STUDY OF THE ECOLOGY AND DISTRIBUTION OF THE SNAIL INTERMEDIATE HOST OF *SCHISTOSOMA HAEMATOBIUM* IN RELATION TO LOCAL TRANSMISSION IN THE MALUMFASHI AREA OF NORTHERN NIGERIA

BY

MARGARET ARIBIYO TAYO

B.Sc. Combined Honours, Aston, England, 1974

M.Sc. London, 1975

A DISSERTATION

Submitted to

Ahmadu Bello University

in partial fulfillment of the requirements

for the degree of

DOCTOR OF PHILOSOPHY

Department of Community Medicine

May, 1982

THESIS APPROVAL

This thesis by Margaret Aribiyo Tayo meets the regulations governing the degree Doctor of Philosophy of Ahmadu Bello University and is approved for its contribution to scientific knowledge and literary presentation.

External Examiner:

E.A. Malek,
Professor of Parasitology,
Department of Tropical Medicine,
School of Public Health and
Tropical Medicine,
Tulane University,
New Orleans, Louisiana 70116,
U.S.A.

Internal Examiners:

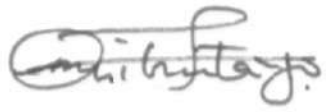
A.A. Ilemobade,
Professor of Parasitology,
Dept. of Vet. Parasitology &
Entomology,
Ahmadu Bello University,
Zaria.

P. Wijeyaratne,
Senior Lecturer in
Dept. of Community Medicine,
Ahmadu Bello University,
Zaria.

Date: 5 Nov. 1982

DECLARATION

I declare that this work is wholly the author's and has not been part of any presentation for any other qualification.



Miss Margaret Aribiyo Tayo
(Author)

ACKNOWLEDGEMENT

I would like to record my appreciation of the assistance I have received during the course of this work. I am indebted to Dr. V. G. F. Smith and Dr. Wijeyaratne, who accepted to supervise these investigations, for the advice so readily given during the years. I am especially indebted to Professor A. A. Ilemobade, who kindly accepted to replace Dr. V. G. F. Smith on his departure from Nigeria, for the invaluable assistance received in the writing up of this thesis. Appreciation is also due to Dr. G. Webbe for the help received in the design of these investigations, Professor F. M. Ukoli, Dr. A. B. Bandipo for valued discussions and advice, Dr. Schillhorn van Veen for inspiration and assistance with the snail identification. Thanks are also due to Mr. A. Adeleke, Mr. and Mrs. Adesanya and Miss T. Aken'ova for their moral support.

I am grateful also to Mr. Eze of the Federal Ministry of Health Laboratory, Kaduna for permitting water analysis to be carried out in the laboratory, Mr. Samuel Ogidan of the Soil Survey Section, Funtua Agricultural Project, for help rendered with the soil survey and the National Institute for Medical Research, Nigeria for the provision of funds and facilities and the constant encouragement.

Practical assistance was ably rendered by Garba Ahmed, Umaru Abdullahi, Bernard Maigizo and Bernard Aguleh, to whom also thanks are due.

Lastly, I am grateful to Mr. Peter Bijimi for typing this thesis.

TABLE OF CONTENTS

Page

DEDICATION iii

ACKNOWLEDGEMENT iv

CONTENTS v

LIST OF TABLES viii

LIST OF FIGURES xii

CHAPTER 1: INTRODUCTION 1

CHAPTER 2: LITERATURE REVIEW 4

2.1: Geographical Distribution of Schistosomes in Africa 4

2.2: Epidemiology of Schistosomiasis 5

2.3: Pathogenesis of Schistosomiasis 12

2.4: Control of Schistosomiasis 15

2.5: Schistosomiasis in Nigeria 18

2.6: Schistosomiasis in Malumfashi 22

CHAPTER 3: MATERIALS AND METHODS 25

3.1: The Study Area 25

3.1.1: Location 33

3.2: Field Studies 44

3.2.1: Snail Survey 44

3.2.2: Effect of Climate and Season on Snails 46

Page

3.2.3: Physico-Chemical Factors of Snail Habitats 53

3.2.4: Aestivation of B. (P.) globosus 56

3.2.5: Malacological Survey of Reservoirs of Low Earth Dams 57

3.3: Laboratory Studies 61

3.3.1: Growth of B. (P.) globosus 61

3.3.2: Infection of Snails 62

3.3.3 Examination of Snails for Infections.. 64

3.3.4: Cercarial Shedding Patterns 65

3.3.5: Infection of Sentinel Mice 66

3.4: Human Behavioural Studies 71

3.4.1: Man-Water Contact Studies 71

3.4.2: Migration 74

CHAPTER 4: RESULTS 75

4.1: Field Studies 75

4.1.1: Snail Survey 76

4.1.2: Effect of Climate and Season on Snails 77

4.1.3: Physical and Chemical Characteristics of Snail Habitats 94

4.1.4: Aestivation of B. (P.) globosus 99

4.1.5: Malacological Survey of Reservoirs of Low Earth Dams 99

4.2: Laboratory Studies 104

Page

4.2.1: Growth of B. (P.) globosus 104

4.2.2: Infection of Snails 107

4.2.3: Examination of Snails for Infection .. 108

4.2.4: Cercarial Shedding Patterns 112

4.2.5: Infection of Sentinel Mice 112

4.3: Human Behavioural Studies 114

4.3.1: Man-Water Contact Studies 114

4.3.2: Migration 129

CHAPTER 5: DISCUSSIONS 133

CHAPTER 6: RECOMMENDATIONS AND CONCLUSIONS 152

REFERENCES CITED 157

APPENDIX 175

ABSTRACT

LIST OF TABLES

Page

1. Distribution of human schistosomes in Africa 6
2. Distribution of animal schistosomes in Africa 7
3. The study villages, their populations, areas and distances from Malumfashi town 35
4. Frequency of occupation in a typical village (Ruwan Sanyi) 37
5. Trees of economic importance in the Study Area 37
6. Distribution of wells in the Study Area 39
7. Numbers of latrines present in a typical village (Ruwan Sanyi) 39
8. Climate in the Study Area 39
9. Age, proximity to dwelling area, and location of the surveyed low earth dams 59
10. Relationship of different habitats to snail numbers..73
11. Relative abundance of three snail species collected from habitats (during 1976-78) within the hamlets .. 78
12. Relative abundance of snail species (collected between June and November, 1976-77) in different habitats by hamlet 80
13. Relative abundance of 3 different species of snails in different habitats in the hamlets 81
14. Relationship of different habitats (sites) in the hamlets, to schistome infections in Bulinus globosus and Biomphalaria pfeifferi. 81

Page

15. Some characteristics of snail habitats 82

16. Frequency of occurrence of B. (P.) globosus in association with different materials in the wet season 82

17. Monthly snail collection in the study area 84

18. Fluctuation in B. (P.) globosus population with S. haematobium infection rates (1976-77) 89

19. Fluctuation in B. (P.) globosus population with S. haematobium infection rates (1977-78) 90

20. Relationship of different habitats to S. haematobium infection rates in B. (P.) globosus .. 92

21. Monthly variation in the proportion of young, adult and old snails in natural populations of B. (P.) globosus 92

22. Monthly distribution, by size, of B. (P.) globosus collected from 5 ponds..... 96

23. Snail species found in mud samples collected from dried snail habitats .....,100

24. Distribution of human schistosomiasis infections in snails collected from the low earth dams 101

25. Coexistence of snails in the dams..... 103

26. Mean monthly snail density in Ruwan Sanyi Dam 103

Page

27. Observed human-water contact activities by sex and age, at the Ruwan Sanyi Dam, during a 13 hour period (6 a.m.-7 p.m.) 105

28. Laboratory infection of B. (P.) globosus with S. haematobium miracidia 109

29. Natural infections found in snails 109

30. Exposure of sentinel mice in natural snail habitats 115

31. Distribution by sex of responses on knowledge of schistosomiasis and reasons for the use of water sites 115

32. Distribution by sex of responses on the diurnal and seasonal use of water sites 117

33. Distribution by sex of responses on the degree of bodily contact with, and contamination of water sites 117

34. Distribution by sex and age group of responses on different water-contact activities 118

35. Frequency of water-contact activities observed at different water sites 118

36. Diurnal variation observed in water contacts by sex, season and age group 119

37. Seasonal distribution of observed water-contacts .. 119

Page

38. Frequency of observed outdoor social and religious water-contact activities, by sex and season 121

39. Frequency of observed water-contact activities by age group (in years) 122

40. Age distribution of observed water-contact activities of males and females 123

41. Distribution of 3 types of water contacts observed, by sex, age and season 125

42. Duration of observed water-contacts by the different age groups, in two seasons 125

43. Duration of observed water-contact activities in the dry and wet seasons 127

44. Degree of bodily contact with water of those observed, by sex and age group..... 130

45. Distance moved by migrants 130

46. Seasonal population movement 132

47. Reasons for movement 132

LIST OF FIGURES

Page

1. Map showing the location of the Agricultural Development Project Areas in Nigeria, as at 1979 ... 23
2. Map showing the location of Malumfashi Local Government Area within Kaduna State 26
3. Map showing the distribution of settlements, roadways and watercourses in the Study Area 27
4. A woman washing clothes near a water hole dug in the Kafur river bed, during the dry season 29
5. A woman drawing water from a privately owned well in Ruwan Sanyi hamlet 29
6. A Communal Local Government constructed well in Kuringafa hamlet 31
7. A pond - a major water source for household use in Kuringafa hamlet 31
8. Part of the compact settlement of a typical village (Ruwan Sanyi village) 32
9. Climate in the Study Area 43
10. Map showing the water courses and survey sites in the Study Area 45
11. A sketch map showing the location of 13 sites used for longitudinal studies 48

Page

12. Map showing the location of the low earth dams, constructed within the Funtua Agricultural Development Project Area, as at 1979 58

13. Location of Ruwan Sanyi Dam in relation to the settlements and, the main water contact points..... 60

14. Exposure of sentinel mice in a pond in Masari hamlet 69

15. Fluctuations in snail densities in relation to rainfall 85

16. B (P.) globosus - snail intermediate host of S. haematobium, collected in habitats from the Study Area 86

17. Monthly populations of B. globosus and associated S. haematobium infections 88

18. Monthly proportions of young, adult and old B. (P.) globosus 93

19. Monthly distribution of different size groups of B. (P.) globosus collected from 5 ponds in Ruwan Sanyi hamlet..... 95

20. Variation in total solids, total alkalinity, electrical conductivity, dissolved oxygen and pH of snail habitats in the Study Area 98

Page

21. Growth of laboratory bred B. (P.) globosus 106

22. Size frequency of infected B. (P.) globosus collected from natural habitats and, cercarial shedding by similar size groups (5-15.0mm) of laboratory infected ones 110

23. Monthly proportion by size of infected B. (P.) globosus 111

24. Daily and diurnal shedding of S. haematobium cercariae by B. (P.) globosus 113

25. Water contact activities at the Malumfashi dam..... 128

CHAPTER 1

INTRODUCTION

Schistosomiasis is one of the major parasitic infections of man in the tropical and sub-tropical areas of the world, second only to malaria in its socio-economic and public health importance. Billions of people, mammals, birds and molluscs are known to suffer from infections with many different species of schistosomes (Warren, 1978). Iarotski and Davis (1981) estimated that 500 million people in the world are at risk, 200 million of whom are infected (WHO, 1965). The economic losses due to schistosomiasis are manifested in reduced work output due to increased absenteeism and cost of control measures (Iarotski and Davis, 1981). Developments such as construction of dams for agriculture and hydroelectric power provide ideal conditions for the snail hosts to flourish thus resulting in increased transmission of schistosomiasis.

In most tropical and sub-tropical regions of the world, it is estimated that up to 90% (WHO, 1972) of the human population reside in the rural areas, where factors favouring the incidence and transmission of schistosomiasis abound. It is, therefore not surprising that major thrusts in the control of schistosomiasis have, over the years, been concentrated largely in the rural areas.

Since productivity is an index of the health status of any given population and since most of the population is

concentrated in the rural areas where schistosomiasis has its greatest impact, it is important that the disease be controlled. This is particularly important in view of current efforts at developing the infrastructures in the rural areas; by construction of dams for increased agricultural output and which dams provide suitable environment for the snail intermediate hosts of schistosomes.

In Nigeria, as in most developing countries, due to limited resources, and infrastructural facilities, and competing interests, the financial allocations to health delivery programmes are comparatively small. Thus, any control programme must of necessity be developed within the financial capabilities of the government in terms of design and implementation.

Research Problem

In any attempt to control schistosomiasis, three main approaches which depend upon interrupting the life cycle of the parasite, are available. These approaches which are not mutually exclusive are:

(1) Elimination of the snail intermediate hosts through chemical, biological and ecological means.

(2) Elimination of the parasite in the final host through chemotherapy of all infected persons.

(3) Prevention of exposure of susceptible hosts through improved sanitation, provision of adequate safe water, health education and better agricultural engineering through water related projects.

However, the link generally regarded as most vulnerable in the schistosome life cycle is the snail. Any attempt to control the growth of the snail in the field needs to be based on a thorough understanding of the biology and ecology of the particular species. These would provide reliable baseline data for intervention studies. Thus the objectives of the present studies are:-

1. Identification of the snail species present in the Malumfashi area.
2. Investigation of the local snail intermediate hosts of Schistosoma haematobium in the area.
3. Determination of the effects of climate and season on snail populations and associated S. haematobium infections.
4. Investigation of the transmission of S. haematobium in the area.
5. Assessment of the additional risk constituted by the current scheme of the introduction of low earth dams to a population living in an endemic area.

In Africa, schistosomiasis is a disease of considerable and growing importance due to inadequate potable water and considerable water resources development. The human schistosome species in Africa are S. mansoni, S. haematobium and S. intercalatum. The animal schistosome species are S. bovis, S. mattheei, S. leiperi, S. margrebowiei and S. rodhaini. All these schistosomes can generally be divided, on the basis of morphological criteria, into two groups, the S. mansoni and S. haematobium complexes (Cowper, 1971). The distribution of these schistosomes is linked to that of the suitable snail hosts. The distribution of the schistosomes in Africa is presented in Tables 1 and 2.

S. mansoni has a limited distribution in Africa as compared to S. haematobium, the latter being the predominant species in North, West, East and South Africa. In Central Africa, S. mansoni is more widely distributed than S. haematobium particularly in Central African Republic, Congo and Uganda. S. intercalatum is endemic in Zaire, Gabon, Cameroon and isolated cases have been reported from Senegal, Upper Volta, Chad, Central African Republic, Congo and Nigeria (Cowper, 1971; Wright, 1973; Pitchford, 1977; Iarotski and Davis, 1981).

2.2 Epidemiology of Schistosomiasis

Transmission of schistosomiasis involves man (the definitive host), the snail intermediate host (passively infected) and water (the common external environment in which both the snail and man become infected). The factors

Table 1: Distribution of human schistosomes in Africa.

Species	Intermediate Host	Final Host	Distribution
S. mansoni	B. pfeifferi	Man, baboon, shrew, rodents.	Africa south of the Sahara.
	B. choanomphala		Lake Victoria.
	B. alexandrina		Egypt, Sudan.
	B. sudanica		Sudan, Uganda, Kenya, Tanzania, Central African Republic, Ghana, Zaire.
	B. camerunensis		Zaire-Cameroon.
S. haematobium	B. globosus	Man, rarely monkeys	Africa south of the Sahara.
	B. africanus		Cameroon, Kenya, Tanzania, Mozambique, Zambia, Zimbabwe, South Africa.
	B. nasutus		Uganda, Kenya, Tanzania.
	B. truncatus		Morocco, Algeria, Tunisia, Egypt, Sudan, Ethiopia, Mauritania, Mali, Chad, Ghana, Nigeria, Cameroon, Zaire.
S. intercalatum	B. forskalii	Man	Cameroon, Gabon, Central African Republic.
	B. globosus		Zaire.

Table 2: Distribution of animal schistosomes in Africa

Species	Intermediate Host	Final Host	Distribution
S. bovis	B. globosus B. africanus B. forskalii B. truncatus	Cattle, sheep goat, equines, camel and antelope.	Sudan, East, and West Africa
*S. mattheei	B. globosus	Cattle, sheep, equines, antelopes, baboons	South Africa, Zimbabwe, Nigeria and Zaire.
*S. leiperi	B. africanus	Antelopes and various herbivores	Zambia, Southern Sudan
*S. margrebowiei	B. tropicus B. forskalii	Cattle, zebra, gnu, antelopes	Zambia, South Africa
*S. rodhaini	B. pfeifferi B. sudanica	Riverine rodents, dog, serval cat	Zaire, Kenya, Uganda

* Reported in man.

necessary for transmission to occur in any given area are: infection in the population, a low level of sanitation and the presence of snails susceptible to infection in the water used by the population for domestic, religious, recreational and occupational purposes.

Man becomes infected by coming in contact with water into which the fork-tailed cercariae of the schistosome have been discharged from infected snails. The disease is perpetuated through infected persons who defecate in or near water courses containing the appropriate intermediate host (Gordon, Davey and Peaston, 1934; Farooq and Mallah, 1966; Dalton and Pole, 1978). It has been suggested that the washing of faecally contaminated clothing and soiled hands through ablution, are responsible for infections in snails (Chernin and Antolics, 1973; Husting, 1965; Prentice, Panesar and Coles, 1970). The act of ablution is of considerable importance in contamination of water habitats because of the frequency with which it is performed and its non-dependence on rainy season. Sewage from homes in endemic foci, emptying into streams aids the propagation of the infection (Rowan, 1964). The younger age group have been recognized as the main contaminants of the environment (Upatham, Sturrock and Cook, 1976). Children acquire the infection as soon as they are able to play in infected waters (Siegal, 1968; Pugh and Gilles, 1978). Occupational exposures have been identified as farming, fishing, boating, in inland waters and washing of clothes (Pimentel, Gerhardt, Williams, White and Ferguson, 1961; Gilles, Lucas,

Lindner, Cockshott, Anand, Ikeme and Cowper, 1965b, Farooq and Mallah, 1966; Hairston,1973; Dalton and Pole, 1978).

Bruce-Chwatt (1968) and Gordon-Smith (1972) amongst others have suggested that migration may contribute to the spread of disease and diminish the efficacy of control measures. The importance of migration to the spread and indeed control of schistosomiasis is well recognised. Onabamiro (1971) working in Sierra Leone attributed the presence of urinary schistosomiasis in school children to migration outside the area. Ruyssenaars, Van Etten and M^cCullough (1973) working in Tanzania highlighted the importance of migration to schistosomiasis in the area.

The snail is an essential link in the transmission chain. The snail intermediate hosts of schistosomiasis have been observed in various habitats, both temporary and permanent, in ditches, swamps, wells, lakes, dams, pools, streams and slow-flowing rivers. Factors concerning the role of the snail in the transmission of schistosomiasis are: the snail biotic potential, aestivation capacity, host-parasite compatibility, miracidial concentration, diurnal patterns of cercarial production and ecological changes affecting the snail habitat. The density of snail populations is an important factor. Population densities vary greatly from time to time and place to place, depending primarily on temperature and rainfall resulting in seasonal transmission patterns (Gordon et al., 1934; Webbe, 1960; 1962b, 1964a; Shiff, 1964b, Hira and Muller, 1966; Appleton, 1978, Upatham, Koura, Ahmed

and Awad, 1981). Pronounced seasonal fluctuations in the density and breeding of snails have been observed by several workers (M^{c}Mullen, 1947; Olivier and Barbosa, 1955a,b, Parent and Lietar, 1955; Smithers 1956; Cridland, 1957a, b, 1958; M^{c}Cullough, 1957a, b, 1962; Rowan, 1959; Hairston, 1961; Ritchie, Radke and Fergusson, 1962; Teesdale, 1962 and Sodeman, 1979). These fluctuations have been attributed to factors such as temperature, drying, flooding, oxygen tension, parasitism, presence or absence of vegetation. Shiff (1964a) studying the influence of temperature on the intrinsic rate of natural increase of B. (P.) globosus in Rhodesia found 25^{o}C to be the optimal temperature. Mozley (1959) stressed the presence of microhabitats under natural conditions in which snails may seek out the best habitat. Gordon et al., 1934; Malek, 1958; Webbe, 1964a; Hira and Muller, 1966 have all drawn attention to the wide temperature ranges that occur in snail habitats.

Transmission of schistosomiasis is affected by seasonal and hydrological changes which influence the life cycle of the snail host, the production of cercariae and also determines human contact with water. It is known that schistosomiasis occurs over areas with isotherms of 20-34^{o}C but flourishes best in areas in which warm temperatures prevail (Pitchford, 1977). In such areas, transmission can occur throughout the year while, in areas with periods of lower temperatures the transmission can be curtailed during parts of the year. In arid and semi-arid areas, interruption of transmission can

occur as a result of seasonal drying up of snail habitats. However, the ability of snails to survive aestivation and the great spreading capacity of snails ensures transmission after the end of the dry period. Aestivating snails have been shown to carry immature infections of S. mansoni and S. haematobium from one wet season to the next (Barbosa and Coelho, 1955; Barbosa and Olivier, 1958; Webbe, 1962a).

The nature of water supply within a locality, the density of human population and proximity to water closely relate with prevalence of infection (Hoffman, Lehman, Scott, Warren and Webbe, 1979; WHO, 1953;1980). Heavily populated areas close to water containing efficient intermediate hosts usually show high prevalence, especially if the hygiene standard and habits of the people are such to promote snail infection and subsequent exposure to cercariae. In areas located further away from the water sources with safe water supply, relatively low prevalence rates are reported (Farooq, 1973). In communities with limited water supplies, pollution of water with both stool and urine is high (Essien and Osuhor, 1979;Edungbola, 1980). The available limited water is often heavily polluted with urine through such activities as swimming, bathing, and washing of clothes. These activities have also been found to provide the most frequent opportunities for infection in Egypt, St. Lucia, Ghana, Nigeria (Farooq and Mallah, 1966; Jordan, Bartholomew, Unrau and Cook, 1975; Dalton and Pole, 1978, Tayo, Pugh and Bradley, 1980). Studies carried out in Egypt, St. Lucia, and Nigeria show that water contact may be the critical factor in the

transmission of schistosomiasis. Frequent contact with contaminated water is usually related to the development of significant disease (Dalton and Pole, 1973). Jordan (1972) reported a close correlation between water contact and infection rates of males and females. The report by Pugh and Gilles (1978) on the absence of urinary schistosomiasis in children aged 0-4 years correlates with the findings on the man-water contact studies in the area (Tayo et al., 1980).

Man-made transmission foci are closely related to agricultural development in that irrigation and reservoirs offer favourable habitats for the molluscan host and thereby opportunities for disease transmission. The introduction of new irrigation schemes in the form of canals, drains, storage dams and reservoirs is an important aspect of economic development which leads to increased snail populations (WHO, 1973b;1980) and prevalence of infection in humans. A sharp increase in the number of infected persons in Egypt, Tanzania, Ghana, Congo, Eastern Transvaal and Nigeria have been reported (Paperna, 1969, Wuddy, 1975; Matovu, 1978; Pugh, Burrows and Tayo, 1980b).

2.3 Pathogenesis of Schistosomiasis

Pathogenicity of the schistosome is species dependent, related to worm burden and egg production. Deposition of eggs in tissues is the main cause of pathogenicity. Vesical schistosomiasis is normally mild and frequently sub-clinical

(Edington, 1957; Lucas, Adeniyi-Jones, Cockshott and Gilles, 1966) but a minority of infection causes much more serious and even fatal pathological changes (Forsyth and Bradley, 1964, 1966; Forsyth and Macdonald, 1965, 1966; Oyediran and Akinkugbe, 1979).

The clinical symptoms are related to the stage of infection. For both S. mansoni and S. haematobium, apart from an initial itching at the site of cercarial penetration, there are usually no clinical signs at the invasion stage.

For intestinal schistosomiasis, symptoms of acute intestinal disturbances start at the early stage of egg deposition. Fever, chills, sometimes urticaria, headache and nausea are probably attributed to allergic and toxic reactions to the eggs. Acute enteritis results in brownish diarrhoea. Liver infection and inflammation of the mesenterial lymph nodes result in abdominal pain and anaemia. Chronic infection results in intestinal dysfunction, intermittent diarrhoea and malnutrition due to passage of undigested foodstuffs in combination with chronic dysfunction of the liver (cirrhosis). Enlargement of the spleen and ascites may cause protusion of the abdomen.

In vesical schistosomiasis, loss of appetite, headache, generalised pains, urticaria and intermittent fever due to allergic toxic reactions to the schistosome eggs may occur at the early stage of egg deposition. During this stage, the first eggs are passed in the urine. Granuloma formation and inflammation of the mucous membranes of the urinary bladder

(cystitis) and urethra (urethritis) result in frequent urge to urinate and bladder colic. Blood is passed in the urine (haematuria) and this is a common symptom which provokes suspicion. Inflammatory changes result in albuminuria.

In the chronic stage of infection, increasing numbers of egg granulomas cause thickening and fibrosis of the bladder wall (chronic cystitis). This results in frequent micturition due to loss of natural elasticity of the bladder wall. Bladder calculi may cause pain and further hydronephrosis in extreme cases. Uraemia and kidney failure may be fatal (Ahochiri, 1966; Oyediran and Akinkugbe, 1970; Edington, Lichtenberg, Nwabuebo, Taylor and Smith, 1970). Hypertension and chronic pyelonephritis have been reported to be associated with S. haematobium infections in Egyt (Abdel-Salam and Abdel-Fattah, 1977). However, no association has been found between hypertension, chronic pyelonephritis and urinary schistosomiasis in Tanzania, Nigeria and Ghana (Forsyth and Bradley, 1966; Forsyth, 1969; Edington et al., 1970; Wilkins and El-Sawy, 1977). Proteinuria, haematuria, pyuria and bacteriuria are significantly associated with S. haematobium infections (Soyannwo, 1973; Wilkins and El-Sawy, 1977). Urinary schistosomiasis produces both inflammation and obstructive lesions of the urinary tract and, hydroureter and hydronephrosis are relatively common complications. Hydronephrotic kidneys are more prone to acute bacterial infections in Egypt (Abdel-Salam and Abdel-Fattah, 1977). High incidence of severe lesions revealed by

intravenous urography (calcified bladder, ureteric deformities, hydronephrosis) has been reported (Forsyth and Macdonald, 1965, 1966; Forsyth and Bradley, 1964, 1966; Gilles, Lucas, Adeniyi-Jones, Lidner, Anand, Braband, Cockshott, Cowper, Muller, Mira, Wilson, 1965a; Gilles et al., 1965b, Gelfand, Hunt and Clarke, 1965; Forsyth, 1969; Oyediran, 1976; Oyediran, Abayomi, Akinkugbe, Bohrer and Lucas, 1975) in the youngest age groups in Tanzania, Nigeria and Senegal. Lucas et al. (1966), Chapman (1966) and, Macdonald and Forsyth (1968) suggest that schistosomiasis may be the cause of considerable morbidity, unsuspected so far in adolescents and children, as well as adults. S. haematobium can cause pulmonary arteritis progressing to corpulmonale, which is an irreversible and fatal condition. In Egypt, Shaw and Chareeb (1938) considered 58% of total pulmonary bilharzial involvement to be due to S. haematobium infection alone. There is evidence of some relation between the occurrence of cancer of the bladder and urinary bilharziasis (Abul-Fadl and Khalafallah, 1961). This is usually observed at a relatively young age.

