DIS TBI BUTTON AND RELATIVE ABUNDANCE OP SNAIL VECTORS OF SCHISTOSOMIASIS IN SOME DAMS IN AND AROUND ZARIA, NORTHERN NIGERIA

BY

Peter Jacob Hassan

A thesis submitted in partial fulfilment of the requirements for the award of the degree of Master of Science (M.Sc.) in Zoology.

DEPARTMENT OP BIOLOGICAL SCIENCES
FACULTY OP SCIENCE
AHMADU 3ELL0 UNIVERSITY
ZARIA

AUGUST, 1988

DEDICATION

This work is sincerely dedicated to my dearly beloved and committed wife, Mrs Susan Fumilayo Hassan (Nee Aminu) and my loving son, Master Shulnom Jeremiah Hassan. Their contributions, patience and prayers have made this work a good success.

DECLARATION

I do hereby declare that this thesis is a record of my own research. It has never been presented by me or anyone else in any previous application for a higher degree.

P. J. HASSAN

11/x/88

Date

CERTIFICATION

This Thesis entitled, "Distribution and relative abundance of Snail Vectors of schistosomiasis in some dams in and around Zaria, northern Nigeria" by Peter Jacob Hassan meets the regulations governing the award of the degree of Master of Science of Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

Dr Charles G. Vajime Supervisor	Date
Dr Charles G. Vajime Head of Department	Date
Dean, Postgraduate School Ahmadu Bello University Zaria	Date

ACKNOWLEDGEMENT

In a work like this, it is extremely difficult to acknowledge every assistance received during its course. However, certain categories of people cannot escape memory for every effort they rendered.

I am therefore sincerely grateful to Dr. C.G. Vajime, my supervisor for his guidance in planning the work, for his constructive criticisms during the course of the work.

I also want to express my sincere gratidude to Mr. S. Ebele who painstakingly read and corrected the draft. I am also grateful to Professor J.O.D. Adegboye for his continuous moral support during the course of this work. I thank Mrs G. Onyebuchi for typing the scripts.

I am indebted to the Ahmadu Bello University who provided the grant for research.

Finally, I am grateful to all those who in one way or the other were concerned about the success of this work. The battle is now over and VICTORY IS WON. ALL GLORY TO THE LORD JESUS CHRIST.

TABLE OF CONTENTS

Contents PAGE

Contents PAGE

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

Satedams (Kubanni, Makwaye, Maska, Kangimi, Maigana, zaria Birnin Gwari), three ponds in Zaria City and a stream in Samaru village were surveyed from June, 1986 - May, 1987 to determine the distribution of snail vectors of human schistosomiasis.

Three species of these snails were observed in the area namely, Bulinus (Physopsis) globosus (Morelet) Bulinus forskalii and Biomphalaria pfifferi (Krauas) B. glojbiasjis is a vector of urinary schistosomiasis, the parasite being Schistosoma haematobium. B. forskalii is a suspected alternative host of S. haematobium while Biomphalaria pfeifferi is a vector of intestinal schistosomiasis, the parasite being S. mansoni.

The abundance of these snail vectors varied with the season and among habitats. There were more snails at the beginning of the dry season than any other time of the year. There were also more snails in the ponds than any other site of collection.

Of the three species of snails collected B. globosus had the highest number during the period in which the research was conducted, it was also the most wide spread snail species, and co-existed with B. forakaiii. B. pfeifferi was least represent both in terms of numbers and distribution in the sites.

All through the duration of the work juvenile snails were observed to co-exist with adults, and occurred throughout the time of research work. Their number, however, depended on

the number of adults in a particular habitat. This, therefore, strongly suggested that reproductive activities of these snails were going on throughout the year.

Observations made on the three snails species for the presence of furoocercous cercariae showed that the two forms of Bchistosomiasis were endemic in the area as all the three species shedded furoocercous cercariae. However, it was noted that urinary schistosomiasis was more prevalent than the intestinal form because the greatest number of furcoceroous cercariae were produced by Bulinus globosus which is the vector. Snail examinations further pointed to the fact that snail infestation by the furoocercous cercariae was throughout the year, and not seasonal.

The Principal factors which seem to determine the distribution of these snails were availability of water its nature, presence of aquatic vegetation and human-water contact degree.

Kubanni dam was observed to be filled by late May or early June, thereafter, water starts spilling over at the spillway while Makwaye dam was not filled until late July or early August. Makwaye dam showed highest snail densities dominated by B. globosus. A contributing factor might be the presence of better vegetation growth in the Makwaye dam. Observations also showed that snails decrease in their number with distance from the town (Zaria).

CHAPTER ONE

1.0 INTRODUCTION

The role played by some freshwater snails in transission of schistosomiasis (bilharziasis) has been highlighted by Cowper (1963), Zakari (1977) and Ebele (1981). It is known that these freshwater snails act as vectors of the parasites which cause schistosomiasis in man and other animals. The parasite Schistosoma which is responsible for schistosomiasis needs a freshwater snail as an intermediate host to complete its life cycle (Davis, 1976).

The importance of the study of freshwater snails in the epidememiology of snail borne diseases has been highlighted by Okwusa et al (1980). He noted that this is very important in controlling the transmission of the diseases. In Nigeria, there are three species of snails that are incriminated vectors of schistosomiasis (Cowper, 1963). The snails are Bulinus globosus, Bulinus forskalii and Biomphalaria pfeifferi. Smith (1975) reported the occurrence of these three snail species in Samaru, Zaria.

Schistosomiasis is undoubtedly the most important helminth disease in the world today (Smyth, 1981) and is known to constitute a major health problemin Nigeria (Cowper 1963). The disease saps a lot of energy and sometimes leads to the death of victim by causing injurious effects on the liver, intestine, kidneys, bladder mesentiric veins and urinary tracts (Okpala, 1957).

There are two forms of schistosomiasis which affect man. There are the urinary and the intestinal forms (Davis, 1976). There are now four species of the parasite known to cause the disease in man. These are Schistosoma mansoni, S. japonicum, S. haematobium and S. intercalatum. While S. japonicum and S. mansoni are known to live in the mesentric veins of the small and large intestine and cause the intestinal schistosomiasis, S. haematobium lives in the vein of the bladder and causes urinary schistosomiasis. S. intercalatum is known to inhabit the rectum and pelvis and may produce clincal picture of a bowel infection (Davis, 1976).

S. mansoni is endemic in the Arabian Peninsula, lower Egypt and the Sudan (Davis, 1976). S. haematobium is known to be endemic in South Africa, North Africa, Iran, Saudi Arabia and Yemen (Jordan et al., 1978). S. intercalatum has been incriminated in Zaire, Central and West Africa, Cameroon, Chad and Nigeria (WHO, 1984).

The information on the distribution of snail vectors of schistosomiasis in Nigeria is very scanty. Okwuosa et al. (1980) stated that studies of ecology, bionomics and the population dynamics of the molluscan vectors in Nigeria have remained axiomatic to the planning of an effective control measure. William (1970) observed that the most important ecological problem is the yet unexplained irregular distribution of freshwater snails in unpolluted freshwater habitats. Okwuosa et al. (1980) stated further that snail ecologists have at various times tried to correlate snails distribution with physio-chemical environmental factors. Boycott (1936) stated that there is some degree of correlation between snail distribution in various habitats and the chemistry of the water.

freshwater snails is independent of water chemistry. However, it is the combined effect of all physic-chemical parameters that tend to affect the abundance and distribution of snail vectors of schistosomiasis and not just a single factor.

1.1. WATER DEVELOPMENT IN NIGERIA:

Water development in Nigeria in the forms of dams and impoundments has continued for the past two decades without a corresponding systematic survey and documentation of the snails vectors which thrive in these water bodies to highlight the effects of water development on the snails. There are vast areas of land that have been claimed by dams of considerable sizes such as Kainji dam. This dam which was completed in 1968 is 8.3km long, and impounds a lake of 1250km^2 (Simpson, 1975). Subsequently, more rivers have been impounded in Nigeria to provide water for irrigation, fishery and improved navigation across the river-to obviate the adverse effects of drought and harsh weather.

1.2. DAMS AND WATER DEPENDENT DISEASES:

The creation of man made lakes in Nigeria has resulted in the prevalence of schistosomiasis and other water borne diseases as malaria, onchocerciasis and filariasis. The health hazards associated with water development are known to date back to the time of the Hippocrates or even earlier (Richard *et al*., 1977).

1.3. HISTORICAL RESUME OF WATER RELATED DISEASE:

Manson (1877) reported the existing association between water and filariasis. Malaria is also known to depend on water. Snow (1955) reported the relationship existing between cholera and water. These reports and many others have encouraged intensive and extensive research to establish clearly the role of water in disease transmission. Malaria and filariasis for instance have been known to be transmitted by mosquito whose larvae depend on water for the completion of their life cycles. Similarly, it is known that Simulium damnosum (s.l.), the vector of onchocerciasis is found in fast flowing streams where it lays its eggs. Beside, Guinea worm and Schistosoma have all been known to depend on certain freshwater snails for the success of their life cycles (Jordan, 1975). From the foregoing, it is seen therefore, that water development in Nigeria has to a large extent affected the health of thousands of people as in other countries.

The daming of a river often leads to a number of changes in the ecological features of the area, and many microhabitats, favourable for snail growth are created as a result of these changes. The over-all result is that there is an increase in the disease which may even extend to areas previously unaffected by the disease.

A general look at dams and other irrigation projects in Nigeria has shown that health considerations are incorporated into water projects far too late and are often uncoordinated to combat health crisis which have resulted in untold hardships and scourge on the human population (Esien, 1986). A few highlights on the magnitude of dams and irrigation schemes on health and disease transmission and their prevalence in Nigeria and other parts of the world are instructive. Surtee (1970) identified six ecological consequences of irrigation which affect snails and insect populations. These changes may cause marked changes in the transmission of schistosomiasis, onchocerciasis, malaria, arboviral infections and filariasis (Cairncross et al., 1983). The transition from intermittent to perennial irrigation in Egypt, for instance, has resulted in a tenfold rise in the prevalence of schistosomiasis (Bradley, 1979).

Schistosomiasis has been shown to increase in direct proportion to the establishments of dams, especially in the areas where the disease is endemic and sanitation is generally poor (Tayo et al., 1978). They observed that Malumfashi, a district in Katsina state of Nigeria with many small earthen dams was experiencing high prevalence rate of schistosomiasis ranging from 41% - 51% following the construction and operations of new dams in the area. In Nigeria, within a year of the completion of Kainji dam Bulinus globosus and Biomphalaria pfeifferi the intermediate hosts of S. haematobium and S. mansoni respectively were found to be common in the vicinity of the lake (Betterton, 1984). In the South Chad irrigation projects, Borno state, Nigeria the snail intermediate host of S. haematobium were found to be present in the irrigation canals only seven months after initial flooding with the transmission occuring in the pilot area.

The large dams and irrigation schemes in Nigeria during the past two decades have undoubtedly created new habitats for snail vectors of schistosomiasis in areas that were previously unaffected by the disease or where prevalence was low (Betterton, 1984).

1.4. SCOPE OF RESEARCH:

Though data on schistosomiasis in Nigeria is considerably large, the ones that deal with the snail intermediate host are scanty, and worse still the ones on Zaria. Subsequently, the present work is aimed at providing baseline data on the snail ecology for a wide expense of land with Zaria as a focal point. Also changes in the habitats subsequent to the creation of dams and other irrigation projects are to be monitored from information obtained from the study of the snails. In addition, information collected from the study of snail vectors of schistosomiasis will be very useful for selecting the right control measures. The aim of the project therefore is to:

(a) Sample snail vectors of schistosomiasis in some dams including ponds in Zaria city and Samaru stream.

(b) Estimate the range of distribution of these snails in ralation to their habitats.

(c) Obtain a picture of the monthly relative density of snail vector population at chosen sites and,

(d) Determine the vector capacity of each snail by examining it for the presence of furcocercous cercariae.

CHAPTER TWO

2.0. REVIEW OF LITERATURE

2.1. THE HISTORY OF SCHISTOSOMIASIS:

The earliest clue regarding schistosomiasis dates to as far back as 1847, when in Japan Fujii described a disease he named Katayama, which is now known as acute Schistosomiasis (WHO, 1984).

The first scientific study of the disease, however, was made by a pathologist, Theodore Bilharz, after whom the disease, Bilharziasis is named. This was in Egypt in 1851 (WHO, 1984). Bilharz described the parasitic fluke and observed Schistosome eggs in the intestines and urinary bladder of man. He, however, mistakenly concluded that the miracdia which hatched from the egg as they deposited in freshwater were the infective stages for man and he postulated an intermediate stage of development in water (WHO, 1984).

Later, in 1902, Sir Patrick Manson in Britain reported that there are two species of Schistosoma, one with a lateral spined ova depositing its egg in the rectum and bladder and the other with a terminal spine depositing its eggs in the mesentric vein supplying the intestines.

In 1904, Fujiro Katsurada in Japan discovered Schistosoma japonicum in a cat and soon thereafter in man. In 1909, Fujiro demonstrated that animals which were immersed in streams in endemic areas developed very heavy schistosome infections, while controlled animals covered with protective wrappings did not develop any infection (WHO, 1984).

