Sambon and others were confirmed by the experimental work of Leiper in 1915 and later by other investigators (Belding, 1965).

Concurrently with the work carried out by Bilharz in Egypt, other Scientists and Physicians were also becoming aware of this disease, particularly in Japan where in 1847, four years before Bilharz described his new trematode, Yoshinao Fujii, a Physician working in Numakuma County, reported occurrence of *Schistosoma japonicum* in district of Kawanami (Belding,1965). He also noted that the disease was most severe in Katayama district but was also found in other several nearby areas notably Ikariyama District and that it was called 'Katayama' disease. So the first description of Oriental schistosomiasis or 'katayama' disease was made by Fujii (1847). Between 1890 and 1904 Yamagiwa, Kurimoto and Fujinami found the eggs in various organs of human beings at autopsy, and Fujinami (1904) found the eggs in the faeces of patients afflicted with 'katayama' disease (Belding, 1965). Calcified eggs of schistosomes have been found in Egyptian mummies dating from 1200 to 1000 BC (Contis and David, 1996).

The distribution of schistosomes in man is governed by the existence of suitable intermediate molluscan hosts. Korte and Mott (1989) gave an estimate of 90 million people infected in Africa alone and about 100 million others at risk of infection. *Schistosoma haematobium* co-exists with *Schistosoma mansoni* and the distribution of the two species is somewhat confusing. *Schistosoma haematobium* is highly endemic in the Nile Valley, present from Morocco to Egypt on the Mediterranean Coast, in Ethiopia and in the Sudan where it co-exists with *Schistosoma mansoni*. In West Africa, it is more widely disseminated than *Schistosoma mansoni,* occurring in

Senegal, Guinea, Sierra-Leone, Liberia, Ghana, Nigeria, Chad, the Central African Republic, the Congo Republic, Gabon and Angola; also widely distributed in the countries in East Africa, including Madagascar and the Islands of Mauritius (Belding, 1965). *Schistosoma mansoni* is prevalent in the Nile Delta in Egypt, in Sudan, Ethiopia, Libya, Central Africa and East Africa. In West Africa, it is present in Nigeria, Ghana, the Cameroon, Chad, Central African Republic, the Congo and Gabon. It is found in Venezuala, the Guianas, Eastern Brazil, Dominican Republic and Puerto Rico. The distribution of *Schistosoma japonicum* is confined to the Far East-Formosa, Celebes and several Islands of Philippines (Belding, 1965).

The pattern of distribution of schistosomiasis is changing in two opposite directions: the increase of irrigation systems favours its spread and control schemes block its transmission. Water development projects in Africa are essential but often associated with an increase in water-borne diseases such as schistosomiasis. New fresh-water habitats for snail intermediate hosts of schistosomes may be created by construction of dams and irrigation projects. Greater opportunities for water contact lead to increase of both urinary and intestinal schistosomiasis as has been observed in villages along the shores of the Volta (Ghana), Kariba (Zimbabwe), Kainji (Nigeria) and Nasser (Egypt and Sudan) lakes, (Hira, 1969; Paperna, 1969; Hunter, Rey, Adekolu-John and Mott, 1993 and Piequet, Ernould, Vereuysse, Southgate, and Rollinson, 1995).

Humans are the major reservoirs of human schistosomes causing schistosomiasis. Apart from the role of humans as the major reservoirs of infection, other mammals have been incriminated as not less than 38 mammals have been found to be naturally infected by *S. mansoni* (Rollinson, 1987). A review of the situation in Brazil showed that at least 15 specimens of mammals, mostly rodents,

were naturally infected by *S. mansoni* (Rey, 1992). Since 1962, natural *S. mansoni* infections have been found in cattle in Brazil, Sudan and Venezuela (Coelho, Lima, and Nogueira, 1989). Although experimental infections with *S. haematobium* have been achieved in large primates and most recently in hamsters, there is no evidence of natural infection in other mammals (Imbert-Establet, 1992).

CHAPTER TWO

LITERATURE REVIEW

2.1   DISTRIBUTION OF SCHISTOSOMIASIS

Schistosomiasis is widely distributed in the world. The areas affected are the Americas (Brazil, Venezuela and Suriname as well as several Caribbean Islands),the Eastern Mediterranean (Islamic Republic of Iran, Iraq, Saudi Arabia, Syrian Arab Republic and Yemen), Eastern Asia (Cambodia, China, Indonesia, Japan, People's Democratic Republic of China, the Philippines) and some parts of Africa. Like many other parasitic helminths, the distribution and intensity of schistosome infections are variable by locality. This is particularly true with this parasite, mainly due to the strictly limited ecological conditions for habitats of vector snails and conditions of habitats in relation to annual rainfalls, unexpected drought, irrigation projects and industrial activities (Kaneko, Esiaku, Yoshikazu, Hiroshi, Okoronkwo, and Toshiyuki,1991). *Schistosoma haematobium* is found in 53 countries in the Middle East and Africa including the Island of Madagascar and Mauritius. There is also an ill-defined focus of *S. haematobium* in India. Intestinal schistosomiasis is found in 45 countries including the Arabian Peninsula, Egypt, Sudan, Sub-Saharan Africa, Brazil, some Caribbean Islands, Suriname and Venezuela. *S. intercalatum* has been reported from ten countries within the rain forest belt of Central Africa. Two geographically isolated strains of *Schistosoma intercalatum* are recognised, the lower Guinea strain and the Congo strain which differ from each other in a number of characteristics (Jourdane *et al.*, 2001). *S. japonicum* is endemic in China, Indonesia and the Phillipines and has been reported in Thailand. *S. mekongi* is found in Cambodia and Laos along the Mekong River (WHO, 1984).

Fig. 1: Global Distribution of *Schistosoma mansoni*

Source: WHO, 1998.

Key

Endemic Areas

Areas free of *S. mansoni*

Fig. 2: Global Distribution of *Schistosoma haematobium*

Source: WHO, 1998.

Key

■ Endemic Areas

□ Areas free of *S. haematobium*

Fig. 3: Global Distribution of *Schistosoma japonicum*

Source: WHO, 1998.

Key

 Endemic Areas

 Areas free of *S. japonicum*

The global distribution of schistosomiasis has changed significantly in the past 50 years, with control successes achieved in Asia, the Americas, North Africa and Middle East. Schistosomiasis has been eradicated from Japan, transmission has been stopped in Tunisia and very low in Morocco, the Philippines, Saudi Arabia and Venezuela (WHO, 1984). However, environmental changes linked to water resources development, increasing population and population migrations has led to the introduction and spread of the disease to previously low or non-endemic areas, particularly sub-Saharan Africa. The building of the Diama dam on the Senegal River has introduced intestinal schistosomiasis to both Mauritania and Senegal. Refugee movements, and population displacement in the horn of Africa have also introduced intestinal schistosomiasis to Somalia and recently to Djibouti. Despite the progress in control, the disease still remains endemic in 76 developing countries putting more than 600 million people at risk of infection. Over 200 million people are currently estimated to be infected. It is estimated that more than 80% of all these people infected by schistosomiasis live in Sub-Saharan Africa (WHO, 1984).

There are a number of less important species of schistosomes infecting man. *S. intercalatum* is endemic in parts of Zaire, Gabon, Cameroon, with small foci in Central African Republic, Chad, Nigeria, Upper Volta (WHO, 1984).

S. malayensis was recently reported in Malaysia. In addition, a number of animal species accidentally infect man to cause zoonotic infections. These include *S. bovis* infecting cattle, sheep, and goats in Africa, parts of Southern Europe, and Middle East; *S. matthei* infecting cattle, sheep and goats in Central and Southern Africa; *S. margrebowiei* infecting antelope, buffalo, and water buck in Southern and Central Africa; *S. curassoni* infecting domestic ruminants in West Africa and *S. rodhaini* infecting rodents and carnivores in parts of Africa (WHO, 1984).

2.2   SCHISTOSOMIASIS IN NIGERIA

Several isolated studies on the prevalence of the disease in Nigeria have been reported following the extensive survey of the former Northern Nigeria by Ramsey in 1935. According to the legend Blair, (1956), the Fulani tribe of Northern Nigeria brought schistosomiasis with them during their migration from the Upper Nile Basin. The disease, therefore has a long history in Nigeria. It is essentially an infection of rural agricultural communities where rural lifestyle and behaviour encourage the contamination of inland water with human excreta and urine. Until recently, schistosomiasis was not considered a public health problem in Nigeria for two reasons. Firstly, schistosomiasis was restricted to rural communities where hygiene is inadequate, where poverty prevails, where malnutrition and infection with other parasites are common (Coutinbo, Ferreira, Feitas,Silva, Caralcanti and Samica, 1992). Secondly, it is a disease common to school aged children in whom the disease remains silent or mildly asymptomatic for many years. To this end, most previous studies on schistosomiasis in Nigeria were concentrated in rural areas (Arinola, 1995).

According to Cowper (1963), the distribution of *S. haematobium* was described as being almost universal in the North, and patchy elsewhere. *S. haematobium* is probably endemic in the Northern region, and some areas are marked particularly by heavy infection rates. These areas include Katsina, Kano, Zaria, Kaduna, Birnin Kebbi and Argungu. Infection of man by both *S. mansoni* and *S. haematobium* is wide-spread in two of the former regions of Nigeria – West and North, and less in the East. Other parts of the Northern region from which high or fairly high infection rates have been reported are Plateau area, Yola, Biu area, Maiduguri, Potiskum area, the Wulgo area of Lake Chad Basin, the Riverine area

along the Niger from Wawa to Pategi and Bida. Various studies have been carried out to show prevalence and intensity of schistosomiasis in various States in Nigeria (Okpala 1961; Gilles, Lucas, Adeniyi-Jones, Linder, Anand, Braband, Cookshot, Cowper, Muller, Hira, and Wilson, 1965; Abayomi, Oyediran, and Akinkugbe, 1971; Pugh and Gilles 1978; Tayo, Pugh, and Bradley, 1980; Ejezie and Adesemano, 1981; Olusanya, Shonekan, and Odionu, 1984; Ogbe and Olojo, 1989; Awogun, 1990; Anosike, Okafor, and Onwuliri, 1992; Adeoye and Ipeayeda, 1994; Emejulu, Atabaraonye, Ezenwaji, and Okafor, F.G. 1994; Fajewonyomi and Afolabi, 1994; Mafiana and Adesanya, 1994; Adeoye and Akabuogu, 1996 and Ekejindu, L.M., Onyali, I.O., Ozumba, N. A. and Ibe, C.C. 1999). Akogun and Obadiah (1996) also reported that schistosomiasis is common in Nigeria and is especially associated with water related activities. In its geographical distribution in Nigeria, urogenital schistosomiasis is regarded as a disease mainly of the semi and dry savannah region, especially areas where there are irrigation schemes. In Nigeria, the earliest known report of high prevalence of haematuria relates to the dry North (Donges, 1967). There were some reports on the epidemiology in the city area of Ibadan (Akinkugbe, 1962) Investigations indicate that the disease may be increasing in prevalence and importance particularly in the remote poorly accessible rural communities (Amole and Jinadu, 1994; Egwunyenga, Nmorsi, and Omokaiye, 1994 and Abolarinwa, 1999). Dams and irrigation projects which are wide-spread in Nigeria, electric power, as water emanating from the water- flow creates suitable environment for snail breeding and industrial developments have contributed significantly to the spread of schistosomiasis. Ironically, these otherwise beneficial development activities favour increased transmission of water based diseases. Migrants, workers, and herdsmen, who represent a significant number of people in

endemic areas, are both carriers and target for infection. Thus schistosomiasis will be very much a concern for some time in Nigeria.

2.3   SCHISTOSOMIASIS IN PLATEAU STATE

Like many other parasitic helminthes, the distribution and intensity of schistosomiasis are variable by locality, mainly due to the strictly limited ecological conditions for the habitat of the vector snails and changing conditions of habitat in relation to annual rainfalls, unexpected drought, irrigation schemes and other water development projects (Kaneko *et al.,* 1991).

In 1991, the Ministry of Health of old Plateau State (now Nassarawa and Plateau States), carried out a schistosomiasis prevalence survey in some local government areas of the State and obtained the following infection rates - Akwanga Local Government Area, 2.0%, Nassarawa Local Government Area, 15.7% and then Jos Local Government Area (comprising Jos East, Jos North and Jos South Local Government Areas then), 0.9%. From that survey, the overall prevalence of schistosomiasis in the then Plateau State (comprising present Plateau and Nassarawa States) was given as 4.7%. Shiwaku, K., Takahashi, M. and Nwoke, B.E.B. *(*1986) reported a prevalence of 18.9% for *S. mansoni* in Jos.   Kaneko *et al.* (1991) recorded prevalence of 25% among school children in Jos; Okpala, Nwobu, Agba, and Chukwubuike, *(*2002) recorded prevalence of schistosomiasis in school children in Kwall, Bassa Local Government Area as 6.25% and Okoronkwo, Zoakah, and Kpamor, (2003), in their survey of infectious diseases in a drought afflicted community in Northern Nigeria recorded prevalence of urinary schistosomiasis in Jos as 18.3%. Owing to the marked focality of transmission of this disease, and variation in transmission characteristics, new studies are often encouraged with the hope that much of the area can be covered and the areas at risk determined (Anosike *et al.,*

1992).   This infection has attracted and is still attracting numerous surveys and reports.

2.4   SUMMARY OF LIFE CYCLE OF SCHISTOSOMES

People are infected by contact with cercaria-infested water used in normal daily activities such as personal or domestic hygiene, and swimming or by professional activities such as fishing, rice cultivation, and irrigation. Due to lack of information or insufficient attention to hygiene, infected individuals may contaminate water bodies with their faeces or urine containing the eggs of the parasites. The eggs on contact with water, release miracidia which penetrate   intermediate hosts (snail vectors) where thousands of infective cercarial forms are produced.   The cercariae are then excreted by the snails into the water body. These cercariae can penetrate bare skin of man on entering the water body within a few seconds. Within 30 to 45 days the parasites are transformed into male and female worms in the blood venules surrounding the intestine or urinary bladder.   The female lays from 200 to 2000 eggs per day, depending on the species.

The life cycle comprises the passing of the egg from the definitive host, its hatching in water, with the liberation of a free swimming miracidium; penetration of a suitable snail host by the miracidium; the metamorphosis of the larva into primary and secondary sporocysts and cercariae in the snail; the eruption of free swimming cercariae into the water body; the penetration of the skin of man by the cercariae and the migration and growth of the immature worms in the liver and blood venules (Belding, 1965).

Fig.4: Life Cycle of a Parasitic Schistosome of Man. a, man infected with adult worm; b, ovum passed in faeces or urine; c, free swimming miracidium; d, metamorphosis in snail with formation of primary sporocyst, secondary sporocyst and cercariae; e, free swimming cercaria; f, man infected by cercaria in water through skin.

Source: Belding, 1965.

Fig.5: Eggs and Miracidia of Important Schistosomes of Man.
c.g. cephalic gland; e.p., excretory pore; e.t., excretory tubule; f. c., flame cell; g.gut.,
g.c., germinal cells; l.d., lateral duct; l.g., lateral gland; m. mouth., n, nervous system;
n.t., nerve trunk; r.g., refractile globule; vt.m., vetelline membrane; t.s., terminal spine;
l.s., lateral spine; l.k., lateral knob. Source: Belding, 1965.

2.5   PATHOLOGIC EFFECTS OF SCHISTOSOMIASIS

Human schistosomiasis is caused by different species of the trematode or fluke, *Schistosoma*.   Each species may give rise to acute or chronic disease with widely differing symptoms and clinical signs. The different species of schistosome causing schistosomiasis in man have their target organs, for example urinary schistosomiasis has its target organ as the urinary bladder, ureters and kidneys where it induces histopathological bilharziasis and epididymo-testicular bilharziasis in children (Edington and Giles, 1979). Some important clinical signs and symptoms have been described in association with urinary and intestinal schistosomiasis. These include albuminuria, haematuria, appendicitis and schistosomal ulceration of the urinary bladder (WHO,1993).