2.4 Control of Schistosomiasis

An understanding of the epidemiology of the disease has helped to define what can feasibly be done in terms of control efforts. As the epidemiology of the disease involves the human definitive host, the snail intermediate host and the schistosome,

control efforts have been aimed at any or more of these links (WHO, 1973b; 1980). However, since the snail is regarded as the most vulnerable link in the life cycle of the parasite, the best single method of control has been the eradication of the snail (Webbe, 1974; WHO, 1973b; 1980). Efforts aimed at reducing the snail populations have centred on biological (Jordan, Christie and Unrau, 1980; M^{c}Cullough, 1981) and, chemical means and improved environmental engineering (Diamant, 1977).

The use of molluscicides in reducing numbers of the snail intermediate hosts of S. haematobium in Ghana, Tanzania, Egypt and those of S. mansoni in Egypt (using niclosamide) and, S. japonicum in Japan (using sodium pentachlorophenate) gave reductions in incidence of human disease of 0% to 34% (WHO, 1973b). Comparable results were also reported for S. haematobium infections in Southern Rhodesia after molluscicidingin two types of irrigation system with niclosamide. The present status of the biological control of snail intermediate hosts has been summarised by M^{c}Cullough (1981). B. glabrata populations have been controlled biologically (using Marisa cornuarietis - a competitor non-vector snail species) in certain types of habitats in Puerto Rico (WHO, 1973b; Jobin, Brown, Velez and Fergusson, 1977). The effectiveness of Helisoma duryi on populations of B. pfeifferi in Tanzania has also been reported (Frandsen and Madsen, 1979). Pesigan, Farooq, Hairston, Jaurequi, Garcia, Santos and Besa (1958a, b) reported reduction in the transmission of S. japonicum in the Philippines by

changing the ecology of the snail habitats. Chu (1978) reported that the removal of a common aquatic weed (Ceratophyllum) from the Volta Lake in Ghana reduced the populations of both infected and uninfected B. truncatus - the intermediate host of S. haematobium in the area. Diamant (1977) discussed the possible means of modifying the environment through observations of human, snail and parasite habits to eliminate both the snail and the need for human to come in contact with infested water. In St. Lucia, the provision of adequate piped water supply reduced markedly human contact with water by 82% and exposure time by 96%. A decrease in both prevalence and incidence among infants was also reported (Unrau, 1975; Jordan et al., 1975, 1978). Pitchford (1970) reported a reduction in prevalence of both S. mansoni and S. haematobium infections in South Africa after the provision of safe water for domestic and recreational use coupled with fencing off of transmission site. Barbosa, Pinto and Souza (1971) reported similar results in Brazil after the provision of latrines and safe water for domestic and recreational use.

Major schistosomiasis control projects have been focused on integrated measures. In the Egypt 49 project, the combined use of molluscicides and chemotherapy reduced prevalence from 46.5% to 7%. In Leyte, control measures against S. japonicum centred on the provision of sanitation, water supplies, molluscicide, drainage, improved agricultural engineering and health education (Hoffman et al., 1979). The Volta Lake project

in Ghana is using molluscicide, removal of Ceratophyllum and chemotherapy. In Puerto Rico, this involves chemotherapy of specific populations, molluscicide, habitat modification, sanitation and provision of water supplies (Jobin et al.,1977). In St. Lucia, chemotherapy of screened population, molluscicide and provision of water to households are the methods of control (Unrau, 1975; Jordan et al., 1975).

2.5 Schistosomiasis in Nigeria

In Nigeria, the two main schistosome species responsible for disease in man are S. mansoni and S. haematobium, the latter being more widespread (Cowper and Woodward, 1961; Cowper, 1963; 1973; Edington et al., 1970). S. haematobium is endemic throughout the northern and western parts of the country while it is less common in the eastern part. S. mansoni is almost as widespread as S. haematobium in the northern part of Nigeria, though less frequently recorded because of greater difficulties in diagnosis while it is less frequently encountered in the western part. There are no records of its occurrence in the eastern part (Cowper, 1963; 1973; Edington et al., 1970; Wright, 1973). Varying endemicity has been reported from different parts of the country (Taylor, 1932; Soyanwo, 1973, Bell and Howells, 1973; Pugh and Gillies, 1973; Adekolu-John, 1980; Ejezie, 1981).

S. haematobium infection rates of 3% to 95% have been reported from the northern parts of the country with the

highest rates for Sokoto, Katsina and Kankiya (M^cCullough, 1927b Ramsey, 1934; Blair, 1956; Collard, 1962; Cowper, 1963; Bell and Howells, 1973; Pugh, 1978; Adekolu-John, 1980). In the southern parts of the country, infection rates of 1.4% to 100% have been reported from Epe, Ibadan and Abeokuta (Blair, 1956; Cowper and Woodward, 1961; Akinkugbe, 1962; Gilles et al. 1965a; Siegal, 1968; Edington et al., 1970; Donges, 1972; Soyannwo, 1973; Oyediran, 1976; Ejezie, 1981). Oldenburg (1942) reported 20% infection rate in Ogoja and Owerri in the eastern part of the country.

S. mansoni infection rates ranging from 0.2% in the southern (Ibadan) to 78% in the northern (former Ilorin province) parts of the country have been reported (Taylor, 1932; Ramsey, 1934; Blair, 1956; Cowper and Woodward, 1961; Cowper, 1973). Infections recorded in Bida, Kaduna, Zaria, Kano, Plateau, Maiduguri and Biu were reported to be less than 50% of infections with S. haematobium (Cowper, 1973).

The intensity and prevalence of the disease increase with increasing age (Blair, 1956; Ejezie and Ade-Serrano, 1981) with a peak at 20 (Pugh, Bell & Gilles, 1980c). Higher prevalence rates and intensity of infection occur in males (Donges, 1972; Bell and Howells, 1973; Soyannwo, 1973; Pugh, and Gilles, 1978).

The established snail intermediate hosts are Bulinus (P.) globosus for S. haematobium and, Bioiphalaria pfeifferi for S. mansoni. There has been only little work done on the transmission of schistosomiasis in the country, particularly with reference to the intermediate hosts. The few studies on

the biology and bionomics of snail intermediate hosts of schistosomiasis in Nigeria have been carried out in the southern part of the country (Hira and Muller, 1966, Hira, 1969a, 1969b, 1970, Asumu, 1975; Okwuosa, 1979, Ndifon, 1979). These workers reported B. (P.) globosus as the most abundant and widespread of the snail intermediate hosts. The species was also reported to be widely distributed in temporary ponds and slow-flowing streams. Infection rates in the snails correlate with the infections in humans. Infection rates of 0 to 82% have been reported for B. (P.) globosus (Donges, 1972; Asumu, 1975; Okwuosa, 1979). Lower infection rates of 0.23% to 3.57% have been reported for B. pfeifferi (Asumu, 1975; Okwuosa, 1979). Highest infections occur between October and April (Hira, 1969b). Snail populations fluctuate and peak populations are recorded in the rainy season with the least population in the peak dry season.

Okpala (1961) suggested B. (B.) truncatus as the probable vector of S. haematobium in Epe. B. forskalii, though widely distributed, has not been reported as an intermediate host of S. haematobium in Nigeria.

Literature on clinico-pathological effects of S. mansoni infection in Nigeria is very scanty. Edington et al. (1970) detected S. mansoni eggs in 10 instances of 673 human cadavers and considered the mortality caused by the infection as low.

Majority of persons with S. haematobium infections are apparently in good health and show no specific clinical manifestation. However, Nnochiri (1966) observed severe

complications involving the urinary tract in 102 of 179 patients he studied in Lagos. Edington et al. (1970) found S. haematobium ova in 20% of 673 unselected human cadavers in Ibadan. He further reported that hydroureter and hydronephrosis were relatively common complications with acute pyelonephritis being sometimes a harzard. Oyediran and Akinkugbe (1970) considered the association (observed in 127 patients) of chronic renal failure and urinary schistosomiasis to be more than fortuitous. Soyannwo (1973) reported that schistosomiasis predisposes to kidney failure and and bacteriologic involvement of the urinary tract. However, the prevalence of bacterial urinary infection in Nigerian patients with vesical schistosomiasis is low and the bacteriuria rates in persons with S. haematobium infection do not differ significantly from those in uninfected controls (Pi-Sunyer, Gilles and Wilson, 1965; Soyannwo, 1973; Oyediran, 1976). Lucas et al. (1966), Pugh, Jakubowski and Gilles (1979d) and Pugh& Gilles,(1979c) have reported that some of the lesions including hydronephrosis are reversible following specific chemotherapy and may be spontaneously reversible.

The inadequacy of provision of safe potable water and proper sanitation is most pronounced in the rural areas where over 80% of the population reside. This inadequacy compels the people to come in contact with infected surface waters. The most important water-contact activities have been identified as drinking, swimming, bathing, washing of arms and legs, playing, fishing and washing of clothes (Tayo et al., 1980).

The present emphasis, by the government to boost agricultural output (through irrigation) from the rural areas to feed the ever growing urban population is reflected in the number of huge agricultural projects set up in large areas of the country, within the past 6 years (Figure 1). There are about 11 river basin authorities distributed all over the country and many of these have little or no health input. The provision of unsafe water supply in other parts of the world, under similar conditions has resulted in an increase in the experience of schistosomiasis and other water borne diseases (WHO, 1973b). Recent reports from areas where water has been impounded (Kainji Lake, Malumfashi-Funtua area) indicate an upward trend in the transmission of schistosomiasis (Waddy, 1975, Tayo and Jewsbury, 1978; Pugh et al., 1980b). There has been no strategy to control schistosomiasis in Nigeria despite the endemicity and increasing transmission. It is feared that the present water resources and agricultural developments in the country will result in an upward trend in the transmission of schistosomiasis unless an attempt is made to control the disease.

2.6 Schistosomiasis in Malumfashi

In Malumfashi, there is a patchy distribution of urinary schistosomiasis. The first report on schistosomiasis in the Malumfashi area was made by Bell and Howells (1973). A low prevalence rate of urinary schistosomiasis of 8.7% was reported

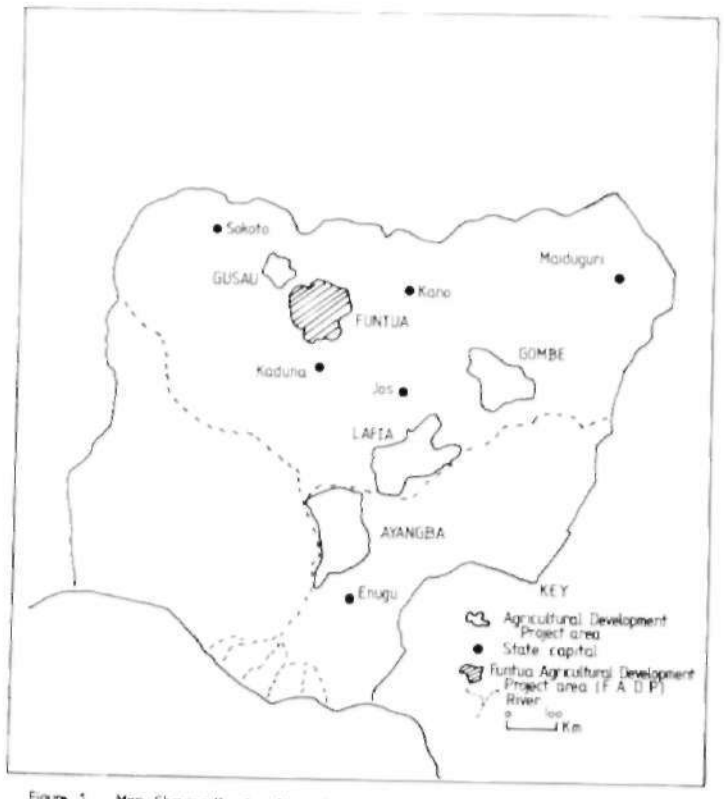


Figure 1 Map Showing the Location of the Agricultural Development Project Areas in Nigeria, as at 1979

for Mahuta village and the highest rate of 80.4% for Ruwan Sanyi village. Boys were found to be four times as infected as girls (Pugh and Gilles, 1978). Maximum infections of 80.4% were recorded for boys aged 10-12 years. The infection is acquired after the age of 4 years and prevalence rises steeply from 8 to 25 years declining thereafter to a constant after the age of 40 years (Pugh, 1979b). The transmission potential for males under 21 years of age was reported as 77% representing a considerable proportion of the overall figure of 87.3% for all males. The peak period of egg excretion was reported to be between 1400 and 1500 hours (Pugh, 1979a). Animal schistosomiasis play no role in the epidemiology of urinary schistosomiasis in Malumfashi (Pugh, Schillhorn van Veen and Tayo, 1980a). There is no record of detailed studies on the intermediate hosts of schistosomiasis in Malumfashi area. The study reported by Tayo and Jewsbury (1978) centred on changes observed in the snail populations in one of the low earth dams constructed by the agricultural development project in the area.

CHAPTER 3

MATERIALS AND METHODS

3.1 The Study Area

The study area lies in the Malumfashi Local Government Area (L.G.A.) of Kaduna State, Nigeria. This L.G.A. comprises of 23 villages, with a total population of 202,180, as at 1979, covers approximately 2,200km^2 and has its headquarters in Malumfashi town. This town is the largest in the L.G.A. with a population density of slightly over 200 per square mile (Bell and Howells, 1973). The southern boundary extends to about 210kms from Kaduna, the State Capital while Kano and Sokoto States lie on its north-east and north-west borders respectively (Figure 2). The vegetation of the L.G.A. is typical savanna. The geology of the area has been described by Bell and Howells (1973) and Bradley, Gilles and Shehu (1977). The parent material is basement complex. The country rock is granite, usually overlain with laterites and various alluvial deposits. Whalebacks and small inselbergs of granite have been reported in the area (Ogidan, pers. comm.). The most prominent features of the landscape in many parts are lateritic ironstone-capped hills. Soil erosion is a constant feature of the area. Erosion with gully formation occurs, where slopes are steeper, with mainly gentle slopes.

Most of the rivers in the area are sandy and flow only during the rainy season (Figure 3). These rivers usually dry up

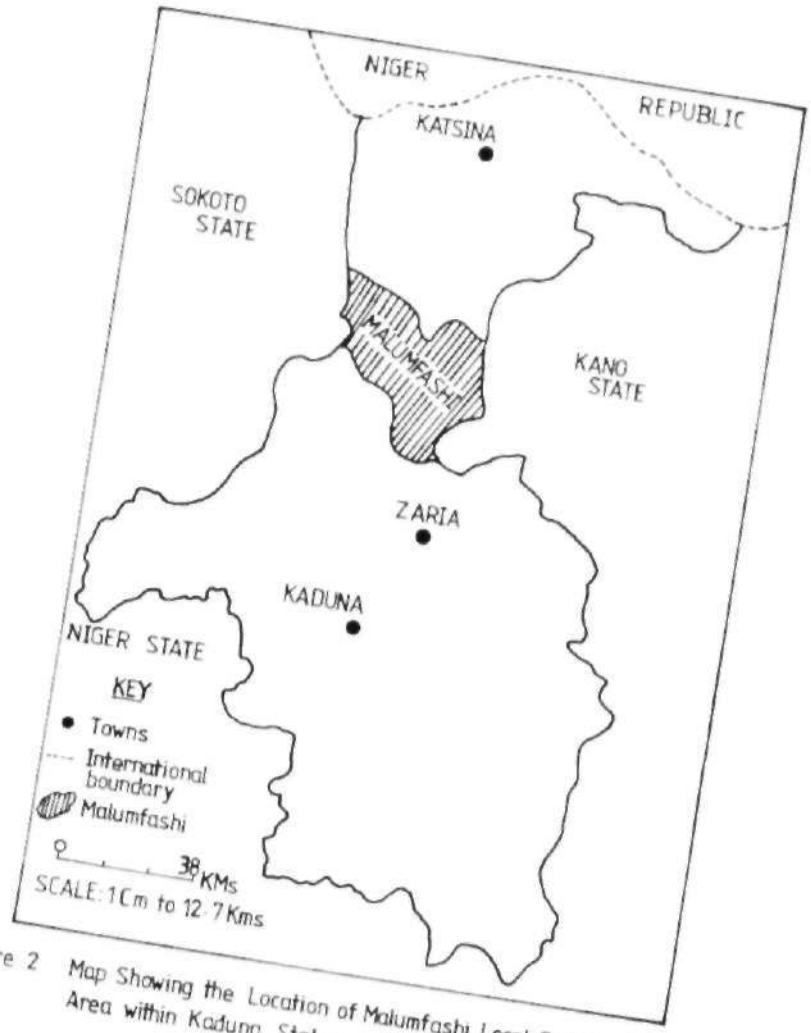


Figure 2 Map Showing the Location of Malumfashi Local Government Area within Kaduna State.

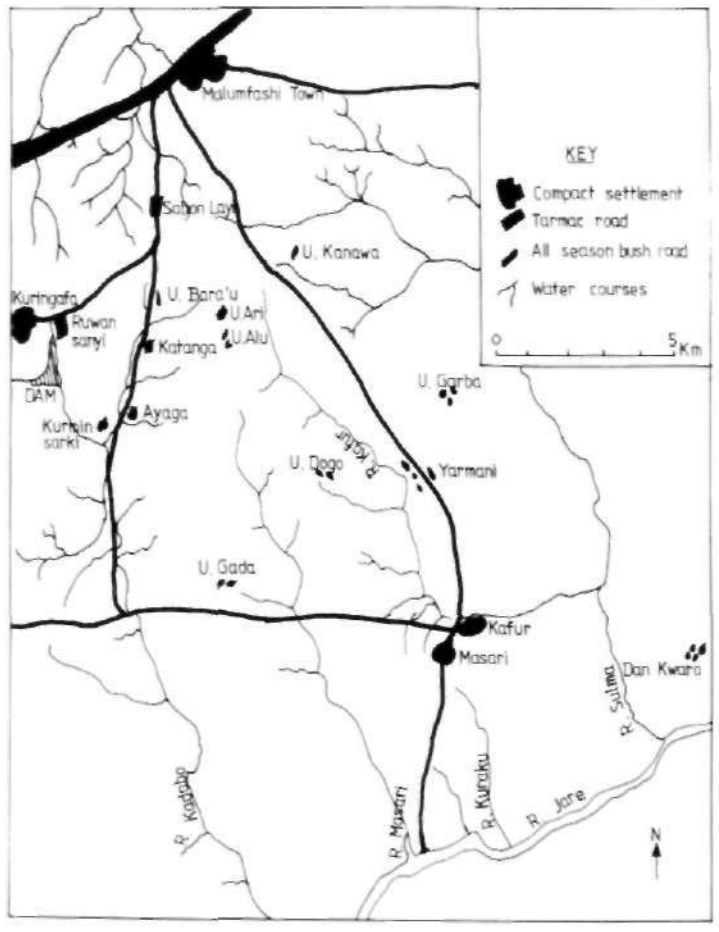
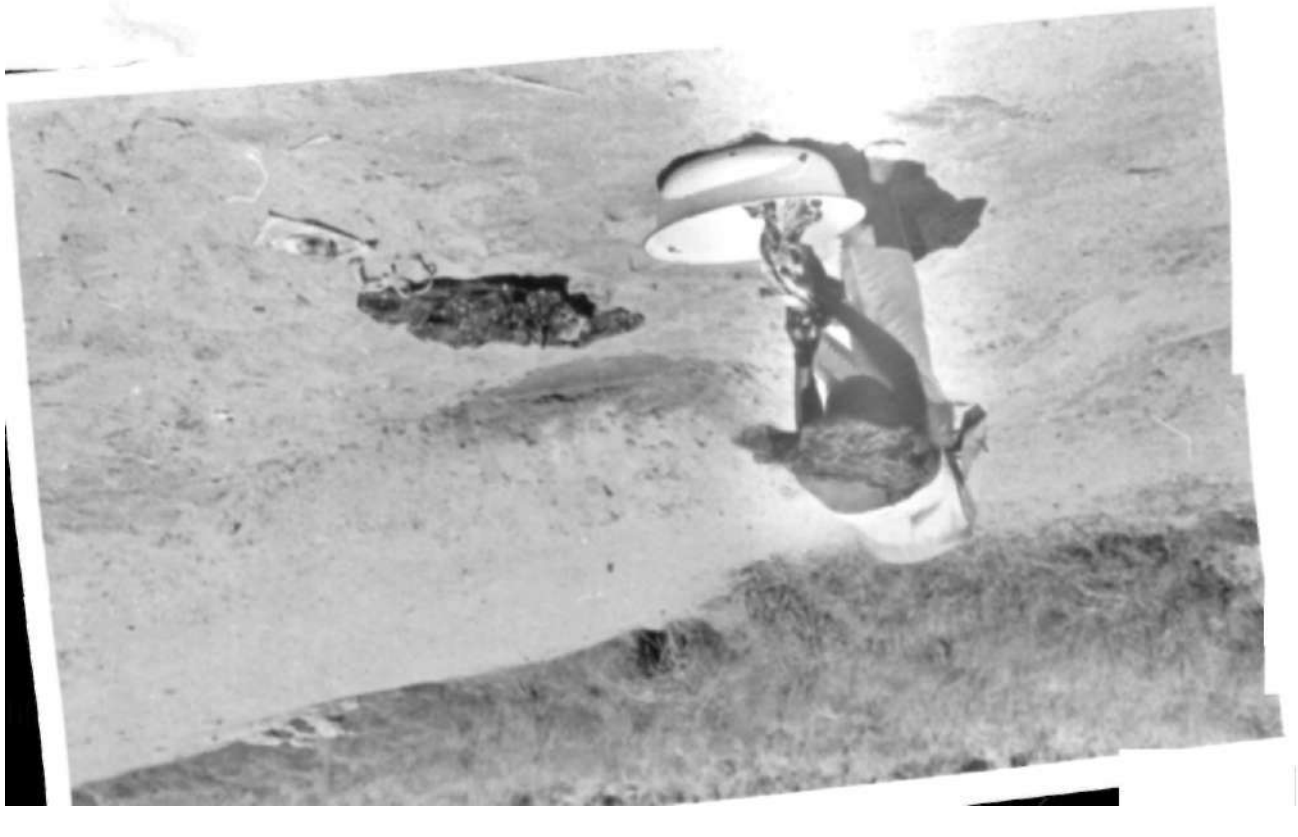


Figure 3 Map Showing the Distribution of Settlements, Roadways and Water courses in the Study Area.



the L.G.A. The piped water supply enjoyed by those living within Malumfashi town is still far from adequate. The pipe-borne water is obtained from boreholes and serves only a small proportion of the inhabitants. Furthermore, the supply is controlled - being delivered in the early hours of the day for a period of 2 to 3 hours (usually between 5.30 a.m. till 8.30 a.m.). The larger majority of the people satisfy their water needs by depending on traditional wells that are individually owned (Figure 5) and located within compounds where geological formation and depth of the water table make this possible. Otherwise they have to depend on: communal wells constructed sometimes by the L.G.A. (Figure 6) ponds (Figure 7), streams and rivers which are usually polluted by animal, human wastes and organic matter of all kinds. The recently constructed low earth dams by the former Funtua Agricultural Development Project (F.A.D.P.), based in Funtua, some 48kms. away from Malumfashi, have provided another

importance during the dry

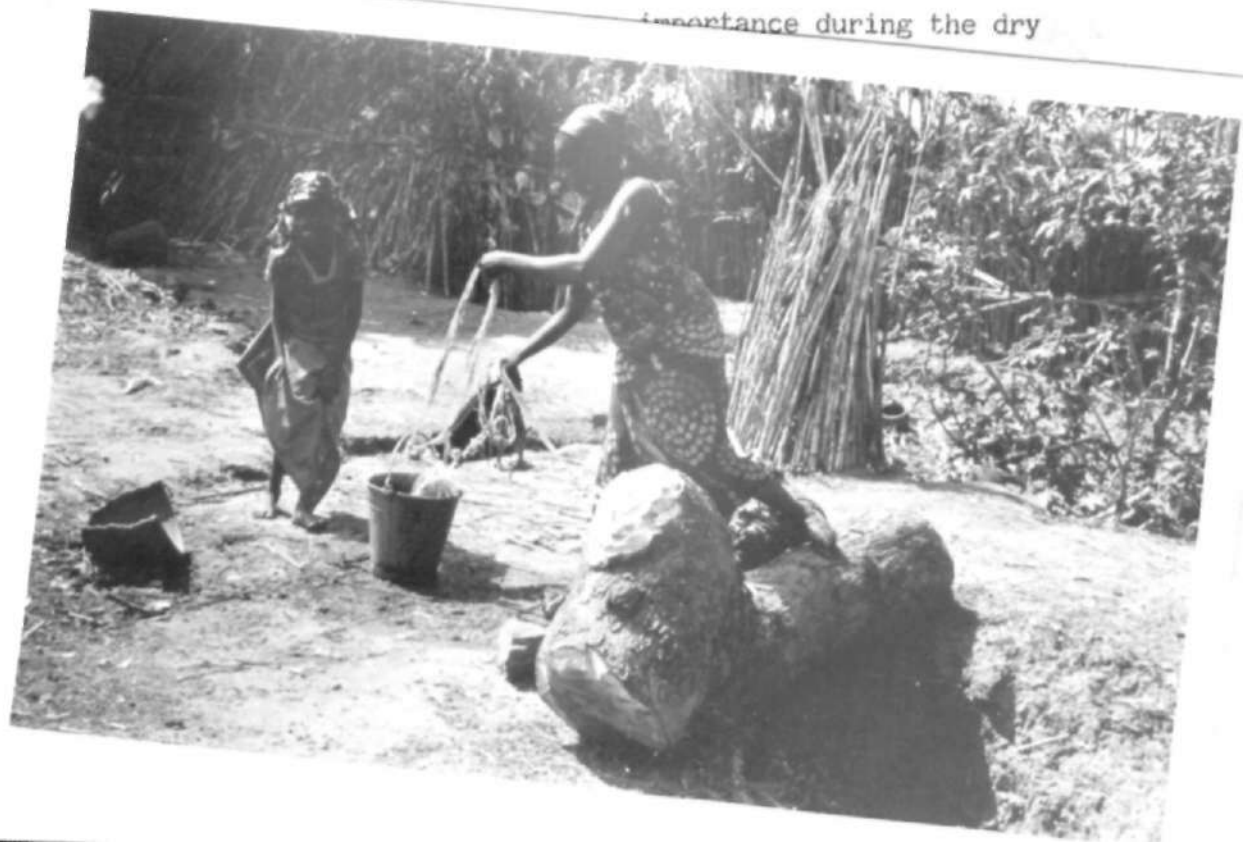




Figure 6: A communal, Local Government constructed well in Kuringafa hamlet.