Furthermore, in 1913 Keinosuke Miyairi and Masatsugu Suzuki successfully carried out experiments which incriminated an amphibious bisexual snail as the intermediate host of Schistosoma in Japan. Following their discovery, Leiper in 1914 exposed snails and mammals to massive number of infective forms of schistosomes and thereby discovered that the intermediate hosts are the freshwater snails (WHO, 1984). By 1918, he had differentiated between *S. haematobium* which he observed has eggs with terminal spine and *S. mansoni* which has eggs with a lateral spine (WHO, 1984).

As far as diagnosis and treatment of schistosomiasis were concerned, Bilharz made the first preliminary attempt to attack the blood fluke worms in the urinary bladder. He used a substance known as colonel (WHO, 1984). In 1916, however, the first successful antimonial agent (tartar emetic) for the treatment of schistosomiasis was described (WHO, 1984). This chemotherapy and others continued to be the main methods of treatment until the advent of a single-dose drug like praziquantel which is used for the treatment of all human schistosomiasis (WHO, 1984).

2.2. LIFE CYCLE OF THE PARASITES CAUSING SCHISTOSOMIASIS:

Davis (1976) reported that the life cycle of human schistosome progressed within three distinct and separate milieux. These are the definitive host which may be a man, the intermediate host and the environment to which the snail host or human host has access.

The adult female Schistosoma haematobium lives in the veins of human bladder and there it lays eggs. These eggs may move to other parts of the body or may even cut through the vein wall into the surrounding tissues. During micturition these eggs may pass with the urine to the exterior (Smyth, 1981). Under favourable environmental conditions the eggs hatch and free swimming miracidia are liberated. The miracidium will die unless it finds a suitable water snail. When it finds a suitable snail host, it borrows through the soft part of the snail and then undergoes an asexual reproduction to form the cercaria, another larval form. This free swimming cercaria is released into the surrounding water. When man comes into contact with infected water the cercaria will penetrate the skin. This will later develop into an adult which will reach sexual maturity in about three weeks (Smyth, 1981).

S. mansoni has Biomphalaria pfeifferi an aquatic snail as its intermediate hosts, S. haematobium has Bulinus globosus as an intermediate host while S. japonicum may have B. forskalii as its intermediate host. Davis (1976) reported that the life of the adult worms within the body of a definitive host could be extremely variable. It is shorter in the inhabitants of the endemic zones who may acquire repeated infections and some degree of immunity than non-immune visitors or travellers to the endemic zone. The worm can live in the body of its definitive host for about 28 years (Davis, 1976). The incubation period varies for each species of schistosome and probably ranges from 4 to 16 weeks (Davis, 1976). Heavy worm burdens in the definitive hosts are a direct result of either a severe initial exposure to infected waters or a series of exposures over a relatively short period of time.

2.3. SCHISTOSOMIASIS:

Schistosomiasis is a chronic disease that is caused by a parasitic blood fluke belonging to the genus Schistosoma. In terms of severity and socio-economic importance, the disease is next to malaria, with over 200 million people infected all over the world (Davis, 1976). There are two forms of the disease infecting man, the urinary and the intestinal forms. Schistosomiasis may occur in man, numerous other mammals and birds (Davis, 1976).

2.4. DISTRIBUTION OF SCHISTOSOMIASIS:

Until recently, schistosomiasis was thought to be only confined to the Nile basin of Egypt. This assumption is probably due to the fact that the parasitic fluke responsible for the disease was isolated and described first in Egypt in 1851 by Theodore Bilharz (Spink, 1978). It is now know that the disease is also endemic in areas around the equitorial regions and the Congo basin, and only recently the endemicity has expanded to include all of Africa, Latin America and the Asians countries. Essentially it can be described as a fact of life for the tropical countries (Davis, 1976). The disease is considered to be widely distributed without any geographical exclusions in the world (Davis, 1976). Schistosoma japonicum, for instance is known to be endemic in some islands of the Philippines, Celebes, Thailand and the lower Mekong basin (Davis, 1976). S. mansoni is distributed in both tropical and subtropical countries. It is endemic in Arabian Peninsula and hyperendemic in the lower

Egypt and the Sudan (Davis, 1976). The disease endemicity further extends from the African sub-sahran zone to Cape Province of South Africa. It is also known to be endemic in countries like Brazil, Surinam, Venezuela, Carribbean islands of Dominican Republic, Guadeloupe, Martirique, Puerto Rico and St. Lucia (Davis, 1976).

S. haematobium is endemic in countries South of Sahara to Cape Province in South Africa. In North Africa, it is known to be hyperendemic in the Nile Delta, Algeria, Lybia, Morocco, and Tunisia. It also occurs in Iran, Iraq, Saudi Arabia, Syria and Yemen (Jordan et al., 1978).

S. intercalatum which was first incriminated in Zaire another parasitic blood fluke responsible for human schistosomiasis, has further been reported in Central and also West Africa, Cameroon, Chad, Congo-Brazzarille, Nigeria and Upper Votta (WHO, 1984).

In Nigeria, very little was known of schistosomiasis until the preliminary survey made by Sharp (1924) in which he discovered that some prisoners were infected with S. mansoni. McCullough (1927) found the eggs of S. haematobium to be very common in the urine of people in the northern Nigeria. The first comprehensive work of surveys of schistosomiasis in Nigeria was done by Ramsay (1932). He reported that S. haematobium and S. mansoni were endemic in Nigeria. He described schistosomiasis as "rampant" and more common among children. This was so because children use infected water bodies as playing sites. Odenburg (1942) reported the existence of bilharzial appendicular lessions in

Kaduna and Abeokuta hospitals Ramanowski (1955) and Ikejiani (1955) reported bilharzial ulcer and non-gonorrhoeal urethritis respectively in Ibadan. Blair (1956) reported that the disease was especially prevalent in the swampy regions along the great reivers of northern Nigeria but that it could be equally prevalent in the villages where the only water supply was obtained from borrow pits. He also highlighted that the peak prevalence was found in children, although adults who are fishermen by profession and irrigation workers were also highly subject to the disease. Cowper (1963) reported that schistosomiasis was hyperendemic in the area West of a line drawn through Katsina-Zaria-Kaduna. Odei (1961) described Bulinus globosus and Biomphalaria pfeifferi as the snail intermediate host of the parasitic flukes. Pugh (1979) reported high incidence of schistosomiasis among children above five years in Malumfashi area of Katsina State. Hira (1966), studied freshwater snails of Ibadan, Tayo and Jewsbury (1978) studied freshwater snails of norther Nigeria and Okwuosa, et al. (1980) studied the ecology of freshwater snail vectors schistosomiasis in South-West Nigeria. In all these studies snails were incriminated as the intermediate hosts of parasitic blood fluke. Ebele (1981) and Betterton (1983) studied the ecological aspects of these snails. They reported that temperature, oxygen and calcium content of the water affect the abundance and distribution of snails.
Ebele et al. (1981) working on hospital records from Zaria noted that majority of the people infected with S. haematobium were below the age of 20. Eseoke (1978) reported that 472 cases of schistosomiasis were treated in the Zaria City health centre in 1976/77. Gana (1979) surveyed the prevalence of urinary

schistosomiasis in children at Kofar Doka primary school and discovered that 3.2% of the girls and 13.4% of the boys were infected. Schistosomiasis, therefore, is still an important disease of children in Zaria.

2.5. SOCIO-ECONOMIC IMPORTANCE OF SCHISTOSOMIASIS:

Schistosomiasis is a benign disease but the intensity of infection may be increased as eggs load in the tissue get higher. The disease is most prevalent in children. This is because they frequent water bodies that are infected more than any other age group (Davis, 1976).

Schistosome worms *per se* do not cause disease, but eggs retained in the tissues of the definitive host cause tissue reactions leading to pathological changes (Simpson, *et al.*, 1975). These changes are related to the number of eggs in the tissue and these in turn depends on the number of adult worms in the tissue of the definitive host.

Acute schistosomiasis may be associated with fever, headache, mild abdominal pain and sometimes cough (Simpson, *et al.*, 1975). Although direct mortality from the disease is low, the global prevalence and the multiplicity of the chronic pathological sequence of infection present a profound burden on the public health (Davis, 1976). In case of infection with *S. haematobium*, symptoms of micturition, dysuria and haematuria may be noticed. In some areas with high endemicity haematuria may be associated with virility (Simpson, *et al.*, 1975). The loss in blood as a result may lead to severe fatigue which will hamper the work efficiency of the infected persons leading to loss in many man hours.

2.6. THE CONTROL OF SCHISTOSOMIASIS:

To control schistosomiasis simply means to reduce to minmal levels of transmission, prevalence, incidence and intensity of infection and consequently reduce the clinical consequences of the infection.

The control of schistosomiasis is dependent on three man areas: reduction of the number of the snail intermediate hosts, reduction of the degree of contamination of natural waters by human wastes - excreta and urine, reduction of human contact with infected water and treating the disease in persons already infected.

2.6.1. SNAIL CONTROL USING MOLLUSCICIDES:

The life cycle of the blood fluke which cause schistosomiasis cannot be complete unless there is a suitable snail intermediate host. Reduction of the snail intermediate hosts, therefore will reduce the chances of completing the life cycles. Snail intermediate hosts are controlled by the use of synthetic and plant molluscicides. The nature of design of irrigation projects and dams affects the population of snails (WHO, 1980). Effective synthetic molluscicides include niclosamide, trifenmorph and nicotinanilide group of compounds (WHO, 1980). Other commonly used chemical molluscicides are sodium pentachlorophenate and copper sulphate. Snails can also be controlled using plants which have molluscicidal properties. Plants that have been used to control snails effectively include Balonites aegyptiaca , B. maughamii, Sapindus saponaria and Agonandra brasilinsis (Helmut et al., 1981). In Nigeria encouraging results were obtained with the aqueous and methonolic extracts of Tetrapleura tetraptera (Adewunmi et al., 1980). The use of plant molluscides may eliminate the expense on costly synthetic molluscicides.

2.6.2. SNAIL CONTROL BY BIOLOGICAL METHODS:

The application of chemical molluscicides has resulted in environmental pollution and chemical poisoning as these chemicals are passed along the food chain. These have made the biological control very needful. Potential biological agents such as fish and parasites have been used as potential competitors or predators to check the population size of snail intermediate hosts (WHO, 1980). The most attractive biological control method at the present is intermolluscan competition and predation. With this method possible competitive snail species such as Marisa cornuarietis, Helisoma duryi, Pomacea haustrum, Potamopygrus jenkinsi and Physa spp. are introduced into the snail environment to compete for food, oxygen etc. for survival (WHO, 1980). Marisa cornuarietis has proved very successful in Pueto Rico.

2.6.3. REDUCTION OF SCHISTOSOMIASIS BY ENVIRONMENTAL MODIFICATION:

The control of schistosomiasis by environmental modification is carried out by provision of adequate domestic water supply and adequate health education. Provision of adequate domestic water will reduce the frequency of man-water contact. This in turn reduces the chances of schistosomiasis transmission. WHO (1980) has observed that weed control in lake volta and the filling and draining of snail habitats in Iran have reduced snail population. Health education should also be carried out thoroughly and this should be based on a clear understanding of the people's perception of the disease.

2.6.4. CONTROL OF SCHISTOSOMIASIS BY TREATING IT:

Treatment of schistosomiasis by drug in the past was equally dangerous as the disease itself (WHO, 1984). Today, however, there are drugs available for effective treatment of the infection. For instance, praziquantel has been shown to be useful in combating all forms of the disease (WHO, 1984). Also meterifonate is used against the urinary forms, while oxamniquine is employed against the worms infecting the intestine (WHO, 1984). All these drugs can be employed in large scale control programmes. A survey of Egyptian school children showed that single doses reduce infections from 90% to 13% (WHO, 1984). Finally, though much has been said and done as schistosomiasis, a lot still remain to be discovered. In the tropics the disease is on the increase. This is because of the increase in man-water contact as a result of irrigation schemes. The numerous new irrigation and water projects carried out especially in the third world are usually ill-conceived and therefore ill-planned, thereby making them a risk to health.

CHAPTER THREE

3.0. MATERIALS AND METHODS

3.1. THE STUDY AREA:

The study area comprises six lakes (Kubanni, Makwaye/ Bomo, Maska, Maigana, Kangimi and Birnin Gwari), three ponds in Zaria City (Fig. 2) and Samaru Stream (Fig. 1). A brief description of the study area is given below:-

3.1.1. SAMARU STREAM:

Samaru stream is located by the Ahmadu Bello University near Samaru village. The stream flows in a north-south direction along a 3km valley. The stream receives run-offs from the Samaru village, other built up areas such as the university residential quarters and from both cultivated and uncultivated lands. The stream discharges into river Kubanni.