Pathology of schistosomiasis includes several disease states, which are related to different stages in the life cycle of the organism; these conditions include sites of cercarial invasion of the skin in schistosome-infested water which presents intense pruritic papules, particularly on the feet and lower legs and is referred to as cercarial dermatitis or "Swimmers' itch" (Mulvihill and Burneth, 1990).   Individuals with large adult worm burden may exhibit features of serum sickness, including fever, arthralgia and possibly cardio-vascular collapse when the worms begin to release large numbers of eggs into the circulation. This reaction to eggs in the blood stream is also known as "Katayama fever" (Doherty, Moody, and Wright, 1996). The eggs are generally deposited in the soft tissues where they are destroyed by the resultant florid inflammatory response, which is predominantly granulomatous. Some of the eggs become calcified and as such schistosoma "fossils" which are generally surrounded by dense fibrosis can be seen even decades following infection. The abundant fibrotic reaction to these eggs can give rise to the chronic presentation of

schistosomal disease, which includes extensive "pipestem" fibrosis of hepatic portal tracts with liver dysfunction and failure in severe cases (Kamel, Elwi, Cheever, Mosimann, and Danner, 1978), granulomatous fibrosing angitis of the lung with cor-pulmonale in severe cases and mural fibrosis of the urinary bladder with obstructive/reflux uropathy (Moris and Knauer, 1997). Granulomatous inflammation with fibrosis has also been noted in the central nervous system (C.N.S), female genital tract, and lymph nodes (Helling - Giese, Kjetland, Gundersen, Poggensee, Ritchter, Krantz, and Feldmeier, 1996 and Pittella, 1997). In *Schistosoma mansoni*, after a number of years the pathogenic reaction is a cellular, granulomatous inflammation around eggs trapped in the tissues, with subsequent fibrosis. All areas of both the small and large intestine may be involved, with the large intestine showing the most severe lesions, whereas severe pathology in the small intestine is only rarely observed, even though large numbers of eggs may be deposited here. Colonic polyps are also sometimes seen, especially in Egypt (Cheever and Karmel, 1978).

In *Schistosoma. japonicum* infection the primary cause of pathology here is a granulomatous reaction to eggs trapped in the liver, and both the acute and chronic aspects of the disease are similar to that of *S. mansoni* infections, although the acute disease, 'Katayama' fever, is more common here than for *S. mansoni.* The chronic stage of the disease may also be more severe, owing to the greater egg output and longevity of *S. japonicum* females compared with those of *S. mansoni.*

In *Schistosoma. haematobium* infection, the adult parasites are found in small venules around the bladder and urethra, with the majority of egg deposition in the tissues of these organs, as eggs pass through the bladder wall to leave the body in the urine. The disease caused is chronic in nature, with the most frequently affected

organ being the urinary bladder, where calcification of eggs trapped in the tassels often occurs. The disease is characterised by blood in the urine (haematuria), hence the infection is often referred to as 'urinary schistosomiasis'. Cancer of the bladder is an important complication of infection with *S. haematobium.* Eggs may be deposited in the liver, often in high numbers, and granuloma formation may occur, but this is much less severe than with *S. mansoni* (WHO, 1998).

In schistosome species where man is not a permissive host, cercarial dermatitis, 'swimmers' itch', occurs where the parasites are not capable of fully developing into adults. Cercarial dermatitis occurs shortly after penetration of the host's skin by these cercariae, and is caused by dead or dying larvae in the skin. It is a hypersensivity reaction, characterised by skin rashes, the severity of which varies considerably, depending on factors such as the degree of previous exposure to the cercariae and the number of cercariae (WHO, 1998).

Symptoms of chronic infection may include general malaise, abdominal pain, headache, enlarged liver, spleen, and lymph nodes and blood, pus and mucus in the stool or urine; cirrhosis of the liver may develop as lesions accumulate (Pittella, 1997). The connection between schistosomiasis and neoplasia has intrigued scientists for decades. The best described association is that between *Schistosoma haematobium* infection of the urinary bladder wall and squamous metaplasia and carcinoma of the trigonal area (Godwin and Hanash, 1984). Studies in endemic areas (Egypt and the Middle East) demonstrate a marked elevation in incidence of squamous cell carcinoma of the bladder even in relatively young patients with long standing schistosomiasis (Schwartz, 1981). Although not well-established, a pathogenetic link between schistosomiasis and neoplasia of other organs has been proposed. Deposition of eggs in the distal colon and areas of similar sluggish venous

flow (i.e. the haemorroidal veins surrounding the distal rectum and anus) has been associated with intense fibro-inflammatory reaction and even stricture formation. This reaction is similar to that noted in the urinary bladder, and studies have demonstrated a moderately increased incidence of colonic adenocarcinoma in the setting of severe infection of a chronic nature (Lemmer and Fripp, 1994). Nmorsi, Egwunyenga, Ukwandu, and Nwokolo, (2005) reported sensitivities of urinary symptoms as eosinophiluria, proteinuria and haematuria.

2.6 PUBLIC HEALTH IMPORTANCE

Schistosomiasis is one of the most wide-spread of all human parasitic diseases, ranking second only to malaria in terms of its socio-economic and public health importance in tropical and subtropical areas. It is also the most prevalent of the water-borne diseases and one of the greatest risks to health in rural farming areas of developing countries. As a main rural, often occupational disease, schistosomiasis principally affects people who are unable to avoid contact with water, either because of their profession (agriculture, fishing) or because of lack of reliable sources of safe water for drinking, washing and bathing. As a result of low level of resistance and intensive water contact when playing and swimming, children aged between 10 and 15 years are the most heavily infected. Increased population migrations help to spread the disease, and schistosomiasis is now occurring increasingly in peri-urban areas. Although most people in areas of endemicity have light infections with no symptoms, the effects of schistosomiasis on a country's health and economy are serious. In several areas (e.g. North-eastern Brazil, Egypt, Sudan) the working ability of the rural inhabitants, many man-hours and attendance to school by school children are severely reduced as a result of the weakness and lethargy caused by the disease (Kamel *et al.,* 1978).

2.7   DIAGNOSIS OF SCHISTOSOMIASIS

The most obvious method of diagnosis is identification of eggs in stool for *S. mansoni* and *S. japonicum* or in urine for *S. haematobium*. For this diagnosis, a simple faecal or urine smear is often inadequate; therefore some type of egg concentration technique is required (Barreto, 1991). If no eggs are found but the outward symptoms are suggestive of schistosomiasis, then rectal, liver or bladder biopsies may be necessary (Brown, 1975).

Efficient methods for the concentration of eggs in urine for epidemiological work include sedimentation by centrifugation;   filtration through millipore filters have also been adopted by many workers (Salih, 1979; Saladin, Saldin, Dennis, and Degremont, 1980). In most developing countries in tropical Africa today where schistosomiasis and other important parasitic diseases are endemic, poor economy has resulted in drastic cuts in the funding of scientific research by most of these countries; the consequent chronic shortage of foreign exchange has made it very difficult for scientists in these countries to procure the necessary equipment all of which are imported from foreign countries. There is, therefore need for alternative procedure that will be simple, and cheaper but will also give comparable and reliable results (Asaolu and Ofoezie, 1988-1990).

2.8   TREATMENT AND CONTROL OF SCHISTOSOMIASIS

Treatment of schistosomiasis is targeted at several aspects of the life-cycle of the parasites, schistosomes. Drug treatment is still the principal method of control. However, the degree of recovery from the infection depends on the extent of the damage caused by the infection. If extensive fibrosis has occurred this cannot be reversed and there is a permanent damage. According to WHO (1998), until 1970 treatment of schistosomiasis was nearly as dangerous as the disease itself. Modern

treatment is effective and without risk. Three new drugs have revolutionized treatment: Praziquantel - the chemotherapy of choice is praziquantel, a quinolone derivative which is generally administered in an oral form in one or two doses from 40- 60mg/kg body weight. Praziquantel is effective in the treatment of all forms of schistosomiasis with virtually no side effects. On the other hand, Global 2000, stated that the following groups of people should not take praziquantel - anybody who always reacts to the drug, a seriously sick person, pregnant women, children under four years and breast- feeding mothers and that in some cases there may be mild reactions such as headache, tiredness, dizziness, or loss of appetite. The drug should not be taken on an empty stomach. Other drugs are oxamniquine used exclusively to treat intestinal schistosomiasis in Africa and South America and metrifonate effective for the treatment of urinary schistosomiasis. Although re-infection may occur after treatment, the risk of serious disease developing in the body organs would have been greatly reduced and there would be marked regression of lesions in young children following treatment of the infection. Young schistosomes are more susceptible to drugs than later developmental stages (Shelly and Alan, 2006). The control of schistosomiasis other than with the use of drug therapy is difficult and as yet there is no effective vaccine (Mott, Desjewe, Moneayo, Ranque, and Readt, 1995).

Other methods of control are drainage of marshy areas where snails breed, improved sanitation, supply of safe drinking water, education of the public on personal and environmental hygiene, the use of molluscicides, and introduction of bio-control agents (Mott *et al.,* 1995). It is important to provide water for drinking, bathing and washing clothes; good village water supplies with pumps and pipes or pit-wells encourage people to stay away from streams and ponds that may be

infested with cercariae. The health authorities should provide information on the safety of open water. People should avoid swimming, wading, washing or bathing in water suspected of infestation with the infective stage. However, because detailed information is generally not available, it is safer to consider all freshwater bodies in endemic areas as potential transmission sites. For agricultural workers at constant risk of infection, periodic examination and treatment should be the most feasible approach to disease control. Defaecation or urination in or near open water bodies should be avoided so that snails have less chance of becoming infected. Latrines or toilets should be constructed, and children should be taught how to use them (Mott *et al.*, 1995).

In 1984, WHO in association with the health ministries of several endemic countries, including Botswana, Egypt, Madagascar, Mauritius and the Tanzanian island of Zanzibar launched a massive programme to assess control methods. The findings of this programme were as follows:

Single dose of praziquantel is effective in reducing prevalence and in containing the disease, schistosomiasis. Treatment must be accompanied by health education; praziquantel can be safely administered by primary health care team, and it is almost always necessary to repeat the treatment, but the interval may be up to five years in some situations where transmission is low. A demonstrable effective control strategy (endorsed by a WHO expert committee) established for schistosomiasis is based on quantitative epidemiological evaluation, chemotherapy, supplemental mollusciciding, follow-up of patients, community education and integration of control operations into health care systems (UNDP/World Bank/WHO, 1997). Schistosomiasis requires, among other measures, both scientific and social methods – educating rural populations to prevent human contamination and exposure to potential transmission

sites and adequate disposal of human waste - stool and urine (Sturrock, 2001) and use of ultrasonography in large scale control intervention (Artemis, Sacko, Keita, Gabrielli, Dembele, Clement, Whawell, Donelly, Fenwick, Traore and Webster, 2007).

The increasing number of water resources projects, essential for industrial and agricultural expansion in developing countries, is a matter of great concern to schistosomiasis experts. Water impoundments of all sizes, including man-made lakes and irrigation systems, provide excellent habitats for fresh water snails and encourage close and frequent contact between people and infested water bodies. Schistosomiasis and other water-borne diseases, whether introduced or spread by water development projects, can have a severe impact in economic terms (loss of labour and cost of treatment), quality of life and can delay the completion of projects if construction workers or the local population become infected. However, it is now possible to institute control measures from the moment such a project is planned. Screening and treatment of the population and all employees of the development project and their families in the project area and potential migrant populations reduce the risk of schistosomiasis becoming a major public health problem. Good water management practices, where necessary supplemented by regular application of molluscicides, may limit the distribution of snails. The lower the potential for transmission from the start, the smaller the chance that serious disease will develop. Documented successes in the schistosomiasis control have also consistently been linked to political will or commitment, the involvement of peripheral authorities and allocation of local resources and long term implementation of concerted control strategy (WHO, 1998).

2.9 REVIEW OF DISTRIBUTION OF SNAIL INTERMEDIATE HOSTS OF SCHISTOSOMES

The planorbid snails, *Bulinus* species, act as the intermediate hosts of *Schistosoma haematobium* (Thomas, 1973). Cowper (1963) observed two distinct strains of *S. haematobium* in West Africa, one transmitted by only *Bulinus truncatus* and the other transmitted by *B. globosus. B. globosus* is the common representative of the genus *Bulinus* in Nigeria and the vector of the majority strain of *S. haematobium. Bulinus* has also been incriminated as the intermediate host of *S. intercalatum* (Thomas, 1973). Cowper (1963) reported that the established vector of *S. mansoni* throughout West Africa is *Biomphalaria pfeifferi* and that it is known to occur in Ibadan, Epe, Zaria, Vom, Biu, Lake Chad area and Jos Plateau.

Betterton, Ndifon, Bassey, Tan, and Oyeyi, (1988). studied human infections near dam sites and the distribution and habitat preferences of snail intermediate hosts and found 5 species with *Bulinus senegalensis* being the most widely spread. Ndifon and Ukoli (1989) carried out snail investigation in South Western Nigeria and recorded that *B. globosus*, was the most widely distributed followed by *B. feifferi. Bulinus forskalii* was among the snail intermediate hosts of schistosomes during an investigation of the Lake Chad Basin of Borno State (Lambo, 1982). *Bulinus senegalensis* was reported as the intermediate host of *Schistosoma haematobium* in Chad irrigation scheme in Borno State and near Benin City (Ukoli, 1984).

2.10 PHYSIOLOGY AND ADAPTATION OF SNAILS

Snails use water and vegetables for food, shelter and as substrate for laying their eggs. Absence of all or any of the above factors adversely affects the existence of snails. Spoel, Van-Bruggen and Lever (1979) stated that at low temperature of about 14^0C and a high photoperiod, the egg-mass production of snails ceases. At pH of 6.0, egg-laying and hatching is maximal. Hodasi (1978) experimented on the effect of dryness or aestivation on growth, reproduction and mortality of snails. He recorded that the reproduction potential was reduced and the young snails withstood desiccation better than adult ones. After the aestivating period, there was no significant difference in their size, but during the aestivation, the snails stopped feeding and entered a stage of dormancy by fixing their shell apertures to the mud surface or wall of the container. Fish ponds increasingly constructed in Brazil and other countries in the tropics for the purpose of supplying proteins to increasing populations, have been identified as another potential source of schistosomiasis infection, especially if they are not properly maintained (Ferguson and Ruiz-Tieben, 1971).

2.11 CONTROL OF INTERMEDIATE HOSTS (SNAILS)

The incidence of all trematode infections of both medical and veterinary importance can be checked by effective control of their snail intermediate hosts. The various control measures applied include use of molluscicides, alteration of the aquatic environment and biological control. To achieve an effective control programme, knowledge of the aestivating period, the infective period and the habitat of the snail hosts are important (Jobin, 1978).

2.11.1 Application of Molluscicides

There are various chemicals used in snail control. Use of chemicals may be successful in control but it also has a number of disadvantages, such as cost, and very importantly, the toxicity of the chemicals which may kill non-target aquatic

organisms such as fish which the affected population may rely on. Some plants and their extracts are used in controlling snail hosts due to their mollusciciding activities. Singh and Agarwal (1988) reported the effectiveness of the latex of a plant, *Euphorbiales,* in snail control. The water extract of *Tetrapteura tetraptera* was found to be very active as a molluscicide in control of schistosomiasis and fascioliasis (Adewunmi, 1984). Agaceta, Dumay, Batolos, Escardo, and Bandiola, (1981) recorded 7 local plants – *Croton tiglium, Enteada phoseohoides, Nicotiana tabacum, Corzya balsamifera, Citrus mitis, Jatropha curcas,* and *Menispermas coclus* that show strong molluscicidal activity when used at a concentration of 100-500 ppm. Also methanolic extract of *Deterium microcapum* has molluscicidal activities (Panda and Kela, 1997). The mortality of the snails was 55-98%. Other methods such as growth of certain plants on the sides of water ways have been introduced. The barriers of endod (*Phytolacca dodecandra*) have been reported to be naturally molluscicidal when they fall into water body. Osuala and Okwuosa (1993) reported that the stem back extract of neem plant, A*zadirahta indica,* caused a 100% mortality on *Bulinus*, *Biomphalaria and Lymnea* species.

The current molluscicide of choice is niclosamide which is available in a paste form. It is generally mixed with water and sprayed on snail habitat areas. At low concentration, it is highly toxic to snail and their egg masses. For practical use, a concentration of 0.6 – 1mg/L is recommended with an exposure time of 8 hours. The compound is safe to handle and after dilution, is non toxic to water plants and crops. However, it is very toxic to fish. Fish killed by the molluscicide can be safely eaten. Other chemicals used include Bayluscicide, sodium pentachlorphenate, acerolsein, copper sulphate, and manganese sulphate (Yescoth and Hanson, 1976).

2.11.2 Alteration of the Aquatic Environment

This includes altering the flow of the water, clearance of vegetation and drainage at certain times of the year. Disadvantages of these methods include damage to fish population, and creating suitable environment for other disease vectors such as *Simulium* to breed (WHO, 1993).

2.11.3 Biological Control

This can be achieved by introducing competitor snail species such as *Marisa cornuarietis* which compete with *Biomphalaria* snails for food and eat their eggs. Also snail eating fishes can be introduced into the water (Spoel *at al.,* 1979). Perez, *et al.* (1991) reported that the snail, *Thiara granifera* competed with *B. glabrata* for space. A field trial in a Brazilian Lake indicated that *Tilapia melanopleura* was a predator of *Biomphalaria glabrata.* In Bahia, the local fish, apaiar (*Anthronatus ocelatus),* was used for snail control. Several other fish species such as T*. rendalli* and the chichlid, *Sargochromis codringtoni* have been found to be effective predators of snail intermediate hosts *(*Perez *et al*., 1991).