The People and Organization of Life

The population consists of three main ethnic groups: the Hausas, Fulanis and Maguzawas representing 63.0%, 12.7% and 23.9% respectively of this population. The remaining 0.45% is made up mostly of Beriberis. This rural population is found in two types of settlement: the compact (Figures 8) and scattered. About 63.0% live in compact while the remaining 37.0% can be found in the scattered settlements. The Fulanis and Maguzawas predominate in the scattered while the Hausas predominate in the compact settlement. The religion of the people follows very closely their ethnic affinity. The Hausas and Fulanis are moslems while the Maguzawas are either christians or pursue traditional beliefs. Maguzawas and Hausas speak the Hausa language while the Fulanis speak Fulfude and the Hausas differ from the Maguzawas in their habits and facial marks. The moslem Hausas are largely peasant farmers and their wives lead a recluse way of life. The Maguzawa women, on the other hand, are active farmers and are also famous brewers of local alcohol. There are 3 groups of Fulanis: the nomadic Fulani, the semi-settled and the settled Fulani. The nomadic Fulani farms during the rainy season and practise cattle husbandry in the dry season while the settled Fulanis are peasant farmers. Farming is the principal occupation of the people. The main food crops are guinea-corn, millet, cowpeas, maize, sweet potatoes, coco-yam and cassava, with cotton and groundnuts serving as the important cash crops. Individual

farmers farm on small dispersed farms. The Fulani cattle herders provide sour milk and butter as daily source of revenue. Domestic animals such as sheep, goats, fowls are reared by all the three ethnic groups.

3.1.1. Location

The study area comprises the following five villages: Kafur, Masari, Ruwan Sanyi and parts of Yari Bori and Mahuta (Figure 3). The area covers approximately 250km^2 and is drained by the Jare river and its tributaries within the Lake Chad drainage basin. There are a total of fourteen hamlet areas with a total population of 12,777 (Table 3). The population density for the area is 51 per square kilometre. Ruwan Sanyi village is 9.6kms south-west of Malumfashi town. It consists of Ruwan Sanyi gari, Ungwar (U.) Ari, U. Alu, U. Kanawa, U. Bara'u, Kurmin Sarki, Ayaga and Katanga. Kafur village area comprises Kafur gari, Yarmani, Budawa and U. Garba. Masari village area lies about 1km. west of Kafur village. Kuringafa is a hamlet area of Yari Bori village area while Dankwaro hamlet is one of the hamlet areas in Mahuta village area. Mahuta village lies some 27.2 kms south-east of Malumfashi town.

Ruwan Sanyi village area alone accounts for 41.0% of the total study area population which is predominantly rural. Forty nine per cent of this population is made up of males and the rest 51.1% by females. In both sexes, the age group 0-4 years is the largest (24.0%), age groups 5-9 and 20-29 years come next with 17.0% each, then age groups 15-19 years (9.2%), followed by

Table 3: The study villages, their populations, areas and distances from Malumfashi town.

Village Area	Approx. Area (km^2)	Distance from Malumfashi town (km)	Population
Kafur	80	19.0	4,967
Mahuta (Dankwaro)	60	37.0	513
Masari	27	20.0	452
Ruwan Sanyi	70	9.6	5,268
Yari Bori (Kuringafa)	13	16.6	1,577
Total			12,777

10-14 years (8.9%) with 30 years and over with 24.8%. This population is made up by the three ethnic groups: Hausa, Maguzawa and Fulani. Hausas account for 63.0%, Maguzawa 24.0% and Fulanis 13.0% of the population.

Most of the hamlets are occupied by substantial number of Hausas and Fulanis while the few Beriberis are found in Babban Birni, Kafar gari and U. Ari. Kurmin Sarki and U. Alu hamlets have a 100% Hausa population while five of the hamlets do not have Maguzawas. The religion of the people very closely follows their ethnicity. The people live in mud houses (Figure 6) with thatched roofs though temporary shelters for the semi-nomadic Fulanis are made out of dried guinea-corn stalks. The highest institutions in the study area are elementary schools and koranic schools which are held informally in open air or under shades of trees. However, at the end of primary education, it is possible for most children to move to Malumfashi town to attend secondary schools. Males are more likely to go beyond the elementary school than their female counterparts hence the wide disparity in literacy rate between the two sexes. The females are usually married off early, between the ages of 10 and 14 years with a mean of 13 years. Most men get married around 20 years of age. 45.3% of the study area population is married.

The main occupations are farming and cattle husbandry (Table 4). Most farming is carried out by individual farmers on small dispersed farmlands. Children usually help their

Table 4: Frequency of occupation in a typical village (Ruwan Sanyi)

Occupation	Male	Female	Total
Farmer	178	62	240
Housewife		59	59
Cattle rearer	9		9
Butcher	4		4
House-help	12	8	20
Student	57	17	74
Milk seller		1	1
Civil servant	5		5
Total	265	147	412

Table 5: Trees of economic importance in the Study Area.

Name of Trees			Major uses
Botanical	English	Hausa	
Butyrospermum pakii		Kadanya	Kernels-butter for cooking, lighting, wood for bowls, mortars.
Butyrospermum paradoxum	Shea butter	Kadanya	
Parkia clappertonia	Locust bean	Dorowa	Pulp-for food; Kernels-food, fooder; Timber-mortar, basins etc. Very valuable.
Adansonia digitata	Baobab	Kuka	Fodder. Leaves and kernel for food, rope and other minor uses.
Isoberlinia doka		Doka	
Distrustaches glomeratte			
Dichrostachys cinerea		Dundu	
Vitex doniana	Black plum	Dinya	Fruits-for sweets. Young leaves-for food and medicine
Annona senegalensis	Wild custard apple	Gwandar Daji	
Acacia seyal	Thirsty thorn	Dushe	
Prosopis africana		Kiriya	Timber-many uses; charcoal kernel - for food by some, after processing.

parents on the land, outside school period. With the establishment of the F.A.D.P. in 1976, an agricultural project which covers the Malumfashi L.G.A., agriculture is likely to be on a larger scale in the future. The crops cultivated in the study area are maize, rice, cassava, millet, guinea-corn, groundnut, cotton, onion, cowpea, and sugar cane. The trees of high economic importance to the farmers are listed in Table 5. The land is usually prepared at the end of April, with the onset of the rainy season, up till September. As farmers rely solely on rainfall for irrgation of the land and since irrigation is not widely practised, the majority of the crops are cultivated during the rainy season. Harvesting of all crops takes place largely in September. Millet is harvested in August, cotton in December, guinea-corn in October and cassava in February.

Water Supply

Pipe-borne water is non existent in the area. The people depend largely on surface water and well water for their needs. The major source of water supply is through the accumulated pond and stream water during the rainy season. In the dry season, these usually dry out, thus creating a problem of an alternative source. This compels the people to dig up holes along stream lines until they reach the underground water table (Figure 4).

Wells are either communal (built by the L.G.A.) or privately owned, in which case, they are situated within the

Table 6: Distribution of wells in the Study Area

Hamlet	No. of Compounds	Wells		
		No.	Holding water	Local Government owned
Ayaga	47	8	5	
Budawa	74	6	6	1
Dankwaro	93	30	8	
Kafur	300	54	32	1
Katanga	233	37	7	1
Kuringafa	332	53	9	2
Kurmin Sarki	65	22	22	
Masari	105	29	22	2
R. Sanyi	341	54	33	2
Ungwar Ari	74	29	21	
Ungwar Barau	178	14	4	
Ungwar Garba	29	9	8	
Yarmani	21	6	6	1
Total	1,892	351	183	10

Table 7: Numbers of latrines present in a typical village (R. Sanyi)

	Hausa	Maguzawa	Fulani	Total
Compounds with latrine	63	7	4	74
Compounds without latrine	15	25	20	60
Total Compounds	78	32	24	134

Table 8: Climate in the Study Area

	1976-77	1977-78	1978-79
Average yearly max. temp. (^{o}C)	32.3	32.8	36.2
Average yearly min. temp. (^{o}C)	17.8	18.0	16.3
Total amount of rainfall (mms)	754.1	1020.0	817.0

owner's compound (Table 6). The majority of the wells are ill constructed and there is no special effort made to protect them from contamination. Private wells are often situated very near pit latrines; storm and spilled water carrying debris and other contaminants drain into these wells. The habit of the people of drawing water with a rope and sac lends to further contamination of the water. Wells constructed by the L.G.A. also have no casing for protection against pollution although they are sometimes lined with concrete and have aprons. The pulley systems of these wells do not function and this results in the use of various ropes and sacs in obtaining water from them (Figure 6). Ponds are usually excavated sites, filled with rain water (Figure 7) and play a major role as water source in the study area. Water obtained from the wells are used mainly for cooking and drinking. Surface water in streams, ponds and rivers is used for a variety of purposes such as watering cattle, washing of clothes, bathing, drinking, cooking and washing of vegetables. All these activities are carried out usually at the water sites except bathing especially in the case of women. Surface water is a constant feature in the area during the early wet season, the wet season and the period just after the rains. It eventually dries up as the dry season progresses around February to March. The water table drops substantially as the dry season progresses, due to water utilization by man and the drainage of the subsoil towards the river systems. The streams are reduced to a series of isolated

little pools by the end of the dry season. Their flow rate is negligible except during the rains. It is not unusual to find the majority of the wells without water during the months of February to early April. Waterholes (Figure 4) are dug along river-beds during late dry season when the people experience an acute water shortage, thus depending on sub-surface water for their needs. Dried wells are usually dug deeper at this time to obtain water. Water selling in some of the hamlets becomes a lucrative trade for some.

Sanitation

There is no central sewage system in the area. The traditional type of pit latrines is utilized although some compounds lack them; resulting in the use of nearby bushes. These pit latrines are usually to be found in Moslem compounds (Table 7) and are usually one arm length deep. They are filled within one year thus necessitating the digging of a new latrine at the end of this period. In the settlements of Fulanis and Maguzawas, who predominate in the scattered compounds, latrines are rather infrequent and squatting in nearby bushes is the practice. It is known, in Africa that the collection as well as the disposal of excreta and major refuse causes the spread of communicable diseases and of relapses after treatment resulting in unsatisfactory environmental health.

The Climate

The climate is a tropical continental climate with distinct wet and dry seasons (Figure 9). The wet season is from May to October. This is followed by the cold, dry and dusty harmattan period from November to February. A dry and hot season prevails in March ending in April. It is noteworthy that, as regards season, the Malumfashi people recognize five periods in the year. The first period called 'Damuna' lasts for about six months (May to October). This is the rainy season. It is followed by 'Agazari' - the hot season following the cessation of the rains lasting roughly one month (Oct.-Nov.). The third period is 'Dari' - the cold dry and dusty harmattan period lasting from November to February. This is followed by 'Rani' - the hot dry season lasting from February to March. The last period is 'Bazara' - the hot season from dry to humid, just before the rains and usually in April.

The mean rainfall recorded at the Malumfashi Cotton Ginnery for the years 1962-76 was 962mm. with a range of 536-1225mm. The mean rainfall recorded for the period of 1977-79 was 863.7mm. with a range of 754mm. to 1020mm (Table 8). The rain falls mainly between May and October with light and isolated showers in March and April and the peak rainfall in August.

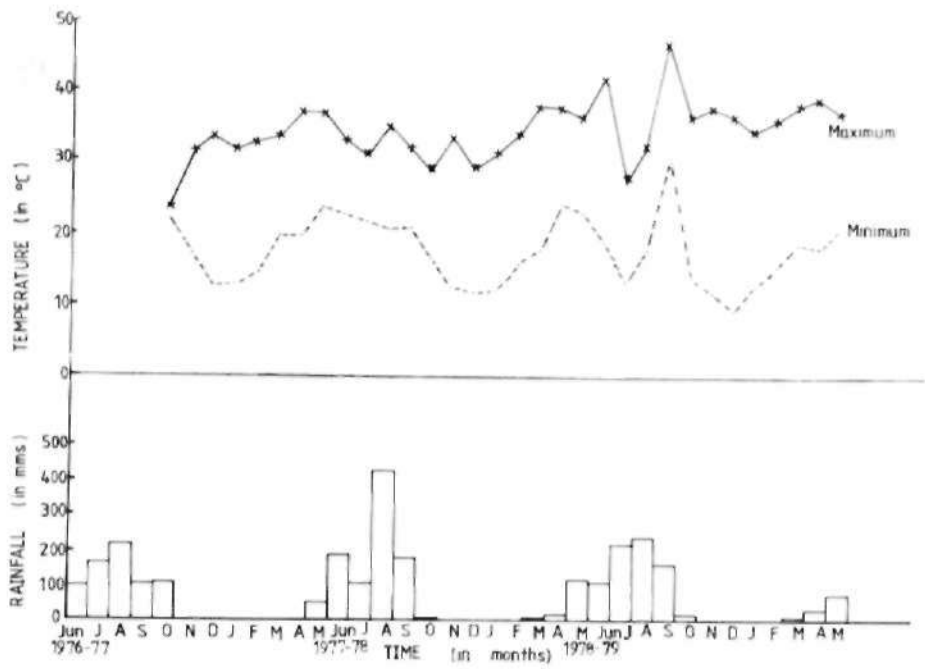


Figure 9 **Climate in the Study Area.**

3.2 FIELD STUDIES

Location and Mapping of Water Courses

The location and mapping of water courses in the studied hamlets of R. Sanyi, Katanga, U. Ari, Ayaga, Kuringafa, Kafur, Dankwaro, Masari, U. Garba, Yarmani, Budawa, U. Alu and Kurmin Sarki were accomplished by visiting the areas, questioning the people and visually verifying their claims before mapping. The larger water bodies were easily located with the aid of the 1975 air photograph of the area, prepared by the land use section of the F.A.D.P. Observations of the people collecting and carrying water helped to locate other more commonly utilized water sources.

3.2.1. Snail Survey

Fifty two sampling sites comprising streams, rivers and ponds, representative of the water bodies in the study area were surveyed for aquatic snails (Figure 10) using the method described by Webbe (1962a, b). A standard scoop net with a (30 x 30cm) frame of steel bars and wire mosquito netting with a mesh of 6.5 per cm. was used in the survey. The mesh size is small enough to collect all snail sizes in the appropriate porportions according to the actual size distribution of the population. The scoop was 10cm. deep and had an 8cm. blade soldered to the frame with a long wooden handle attached at the other end. To standardize the collection, the same collector scooped fixed areas for a fixed

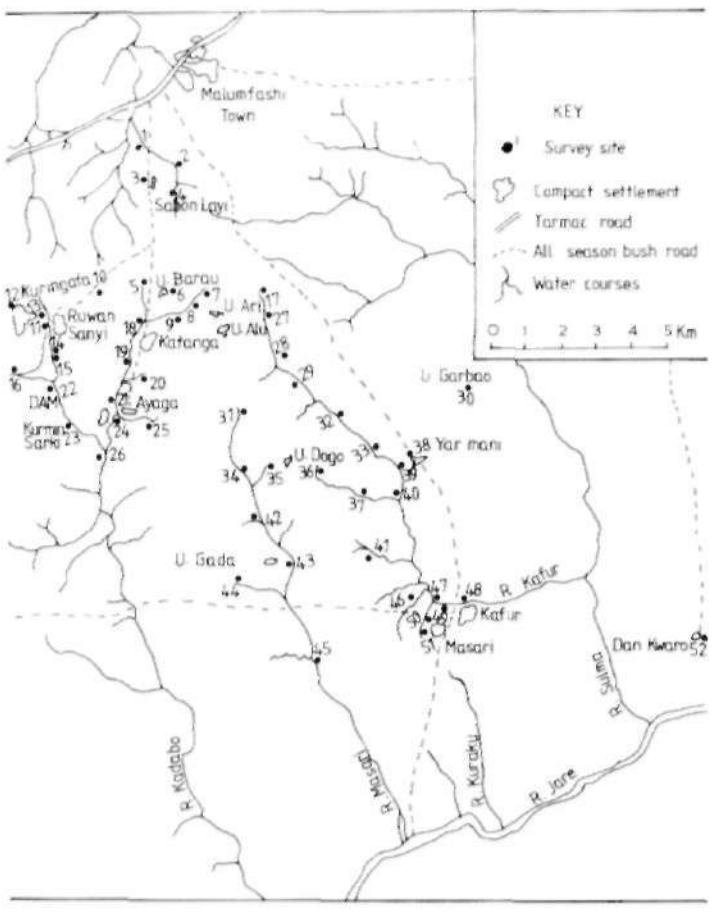


Figure 10 Map Showing the Water courses and Survey Sites in the Study Area.

period of ten minutes and everything scooped within this time was placed in a metal basin. At the end of the period, a meticulous search for snails amongst the contents of the basin was carried out by visual inspection of each collected material. The snails from each site were placed on moist leaf in labelled container for examination in the laboratory. In the laboratory, the species, size and infection rates of each snail sample collected from the different habitats were determined. The species of the snails were determined with the aid of a W.H.O. snail identification field guide to West African freshwater snail species (1973a). Size determination for population size distribution was carried out, with the aid of a metal vernier caliper, by measuring the height in the case of Bulinus globosus, B. forskalii, Lymnaea natalensis and the maximum diameter for Biomphalaria pfeifferi with an accuracy of measurement of 0.1mm.

3.2.2. Effect of Climate and Season on Snail. Abundance of Snail Species

Monthly surveys were carried out for a period of six months (June to November, 1976) in a total of three hundred and sixty three potential snail habitats (comprising 232 sites along river courses, 112 in ponds and 19 along streams) in the studied hamlets, to determine the relative abundance of the different species of aquatic snails occuring in these sites and in each hamlet. This study was repeated in the following year, 1977, in two hundred and sixty two sites (comprising 49

sites in ponds, 17 in streams and 146 along rivers).

Seasonal fluctuations in snail densities

Monthly fluctuations in the densities of all the aquatic snail species were recorded in one hundred of the snail habitats for two consecutive years (1976-78).

Eighteen of these sites (Figure 11) comprising ponds (sites A-F) streams (sites G-L) and rivers (sites M-R) were studied in detail with particular reference to B. (P.) globosus and S. haematobium infections.

Site A.

This pond is located in Masari hamlet, close to the dispensary. It is a seasonal pond made permanent by the villagers by re-digging the pond to a greater depth during the peak dry months of March and April, to ensure continuous water supply. The substratum is mud and the edge is clothed by grass. Bladderwort and grasses grow inside this pond particularly in the wet season. It is about 214cms. deep and covers an area of 8.938×10^5 sq. cms.

Site B.

This pond covers an area of 5.91×10^6 sq. cms., has a depth of 305cms. and is located on the southern part of Kafur village. In the dry season, it becomes a collection of isolated wells. It is permanent and like all ponds in the study area, it resulted from the traditional use of mud as building material. It has a luxuriant growth of bladderwort, Nymphaea lotus, grasses and other aquatic animals e.g. frogs,

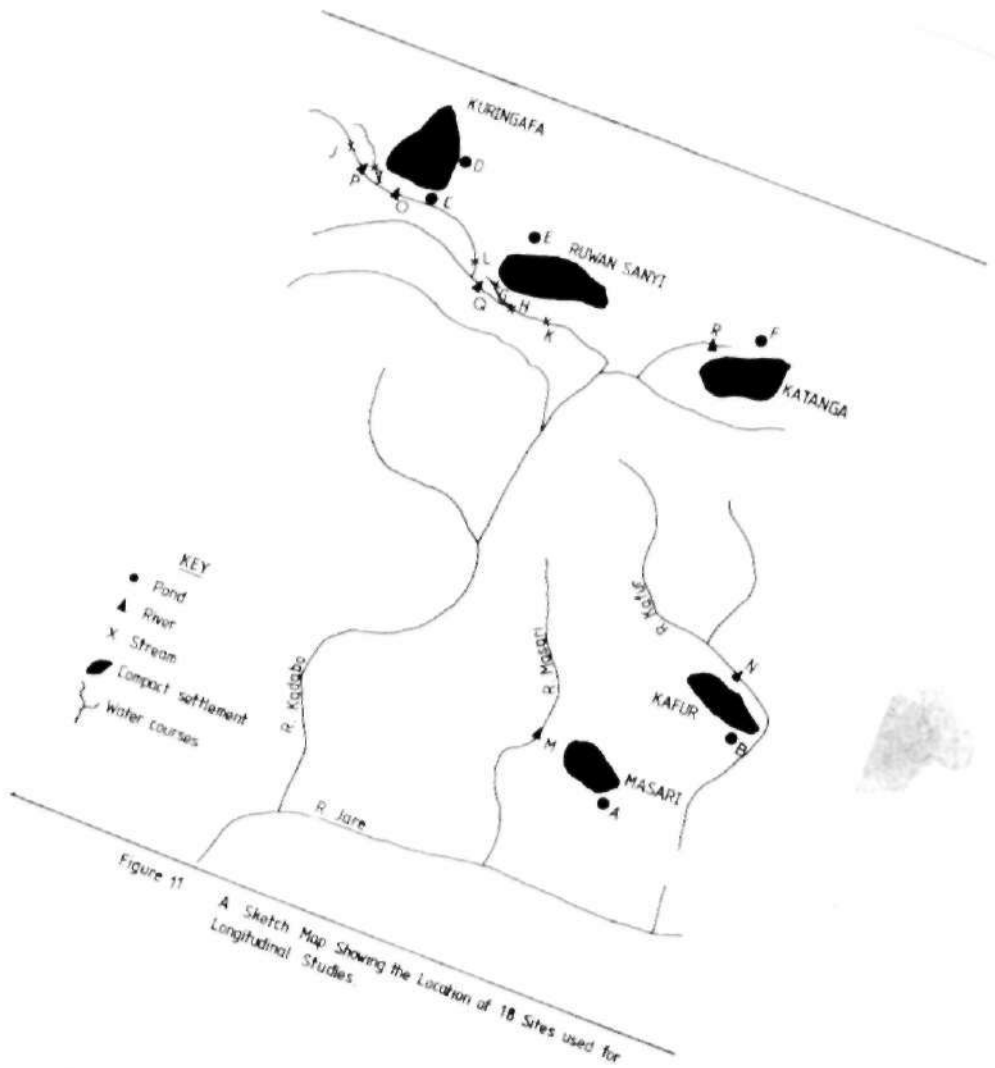


Figure 11 A Sketch Map Showing the Location of 18 Sites used for Longitudinal Studies

arthropods, tilapia fish particularly during the wet season. It is very popular with the villagers and can be considered a recreational centre particularly for the women.

Site C

It is a pond located to the south of Kuringafa hamlet and is a major source of water for drinking (Figure 7) and household use. It covers an area of 4.93×10^5 sq. cms., has a depth of 274cms. and is surrounded by banana, tomato, sugar-cane and potatoe farms. It is made permanent by re-digging during the dry season to ensure constant water supply. Some species of grasses and bladderwort grow within this pond, particularly in the wet season.

Site D

This pond is located within farms in the southern part of Kuringafa and is partly shaded by overhanging stems of a mango tree growing close to it with its roots within the site. It is a temporary habitat that dries up in the dry season and has an area of 7.95×10^5 sq. cms. with a depth of 107cms.

Site E

This pond is located amongst farmsteads in the western part of R. Sanyi hamlet. It is permanent and covers an area of 2.92×10^5sq. cms. with a depth of 198cm. The water in this site, as in others, contracts in the dry season. Sugar-

cane is grown close to this pond and grasses form the main vegetation within the site.

Site F

The pond covers an area of 4.93×10^5sq. cms. with a depth of 153cms. and is located in Katanga hamlet by the bridge. It is seasonal and is clothed by grass along its length and has a luxuriant growth of bladderwort, Nymphaea lotus, arthropods and aquatic animals such as frogs, tilapia fish during the wet season.

Site G

This stream site is located in the south of R. Sanyi hamlet. It is seasonal and dries up in the dry season resulting in intermittent pools along its length. The site is partly shaded by overhanging branches and leaves of a tree growing on its bank and it is clothed along its length by grass. It has a muddy substratum and plants such as Nymphaea lotus are common inside it during the rainy season.

Site H

This stream site is located in R. Sanyi on the southern part. It is exposed but is heavily clothed with grass along its length. It is seasonal and has a luxuriant growth of Nymphae lotus in the wet season.

Site I

This stream site is located in Kuringafa, on the southern

part of the hamlet. It is permanent, exposed and is clothed by grass for most of its length. It became part of the R. Sanyi dam, with the construction of this dam in May, 1977.

Site J

It is a seasonal stream located in the southern part of Kuringcfa hamlet. It has some aquatic vegetation and is partly shaded by a mango tree growing on its bank. The seeds from this tree drop into the site during the wet season.

Site K

This is a permanent stream located in R. Sanyi. It formed part of the R. Sanyi dam in May, 1977. It has a luxuriant vegetation.

Site L

This stream site is located in R. Sanyi hamlet, has a mud substratum and is partly shaded by shrubs which grow on its bank.

Sites M-R

These are sites along river courses. Site M is located on the western part of Masari hamlet, on Masari river. It is exposed for most of its length with very little aquatic vegetation. The substratum is a mixture of mud and sand.

Site N is seasonal and lies along the River Kafur on the southern part of Kafur hamlet. It has a sandy substratum mixed with small gravels and is devoid of any vegetation (Figure 4).

Site O is seasonal and is located between farmsteads in the southern part of Kuringafa hamlet. It has a clay substratum with grass growing along its bank. It is highly utilized by the villagers, particularly men for washing clothes and bathing.

Site P is seasonal and is located in Kuringafa hamlet. It is exposed and has some aquatic vegetation. The substratum is a mixture of rock and mud.

Site Q is seasonal, has a mud substratum and lies within farmsteads to the south of R. Sanyi hamlet. A footpath leading from the farms to the hamlet cuts across this site. Nymphae lotus, bladderwort and grasses are noticeable in this site, in the wet season.

Site R is seasonal, has a mud substratum and is located along Katanga river in Katanga hamlet. It is exposed with some grass growing on its bank.

The sites were surveyed monthly using the scoop method. Data was kept (Appendix C) on each visit on the colour of the water, exposure of the habitat, temperature of the habitat (which was measured at a depth of 8 inches below the surface with a Celsius thermometer), presence of aquatic vegetation and animals.

The amount of rainfall was measured at base (in A.B.U. Hospital, Malumfashi) and data was kept on air temperature, both minimum and maximum. Soil and water samples from some of these sites were analysed for physico-chemical factors which

might be related to the presence of B. (P.) globosus in these habitats.

The B. (P.) globosus collected during the monthly surveys were taken to the laboratory for further examination. Records were kept on the size and infection rates in these snails, by measuring and observing human furcocercous cercariae. Records were also kept on the presence of egg masses on snail shells and the number of eggs per egg mass.

3.2.3. Physico-Chemical Factors of Snail Habitats

Soil Survey

Soil survey was carried out with the help of Mr. Samuel Ogidan, a soil officer of the Land Use Planning Department, (Soil Survey Section) of F.A.D.P. To evaluate the chemical composition of the soils, composite soil samples were obtained from 5 sites (2 ponds, 2 rivers 1 stream). At each sampling site, profile pits were dug, described and classified. Soil from five different depths ranging from 0-154.94cms. were described (Appendix D) and collected in polythene bags for further analysis in the laboratory. The chemical analysis of the soil samples was carried out at the Soil Survey Section of A.B.U. in Zaria, using methods of soil analysis (Black, Evans, White, Ensminger and Clark, 1965). Phosphorus content of the soil was determined by colorimetric method. Exchangeable bases, sodium, potassium, calcium and magnesium were determined using the flame photometer. The cation exchange capacity was determined by washing the leached soil

with alcohol and distilling with sodium hydroxide solution to recover the ammonia, which was then estimated titrimetrically.