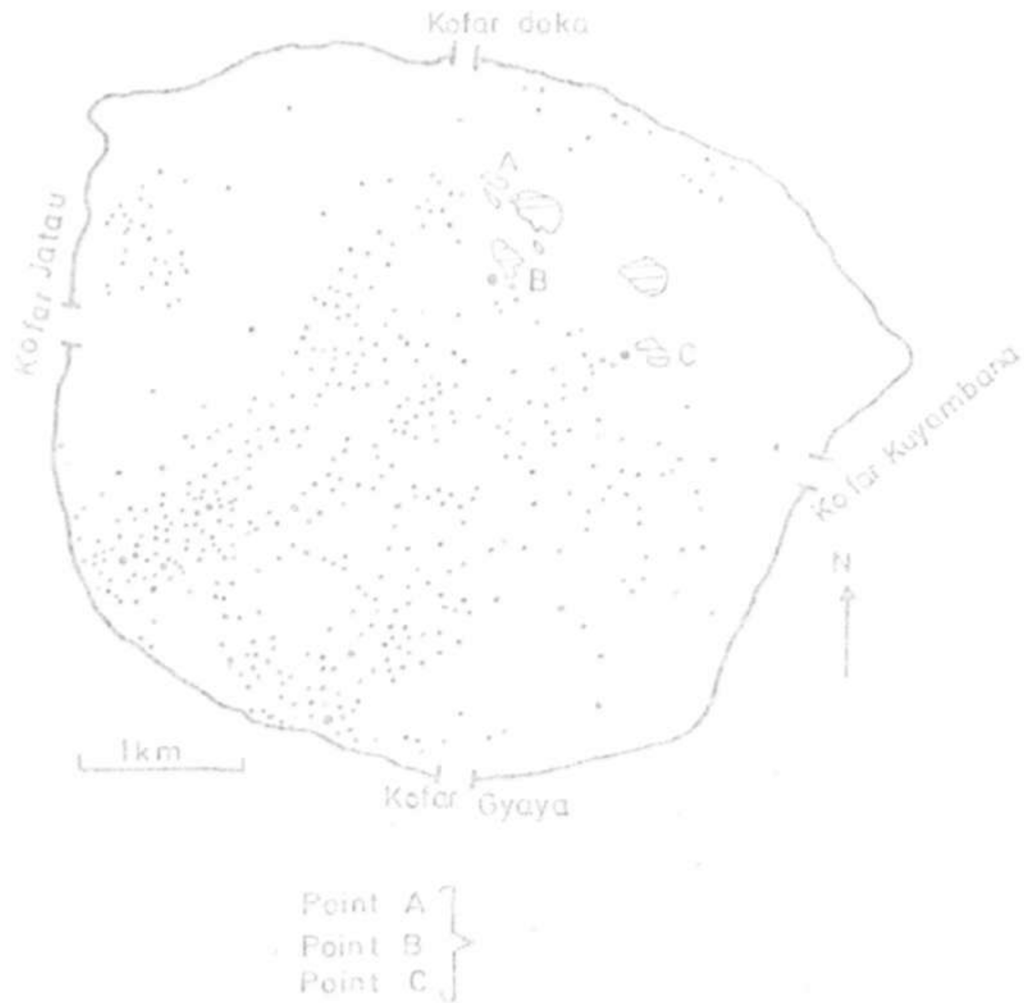
While some parts dry up living just bare sand. During the dry season, especially January to April seapages of water along the slopes of the valley [illegible] in various places.

The water in the valley is used for small scale irrigation, watering of cattle and domestic purposes - washing of clothes and bathing. Smith (1975) noted that the stream is highly polluted with organic matter . He also reported that along much of the length of the stream the channel cuts through superficial deposits of alluvium and younger laterite and consists of deep pools separated by shallow riffle areas. He noted furthermore that

FIG-1: MAP OF SAMARU STREAM SHOWING SAMPLING SITES

After Smith (1975)

Fig.2:Distribution of borrow pits in Birnin Zaria.Each dot indicates the position of a borrow pit revealed from maps, aerial photographs or personal observation. Some of the pits have been filled in deliberately natural processes but vast majority still hold water, for atleast part of the year.



After Ebele 1981

water flows directly along the basement rocks which are granites and gueisses in nature.

During the dry season when the level of water is generally low, the water body becomes stagnant while in the rainy season and especially during the heavy rain in August the velocity of the flow becomes quite high. These factors cause rapid erosion of the banks. Smith (1975) noted that plans were underway to reduce the pollution level of this stream by putting the two university halls that discharge effluent into the stream to a piped waste disposal line and abandonment of the Samaru abatoir.

3.1.2. KUBANNI LAKE:

This lake is located south of the botanical garden of the main campus, Ahmadu Bello University. The dam was constructed in 1970 (Ologe, 1973). It was constructed by the University to forestall the persistent acute shortage of water in the main campus for both domestic and laboratory uses.

The dam was constructed with a wall of about 800m long, a central section of concrete of about 10.36m high above the river bed, a reservoir covering about 80.94 hectres which has a useful capacity of 2.4 million cubic metres, (Ologe, 1973). This dam serves a catchment area of 57sq km (Ologe, 1973). The lake is also, of recent been used as a reserch site. The water budget of Kubanni dam is controlled by five factors namely, run-offs from the catchment and ground water inflow, evaporation, ground water outflow plus seepages and withdraws for man's use. The amount of water believed to be lost by seepage is within the range of 200-280 thousand litres per day (Igharo, 1972, Anyam 1980).

A considerable amount of erosion is a major feature of this dam and this is occasioned by the distinctiveness of the Savanna environment, and that of the basin itself. The intensity of the rains and it seasonality also cause great rain splash erosion and high rates of run-offs, which cause sheet erosion, (Ologe, 1973). Agriculture, tree-cutting for various purposes, indiscriminate bush burning and cattle grazing and all human activities that have tampered with the typical nature of the guinea savanna vegetation of the dam area. This has transformed it to that of an open savanna woodland in this area. The resultant open vegetation has permitted unchecked soil erosion of various categories along dam, which are higher during the first half of the rain (Anyam, 1980).

A careful observation reveals that proper clearing of vegetation was not carried out before the dam was constructed. This has left behind woody plants which stick out of the water especially along the dry season when the water level is low. These have, however provided suitable substratum for snails to attach theselves.

3.1.3. MAKWAYE LAKE:

The dam is situated some 6km east of ABU in the direction of the Zaria - Funtua road. The dam was constructed in 1966 by the Nigeria Tobacco Company (NTC), to serve the company's Tobacco Farm.

During its construction hydrological data of the valley of the stream feeding the dam were not available (Nayolor and Beredego, 1969). This therefore implies that maximum flood discharge of the valley is known only by approximations.

The dam has a catchment area of 184.3 hectres (Anyam, 1980) and lies in a N.E. - S.W. direction. Lying on the upper part of Makwaye valley is the Bomo reservoir which existed even before the construction of the dam. The performance of this reservoir and the rainfall run-offs records at the Institute of Agricultural Research (I.A.R.), Samaru provided the basis for the estimation of maximum flood discharge from Makwaye dam. The amount of water needed by the dam determined the nature of the spillway. Since the volume of water expected to be handled was by far larger than the size of the dam a two-side weir spillways was made.

The dam was built on a compact brown or grey clay with patches of white shale and silt. The area lies on a bisected tertiary peneplain which is underlain by rocks of basement complex (Nayolor et al., 1969). Exposure of coarse porphyritic older granite and finer grained dark coloured granite are often found extensively in the area. No outcrops were, however, found in the catchment area. A large amount of area is covered by a reddish-brown iron-stained laterite and clay (Anyam, 1980).

The immediate banks of the lake are covered with thick grasses. These serve to check soil and gully erosion.

3.1.4. MAIGANA DAM:

This dam is located some 20km along Zaria-Jos road. It was constructed in the late seventies by the Kaduna State Agricultural Project and used mainly for fishing. Originally, the earthen dam was the site of about tenfish ponds which were later harnessed to form the dam.

During the rainy season the lake overflows its banks but retreat drastically to form isolated ponds as soon as the dry sets in. It is in these isolated ponds that fishing activities is carried out.

Settlements around the lake are few and human activities in the vicinity of the lake include small scale farming, local block industry (during the dry season) and fishing which was mainly carried out by government employee over -seeing the dam.

The immediate banks are covered with thick and tall frasses, which reduce the extend of erosion, but heavy grazing by cattle along the bank of the lake is carried out during the dry season.

3.1.5. KANGIMI LAKE:

The dam is situated some 25km from Mararaban Jos, off Kaduna-Jos road. It was construoted in the late seventies by the Kaduna State Water Board to provide sufficient water during the dry season for domestic utilization in Kaduna town. It has a large central reservoir and has a concrete embarkment. During the dry season when the water level is low more waters is allowed to flow out for use in Kaduna town. Human activities around the dam area are restricted to fishing and small scale farming.

3.1.6. BIRNIN GWARI LAKE:

The dam is situated at the outskirts of Birnin Gwari town. It was construeted by the Kaduna State Water Board to provide water for domestic purposes in the area. It has a small central reservoir and stone-lined banks. The vegetation around the dam comprises of shrubs and tall grasses, wheat and maize are the main crops grown in the area.

3.1.7. MASKA LAKE:

The dam is situated some 45km along Zaria-Funtua road. It was constructed by Kaduna State Agricultural Project to provide a system of ponds for fishery. Cattle grazing is heavy around the dam area and farming is hardly practiced. The vegetation around the dam comprises shrubs, shot trees and tall grasses.

3.1.8. PONDS IN ZARIA CITY:

Zaria City is a provincial capital with an estimated area of about 7.5sq km. As per 1963 census, this historical town has a population of about 60,000 and mainly regarded as the home of the primary settlers. The City was once enclosed by a thick wall, the rudiments of which are still standing today. These walls are believed to have been built as far back as the 15th century mainly to protect the city against invaders. Four main gates "Kofar" lead into the city. They are Kofar doka, Gyaya, Kuyambana and Jatau (Fig. 2).

Unlike other parts of Zaria such as Tudun Wada and Sabon-Gari, Birnin Zaria is not completely built up and many farm lands still remain permanent features of this area. The houses are mainly concentrated around the market area and consist of both traditional mud houses as well as bungalow-type houses.

Borrow pits form a common feature of this city. They were created through digging of the soil used for local building purposes. These pits are filled up with water during the rainy season. They also receive effluent from nearby houses. They are used for bathing, washing and sometimes fishing. During the dry season the water is used for making bricks for traditional house constructions. Some of these pits dry up completely during the dry season.

3.1.9. ZARIA DAM:

The dam is located near the Government Commercial College. It was constructed by Kaduna State Water Board in the late seventies to provide sufficient water for the people in Zaria. Cattle grazing is heavy around the dam especially during the dry season when the cattle are taken their to drink water. Small scale farming is practiced along the lake and fruits like tomato are grown in the area during the dry season. Vegetation around the dam is scanty and comprises of short grasses and trees.

3.2.0. PRELIMINARY SURVEYS:

A number of preliminary surveys were carried out on the sites to earmark suitable collection sites. These surveys involved visiting the sites, making first hand observations and asking questions from people around the site. Sampling sites were located at the banks of the ponds, lakes and streams. Each site was visited twice a month.

Sampling continued throughout the period of survey. During seach visitation to the sites snails were observed carefully and then collected.

3.2.1. COLLECTION OF SNAILS:

The method used for snail collection was that of Paperna (1957) and Smith (1975). Collection were carried out in the morning between 9 and 11 am. Two methods were employed for the purpose of collecting snails - direct hand picking and by scoop net.

3.2.2. HAND PICKING TECHNIQUE :

This method was after Smith (1975). Using this method snails on the concrete banks were simply picked up and dropped into a plastic container which contain some water from the site. This was done for a period of about 10 minutes. The snails were taken to the laboratory for observation and identification.

3.2.3. THE SCOOP NET METHOD:

The hand-picking technique (Smith, 1975) did not prove to be efficient enough, the main disadvantages being the fact that only few snails were collected by the method, snails at the bottom of water were not collected as they could not be reached and the method was also labour intensive. The scoop net is a long-handled net fitted with plastic mosquito netting (Betterton, 1984). The mesh size of the net was between 3mm - 4mm. Using this net 5 blind sweeps were made through the water. Snails caught in the bag were sorted into containers. This procedure was repeated five times at each site. Snails collected were taken to the laboratory.

3.2.4. LABORATORY ANALYSIS:

In the laboratory, snails were sorted out according to species and sizes. Snails were then grouped into adult and young. The size and number of whorls were used as basis for classification (Wright, 1971 and WHO, 1973). Snails with width size less than 5mm were grouped as young snails. The number of each snail species collected was recorded against the month of collection. The average number of snails collected from each site was taken as the number of snails collected from the site during the month.

3.2.5. IDENTIFICATION OF SNAILS:

Snails were identified in the laboratory with the help of identification keys by the World Health Organization (1973). The Keys proved very helpful for all aspects of identification. Where the writer was in doubt more experienced Senior Staff Members in the department were consulted for confirmatory identification.

3.2.6. EXAMINATION AND COLLECTION OF FURCOCERCOUS CERCARIAE:

To examine and collect furcocercous cercariae from snails the method of Webbe and Jordan (1969) was employed. Snails were kept in glass containers with some distilled water and electric light from a 60wats electric bulb was shone on the snails. After about twenty minutes the water was observed for the presence of any furcocercous cercariae. Snails can also be examined for furcocercous cercariae after exposing them to direct sunlight for about 15 minutes. The function of the light was to induce the furcocercous cercariae to be released with relative ease (Webbe et al., 1969).