2.11.4 Reduction of Snail Habitats

Snails need vegetation for food, shelter and as a substrate for their eggs. The removal of vegetation in irrigation ditches and canals reduces the number of snails. However, to clear manually, one usually has to get into the water which is dangerous, while mechanical clearance is very expensive. The cleaning of canals may also help in the control of other diseases, including malaria, and may improve the effective use of irrigation water. A disadvantage of this method is the need for frequent repetition. Where sufficient resources are available, canals can be lined with cement to prevent or reduce the growth of vegetation. People can also remove plants from places where children swim or where clothes or dishes are washed. Under certain

conditions, the plant-eating Chinese grass carp-fish, *Ctenopharyngodon idella,* may

be suitable for the biological control of aquatic plants (Istifanus, 1988).

CHAPTER THREE

MATERIALS AND METHODS

3.1 THE STUDY AREA

According to Plateau State Ministry of Establishment, Internal Affairs and Information, Jos South Local Government Area (JSLGA) is located south of Jos between longitude 8^0 $48'$W. and latitude 9^0 $94'$N., in North Central Geo-political Zone of Nigeria. The headquarters is at Bukuru, which is about 15 kilometres from Jos town, the capital of Plateau State. The area is about 1,250 metres above sea level. With the exception of Obudu, in Cross River State, Jos is the coldest part of Nigeria by virtue of the Plateau. Topographically and climatically the area is very close to Jos. The high land is slightly undulating and rises from the steep escarpments of the riverine plains of the river Benue and descends towards Bauchi State. Located in the middle belt zone of the country, the vegetation is grassland savanna and the landscape is treeless, mostly rocky, with chains of hills and many captivating rock formations. The average minimum and maximum temperatures are 22^0C (71.6^0F) and 30^0C (86^0F) respectively. Two seasons are distinct, the wet season which lasts from April to October and the dry season from November to March. The wet season is characterised by heavy rains and subsequent flooding of the banks of rivers, streams, ponds and other hydrological resources, while the dry season is characterised by cool, dry, high temperature in February and March. Mean annual rainfall varies from 131.75cm in the southern part of the State to 141.5cm on the plateau.

Fig. 6: Map of Jos South Local Government Area
Source: Jos South Local Government Council.

The study area for the present work, Jos South Local Government Area, has many irrigations systems, streams and some ponds or pools of water that resulted from the mining activities inter-connected by little beds of streams seasonally. These bodies of water were often used for domestic washings, swimming or as playing areas especially by children. The inhabitants of the area are engaged in different activities such as farming, civil service and other trades.

During the dry season, farmers make use of the streams for their dry season farming. In some areas the inhabitants dispose of their stool and urine indiscriminately, including vicinities of the water bodies in the study area.

The indigenous ethnic group in the Local Government Area is Berom. Other ethnic groups commonly found in the Local Government Area are Jarawa, Hausa, Fulani, Ibo, Tiv, Idoma and Yoruba. Agriculture is the main occupation of the indigenes.

The locations selected for the work were Dogon Karfe, the boundary with Jos North Local Government Area, Gigiring, Anglo-Jos (Zaramaganda), Bukuru, National Institute for Policy and Strategic Studies Kuru/Vom, Zawan, Mararaba Jama'a and Farin-Lamba, boundary with Riyom Local Government Area.

3.2. SAMPLING TECHNIQUES

3.2.1 Participants

The participants were made up of inhabitants in the selected areas in Jos South Local Government Area, Plateau State, Nigeria.

3.2.2 Local Government Council Area Population

The population of the Local Government Area as supplied by the Local Government Council was 160,000 but now 306,716 people of all ages and both sexes.

3.2.3 Sample Size

The sample size of 6,377 was determined using the formula described by Benneth, S., Woods, T., Liyange,W. M. and Smith, D.L. (1991).

3.2.4 Sample Selection

The multi stage sample selection described by Benneth *et al.(*1991*)* was used.:

The Local Government Area has 12 wards from which 8 were selected by balloting (i.e simple random selection) for the study.Individuals in the households and schools in the selected wards were screened for eggs of schistosomes .

From each ward there were approximately 160, 000 ÷ 12 or 13,333 persons for sampling. Therefore, from eight (8) wards there were approximately 13,333 x 8 persons as sampling frame = 106664 from which a sample size (stool and urine) of 6377 was taken. The sampling interval was 106664 ÷ 6377 = 17/1 = 1:17. Selection of individuals from households and schools was such that every seventeenth (17th) individual was given two sample containers for collection of stool and urine respectively. They were instructed on the quantity, when and how to collect the samples.

3.3. DATA COLLECTION

3.3.1 Permission to Proceed

Permission to proceed for the study was sought for and obtained from the Chairman of the Local Government Area after which the District and Ward Heads were approached for same and their consents obtained.

3.3.2 Sample Collection.

Urine, stool and snails

A pre-tested interviewer administered questionnaire was used to elicit information on the following: name, age, sex, religion, ethnic group, residential status, occupation, toilet facilities, sources of water supply and water contact activities (Appendix 1). Data were collected from 1999 to 2002 (over a period of three years) and from November 2003 to October 2004. This gap was the period between presentation of upgrading seminar and approval to continue. Five Research Assistants were trained and used for some aspects of data collection and preparation of the samples, stool and urine for microscopic examinations. Training consisted of use of standard laboratory techniques, sample collection, preparation of urine samples for microscopy by centrifugation (Dazo and Biles, 1974) and preparation of stool samples by formol-ether concentration technique (Allen and Ridley, 1970). The Laboratory Assistants were also trained on methods and the time of snail collection, 10.00a.m. to 12.00 noon (WHO, 1965, 1985).

3.4 PLAN FOR DATA ANALYSIS

The data collected were subjected to Chi-square test as the relationship between two variables were compared.

3.5   MALACOLOGICAL STUDY

All the fresh water bodies in the study locations (sections) were surveyed for snail intermediate hosts to determine sites for data collection. Snail sampling was carried out with long-handed scoop net. Manual search for snails from various objects in the water bodies was done where applicable, with the aid of forceps by picking the snails one at a time.

Streams and irrigation systems at Dogon-Karfe, Gigiring, Anglo Jos, Bukuru, National Institute for Policy and Strategic Studies, Kuru/Vom, Zawan, Mararaba Jama'a and Farin-Lamba were surveyed for snail intermediate hosts. This was done using a scoop net with long hand. With the scoop net several random scoops were made at each stream for about 45 minutes, per site. In some areas the snails were picked by hand in gloves. Surveys were done during the dry and the rainy seasons of each year. Rain boots and hand gloves were worn as a precaution against infection by cercariae during the collection. The snails collected were put in wide mouthed universal bottles loosely corked, and taken to the laboratory for examination for cercariae.

3.6   PHYSICO-CHEMICAL PARAMETERS OF THE WATER BODIES

Water samples for water quality studies were collected from each stream with one litre plastic bottles and carried to the laboratory for analysis. Collection of water samples preceded the search for snail vectors from each stream investigated.

3.7 EXAMINATION OF THE SPECIMENS

3.7.1 Examination of Snails

On arrival to the laboratory, the snails were separated and identified, using the standard keys described by Brown and Christensen (1993). Each species was placed in a separate container. Groups of 10 snails were placed in a glass beaker of 250ml capacity. One hundred millilitres (100ml) of water was added, and then exposed to sun- light for 30 minutes, to facilitate shedding of cercariae by the snails. The water was examined for cercariae under dissecting microscope. All the snails in the containers that were positive with cercariae were separated and examined further, by placing each of them in a separate beaker, 10mls of water added, exposed to sunlight for 30 minutes and the water examined for cercariae. All the positive ones were separated from the negative ones and each group added up.

3.7.2 Measurement of Chemical Parameter of the Water

The streams and irrigation canal systems surveyed included those at Dogon-Karfe, Gigiring, Zaramaganda in Anglo-Jos, Fwagul in Bukuru, National Institute for Policy and Strategic Studies Kuru/Vom Road, Zawan, Mararaba Jama'a and Farin Lamba. Water quality tests – dissolved oxygen (DO), alkalinity, conductivity, pH and temperature (^{0}C), of these water bodies were carried out as follows:

Dissolved oxygen

Dissolved oxygen was measured using the modified Axide Winkler method, adapted from Standard Methods for the Examination of Water and Waste water (Hach Chemical Company, 1971). In this modification, the sodium thiosulphate titrant was replaced by phenylarsine oxide (PAO) solution which is more resistant to decomposition by bacteria and is more stable for longer periods without standardisation. For increased stability and convenience, Hach Chemical Company

whose instrument was used for this analysis, formulated the test reagents into dry, pre-measured powder pillows.

Procedure

Water samples were collected into 60ml glass-stoppered bottle to which a glass bead and the contents of one Dissolved Oxygen 1 Reagent Powder Pillow and one Dissolved oxygen 2 Reagent Powder Pillow were added. The mixture was shaken to mix. A flocculent precipitate, brownish in colour, was formed if oxygen was present in the sample. This floc was allowed to settle until the solution became clear. Then the contents of one Dissolved Oxygen 3 Reagent Powder Pillow was added, then mixed again until the floc dissolved and left a yellow iodine colour.

Into a titration flask was introduced 5.8ml of the above solution.Using special pipette, Phenylarsine oxide (PAO) titrant was then added drop-wise into the solution, the drops added being counted until the sample changed colour from yellow to colourless.The mg/L Dissolved Oxygen was taken to be equal to the total number of drops added, one drop being equivalent to 1mg.

Determination of alkalinity

The determination of alkalinity was based on the Titration method adapted from Standard methods for the examination of Water and Waste water (Hach Chemical Company, 1971).

Alkalinity is expressed as "P" (phenolphthalein) alkalinity or as "T" (total) alkalinity. Both types were determined by titration with 0.020N Sulphuric Acid Standard solution, to an end point evidenced by the colour change of a standard indicator solution.

The 'P" alkalinity was determined by titration to a pH of 8.3 (the phenolphthalein end point) and this registered the total hydroxide and carbonate (C_aCO_3) present.

The "T" alkalinity was determined by titration to a pH of 4.5. The total alkalinity usually includes all carbonate, bicarbonate and hydroxide alkalinity. The range of normal values for surface and well waters is 0-250mg. L^{-1}

Determination of conductivity

The Direct Measurement Method was used in the determination of Electric Conductivity of the water samples. The instrument used was the 0150 portable conductivity/TDS meter (Hach Chemical Company, 1997).

Procedure

Water samples collected in clean plastic containers were analysed immediately after collection. The meter was immersed in a beaker containing the sample solution. The probe was moved up and down to free any bubbles from the electrode area. The meter was read after ensuring that it was in the COND mode. The results were read in $Ms/cm^{-1.}$

pH:

 This was measured using the pH meter, type, 3305; model Jenway.

Temperature: This was measured with a mercury in glass thermometer calibrated from 0-50°C. The thermometer was held in-situ for 2 minutes and reading taken.

3.7.3 Examination of Stool Samples

The formol-ether concentration method described by Allen and Ridley (1970) was used for the preparation of the stool samples for examination. Using an applicator stick, 1g of each stool sample was put into a centrifuge tube containing 7cm^3 of 10% formol saline. This was emulsified and filtered through a coffee filter,

into another centrifuge tube. To the faecal suspension, $3cm^3$ of diethyl ether was added, stoppered and shaken vigorously and centrifuged at 3000 revolutions per minute for 3 minutes. After the centrifugation, four distinct layers were formed, made up of the sediment, formol saline, faecal debris and ether, at the topmost.

The faecal debris was dislodged with an applicator stick and the upper 3 layers poured off without disturbing the sediment which was examined for parasites. A drop of the deposit was pipetted onto a clean microscope slide covered with a clean cover slip avoiding air bubbles and overfloating. Examination was carried out under x10 and x 40 objectives of a microscope, for the eggs of schistosomes.

3.7.4 Examination of Urine Samples.

Each urine sample was prepared for examination using the method described by Dazo and Biles (1974). Each sample was mixed very well, by turning the container gently up and down several times for about 30 seconds, poured into a centrifuge tube, and centrifuged at 3000 revolutions per minute for 3 minutes. The supernatant was discarded gently without disturbing the sediment. A drop of the sediment was pipetted onto a clean glass slide, covered with a clean cover slip and examined under X10 and X40 objectives of a microscope for *Schistosoma haematobium* eggs.

CHAPTER FOUR

RESULTS

4.1   SAMPLES COLLECTED

Snails.

A total of 1081 snails were collected from 1999 to 2004.

During the dry season in 1999, a total of 611 snails were collected. The snails were made up of 154 *Bulinus* species, 99 *Biomphalaria* species and 358 *Lymnea* species. In the wet season, only 92 snails were collected comprising of 7 *Bulinus, 16 Biomphalaria,* and 69 *Lymnea.* A total of 703 snails were collected in 1999 (Table 1).

In the year 2000, a total of 255 snails (196 in dry and 59 in wet season) were collected. The 196 snails collected in dry season were made up of 39 *Bulinus*, 48 *Biomphalaria* and 109 *Lymnea* species. The 59 snails collected in the wet season were made up of 20 *Bulinus*, 20 *Biomphalaria* and 19 *Lymnea* species (Table 1).

In 2001, a total of 87 snails were collected (65 in the dry season and 22 in the wet season). The dry season collections included 16 *Bulinus*, 13 *Biomphalaria*, and 36 *Lymnea* species, while the wet season collections were made up of 5 *Bulinus*, 2 *Biomphalaria* and 15 *Lymnea* species (Table 1).

Collections in 2002 were done only in the wet season as the approval to proceed with the work was being awaited. A total of 36 snails were collected in that year and were made up of 8 *Bulinus*, 5 *Biomphalaria* and 23 *Lymnea* species (Table 1).

In 2003/2004, no snail host was collected from the locations surveyed in both dry and wet seasons (Table 1).

Table 1 Shows seasonal collection of snail vectors in the study area for the duration of the research. A total of 1081 snails were collected between 1999 and 2004. In 1999 a total of 703 snails were collected, 255 in 2000, 87 in 2001, 36 in

2002 and none in 2003/2004. Highest number of snail vectors 703(65.03%) were collected in the year 1999, followed by the year 2000 when 255 (23.61%) were collected. Only 87 (8.06%) were collected in 2001 while in 2002. 36 (3.33%) were collected and in 2003/2004, no snail was collected (0%).

Table 1: Seasonal Collection of Snail Species in the Study Area for the Duration of the Research

Locations

Year	Season	Dogon-Karfe			Gigiring			Anglo Jos			Bukuru			Vom/nipss			Total
		Bu	Bi	Ly	Bu	Bi	Ly	Bu	Bi	Ly	Bu	Bi	Ly	Bu	Bi	Ly	
1999	Wet	2	4	18	2	3	7	0	0	0	1	3	10	2	6	34	92
	Dry	40	32	61	34	43	69	0	0	0	20	18	104	60	6	124	611
2000	Wet	7	10	5	3	3	4	0	0	0	3	4	5	7	3	5	59
	Dry	0	0	0	3	10	30	0	0	0	20	30	49	16	8	30	196
2001	Wet	0	0	0	2	1	4	0	0	0	2	1	5	1	0	6	22
	Dry	0	0	0	2	8	8	0	0	0	10	5	18	4	0	10	65
2002	Dry	0	0	0	1	1	8	0	0	0	5	3	10	2	1	5	36
2003/	Wet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	Dry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL			179			246			0			326			330		1081

Key: Bu= *Bulius,*

Bi= *Biomphalaria.* Ly= *Lymnea*

4.2   STOOL AND URINE SAMPLES

Consent was obtained from each participant and the objective of the collection was explained. Two screw capped universal bottles, both carrying the same identification number, were given to each consenting participant for collecting stool and urine samples. They were instructed on how, when and the quantities of stool and urine to collect. They were told to collect early morning samples, the urine of which should contain mid stream and the last drops of the urine. In Muslim households where entry was restricted to men, my woman assistant collected the samples from the women volunteers.   The samples were retrieved from the participants on the following day and taken to the laboratory for microscopic examination.   As they submitted their samples, with the aid of the questionnaire, information on their age, sex, occupation, sources of water supply, nature and type of their toilet facilities and residential status were noted and recorded against each identification number in the log book.   Samples were collected seasonally (wet season, April – October and dry season, November – March). A total of 6,377 stool and urine samples, made up of 3,190 stool samples and 3,187 urine samples were collected from 1999 to 2002 and from November, 2003 to October, 2004.

The gap between 2002 and 2003/2004 was for population of snail vectors to build up in the ecological environment and the out-come of human infections that were treated before sampling.