Water chemistry

Water samples were collected from three snail habitats (a pond, stream and a river) in the month of January in the dry season and in the month of August in the wet season. The samples were collected in the morning in five litre capacity bottles and kept at a temperature of $4^{o}C$, in a cold box, until analysed. Analysis of the samples was carried out at the Federal Ministry of Health laboratory in Kaduna, using standard methods (A.P.H.A., 1971; Heffer, 1960).

To determine the colour of the water, 50mls. of the sample was placed in a Nessler cylinder and the colour was compared with Nessleriser disc NSA. One hazen unit is equivalent to a solution of potassium chlorpatinate containing 1 p.p.m. of platinum.

A pH meter was used for the determination of hydrogen ion concentration using a buffer solution of pH 7 as a standard. The conductivity was determined with a conductivity bridge and distilled water was used for calibration.

A mixed indicator containing phenolphthalein and methyl orange was used to determine the phenolphthalein alkalinity (as $CaCO_3$), the methyl orange alkalinity (as $CaCO_3$). A few drops of indicator was added to 100mls. of the sample which was titrated against N/50 HNO_3. The titre from pink to green colour gives the phenolphthalein alkalinity while the

titre from green to golden yellow colour gives the methyl organge alkalinity. The total titre gives the total alkalinity.

To determine the total hardness, one total hardness indicator tablet was added to 100mls. of unfiltered sample and 2mls of ammonia buffer solution. When the tablet had dissolved completely, the solution was titrated with N/50 E.D.T.A. The titre was multiplied by 10 and expressed as parts per million.

Oxygen demand was determined as oxygen absorbed from potassium permanganate in 3 hours at $37^{o}C$. 250mls of blank (distilled water) and 250mls of sample were each placed in a 500ml. reagent bottle. 10mls. each of N/4 sulphuric acid and N/80 potassium permanganate were added to each bottle, shaken and incubated at $37^{o}C$ for three hours. Hourly observation of the specimen for colour development during incubation was carried out. A colour change during incubation required a further addition of 10mls. of $KMnO_4$. After incubation, the bottles were cooled to room temperature after which 5mls. of 5% potassium iodide was added to each bottle and each mixture was titrated against N/80 sodium thiosulphate (NaS_2O_3) using 1ml. starch solution as the indicator. In cases where more than one quantity of $KMnO_4$ was added, the titre was multiplied by the number of times $KMnO_4$ was added.

Total solids dried at $180^{o}C$ for 1 hour was determined as follows: An aluminium soil container was placed in 1N dilute

H_2SO_4 overnight after which it was removed, washed with both tap and distilled water and dried for one hour at 180°C in an oven. The dried foil was placed in a dessicator using copper sulphate as the dehydrator. It was passed through a bunsen flame and placed in a dessicator to cool after which it was weighed. 50mls. of the water sample was placed inside the foil and allowed to evaporate using steam from a water bath. The dry dish was removed, placed in the oven at 180°C for one hour, then in the dessicator to cool and later weighed. The difference between the two weights gives the total solid in the sample.

The value for the total dissolved solid was obtained by processing 50ml. of filtered sample as above and subtracting this weight from the value obtained for total solids. Total solids after ignition was determined by heating the container with the total solids, cooling in a dessicator and weighing. The difference between this weight and that obtained for total solids is the weight of the organic matter in the sample. The value for suspended solids is obtained by subtracting the value for dissolved solids from that for total solids.

3.2.4. Aestivation of Bulinus (Physopsis) globosus

Five temporary snail sites (A,B,C,D,J) known to harbour B. (P.) globosus and other snail species were studied. Mud samples were collected from these sites between January and March, 1978, from a 30.5cms. x 15.24cms. area dug up to a depth of 91.4cm. The sample was placed in a polythene bag and taken

to the laboratory where it was washed through a 16mesh/ 2.54cm. sieve, with plenty of water. A record was kept on the size, number and species of all snails recovered.

3.2.5 Malacological Survey of Reservoirs of Low Earth Dams

A point survey of each of the low earth dams in the Malumfashi and Funtua Local Government Areas (Figure 12) was carried out to establish the presence therein of snail intermediate hosts of schistosomiasis. The survey was carried out between May and August 1978 (Table 9). Survey sites were chosen to cover the whole dam and the number of sites for any one dam is a reflection of the size of that dam. The physical features of these dams are listed in Appendix E. Forty eight scoops were taken at each of the survey sites of any one dam, separated from the next by a distance of 400 metres. The contents of the scoop was placed in a plastic bowl and later sorted for snails. The snails obtained were taken to the laboratory for measurement and examination for trematode infections particularly those of S. haematobium and S. mansoni by the crushing method. A more detailed longitudinal study of one of the larger dams, the Ruwan Sanyi dam, located just south of R. Sanyi and Kuringafa hamlets (Figure 13) was carried out between December, 1977 and November, 1978. A thirteen hour observation (6 a.m.-7 p.m.) of human-water contact activities was made at this dam. The activities, sex and age of persons using the site were recorded.

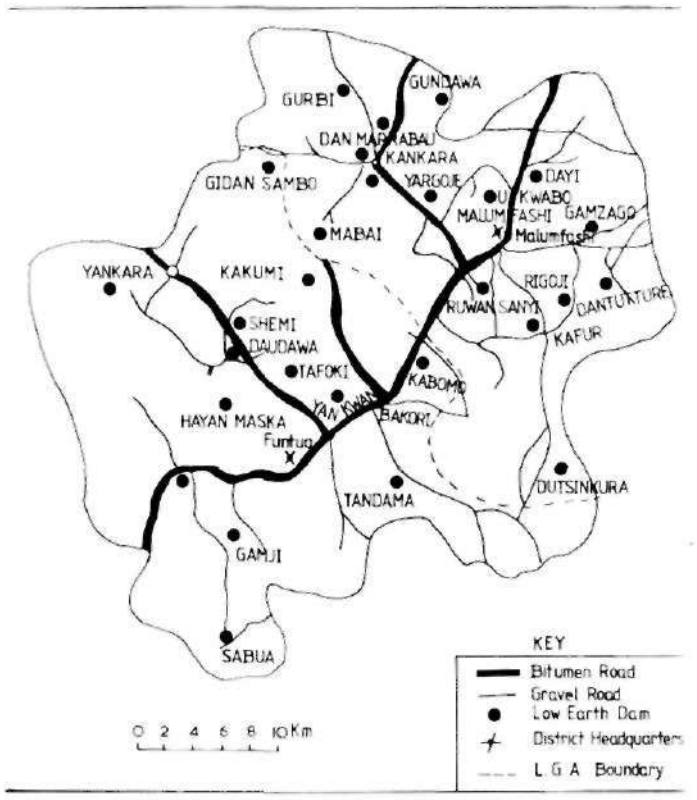


Figure 12 Map Showing the Location of the Low Earth Dams Constructed Within the Funtua Agricultural Development Project Area as at 1979.

Table 9: Age, proximity to dwelling area, and location of the surveyed low earth dams

Dam	Age at time of survey (in months)	Proximity to dwelling area (in kms)	Location
Yargoje	14	1.00	Malumfashi L. G. A.
R. Sanyi	14	0.27	"
Dayi	12	3.00	"
Kankara 1	12	0.05	"
Kankara 2	12	1.50	"
Gamzago	12	0.27	"
Dutsin Kura	12	0.07	"
Malumfashi	10	0.14	"
Zango	7	1.00	"
Dan Marabau	7	0.07	"
Gundawa	7	0.05	"
Rigoji	6	0.18	"
Tafoki	14	1.00	Funtua L. G. A.
Gidan Sambo	14	1.00	"
Gamji	14	0.82	"
Sabua	14	0.14	"
Shemi	14	0.14	"
Tandama	14	0.05	"
Kabomo	12	1.00	"
Mabai	7	1.00	"
Kakumi	7	1.00	"
Daudawa	6	0.05	"

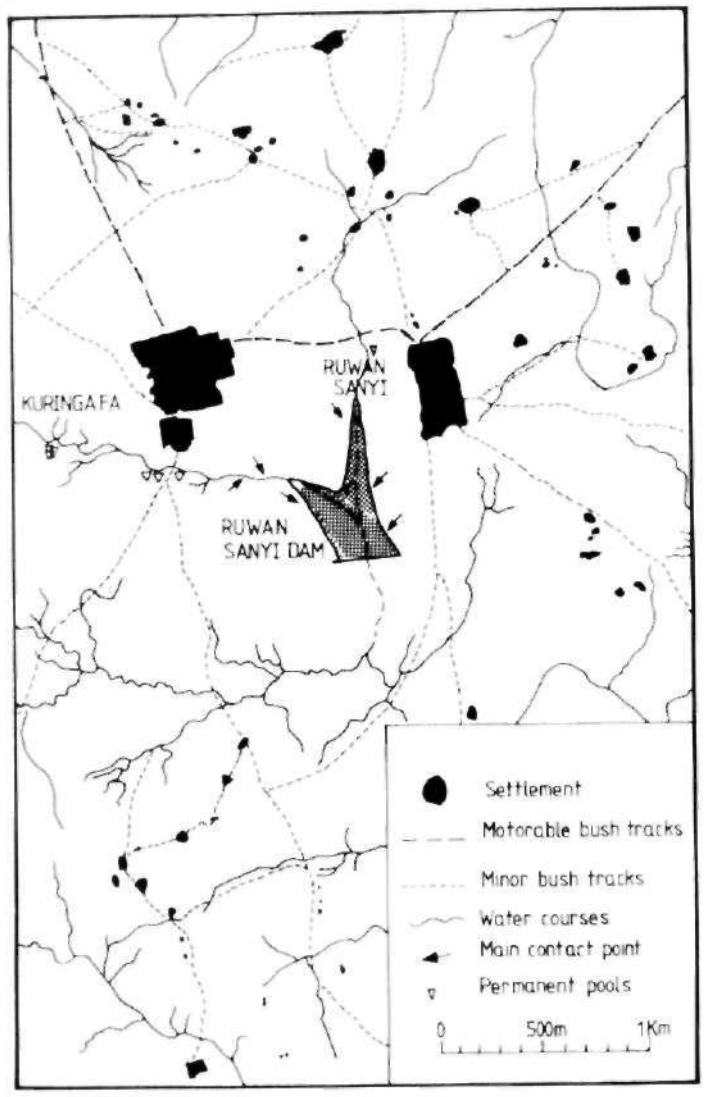


Figure 13 Location of R. Sanyi Dam in Relation to the Settlements and the main Water contact Points.

3.3 LABORATORY STUDIES

3.3.1. Growth of Bulinus (P.) globosus

Egg masses of B. (P.) globosus were obtained from natural habitats and maintained in the laboratory in glass aquaria at room temperature (24°-27°C) until they hatched and matured. The eggs laid by these mature snails were transferred to other tanks and used in studying the growth of the species. It was not possible to study the growth under controlled temperature as the hospital in which the laboratory is situated relied on power generators which were switched on only during certain short periods of the day, on days when the generators functioned.

Observations were made on the time of and size at first egg laying and the growth rate was determined weekly over one year (at a fluctuating room temperature of 21°C-31°C). The growth rate was determined weekly by measuring (base to apex) the growing snail with a microscope fitted with an occular micrometer and the larger snails with a metal vernier caliper. The number of eggs per egg mass was also determined microscopically using a X 4 objective. Dead snails were removed from the tanks, measured and recorded.

Maintenance of Snails

The snails were reared and maintained in seven litre capacity glass tanks at room temperature ranging between 21°C and 31°C. A maximum of 20 snails were maintained in each

tank. Stored, untreated tap water pumped from bore holes was introduced into the tank. Each tank contained a plant (Ludwigia spiralis) bedded in one centimetre of gravel. Aeration was carried out by air stones linked to a "Hy-flo" pump. Perspex sheets were placed over the water surface of each tank for egg deposition, to facilitate transfer of eggs during monthly cleaning of the tank. Processed lettuce and also tetramin fish food (when available) were used in feeding the snails particularly the newly hatched ones. The lettuce was processed as follows: Each fresh lettuce leaf was washed and placed in boiling water for 8 minutes after the removal of the midrib. The bowl of boiling water with the lettuce was placed under a running tap for rapid cooling. The lettuce was removed singly, after cooling, and spread out on trays to dry until crisp either in an oven or out in the sun after which, all dried lettuce was stored in a dry tin until needed.

3.3.2. Infection of Snails

Harvest of Miracidia

Urine samples were collected from S. haematobium infected male children of R. Sanyi village, between 1200 and 1400 hours in specimen containers. The urine was sieved through a 30 mesh sieve and a 60 mesh sieve respectively into conical sedimentation glass. The glass was filled with normal saline and left to sediment for 20 minutes in the dark. The supernatant was poured off and normal saline added to the

substrate. Another 20 minutes was allowed for sedimentation after which the supernatant was again poured off. The procedure was repeated twice more. Finally, freshwater was added to the substrate which was again left to sediment in the dark for 20 minutes. The supernatant was poured off and the sediment was transferred into a petri dish which was placed under strong light at a temperature of 26°C. After 30-90 minutes, the hatched S. haematobium miracidia were picked up by means of a drawn glass pipette under the dissection microscope and transferred in numbers of 8-10/ml into each well of a perspex haemaglutination plate.

Exposure of Snails to Miracidia

Laboratory bred snails (B. globosus, B. forskalii and B. pfeifferi) measuring between 5 to 6mm. in size were used. Fifty snails of each species were exposed singly to 8-10 miracidia of S. haematobium in wells of an haemaglutination plate. The snails were placed with the aperture downwards in the well, to ensure maximum contact with the miracidial suspension. The haemaglutination plate was covered with a sheet of perspex, to prevent the snails from crawling out, and placed under light at 26°C for 6 hours. The snails were transferred to aquaria and maintained for 48 days before they were observed for mature infections, i.e. shedding of cercariae.

The number of Miracidia necessary for infecting B. globosus

One hundred laboratory bred B. globosus measuring 5-6mm in size were exposed in groups of 10 to varying numbers of miracidia (1-10) as described above. They were transferred to aquaria and maintained (10 snails per tank) for 48 days after which they were examined for S. haematobium cercariae.

3.3.3. Examination of Snails for Infections

Two methods were employed in the examination of snails for infections. These were the crushing and shedding methods. Snails collected from sampling sites during routine surveys were grouped into species for each site. Each measured snail was placed between two 50mm x 75mm glass slides and slight pressure was applied with hands to crush the snail. After crushing, the top glass slide was removed and a drop of distilled water was added to the crushed snail before examination under the microscope. The water attracts the cercariae out of the snails. Only mature infections i.e. the cercarial stage were recorded. Record was kept on the infection rate for each species group collected from each site. Infected slides were disinfected in a beaker of methylated spirit.

In the shedding methods, snails were either placed singly or en masse , in a beaker containing 50ml distilled water. The container was placed outside for 4 hours after which it was examined for emerged cercariae. The snails were

removed from the beaker and the cercarial suspension obtained was gently swirled from side to side to obtain an evenly distributed suspension. Three aliquots of 0.1ml. were transferred with a pasteur pipette onto 3 different glass slides. The cercariae were killed and stained with Lugols iodine to fascilitate counting. A fresh set of three aliquots was taken at anytime the three readings differed by more than 10%.

Identification of cercariae was made (Appendix J) following the descriptions made by Gordon et al. (1934); Probert (1965); Ansari (1973) and Malek and Cheng (1974). Cercariae of S. haematobium and S. mansoni were identified as being furcocercous, lacking eyespots and a pharynx and a shape of a spindle. Other features used are: an obvious constriction separating the body, the presence of the oral and ventral suckers (with the oral sucker occupying about one third of the body), four pairs of flame cells (readily visible in specimen mounted in dilute sodium chloride solution), two pairs of pre-acetabular and 4 pairs of post acetabular glands (occupying the posterior two thirds of the body).

3.3.4. Cercarial Shedding Patterns

Different Size Groups of B. (P.) globosus

Ten groups of ten laboratory infected B. (P.) globosus measuring between 5 to 15mm. were observed for the shedding

of S. haematobium cercariae. Selection of the size range was based on the result of field observation on size distribution of infected B. (P.) globosus. Snails from each size group were shed, each day, between 10 a.m. and 2 p.m. in glass beakers for a period of 7 days. The number of cercariae shed was determined as earlier described.

Daily pattern of output

The diurnal shedding of S. haematobium cercariae by 40 B. (P.) globosus with patent infections was observed over a period of 30 days. These 40 snails were shed in 4 groups of 10 in beakers of distilled water, as earlier described over the four periods: 7-11 a.m., 11 a.m.-3 p.m., 3-7 p.m. and 7-11 p.m. At the end of each shedding period, the snails were removed and placed in a fresh beaker containing equal amount of distilled water. The number of cercariae shed was determined as earlier described and pooled for each period while the shedding for each period was recorded per snail. Similar observations were carried out for similar sized groups and numbers of field collected B. (P.) globosus with patent S. haematobium infection.

3.3.5. Infection of Sentinel Mice

Sentinel mice were infected in the laboratory for further species identification of infection observed in natural populations of B. (P.) globosus. Sentinel mice were also exposed in the field, to detect cercariae in natural water.

Many methods have been described for infecting animals with schistosomal cercariae. Olivier and Stirewalt (1952) described the tail immersion method for infecting mice while Smithers and Terry (1965) described the ring method and, the pouch method. Moore and Meleney (1955) described the use of intraperitoneal infection of cercariae while Warren and Jane (1967) described the sub-cutaneous method. In this study, the paddling method was employed. Purnell (1966) showed that male animals (hamsters and mice) were more susceptible to infection than the female ones when both sexes were exposed to cercariae of S. mansoni.

For further identification of the species of human furcocercous cercariae shed by natural populations of B. (P.) globosus, and laboratory infected ones, two groups of 20, six months old laboratory bred male mice were each exposed to cutaneous penetration by actively swimming cercariae from these two sources.

Each mouse was placed in a 500ml. capacity glass beaker and water at 30°C was added, bathing the mouse to half way up the abdomen. It was left in this condition for 10 minutes, to get used to the environment, during which time, it voided excretory products. At the end of the ten minutes, the mouse was removed and placed in a clean beaker holding equal amount of water at 26°C. The suspension of cercariae was carefully introduced into the beaker and the mouse was maintained in this condition for 30 minutes. After exposure, the mouse was maintained on mouse cubes and water for a period

of 3 months in the laboratory. At the end of the period, each mouse was killed and perfused for the adult worms which were identified as described.

Several filtration and centrifugation techniques have been devised for detecting cercariae in natural water (Rowan, 1965). These methods, however, have still some disadvantages, primarily due to the effect of turbidity and can only be used successfully in clean water. Furthermore they do not enable an evaluation of the infectivity of the cercariae collected or a knowledge of the schistosome species. Rowan (1957, 1965) reported the recovery in the field of concentrations of one (1) cercaria per 100 litres of water with the continuous centrifugation technique. This method could not be used in the study area because of turbidity of the water in the habitats. To detect cercariae in natural waters, monthly exposures of 5, six months old laboratory bred male mice (belonging to the same cohort) in a stream (site K, located in R. Sanyi hamlet) and a pond (site A, located in Masari hamlet) were carried out over a one year period. The mice were exposed between 1000 and 1400 hours (when cercarial densities should be high (Rowan, 1958; Sturrock, 1965; M^{c}Clelland, 1967). The mice were held in a restraining device (Figure 14) made of 16 mesh/2.54cm. wire gauze, held on both ends with ropes tied onto a long wooden pole. The pole was fixed in the bottom stratum of the habitat with the rope lowered to half submerge the mice in the water. The mice were left in this position for 30 minutes



Figure 14: Exposure of sentinel mice in a pond in Masari hamlet.

after which they were removed, placed in mice cages and transferred to the laboratory where they were maintained on mouse cubes and water for a 3 month period. At the end of this period, they were killed and perfused for the adult worms.

Perfusion of Mice

The method described by Smithers and Terry (1965) was used in the perfusion of the mice for the recovery of adult schistosomes. The mice were killed with chloroform in capped plastic jars instead of nembutal which was not available. The ventral fur of each mouse was soaked with distilled water and the abdominal and chest cavity was carefully cut open avoiding the major vessels. The mouse was clipped to a perfusion board and the hepatic portal vein was severed open with a needle. A 20 gauge needle filled with perfusion fluid (citrate saline solution) was inserted into the left ventricle to flush the worms out, via the hepatic portal vein opening, into an erhlenmeyer flask. Perfusion was completed when the intestinal veins were observed to contain no more blood. The abdominal cavity and the intestines were sprayed with perfusion fluid from a wash bottle. The contents of the erhlenmeyer flask was transferred to a sedimentation glass and allowed to sediment (four times) each time for 20 minutes in 0.9% saline until the supernatant became colourless. The worms were transferred to a petri dish after pouring off the supernatant. The intestine was taken

out, placed in 0.9% saline in a petri dish and searched under the dissecting microscope, for additional worms.

Identification of adult worms was made by observing the following features: the number of testes and presence of small cuticular papillae in the male worm and, the appearance of the egg in the uterus of the female worm, the position of the ovary in the female worm as well as the size of both sexes.

3.4. HUMAN BEHAVIOURAL STUDIES

3.4.1. Man-Water Contact Studies

A proper perspective of the problem of schistosomiasis requires an understanding of human habits in relation to the use of water. Direct field observations provide an insight into the problem of the transmission of the disease and also yields vital information useful in any attempt at control of the disease.

The man-water contact studies were carried out in an area enclosing Ruwan Sanyi, Kuringafa, U. Barau and Kurmin Sarki hamlets. A questionnaire was prepared (Appendix G) to obtain the following information from the area: particular type of water source utilized, sanitary habits, religion, occupation, migration, experience and knowledge of S. haematobium infection (haematuria is well known amongst the villagers as tsagiya). 106 randomly chosen compounds (obtained

from demographic data collected by A. K. Bradley for the project) were included in the first part of the study which lasted for five weeks with working hours of 7.30 a.m. to 5.00 p.m. (Mondays to Saturdays). These compounds (made up by 59 Hausa, 30 Maguzawa and 17 Fulani compounds) had a population of 675; 373 males and 302 females. The age distribution of the 373 males is 96 (5-9 years), 85 (10-14 years), 68 (15-24 years) and 124 (25 years +). The age distribution of the 302 females is 92 (5-9 years), 42 (10-14 years), 36 (15-24 years) and 132 (25 years +). The various occupations are represented in this sampled population. Names of all the 675 individuals were filled by compound in questionnaire forms (Appendix G) at base. Visits were made to each of the sampled compound when each listed individual was questionned and the questionnaire completed.

The main part of the study involved an intensive series of observations over a 2 months period carried out in the dry season and repeated in the wet season. The water sites at which the observations were made comprised streams, ponds dams and rivers representing the various water sources available in the area. An earlier study showed daily variations in the frequency of water-contacts in the different hamlets. Observations were therefore made on successive days over an entire week at each of the sites. An observation of the timing of water collecting in the villages over a seven day period revealed that water fetching and related activities

commenced in the villages as early as 6 a.m. and ended by 7 p.m. Observation period was therefore chosen to cover this period on each day of the study. Recording forms, pencils, eraser, sharpener, wrist watch, clipboard, file and snacks were required for the observation. The land around the water sites is exposed and flat, thus making the use of field glasses, which could have arose suspicion on the part of the villagers and possibly result in an alteration of their behaviour, unnecessary. The fact that the villagers were accustomed to seeing research workers in the area, in similar settings ensured surreptitious observations.

An intensive series of observations recorded the exposure period of various water-contact activities. Another series concentrated on the diurnal variation of activity around the sites while the third concentrated on the degree of body immersion associated with water-contact, in sex and age specific groups. The various categories of activities were listed (Appendix H) on the recording sheet. 'Wadu' is the ritual washing of the feet, arms, mouth, face, ears and hair by Moslems before each prayer (usually preceded by urination and ablution). Ablution is performed by squatting close to the water's edge and washing the peri-anal area. Angling involves some wetting of the hands whereas fishing requires considerable bodily exposure through wading in deep water with nets. Urination commonly occurs while fishing, bathing, swimming and playing in water but obviously cannot be observed. In terms of schistosomiasis

transmission, water contact activities may be grouped under three headings: contamination, involving the infection of snails (e.g. urination); exposure, involving the infection of man (e.g. washing) and, mixed where both types of infections occur (e.g. bathing). Wadu is strictly an exposure activity but it is listed together with ablution because the two are frequently associated.

3.4.2. Migration

A list was compiled (from the demographic data) of those who had moved either into or out of Ruwan Sanyi village (a typical village in the study area) between the period 1975-1978. The list included the sex, name, age, household and compound numbers of all those who had moved within the period. Visits were paid to each of the compounds to obtain information on the migration history such as where the person moved to or from and reason for the movement. The data on migration was also updated during these visits.

CHAPTER 4

RESULTS

4.1. FIELD STUDIES

Location and Mapping of Water Courses

The water courses present in the study area are shown in Figure 3. In Ruwan Sanyi, the Ruwan Sanyi stream runs through the west to the south of the hamlet. Isolated pools of water and ponds are also to be found in the west, south and northern parts of the hamlet. Katanga stream runs from the west to the south of Katanga hamlet and joins Ugwan (U.) Ari stream on the eastern part. Various ponds are also to be found to the west of the hamlet. U. Ari stream runs on the western parts of U. Ari hamlet. Several ponds are also present in this part of the hamlet. A stream, Rafin Ayaga, runs to the south of Ayaga hamlet. In Kuringaga hamlet, Kuringafa stream runs from the west to the south of Kuringafa hamlet while many ponds are located in the south. River Kafur runs north of Kafur hamlet, close to the primary school. Various ponds are located to the south of the hamlet.

In Dankwaro hamlet, Rivers Meikunkure and Dankalma (which join in the wet season) are located on the eastern part of the hamlet while River Jare lies to the south.

River Masari lies on the western part, some 5 kms. away from Masari hamlet. River Jare lies to the south, 1½ kms.

away from the hamlet while River Karaku lies on the south eastern part at a distance of ½ km. from the hamlet. Rivers Kuraku and Masari are tributaries of River Jare. In Yarmani hamlet, a stream runs to the west of the hamlet. In Budawa hamlet, a stream runs from the north to the west of the hamlet. In U. Garba, a stream runs from the north to the west of the hamlet. Isolated pools of water and ponds are also present in this part of the hamlet.