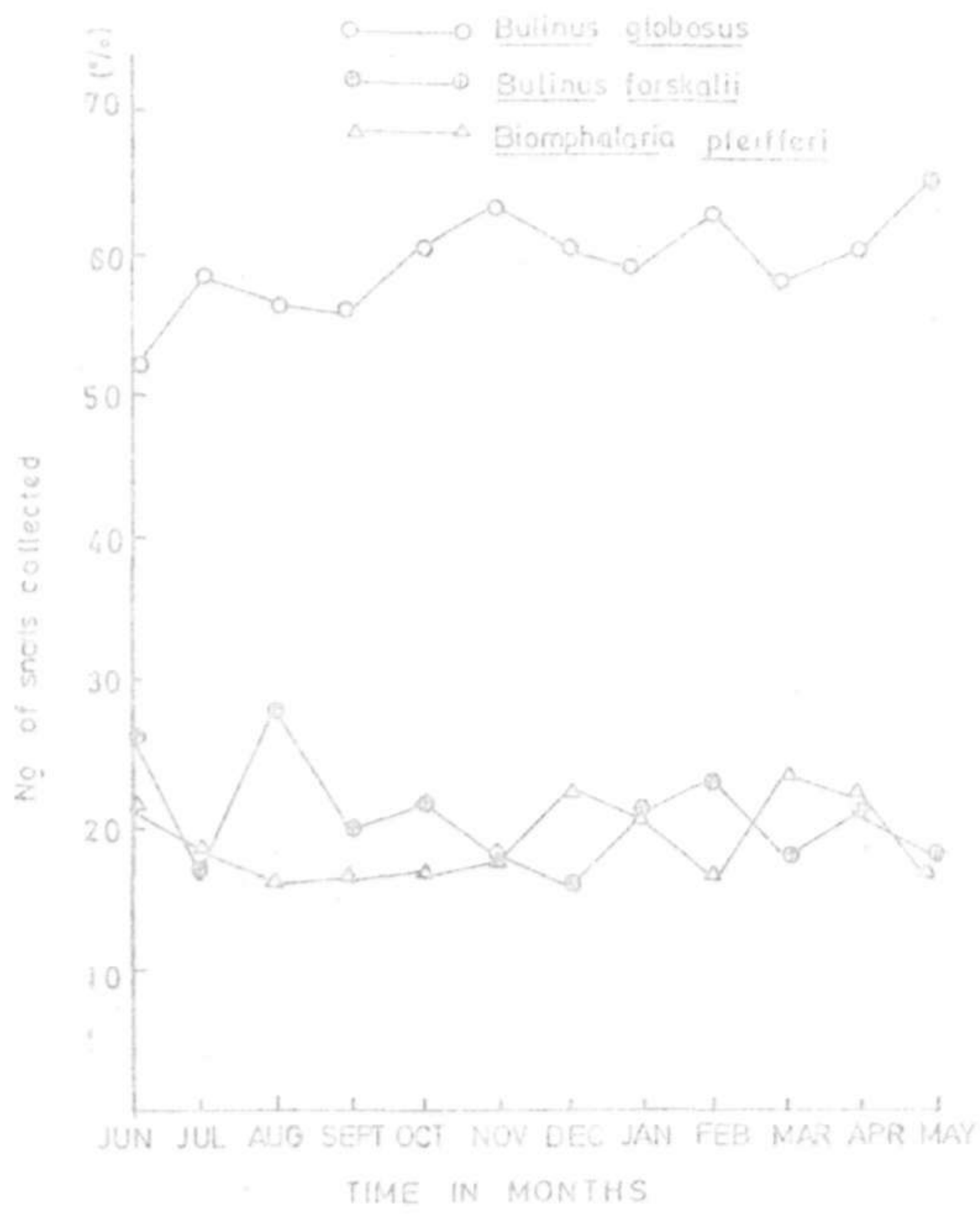
CHAPTER FOUR

4.0 RESULTS

During the period of this study many freshwater snails were found in the sites invarious abundance, and their number varied between months and seasons. All together 9,188 snail vectors of schistosomiasis were collected during the one year period under investigation (Table 1). These snails fall into three different species and of them all vectors of human schistosomiasis. The species were: *Bulinus globosus*, *Bulinus forskalii* and *Biomphalaria pfeifferi*. Of all the snails collected *Bulinus globosus* (4,354) was the highest in number, while *Bulinus forskalii* (2,175) was the next in number, and *Biomphalaria pfeifferi* (1,659) was the least (Table 1).

Bulinus globosus was observed to be the most widely distributed and was found in every site of collection. *Biomphalaria pfeifferi* was more restricted in distribution. While *Bulinus globosus* was observed to breed least in areas where human or animal activities were highest and where the water tended to be polluted with organic matter, *Bulinus forskalii* and *Biomphalaria pfeifferi* favoured less polluted water, where organic decay was minimal. Figure 3 shows the relative abundance of all these snails as distributed during the months of study. From the figure it is seen that *Bulinus globosus* had the widest range of distribution throughout the period of study than any of the two others species. *Bulinus forskalii* and *Biomphalaria pfeifferi* had nearly a similar pattern of distribution.

FIG-3: Monthly relative abundance of snail vectors of schistosomiasis



Though the three snail species were observed to shed furcocercous cercariae, only few members of seach species actually shed cercariae (Table 3). During the period of study young snails of each species were also collected in their habitats (Table 2).

Figures 4 and 5 show the relative abundance of young snail furcocercous cercariae between June, 1986 and May 1987 respectively. As shown in Figure 4 the peak abundance of young snails of Bulinus globosus occurred in November, that of Bulinus forskalii occurred in September while that of Biomphalaria pfeifferi had their greatest number of young snails around the month of November, the least number of young snails of Bulinus forskalii occured during this period (Fig. 4).

A prominent feature in the result is the marked difference that occurred in the seasonal relative abundance of these snails (Table 1). The greatest number of snails (1363) was observed to occur in the month of October which also corresponds with the beginning of the dry season period. Few snails were collected when the habitats were almost dry in the months of April and May (Table 1). Empty shells of all the three snail species were observed during the investigations and these were more abundant during the dry season. This points to the fact that mortality rate of the snails was higher during the dry season.

From Tables 1 and 2 it can be seen that the occurrence of young snails during the period of study was throughout the year. However, as it pointed out from the tables their number varied considerably with the season. A total of 3,042 young

FIG.4: MONTHLY RELATIVE ABUNDANCE OF YOUNG SNAIL VECTORS OF SCHISTOSOMIASIS

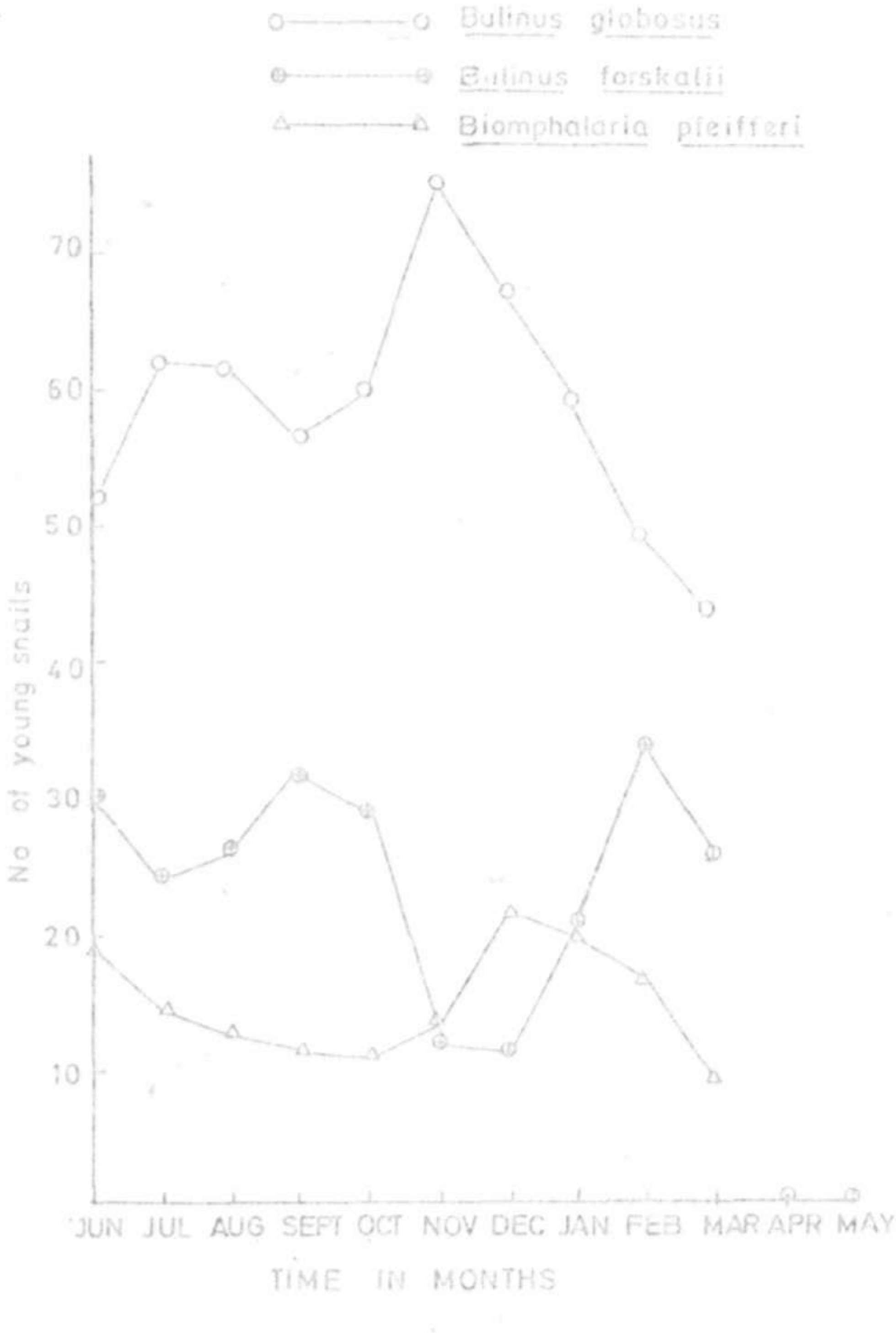
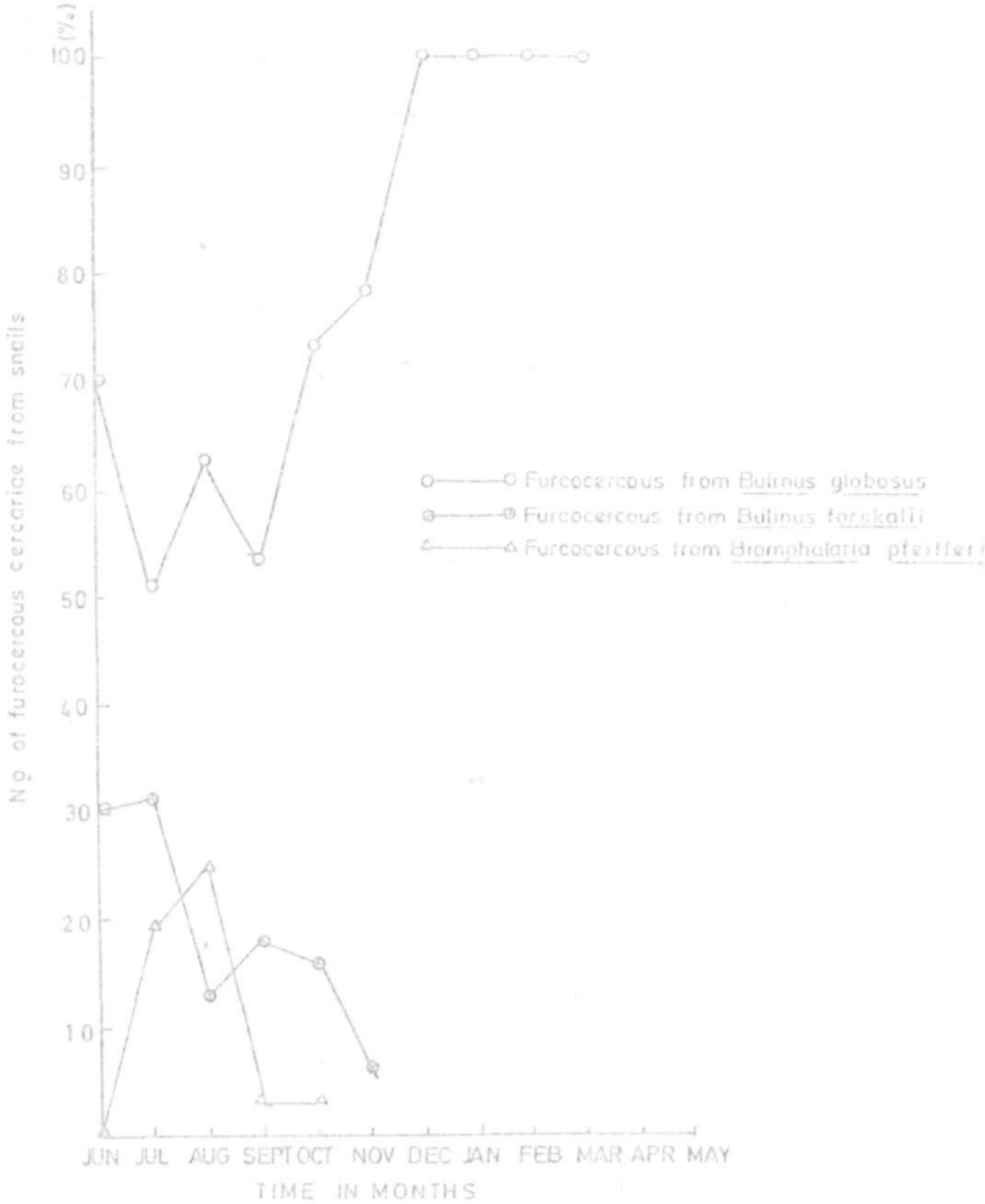


FIG.5: MONTHLY RELATIVE ABUNDANCE OF FURCOCERCOUS CERCARIAE



snails of the three species were collected during the period of investigation (Table 2). Of this number 1,876 was Bulinus globosus, 720 Bulinus forskalii and 446 Biomphalaria pfeifferi (Table 2).