Plate 1:   **Collection of snails**

Plate 2: *Biomphalaria* **Snails**

Plate 3: *Bulinus* **Snails**

Plate 4:   *Lymnea* **Snails**

4.2.1 Stool Samples

In 1999, a total of 735 stool samples were collected. In wet season (April – October) 357 were collected and in dry season (November 1999 to March 2000) 378 stool samples were collected. In 2000, 722 stool samples were collected, 362 in wet season and 360 in dry season. In 2001, 708 samples were collected, 347 in wet season and 361 in dry season. In 2002, 374 samples were collected in dry season. In 2003/2004 a total of 651 stool samples were collected, 308 in wet season and 343 in dry season (Table 2).

Table 2 shows stool samples collected from all the locations seasonally between 1999 and 2002 and between November 2003 and October, 2004. In 1999, 735 samples (23.04%) were collected, 722 (22.63%) in 2000; 708 (22.19%) in 2001;374 (11.72%) in 2002 and 651 (20.41%) in 2003/2004

Table 2:   Stool Samples Collected Seasonally Between 1999 and 2004

Year	Total	Season	Number Collected (%)
1999	735	Wet	357 (11.19)
		Dry	378 (11.85)
2000	722	Wet	362 (11.35)
		Dry	360 (11.29)
2001	708	Wet	347 (10.88)
		Dry	361 (11.32)
2002	374	Dry	374 (11.72)
2003/2004	651	Wet	308 (9.66)
		Dry	343 (10.75)
Total	3190		3190

4.2.2   Urine Samples

In 1999, 732 urine samples were collected, 357 in wet season and 375, in dry season. Similarly, in 2000, 723 samples were collected, 363 in wet season and 360 in dry season. Also in 2001 707 samples were collected, wet 347 and dry season 360. In 2002, 374 urine samples were collected in dry season, while in 2003/2004 651 urine samples were collected, 308 in wet season and 343 in dry season (Table 3).

Table 3 shows urine samples collected seasonally during the study from all the selected locations. A total of 3187 urine samples were collected between 1999 and 2004. In 1999,732(22.97%) samples were collected; 723(22.69%) collected in 2000, 707(22,18%) in 2001; 374(11.74%) collected in 2002 and 651 (20.43%) were collected in 2003/2004.

Table 3:   Urine Samples Collected between 1999 and 2004

Year	Total	Season	Number Collected (%)
1999	732	Wet	357 (11.19)
		Dry	375 (11.85)
2000	723	Wet	363 (11.38)
		Dry	360 (11.29)
2001	707	Wet	347 (10.88)
		Dry	360 (11.29)
2002	374	Dry	374 (11.72)
2003/2004	651	Wet	308 (9. 66)
		Dry	343 (10.75)
Total	3187		3187

4.3   STOOL AND URINE SAMPLES COLLECTED SEASONALLY FROM EACH SAMPLING LOCATION FROM 1999-2004

4.3.1   Stool Samples

Stool samples were collected from different location in both wet and dry season from 1999 to 2004. In 1999, 75 stool samples were collected in Gigiring in wet season and 78 in dry season. In the same year 70 samples were collected in wet season and 70 in dry season at Dogon-Karfe. 65 samples were also collected in wet season and 75 in dry season at Anglo-Jos. In Bukuru, 70 samples were collected in wet season and 75 in dry season and at Vom/NIPSS Kuru, 77 samples were collected in wet season while 80 were collected in dry season.

Similarly, in the year 2000, 65 samples were collected in each of the seasons at Gigiring while in Dogon-karfe 70 samples were collected in wet season and 68 samples in dry season. In Anglo-Jos, 72 samples were collected in wet season while 75 were collected in dry season. In Bukuru, 70 samples were collected in wet season and 75 in dry season and in Vom/NIPSS, 85 samples were collected in wet season and 77 in dry season.

In 2001 samples were collected in both wet and dry seasons from the locations as follows: Gigiring, 68 in wet season, 67 in dry season; at Dogon-karfe, 71 in wet season and 72 in dry season; at Anglo-Jos 65 in wet season and 77 in dry season; at Bukuru, 69 in wet season and 65 in dry season and Vom/NIPSS,Kuru, 74 in wet season and 80 in dry season.

In 2002 the following collections were done in wet season from the location as follows: Gigiring, 74; Dogon-karfe, 78; Anglo-Jos, 66; Bukuru, 75 and Vom/NIPSS, 81.

In 2003/2004, collections were made from Zawan, Mararaba-Jama'a, and Farin-Lamba as follows: Zawan wet season, 110 samples, dry season 116; Mararaba-Jama'a wet season, 104 and dry season 102 and Farin-Lamba, 94 in wet season and 125 in dry season (Table 4).

Table 4 shows stool samples collected from each sampling location in the seasons from 1999 to 2004. The table indicates the number of samples collected from each of the selected locations. In 1999 a total of 735 samples were collected;722 in 2000;708 in 2001; 374 in 2002 and 651 in 2003/2004.

Table 4:   Stool Samples Collected Seasonally in each Sampling Location between 1999 and 2004

Location	Season	Year				
		1999	2000	2001	2002	2003/2004
Gigiring	Wet	75	65	68	74	-
	Dry	78	65	67	-	-
Dogon-karfe	Wet	70	70	71	78	-
	Dry	70	68	72	-	-
Anglo-Jos	Wet	65	72	65	66	-
	Dry	75	75	77	-	-
Bukuru	Wet	70	70	69	75	-
	Dry	75	75	65	-	-
Vom/NIPSS	Wet	77	85	74	81	-
	Dry	80	77	80	-	-
Zawan	Wet	-	-	-	-	110
	Dry	-	-	-	-	116
Malaraba-Jama'a	Wet	-	-	-	-	104
	Dry	-	-	-	-	102
Farin-Lamba	Wet	-	-	-	-	94
	Dry	-	-	-	-	125
Total		735	722	708	374	651 =3190

4.3.2   Urine Samples

Similarly, urine samples were collected from the sampling locations from 1999 to 2004. The urine samples were as follows; in 1999, 75 samples were collected in each of the seasons at Gigiring; at Dogon-Karfe, 70 samples were collected in each season; at Anglo-Jos, 65 samples were collected in wet season and 75 in dry season; at Bukuru, 70 samples were collected in wet while 75 were collected in dry season and at Vom/NIPSS, in wet season 77 samples were collected while 80 were collected in dry season.

Similarly in 2000, urine samples were collected in both wet and dry seasons as follows: at Gigiring, 65 samples were collected in each of the season, while at Dogon-Karfe,70 urine samples were collected in wet season and 68 in dry season; at Anglo-Jos, 72 samples were collected in wet season and 75 in dry season; at Bukuru, 70 samples were collected in wet season and 75 in dry season and at Vom/NIPSS, 85 samples were collected in wet season while 77 were collected in dry season.

Also in 2001, urine samples collected in the seasons were as follows: at Gigiring, 68 in wet and 67 in dry season; at Dogon-Karfe, 71 samples were collected in wet season and 72 in dry season; at Anglo-Jos, 65 samples were collected in wet season while 77 were collected in dry season; at Bukuru, 69 samples were collected in wet season and 65 in dry season and at Vom/NIPSS Kuru, 74 samples were collected in wet season while 80 samples were collected in dry season.

In 2002, both stool and urine samples were collected only in wet season following the design of the research to allow for the build up of infectivity as follows: Gigiring, 74, Dogon-Karfe, 78, Anglo-Jos, 66, Bukuru, 75 and Vom/NIPSS, 81.
In 2003/2004, urine samples were again collected in both wet and dry season from different locations as indicated: Zawan, 110 samples were collected in wet season and 116 in dry season; at Malaraba-Jama'a, 104 samples were collected in wet

season and 106 in dry season and Farin-Lamba, 94 samples were collected in wet season and 125 in dry season (Table 5).

Furthermore, in 1999, a total of 733 (23.36%) samples were collected,722(22.65%) in 2000;708 (22.22%) in 2001; 374 (11.74%) in 2002 and 651(20.43%) in 2003/2004 (Table 5)

Table 5: **Urine Samples Collected Seasonally in each Sampling Location between 1999 and 2004**

Location	Season	Year				
		1999	2000	2001	2002	2003/2004
Gigiring	Wet	75	65	68	74	-
	Dry	75	65	67	-	-
Dogon-karfe	Wet	70	70	71	78	-
	Dry	70	68	72	-	-
Anglo-Jos	Wet	65	72	65	66	-
	Dry	75	75	77	-	-
Bukuru	Wet	70	70	69	75	-
	Dry	75	75	65	-	-
Vom/NIPSS	Wet	77	85	74	81	-
	Dry	80	77	80	-	-
Zawan	Wet	-	-	-	-	110
	Dry	-	-	-	-	116
Mararaba-Jama'a	Wet	-	-	-	-	104
	Dry	-	-	-	-	102
Farin-Lamba	Wet	-	-	-	-	94
	Dry	-	-	-	-	125
Total		733	722	708	374	651 =3187

4.4   PARASITOLOGICAL SURVEYS

4.4.1   Result of Stool Assay

Out of the total of 3190 stool samples examined only 13(0.41%) were positive for *Schistosoma mansoni* (Table 6).

4.4.2   Result of Urine Assay

A total of 3187 urine samples of the inhabitants of the study area were examined. Out of the 3187 urine samples 8(0.25%) were found positive with eggs of urinary Schistosome i.e *Schistosoma haematobium* (Table 6).

Out of a total of 6377 samples (stool and urine) examined in the study area 21 were positive for Schistosomiasis giving an overall prevalence of 0.32%. Thirteen 13(0.41%) were positive with *Schistosoma mansoni* and eight 8 (0.25%) with *Schistosoma haematobium* (Table 6).

Table 6: Prevalence of *Schistosoma* Species in Inhabitants of Jos South Local Government Area of Plateau State, Nigeria

	S. mansoni		*S. haematobium*			
No.of Stool Examined	No. positive (%)		No.of Urine Examined	No. positive (%)	Stool & Urine	Total No. positive (%)
3190	13 (0.41)		3187	8 (0.25)	6377	21 (0.32)

4.4.3   Age- Related Prevalence of Schistosomiasis

With regards to age, 11 – 20 year age range recorded highest prevalence compared with other age ranges. Out of 801 inividuals examined in this age range, 14 recorded presence of schistosoma eggs (8 in their stool and 6 in their urine) giving a total prevalence of 1.75% (Table 7). The age range 21 – 30 years had a total prevalence of 0.57% as 3(0.43) out of 697 individuals examined in this group recorded presence of eggs of *Schistosoma mansoni* in their stool and 1(0.14%) had eggs of *Schistosoma haematobium* in his urine. Also 31 – 40 years age range recorded a total prevalence of 0.62%; out of 486 individuals of this age range, 2 (0.41%) had eggs of *Schistosoma mansoni* while 1(0.21%) was noted to have eggs of *Schistosoma haematobium* (Table 7).

As regards the prevalence of schistosomiasis in different age groups it was noted that individuals in age group 11-20 years were found to be more infected 14 (1.75%) than those in other age groups. Similarly, individuals in 21-30years group 4(0.57%) and 31-40 years age group 3(0.62%) were also susceptible (Table 7). On the other hand, individuals in age group 1-10 years, 41-50 years and 50 years and above were found not infected (Table 7).

Table 7: **Prevalence of Schistosomiasis in the Different Age Groups of Inhabitants in Jos South Local Government Area, Pateau State, Nigeria**

Age (Years)	Number examined	*Schistosoma mansoni* Number infected	% positive	*Schistosoma haematobium* Number infected	% positive	Total Number infected	% positive
0-10	588	0	0.00	0	0.00	0	0.00
11-20	801	8	1.00	6	0.75	14	1.75
21-30	697	3	0.43	1	0.14	4	0.57
31-40	486	2	0.41	1	0.21	3	0.62
41-50	387	0	0.00	0	0.00	0	0.00
51 and above	231	0	0.00	0	0.00	0	0.00
Total	3190	13	0.41	8	0.32	21	0.66

χ^2 calculated = 22.51: χ^2 tabulated = 11.07,   df=5, P<0.05

4.4.4 Sex – Related Infection Rate

In this study, males recorded higher prevalence rate 14(0.88%) than the females, 7(0.44%) (Table 8). Out of 1584 males screened, 9(0.57%) were infected by *Schistosoma mansoni* while 5(0.32%) were infected with *Schistosoma haematobium* while 4(0.25%) out of 1,606 females examined showed evidence of intestinal Schistosomiasis infection; Table 8 further revealed that 3(0.19%) infected with urinary schistosomiasis (Table 8). Acomparative analysis of the results showed that infection in males and females did not differ significantly (P>0.05) (Table 8).

Table 8 shows prevalence of schistosomiasis in both sexes of the inhabitants of Jos
South Local Government Area, Plateau State. Males were more infected,
1(0.88%) than females, 7 (0.44%). *Schistosoma mansoni* infected 9 males (0.57%)
and 4 females (0.25%) while *Schistosoma haematobium* infected 5 males (0.32%)
and 3 females (0.19%).

Table 8: **Prevalence of Schistosomiasis in Relation to Sex in the Inhabitants of Jos South Local Government Area, Plateau State, Nigeria**

Sex	Number Examined	*Schistosoma mansoni*		*Schistosoma haematobium*		Total Number infected	% positive
		Number infected	% positive	Number infected	% positive		
Males	1584	9	0.57	5	0.32	14	0.88
Females	1606	4	0.25	3	0.19	7	0.44
Total	3190	13	0.41	8	0.25	21	0.66

χ^2 calculated = 2.450, χ^2 tabulated = 3.841, df1, P>0.05

4.4.5 Occupation – Related Prevalence of Schistosomiasis

The prevalence of schistosomiasis in four occupational groups, namely students/pupils, farmers, civil servants and other trades is presented in Figure 7.

At least one person in each occupational group in the study area was infected by schistosomiasis. Students/pupils recorded the highest prevalence. Eight (8) (0.61%) of a total of 1311 volunteers examined in the group had eggs of *Schistosoma mansoni* in their stool and 5(0.38%) had eggs of *Schistosoma haematobium* in their urine (Figure 7). Of 881 farmers examined, 3(0.34%) had eggs of *Schistosoma mansoni* in their faeces while 2(0.23%) recorded eggs of *Schistosoma haematobium* in their urine(Figure 7). Only one civil servant (0.16%) had egg of *Schistosoma mansoni* in his faeces and of the other trades, 2(0.52) had eggs of schistosomes, one in stool and the other in urine (Figure 7).
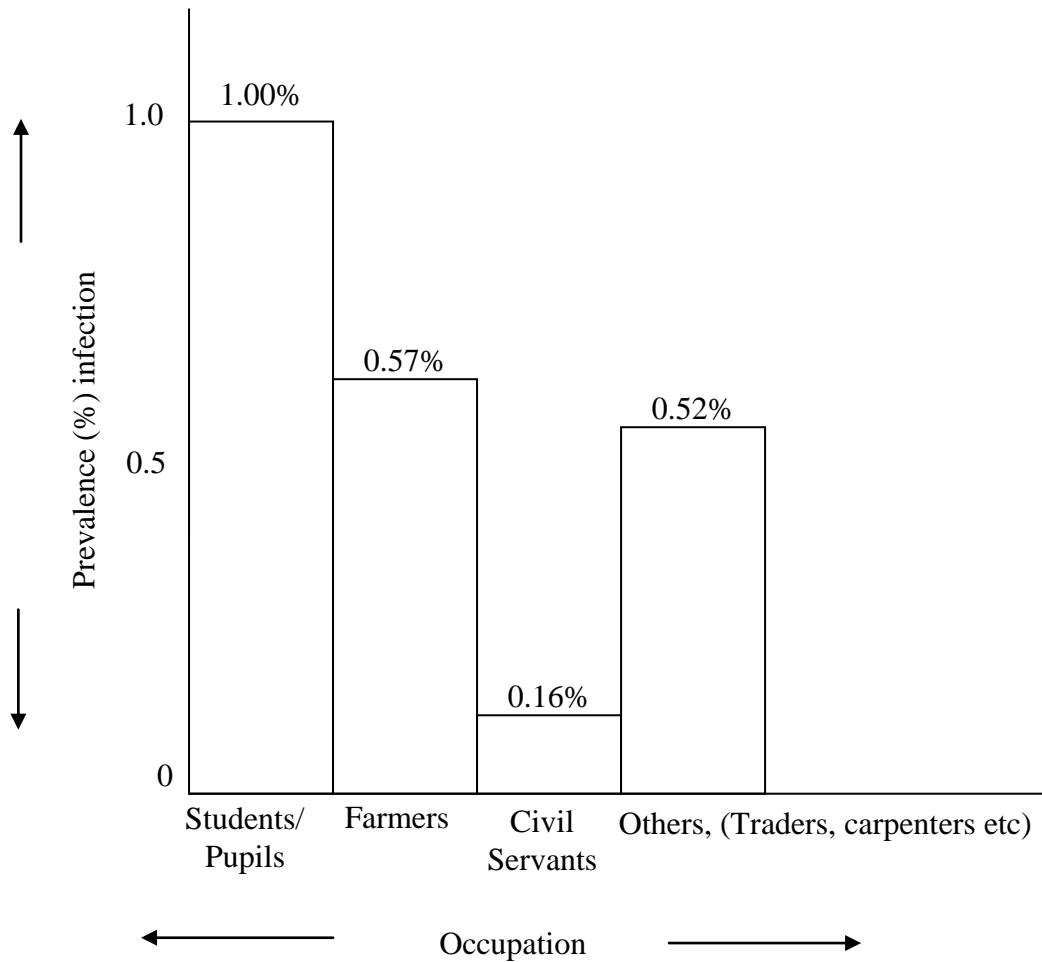
Figure 7: Prevalence of Schistosomiasis in Relation to Occupation of the Inhabitants in the Study Area.