4.1.1. Snail Survey

Snail survey of the 52 sites (comprising 22 ponds, 22 river sites and 8 stream sites) revealed only the presence of the following aquatic snail species (which are of medical importance): Bulinus (P.) globosus, Bulinus (B.) forskalii and Biomphalaria pfeifferi. Identification of these snails was confirmed at the Danish Bilharziose Laboratory in Denmark. Eighteen of the 22 ponds contained these snails. Eight ponds had B. (P.) globosus alone while one pond had only B. (B.) forskalii. Six ponds had both B. (P.) globosus and B. (B.) forskalii while the remaining three ponds each had B. (P.) globosus and B. pfeifferi; B. (B.) forskalii and B. pfeifferi and all three species respectively. Bulinus (P.) globosus was the most abundant of the snail species collected from these ponds. It accounted for 88.1% of the 1070 snails collected. B. pfeifferi was the least abundant (4.2%). Human furcocercous cercariae were recorded in 4.56% and 4.4% of B. (P.) globosus and B. pfeifferi respectively. This

infection was not observed in B. (B.) forskalii.

Sixteen of the 22 river sites contained the three species. Ten sites had both B. (P.) globosus and B. (B.) forskalii, 5 had B. (P.) globosus alone and one (1) had all the three species. Bulinus (P.) globosus was the most abundant species collected from these sites. It accounted for 76.4% of the 539 snails collected. B. pfeifferi was the least abundant (0.2%). Of the B. (P.) globosus, 11.89% were found infected with human furcocercous. This infection was not observed in both B. pfeifferi and B. (B.) forskalii.

Snails were found in six of the eight streams surveyed No B. (P.) globosus was collected. Three of the sites had B. pfeifferi only and the rest 3 had both B. pfeifferi and B. (B.) forskalii. B. pfeifferi was the most abundant species. It accounted for 78.4% of the 371 snails collected. Of the B. pfeifferi, 6.53% were found infected with human furcocercous cercariae.

There is no significant difference in the numbers of snails in the different habitats (Table 10).

4.1.2. Effect of Climate and Season on Snails

Abundance of Snail Species

Table 11 shows the relative abundance of the snails in the hamlets. B. (P.) globosus was the most widespread of the three (3) species of snails collected from the study area in 2 years, accounting for 78.8% of all snail collections. It was

Table 10: Relationship of different habitats to snail numbers

Habitat	No. of sites surveyd	No. with snails	Species of snails		
			B.glob.	B. pfei.	B. forsk.
Pond	22	18	943	45	82
River	22	16	412	1	126
Stream	8	6	0	291	80
Total	52	40	1355	337	288

X^2 = 0.53 P > 0.05

Table 11: Relative abundance of three snail species collected from habitats (during 1976-1978) within the hamlets.

Hamlet	No. of snails	Relative abundance (in %)		
		B. glob.	B. forsk.	B. pfei.
R. Sanyi	3572	56.47	10.75	32.78
K/gafa	5995	81.07	17.11	1.82
Kafur	454	80.4	19.6	
U. Garba	785	97.71	2.29	
Masari	639	90.92	9.08	
U. Ari	2098	94.52	5.48	
Ayaga	143	93	7.0	
U. Bara'u	265	91.32	7.55	1.13
Katanga	1665	90.63	9.37	
Budawa	263	100		
Yarmani	83	75.91	20.48	3.61
Dankwaro	302	47.02	52.65	0.33
Kurmin Sarki	167	1.35	0.68	97.97
Total	16431	78.8	12.5	8.7

collected in all but one of the hamlets. In Kurmin Sarki hamlet, B. pfeifferi was the most common species. B. forskalii was the next most abundant species accounting for 12.5% of all snails collected. B. pfeifferi accounted for 8.7% of the collections. The distribution of this species was found to be localised. It was collected in 6 out of 12 hamlets.

Table 12 shows the relative abundance of the different snail species in the different hamlets with reference to the habitats surveyed. As evident in this table, there was no difference between the data obtained in two consecutive years (1976-78)). The data indicate that the different species of snails tend to show preference for a particular habitat. B. (P.) globosus was collected mostly from pond sites (Table 13). It was also the most abundant snail species in the river sites. B. forskalii was collected mostly from the river sites in the 1976-77 survey and in stream sites in the 1977-78 survey. B. pfeifferi accounted for the majority of snails collected from the stream sites in the 1976-77 survey while in the 1977-78 survey, it was collected mostly from the river sites. There is a significant difference in the infection rates in snails in the different types of habitats (Table 14). Furthermore there is a significantly higher infection rate in snails collected from the pond sites as compared to either those from the river or stream. Table 15 gives some characteristics of snail habitats. All the three species were collected more along the edges than

Table 12: Relative abundance of snail species (collected between June and November, 1976-77) in different habitats by hamlet.

Hamlet	Bulinus (P.) globosus in				Bulinus (B.) forskalii in				Biomphalaria pfeifferi in			
	River	Stream	Pond	Total	River	Stream	Pond	Total	River	Stream	Pond	Total
1976												
R. Sanyi	217	406	955	1578		55	85	140	2	1220	14	1236
Kuringafa	1500		2774	4364	826		306	1132	13	212	89	314
Kafur	3		209	212	11		87	98	1			1
U. Garba	359		243	602	15		3	18	1			1
Masari	182		190	372	34			34				3
U. Ari	393		1085	1478	45		19	64				
Ayaga	87			87	9			9				
U. Bara'u			65	65			1	1				
Katanga	428		630	1058	116		57	173	1		4	5
Total	3259	406	6151	9816	1056	55	559	1669	18	1432	110	1560
% of Total	33.2	4.1	62.7		63.3	9.33	33.4		1.2	91.8	7.0	
1977												
R. Sanyi	22	97	215	334	5	13	1	9		25	41	66
Kuringafa	238	68	296	602	45	2	56	103		122	3	125
Kafur			153	153			3	3				
U. Garba	95		166	261								
Masari	67		127	194	5			5				
U. Ari	106		491	597	39		9	48	1			1
Ayaga	8			8								
U. Bara'u	4	13	184	201	7		18	25				
Katanga	212		210	422	23		13	36				
Total	752	178	1842	2772	124	15	100	239	1	147	44	192
% of Total	27.1	6.4	66.5		51.9	6.3	41.8		0.5	76.6	22.9	

Table 13: Relative abundance of 3 different species of snails in different habitats in the hamlets.

Habitat	No. of snails	Relative abundance of species (%) B. glob.	B. forsk.	B. pfei.
	1976-77			
Pond	6819	90.2	8.2	1.6
River	4333	75.2	24.4	0.4
Stream	1893	21.5	2.9	75.6
Total	13,045			
	1977-78			
Pond	1986	92.8	2.2	5.0
River	877	85.8	0.1	14.1
Stream	340	52.4	43.2	4.4
Total	3203			

Table 14: Relationship of different habitats (sites), in the hamlets, to schistosome infections in B. globosus and B. pfeifferi.

Habitat	Sites: No. examined	No. with infected snails
	1976	
Pond	112	52
River	232	66
Stream	19	6
Total	363	124
	$X^2 = 10.92$ $P < 0.005$	
	1977	
Pond	99	20
River	146	13
Stream	17	7
Total	262	40
	$X^2 = 15.25$ $P < 0.005$	

Table 15: Some characteristics of snail habitats

Snail species	*No. of sites where snails were found		Habitat							
			Substratum			Exposure			Vegetation	
	Tem-porary	Per-manent	Clay	Rock	Sand	Fully	Partly	Shaded	Present	None
Bulinus (P.) globosus	266	42	222	12	74	201	76	29	74	234
Bulinus (B.) forskalii	134	24	120	10	28	130	20	8	55	103
Biomphalaria pfeifferi	55	14	49	2	18	40	12	17	13	56
Total	455	80	391	24	120	371	110	54	142	393

* Mixed infestations occurred in many of the sites.

Table 16. Frequency of occurrence of B. (P.) globosus in association with different materials in the wet season.

Materials	No. of snails	%
Decaying leaves	1530	54.7
Fruits and leaves	539	19.3
Sugar cane stalk	380	13.6
Guinea corn stalk	150	5.4
Mango seeds	123	4.4
Alone	73	2.6
Total	2794	

in depths of the habitats and, mostly in temporary habitats. These habitats were seasonal as they dried out in the dry season. Of the 292 recorded dry habitats during the year, 4 dried in October, 78 in November, 144 in December, 19 in January, 23 in February and 12 each in March and April. The snails showed preference for habitats with clay substratum. Most of the snail habitats were exposed and had some vegetation. B. (P.) globosus was collected mostly from ponds and on several materials within the different habitats as shown in Table 16.

B. pfeifferi was collected mostly from streams and B. (B.) forskalii from rivers. All three species of snails were often collected attached to leaves of Nymphae lotus though the presence of this plant was not found to be indicative of the presence of the snails in the habitats.

Seasonal Fluctuation in Snail Densities

Table 17 shows the fluctuations in numbers of snails collected monthly over a two year period. As evident in this table, there was no difference between the data obtained in two consecutive years. The snail populations are most strongly influenced by the rains which had the effect of stimulating an increase in the population and also causing great decimation of the population (Figure 15). All three species of snails reached peak population in August, time of peak rainfall. They subsequently declined to zero by April. This is as a result of the drying up of the habitats between

Table 17: Monthly snail collection in the Study Area.

Snail	Jun.	J.	A.	S.	O.	N.	D.	J.	F.	M.	A.	May
					1976-77							
B. globosus	966	2168	3145	1540	1237	540	408	63	12	6	0	0
B. forskalii	261	472	912	244	141	38	5	4	0	0	0	0
B. pfeifferi	113	257	365	88	223	54	43	0	0	0	0	0
Total	1340	2897	4422	1872	1601	632	456	67	12	6	0	0
					1977-78							
B. globosus	386	630	1145	401	197	74	50	62	40	13	2	3
B. forskalii	48	34	34	5	0	0	0	0	0	0	0	0
B. pfeifferi	88	170	170	68	45	23	0	0	0	2	0	6
Total	522	834	1349	474	242	97	50	62	40	15	2	9

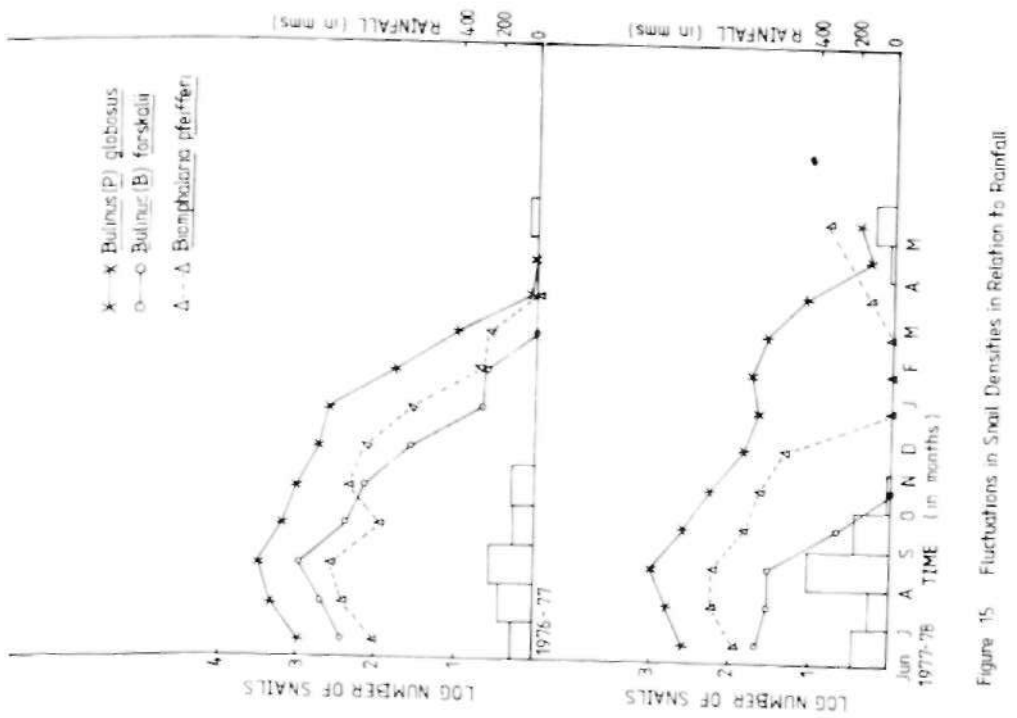


Figure 15 Fluctuations in Snail Densities in Relation to Rainfall

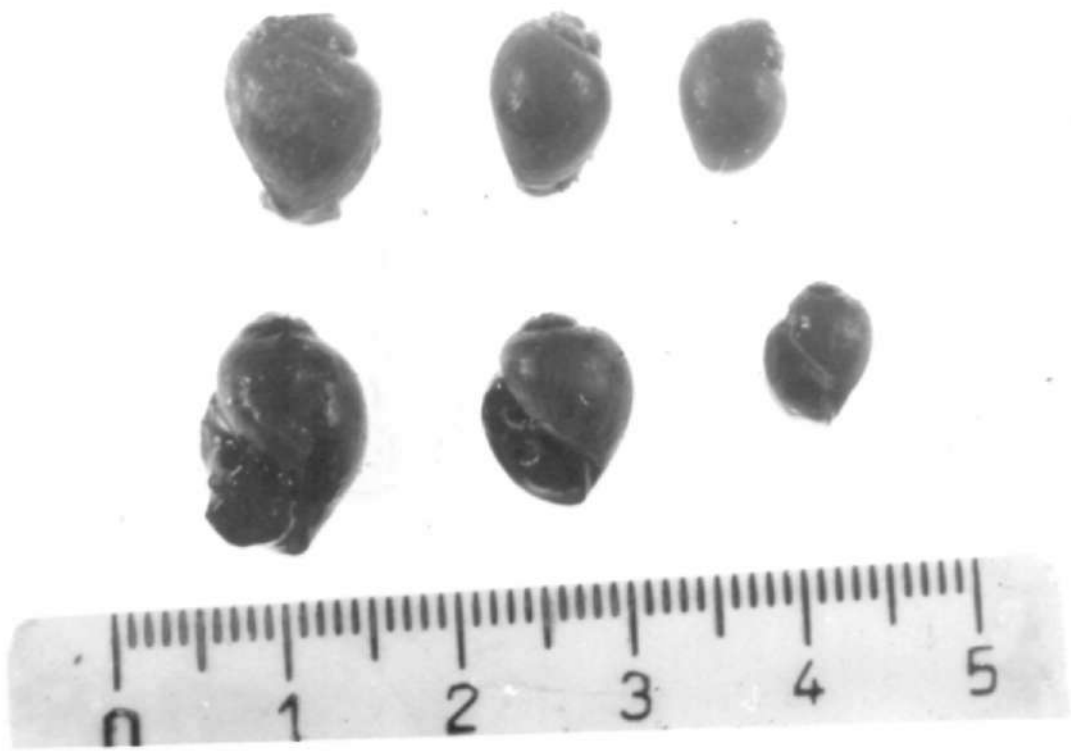


Figure 16: B. (P.) globosus - snail intermediate host of S. haematobium, collected in habitats from the study area. Manification = x 2.5.

October and April. Once the habitats refilled in May, the snails showed a very intense reproduction resulting in maximum densities during the rainy season. Of the three species of snails, B. (B.) forskalii was the first to disappear from the habitats; indicative of its inability to withstand adverse conditions.

Bulinus (P.) globosus

Figure 17 shows the monthly fluctuation in the population of B. (P.) globosus in three types of habitats, over a two year period.

In ponds, population of B. (P.) globosus reached a peak in August, the month of peak rainfall. The population decreased thereafter to lowest numbers in April as a result of reduced reproduction due to increasing adverse conditions (drying out and high temperatures) in these habitats. Infection rates in these snails (human furcocercous cercariae) were highest in the dry months of November to March with a peak in 1976-77, in November and, in March in the following year. Infections were recorded in the ponds throughout the year except in the peak dry month of April when most of the habitats had no water. Tables 18 and 19 or Figure 17 give the monthly fluctuation in population of the species with infection rates by site for two consecutive years. All the pond sites (A-F) were found infected with human furcocercous cercariae.

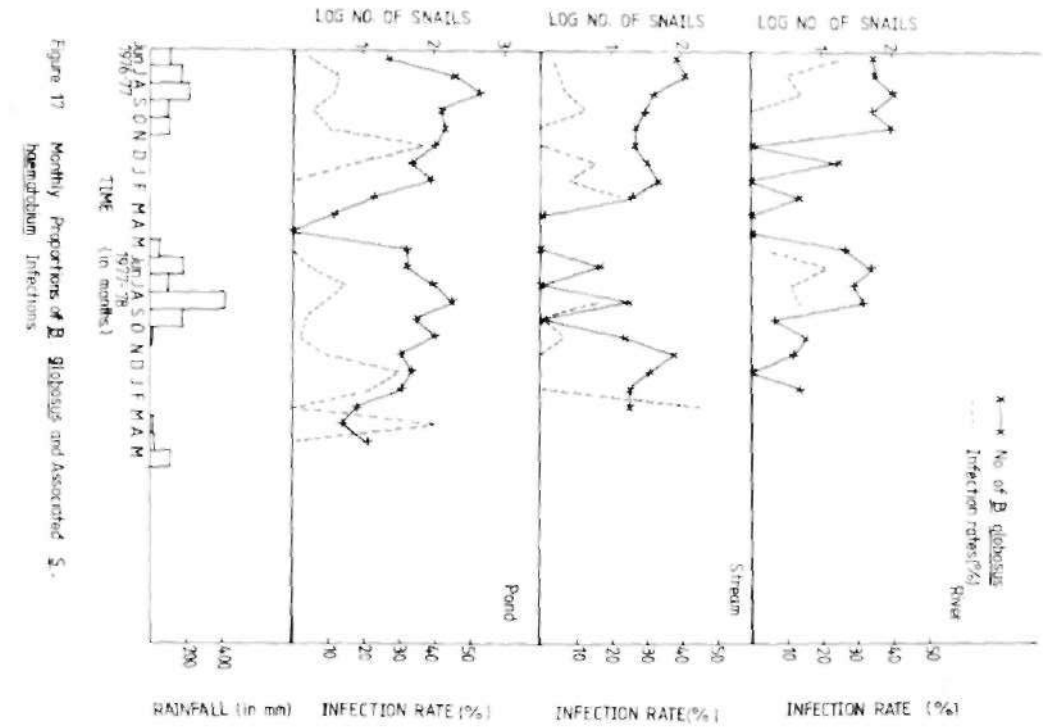


Figure 17 Monthly Proportions of *B. globosus* and Associated *S. haematobium* Infections

Table 19: Fluctuation in B. (P.) globosus population with S. haematobium infection rates (1977-78)

SITE		Jun.	J.	A.	S.	O.	N.	D.	J.	F.	M.	A.	M.	Total
Pond	A	2	2(1)	32	16	28	21	14(10)					11	126(11)
	B	10	10(3)	16(1)	4	12								52(4)
	C	5(2)	80(11)	123(16)	20(2)	50(1)	3	1						282(32)
	D	27	5	3		2								37
	E			3	4	4(1)	7(3)	24(4)	12(3)		5(2)			59(13)
	F		3	14	10	10	4	10(1)	24(5)	8				83(6)
Total		44(2)	100(15)	191(17)	54(2)	106(2)	35(3)	49(15)	36(8)	8	5(2)		11	639(66)
Infection rate(%)		4.5	15.0	8.9	3.7	1.9	8.6	30.6	22.2		40.0			10.3
Stream	G			6(1)	1		3		4					14(1)
	H													
	I	7(1)					5	10		8				30(1)
	J						12	7						19
	K			11(1)		15(1)	29	8	7	5(4)				75(6)
	L			2(1)			29	8	7	5(4)				51(5)
Total		7(1)		18(3)	1	15(1)	78	33	18	18(8)				139(13)
Infection rate(%)		14.3		16.7		6.7				44.4				6.9
River	M			17			4							21
	N	1												1
	O	16(9)	18(3)	18(5)										52(17)
	P	18(2)			2	6								26(2)
	Q	5	9	3										17
	R	12							5					17
Total		52(11)	27(3)	38(5)	2	6	4		5					134(19)
Infection rate(%)		21.2	11.1	13.1										14.2

( ) parenthesis = number with human furcocercous cercariae.

In the streams the peak population of B. (P.) globosus was obtained after the rainy season, in January (in 1976-77 survey) and in November in the following year. Snail numbers decreased during the rainy season. Infection rates reached a peak in these habitats in February. No snail was collected from March to May due to the drying out of and adverse conditions in the remaining habitats. Only three of the six stream sites studied in the two years harboured infected B. (P.) globosus.

In the river sites, the highest numbers of B. (P.) globosus were obtained in August in the 1976-77 survey and in June, the following year. The population decreased after the peak rainfall in August. There was another peak in the population in the dry months of December to February, just before the population declined to zero in March. Infections were observed for short periods of the year (May to August). Three of the 6 sites surveyed had infected snails.

There is a significant difference ($P < 0.005$) in the S. haematobium infection rates in snails collected from the different habitats (Table 20). Furthermore, there is a significantly higher ($P < 0.005$) infection rate in snails collected from the pond sites as compared to either that in the river or stream site.

Figure 18 or Table 21 shows the monthly proportion of young, adult and old B. (P.) globosus collected from ponds. In June adult snails (7.6-15.0mm.) predominated over young (0-7.5mm.) and old snails ($\geq$15mm.). Old snails were the

Table 20: Relationship of different habitats to *S. haematobium* infection rates in *B. (P.) globosus*

Habitat	No. of snails	No. infected
	1976-1977	
Pond	1311	161
River	418	37
Stream	417	30
Total	2146	228
	X^2 = 10.338	(P < 0.005)
	1977-1978	
Pond	639	66
River	134	19
Stream	189	13
Total	962	98
	X^2 = 4.6096	(P < 0.005)

Table 21: Monthly variation in the proportion of young, adult and old snails in natural populations of *B.(P.) globosus*

	1976-77											
	Jun.	J.	A.	S.	O.	N.	D.	J.	F.	M.	A.	M.
					LIVE							
Young (0-7.5mm)	.12	.62	.58	.46	.51	.55	.39	.09	.10			.42
Adult (7.6-15.0mm)	.84	.35	.39	.50	.45	.42	.57	.89	.90	1.0		.58
Old (>15mm)	.04	.03	.03	.04	.04	.03	.04	.02				
					DEAD							
Young	.23	.56	.18	.19	.67		1.0					
Adult	.77	.42	.64	.69	.25			1.0	1.0	1.0		1.0
Old		.02	.18	.12	.08							

Figure 18 Monthly Proportions of Young, Adult and Old B. (P.) globosus

least collected throughout the year and by February adult snails only were found in the habitats. In July to November young snails predominated as a result of intense reproduction. Thereafter adult snails predominated until the habitats dried out in April. This is probably due to a reduction in the reproductive rate. As evident in Figure 18, the number of adult snails increased with decrease in the number of young snails and vice-versa. Reproduction was evident once the habitats were refilled in May. Adult snails made up a large majority of measured dead snail shells collected, throughout the year, from the habitats. Young snails made up the entire dead shells collected in November indicative of their inability to withstand adverse conditions as harmattan season starts in November with very high temperatures in the day time and very low ones at night. Figure 19 or Table 22 shows the monthly distribution by size groups of B. (P.) globosus. It is evident that the young and old snails were mainly found in the wet months of June to October. In March, only adult snails were collected, suggesting that it is these adult snails that maintain the population during unfavourable periods

4.1.3. Physico-Chemical Characteristics of Snail Habitats

Soil Analysis

Analysis of soil samples from five sites (two control and three test) showed no differences in the pH, organic matter, total bases, base saturation and cation exchange capacity. The

Table 22: Monthly distribution, by size of B. (P.) globosus collected from 5 ponds

Snail size in mm	1977-78 Feb.	M	A	M	J	J	A	S	O	N	D	J	Total
0-1					1								1
1.1-2							1	2	1				4
2.1-3					4	2	5	1					12
3.1-4	1				6	6	10	1	1			1	26
4.1-5				16	8	8	13	4	1	1	4	3	58
5.1-6	3			21	10	12	10	7	1	3	4	2	73
6.1-7	1			66	23	12	25	3	5	14	15	4	168
7.1-8	3	1		127	35	24	39	10	4	15	36	5	299
8.1-9	11	1		65	46	42	23	14	8	16	37	12	275
9.1-10	9	1		80	47	20	31	17	5	19	27	7	263
10.1-11	9	1		13	69	19	12	6	6	18	15	15	183
11.1-12	2	2		13	65	17	18	3	4	14	9	7	154
12.1-13	2			4	40	15	12		1	3	6	5	93
13.1-14				2	23	12	14	1	2	7	3	2	66
14.1-15				4	24	4	11	3	2		1		49
15.1-16				1	5		4					1	11
16.1-17					2		1						3
17.1-18						1	1						2
18.1-19					2								2
19.1-20						1							1
Total	41	6		412	410	195	230	72	41	115	157	64	

hydrogen ion concentration was acidic in both test (5.7-6.1) and control sites (5.3-5.5) suggesting acid soils. The organic matter, total bases and base saturation were moderate while cation exchange capacity was low. The calcium and magnesium values for the control sites ranged from 2.3 to 2.66 milli-equivalent (meq.) and 2.16-3.19 m.eq. in the test.

Water Analysis

The result of the water analysis is only an indicator of the physico-chemical characteristics in snail habitats in the study area. Since, analyses were carried out only in one month each in the two seasons, due to technical problems, the results could only be indicative. Ideally, however, samples ought to have been analysed monthly in both snail habitats and non-habitats for a period of one year and, related to: the presence or not of snails in the sites and changes in the snail populations. Figure 20 shows the results of the chemical analyses of the water from the three habitats in the two seasons. pH was alkaline in all habitats in the two seasons except in the stream in the wet season when the recorded pH was slightly acidic (6.6). There were decreases in the dry season figures for conductivity, oxygen absorbed, total solids, organic matter and suspended solids in both the stream and river habitats as compared to the wet season figures. In the pond, however, with the exception of conductivity, increases were recorded for all

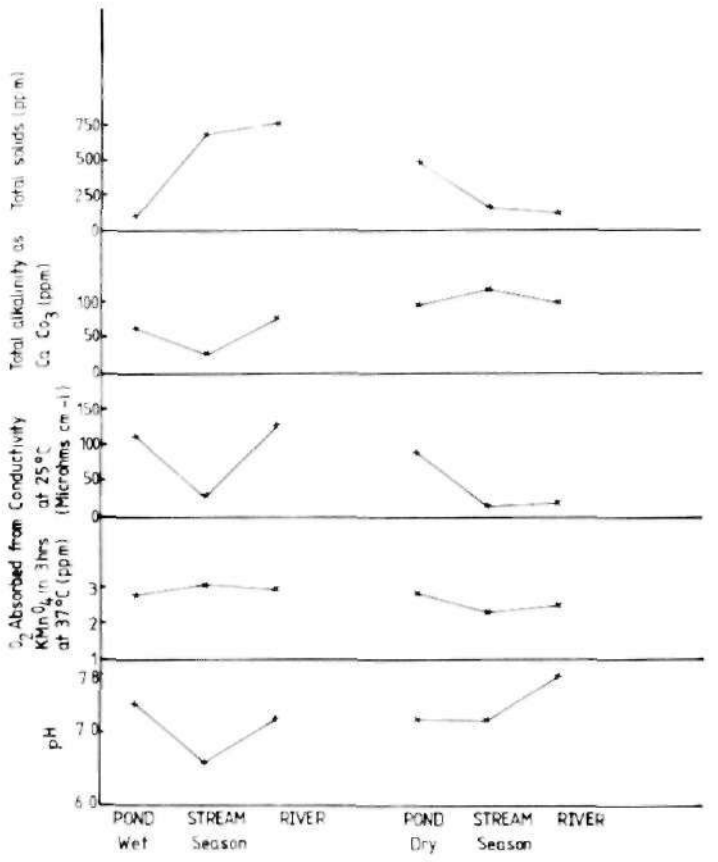


Figure 20 Variation in Total Solids, Total Alkalinity, Electrical Conductivity, Dissolved Oxygen and pH of Snail Habitats in the Study Area

these factors. Slight decreases in pH, total hardness were recorded for this habitat in the wet season. In the river and stream, increases were recorded in the pH and total alkalinity in the dry season. Total hardness increased in the stream with negligible difference for the river.