Table 3 shows the distribution of furcocercous cercariae among the three snail species collected during the investigation. A total of 118 cercariae were collected, out of which 82 were from Bulinus globosus, 18 from Bulinus forskalii and 18 from Biomphalaria pfeifferi. This suggests the fact that the vector capacity of the three snails varies greatly with the species and that Bulinus globosus pose a bigger threat than any of the other two snail species. The highest number of furcocercous cercariae occurred among Bulinus globosus, followed by Bulinus forskalii and lastly by Biomphalaria pfeifferi (Fig. 5). A more detailed account of species observation in their sites is given below:-

4.1.1. Bulinus globosus:

The distribution and abundance of this snail species was found to decrease greatly with distance from Zaria. That is to say there were more Bulinus globosus in Zaria town than they were in places like Maska dam or Kangimi dam. This seem to be due to the fact that the water in the township of Zaria is more polluted than water bodies further from city. In this respect there were more Bulinus globosus in the Old Zaria City where three ponds were surveyed than in any other site studied. The greatest number of this species occurred in October when 1363 snails were collected. The least number of this species was, however, collected in May when only 130 snails were collected. October corresponds to the beginning of dry season, while May marked the end of dry season or the beginning of rainy season.

The population of young snails of this species also was observed to declined with adults, thus reflecting the effect of the weather on them. Their population grew to a peak number of 566 in November, thereafter it declined drastically to a minimum in April and then remaining low throughout the period under investigation (Table 2).

4.1.2 Bulinus forskalii:

This species of snails was observed to be the second largest number collected during the period of studies. A total number of 2175 snails of this species were collected during the research period with a peak number of 378 in the month of September (Table 1). This month does not correspond to the peak number in Bulinus globosus. Thereafter, the number began to decline to a minimum of 23 snails in May.

A total number of 720 young snails of Bulinus forskalii were collected during the period of studies (Table 2). The number was 107 in June 1986 when the investigation started and rose to a peak in October with 147 young snails. The number declined steadily to a minimum in April when no snails were collected in the habitats. It was observed that some of the snails shed furcocercous cercariae during the investigation, the number of cercariae seemed to depend on the number of adult snails.

4.1.3 Biomphalaria pfeifferi:

Table 1 shows the numner of B. pfeifferi collected during period of studies. It is seen that 1,659 snails were collected. It is also seen that the number of Biomphalaria pfeifferi rose to a peak (227) in November and thereafter the number declined drastically to a minimum in May when only 22 snails were collected. Observations of this snail species showed that the highest number occurred among the ponds from Zaria town. The highest number was collected in Kangimi dam a distance of about 50km from Zaria. Table 2 shows the distribution of the young snails during the investigation. The number varied throughout the period declining to a minimum in April when no young snails were seen in the habitats. Observation of furcocercous cercariae from this species showed that they were far less infected than Bulinus globosus (Table 3).

4.2.0. SNAIL ECOLOGY:

It was generally observed that snils in each site perferred ditches, isolated pools of water and slow flowing water bodies. Usually it was observed that the snail vectors co-exist in a particular site except for differences in their numbers. Other factors that affected the distribution of these snails vectors include water level fluctuation, drying of the habitat and absence or presence of vegetation. In isolated pools where the water was less disturbed it was observed that there were many snails in the habitat. When the water level decreased as it happened during the dry season, many of the snails died as evident by the presence of empty shells. These snails were fewer in number where the vegetation growth was poor.

4.2.1. KUBANNI LAKE AREA:

The lake has a lot of aquatic vegetation seen as emergent growth from the water. These vegetational growth provided attachment sites for the snails. Snails collected here include, *Bulinus globosus*, *Bulinus forskalii* and *Biomphalaria pfeifferi* (Table 4). These snails were observed and collected from the stoned embarkment which provided surfaces for their attachment. Variations in relative abundance were observed during the period of the investigation. During the dry season period, a lot of the snails were exposed and this led to the death of many snails, as the water level reduced. Empty snail shells were seen in the area suggesting that the snails were dead at the time.

Young snails were observed and collected from Kubanni but it was observed that their number decrease with decrease in water level. During this time many of the suitable substratum were exposed permanently.

4.2.2. MAKWAYE LAKE AREA:

There was much thicker vegetation growth in this lake than in Kubanni. There were spreading masses of *Ipomoea aquatica* over the water and snails were observed to be clinging to the underside of these plants. Table 5 shows the summary of snails collected from Makwaye dam. It is seen that a total of 2,442 snails were collected from this site. Out of this number 1436 was *Bulinus globosus* 418 was *Bulinus forskalii* and 598 was *Biomphalaria pfeifferi*. Observations showed that more snails were collected from Makwaye than from Kubanni lake (Tables 4 and 5). There were also more

Biomphalaria pfeifferi in Makwaye than in Kubanni lake. The highest number (351) of snails were collected in October. It was observed that snails tended to be more abundant in sheltered areas especially where the vegetation was dense.

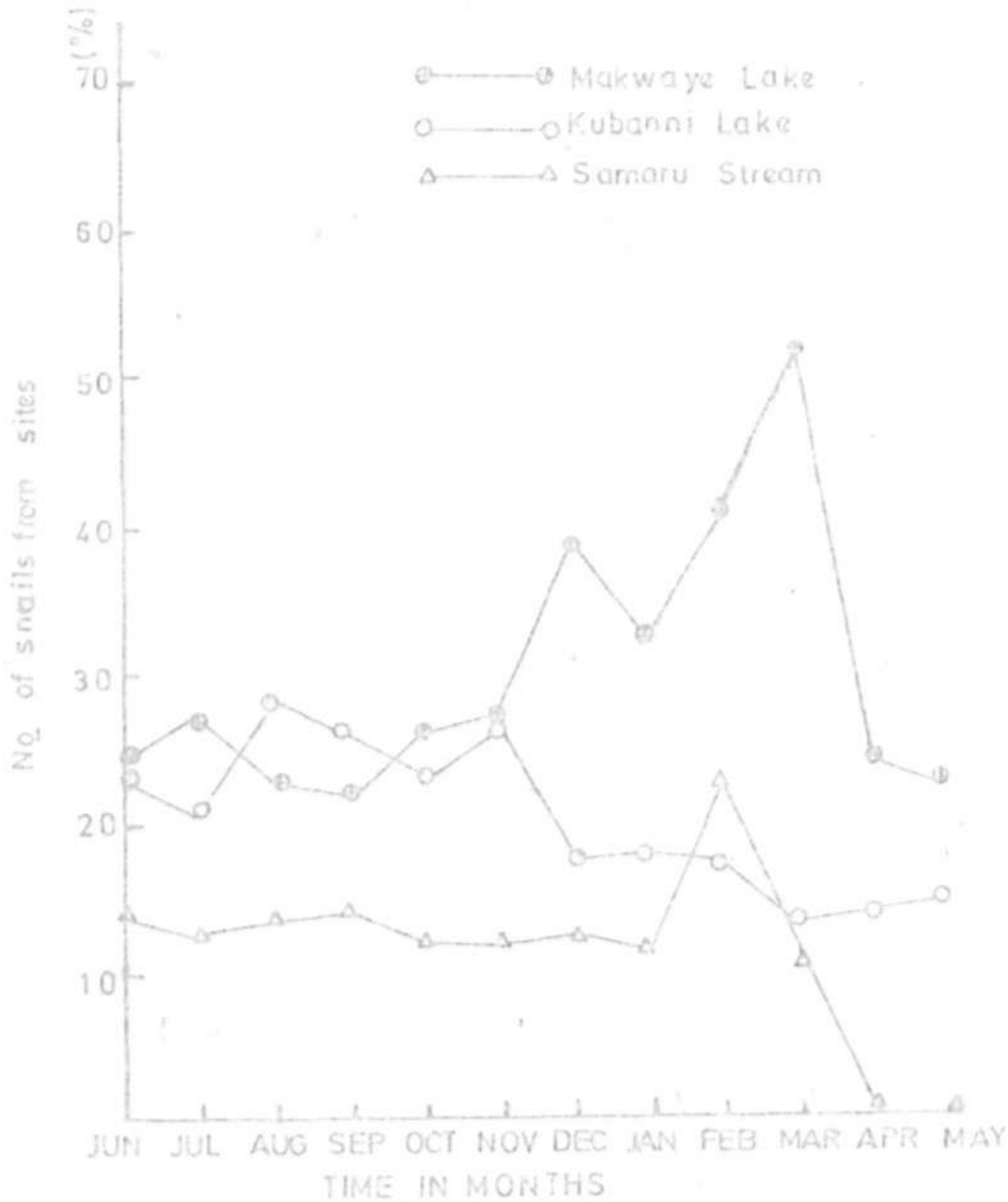
4.2.3. SAMARU STREAM:

The summary of observations made from Samaru stream is shown in Table 6 and Appendix 10. Altogether a total of 1199 snails were collected from this stream. Adult snails were observed to be more abundant than young snails and by the end of March 1987, no snails were collected from the stream. Snails collected were Bulinus globosus, Bulinus forskalii and Biomphalaria pfeifferi. It was observed that Bulinus globosus was the dominant snail in this site. This will seem to suggest that the occurance of urinary and intestinal schistosomiasis in the area is highly probable. Snail were most abundant in October and November, after which the number started to decline. Many empty snail shells were observed the number increased with the dry season. Figure 6 shows that the greatest number of snails were collected from Makwaye, followed by Kubanni and the least from Samaru stream.

4.2.4. MAIGANA DAM:

Investigation did not start in this dam till February 1987. At the time of start of the investigation it was observed that the water level was very low. Table 13 shows the summary of observations from this dam. A total of 273 snails were collected. Out of this 169 were Bulinus globosus, 39 were Bulinus forskalii and 72 were Biomphalaria pfeifferi. A total 64 adult snails were collected. 41 of these were Bulinus globosus, 13 were Bulinus

FIG.6: MONTHLY RELATIVE ABUNDANCE OF SNAIL VECTORS OF SCHISTOSOMIASIS IN MAKWAYE, KUBANNI AND SAMARU STREAM



forskalii and only 10 were Biomphalaria pfeifferi. Majority of the snails collected were young snails that have just hatched at the time of collection.

4.2.5. MASKA DAM:

Investigations started here in February, 1987 (Table 12). A total of 64 snails were collected from this dam during this period. These snails include Bulinus globosus (57) Bulinus forskalii (1) and Biomphalaria pfeifferi (6). Of the 64 snails only 11 were adults. Though snails were not observed in vast numbers, the microhabitats of the three species overlapped. The few snails observed here were **attached** to woods and leaves on the surface of water. Snails were observed to show a marked preference for the banks where the water was calmer and where emergent vegetation occurred. There were considerable fluctuations in the number of snails between months.

4.2.6. BIRNIN GWARI DAM:

Table 10 shows the observations made in Birnin Gwari dam. A total of 339 snails were collected from this dam. It was observed that the most abundant snail was Biomphalaria pfeifferi. Out of the 399 snails only 69 were adults and 330 were juveniles. No snails haboured any furcocercous cercariae in them. This was probably due to the fact that majority of the snails were still in the juvenile stage. Snails in the dam were mostly found in small isolated pools of water. Biomphalaria pfeifferi, dominant snail species was observed to show a preference for sandy soil and it was observed that some of these snails were burrowing into the soil.

As the dry season progressed water in the dam receded towards the middle of the dam leaving behind empty snail shells on the sandy shores. Of all the areas studied none surpassed the Birnin Gwari Dam in terms of abundance of dead snails.