Figure 7 highlights prevalence of schistosomiasis in different occupational groups. Students/pupils were more infected, 13(1.00%), followed by farmers 5(0.57%) while civil servants were least infected 1 (0.16%) and individuals in other trades had a prevalence of 0.52%.

4.4.6   Sources of Water Supply

Figure 8 shows prevalence of schistosomiasis in participants who used various sources of water supply. The available sources were pipe-borne water, bore hole water and stream water.

Individuals whose sources of water supply for domestic use were streams recorded highest prevalence. Out of 643 individuals among this group of people screened, 10(1.56%) were infected by schistosomes – 7(1.09%) by *Schistosoma mansoni* and 3(0.47%) by *Schistosoma haematobium*. This group was closely followed by individuals whose source of water supply were boreholes (0.70%). Out of 1009 individuals in this group, 4(0.40%) were infected by *Schistosoma mansoni* and 3(0.30%) by *Schistosoma haematobium*. Volunteers whose source of water supply was pipe- borne had least prevalence of 0.26%. Two 2(0.13%) out of the 1009 individuals were infected by *Schistosoma mansoni* and two 2(0.13%) by *Schistosoma haematobium*. The difference in the infection rate of the groups was statistically significant ($p < 0.05$) (Figure 8).
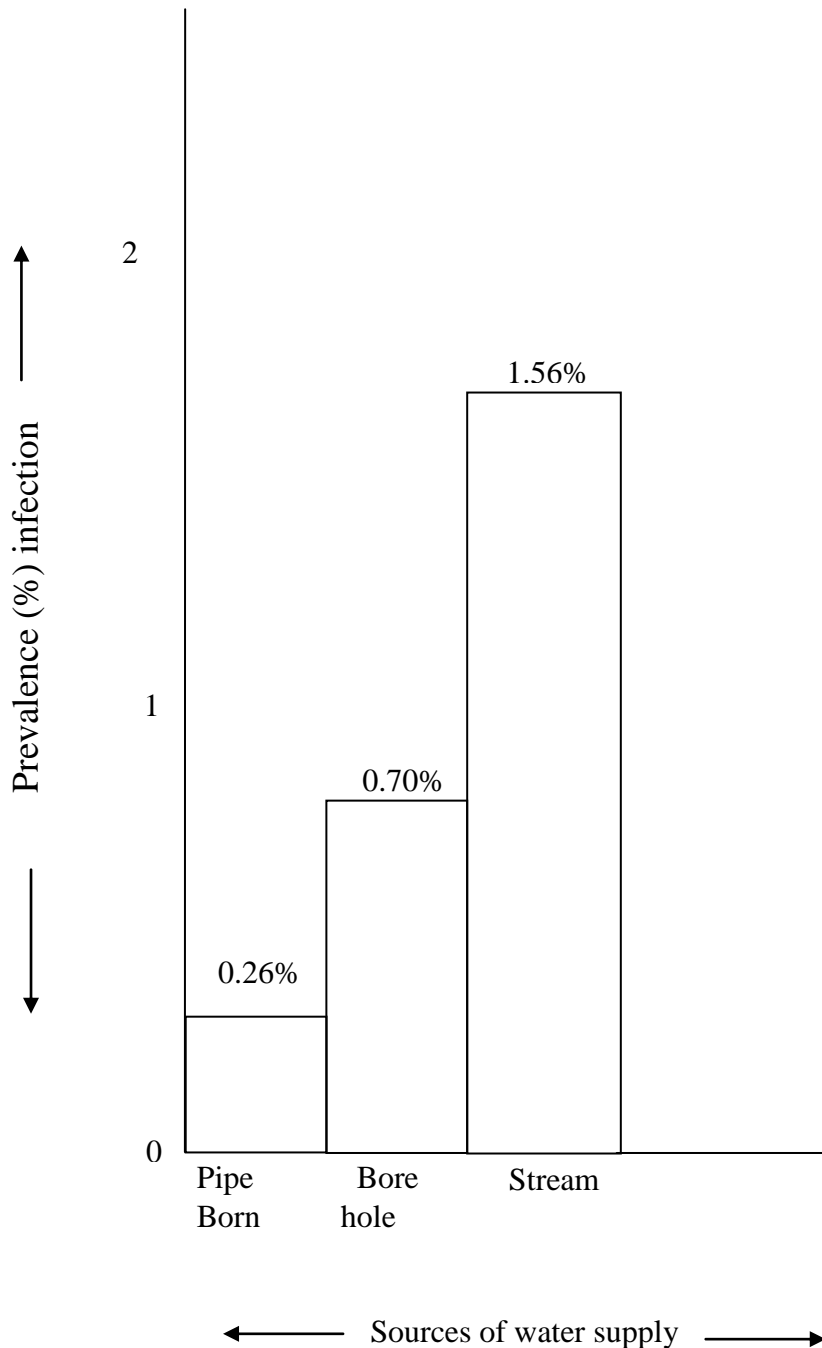
Figure 8: Prevalence of Schistosomiasis in Relation to Sources of Water Supply.

Figure 8 Indicates effects of sources of water supply on transmission of schistosomiasis in the area. Individuals whose sources of water supply were streams were more infected 10 (1.56%),while those who used pipe-borne water were least infected 4(0.26%) and those who used bore holes had prevalence of 0.70%.

4.4.7   Toilet Facilities.

Figure 9 shows infection rates in individuals who used different types of toilet facilities-bush, pit latrine and water closet system (w.c.s.).

Individuals who used bush as their toilet facility recorded highest prevalence (1.75%) compared with those who used water closet system and those who used pit. Out of 510 volunteers who used bush for toilet; 10(1.75%) were infected by schistosomiasis, 7(1.23%) of then infected by intestinal and 3 (0.35%) by urinary schistosomiasis. The prevalence among uses of water closet system was 0.26% as only 1(0.07%) person out of 1538 volunteers examined was infected by *Schistosoma mansoni* and 3(0.20%) by *Schistosoma haematobium*. Individuals whose toilet facility was pit had a total prevalence rate of 0.65%; out of 1082 volunteers, 5(0.46%) were found infected by *Schistosoma mansoni* while 2(0.18%) had *Schistosoma haematobium* infection (Figure 9).
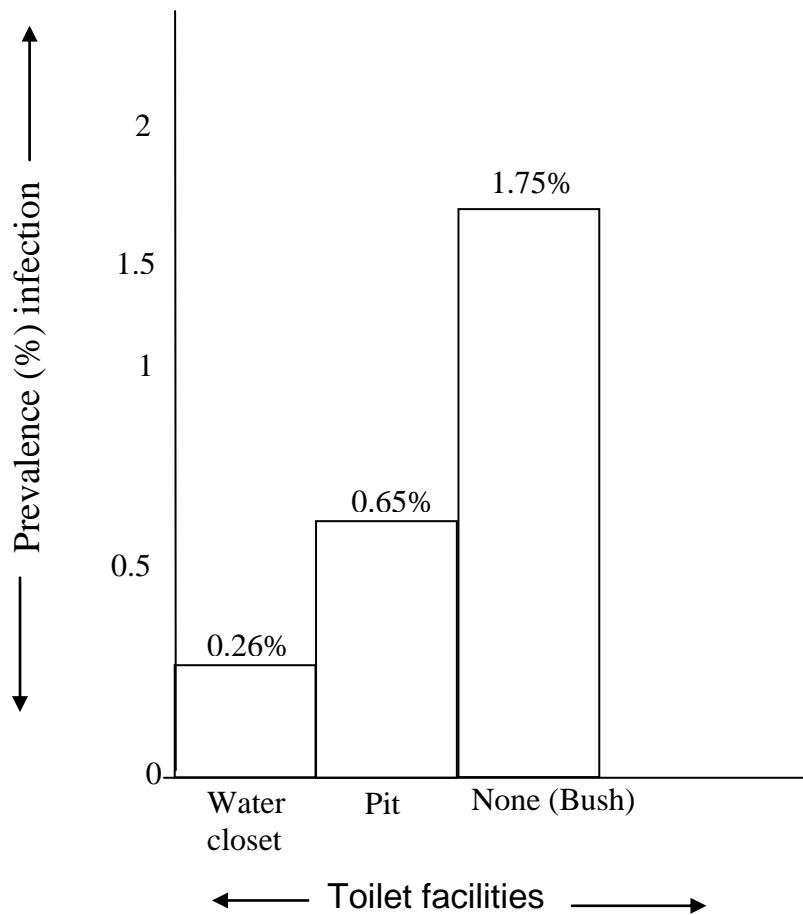
Figure 9: Prevalence of Schistosomiasis in Relation to Toilet Facilities used by the Individuals.

Figure **9** highlights the relationship between toilet facilities and transmission of schistosomiasis. It was found out that individuals who used water closet system as toilet facility were least infected 4(0.26%) compared with those who used pit latrines 7 (0.65%) and those who usd bush 10 (1.75%).

4.4.8 Seasonal Infection of Individuals in the Study Area

Table 9 highlights the prevalence of infection within the seasons (wet and dry season). It was observed that 10(0.62%) individuals were infected in dry season (October to March). The month of February had highest prevalence of 1.19%, followed by the month of March 0.90%. The months of November, December and January, recorded one infection each giving prevalence of 0.39%, 0.35% and 0.31% respectively. None of the participants was found infected in the month of October.

Similarly, out of 1362 individuals examined in wet season, 11(0.70%) were infected by schistosomiasis, 6(0.31%) by *Schistosoma mansoni* and 5(0.39%) by *Schistosoma haematobium*. Out of 220 individuals examined in the month of May, 4(1.82%) were infected by schistosomiasis, 3(1.36%) by *Schistosoma mansoni* and 1(0.45%) by *Schistosoma haematobium).* Also in the month of September, 4(1.75%) out of 235 individuals screened were infected by schistosomiasis (one of the four infections was *Schistosoma mansoni* while 3(1.28%) were *Schistosoma haematobium).* Only one infection occurred in each of the months of June, July and August giving prevalence of 0.45%, 0.44% and 0.41% respectively (Table 9).

Table 9 shows seasonal infection of individuals in diferent locations of the study area. More 11(0.70%) individuals were infected by schistosomiasis in wet season than in dry season, 10(0.62%). In dry season 7 persons were infected by *Schistosoma mansoni* and 3 persons by *Schistosoma haematobium* while in wet season 6 persons were infected by *Schistosoma* mansoni and 5 indivisuals by *schistosoma haematobium*.

Table 9: **Prevalence of Schistosomiasis in Wet and Dry Seasons in Jos South Local Government Area, Plateau State, Nigeria**

Season	Number Examined	*Schistosoma mansoni* Number Infected (%)	*Schistosoma haematobium* Number Infected (%)	Total Number Infected (%)
Dry: October				
	220	0(0.00)	0(0.00)	0(0.00)
November	320	0(0.00)	1(0.39)	1(0.39)
December	289	1(0.35)	0(0.00)	1(0.35)
January	326	0(0.00)	1(0.31)	1(0.31)
February	335	3(0.90)	1(0.30)	4(1.19)
March	338	3(0.90)	0(0.00)	3(0.90)
Total	1828	7(0.44)	3(0.19)	10(0.62)
Wet:				
April	214	0(0.00)	0(0.00)	0(0.00)
May	220	3(1.36)	1(0.45)	4(1.82)
June	221	1(0.45)	0(0.00)	1(0.45)
July	227	1(0.44)	0(0.00)	1(0.44)
August	245	0(0.00)	1(0.41)	1(0.41)
September	235	1(0.41)	3(1.28)	4(1.70)
Total	1362	6(0.31)	5(0.39)	11(0.70)
Grand total	3190	13(0.41)	8(0.25)	21(0.66)

χ^2 calculated = 9.039; χ^2 tabulated = 19.68, df= 11, P>0.05

4.4.9 Infection of Individuals in Different Locations of the Study Area

Of the eight (8) locations in the study area, individuals in six (6) of the locations recorded schistosomiasis infection. These were Vom/NIPSS Kuru, with highest prevalence of 1.34%, 2(0.38%) individuals were infected by *Schistosoma mansoni* while 5(1.00%) had *Schistosoma haematobium* infections; this is followed by Bukuru 6 (1.20%), where 4 (0.79%) had *Schistosoma mansoni* and 2(0.40%) had *Schistosoma haematobium* infection. At Anglo-Jos, where 509 volunteers were screened, 2(0.40%) were infected by *Schistosoma mansoni* and 1(0.20%) by *Schistosoma haematobium*. Dogon-Karfe and Gigiring recorded prevalence of 0.40% and 0.20% respectively while Malaraba-Jama'a and Farin-Lamba recorded no infection(0%) (Figure 10).
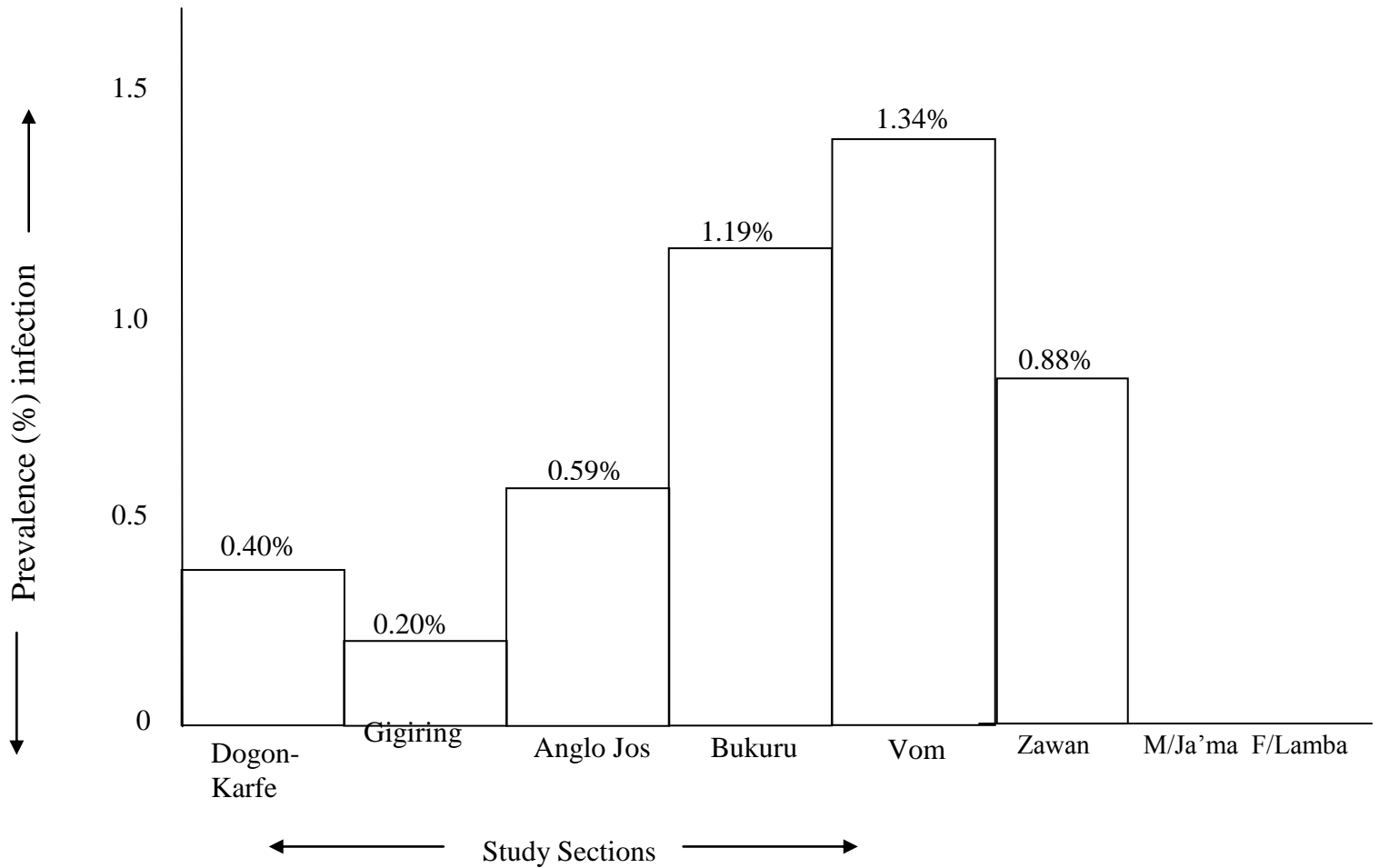
Figure 10: Prevalence of Schistosomiasis in relation to locations.