4.1.4. Aestivation of B. (P.) globosus

Table 23 shows the result of the survey of five habitats (4 ponds - A, B, C, D and 1 stream J) which harboured B. (P.) globosus amongst other snail species prior to drying out. Four live B. globosus were found in mud samples collected from site A in January and site C in both January and February 1978 indicating that the species aestivate once the habitats become dry. The sizes of these snails ranged from 5.5 to 15.0 mm. suggesting that only mature snails survive adverse conditions in the dry season by aestivating and it is probably these mature snails that recolonise the habitats once refilled in May by the April and May rainfalls. Dead shells of B. globosus and F. eburnensis were also found in the samples during the survey.

4.1.5. Malacological Survey of Reservoirs of Low Earth Dams

Table 24 shows the aquatic snail species collected from the dams. Bulinus (P.) globosus was the most abundant of the four snail species collected, accounting for 74.5% of the collections. Snail intermediate hosts (B. (P.) globosus -

Table 23: Snail species found in mud samples collected from dried snail habitats

Date of Survey	Site	Snail species	Size of snail (mm)		
			Empty shell	Live snail	Total
27/1/78	A	B. globosus	8.9	8.0	2
	B	B. globosus	9.1		1
		F. eburnensis	2.0		1
	C	B. globosus	15.0	15.0, 5.5	3
	D				
	J				
27/2/78	A				
	B				
	C	B. globosus	10.8, 8.0	7.0	3
	D				
	J				
27/3/78	A	B. globosus	3.5, 9.2		2
	B				
	C	B. globosus	12.1,8.0,6.3		3
	D				
	J	B. globosus	10.2		1

Table 24: Distribution of human schistosomiasis *infections in snails collected from the low earth dams

Dam	No. of sites surveyed	Snails Collected									
		B. glob.			B. pfei.			** B. forsk.		** L. natalensis	
		No.	Av. size	Infection rate(%)	No.	Av. size	Infection rate(%)	No.	Av. size	No.	Av. size
Dutsin Kura	16	8	10.95		9	6.2	3				
Ganzago	7	1	13.0		1	11.0					
Malumfashi	12										
Kankara 1	8										
Kankara 2	30				12	6.12		23	4.62		
Kabomo	8										
Dayi	23	121	8.71	11.9				1	8.0		
R. Sanyi	25	17	10.35		18	10.81	8.7			13	9.33
Tandama	19	96	10.52	2.0							
Sabua	10	4	7.41								
Canji	8										
Yargoje	10	22	11.21								
Shemi	14	5	3.54					46	2.43		
Tafoki	42	110	13.84								
Gidan Sambo	18	6	10.4								
Gundawa	12										
Dan Marabau	16										
Mabai	30										
Rigoji	8	13	5.23								
Zango	10										
Daudawa	10										
Kakumi	10							9	6.97		
Total		403 (74.6%)			40 (7.4%)			84 (15.6%)		13 (2.4%)	

* human furcocercous cercariae.
** No infections.

ISRAH LIBRARY * ILISIT
RECEIVED
16 FEB 1983
NIGERIA
281673

intermediate host of S. haematobium and B. pfeifferi - intermediate host of S. mansoni and B. (B.) forskalii - possible intermediate host of S. intercalatum) of schistosomiasis were collected in 13 of the 22 dams surveyed. Two of these had both B. (P.) globosus and B. pfeifferi, 2 had both B. (P.) globosus and B. (B.) forskalii, one each had B. pfeifferi with B. (B.) forskalii and B. (P.) globosus, B. pfeifferi with L. natalensis (snail intermediate host in fascioliasis) respectively. Six had B. (P.) globosus only and one had only B. forskalii. B. (P.) globosus collected from Tandama and Dayi dams were found infected with human furcocercous cercariae suggesting that these dams are transmission sites for S. haematobium. B. pfeifferi also collected from the Dutsin Kura and Ruwan Sanyi dams were found infected with human furcocercous cercariae suggesting that these dams are transmission sites for S. mansoni. Table 25 shows the coexistence of the snails in the dams. B. truncatus rohlfsi was collected with all the above mentioned species from the dam on the Funtua -Zaria road. Table 26 gives the mean monthly snail density in R. Sanyi Dam. The three snail species found in this dam were B. (P.) globosus, B. pfeifferi and L. natalensis. The peak densities were obtained between June and July just before the peak rainfall. A sharp decrease was observed in August, the period of peak rainfall. With the exception of L. natalensis, snails were collected throughout the year from this dam. It is suggested that the continuous presence of snail intermediate hosts of

Table 25: Coexistence of snails in the dams

Snail species	Frequency of occurrence	% of frequency of occurrence
B. globosus alone	51	58.0
B. forskalii alone	7	8.0
B. pfeifferi alone	7	8.0
B. glob. + B. forsk.	3	3.4
B. glob. + B. pfei.	11	12.5
B. glob. + L. nat.	1	1.1
B. forsk. + B. pfei.	2	2.3
B. pfei. + L. nat.	2	2.2
B. glob. + L. nat. + B. pfei.	3	3.4
B. glob. + B. forsk. + B. pfei.	1	1.1

Table 26: Mean monthly snail density in Ruwan Sanyi Dam

Month	Snail Collections			
	B. globosus	B. pfeifferi	L. natalensis	Total
Dec. '77	20	19	3	42
Jan. '78	8			8
Feb.	7	2		9
Mar.	5	2		7
Apr.	3	3		6
May	17	23	13	53
Jun.	117	129	25	271
Jul.	143	99		242
Aug.	21	4	7	32
Sept.	20	41	1	62
Oct.	7	52	9	68
Nov.	1	43	5	49
Total	369	417	63	849
% Total	43.46	49.12	7.42	

schistosomiasis in this dam will result in an increase in the transmission of schistosomiasis in the nearby hamlets. B. pfeifferi accounted for 49.12% and B. globosus, 43.46% of the collections making this dam an important potential transmission site for both urinary and intestinal schistosomiasis. The presence of L. natalensis in this dam for 7 out of 12 months is of epidemiological importance in the transmission of cattle fascioliasis in the area.

A thirteen hour observation of water users at this dam showed that the dam is frequented for various activities by the people residing in the nearby hamlets (R. Sanyi and Kuringafa). Table 27 shows that a greater percentage (96.0%) of those observed were males. The males observed represented 15.88% of the total male population ($\geq$ 5 years) in R. Sanyi hamlet. The females observed represented 0.63% of the total female population ($\geq$5 years) in this hamlet. No child of below 5 years of age was observed at the site. Of the males observed, those aged 10-14 years had the most frequent contacts (39.2%) with water while the least (11.2%) was recorded for those over 25 years of age.

4.2. LABORATORY STUDIES

4.2.1. Growth of B. (P.) globosus

Figure 21 shows the growth of laboratory bred B. (P.) globosus. This snail reached maturity (began to lay eggs) when it was 4½ weeks old and had an average size of 4.8mm.



successfully infected and shed cercariae of S. haematobium.

The minimum infective dose of miracidia of S. haematobium for this species was 3 (Table 28). Varied numbers of exposed snails died before the end of the experiment. It is not clear if this was due to over-infection.

4.2.3. Examination of Snails for Infections

The different types of trematode cercariae observed in field collected snails, during the study are listed in Table 29. B. (P.) globosus was the only snail species found with S. haematobium infections in nature but other trematode infection such as echinostomes, gymnocephalous and xiphidio-cercariae as well as amphistome were common infections of all the species of snails collected. This further confirms that B. (P.) globosus is the intermediate host of S. haematobium in the study area. The frequency of different size groups of 500 B. (P.) globosus found naturally infected with S. haematobium cercariae is shown in Figure 22. No snail measuring below 5 mm. was found to be infected. Those measuring 9.1-10.0 mm. had the highest frequency of 24.6%. Figure 23 shows the monthly representation by young, adult and old infected B. (P.) globosus collected from natural habitats. Infected snails were collected throughout the year except in February, March and April. The majority of the infected snails were adult while old snails were the least.

Table 28: Laboratory infection of B. (P.) globosus with S. haematobium miracidia

No. of Snails exposed	No. of Miracidia per snail	No. found infected	Infected survivorship after 40 days
10	1	0	9
10	2	0	9
10	3	2	8
10	4	6	10
10	5	5	9
10	6	6	9
10	7	5	7
10	8	8	10
10	9	7	9
10	10	7	8

Table 29: Natural infections found in snails

Snail species	No. examined	No. infected	No. and type of infection	Infection by cercarial type (%)
B. (P.) globosus	5114	608	538; S. haematobium	10.5
			43; Echinostome	0.8
			27; Gymnocephalous	0.5
B. (B.) forskalii	2556	109	87; Gymnocephalous	3.4
			9; Xiphidio	0.4
			13; Amphistome	0.5
B. pfeifferi	1000	64	28; S. mansoni	2.8
			8; Echinostome	0.8
			12; Gymnocephalous	1.2
			16; Xiphidio	1.6

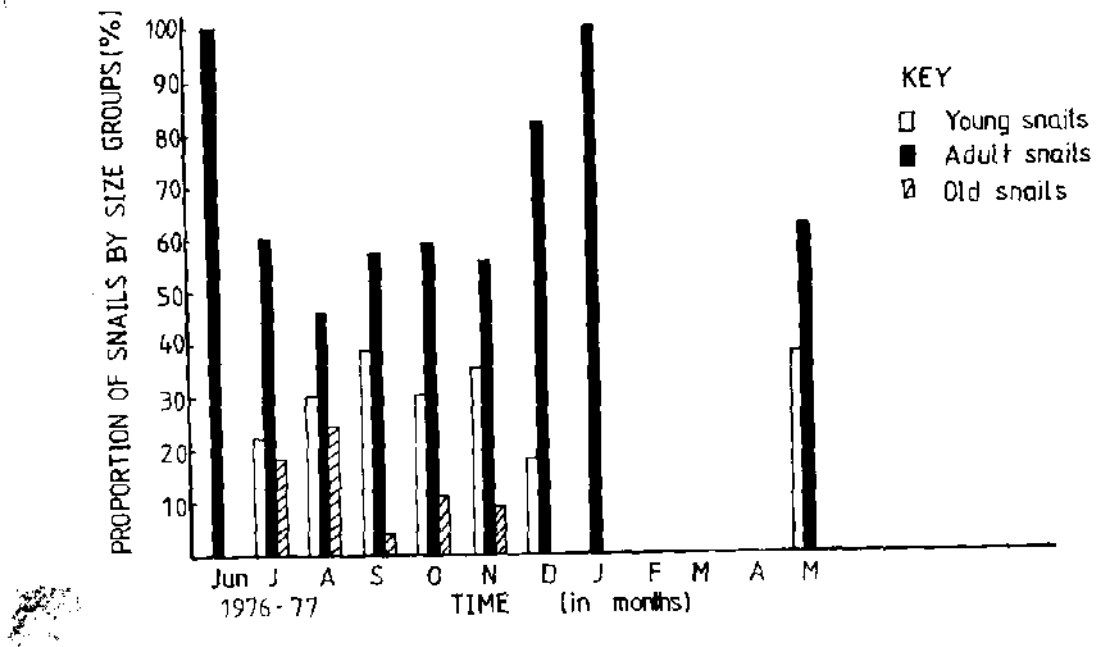


Figure 23 Monthly Proportion by Size of Infected B. (P.) globosus.

4.2.4. Cercarial Shedding Patterns

The number of cercariae shed by different size groups of B. (P.) globosus is shown in Figure 22. It appears that the older the snail, the higher the cercarial output. The highest output was obtained for the size groups measuring between 13.1 and 14.0 mm. Daily observations of 40 B. globosus, over one month, on the shedding of S. haematobium cercariae is shown in Figure 24. The daily cercarial output steadily increased reaching peak output between the 8th and 16th day. Thereafter, there was not much difference in the output. A diurnal pattern was observed in the shedding of S. haematobium cercariae by both laboratory bred and infected and, naturally infected field collected populations of B. (P.) globosus (Figure 24). Peak shedding occurred between 11 a.m. and 3 p.m. and the output during this period accounts for 55.5% of the daily output. This would result in the highest cercarial concentration in natural habitats at this period thus making this interval the period of greatest risk of infection.

4.2.5. Infection of Sentinel Mice

Seven of the twenty mice exposed to furcocercous cercariae shed by naturally infected B. globosus were successfully infected and the adult worms obtained at perfusion were identified as S. haematobium so also were the eggs produced by these worms. Eight of the twenty mice exposed to furcocercous cercariae obtained from laboratory infected

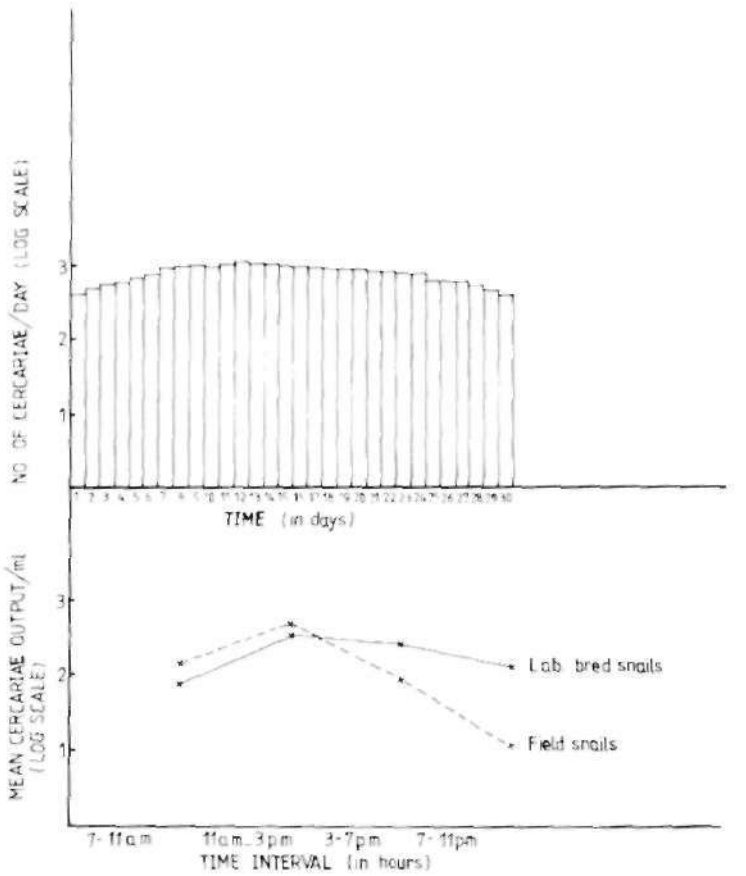


Figure 24 Daily and Diurnal Shedding of S. haematobium Cercariae by B. (P.) globosus.

snails were also successfully infected and the adult worms obtained at perfusion were identified as those of S. haematobium. This fully confirms the species of the cercariae type observed in field snails and those obtained from laboratory infections of sentinel snails. The result of the exposure of sentinel mice in natural habitats, as an index of infectivity and cercarial density is shown in Table 30. Mice exposed between June and January in the pond site became infected, suggesting that this is the period of transmission. The highest worm load was recorded in mice exposed between November and January suggesting that higher transmission occurs in the dry season. No infections were found in mice exposed between February and May. A similar trend was observed in the stream site. Cercarial density was higher in the pond compared with the stream as shown by the worm load in the mice. This is an index of greater infectivity of the pond.

4.3. HUMAN BEHAVIOURAL STUDIES

4.3.1. Man-Water-Contact Studies

Response

Tables 31 to 34 summarise the responses of those interviewed. A higher response was obtained from males (71%) than from females (40%). Majority (78.9%) of the people had knowledge of schistosomiasis while 12.4% had received treatment for the disease (Table 31). People use surface

Table 30: Exposure of sentinel mice in natural snail habitats

		POND			STREAM		
	No. of mice exposed	No. of infected mice	Worm load		No. of infected mice	Worm load	
			Average	Range		Average	Range
Jan. '77	5	4	38	12-51	0	-	-
Feb.	5	0	-	-	0	-	-
Mar.	5	0	-	-	0	-	-
Apr.	5	0	-	-	0	-	-
May	5	0	-	-	0	-	-
Jun.	5	1	30	30-	2	7	5-9
Jul.	5	2	31	26-36	1	12	12-
Aug.	5	0	-	-	0	-	-
Sept.	5	1	32	32-	1	15	15-
Oct.	5	2	17	14-20	0	-	-
Nov.	5	2	15	8-22	2	23	6-40
Dec.	5	3	20	10-28	0	-	-

Table 31: Distribution by sex of responses on knowledge of schistosomiasis and reasons for the use of water sites

	Knowledge of schistosomiasis			Reasons for use of water sites		
	None	Has	Previously treated	Only source	Good	Proximity
Male	32	199	42	35	69	153
Female	4	126	9	4	4	47
Total	36	325	51	39	73	200
%	8.7	78.9	12.4	12.5	23.4	64.1

water for various reasons. More people use the source during the dry than in the wet season. On the diurnal use of water a higher percentage claimed usage in the afternoon (Table 32). A few persons admitted to bodily contact with water while a large majority denied (Table 33). Excretion by water sites is an accepted practise in the area. Bathing topped the list of frequency of water-contact activities (45.5%). Other main water-contact activities were (Table 34): washing of clothes (40.7%), drinking (5.84%) religious activities (3.3%) and collection of water (2.33%).

OBSERVATION

Frequency of Water Contacts at Different Water Sites

The frequency of water contacts at different water sites is shown in Table 35. In R. Sanyi hamlet, the majority of the water activities were recorded, during the dry season, at the dam; in Kuringafa at the stream; in Kurmin Sarki at the river while equal observations were made at both the stream and pond in U. Barau. Kuringafa hamlet stands out as one area where the risk of acquisition of schistosomiasis will be greatest, in view of contact with potential transmission sites. The situation remained virtually unchanged even in the wet season.

Diurnal Variation in Different Types of Water Activities

Table 36 shows the incidents of water activities. The highest incident (35.4%) was recorded for the 12-3 p.m. period, which was observed to be the period of peak cercarial shedding

Table 32: Distribution by sex of responses on the diurnal and seasonal use of water sites

	Season			Time of the Day			
	All Seasons	Dry	Wet	Morning	Midday	Afternoon	Evening
Male	35	123	61	0	101	109	10
Female	9	61	20	0	25	28	4
Total	44	219	81	0	126	137	14
%	16.4	53.5	30.1	0	45.5	49.5	5.0

Table 33: Distribution by sex of responses on the degree of bodily contact with and contamination of water sites

	Degree of bodily contact				Contamination of water sites	
	Complete immersion	Arms only	Up to ankles	None	Excrete nearby	Excrete away from
Male	6	1	40	160	79	122
Female			11	43	23	30
Total	6	1	51	203	102	152
%	2.3	0.4	19.5	77.8	59.8	40.2

Table 34: Distribution by sex and age group of responses on the different water-contact activities.

Activity	Age Groups (in years)							
	5-9		10-14		15-24		25+	
	Male(M.)	Female(F.)	M.	F.	M.	F.	M.	F.
Washing clothes	23	9	50	4	31	4	67	21
Washing dishes		3				1	1	7
Bathing	34	12	50	7	33	5	73	20
Swimming								
Religious purposes		1	3		3		9	1
Collecting water	2	1	6	1			2	
Drinking		1	4	1	4	1	7	12
Total	59	27	113	13	71	11	159	61

Table 35: Frequency of water activities observed at different water sites

Hamlet	STREAM		DAM		POND		RIVER	
	DRY SEASON (D.S.)	WET SEASON (W.S.)	D.S.	W.S.	D.S.	W.S.	D.S.	W.S.
R. Sanyi	332	255	1063	477	332	255	ND	ND
Kuringafa	1398	590	60	473	610	1017	ND	ND
U. Bara'u	99	77			99	258	239	248
Kurmin Sarki							311	468
Total	1829	922	1123	950	1041	1530	550	716

ND - Not determined.

No Dam in U. Bara'u and river is only type of surface water in K. Sarki.

Table 36: Diurnal variation observed in water-contacts by sex, season and age group

	6-9 a.m.		9-12 noon		12-3 p.m.		3-7 p.m.	
	DRY SEASON (D.S.)	WET SEASON (W.S.)	D.S.	W.S.	D.S.	W.S.	D.S.	W.S.
Male	626	388	516	686	1268	1344	867	1023
Female	419	95	161	124	122	122	241	76
Total No. of incidents in period	1528		1487		2856		2207	
% incidents in period	18.9		18.4		35.4		27.3	
Age Group (in yrs.)								
5-24 yrs.	335		464		1120		1168	
25+ yrs.	319		424		750		666	

Table 37: Seasonal distribution of observed water contacts.

Season	Observation period (hrs.)	Total No. of contacts	No. of contacts per hr.	Seasonal index of frequency of contacts (all year = 100)
Wet	1,456	3,656	2.5	81
Dry	1,092	4,128	3.8	123
Total	2,548	7,784	3.1*	100

* The number of contacts per hour for female is 0.5 and for males, 2.5.

by B. (P.) globosus. Thus human behaviour in terms of peak time of water contact and, the snail parasite behaviour (i.e. diurnal shedding pattern by B. (P.) globosus) help to promote transmission of the disease. The diurnal variations of water activities in the different sexes and age groups show that the younger age group (5-24 years) were recorded more often at each of the periods than the older age group (>25 years). The frequency of the two sexes was a ratio of 4.9 males to 1 female.

Frequency of Water Contact Activities

The frequency of water contacts was higher in the dry than in the wet season (Table 37). Activities recorded for males in both the wet and dry seasons were more than for the females (Table 38). Males recorded in the wet season were 8 times as many as the females while in the dry season, the ratio was 4 to 1. For males, there was little difference in the numbers recorded in the two seasons whereas twice as many females were observed in the dry as compared to the wet season. Drinking was the most important water-contact activity for both sexes and for all age groups (Table 39). It accounted for 23.2% of all activities. The next most important activity was bathing for males and, collection of water for home use for females. Washing of arms and legs came next for both sexes. Amongst males (Table 40) fishing, angling and swimming were mainly activities of those aged 10-24 years while adult (> 25 years) were mainly responsible for ablution,

Table 38: Frequency of observed outdoor social and religious water-contact activities by sex and season.

Activity	Male		Female	
	Number of activities in Season			
	Wet	Dry	Wet	Dry
Washing (W.) clothes	146	109	33	13
W. utensils	27	6	21	2
W. animals	2	7		6
W. vegetables	22	1	4	
W. arms, legs	533	425	133	118
Bathing, playing	606	443	18	11
Swimming	108	617		47
Urination	162	49	5	2
Defecation	52	11		
Ablution	78	13	1	
Wadu	275	53	3	7
Taking water	1,039	1,467	170	672
Crossing water	91	7	33	5
Angling	8	10		1
Net fishing	81	26		
Total	3,235	3,244	421	884

Table 39: Frequency of observed water contact activities by age group (in years).

Activity	Age group in years				
	5-9	10-14	15-24	25+	Total
Washing (W.) clothes	27	44	67	163	301
W. utensils	2	6	10	38	56
W. animals		7		8	15
W. vegetables	3	4	6	14	27
W. arms, legs	115	277	251	571	1214
Bathing, playing	132	195	304	447	1078
Swimming	126	278	273	95	772
Urination	10	23	57	128	218
Defecation	4	3	13	43	63
Ablutions	4	9	18	61	92
Wadu	9	20	66	243	338
Collecting water for:					
building		12	6	24	42
home	112	232	330	559	1233
farm	22	28	26	70	146
cattle	10	32	34	43	119
Crossing footpath	19	26	31	60	136
Fishing	3	41	47	16	107
Angling	3	2	11	3	19
Drinking	180	375	430	823	1808
Total	781	1614	1980	3409	7784

Table 40: Age distribution of observed water-contact activities of males and females.

Activity	Percentage of particular activity in age-group (years)				
	0-4	5-9	10-14	15-24	25+
		Males			
Washing (W.) clothes		8	12	24	56
W. utensils, animals, vegetables		8	9	17	66
W. arms, legs		9	21	22	48
Bathing, playing		12	18	29	41
Swimming		16	33	38	13
Defecation		5	9	25	61
Ablution, Wadu		33	6	20	71
Taking water		9	20	27	44
Crossing water		12	15	24	49
Fishing, angling		5	35	46	14
All activities		10	20	27	43
Distribution of male population	470	335	210	232	620
		Females			
Washing (W.) clothes		15	28	13	44
W. utensils, vegetables			18	18	64
W. arms, legs		11	31	14	44
Bathing, playing		28	14	17	41
Swimming		21	79		
Defecation		14	14	14	58
Taking water		13	24	19	44
Crossing water		18	29	21	32
All activities		13	28	17	42
Distribution of female population	432	324	123	362	624

wadu, defecation, urination, washing of arms and legs and water fetching. Amongst females, swimming was solely an activity of those aged 5-14 years old and; fishing and angling were not observed as female activities. Overall, collection of water for home use came next to drinking in order of importance. It accounted for 15.8% of all activities. Other important activities were washing of arms and legs (15.6%), bathing (13.8%), swimming (9.9%), wadu (4.3%) and washing of clothes (3.9%).

With the exception of drinking, the following were the important water contact activities for the different age groups: bathing, swimming, washing of arms and legs and collection of water for home use. The order of importance in the different age groups were as follows: 5-9 years and 10-14 years: swimming, washing of arms and legs and collection of water for home use; 15-24 years: collection of water for home use, bathing, swimming and washing of arms and legs and for 25 years and above: collection of water for home use, washing of arms and legs, bathing and wadu.

Type of Activity

Majority of activities (60%) recorded for males in both dry and wet seasons fall into the exposure category (Table 41). The same pattern was observed for the females with exposure activities accounting for over 90%. For both sexes, exposure and contaminating activities were lower in the dry season compared to the wet. Mixed activities decreased in the wet season.

Table 41: Distribution of 3 types of water-contacts observed by sex, age and season.

	Number of incidents of different types of water-contacts					
	Exposure		Contamination		Mixed	
	Dry Season (D.S.)	Wet Season (W.S.)	D.S.	W.S.	D.S.	W.S.
Male	2064	2134	60	219	1021	757
Female	823	407	2	5	58	19
Total	2887	2541	62	224	1079	776
	Age distribution of different types of water contacts					
5-9 yrs.	508		14		263	
10-14	1060		26		444	
15-24	1249		75		577	
25+	2611		171		571	
Total	5428		286		1855	

Table 42: Duration of observed water-contacts by the different age groups, in two seasons.