4.2.7. KANGIMI DAM:

Observations from this dam are shown in Table 11. A total number of 125 snails were collected from this site. These were Bulinus globosus, Bulinus forskalii and Biomphalaria pfeifferi. The highest number (96) of snails collected was Biomphalaria pfeifferi (Table 16). The snails in the site were found in isolated water pools, ditches and other small water bodies. Snails preferred stems of emergent and floating plants. During the dry season, it was observed that these bodies of water either completely dry up or become extremely shallow. During the flood periods snails in the dam either disappeared completely or reduced as they were considerably disturbed and dislodged from their substratum. These snails, however, reestablish themselves as soon as the water becomes calm again. Many empty snail shells were found at the site during both the dry and the rainy season. The dislodged snails during the rainy season died in the floods that occurred in the rainy season. The dessication occasioned by the dry season also caused their death.

4.2.8. ZARIA DAM:

Table 14 shows the summary of observations made at this dam. The result shows that only 101 snails were collected from Zaria Dam between February and May (Table 14). From this dam the largest number of snails was Bulinus forskalii (69), followed by Biomphalaria pfeifferi (35) and lastly Bulinus globosus (2).

The dam channels were very muddy with only scanty vegetation, Snails were found attached to the vegetation, stones and other hard objects. Snail population in this habitat declined sharply with the dry season. Only few of the snails from this dam shed furcocercous cercariae. It was observed that Bulinus forskalii from this habitat did not shed any cercariae.

4.2.9. PONDS IN ZARIA CITY:

4.2.9.1. POND A:

Table 7 is the summary of observations made in pond A. A total of 1363 snail vectors of schistosomiasis were collected here from June, 1986 to May 1987. The snail number increased gradually from June (144), reached a peak in September (216) and then started to decline until April when no snail vectors of schistosomiasis were collected.

Of the snails Bulinus globosus was the highest in number (990), Bulinus forskalii (231) was next and lastly Biomphalaria pfeifferi (142). A total of 426 young snails were collected from this habitat.

4.2.9.2. PONDS B:

Table 8 gives the summary of observations made in Pond B. A total of 1668 snail vectors of schistosomiasis were collected including 1281 Bulinus globosus, 230 Bulinus forskalii and 159

Biomphalaria pfeifferi. A great majority of *Bulinus globosus* (726) were young snails. The number of snails rose from June (204) to a peak in October (281) and then declined to a minimum in February when no snails were collected.

4.2.9.3. POND C:

Table 9 shows observations made from Pond C. Only 771 snail vectors of schistosomiasis were collected from this pond. The peak number (142) was in October. A total of 214 young snails were collected from this pond.

4.3.0. PARASITOLOGICAL EXAMINATION:

Some snail vectors of schistosomiasis were observed to shed furcocercous cercariae. The number of cercariae shedded was, however very small. Results of this are shown in Appendices 5, 6, and 7). Of the furcocercous cercariae shedded, the highest number (82) was produced by *Bulinus globosus*.

(a)

FIG 7: BIOMPHALARIA PFEIFFERI

(b)

FIG 8: BULINUS GLOBOSUS

(c)

FIG 9: BULINUS FORSKALII

TABLE 1: Relative Abundance and Distribution of Snail Vectors of Schistosomiasis

Month		Total Collection	*Bulinus globosus*	*Bulinus forskalii*	*Biomphalaria pfeifferi*
JUNE	86	1020	524	286	210
JULY	86	1107	645	273	189
AUG	86	1182	664	327	191
SEPT	86	1340	744	378	218
OCT	86	1363	822	317	224
NOV	86	1270	803	240	227
DEC	86	752	454	128	170
JAN	87	487	286	99	102
FEB	87	260	166	51	43
MAR	87	136	79	24	33
APR	87	136	82	29	30
MAY	87	130	85	23	22
TOTAL		9180	4551	2175	1659

TABLE 2: Relative Abundance and Distribution of Young Snail Vectors of Schistosomiasis

Month		NUMBER OF YOUNG SNAILS			
		Total Collection	*B. globosus*	*B. forskalii*	*Biomphalaria pfeifferi*
JUNE	86	355	180	107	68
JULY	86	354	218	84	52
AUG	86	358	220	93	45
SEPT	86	424	239	136	49
OCT	86	504	301	147	56
NOV	86	566	422	69	75
DEC	86	268	179	31	58
JAN	87	137	81	29	27
FEB	87	53	26	18	9
MAR	87	23	10	6	7
APR	87	0	0	0	0
MAY	87	0	0	0	0
TOTAL		3042	1876	720	446

TABLE 3: Relative Abundance and Distribution of Furcocercous Cercariae

Month		Total Cercariae	B. globosus	B. forskalii	Biomphalaria pfeifferi
JUNE	86	10	7	3	0
JULY	86	16	8	5	3
AUG	86	16	10	2	4
SEPT	86	17	9	3	5
OCT	86	26	19	4	3
NOV	86	18	14	1	3
DEC	86	9	9	0	0
JAN	87	4	4	0	0
FEB	87	1	1	0	0
MAR	87	1	1	0	0
APR	87	-	0	0	0
MAY	87	-	0	0	0
TOTAL		118	82	18	18

TABLE 4: Relative Abundance and Distribution of Snail Vectors of Schistosomiasis in Kubanni Lake.

		Bulinus globosus		*Bulinus forskalii*		*Biomphalaria pfeifferi*	
Month	Total Collection	OLD	YOUNG	OLD	YOUND	OLD	YOUNG
JUNE 86	232	91	49	28	22	30	12
JULY 86	228	71	27	50	30	35	15
AUG 86	336	115	45	72	48	42	14
SEPT 86	347	88	46	92	76	34	11
OCT 86	314	114	73	49	26	36	16
NOV 86	327	57	133	55	20	37	25
DEC 86	131	53	23	21	9	15	10
JAN 87	87	29	13	25	0	15	5
FEB 87	45	28	4	0	0	13	0
MAR 87	18	9	2	0	0	5	2
APR 87	19	12	0	7	0	0	0
MAY 87	19	11	0	6	0	2	0
TOTAL	2103	678	416	405	231	264	110

TABLE 5: Relative Abundance and Distribution of Snail Vectors of Schistosomiasis in Makwaye Dam.

Month		Total Collection	*Bulinus globosus*		*Bulinus forskalii*		*Biomphalaria pfeifferi*	
			OLD	YOUNG	OLD	YOUNG	OLD	YOUNG
JUNE	86	244	90	53	32	24	26	19
JULY	86	294	104	46	52	27	40	25
AUG	86	274	127	51	40	18	23	15
SEPT	86	296	144	56	22	14	42	18
OCT	86	351	128	75	20	17	53	22
NOV	86	343	76	141	19	11	59	41
DEC	86	289	74	86	22	9	66	32
JAN	87	155	50	22	9	16	38	20
FEB	87	106	42	6	18	12	19	9
MAR	87	71	33	5	12	6	10	5
APR	87	32	12	0	10	0	10	0
MAY	87	29	15	0	8	0	6	0
TOTAL		2484	895	541	264	154	392	206

TABLE 6: Relative Abundance and Distribution of Snail Vectors of Schistosomiasis in Samaru Stream.

			Bulinus globosus		*Bulinus forskalii*		*Biomphalaria pfeifferi*	
Month		Total Collection	OLD	YOUNG	OLD	YOUNG	OLD	YOUNG
JUNE	86	141	51	22	27	15	16	10
JULY	86	139	52	22	38	12	10	5
AUG	86	160	53	20	47	15	20	5
SEPT	86	183	56	21	49	21	33	3
OCT	86	167	52	35	51	19	8	2
NOV	86	150	47	45	34	16	8	0
DEC	86	92	46	24	15	7	0	0
JAN	87	80	41	19	12	8	0	0
FEB	87	59	27	11	15	6	0	0
MAR	87	28	12	3	6	0	7	0
APR	87	0	0	0	0	0	0	0
MAY	87	0	0	0	0	0	0	0
TOTAL		1199	437	222	294	119	102	25

TABLE 7: Relative Abundance and Distribution of Snail Vectors of Schistosomiasis in Pond A.

Month		Total Collection	*Bulinus globosus*		*Bulinus forskalii*		*Biomphalaria pfeifferi*	
			OLD	YOUNG	OLD	YOUNG	OLD	YOUNG
JUNE	86	144	49	19	25	15	24	12
JULY	86	145	67	37	14	6	18	3
AUG	86	170	60	60	23	5	18	4
SEPT	86	216	95	51	28	10	23	9
OCT	86	215	97	53	35	19	9	2
NOV	86	200	99	66	18	7	10	0
DEC	86	117	66	26	15	0	8	2
JAN	87	93	68	14	10	1	0	0
FEB	87	48	43	5	0	0	0	0
MAR	87	15	15	0	0	0	0	0
APR	87	0	0	0	0	0	0	0
MAY	87	0	0	0	0	0	0	0
TOTAL		1363	659	331	168	63	110	32

TABLE 8: Relative Abundance and Distribution of Snail Vectors of Schistosomiasis in Pond B.

			Bulinus globosus		*Bulinus forskalii*		*Biomphalaria pfeifferi*	
Month		Total Collection	OLD	YOUNG	OLD	YOUNG	OLD	YOUNG
JUNE	86	204	46	72	35	15	26	10
JULY	86	294	100	150	21	3	16	4
AUG	86	310	162	100	21	2	20	5
SEPT	86	237	73	120	23	5	13	3
OCT	86	281	76	135	30	5	25	7
NOV	86	193	52	76	27	8	23	7
DEC	86	93	23	41	15	0	13	1
JAN	87	56	20	32	16	4	2	0
FEB	87	0	0	0	0	0	0	0
MAR	87	0	0	0	0	0	0	0
APR	87	0	0	0	0	0	0	0
MAY	87	0	0	0	0	0	0	0
TOTAL		1668	552	726	188	42	138	37

TABLE 9: Relative Abundance and Distribution of Snail Vectors of Schistosomiasis in Pond C.

Month		Total Collection	*Bulinus globosus*		*Bulinus forskalii*		*Biomphalaria pfeifferi*	
			OLD	YOUNG	OLD	YOUNG	OLD	YOUNG
JUNE	86	101	17	11	32	16	20	5
JULY	86	101	25	8	14	36	18	0
AUG	86	135	26	6	23	25	21	2
SEPT	86	121	40	18	28	10	20	5
OCT	86	142	47	13	35	19	21	7
NOV	86	105	49	13	18	7	16	2
DEC	86	51	13	2	15	0	18	3
JAN	87	13	7	1	0	0	2	3
FEB	87	2	0	0	0	0	0	2
MAR	87	0	0	0	0	0	0	0
APR	87	0	0	0	0	0	0	0
MAY	87	0	0	0	0	0	0	0
TOTAL		771	224	72	193	113	136	29

TABLE 10: Relative Abundance and Distribution of Snail Vectors of Schistosomiasis in Birnin Gwari Dam.

Month	Total Collection	*Bulinus globosus*		*Bulinus forskalii*		*Biomphalaria pfeifferi*	
		OLD	YOUNG	OLD	YOUNG	OLD	YOUNG
FEB 87	100	2	8	0	0	10	80
MAR 87	98	0	10	0	0	6	84
APR 87	76	6	10	0	0	0	50
MAY 87	125	5	20	0	0	10	90
TOTAL	399	13	48	0	0	26	304

TABLE 44: Relative Abundance and Distribution of Snail Vectors of Schistosomiasis in Kangimi Dam.

Month	Total Collection	*Bulinus globosus*		*Bulinus forskalii*		*Biomphalaria pfeifferi*	
		OLD	YOUNG	OLD	YOUNG	OLD	YOUNG
FEB 87	50	3	10	0	2	5	30
MAR 87	30	0	0	0	0	7	23
APR 87	21	0	7	0	0	5	10
MAY 87	24	1	7	0	0	6	10
TOTAL	125	4	24	0	2	23	73

TABLE 12: Relative Abundance and Distribution of Snail Vectors of Schistosomiasis in Maska Dam.

		Bulinus globosus		*Bulinus forskalii*		*Biomphalaria pfeifferi*	
Month	Total Collection	OLD	YOUNG	OLD	YOUNG	OLD	YOUNG
FEB 87	20	5	15	0	0	0	0
MAR 87	16	2	12	0	0	0	2
APR 87	18	3	10	0	1	0	4
MAY 87	10	0	10	0	0	0	0
TOTAL	64	10	47	0	1	0	6

TABLE 13: Relative Abundance and Distribution of Snail Vectors of Schistosomiasis in Maigana Dam.

Month	Total Collection	*Bulinus globosus* OLD	*Bulinus globosus* YOUNG	*Bulinus forskalii* OLD	*Bulinus forskalii* YOUNG	*Biomphalaria pfeifferi* OLD	*Biomphalaria pfeifferi* YOUNG
FEB 87	70	13	35	2	0	0	20
MAR 87	84	15	40	5	10	2	18
APR 87	62	13	26	0	7	3	14
MAY 87	57	0	27	6	9	5	10
TOTAL	273	41	128	13	26	10	62

TABLE 14: Relative Abundance and Distribution of Snail Vectors of Schistosomiasis in Zaria Dam.