Figure 10 shows prevalence of schistosomiasis at different locations of the study area. The infection rate was more in Vom/NIPSS Kuru and environs 7(1.34%) closely followed by infection rate in Bukuru 6(1.20%). There were low infection rates at Anglo-Jos 3(0.60%), Dogon-Karfe 2(0.40%), Zawan 2(0.88%) and Gigiring 1(0.20%). Maraba-Jama'a and Farin-Lamba had 0% infection rate.

4.4.10   Prevalence of Schistosomiasis in relation to Religion in the Study Area

Table 10 shows influence ofreligion on the prevalence of schistosomiasis in the study area.

Out of a total of 2,134 Christians screened, 13(0.61%) had eggs of Schistosomes. Eight 8(0.37%) had eggs of *Schistosoma mansoni* in their stool while 5(0.23%) had eggs of *Schistosoma haematobium* in their urine. The rate of infection among the Moslems in the same areas was slightly higher as 8(0.76%) of 1056 Moslems examined were positive for eggs of schistosomes.Five (5) (0.47%) had eggs of *Schistosoma mansoni* in their stool and three (3) (0.28%) eggs of *Schistosoma haematobium* in their urine. This slight difference in infection with schistosomiasis among members of these two religious groups, Christianity and Islam, was not statistically significant, $P>0.05$ (Table 10).

Table 10 shows the influence of religion on the prevalence of schistosomiasis in the study area. Out of the 2134 Christians examined 13 (0.61%) were infected and out of 1056 Moslems examined 8 (0.76%) were infected. The difference in infection rate between the two religious groups was not statistically significant (P>0.05).

Table 10: Prevalence of Schistosomiasis in Relation to Religion in the Study Area

Religion	Number Examined	*Schistosoma mansoni* Number infected (%)	*Schistosoma haematobium* Number infected (%)	Total Number infected (%)
Christianity	2134	8(0.37)	5(0.23)	13(0.61)
Islam	1056	5(0.47)	3(0.28)	8(0.76)
Total	3190	13(0.41)	8(0.25)	21(0.66)

χ^2 calculated = 0.213; χ^2 tabulated = 3.841,   df=1, P>0.05

4.5   MALACOLOGICAL SURVEY

4.5.1 Relationship between Snails Shedding Cercariae and average water quality values

The values of pH of water samples ranged from 5.5 in Vom/NIPSS Kuru stream to 7.5 at Dogon-Karfe, temperature ranged from 29.5 at Farin-Lamba and Gigiring to 30.5 at Vom/NIPSS stream. Dissolved oxygen from 2.0gm/L in four (4) of the eight (8) locations – Farin lamba, Malaraba-Jama'a, Zawan and Anglo-Jos to 5.0gm/L in Vom/NIPSS Kuru stream. Similarly alkalinity and conductivity had their average ranges as 60mg/L^{-1} to 90mg/L^{-1} and 0.7 to 0.8Ms/cm^{-1} respectively.

Three different snail species were encountered during the study. They were Bulinus globosus,Biomphalaria pfeifferi and *Lymnea natalensis.* All the snails except 85 among those collected at Vom/NIPPS did not shed cercariae giving a prevalence of infection as 13.51%.

Table 11 shows that only some of the snails 85(26%) collected at Vom/NIPSS Kuru stream were shed cercariae. The stream at Vom/NIPSS, had lowest pH and alkalinity values but highest dissolved oxygen value. The difference in the collected in other streams was statistically significant (P>0.05).

Table 11 also shows relationship between numbers of snails that shed cercariae and the average water quality values. Only 85 of 330 snails collected at Vom/NIPSS Kuru stream shed cercariae while the rest snails collected from other locations did not shed cereariae. The average pH and alkalinity values of the Vom/NIPSS Kuru stream which contained the infected snails were lower than those of other streams which contained uninfected snails. Also the average dissolved oxygen of Vom/NIPSS stream was higher than those of the rest of *streams.*

Table 11   shows the relationship between snails that shed cercariae and the average water quality values. Only 85 (25.76%) of 330 snails collected at Vom/NIPSS Kuru shed cercariae while the rest snails collected from other locations did not shed.The average pH and alkalinity of the Vom/NIPSS Kuru stream which contained the infected snails were lower than those of other streams which harboured uninfected snails. Also the average dissolved oxygen of Vom/NIPSS Kuru stream was higher than those of the rest of streams.

Table 11:   Relationship between Number of Snails that Shed Cercariae and Average Water Quality Values

Sampling Site	Number of snails collected	Number of snails infected (%)	Average Water Quality Values				
			pH	Temp. ^{o}C	Dissolved Oxygen	Alkalinity MgL^{-1}	Conductivity Ms/cm^{-1}
Dogon-Karfe	179	0(0.00)	7.5	30.0	4.0	60	0.7
Gigiring	246	0(0.00)	6.5	29.7	3.0	100	0.7
Anglo-Jos (Zaramaganda)	0	0(0.00)	6.5	30.3	2.0	90	0.7
Bukuru (Fwagul)	326	0(0.00)	6.5	29.5	3.0	120	0.8
Vom/NIPSS	330	85(25.76)	5.5	30.5	5.0	20	0.8
Zawan	0	0(0.00)	65	30.0	2.0	90	0.7
Malaraba Ja'ma	0	0(0.00)	6.5	30.3	2.0	90	0.7
Farin Lamba	0	0(0.00)	6.5	29.5	2.0	90	0.7

KEY: NIPSS = National Institute for Policy and Strategic Studies

χ^2 calculated = 19.6, χ^2 tabulated = 5.991, df=7, $P<0.05$

Table 12 shows the cercarial infection rates of the snail species collected during the study. Out of the 629 *Lymnea* snails collected 85(13.51%) shed cercariae while the 249 *Bulinus* and 203 *Biomphalaria* snail species did not shed cercariae.

Table 12:   Cercarial Infection Rates of the Snail species collected during the Study

Species	Number. Collected	Number Infected (%)
Bulinus globosus	249	0(0.00)
Biomphalaria pfeifferi	203	0(0.00)
Lymnea natalensis	629	85(13.51)
Total	1081	85(7.86)

χ^2 calculated = 66.3; χ^2 tabulated = 5.99,   df=1, P<0.05

4.6   OTHER PARASITES ENCOUNTERED IN THE STUDY AREA

Apart from schistosomes, other parasites, both intestinal and urinary, were encountered during the study. The parasites included protozoa and other helminths. Protozoa species were *Entamoeba coli,* (11.22%), *Entamoeba histolytica* 266(8.34%), *Giardia intestinalis* 47(1.47%), *Iodoamoeba butschlii 13(0.46%) and Trichomonas vaginalis,* the only urinary parasite found during the study, 8(0.25%).

Other helminth species seen were *Taenia species 5(0.16%), Hymenolepis nana* 47(1.47%), Hookworm 393(12.32%), *Ascaris umbricoides* 192(6.02%), *Strongyloides stercoralis* 48(0.50%), *Trichuris trichiura* 8(0.25&) *and Enterobius vermicularis* 8(0.25%). Among the protozoa, *Entamoeba coli* had the highest prevalence while hookworms had the highest among the helminths.
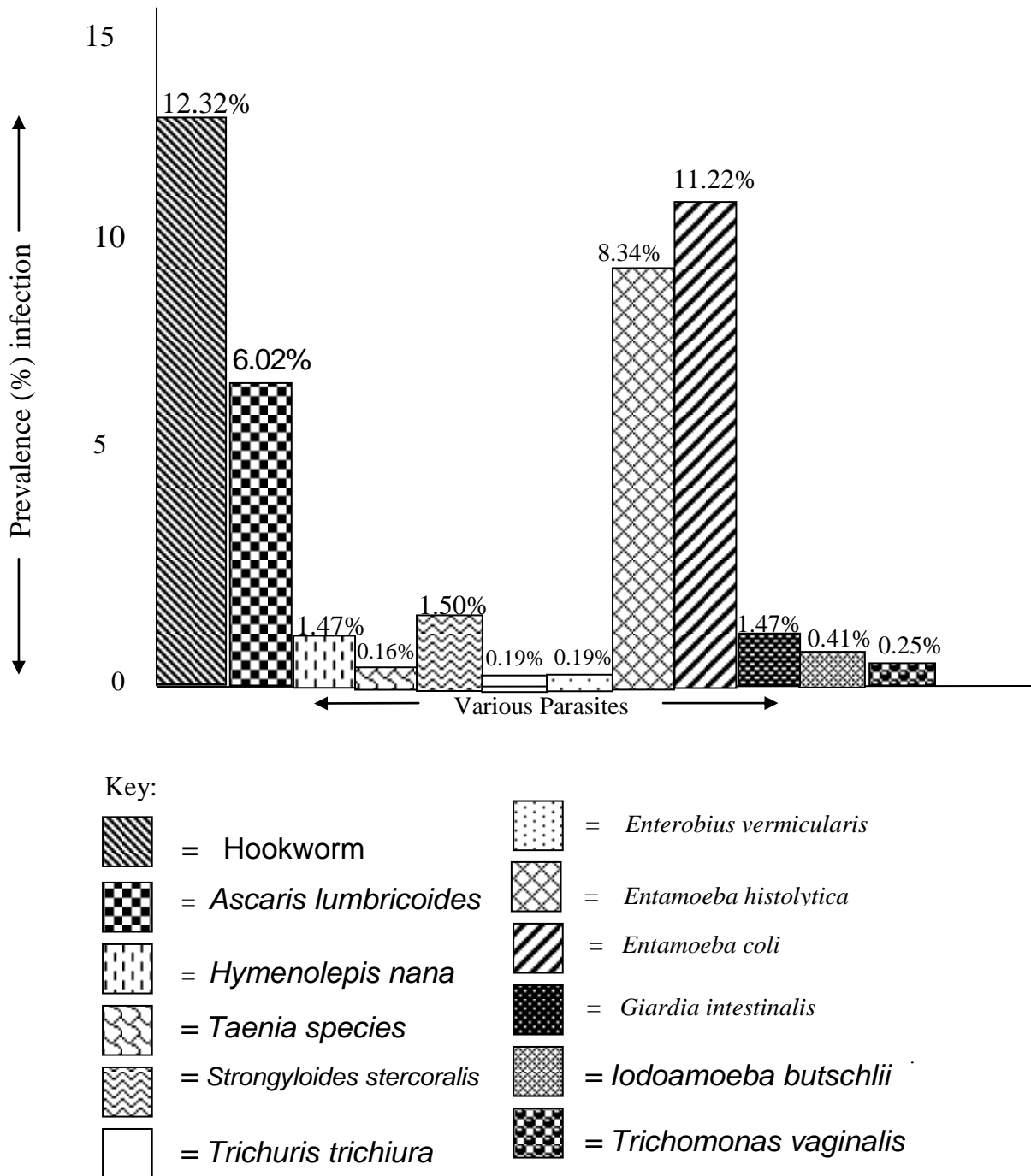
Figure 11: Prevalence of other parasites encountered during the study.

Figure 11   shows other parasites encountered in 3190 inhabitants of Jos South

Local Government Area, Plateau State, Nigeria, during the study. A total of twelve

different types of parasites (intestinal, 11 and urinary, 1) were encountered during the study. Among the protozoa, *Entamoeba coli* had the highest prevalence 358(11.22%) followed by *Entamoeba histolytica* 266(8.34%) and the least, the only urinary parasite, *Trichomonas vaginalis* 8(0.25%) and among the helminths, hookworms had the highest prevalence 393(12.32%) followed by *Ascaris lumbricoides,* 192(6.02%) and the least was *Taenia species* 5(0.16%). Infection rate was highest in Zawan (243), followed by Mararaba Jama'a(185) and lowest in Vom (73) followed by Bukuru (102). Infection was highest with hookworm (393) followed by *Entamoeba coli (358)* and *Entamoeba histolytica* (266).

CHAPTER FIVE

DISCUSSION

5.1   PARASITOLOGICAL SURVEY

5.1.1 Overall Prevalence of Schistosomiasis in the Study Area

The overall prevalence of 0.32% for schistosomiasis (25% for *Schistosoma haematobium* and 0.41% for *Schistosoma mansoni*) indicates low endemicity of infection in our studied locality. These observations are contrary to the reports of Anosike *et al*. (1992) Mafiana and Adesanya (1994), Ofoezie, Bolton, Imevbore, and Christensen, (1996), Okpala et *al*. (2002), Okpala. Nwobu, Agba, and Akor, (2003), Okpala, Agwu, Agba, Chimezie, Nwobu, and Ohihoin (2004), Nwosu, Anosike, Nwoke and Uwaezuoke (2005) , Nmorsi, Ukwandu, Ogoinja, Blackic and Odike (2007) and Mordi and Ngwodo (2007). All the researchers mentioned above recorded higher prevalence rates in their study areas. The low prevalence of the disease, recorded in the inhabitants from the study area may probably be due to the fact that some of the localities such as Dogon-Karfe, Anglo-Jos and Vom/NIPSS have urban settlements with improved water supply and toilet facilities. Further more, since the snails did not shed the infective stage, cercariae, the streams were not harbouring the infective stage. This resulted to the residents who came in contact with the streams not being infected.

5.1.2 Infection of Individuals in Different Locations

Of all the locations studied, infection of the individuals was highest in Vom and Bukuru and lowest in Gigiring. This pattern of infection of individuals in different locations in the study area was similar to those recorded by Anosike *et al.* (1992), Dunah and Bristone, (2000), Chidi *et al.* (2006) and Uneke *et al.* (2007). The major factors that might be responsible for the higher prevalence in Vom and Bukuru are low literacy level, poor sanitation due to lack of basic amenities such as water, inadequate and indiscriminate disposal of human wastes - stool and urine in Bukuru; migration of infected individuals from endemic areas into the study areas as recorded in both Vom and Bukuru and high water contact activities in surrounding streams which may be harbouring snails shedding cercariae.

5.1.3 Human Water Contact Activities – Age Related Infection

In this study, individuals within the age range of 11-20 years were found to be more infected by the disease, schistosomiasis than individuals in other age groups. This finding is consistent with those of Egwunyenga (1994), Arinola (1995), Ukwandu and Bukbuk (1996) Amazigo, Anago-Amanze, and Okeibunor (1998), Abolarinwa (1999), Mafiana, Ekpo, and Ojo, (2003), Okpala *et al.* (2004), Nwosu, Anosike, Nwoke, and Uwaezuoke, (2005) and Nmorsi *et al.* (2007). The possible reason for this findings may be probably because they spent more time in infested streams for one or more water contact activities, such as bathing, playing, swimming or washing clothes, as a result, they get infected by the infective stage of the parasite, cercariae. This group also contaminates the streams with their urine and faeces which may contain the eggs of the parasites. So they act as sources of transmission of the disease. It was noted in the study that infection with the disease, schistosomiasis is

age-dependent as individuals in younger age ranges and those in older age ranges were not infected. This may be due to age – dependent reduction in exposure indices in the younger and the older age ranges and awareness or early treatment of the infection in the older age ranges.

5.1.4   Sex – Related Infection

In this study, males were more infected by the disease, schistosomiasis than the females. This finding is in consonant with the work of other research fellows such as Okpala *et al.* (2002 and 2004), Egwunyenga *et al.* (1994), Arinola (1995), Abolarinwa (1999), Okpala, Nwobu, Agba, and Akor, (2003), Okoronkwo *et al.* (2003), Chidi, Anosike, and Iwuala, (2006), Olufemi, Ndubuisi, Oluseyi, Adebayo, Aliu, Emmanuel, Flourish, Adetoun, Adeshina, Ganiyat, Oluwatosin, and Udia, (2007), Uneke, Oyibo, Ugwuoru, Arinzechukwu, and Iloegbunam, (2007) and Ukwandu and Nmorsi (2008). The high prevalence recorded in males may be due to higher water contact activities by males as they are more involved in farm work than the females. Similarly, males also undertake other water contact activities such as fishing, swimming and bathing in the infested water bodies while females do not participate in these activities due to socio-cultural grounds. For instance the development of secondary sexual characters which prevents females from visiting streams unlike their male counterparts. As a result, males get more exposed to cercarial infested water bodies and get infected by the parasites.