Age group (in years)	Wet Season				Dry Season			
	No. of persons observed	Exposure period (min.) Total	Average	Range	No. of persons observed	Exposure period (min.) Total	Average	Range
5-9	293	3082	10.5	1-102	391	8267	21.1	1-153
10-14	536	6211	11.6	1-130	994	19430	19.5	1-258
15-24	1754	7797	4.4	1-93	1120	20016	17.9	1-251
25+	1674	22540	13.5	1-225	1586	18580	11.7	1-300

For the different age groups, exposure accounted for the greatest percentage (72%) of all the three types of activities followed by mixed and contaminating activities respectively. The older the age groups the higher the number of incidents observed for exposure activity in both seasons. A similar observation was made for both contaminating and mixed activities in the wet season but, in the dry season, the number of incidents recorded for the age group 15-24 years predominated.

Duration of Water-Contact Activities

In the wet season, adults spent more time in contact with water than the young ones (Table 42). In contrast, in the dry season, however, the younger age groups spent more time at the site, than did the older age group.

For all age groups, except 25 years and above, there was a marked increase of exposure in the dry season as compared to the wet season. On the other hand, in the age group 25 years and above, there was a slight decrease of exposure period in the wet season compared with the figure obtained for the dry season.

Table 43 gives the exposure period associated with various water contact activities for the dry and wet seasons. In both seasons, contact activities such as washing of clothes, fishing, collection of water, swimming and bathing required the longest exposure period and since these activities were mainly carried out by the younger age group (5-24 years) it would

Table 43: Duration of observed water-contact activities in the dry and wet seasons.

Activity	Wet Season				Dry Season			
	No. of person observed	Exposure period(min.) Total	Average	Range	No. o persons observed	Exposure period(min.) Total	Average	Range
Washing (W.) clothes	152	5616	37	2-255	133	6627	50	2-300
W. utensils	28	458	16	5-43	16	320	20	3-84
W. animals					7	15	2	1-7
W. vegetables	12	70	6	1-17	9	38	4	1-10
W. arms, legs	507	4614	9	1-33	584	7465	13	1-40
Bathing,playing	568	6812	12	1-130	509	10440	20	1-153
Swimming	104	1438	14	2-92	598	16018	27	1-300
Urination	153	459	3	1-4	104	312	3	1-4
Defecation	24	192	8	2-11	17	119	7	4-10
Ablution	52	335	6	1-8	19	78	4	2-5
Wadu	154	1491	10	1-30	161	1488	9	1-25
Collecting water for:								
building house	6	67	11	1-30	50	432	9	3-20
home	578	6998	12	1-65	688	7066	10	1-20
farm	43	218	5	1-15	46	184	4	1-37
cattle	24	404	18	1-30	75	1487	20	1-30
Crossing water	90	450	5	1-25	77	482	6	1-30
Fishing	55	1671	30	2-116	20	846	42	3-95
Angling	29	223	8	2-26	89	811	9	1-62
Drinking	795	6679	8	1-8	893	7144	8	1-12
Total	3,374	38195	11		4095	61374	15	

Figure 25: Water contact activities at the Malumfashi dam.

appear that they stand a higher risk of exposure than the older age group (≥25 years). Also, in terms of contamination of the habitats, it is this group that is responsible.

Degree of Bodily Contact with Water

Complete immersion of the body accounted for the highest of all bodily contacts in all age groups (Table 44). There was a difference in the bodily exposure of the two sexes. Amongst males, complete immersion accounted for the highest bodily contact (49.3%). It was followed by up to ankles, arms only, up to knees, up to waist and up to chest respectively. Amongst females, however, arms only accounted for the highest bodily contact (33.3%). It was followed by up to ankles,up to knees and complete immersion (females normally enter water fully clothed and splash water all over their body) respectively. Thus males expose a greater part of their body in transmission sites. This will result in a higher intensity of infection as more bodily surface is exposed for penetration by the schistosome cercariae.

4.3.2. Migration

There was a population reduction of about 8.2% in three years in R. Sanyi village. In the three years, 1975-1978, 153 people or 7.8% of the population had moved in and 410 people or 21.0% had moved out. All the age and sex groups declined due to emigration. Females migrated more than males.

Table 44: Degree of bodily contact with water of those observed by sex and age group.

	Arms only	Up to ankles	Up to knees	Up to waist	Up to chest	Complete immersion
Males	579	666	462	58	31	1744
Females	146	109	100	12	0	71
Total	725	775	562	70	31	1315
	Bodily contact by age group					
5-9 yrs.	94	92	41	8	1	177
10-14	144	162	107	10	3	394
15-24	173	195	132	16	14	511
25+	314	326	282	36	13	733
Total	725	775	562	70	31	1815
% Total	18	19	14	2	1	46

Table 45: Distance moved by migrants.

Place migrated to	Distance (in Km.) from Study Area	% Immigrants to Study Area	% Emigrants from Study Area to
Malumfashi	9.6	72.30	53.10
Funtua	56	4.65	5.70
Zaria	132	3.00	10.00
Katsina	165	1.55	1.40
Gusau	165		0.96
Kano	185	10.80	14.80
Kaduna	219	1.55	11.0
Hadejia	325	4.65	
Kachia	359		0.96
Jos	447	1.50	0.24
Makurdi	708		0.47
Maiduguri	880		0.47

People migrated far and near (9.6 to 880 kms.). Approximately 75% of all emigrants moved within a radius of 185 kms. and for migrants, 56 kms. (Table 45). More people moved out of the area in the dry season than in the wet for job opportunities. Immigration was higher in the wet season as people returned to farm the land (Table 46). Reasons given for migration are detailed in Table 47. It is evident from the table that males moved mainly for employment and education while females moved for marriage purposes.

Table 46: Seasonal population movement.

	Dry Season	Wet Season
Movement in (M_I)	48	43
Movement out (M_o)	62	33
$M_I - M_o$	-14	+10

Table 47: Reasons for movement

Reasons	Male		Female		Total	
	No.	%	No.	%	No.	%
Marriage	1	1.2	89	56.0	90	36.7
Divorce			22	13.8	22	9.0
Widowed			2	1.3	2	0.8
Employment	47	54.7	20	12.6	67	27.3
Education	18	20.9			18	7.4
Others*	20	23.3	26	16.4	46	18.8
Total	86	35.1	159	64.9	245	

* = those who followed parents, changed house.

CHAPTER 5

DISCUSSIONS

The investigations reported here show that ecological factors favouring transmission of schistosomiasis abound in Malumfashi area. These include: infected persons, a low level of sanitation, the presence of intermediate hosts and a favourable environment. Previous studies by Bell and Howells (1973), Pugh and Gilles (1978) and Pugh et al (1980b) in the study area showed that schistosomiasis was highly prevalent in the population. Bell and Howells (1973) reported prevalence rates of S. haematobium infections ranging from 8.7% to 80.4% in children in the area, while Pugh and Gilles (1978) reported prevalence rates of 1.6% to 60.0% in children (aged 5-15 years) and 4.5% to 24.0% in adults. Coupled with this is the finding in the present investigation of a low level of sanitation based on the number of latrines, defecation and urination patterns. For instance out of 134 compounds (Table 7) investigated, only 74 (i.e. 55.2%) had latrines; and of those questioned about their urination and defecation habits, approximately 40% admitted to excreting near water sources (Table 33). It has been shown (Table 38) that about 4% of water contact activities are accounted for by defecation and urination alone. This means that contamination of the environment with human wastes is bound to be high. This, in fact is further supported by field observations of human excreta

in open fields, around huts and water bodies. Essien and Osuhor (1979) reported an evidence of faecal pollution of human origin from ponds, wells, streams and public stand in the area. The absence of safe and potable water supply compels the people to turn to surface water for their domestic and recreational needs and, which water harbours snail intermediate hosts of schistosomiasis. The indiscriminate defecation and urination, as a result of poor sanitation results in the contamination of water sites by infected persons with schistosome eggs. This is borne out by the study of the three snail habitats (Table 14) which shows a high infection rate in the snail population.

Bionomics of Schistosome Intermediate Host

The snail intermediate hosts of S. haematobium and S. mansoni namely, B. (P.) globosus and B. pfeifferi respectively, have been shown, in the present study, to be widespread in the Malumfashi area. It was further shown that B. (P.) globosus is the intermediate host of S. haematobium and B. pfeifferi of S. mansoni. There are similarities between these findings and those in Ibadan, in the southern part of the country, (Hira and Muller, 1966; Asumu, 1975; Okwuosa, 1979) where B. (P.) globosus was reported as abundant and as the principal intermediate host of S. haematobium and, B. pfeifferi was reported as either absent or sparsely distributed. These species of snails have also been reported as the intermediate hosts of S. haematobium and S. mansoni in the

neighbouring countries of Sierra Leone (Blacklock and Thompson, 1924; Gordon et al., 1934) and Liberia (Sodeman, 1979; Saladin, Saladin, Dennis and Degremont, 1980).

B. (P.) globosus accounted for 79.8% of all snail collections while B. pfeifferi and B. (B.) forskalii accounted for 8.7% and 12.5% respectively. It follows, therefore, that most schistosome infections in humans in the study area would be due to S. haematobium. This in fact was shown to be so by Pugh and Gilles (1978) and Pugh et al (1980c) where they reported prevalence rates of $\leq$ 60% and $\leq$ 5% for S. haematobium and S. mansoni infections respectively. The schistosome infection rates in the different species of snails were found to differ. In B. (P.) globosus, they ranged between 1.1% and 40.0% whereas, in B. pfeifferi, it was only 2.8%. These findings correlate with the observations of infections in humans in the area (Pugh and Gilles, 1978; Pugh et al., 1980c). Reports from other parts of the country (Blair, 1956; Cowper, 1963, 1973; Edington, 1970) indicate a similar trend. Asumu (1975) and Okwuosa (1979) reported the abundance of B. (P.) globosus and and sparse distribution of B. pfeifferi around Ibadan. Although the distribution and relative abundance of the snail intermediate hosts of schistosomiasis are similar both in the northern part as shown by this study and in the southern part as shown by other workers (Hira and Muller, 1966; Hira, 1969, 1970; Asumu, 1975, Okwuosa, 1979; Ndifon, 1979), their infection rates are however, different: it is higher in the north than in the south. This is probably due to the fact that in the north,

the longer dry season compels the people to obtain water from contaminated sources thus increasing the level of infection in the human population. High cercarial infection rates are however, frequently recorded amongst snails. In Sierra Leone, Blacklock and Thompson (1924) recorded infection rates of 2 to 40% in B. globosus. Webbe (1962a) recorded infection rates of 20-80% in B. (P.) nasutus in Tanzania and Sodeman (1979) working in Liberia reported infection rates of 2% in B. globosus and 10% in B. pfeifferi. The infection rate obtained in B. pfeifferi in the study area (2.8%) suggests that the infections in the human is higher than had been reported by Pugh et al., (1980c). Pugh (1979b) reported the lowest prevalence rate of < 11.1% for Kurmin Sarki hamlet. Results of the snail survey suggest that intestinal rather than urinary schistosomiasis is the main problem in this hamlet since almost all snails collected from this hamlet were B. pfeifferi, thus supporting the suggestion of Edington (1970) that S. mansoni infections are less frequently recorded because of greater difficulties in diagnosis.

The wide distribution of B. (B.) forskalii in the area (Table 11) suggests that the species might play a significant role as decoy in the habitats; this might be beneficial in reducing infection rates in the snail intermediate hosts of schistosomiasis. Chernin and Perlstein (1969), Upatham (1972b) and, Upatham and Sturrock (1973a), suggested that miracidia may be removed from a habitat by penetration of snails insusceptible to infection. Schillhorn van Veen et al. (1975)

reported that L. natalensis is responsible for the transmission of fascioliasis in the northern part of Nigeria. The presence of this species in the study area poses a risk of transmission amongst the cattle population. This is even more significant from the viewpoint that most of the cattle in Nigeria are produced in the northern part of the country.

Snails were collected more often in temporary than permanent habitats and, around edges, rather than in depths of habitats. Though snails were often collected attached to a water plant, Nymphae lotus, in the habitats, the presence of the plant was not indicative of the snails presence. As in the prsent investigation, the snails described by Okwuosa (1979) were not found in association with a particular plant. Chu (1978) could not obtain conclusive evidence of an association between the intermediate host of S. haematobium and a weed, Ceratophyllum demersum in Ghana. The fluctuations observed in the size of the snail populations (Figures 15 and 17) could be associated with rainfall. For instance the highest populations of B. (P.) globosus in August coincided with the peak rainfall while the least numbers were obtained in April due to drying out of and adverse conditions such as pollution, disturbance of the habitats by re-digging and high temperatures of the habitats. The situation in all the habitats followed the same trend although highest population was obtained between November and January in the stream which at this time resulted in isolated pools with stagnant water. The decrease in snail numbers in September could be attributed to flushing out of

snails by the heavy downpour in August. A build up in October seemed to result from stabilised conditions within the habitats. Thereafter, the decrease at the onset of harmattan and dry season would appear to be due to the effect of low temperature on reproduction and adverse conditions in the habitats. Asumu (1975) reported that breeding of snails was inhibited when low temperature prevailed. In the present study, as the conditions became more unfavourable in the habitats, fewer snails were collected until in the peak dry months of March and April when no snail was to be found. The decrease in the reproductive rate, at this time, is reflected by the few young snails collected (Tables 21 and 22). The findings of live B. (P.) globosus in mud samples collected from dried up habitats suggest that the snail aestivates during adverse conditions. The snails that were sufficiently protected against dessication and lethal temperatures survived this period. The size range of the live B. (P.) globosus found was 5.5 to 15.0 mm. indicating that the young and adult snails survive better than the old snails. Webbe (1962a, b) reported a similar observation in Tanzania for populations of B. (P.) nasutus. The findings that young and adult snails repopulated the habitats in May, once they were refilled by rains is consistent with aestivation noted in this study (Table 23). The process of aestivation enables the snails to overcome the catastrophic effect of the dry months of March and April on the population thereby ensuring their continuity. Webbe (1962a, b) labelled B. (P.) nasutus with radio-active

Cobalt 60 before the habitat dried and succeeded in collecting two of the snails, seven days after the habitat refilled by rain. Sturrock (1966) showed that B. angulosa can survive dessication for 4 weeks under laboratory conditions. It is, however, possible that water birds and cattle visiting snail habitats might contribute to the introduction of snails into a given habitat.

Rainfall stimulates breeding as large numbers of very young snails and eggs became evident on twigs, plants, snail shells and other materials within the habitats. This increase in breeding resulted in the build up of snail population in May, reaching a maximum around August. Young snails predominated between June and November and would appear to serve as a marker of reproductive capacity. It has been suggested (Southwood, 1977; Appleton, 1978) that the distribution and population dynamics of intermediate hosts of human schistosomes are mostly governed by temperature and rainfall. This suggestion is supported by the observation in the present study which showed that the highest numbers of snails were collected at the peak of the rainy season when the water temperature ranged between 22°-25.7°C in contrast to the low numbers obtained during the harmattan with low temperature (15.5°-18.3°C). The highest temperatures of 27°-30°C during the hot dry months of March to April resulted in the least number of snails in the habitats. However, it appears that rainfall more than temperature is responsible for fluctuation in snail populations. Mozley (1959) stressed the presence of micro-habitats under natural conditions in which

snails may seek out the best habitat and other workers (Gordon et al., 1934; Malek, 1958; Webbe, 1964a; Mira and Muller, 1966) have drawn attention to the wide temperature ranges that occur in snail habitats.

While caution is dictated in extrapolating the results of one snail species to another, nevertheless, there seems to be evidence from field observations that the results obtained for B. (P.) globosus, in the present study, may equally apply with the same force to B. pfeifferi and B. (B.) forskalii. From population studies of B. (P.) globosus, peak populations were obtained between June and August and, October and January. Since June is about the beginning of heavy rains in the area, and October represents the beginning of the dry season, it would appear appropriate to intervene just before the beginning of the rains and the dry season. This is because, there is a need to suppress the population before the peaks are reached. In that way, there would be a more judicious use of molluscicide as well as achieving the most effective result. The second molluscicide effort should take care of those snails and snail eggs that escape molluscicide at the time of the first application. In addition, the second molluscicide may be potentiated by the adverse effect prevailing at the beginning of the dry season. Data obtained in pre-control studies of the roles of different snail populations in schistosomiasis transmission have been utilized by several workers in the design of snail control strategies. Webbe (1964b) utilized such studies in designing a molluscicide

programme to control S. mansoni transmission in a small natural stream running through the town of Mwanza in Tanzania. Carefully timed applications of the molluscicide prevented the seasonal build up of the snails and the associated burst of transmission. Shiff and Clarke (1967) controlled the transmission of schistosomiasis in Rhodesia by limited mollusciciding in sites where most human contact and snails occurred and reported a significant effect on S. haematobium and S. mansoni transmissions. Lyons (1972) utilized data obtained in pre-control studies on the planning and execution of a schistosomiasis control in Ghana. In St. Lucia, Sturrock (1973) reported great reductions in the populations of the snail intermediate host of S. mansoni and an encouraging drop in the incidence of human infections in the area controlled. The growth curve obtained in the laboratory for B. (P.) globosus showed that the growth rate was high (Figure 21) in the first 13 weeks and slowed down thereafter. It also suggests that the full size is attained over a period of 12 months after hatching. This growth curve compares with the ones obtained for B. pfeifferi and B. (P.) globosus (Gordon et al., 1934; Sturrock, 1966); B. sudanica tanganyicensis (Webbe, 1962b); B. nasutus productus (Webbe, 1962a) and B. angulosa (Sturrock, 1965). However, it may be difficult to use such growth curve to estimate the age of field strains by direct extrapolation. This is because, in the laboratory, the environmental conditions are relatively constant whereas in the field, they are quite variable. In the field, the rates of

growth, development and attainment of sexual maturity will depend upon conditions in the environment, including the size of the habitat, available food supply and temperature, and other fauna which may be present. These factors will vary for different snail species and among local strains of the same species. Apart from these extrinsic factors which are mostly seasonal, the density of a snail population is also controlled by intrinsic factors such as birth rate, natural mortality and environmental resistance. These intrinsic factors vary with the size and composition of different populations and environmental conditions.

According to Berrie (1970), the susceptibility of snails to infection varies with species and sometimes within the species. Although in the field studies carried out, the degree of exposure of snails to different species of trematode cercariae could not be ascertained, it would appear that the results obtained accord with the suggestion of Berrie. For instance, out of the overall infection rate of 11.8% in B. (P.) globosus, S. haematobium accounted for over 88% while echinostomes and gymnocephalous cercariae accounted for the rest (Table 29). Similarly B. pfeifferi seemed to show a higher degree of susceptibility to S. mansoni cercariae. A further evidence in support is the finding that in laboratory exposure of B. (P.) globosus, B. pfeifferi and B. (B.) forskalii to cercariae of S. haematobium, only B. (P.) globosus was infected. An interesting finding is the fact that B. (B.) forskalii shed 3 types of cercariae

(gymnocephalous, xiphidio--cercariae and amphistomes) but had no human furcocercous cercariae probably because of its insusceptibility.

The man water contact studies in the study area show that all age groups, and males far more than females, contaminate the habitats (Table 38) by defecating and urinating close to snail habitats. Furthermore the act of ablution was frequently performed, as the community studied is largely a Moslem one. These activities favour the continuity of the parasite life cycle as they ensure that the schistosome eggs are placed in favourable conditions for hatching and infecting the snail intermediate hosts. Husting (1965) and Prentice et al. (1970) pointed out that cleansing of perianal faecal soiling while bathing may also add schistosome eggs to water. Jordan et al. (1980) observed that these habits may be important because of their frequency and non dependence on rainy season. Rowan (1964) showed that sewage may be the source of contamination in Puerto Rico. Faecal material often observed around water sites are probably also introduced into snail habitats on hoofs of animals visiting these habitats. This is important only for materials deposited a short time before it is carried by the animal as the longevity of eggs is decreased by exposure to sunlight (Maldonado, Acosta-Matienzo and Thillet, 1949).

In streams and ponds, B. globosus remained infected for most part of the year (June-March) with infection rates of S. haematobium ranging from 1.1 to 40% and peak infection in

the dry season (November-March) which would appear to be the period when most transmission occurs. The infection rates increased from June to July probably as a result of washings-in of excreta from the banks into snail habitats by the rain. The decrease in infection rates observed in August and September is due to the diluting effect of immature stages and those which died of infection. Influx of young snails during this period resulted in a high number of uninfected snails. With time, these snails matured, became infected and accounted for the increase in numbers of infected snails in October and November. During this period, some of the habitats began to dry up resulting in a build up of human activities around the few remaining water places. Man-water contact studies show that a greater percentage of people frequented the water sites in the dry season. Although, the mouse exposure trials resulted in infections only in those mice exposed between June and January, it should be borne in mind that the highest worm burden was observed in those mice exposed in January, that is, at the early part of the dry season. Thus suggesting that transmission of S. haematobium, in the study area, is higher in the early part of the dry season. Nevertheless, the data indicate that S. haematobium infections of snails occur almost throughout the year (Figure 17). It follows therefore that constant use of these water sources by infected persons result in an increase in the incidence of infected snails, thus increasing the risk of infection of uninfected persons. Webbe (1965)

reported the seasonality of S. mansoni infections in mice exposed in a stream, in Lake Victoria, but observed that the infection did not correspond with times at which largest numbers of infected B. pfeifferi were found. Although the data (Table 20) show that total infection rate in snails collected from river sites, compares with those from the stream sites; in terms of transmission, the stream site is of greater importance because of the length of time the site remained infected over a one-year period (Tables 18 and 19 or Figure 17). In the river, infection rates were recorded in snails over a period of 4 months only (May to August) whereas, in the stream, infections were recorded for 7 out of 12 months. The river habitat was the first to dry out in the study area and in terms of schistosomiasis transmission would appear to be of less importance than the stream and pond as transmission sites. Only mature B. (P.) globosus ($>$ 5 mm) was found naturally infected. This is probably a reflection of maturation period required for the miracidia to develop (4 to 7 weeks) within the snail to the cercarial stage. Furthermore, laboratory observations (Figure 21) showed that a period of 5 weeks was required for the snail to attain a size of 5 mm. Approximately 25% of infected snails fall in the 9.1-10 mm. size group and over 80% of infected snails were adults. These findings suggest that older snails show better compatibility with the parasite than young snails. Old snails ($>$15 mm.) were rarely collected and found rarely infected probably because they were predated upon, as they would

seemingly be more conspicuous to predators due to large size. It could also be that they die off due to natural causes and over-infections. Webbe (1962a) observed that none of the infected B. (P.) nasutus measured less than 6.25 mm. while most of them measured 8.0 mm. in height. Hira and Muller (1966) observed that none of the naturally infected B. globosus measured below 8.0 mm. Christie and Upatham (1977) found that most of the infected B. glabrata fell into the size range of 10.0 to 15.0 mm. diameter with least size of 6.5 mm. Okwuosa (1979) obtained a size range of 5-10 mm. amongst infected B. globosus and reported the size range of 15-20 mm. as rare. Upatham (1981) observed that most of the infected Bulinus (Ph.) abyssinicus, in Somali, measured between 7 and 10 mm. The findings, in the present study that larger-sized B. globosus produced more S. haematobium cercariae as compared to the smaller ones further indicate that older snails are better able to harbour the parasite than the younger ones. Upatham (1981) reported the highest mean cercarial output for largest sized and the lowest in smallest sized B. (Ph.) abyssinicus in Somali. It was established in this study that the minimum of 3 miracidia was required for infecting B. (P.) globosus. In view of the finding of Pugh et al. (1980c) that most of the infected people in the study area, excreted an average of 33 S. haematobium eggs/10 ml. urine, and the finding of Upatham et al. (1976) that up to 64% of S. mansoni eggs from stools hatched into viable miracidia, such high hatchability should ensure

the continuity of the life cycle of the parasite. In nature, however, because of discrete behavioural mechanisms (Chernin and Dunavan, 1962; Shiff, 1968; Upatham, 1972a, b) more than 3 miracidia may be necessary for successful infection. Upatham (1973) observed that the percentages of miracidia successfully penetrating B. glabrata were lower in running than in standing water habitats. This probably accounts for the observation, in this study, of higher infectivity in ponds as compared to streams, particularly, in the wet season.

Behavioural Aspect

The shedding pattern of S. haematobium cercariae by B. (P.) globosus (Figure 24) would appear to favour transmission of the human disease since peak shedding occurred at the same period (11-3 p.m.) as maximal water contact was observed in the population studied. Pugh (1979a) reported a diurnal variation in the egg excretion of subjects infected with S. haematobium in the study area with peak egg excretion at the same period of the day when peak water contact activity was observed in the present study. It, therefore, follows that contamination of the water takes place at the period of peak contact, thus favouring intense transmission as borne out by snail infections (Figure 17). As shown by the

water contact studies, males had a higher water-contact than females in contrast to observations in Egypt (Farooq and Mallah, 1966), Puerto Rico (Jobin and Ruiz-Tiben, 1968), Rhodesia (Husting, 1970) and St. Lucia (Dalton, 1976). The difference in the observations may be due to the fact that in the study area, most women live in reclusion. In Ghana, however, men were recorded more often in contact with water than women (Dalton and Pole, 1978). The relatively higher contacts, longer exposure periods and greater bodily exposure (Tables 38, 42, 44) of males especially at the time of peak cercarial density in the habitats, in the present study, would seem to account for the higher prevalence (4:1) and intensity of infection in males (Bell and Howells, 1973; Pugh and Gilles, 1978; Pugh et al., 1980c) than in females. Jordan (1972) reported a close correlation between water contact and infection rates of S. mansoni of males and females in St. Lucia. Dalton and Pole (1978) found a correlation between water contact and egg output in infected persons in Ghana. In terms of age group, the younger ones ($\leq$ 24 years) frequented and spent longer time in contact with water and therefore stand the greatest risk of infection. Pugh (1979b) reported that this age group is responsible for 77% of the contamination in the area. It is not unlikely that the prevalence age curve reported for the population of this study area (Pugh, et al., 1980c) may be explained on the basis of greater exposure of the young coupled with more frequent contacts with infected waters as compared to the older age group.

No child ≤ 4 years of age was observed at water sites in the present study corresponding with the lack of urinary schistosomiasis in 80 children, aged 1 month to 4 years, examined in the population of Ruwan Sanyi village (Pugh and Gilles, 1978). Siegal (1963) also observed in an area of Ibadan, that the earliest age of infection with S. haematobium was 2 years, with 20% of children aged 2 to 6 years being infected. Onabamiro (1971) attributed very low infections of schistosomiasis in very young children to lesser contact with infected water. This indicates that once children start to walk and frequent infected water sites, they run the risk of becoming infected. The fact that drinking was the most important water-contact activity, in terms of frequency, suggests that adequate supply of safe water would help to reduce transmission.