		Bulinus globosus		*Bulinus forskalii*		*Biomphalaria pfeifferi*	
Month	Total Collection	OLD	YOUNG	OLD	YOUNG	OLD	YOUNG
FEB 87	30	0	0	5	20	2	8
MAR 87	31	0	0	6	14	1	10
APR 87	24	0	0	6	10	3	5
MAY 87	16	2	0	2	6	0	6
TOTAL	101	2	0	19	50	6	29

CHAPTER FIVE

5.0 DISCUSSION

5.1. GENERAL ACCOUNT:

From a total collection of 9,180 snail intermediate hosts of Schistosoma, this study has revealed that three species of these snails were found in the study area. These species include Bulinus globosus, B. forskalii and Biomphalaria pfeifferi. This agrees with the observations of Zakari (1977) and Ebele (1981). In their own observations in Zaria, they reported that these three species of snails occurred in various abundance and distribution.

B. globosus is a known intermediate host of Schistosoma haematobium while Biomphalaria pfeifferi is the intermediate host of S. mansoni (Cowpers, 1973 and Ebele, 1981). Ebele (1981) noted that Schistosoma haematobium and S. mansoni eggs were reported in Hospitals records obtained from Kofar Gyaya and the A.B.U. Teaching Hospitals in Zaria. Earlier, Cowpers (1963) had noted in his study of snail intermediate hosts of Schistosomes that Zaria was one of the towns in the north of Nigeria that had a high Prevalence of the infection. Ebele (1981) noted that B. forskalii is a suspected alternative host for S. haematobium but pointed that this idea was still controversial as authors still do not agree.

Of the three snail intermediate hosts of schistosome found to occur in the study areas B. globosus was the most abundant and also widespread snail. This agrees with observations made by Zakari (1977). He noted that 77% of ponds investigated in Zaria City contained this snail while only 19% contained B. forskalii.

Table 1 shows that 4,551 representing about 49% of the total snails collected during this investigation. This snail was found in every site of study in various abundance. The great abundance registered by this snail might be due to the fact that it favours habitats that are polluted with organic matters. Smith (1975) noted that the abundance of B. globosus decreased along a polluted stream from the source of pollution. This is so because at the source the pollution is too strong for the snail to thrive, but with distance from the source the pollution becomes more diluted and so can support a large number of snails. Also Edington (1970) noted that this snail was more abundant in Ibadan township that in the rural areas of Ibadan. This fact, he stated is due to the fact that the township was more populated and therefore has a greater chance of being polluted with organic matters than the rural areas which were less congested.

Bulinus forskalii and Biomphalaria pfeifferi were restricted in their distribution and also were less abundant than B. globosus. This too might be due to the fact that these two snails prefer a rather less polluted environment than B. globosus (Paperna 1968). This might also explain why Biomphalaria pfeifferi was more abundant in Kangimi dam than any other snail. Kangimi, a village about 50km from Zaria is inhabited by only fishermen and few irrigation workers therefore the chances of being polluted heavily are less likely than a place like Zaria which is heavily populated. From the foregoing therefore it is seen that both forms of schistosomiasis (urinary and intertinal) are very likely to be prevalent in the area of study since their intermediate hosts occur in virtually all habitats investigated.

Table 1 is the distribution of the snails according to months. It is seen that from June 1986 when the investigation started a total of 1020 snails were collected. The number then rose gradually to a peak (1363) in October and then started to decline thereafter to a minimum (130) in May 1987 when the investigation was terminated. The rise in the number of snails corresponds to the rainy season. The rains usually begin early May. In the same vein the decrease in number of snails corresponds to the dry season period. During the dry season water level decreases in all the sites thus exposing the snails to desiccation and eventual death. McCullough (1957) noted that snails are very sensitive to desiccation in an environment. The snail population (Table 1) reaches a peak in October, because during this period the water which contains the snail is generally calm and this made the environment more suitable for the snails. In September the rains are heavy and this reduced the food usually available for snail. Also vegetation and substratum are submerged at this time and thus the snails are dislodged and carried away by the strong currents (WHO, 1978). All through the period of investigation Bulinus globosus maintained the highest number over all the other snails. Thus heavy downpour affected the abundance and distribution of these snails.

The abundance of the snails is also affected by vegetation. This was not investigated in the present study but Okwusoa et al., (1980) noted that Bulinus forskalii were restricted to the roots of partially submerged sedges, Rycrus polystrachyos and Cyperus spp. They also observed that snail usually attach themselves to the surface of green aquatic plants. The aquatic plants serve as a source of oxygen which dissolved in water and which is needed by snails for their respiratory purposes. In this study the most important factors that affects the abundance and distribution of snails is the season. The season determine the volume of water in an environment. Snail mortality was very high during the dry season and the mortality increased with the dry season. This explains why many empty snail shells were observed during this period. The empty snail shells points to the fact that snails were dying as a result of the drying of the habitat.

Table 2 gives the observations made on young snails. The number of young snails in any month was directly related to the adults available. There were few young snails when the adults were few. The adult produce the young and this explains why the number of adults determines that of the young snails. Though the number of these young snails decreases with the setting in of dry season, their presence, however is a pointer that reproductory activities were going on throughout the year by the adult snails which survived. The study has revealed the relative fluctuations of young snails investigated in all the habitats. The proportion of the young snails declined towards January in every site but as soon as the rains set in the number increased appreciably.

5.2. VECTORAL CAPACITY:

All the three snails species shedded furcocercous cercariae, though the number and distribution of cercariae varied with sites and the snails. Emergence of cercariae was highest among the *B. globosus*. The highest number of this snail was collected from Zaria City in Ponds A, B, and C and since the highest number of furcocercous cercariae were produced by Bulinus globosus, it therefore suggests that these ponds must have produced more cercariae than any other site. The reason for this may be due to the fact that Zaria City is heavily populated and contact between man and water is most likely than in any other sites, therefore snails here are more likely to shed furcocercous cercariae than any other site. This agrees with the Mbome (1981) noted.

5.3. SNAIL ECOLOGY:

The richest snail site was Makwaye Bomo Lake. A total number of 2442 snails were collected from this dam. This, however, contrasts with the observation of Mbome (1981). He noted that Kubanni lake was richer in snail intermediate hosts than Makwaye/Bomo lake. This discrepancy may be due to the fact that he spent only few months in the investigation and also he restricted himself to the Bomo reservoir. The richness in snail population of this lake might be attributed to the fact that the water here is generally calm. Anyam (1980) noted that this lake is calm most of the time. Snails tend to prefer an environment where the water is calm. Also Makwaye was richest in aquatic vegetation than other sites. Snails are known to attach themselves to some of these aquatic vegetation (Okwuosa et al., 1980).

The richness of snails observed in Kubanni might probably be due to the fact that the area is also rich in aquatic vegetation. It was however not as rich as Makwaye. This may be due to the fact that there were more wave action in this lake and it is more open thereby making the conditions for snails less attractives. This was also noted by Mbome (1981).

Samaru stream was surveyed by Smith (1975). He noted that the population of Bulinus snails increased downstream from a pollution source. The present work confirms this observation. The prodominance of B. globosus in this stream is due to the fact that the stream is polluted (Smith, 1975). There were few snails observed from Birnin Gwari dam. This may be due to the fact that the observation started here rather late. Only 399 snails were collected. There were no existing snail record from this dam for comparison with the present work. However, it is important to note that very few B. globosus were collected here and no B. forskalii at all. This might be due to the fact that Birnin Gwari is not heavily polluted and chances of pollution in the lake are therefore less. This is because the town is only sparsely populated. This aspect may need further investigation. Biomphalaria dominated in this dam due to the same reason (Smith, 1975).

Maska dam produced the least number of snails. Only 64 snails were collected. This might also be due to the fact that observation did not start here until February, 1987. It is however important to note also that majority of the snails were B. globosus. Majority of the snails were young and this might mean that schistosomiasis is less prevalent in the area. The few snails recorded here may also be due to the fact that the observations were made only during dry season.

In Maigana dam, the trend is the same as all other dams. A decreased in snail population during the dry season was noted. This accounts for rather few snails observed. The dam might be polluted with organic wastes because of heavy human activities such as fishing, small scale irrigation, local bricks making during the dry season. Cattle also heavily grazed the banks of this dam. This may explain why B. globosus was more abundant here than any other snail species.

The poor snail number collected from Zaria dam may be due to the fact that observation was made in the dry season. Snails were mainly collected from ditches and isolated pools. Some of which were already drying up during the time collections were made.

The present work has produced information on the distribution of snail intermediate hosts of Schistosoma on Zaria area, northern Nigeria on a larger expanse. It might now be possible to know the range, abundance and the distribution of these snails around Zaria.

Some difficulties encountered during the course of this work need to be highlighted to end this discussion. Firstly, there was the difficulty of finding relevant literatures that deal with the snail ecology.

Secondly, the problem of examing snails for furcocercous cercariae was there. Snails need careful handling and treatment to induce them to shed the cercariae.

Finally, Okwuosa et al., (1980) noted that the abundance and distribution of freshwater snail intermediate host of schistosomes are associated with other factors such as temperature, dissolved oxygen, pH, alkalinity, calcium ricion concentration, magnesium ion and conductivity. Observations on these aspect were not made in the present study.

REFERENCES

Adewunmi, C.O. and Marquis, V.O. (1980) Laboratory and field trials of the molluscicidal property Calliandra portoricences. Proceedings of the Tenth International Congress of Tropical Medicine and Malaria p. 354.

Adewunmi, C.O. and Sofowora, E.A. (1980) Preliminary screening of some plant extracts for molluscicidal activity, Planta medica. Journal of Medical Plant Research, 39, 57-65.

Alves, (1958) Cited by Okwuosa V.N.& Ukoli, F.M.(1980) Studies of the ecology of freshwater snail vectors of schistosomiasis in South-West Nigeria: Field distribution and relative abundance vis-a-vis physio-chemical environmental factors. Nigeria Journal of Parasitology 1 (2) 87-122.

Anyam, W.R. (1980) Some aspects of the freshwater ecology of two man-made lakes near Zaria, Nigeria. Unpublished M.Sc. Thesis Dept. of Biological Sciences, A.B.U., Zaria.

Betterton, C. (1984) Ecological studies on the snail host of schistosomiasis in the South Chad Irrigation Project Area, Borno State, Norther Nigeria. Journal of Arid Environment 7 (1) 43-57.

Betterton, C., Freyer, S.E. and Wright, C.A. (1983) Bulinus senegalensis in Nigeria. Annals of Trop. Med. and Parasit. 77, 143-149.

Blair, D.M. (1956) Bilharziasis survey in British West and East Africa, Nyasaland and Rhodesia. Bull. Wld. Hlth Org. 15, 203-273.

Boycott, A.E. (1936) The habitats of freshwater Mollusc in Britain. Journal of Animal Ecology 5, 116-186.

Bradley, D.C. (1979) Cited by Esien (1986) Health components of irrigation projects case study of the Sokoto River Basin and Rural Development Authority. (Unpublished).

Cairncross, S. and Feachem, R.G. (1983) Dams, irrigation and health. In: Environmental Health Engineering in the Tropics. p. 223. Published by John Willey and Sons Chichester, England.

Cowper, S.G. (1963) Schistosomiasis in Nigeria. Ann. Trop. Med. Parasit. 57: 307-322.

Cowper, S.G. (1973) Bilharziasis(Schistosomiasis) in Nigeria. Tropical and Georgraphical Med. 25: 105-118.

Davis, A (1976) Schistosomiasis and other helminthic infections. Wld. Hlth. Org. Techn. Rep. Ser. No. 8.

Ebele, S. (1981) Physio-chemical factors affecting the distribution of snail vectors of schistosomes in some ponds in Zaria City. M.Sc. Thesis Dept. of Biological Sciences, A.B.U., Zaria.

Edington, G.M., Lichtenberg, F.V., Nwabueba, I., Taylor, J.R., and Smith, J.H. (1970) Pathological effects of schistosomiasis in Ibadan, Western State of Nigeria. I. Incidence and intensity of lessons. American Journal of Trop. Med. and Hygiene 19: 982-995.

Esien (1986) Health components of irrigation project: case study of the Sokoto River Rima Basin and Rural Development Authority. Proposals for Research. Dept. of Community, A.B.U., Zaria.

Ezeoke, M.C. (1978) A study of the environmental sanitation of Zaria City. Unpublished undergraduate research project. Dept. of Community Medicine, A.B.U., Zaria.

Gana, I.J. (1979) Prevalence study of visical schistosomiasis in Zaria School Children. Unpublished undergraduate research project. Dept. of Community Medicine, A.B.U., Zaria.

Helmut, K. and McCullough, F. (1981) Plant molluscicides. Bull. Wld. Hlth. Org. 59: 3-9.

Hira, P.R. (1966) Studies on the ecology of snails transmitting urinary schistosomiasis in Western Nigeria. Ann. Trop. Med. Parasit. 60: 198-211.

Igharo, P. (1972) Report on the study of permeability and seepage through buried old river channel under the left bank of the Kubanni dam. Dept. of Civil Engineering, A.B.U., Zaria.

Ikejiani, I. (1955) Non-gonorrhoal urethritis. W. Afr. Med. J. 4: 25-29.

Jordan. P. (1975) Schistosomiasis - Epidemiology, clinical manifestations and control. In: Man-made lakes and human health. Stanley N.F. and Alpers M.P. (ed.) Academic Press London p. 35-40.