5.1.5 Occupation Related Infection

In this study, it was observed that occupation of the individuals in the study area played an important role as it had an effect on the infection rate of those screened. The pattern of infection among the four occupational groups indicated that students/pupils were more infected than individuals in other occupantional groups followed by farmers. This observation of the prevalence of schistosomiasis is in agreement with the reports of Egwunyenga *et al.* (1994), Okpala *et al.* (2002, 2003) Okpala *et al.* (2004), Nwosu *et al.* (2005) Nmorsi *et al.* (2005) and *Chidi*, Anosike, and Iwuala (2006). The higher infection rate in students/pupils and farmers could be attributed to their frequent contact with water bodies as the students/pupils visit the streams frequently for bathing, swimming or playing and the farmers use the water from infested streams for their recreational, occupational and domestic activities. These categories of people therefore have greater exposure to infection and as a result, constitute sources of infestation to the water bodies through which other groups may be infected.

5.1.6 Sources of Water Supply

In this study sources of water supply played a major role as individuals whose sources of their water supply were streams, were more infected than those whose sources were the other alternatives i.e bore holes and pipe borne. This observation agrees with the records of Okpala *et al.* (2002, 2003 and 2004), and Nwosu, Anosike, Nwoke, and Uwaezuoke, (2005). The high prevalence rate could be due to the fact that the infected individuals were exposed to streams harbouring the infective stage i.e the cercariae.

Though some individuals in other groups that used bore holes and pipe- borne water, were infected, it could be that these people visited infested streams for

or more water contact activities, got exposed to cercarial containing water and thus got infected.

5.1.7   Availability of Toilet Facilities

The types of toilet facilities available to the inhabitants of the study area had effect on the prevalence of the disease as members of the group that utilized bush as their toilets were more infected than those who used water closet system (w.c.s.) and those who used pit toilets. This observation is in agreement with the work of other researchers in different parts of Plateau State and other parts of the country such as Okpala *et al.* (2002, 2003 and 2004). The higher prevalence rate in the individuals using bush as their toilet facilities can be attributed to the inhabitants in such areas getting exposed in one way or the other to water bodies harbouring the infective stage of the parasites schistosomes in the vicinity of the bushes they utilized. The exposure may be through bathing in the water bodies, wading through the water, defaecating within the water bodies or even drinking the infested water.

5.1.8 Infection of Individuals in Different Locations

Of all the locations studied, infection of the individuals was highest in Vom and Bukuru and lowest in Gigiring. This pattern of infection of individuals in different locations of study area was similar to those recorded by Anosike et al. (1992), Dunah and Bristone, (2000), Chidi et al. (2006) and Uneke et al. (2007). The major factors that might be responsible for the higher prevalence in Vom and Bukuru are low literacy level, poor sanitation due to lack of basic amenities such as water, inadequate and indiscriminate disposal of human wastes – stool and urine in Bukuru; migration of infected individuals from endemic areas into the study areas as observed in both Vom and Bukuru and high water contact activities in surrounding streams which may be harbouring snails shedding cercariae.

5.1.9 Influence of Religion on Schistosomiasis

Among the two major religious groups in the study area, Christianity and Islam, the Moslems were slightly more infecfted than the Christians but the difference was not statistically significant (P>0.05). The slight difference in infection rate may be attributed to the use of water that might be harbouring the infective stage of the parasite, cercariae, at the time of ablution.

5.1.10 Seasonal Infection

Infection rates within the seasons did not follow any particular pattern within the period of this study. Higher infection rates were observed in the months of February (1.19%), May (1.82%) and September (1.70%) while the rates were lower in June (0.45%), July (0.44%), August (0.41%),November (0.39%), January (0.39%) and December (0.35%). Of all the months of the year, April and October were free of infection as no individual was found to be infected by the disease, schistosomiasis. This pattern of seasonal parasitic infections was also recorded by other researchers in Plateau State and other parts of the country such as Okoronkwo *et al*. (2003) and Mordi and Ngwodo (2007). The difference in infection of the inhabitants of the study area by schistosomiasis in months of dry and wet seasons was not statistically significant (P>0.05).This is contrary to the report of Mordi and Ngwodo (2007). The low infection rates in seasons could be due to improved amenities such as water and toilet facilities in some of the localities in the study area and also non- exposure to infested water bodies in rainy seasons when residents do not visit streams for water for domestic activities.

5.2 PHYSICO-CHEMICAL PARAMETERS

In this study, the average physico-chemical parameter values of pH, temperature, dissolved oxygen; alkalinity and conductivity in Dogon-Karfe, Gigiring, Bukuru and Vom/NIPSS Kuru streams were within the ranges that support snail breeding. These values are in consonance with the records of other researchers in Plateau and other parts of the country such as Okwuosa and Ukoli (1980), Agi and Okwuosa (1991) and Ukwandu, Nmorsi, Okholo, Okao, Odaibo, and Okoro (2006) in Nigeria generally. The value of dissolved oxygen was lower (2.0mg/L) in the streams at Anglo-Jos, Zawan, Mararaba-Jama and Farin-Lamba. Snail vectors were not found in these streams. The absence of snails in these streams may probably be due to low dissolved oxygen value. This study has revealed that dissolved oxygen in streams plays an important role in snail breeding ; that snails do not breed in streams with low oxygen content, even if all parameters i.e. pH, conductivity, alkalinity and temperature are within normal ranges for snail breeding.

5.3 MALACOLOGICAL STUDIES

Of the entire snail hosts collected during this study only some *Lymnea* snails 85(7.86%) shed cercariae. The other snail hosts, *Bulinus* and *Biomphalaria* species collected from all the sites did not shed cercariae. The *Lymnea species* were collected at Vom/NIPSS Kuru stream. *Lymnea* snail is the intermediate host of *Fasciola species,* which is a lower animal parasite. It is possible that some lower animals infected with the parasite contaminated the stream with their faeces containing the eggs of the parasite. Twenty-one (21) of the residents of the Local Government Area had the eggs of schistosomes in their faeces or urine. From the history of the infected individuals, they acquired the infection from areas outside the Local Government Area and since the snail vectors of schistosomes in the available

water bodies were not harbouring the infective stage of the disease, cercariae, the infected individuals might not have contaminated the water bodies with their faeces or urine containing the eggs of the parasites.   Again the inhabitants in Vom/NIPSS Kuru being civil servants do not visit the available stream for any water contact activity. The snail hosts of these parasites were therefore not infected and as such did not shed cercariae.

5.4 OTHER PARASITES ENCOUNTERED

During the study, other intestinal and urinary parasites were recorded. The study revealed high prevalence of these parasites which were protozoa and other helminths. The other parasites included protozoans such as *Entamoeba coli,* 358(11.22%), *Entamoeba histolytica*, 266(8.34%), *Giardia intestinalis*, 47(1.47%), *Iodoamoeba butschlii*, 13(0.40%) and *Trichomonas vaginalis*, the only urinary parasite, 8(0.25%), and helminths- *Taenia* species, 5(0.16%), *Hymenolepis nana*, 47(1.47%), Hookworms, 393(12.32%) *Ascaris lumbricoides*, 192(6.02%), *Strongyloides stercoralis*, 48(0.50%), *Enterobius vermicularis*, 6(0.19%) and *Trichuris trichiura*, 6(0.19%). A total of twelve different types of parasites were recorded.

Among the Protozoans, *Entamoeba coli* had highest prevalence while hookworm had highest prevalence among the helminths. This is similar to the reports of other researchers in Plateau State and other parts of the country for notably Okoronkwo and Zoakah (1997), Ofoezie, Bolton, Imevbore, and Christensen, (1996), Ogbonna and Okoronkwo (2000), Okoronkwo (2002), Okodua, Adeyaba, Tatfeng, and Okpala (2003), Atu, Galadima, and Alice, (2006) and Mordi and Ngwodo (2007). The high prevalence of these parasites recorded in the study area was probably due to poor personal hygiene, poor environmental sanitation, indiscriminate disposal of

human wastes (stool and urine) and lack of basic amenities such as pipe-borne water and toilet facilities in some of the localities.

The hypothesis was tested against the results obtained which indicate that the prevalence of schistosomiasis in Jos South Local Government Area was not in the increase.

5.5   Testing of Hypothesis

1.   Chi-square analysis of the Prevalence of schistosomiasis in different age groups of Jos South Local Government Area Inhabitants.

Hypothesis

Ho: Prevalence rate is likely equal among the various age groups.

Hi: Prevalence rate is not likely equal among the various age groups.

Age group (years)	Number examined	Number positive		Number negative		Total
		Observed (O)	Expected (E)	Observed (O)	Expected (E)	
0-10	588	0	3.87	588	584	588 (a)
11-20	801	14	5.28	787	795.7	801
21-30	697	4	4.59	693	692.4	697
31-40	486	3	3.20	483	482.8	486
41-50	387	0	2.55	387	384.5	387
51 and above	231	21(c)	1.52	231	229.5	231
Total	3190			3169		3190(b)

Expected value in each cell was calculated using the formula the formula

$$\frac{a \times c}{b}$$

$$\chi^2 = \Sigma \frac{(0-E)^2}{E} = \frac{(0-3.9)^2}{3.9} + \frac{(14-5.3)^2}{5.3} + \frac{(4-4.6)^2}{4.6} + \frac{(3-3.2)^2}{3.2} + \frac{(0-2.6)^2}{2.6} + \frac{(0-1.5)^2}{1.5}$$

$$+ \frac{(588-584)^2}{584} + \frac{(787 - 795.7)^2}{795.7} + \frac{(693 - 692.4)^2}{692.4} + \frac{(483 - 482.8)^2}{482.8} + \frac{(387-384.5)^2}{384.5}$$

$$+ \frac{(231-229.5)^2}{229.5}$$

= 3.9 + 14.28+0.08+0.01+2.60+1.50+0.03+0.10+0.00+0.00+0.020 + 0.01 = 22.530

χ^2Calculated = 22.51; χ^2 tabulated = 11.07

Conclusion:

Since χ^2 calculated = 22.51 and

χ^2 tabulated = 11.07, we reject Ho. at P<0.05, and the alternative hypothesis (Hi) accepted. This means that there is a significant difference in the proportion of different age groups infected with schistosomes.

2. Chi-square analysis of schistosomiasis in both sexes of the inhabitants of Jos South Local Government Area, Plateau State, Nigeria.

Hypothesis

Ho: Prevalence rate is likely equal in both sexes

Hi: Prevalence rate is not likely equal in both sexes

Sex	Number examined	Number positive		Number negative		Total
		Obsrved (O)	Expected (E)	Observed (O)	Expected (E)	
Males	1584	14	10.43	1570	1573.5	1584
Females	1606	7	10.57	1599	1595.4	1606
Total	3190	21		3169		3190

$$\chi^2 = \sum \frac{(O-E)^2}{E} = \frac{(14-10.43)^2}{10.43} + \frac{(7-10.57)^2}{10.57} + \frac{(1570-1573.5)^2}{1573.5} + \frac{(1599-1595.4)^2}{1595.4}$$

$$= 1.22 + 1.21 + 0.01 + 0.01 = 2.45.$$

χ^2Calculated $= 2.450$; χ^2 tabulated $= 3.841$

Since χ^2 calculated $= 2.450$ and

χ^2 tabulated $= 3.841$, we do not reject Ho. at P>0.05 and the alternative hypothesis Hi accepted. This means that there is no significant difference in the sexes.

Conclusion: The difference in infection among the sexes is not statistically significant.

3. Chi-square analysis of schistosomiasis in different occupational Groups of Inhabitants of Jos South Local Government Area, Plateau State, Nigeria.

Hypothesis

Ho: Prevalence rate is likely equal among the various occupational groups

Hi: Prevalence rate is not equal likely equal among the various occupational groups

Sex	Number examined	Number positive		Number negative		Total
		Observed (O)	Expected (E)	Observed (O)	Expected (E)	
Students/Pupils	1311	13	8.63	1298	1302.4	881(a)
Farmers	881	5	5.80	876	875.2	881
Civil servants	661	1	4.02	610	607	661
Others (artisans)	387	2	2.55	385	384.5	387
Total	3190	21		3169(c)		3190 (b)

All the expected values (E) in all the cells were calculated using the formula $\frac{a \times c}{b}$

$$\chi^2 = \Sigma \frac{(O-E)^2}{E} = \frac{(13-8.63)^2}{8.635.} + \frac{(5-5.8)^2}{5.8} + \frac{(1-4.02)^2}{4.02} + \frac{(2-2.55)^2}{2.55} + \frac{(1298-1302.4)^2}{1302.4} + \frac{(876-875.2)^2}{875.2}$$

$$+\frac{(610-607)^2}{607} + \frac{(385-384.5)^2}{384.5}$$

= 2.12 + 0.11 + 2.27 + 0.12 + 0.01 +0.00 + 0.01 + 0.00 = 4.72

χ^2 Calculated = 4.72; χ^2 tabulated = 7.815

Since χ^2 calculated = 4.72 and

χ^2 tabulated = 7.815, we do not reject Ho. at P > 0.05

Conclusion: There is no significant difference in infection with schistosomiasis in relation to occupation of the inhabitants of the study area.

4. Chi-square analysis of the influence of Sources of Water Supply on the Transmission of Schistosomiasis in Jos South Local Government Area, Plateau State, Nigeria.

Hypothesis

Ho: Prevalence rate is likely equal among the users of various sources of water.

Hi: Prevalence rate is not likely equal among the users of various sources of water.

Source of water	Number examined	Number positive Observed (O)	Number positive Expected (E)	Number negative Observed (O)	Number negative Expected (E)	Total
Pipe borne	1538	4	10.12	1534	1227	1538(a)
Bore Hole	10009	7	6.64	1002	805	1009
Streams	643	10	4.23	613	638.8	643
Total	3190	21(c)		3169		3190(b)

All the expected values (E) in all the cells were calculated using the formula $\frac{a \times c}{b}$

$$\chi^2 = \Sigma \frac{(O-E)^2}{E} = \frac{(4-10.2)^2}{10.2} + \frac{(7-6.64)^2}{6.64} + \frac{(10-4.23)^2}{4.23} + \frac{(1534-1227)^2}{1227} + \frac{(1002-805)^2}{805}$$

$$+ \frac{(613-638.8)^2}{638.8} = 3.769 + 0.020 + 7.870 + 76.813 + 48.210 + 1.040$$

$$= 134.331$$

χ^2 Calculated = 134.331; χ^2 tabulated = 5.991

Since χ^2 calculated = 134.331 and

χ^2 tabulated = 5.991, we do not reject Ho. at $P<0.05$

Conclusion: There is significant difference in infection with schistosomiasis in relation to sources of water supply in the study area.

5. Chi-square analysis of the Relationship between Toilet Facilities and Transmission of schistosomiasis in Jos South Local Government Area, Plateau State, Nigeria.

Hypothesis

Ho: Prevalence rate is likely equal among the users of various toilet facilities

Hi: Prevalence rate is not likely equal among the users of various toilet facilities.

Toilet facility	Number examined	Number positive		Number negative		Total
		Observed (O)	Expected (E)	Observed (O)	Expected (E)	
Water closet	1538	4	10.12	1534	1527.9	1538(a)
Pit	1082	7	7.12	1075	1074.9	1082
None	570	10	3.75	560	566.2	570
Total	3190	21(c)		3169		3190(b)

All the expected values (E) in all the cells were calculated using the formula $\frac{a \times c}{b}$

$$\chi^2 = \Sigma \frac{(O-E)^2}{E} = \frac{(4-10.12)^2}{10.12} + \frac{(7-7.12)^2}{7.12} + \frac{(10-3.75)^2}{3.75} + \frac{(1534-1527.9)^2}{157.9} + \frac{(1075-1074.9)^2}{1074.9}$$

$$+ \frac{(560-566.2)^2}{566.2}$$

$= 3.701 + 0.002 + 10.417 + 0.024 + 0.000 + 0.068 = 14.213$

χ^2 Calculated = 14.213; $\chi^{2 \text{ tabulated}}$ = 5.991

Since χ^2 calculated = 14.213 and

χ^2 tabulated = 5.991, we do not reject Ho at $P < 0.05$

Conclusion: There is significant difference in infection with schistosomiasis in relation to toilet facilities in the study area.

6.   Chi-square analysis of the Prevalence of schistosomiasis in relation to different seasons in Jos South Local Government Area, Plateau State, Nigeria.

Hypothesis

Ho: Prevalence rate is likely equal in all the months of the year.

Hi: Prevalence rate is not likely equal in all the months of the year.