Jordan, P., Bartholomew, R.K., Unrau. G.O., Upatham, E.S., Grist, E. and Christie, J.D. (1978) Further observations from St. Lucia on control of Schistosoma mansoni transmission by provison water supplies. Bull. Wld. Hlth. Org. 56 (6) 965-977.

Manson (1877) Cited by Esien (1968) Health components of irrigation projects: case study of the Sokoto River Rima Basin and Rural Development Authority. A research proposal. Dept. of Community Medicine, A.B.U., Zaria.

Mbome, M.F. (1981) Incidence and distribution of furcocercous cercariae in snails vectors in Zaria, with reference to Bilharziasis. Unpublished B.Sc. Project. Dept. of Biological Sciences, A.B.U., Zaria.

McCullough, F.S. (1987) Cited by McCullough F.S. (1957) The seasonal density of populations of Bulinus globosus and B. forskalii in natural habitats in Ghana. Ann. Trop. Med. Parasit. 51: 235-248.

McCullough, F.S. (1957) The seasonal density of populations of Bulinus globosus and B. forskalii in natural habitats in Ghana. Ann. Trop. Med. Parasit. 651 235-248.

Nayolor, A.H., and Beredugo, Y.O. (1969) The design and construction of the Makwaye dam, Samaru. The Nigeria Engineer 5: 21-29.

Odei, M.A. (1961) A review of the distribution of snail hosts of Bilharziasis in W. Africa. I. Gambia, Ghana, S. Leone. Nigeria and British, Cameroon. Ghana J. Sci. (1 and 2) 5: 50-54.

Odenburg (1942) Cited by Tayo, M.A., Jewsbury, J.M. (1978) Malumfashi endemic diseases research project IV. Changes in snail population following the construction of a snail dam. Ann. Trop. Med. Parasit. 72 (5) 483-487.

Okpala, I. (1957) Diagnosed case of schistosomiasis in Lagos (Nigeria). W.Afr. Med. J. 612: 74-78.

Okwuosa, V.N.,& Ukoli, F.M.(1980) Studies on the ecology of freshwater snail vectors of schistosomiasis in South-West Nigeria. Field distribution and relative abundance vis-a-vis Physio-chemical environmental factors. Nigeria J. Parasit 1 (2) 87-122.

Ologe, K.O. (1973) The Kubanni Dam.
Ologe, K.O. (1973) The Kubanni Dam. Savanna. 2 (1) 68-78.

Paperna, I. (1968) Studies on the transmission of schistosomiasis in Ghana. The infection rate of snails at transmission sites. Ghana Med. J. 7: 63-70.

Pugh, R.N.H. (1979) Malumfashi endemic diseases research project VII. The importance of young males from Malumfashi area, northern Nigeria in the Schistosoma haematobium. Ann. Trop. Med. Parasit. 60: 94-99

Ramanowski (1955) Cited by Haruna A.H. (1982) The occurance of human intestinal parasitic infections (Hookworms and schistosomiasis) in Zaria area. Unpublished B.Sc. Project. Dept. of Biological Sciences, A.B.U., Zaria.

Ramsay, G.W. (1932) A study on schistosomiasis and certain helminithic infections in northern Nigeria. W. Afr. Med. J. 8: 2-10.

Richard, F., Michael, M. and Duncan, M. (1977) Editors of Water, Wastes and Health in Hot Climates. Published by English Language Book Society and John Wiley and Sons, Chichester 399 p.

Sharp (1924) Cited by Okpala, I (1957) Diagnosed case of schistosomiasis in Lagos (Nigeria). W. Afr. Med. J. 612: 74-78.

Simpson, D.I.H. (1975) The Kisum study. In: Man-made lakes and human health. Edited Stanley N.F. and Alpers M.P. 193-208.

Smith, V.G.F. (1975) The effects of pollution in a small stream near Samaru in northern Nigeria. Savanna 4: 155-172.

Spink, W.W. (1978) Infections diseases.
American University Press, New York.
577 p.

Smyth, J.D. (1981) Introduction to Animal Parasitology,
Second Ed. 193-205.

Snow (1955) Cited by Esien, E. (1986) Health components of irrigation project: Case study of the Sokoto River Rima Basin and Rural Development Authority. Research Proposals. Dept. of Community Medicine, A.B.U., Zaria.

Surtees, G. (1970) Cited by Esien, E. (1986) Health components of irrigation projects: Case Study of the Sokoto River Rima Basin and Rural Development Authority. Research Proposals. Dept. of Community Medicine, A.B.U., Zaria.

Tayo, M.A., Jewsbury, J.M. (1978) Malumfashi endemic diseases research IV. Changes in snail population following the construction of a small dam. Ann. Ann. Trop. Med. Parasit. 72 (5) 483-487.

Webbe and Jordan (1969) Human schistosomiasis. Published by William Heineman Medical Books Ltd., London.

WHO (1973) A field guide to African Freshwater Snails. I. West African Species. Published by Snail Identification Centre, Danish. 29 p.

WHO (1980) Epidemiology and Control of Schistosomiasis. Bull. Wld. Hlth. Org. Techn. Rep. Ser. No. 643 1-63.

WHO (1984) Schistosomiasis: new goals. Magazine of Wld. Hlth. Org. 3-30.

William (1970) Cited by Okwuosa, V.N. (1980) Studies on the ecology of freshwater snail vectors of schistosomiasis in South-West Nigeria: Field distribution and relative abundance vis-a-vis physio-chemical environmental factors. Nigeria J. Parasit. 1 (2) 87-122.

Wright, C.A. (1971) Flukes and Snails. The Science of Biology Series. Published by George Allen and Unwin 168 p.

Zakari, M.E. (1977) A survey of ponds in Zaria City with Partication reference to the distribution of snail hosts of schistosomiasis. Unpublished undergraduate research project. Dept. of Biological Sciences, A.B.U., Zaria.

Appendix 1: Monthly Relative Abundance of *Bulinus globosus*

Month	Total Collection	*Bulinus globosus*	Percentage *B. globosus*	No. of Cercariae
JUNE 86	1020	524	51.4	7
JULY 86	1107	645	58.3	12
AUG 86	1182	664	56.2	10
SEPT 86	1340	744	55.5	8
OCT 86	1363	822	60.3	19
NOV 86	1270	803	63.2	18
DEC 86	752	454	60.4	9
JAN 87	487	286	58.7	4
FEB 87	260	166	63.8	1
MAR 87	136	79	58.1	0
APR 87	136	82	60.3	0
MAY 87	130	85	65.4	1
TOTAL	9180	4551		89

Appendix 2: Monthly Relative Abundance of

Bulinus forskalii

Month	Total Collection	*Bulinus forskalii*	Percentage *B. forskalii*	No. of Cercariae
JUNE 86	1020	286	26.0	1
JULY 86	1107	273	16.7	5
AUG 86	1182	327	27.7	2
SEPT 86	1340	378	19.7	3
OCT 86	1363	317	21.5	4
NOV 86	1270	240	18.5	1
DEC 86	752	128	16.1	0
JAN 87	487	99	20.8	0
FEB 87	260	51	23.5	0
MAR 87	136	24	17.6	0
APR 87	136	29	21.3	0
MAY 87	130	23	17.7	0
TOTAL	9180	4551		16

Appendix 3: Monthly Relative Abundance of

Biomphalaris pfeifferi

Month	Total Collection	Biomphalaria pfeifferi	Percentage B. pfeifferi	No. of Cercariae
JUNE 86	1020	210	20.6	2
JULY 86	1107	189	17.1	3
AUG 86	1183	191	16.1	4
SEPT 86	1340	218	16.3	6
OCT 86	1363	224	16.4	9
NOV 86	1270	227	17.9	3
DEC 86	752	170	22.6	1
JAN 87	487	102	20.9	0
FEB 87	260	43	16.5	0
MAR 87	136	33	24.3	0
APR 87	136	30	22.1	0
MAY 87	130	22	16.9	0
TOTAL	9180	4551		28

Appendix 4: Monthly Relative Abunadance of Young Snail Vectors of Schistosomiasis.

Month	B. globosus	B. forskalii	Biomphalaria pfeifferi
	B PERCENTAGE YOUNG SNAILS		
JUNE 86	50.7	30.1	19.2
JULY 86	61.6	23.2	14.7
AUG 86	61.5	26.0	12.6
SEPT 86	56.4	32.1	11.6
OCT 86	59.7	29.2	11.1
NOV 86	74.6	12.2	13.3
DEC 86	66.8	11.6	21.6
JAN 87	59.1	21.2	19.7
FEB 87	49.1	34.0	17.0
MAR 87	43.5	26.1	9.3
APR 87	0.0	0.0	0.0
MAY 87	0.0	0.0	0.0

Appendix 5: Monthly Relative Abundance of Furcocercous Serocariae Sheeded by Bulinus globosus

Month		Total Cercariae	Total Bulinus globosus	% Bulinus globosus
JUNE	86	10	7	70.0
JULY	86	16	8	50.0
AUG	86	16	10	62.5
SEPT	86	17	9	52.9
OCT	86	26	19	73.1
NOV	86	18	14	77.8
DEC	86	9	9	100.0
JAN	87	4	4	100.0
FEB	87	1	1	100.0
MAR	87	1	1	100.0
APR	87	-	-	-
MAY	87	-	-	-
TOTAL		109	82	

Appendix 6: Monthly Relative Abundance of Furcocercous Cercariae Shedded by *Bulinus forskalii*

Month	Total Cercariae	Total *Bulinus forskalii*	% *Bulinus forskalii*
JUNE 86	10	3	30
JULY 86	16	5	31.3
AUG 86	16	2	12.5
SEPT 86	17	3	17.6
OCT 86	26	4	15.4
NOV 86	18	1	5.6
DEC 86	9	-	-
JAN 87	4	-	-
FEB 87	1	-	-
MAR 87	1	-	-
APR 87	-	-	-
MAY 87	-	-	-
TOTAL	118	18	

Appendix 7: Monthly Relative Abundance of Furcocercous Cercariae from Biomphalaria pfeifferi

Month		Total Cercariae	Total Biomphalaria pfeifferi	% Biomphalaria pfeifferi
JUNE	86	10	-	0
JULY	86	16	3	18.2
AUG	86	16	4	25.0
SEPT	86	17	5	3
OCT	86	26	3	3
NOV	86	18	3	-
DEC	86	9	-	-
JAN	87	4	-	-
FEB	87	1	-	-
MAR	87	1	-	-
APR	87	-	-	-
MAY	87	-	-	-
TOTAL		118	18	

Appendix 8: Monthly Relative Abundance of Snail Vectors of Schistosomiasis in Kubanni Lake

Month	Total Snails collected from all sites	Total Sinails collected from Kubanni	% Snails from Kubanni
JUNE 86	1020	232	22.7
JULY 86	1107	228	20.6
AUG 86	1182	336	28.4
SEPT 86	1340	347	25.9
OCT 86	1363	314	23.0
NOV 86	1270	327	25.7
DEC 86	752	131	17.4
JAN 87	487	87	17.9
FEB 87	260	45	17.3
MAR 87	136	18	13.2
APR 87	136	19	13.9
MAY 87	130	19	14.6
TOTAL	9180	2103	

Appendix 9: Monthly Relative Abundance of Snail Vectors of Schistosomiasis in Makwaye Lake

Month	Total Snails collected from all sites	Total Snails collected from	% Snail from Makwaye
JUNE 86	1020	244	23.9
JULY 86	1107	294	26.6
AUG 86	1182	274	23.1
SEPT 86	1340	296	21.7
OCT 86	1363	351	25.7
NOV 86	1270	347	27.3
DEC 86	750	289	38.5
JAN 87	487	155	31.8
FEB 87	260	106	40.7
MAR 87	136	71	52.2
APR 87	136	32	23.5
MAY 87	130	29	22.3
TOTAL	9180	2442	

Appendix 10: Monthly Relative Abundance of Snail

Vectors of Schistosomiasis in Samaru Stream

Month		Total Snails collected from all sites	Total Snails collected from Samaru Stream	% Snails collected from Samaru Stream
JUNE	86	1020	141	13.8
JULY	86	1107	139	12.5
AUG	86	1182	160	13.5
SEPT	86	1340	183	13.6
OCT	86	1363	107	12.2
NOV	86	1270	150	11.8
DEC	86	752	92	12.2
JAN	87	487	80	16.4
FEB	87	260	59	22.6
MAR	87	136	28	20.5
APR	87	136	0	-
MAY	87	130	0	-
TOTAL		9180	1199	

Appendix 10: Monthly Relative Abundance of Snail Vectors of Schistosomiasis in Samaru Stream

Month	Total Snails collected from all sites	Total Snails collected from Samaru Stream	% Snails collected from Samaru Stream
JUNE 86	1020	141	13.8
JULY 86	1107	139	12.5
AUG 86	1182	160	13.5
SEPT 86	1340	183	13.6
OCT 86	1363	107	12.2
NOV 86	1270	150	11.8
DEC 86	752	92	12.2
JAN 87	487	80	16.4
FEB 87	260	59	22.6
MAR 87	136	28	20.5
APR 87	136	0	-
MAY 87	130	0	-
TOTAL	9180	1199	