Seasons Months	Number examined	Number positive Observed (O)	Number positive Expected (E)	Number negative Observed (O)	Number negative Expected (E)	Total
October	220	0	1.18	220	218.6	220
November	320	1	2.11	319	317.9	320(a)
December	289	1	1.90	288	287	289
January	326	1	21.5	325	323.9	326
February	335	4	2.21	331	233.5	335
March	338	3	2.16	325	335.8	338
April	214	0	1.14	214	212.6	214
May	220	4	1.45	216	218.6	220
June	221	1	1.45	220	219.5	221
July	227	1	1.49	226	225.5	227
August	245	1	1.61	244	243.4	245
September	235	4	1.55	231	233.5	235
Total	3190	21(c)		3169		3190(b)

All the expected values (E) in all the cells were calculated using the formula $\frac{a \times c}{b}$

$$\chi^2 = \Sigma \frac{(O-E)^2}{E} = \frac{(1-2.11)^2}{2.11} + \frac{(1-1.90)^2}{1.90} + \frac{(1-2.15)^2}{2.15} + \frac{(4-2.21)^2}{2.21} + \frac{(3-2.16)^2}{2.16} + \frac{(0-1.14)^2}{1.14}$$

$$+ \frac{(4-1.45)^2}{1.45} + \frac{(1-1.45)^2}{1.45} + \frac{(1-1.49)^2}{1.49} + \frac{(1-1.61)^2}{1.61} + \frac{(4-1.55)^2}{1.55} + \frac{(0-1.18)^2}{1.18}$$

= 0.585 + 0.426 + 0.615 + 1.450 + 0.327 + 1.140 + 0.065 + 0.140 + 0.161

+ 0.231 + 3.873 + 0.027 = 9.039

χ^2Calculated = 9.039; χ^2 Tabulated = 19.68

Conclusion: Since χ^2 calculated = 9.038 and χ^2 tabulated = 19.68 we do not reject Ho at P<0.05.

This means that the prevalence of infection with schistosomiasis in different season (months) is not significant in the study area.

7. Chi-square analysis of the Prevalence of schistosomiasis at different Locations in the Study Area.

Hypothesis

Ho: Prevalence rate is likely equal in all the locations.

Hi: Prevalence rate is not likely equal in all the locations.

Locations	Number examined	Number positive		Number negative		Total
		Observed (O)	Expected (E)	Observed (O)	Expected (E)	
Dogon-Karfe	503	2	3.3	501	499.2	503(a)
Giriging	501	1	3.3	500	497.2	501
Anglo Jos	509	3	3.4	506	505.2	509
Bukuru	505	6	3.3	499	501.2	505
Vom	521	7	3.4	514	517.1	521
Zawan	226	2	1.5	224	224.5	226
Malaraba Ja'ma	206	0	1.4	206	204.6	206
Farin Lamba	219	0	1.4	219	217.6	219
Total	3190	21(c)		3169		3190(b)

All the expected values (E) in all the cells were calculated using the formula $\frac{a \times c}{b}$

$$\chi^2 = \Sigma \frac{(O-E)^2}{E} = \frac{(2-3.3)^2}{3.3} + \frac{(1-3.3)^2}{3.3} + \frac{(3-3.4)^2}{3.4} + \frac{(6-3.3)^2}{3.3} + \frac{(7-3.4)^2}{3.4} + \frac{(2-1.5)^2}{1.5}$$

$$+ \frac{(0-1.4)^2}{.4} + \frac{(0-1.4)^2}{1.4} + \frac{(501-499.7)^2}{499.7} + \frac{(500-497.7)^2}{497.7} + \frac{(506-505.6)^2}{505.6}$$

$$+ \frac{(499-501.0)^2}{501.0} + \frac{(514-517.6)^2}{517.6} + \frac{(224-224.5)^2}{224.5} + \frac{(206-204.6)^2}{204.6} + \frac{(219-217.6)^2}{217.6}$$

= 0.512 + 1.603 + 0.047 + 2.209 + 3.812 + 0.167 + 1.400 + 1.400 + 0.003

+ 0.011 + 0.000 + 0.015 + 0.025 + 0.434 + 0.001 + 0.009 = 11.654

χ^2Calculated = 11.654; χ^2 Tabulated = 14.070

Conclusion: Since χ^2 calculated = 11.654 and χ^2 tabulated = 14.070 we do not reject Ho at P>0.05. The difference is not statically significant.

8. Chi-square analysis of the Influence of Religion on the Prevalence of schistosomasis in Jos South Local Government Area, of Plateau State, Nigeria.

Hypothesis

Ho: Prevalence rate is likely equal in both religions.

Hi: Prevalence rate is not likely equal in both religions.

Religion	Number examined	Number positive Observed (O)	Expected (E)	Number negative Observed (O)	Expected (E)	Total
Christianity	2134	13	14	2121	2120	2134(a)
Islam	1056	8	7	1048	1049	1056
Total	3190	21(c)			3169	3190(b)

All the expected values (E) in all the cells were calculated using the formula $\frac{a \times c}{b}$

$$\chi^2 = \Sigma \frac{(O-E)^2}{E} = \frac{(13-14)^2}{14} + \frac{(8-7)^2}{7} + \frac{(2121-2120)^2}{2120} + \frac{(1048-1049)^2}{1049}$$

$= 0.071 + 0.140 + 0.000 + 0.000 = 0.213$

$\chi^2 \text{Calculated} = 0.213$; $\chi^2 \text{Tabulated} = 3.841$

Conclusion: Since χ^2 calculated = 0.213 and χ^2 tabulated = 3.841 we do not reject Ho at P>0.05.

The difference is not statically significant.

9. Chi square analysis of Infection rate of the Snail Species collected during the study.

Hypothesis

Ho: Infection rates of the snails collected are likely equal in all the species.

Hi: Infection rates of the snails collected are not likely equal in all the species.

Snail species	Number examined	Number positive Observed (O)	Expected (E)	Number negative Observed (O)	Expected (E)	Total
Bulinus globosus	249	0	19.6	249	229.4	249(a)
Biomphalaria pfeifferi	203	0	15.9	203	187.0	203
Lymnea natalensis	629	85	49.5	544	579.5	629
Total		85 (c)		996		1081(b)

All the expected values (E) in all the cells were calculated using the formula $\frac{a \times c}{b}$

$$\chi^2 = \Sigma \frac{(0-E)^2}{E} = \frac{(0-19.6)^2}{19.6} + \frac{(0-15.9)^2}{15.9} + \frac{(85-49.5)^2}{49.5} + \frac{(249-229.4)^2}{229.4} + \frac{(203-187)^2}{187}$$

$$+ \frac{(544-579.5)^2}{579.5}$$

$$= 19.6 + 15.9 + 25.5 + 1.7 + 1.4 + 2.2 = 66.3$$

χ^2 Calculated = 66.3; χ^2 Tabulated = 5.991

Conclusion: Since χ^2 calculated = 66.3 and χ^2 tabulated = 5.991 we reject Ho at P<0.05.

The difference in the infection rates of the snail species is statistically significant.

5.6   CONCLUSION

As only 21 of 6,377 specimens examined were positive for *Schistosoma* eggs, the disease had low endemicity in the study area   and the snail vectors, though present, were not harbouring the infective stage of the parasite, cercariae.

From this study, it is concluded that the disease, schistosomiasis has a low endemicity in the study area and is actually declining. The null hypothesis is therefore rejected.

5.7   SUMMARY OF FINDINGS

Out of the 6,377 samples, made up of 3,190 stool samples and 3,187 urine samples, only 21 samples were positive (0.33%) for schistosomiasis. Out of the 3,190 stool samples, 13(0.41%) were positive for intestinal schistosome, *Schistosoma mansoni,* while only 8 (0.25%) of the 3,187 urine samples examined were positive for urinary schistosome, *Schistosoma haematobium*. Of all the age groups examined, the 11-20 years, 21-30 and 31-40 years age groups were more infected (1.75%, 0.57%, 0.62% respectively) compared to the other age groups – younger (1-10 years) and older (41-50 years) and 50 and above each of which recorded 0% prevalence. The age groups, 11-20 years, 21-30 years and 31-40 years are the groups that frequent streams more for one or more water contact activities like swimming, fishing, bathing and playing, than the younger ones, 1-10 years and the older ones, 41-50 years and 50 years and above groups. Males were more infected (0.88%) than the females (0.44%). Males of all ages frequently visit streams for one water contact activity or the other compared with their female counterparts. This study has revealed that water contact has a correlation to the prevalence of schistosomiasis.

None availability of adequate toilet facilities and portable water supply also show correlation to the prevalence of the disease, as those who lack adequate toilet facilities and water supply were more infected (1.56%) compared with those who had the facilities. Students and pupils were more infected (1.00%) than other occupational groups. This group belongs to the 11-30 years age group that were more infected owing to their more contact with water bodies for one activity or the other. They constitute sources of infection.

There was no correlation between water parameters and occurrence and infectivity of the snail intermediate hosts of the disease collected as none of the snail vectors of schistosomes collected was infected. The streams were not infested by the infective stage of the parasites that would have caused the disease, schistosomiasis in the inhabitants of the study area. Of the species of snails encountered, *Lymnea* was found to be most distributed in the water bodies visited. A total of 1,081 snails were collected out of which 85 (7.86%), were infected, all being *Lymnea natalensis* and all were collected from one source, Vom/National Institute of Policy and Strategic Studies Kuru stream, while the rest collected during the study were not infected.

5.8 SUGGESTION ON AREAS OF FURTHER WORK

The disease, schistosomiasis spreads easily from one locality to another. If an infected person happens to come into an area free of the disease, contaminates any available water body containing snail vector of the parasite, schistosome, with his stool or urine containing the eggs of the parasite, the infective stage, cercariae will develop in the snail vector and eventually emerge into the water. If the definitive

host, man enters the stream bare-bodied for any water contact activity, the cercariae will penetrate into the skin initiating infection.

Therefore there is need for similar research to be carried out in neighbouring Local Government Areas and States to ascertain presence of the causative agent of the disease (schistosome) and/or their snail intermediate hosts. If any is detected, efforts should be made to prevent spread by adequately **tr**eating the infected individuals and/or eradicating the snail vectors.

5.9   CONTRIBUTION TO KNOWLEDGE

From the results obtained, the disease schistosomiasis has low endemicity in the Local Government Area. Also the snail vectors were not harbouring the infective stage, cercariae. Based on my knowledge, the disease, the distribution and infectivity of snail vectors have never been studied in the Local Government Area. So the study has provided base- line data on prevalence of the disease, the distribution and the infectivity of snail vectors in the Local Government Area. Furthermore, the findings are necessary for instituting control measures against the disease. These information will encourage the Local Government to institute measures to avoid spread of the disease into her territory.

5.10   RECOMMENDATIONS

Though the disease, schistosomiasis has very low endemicity in the study area as observed from the research, it is recommended that efforts be made to avoid further spread of the disease in the study area. The following are therefore recommended to achieve this goal-

(i)   Detection and treatment of infected individuals.

 (ii).   Periodic survey of water bodies for snail intermediate hosts and if detected, eradicated.

(iii) Public awareness campaign programme on schistosomiasis should be initiated in the area.

(iv) Construction of adequate toilet facilities, and education of the communities on the importance of proper disposal of human wastes (faeces and urine).

(v) Provision of portable water to the masses by both State and Federal Governments to reduce contact/exposure to water bodies which may become infested with infective stage of the disease.

(vi) Water for domestic use should be protected from contamination with

human urine and faeces, some of which may contain the eggs of schistosomes.

(vii) Immigrants into the area especially those from known endemic areas should be screened and treated if found infected.

(viii) Vulnerable groups such as fishermen, irrigation workers and communities with high prevalence should have access to regular screening and treatment for schistosomiasis and appropriate prevention measures promoted within their respective working environments.

(ix) Policy makers should recognize the disease as a focal public health problem and should be willing to promote and support control where and when necessary.

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APPENDICES

Appendix 1: Questionnaire

EPIDEMIOLOGY OF SCHISTOSOMIASIS IN JOS SOUTH LOCAL

GOVERNMENT AREA, PLATEAU STATE, NIGERIA.

QUESTIONNAIRE

1. Name…………………………………………….Age……..Sex……….

2. Religion…………………………………Ethnic Group………………………

3. Residential status………………in other parts of the country………….

4. Occupation [   ] Farmer [   ] Civil Servant[   ] Student/Pupil [   ]

    Others (specify)……………………………………………………………

    If child, occupation of Parent/Guardian…………………………………..

5. Sources of water supply:

    a. [   ]   Pipe-borne   c.   [   ] Pool/Pond

    b. [   ]   Borehole   d.   [   ] River/Stream

    e. [   ]   Drawn well   f.   [   ] Rain water

    g. [   ]   Others (specify)

6. Toilet facilities:

    [   ] W. C. Toilet   [   ] Bucket

    [   ] Pit latrine   [   ] Pond/River

    [   ] Bush   [   ] Anywhere

7. How often do you come in contact with streams/rivers

    [   ] Frequently   [   ] Occasionally

    [   ] Rarely   [   ] Never

8. Have you ever-noticed blood in your urine or/and stool

   Yes/No in [   ] Urine   [   ]   stool [   ]

9. If yes to (7) above; what action did you take

   Hospital   [   ] traditional   [   ] Nothing [   ]

Appendix 2: The numbers of snails collected from 1999 to 2002 and from November 2003 – October 2004.

Year	Season	*Bulinus globosus*	*Biomphalaria pfeifferi*	*Lymnea natalensis*	Total No of Snails
1999	Dry	154	99	358	611
	Wet	07	16	79	92
2000	Dry	39	48	109	196
	Wet	20	20	19	59
2001	Dry	16	13	36	65
	Wet	05	02	15	22
2002	Dry	08	05	23	36
2003-2004	Dry	0	0	0	0
	Wet	0	0	0	0
Total		249	203	629	1081

Appendix 3: Number of individuals screened per section in relation to Sex.

Area	D/Karfe	Gigiring	Anglo-Jos	Bukuru	Vom	Zawan	Malaraba Jamaa	Farin Lamba	Total
Males	233	251	253	255	366	120	101	105	1584
Females	270	250	256	250	255	97	99	129	1606
Total	503	501	509	505	521	217	200	234	3190

Appendix 4: Water Parameters Estimated

The pH of the water sample from the stream was estimated using pH meter. Also estimated were alkalinity and conductivity of the water samples. pH is the reciprocal of the hydrogen ion concentration. The pH value of water samples expresses its tendency to accept or donate hydrogen ions on a scale of 0 (very acidic) to 14 (very basic). Pure water at $25^{o}C$ is neutral and has a defined pH value of 7.0. Most natural waters range from pH 4.0 to pH 9.0 and often are slightly basic due to the presence of carbonates and bicarbonates.

Methods of Determination

pH was measured using the pH probe of the Horiba Water Checher (Model U – 7, Horiba Ltd. U.S.A.).

Alkalinity

Alkalinity refers to the capability of water to neutralize acids. The presence of carbonate, bicarbonates and hydroxides of calcium, magnesium and sodium metals are the most common sources of alkalinity in natural waters. Natural surface waters usually contain less alkalinity than sewage or waste water samples.

Method of Measurement

The free and general alkalinity were measured by titrating the samples of water with standard 0.020N sulphuric acid to pH 8.3 and 4.5 respectively. These equivalent points were established visually using a phenolphthalein indicator (8.3) followed by a mixture of methyl red and bromocresol green (pH 4.5). The range of normal values for surface and well waters is 0 - 250mg. L^{-1}(American Public Health Association).

Dissolved Oxygen

The Content of Oxygen is an important indicator of pollution of a water body, indicating its biological state, the predominant processes in it, the destruction of organic substances, and the intensity of self-purification. This measurement plays an important role in evaluating the conditions of habitation of the flora and fauna in a body of water.

Method of Measurement

The Azid modification of the Winkler method as described in the manual of Hach Direct Reading Environmental Laboratory Model DREL/1A was used.

Electrical Conductivity

Electric Conductivity of natural waters is determined by the presence of substances which dissociate into cations and anions. The unit of electrical conductivity used is the specific electrical conductivity, which is the reverse micro-ohm or the microsiemens per centimeter ($ms.Cm^{-1}$)

Method of Measurement

Electrical Conductivity of the samples was measured using the Electric Conductivity probe of Horiba water Checher (Horiba Ltd., U.S.A.) model U –7.

Temperature

The temperature of water determines the trends and tendencies of changes in its quality. Temperature is an important factor affecting ion and phase equilibria, and influencing the rates of biochemical processes and mineral substance

Method of Measurement

The temperature of the water was measured with a mercury thermometer calibrated from 0.1 to $50^{o}C$ division.

Appendix 5

Sample Size.

The sample size of 6377 was determined using the formula of Benneth *et al.*

(1991). The formula is as follows:

$$N = \frac{Z^2 pq}{E^2}$$

Where N = minimum sample size

Z^2 = 95% confidence interval

Where Z score = 1.96 $\cong$ 2.0.

P =   Prevalence of the condition under study (i.e prevalence of

schistosomiasis in Nigeria)

q =   Complementary prevalence usually 1 – p

E =   level of precision allowed 1 –10%

N $\frac{2^2 \times 0.5 \times 0.5}{(0.02)^2}$ =2500