It has been shown, in this study, that the peak age of migration is between 15 and 24 years and active infections occur in this age group (Pugh and Gilles 1978; Pugh et al., 1980c). Migration would appear to be of significance in the spread of schistosomiasis and therefore, attempt at controlling the disease must take this into account. Furthermore, control attempts should aim at a coverage of at least 9.6 kms. radius around the area of control since over 75% of migrations took place within this radius.

Man-made transmission foci

The present investigation showed that the snail intermediate hosts of schistosomiasis (B. (P.) globosus, B. pfeifferi) were well established in > 50% of the low earth dams present in the study area. It is noteworthy that many of the snails collected were infected with human furcocercous cercariae indicating that these dams are potential sites for the dissemination of schistosomiasis. Tayo and Jewsbury (1978) predicted that the construction of a low earth dam in R. Sanyi village will result in an upward trend in transmission of schistosomiasis in the area. Pugh et al. (1980b) reported an increase in the prevalence of S. haematobium infections in boys of this village, from 41.2% in 1977 to 55.8% in 1979. Paperna (1969) showed that the formation of the man-made Volta Lake in Ghana in 1964 created ideal environment for snail vectors of urinary schistosomiais resulting in an explosion of the disease transmission in the communities surveyed. Similar results have been obtained in several parts of Africa and Asia (WHO, 1967b, 1973, 1980; Waddy, 1975). The dams will serve not only as important transmission sites for schistosomiasis but also for malaria, drancunculiasis, cholera, gastroenteritis in human and fascioliasis in cattle. Furthermore, as these dams are perennial, transmission of schistosomiasis in the study area will occur all year round resulting in continual and increased transmission.

CHAPTER 6

RECOMMENDATIONS AND CONCLUSIONS

From these studies, certain recommendations are indicated. The absence of safe and potable water supply compels the people of Malumfashi area to turn to surface water for their domestic and recreational needs. This source of supply harbours intermediate hosts of schistosomiasis. These snail intermediate hosts have been identified as B. (P.) globosus for S. haematobium and B. pfeifferi for S. mansoni. Therefore an attempt at controlling the disease in the area should also be aimed at controlling the populations of these snails. It is clear that if water supply is adequate and safe, most of schistosomiasis problem will be overcome. In view of the sum budgeted (41.1 million Naira) for the provision of water by the Kaduna State Government for the 1975-80 3rd National Development Programme, it is unlikely that pipe-borne water will be available to more than a third of the population. Therefore emphasis should be laid on the provision of bore-holes and sanitary wells. The available water within the recently constructed low earth dams in the area, by the former Funtua Agricultural Development Project, could be pumped into storage tanks where treatment is carried out and from where water can be tapped for use. The supply should also be adequate, reliable and conveniently available.

From the snail studies, B. globosus populations were highest between June-the beginning of heavy rains and August; and in October-the beginning of the dry season with least numbers in April. Intervention should be made during this period to suppress the population before the peaks are reached. The first molluscicide should be made in June and the second in October to eliminate those snails missed during the first application. The effect of this second molluscicide will be further potentiated by adverse effect prevailing in the habitats at the beginning of the dry season. Furthermore it would reduce the higher transmission of the disease in the human during this period. These two application periods within the year will yield the maximum molluscicidal effect. Since the transmission sites are focal and occur mainly in isolated ponds, in streams and dams where human contact exist, limited focal molluscicide should be carried out in these areas. This would make molluscicide a reality in terms of available funds. However, snail control must be a component of several control measures since aquatic planorbid snails like B. globosus are hermaphroditic and populations can grow explosively and thus significantly alter transmission rapidly.

The studies show that transmission occurs for most part of the year and is highest in the dry season. Those aged ≤ 24 years particularly boys formed the majority of those observed at transmission sites. Therefore a selective chemotherapeutic

control programme for the disease should focus on this age group, particularly boys. Treatment should be carried out between March and April (late dry season) to prevent the contamination of sites with schistosome eggs and thus the snail intermediate hosts.

A low level of sanitation prevails in the study area. Indiscriminate excretion by infected persons results in contamination of water sites with schistosome eggs. Emphasis should therefore be made on environmental sanitation. Sanitary disposal of human wastes should be ensured by the use of pit latrines by all. These were observed in most of the Moslem but not in the non-Moslem compounds. Therefore, construction of latrines should be encouraged not only in homes but also in strategic places like schools, farms and along the road sides for public use. The people should be taught and assisted by the Local Government Health Authority in the construction of sanitary latrines which should be designed such that contamination of water supply will not occur. Behavioural modification of the people to alter human water contact patterns can be achieved by the provision of additional facilities such as public showering places for children and simple communal laundary units for the adults. These facilities should extend to the farms since farmers spend a large proportion of each day on the farms and are religious bound to perform wadu and ablutions during this period. Furthermore a need to quench their thirst and clean up after work arises during this period.

The provision of these facilities should reduce the prolonged contact and extensive bodily exposure, thus transmission, by discouraging contact with infected ponds, streams and rivers in the area.

Health education is important in any attempt at controlling any disease. It is important to explain to the people why it is necessary for them to avoid contact with water particularly around noon which was identified as the greatest risk of infection. Observations on the indiscriminate excretion and the admission by a larger majority of those questioned that they excrete near water sites call for some public enlightenment on the effect of such habit. The age group 5-14 years was identified to be responsible for most of the contamination of the environment. As this age group is generally the first to be reached, through schools, health education on the need for proper use of latrines to reduce contamination can easily be achieved. Furthermore, with the current attention on farmers, the adults could equally be educated on this need.

The low earth dams have been identified, in this study, as potential transmission sites of schistosomiasis amongst other water-borne diseases. Since these dams are perennial, a continuous and increased transmission is envisaged. The impact of the construction of these dams on schistosomiasis, amongst other water-borne diseases, is a reflection of the lack of health consideration in the building of these dams. Perhaps emphasis could have been

placed on the construction of boreholes if geological formations permit instead of low earth dams. In the development of water sources, adequate health consideration must be built in at the planning stage. Without such consideration what seemingly is a development would result in a health hazard.

REFERENCES CITED

Abdel-Salam, E. and Abdel Fattah, M. (1977): Prevalence and Morbidity of Schistosoma haematobium in Egyptian children. Am. J. Trop. Med. Hyg. 26 (3): 463-471.

Abul-Fadl, M. A. and Khalafallah, A. S. (1961): Studies on the urinary excretion of certain tryptophan metabolites in bilharziasis and its possible relation to bladder cancer in Egypt. Brit. J. Cancer 15: 479-482.

Adekolu-John, E. O. (1980): The probable impact of the proposed Jebba Dam on the health aspects of the River Niger Basin of Nigeria. Pub. Hlth., London 94 (4): 235-242.

Akinkugbe, O. O. (1962): Urinary schistosomiasis in Ibadan school-children. W. Afr. Med. J., 11: 124-127.

American Public Health Association (1971): Standard methods for the examination of water and waste water. 13th edit. New York: A.P.H.A.

Ansari, N. (1973): Epidemiology and control of schistosomiasis (Bilharziasis). Publ. on behalf of WHO by S. Karger-Basel-Munchen-Paris-London-New York-Sidney.

Appleton, C. C. (1978): Review of literature on abiotic factors influencing the distribution and life cycles of bilharziasis intermediate host snails. Malacol. Rev. 11: 1-26.

Asumu, D. I. (1975): Studies on the biology of snails and their larval trematodes in Ibadan Freshwater Systems. Ph.D. Thesis, Zoology. Univ. of Ibadan.

Barbosa, F. S. and Coêlho, M. V. (1955): Compartments das formas larvarias de Schistosoma mansoni em Australorbis glabratus (Mollusca Planorbidae), Sujertos a estivacao. pus; avuls Inst. Aggeu Magall e es, 4, 51.

Barbosa, F. S. and Olivier, L. (1958): Studies on the snail vectors of Bilharziasis mansoni in North-Eastern Brazil. Bull. WHO, 18: 895.

Barbosa, F. S.; Pinto, R. and Souza, C. A. (1971): Control of Schistosomiasis mansoni in a small northeast Brazilian Community. Trans. roy. Soc. trop. Med. Hyg. 65: 206-213.

Bell, D. R. and Howells, R. E. (1973): The Malumfashi Pilot Survey 1. Introduction: Malaria and urinary Schistosomiasis. Ann. Trop. Med. Parasit., 67 (1): 1-14.

Berrie, A. D. (1970): Snail problems in African Schistosomiasis. Adv. Parasit., 8: 43-96.

Black, C. A.; Evans, D. D.; White, J. L.; Ensminger, L. E. and Clark, F. E. (1965): Methods of Soil Analysis. Part 2. Chemical and Microbiological Properties. Publ. on behalf of Am. Soc. of Agr. and Am. Soc. for Testing and Materials. Publisher Madison, Winconsin, U.S.A.

Blacklock, D. B. and Thompson, M. G. (1924): Human schistosomiasis due to S. haematobium in Sierra Leone. Ann. Trop. Med. Parasit., 18: 211.

Blair, D. M. (1956): Bilharziasis survey in British West and East Africa, Nyasaland and the Rhodesias. Bull. WHO, 15: 203-273.

Boycott, A. E. (1936): The habitats of fresh water mollusca in Britain. J. Anim. Ecol., 5: 116-186.

Bradley, A. K., Gilles, H. M. and Shehu, U. (1977): Malumfashi Endemic Diseases Research Project 1. Some ecological and demographic considerations. Ann. Trop. Med. Parasit., 71: 443-449.

Bruce-Chwatt, L. J. (1968): Movements of populations in relation to communicable diseases in Africa. E. Afr. med. J. 45: 266-275.

Chapman, D. S. (1966): The surgical importance of bilharziasis in South Africa. Brit. J. Surg., 53: 544-557.

Cheng, T. C. (1974): Molluscicides in Schistosomiasis Control. - New York: Academic Press.

Chernin, E. and Antolics, V. M. (1973): Laboratory transmission of Schistosoma mansoni to snails via formites. J. Parasit. 59: 589-591.

Chernin, E. and Donavan, C. A. (1962): The influence of host parasite dispersion on the capacity of Schistosoma mansoni miracidia to infect Australorbis glabratus. Am. J. Trop. Med. Hyg. 11: 455-471.

Chernin, E. and Perlstein, J. M. (1969): Further studies on interference with the host-finding capacity of Schistosoma mansoni miracidia. J. Parasit. 55: 500-508.

Christie, J. D. and Upatham, E. S. (1977): Control of Schistosoma mansoni transmission by chemotherapy in St. Lucia II. Biological Results. Am. J. Trop. Med. Hyg. 26 (5): 894-898.

Chu, K. Y. (1978): Trials of ecological and chemical measures for the control of S. haematobium transmission in a Volta Lake village. Bull. WHO, 56 (2): 313-322.

Collard, P. (1962): A sample survey to estimate the prevalence of certain communicable diseases in Katsina Province, Northern Nigeria. W. Afr. Med. J., 11 (1): 3-31.

Collings, G. H. (1955): Commercial fertilizers. Their sources and use. 5th edit. Publ. by M^cGraw Hill. pp. 384-394.

Cowper, S. G. (1959): Notes on the snail vector of Schistosoma haematobium in the Ibadan area of Nigeria: With some observations on the pathology of the Liver and Spleen in Mice experimentally infected with S. haematobium and S. mansoni. W. Afr. Med. J. 8: 191.

Cowper, S. G. (1963): Schistosomiasis in Nigeria. Ann. Trop. Med. Parasit., 57: 307-321.

Cowper, S. G. (1973): Bilharziasis in Nigeria. Trop. Geog. Med., 25 (2): 105-118.

Cowper, S. G. and Woodward, S. F. (1961): Parasitic infections recorded at University College Hospital, Ibadan, Nigeria, over a three years period (1957-1960). W. Afr. Med. J., 10: 366.

Cowper, S. G. (1971): A synopsis of African Bilharziasis. London, Lewis, 1971.

Cridland, C. C. (1957a): Ecological factors affecting the numbers of snails in permanent-bodies of water. J. Trop. Med. Hyg., 60: 250.

Cridland, C. C. (1957b): Ecological factors affecting the numbers of snails in temporary bodies of water. J. Trop. Med. Hyg., 60: 287-293.

Cridland, C. C. (1958): Ecological factors affecting the numbers of snails in permanent stream. Ibid., 61: 16.

Dalton, P. R. (1976): A socio-ecological approach to the control of S. mansoni in St. Lucia. Bull. WHO, 54 (5): 587-595.

Dalton, P. R. and Pole, D. (1978): Water contact patterns in relation to S. haematobium infection. Bull. WHO, 56 (3): 417-426.

Dazo, B. C., Hairston, N. G., and Dawood, I. K. (1966): The ecology of Bulinus truncatus and Biomphalaria alexandrina in the Egypt-49 project areas. Bull. WHO 35: 339-356.

Diamant, B. Z. (1977): Environmental engineering control of Bilharzia in the Middle East. Middle East Water and Sewage 1 (2): 71-99.

Donges, J. (1972): An ecological study of Schistosoma haematobium in the forest region of South-West Nigeria. Z. Tropenmed. Parasitol., 23 (3): 272-277.

Edington, G. M. (1957): Schistosomiasis in Ghana with special reference to its pathology. W. Afr. Med. J., 6: 45-57.

Edington, G. M., von Lichtenberg, F., Nwabuebo, I., Taylor, J. R. and Smith, J. H. (1970): Pathologic effects of Schistosomiasis in Ibadan, Western State of Nigeria. Am. J. Trop. Med. Hyg., 19 (6): 982-995.

Edungbola, L. D. (1980): Water utilization and its health implications in Ilorin, Kwara State, Nigeria. Acta Tropica 37 (1): 73-81.

Ejezie, G. C. (1981): The parasitic diseases of school children in Lagos State, Nigeria. Acta Tropica, 38: 79-84.

Ejezie, G. C. and Ade-Serrano, M. A. (1981): Schistosoma haematobium in Ajara Community of Badagry; A study on prevalence, intensity and morbidity. Trop. Geogr. Med., 33: 175-180.

Essien, E. S. and Osuhor, P. C. (1979): Rural water quality control measures: an experience in the Malumfashi District of Northern Nigeria. Publ. Hlth., Lond. 93: 363-370.

Farooq, M. (1973): Review of National Control Programmes. In 'Epidemiology and Control of Schistosomiasis (Bilharziasis)'. Edited by Ansari S. Karger, pp. 392-404.

Farooq, M. and Mallah, M. B. (1966): The behavioural pattern of Social and Religious Water-Contact activities in the Egypt-49 bilharziasis project area. Bull. WHO, 35: 377-387.

Federal Republic of Nigeria. THIRD NATIONAL DEVELOPMENT PLAN 1975-80; Volume II. Project Summary. Publ. The Central Planning Office; Fed. Min. of Econ. Dev., Lagos.

Fenwick, A. (1969): Baboons as Reservoir Hosts of Schistosoma mansoni. Trans. roy Soc. trop. Med. Hyg. 63: 557-567.

Forsyth, D. M. (1969): A longitudinal study of endemic urinary schistosomiasis in a small East African Community. Bull. WHO, 40 (5): 771-783.

Forsyth, D. M. and Bradley, D. J. (1964): Irreversible damage by S. haematobium in school -children. Lancet., 2: 169-171.

Forsyth, D. M. and Bradley, D. J. (1966): The consequences of bilharziasis - Medical and Public health importance in North-West Tanzania. Bull. WHO., 34: 715-735.

Forsyth, D. M. and Macdonald, G. (1965): Urological complications of endemic schistosomiasis in school-children. I. Usagara School. Trans. roy. Soc. trop. Med. Hyg. 59: 171-178.

Forsyth, D. M. and Macdonald, G. (1966): Urological complications of endemic schistosomiasis in school-children. 2. Donge School, Zanzibar. Trans. roy. Soc. trop. Med. Hyg. 60 (5): 568-578.

Foster, R. (1967): Schistosomiasis on an irrigated estate in East Africa. 2. Epidemiology. J. Trop. Med. Hyg., 70 (7): 159-168.

Frandsen, F. and Madsen, H. (1979): A review of Helisoma duryi in biological control. Acta Tropica, 36: 67-84.

Gelfand, M., Hunt, R. H. and Clarke, V. de V. (1965): Visceral deposition of schistosome ova in Central Africans. J. Trop. Med. Hyg. 68 (10): 245-247.

Gilles, H. M., Lucas, A., Adeniyi-Jones, C., Lindner, R., Anand, S. V., Braband, H., Cockshott, W. P., Cowper, S. G., Muller, R. L., Hira, P. R., Wilson, A. M. M. (1965a): Schistosoma haematobium infection in Nigeria. 11. Infection at a primary school in Ibadan. Ann. Trop. Med. Parasit., 59: 441-450.

Gilles, H. M., Lucas, A., Lindner, R., Cockshott, W.P., Anand, S. V., Ikeme, A. and Cowper, S. G. (1965b). Schistosoma haematobium infection in Nigeria III. Infection in boatyard workers at Epe. Ann. Trop. Med. Parasit. 59: 451-456.

Gordon, R. M., Davey, T. H. and Peaston, H. (1934): The transmission of human bilharziasis in Sierra Leone, with an account of the life cycle of the schistosomes concerned, S. mansoni and S. haematobium. Ann. Trop. Med. Parasit. 28:323.

Gordon-Smith, C. E. (1972): Changing patterns of disease in the tropics. Brit. med. Bull. 28: 3.

Hairston, N. G. (1961): Suggestions regarding some problems in the evaluation of molluscicides in the field. Bull. WHO, 25: 731.

Hairston, N. G. (1973): The Dynamics of Transmission. In 'Epidemiology and Control of Schistosomiasis (Bilharziasis). Edited by Ansari S. Karger; pp. 325-336.

Harry, H. W., Cumbie, B. G. and Martinez de Jesus, J. (1957): Studies on the quality of freshwaters of Puerto Rico relative to the occurrence of Australorbis glabratus (Say). Am. J. Trop. Med. Hyg. 6: 313-322.

Heffer, W. and Sons Ltd; (1960): The examination of water. Approved methods for the physical and chemical examination of water. Cambridge, England.

Hill, D. H. and Onabamiro, S. D. (1960): Vesical schistosomiasis in the domestic pig., Brit. Vet. J., 116 (4): 146-150.

Hira, P. R. (1969a): Aspects of the transmission of S. haematobium Bilhar? in Ibadan, Nigeria. W. Afr. Med. J., 18 (1): 28-32.

Hira, P. R. (1969b): Aspects of S. haematobium infection in Bulinus (Physopsis) globosus in Ibadan. W. Afr. Med. J., 18: 59-61.

Hira, P. R. (1970): Aspects of spread and control of schistosomiasis in Ibadan, Nigeria. W. Afr. Med. J., 19 (6): 180-183.

Hira, P. R. and Muller, R. (1966): Studies on the ecology of snails transmitting urinary Schistosomiasis in W. Africa, Nigeria. Ann. Trop. Med. Hyg. 60: 198-211.

Hoffman, Jr. D. B., Lehman, Jr., J. S., Scott, V. C., Warren, K. S. and Webbe, G. (1979): Control of schistosomiasis: report of a workshop. Am. J. Trop. Med. Hyg., 28 (2): 249-259.

Husting, E. L. (1965): A probable method of transmission of Schistosoma mansoni. Centr. Afr. J. Med. 11: 330-331.

Husting, E. L. (1970): Sociological patterns and their influence on the transmission of bilharziasis. Centr. Afr. J. Med. 16: 5-10.

Iarotski, L. S. and Davis, A. (1981): Schistosomiasis in the world. Bull. WHO; 59 (1): 115-127.

Jobin, W. R., Ruiz-Tiben, E. (1968): Bilharzia and patterns of human contact with water in Puerto Rico. Bol. Asoc. méd. P. Rico; 60: 279-284.

Jobin, W. R., Brown, R. A., Velez, S. P., Ferguson, F. F. (1977): Biological control of Biomphalaria glabrata in major reservoirs of Puerto Rico. Am. J. Trop. Med. Hyg. 26: 1018-1024.

Jordan, P. (1972): Epidemiology and control of schistosomiasis. Brit. med. Bull. 28: 55-59.

Jordan, P. (1977): Schistosomiasis - research to control. Am. J. Trop. Med. Hyg., 26: 877-885.

Jordan, P., Bartholomew, R. K., Unrau, G. O. and Cook, J. A. (1975): Control of S. mansoni transmission by provision of domestic water supplies. Bull. WHO. 52: 9-20.

Jordan, P., Bartholomew, R. K., Unrau, G. O., Upatham, E. S., Grist, E., Christie, J. D. (1978): Further observations from St. Lucia on control of Schistosoma mansoni transmission by provision of domestic water supplies. Bull. WHO., 56: 965-973.

Jordan, P., Christie, J. D., Unrau, G. O. (1980): Schistosomiasis transmission with particular reference to possible ecological and biological methods of control. A review. Acta Tropica, 37: 95-135.

Klumpp, R. K. and Chu, K. Y. (1977): Ecological studies of B. rohlfsi, the intermediate host of S. haematobium in the Volta Lake. Bull. WHO., 55 (6): 715-730.

Lucas, A. O., Adeniyi-Jones, C. C., Cockshott, W. P. and Gilles, H. M. (1966): Radiological changes after medical treatment of vesical schistosomiasis. Lancet 1: 631-633.

Luttermoser, G. W. (1963): Infection of rodents with S. mansoni by ingestion of infected snails. J. Parasit. 49: 150.

Lyons, G. R. L. (1972): Ghana 2101: A schistosomiasis control programme depending on the use of molluscicides alone. WHO Expert Committee on Schistosomiasis Control. SCHISTO/WP/72. 6.

Macdonald, G. and Forsyth, D. M. (1968): Urologic complications of endemic schistosomiasis in school-children. Trans. roy. Soc. trop. Med. Hyg. 62: 775-781.

Maldonado, J. F., Acosta-Matienzo, J. and Thillet, C. J. (1949): Biological studies on the miracidium of Schistosoma mansoni miracidia. Part 2. Behaviour of the unhatched miracidium in undiluted stools under diverse environmental conditions. Puerto Rico J. publ. Hlth. trop. Med. 25: 153-174.

Malek, E. A. (1958): Factors conditioning the habitats of bilharziasis intermediate host of the family Planorbidae. Bull. WHO., 18: 785-818.

Malek, E. A. and Cheng, T. C. (1974): Medical and Economic Malacology. Academic Press.

Mandahl-Barth, G. (1958): Intermediate hosts of Schistosoma: African Biomphalaria and Bulinus, Geneva, WHO Monograph series, No. 37.

Mandahl-Barth, G. (1965): The species of the Genus Bulinus, Intermediate Hosts of Schistosoma. Bull. WHO., 33: 33-44.

Matovu, D. B. (1978): Prospects of schistosomiasis at the Kidatu dam project in Tanzania. Trop. Geog. Med., 29 (3): 266-70.

M^{c}Clelland, W. F. J. (1967): Production of Schistosoma haematobium and Schistosoma cercariae in Tanzania. Exp. Parasit. 20: 205.

M^{c}Cullough, F. S. (1956): Transmission of Schistosoma haematobium by Bulinus sp. in Ke district of Gold Coast. Trans. roy. Soc. trop. Med. Hyg. 50: 449-457.

M^{c}Cullough, F. S. (1957a): A preliminary note on the degree of compatibility between Schistosoma haematobium and its bulinid vectors. W. Afr. Med. J., 6: 98.

M^{c}Cullough, F. S. (1957b): The seasonal density of populations of Bulinus (Physopsis) globosus and B. forskalii in natural habitats in Ghana. Ann. Trop. Med. Parasit., 51: 235.

M^{c}Cullough, F. S. (1962): Observation of Bulinus (Bulinus) truncatus rohlfsi (Clessius) in Ghana: the distribution of the snails and their role in the transmission of S. haematobium. Ann. Trop. Med. Parasit., 56: 53.

M^{c}Cullough, F. S. (1981): Biological control of the snail intermediate host of human Schistosoma spp: A review of its present status and future prospects. Acta Tropica, 33 (1): 5-13.

M^{c}Cullough, W. E. (1927): The incidence of Amoebic and helminthic infections in Kano and Katsina cities, Northern Nigeria. J. Trop. Med. Hyg. 30: 117.

M^{c}Mullen, D. B. (1947): The control of Schistosoma japonica; 1: Observations on the habitats, ecology and life cycle of Oncomelania quadrasi, the molluscan intermediate host of Schistosoma japonicum in the Philippine Islands. Am. J. Hyg., 45: 259.

Moore, L. V. and Meleney, H. E. (1955): Development of Schistosoma mansoni in the peritoneal cavity of mice. J. Parasit. 41: 235.

Mozley, A. (1959): Ecological processes. Lond. Lewis.

Ndifon, T. G. (1979): Studies on the feeding, biology, anatomical variations and ecology of vectors of schistosomiasis and other freshwater snails in South Western Nigeria. Ph.D. Thesis, Zoology; Univ. of Ibadan.

Nelson, G. S. (1975): Schistosomiasis. Pages 220-240. Diseases transmitted from animals to man., 6th edit. Charles C. Thomas, Springfield, Illinois.

Nelson, G. S., Teesdale, C. and Highton, R. B. (1962): The role of animals as reservoirs of Bilharziasis in Africa. In 'Bilharziasis': Ciba foundation symposium, p. 127; London: Churchill.

Nnochiri, E. (1966): Urinary schistosomiasis: A review of 179 cases seen in a Lagos clinic. W. Afr. Med. J., 15: 17-21.

Okpala, I. (1961): Studies on Schistosoma haematobium infection in school-children in Epe, Western Nigeria. W. Afr. Med. J. 10 (6): 402-412.

Okwuosa, V. N. (1979): The ecological study of freshwater snails with particular reference to schistosome vectors in Lagos, Oyo and Ogun States of Nigeria. Ph.D. Thesis, Univ. of Ibadan.

Oldenburg, E. (1942): Gesundheitsverhaltnisse und-einrichtungen, arztliche Versorgung und Wishcgste Infektio-nskrankheiten in Nigeria in den Jahren 1921-1937 Dtsch. tropenmed. Z. 46: 193.

Olivier, L. and Barbosa, F. S. (1955a): Seasonal studies on Australorbis glabratus. Say from two localities in eastern Pernambuco, Brazil. Publ. avuls. Inst. Aggeu Magulhaes, 4: 79.

Olivier, L. and Barbosa, F. S. (1955b): Seasonal studies on Tropicorbis Centrimentralis in north-eastern Brazil. Ibid., 4: 105.

Olivier, L. and Stirewalt, M. A. (1952): An efficient method for exposure of mice to cercariae of Schistosoma mansoni. J. Parasit. 38: 19.

Onabamiro, S. D. (1971): Studies on schistosomiasis in Sierra Leone - 1. Ann. Trop. Med. Parasit. 65 (4): 497-504.

Oyediran, A. B. O. O. (1976): Renal function in vesical schistosomiasis. M. D. Thesis. Univ. of Ibadan.

Oyediran, A. B. O. O. and Akinkugbe, O. O. (1970): Chronic renal failure in Nigeria. Trop. Geog. Med. 21: 41-44.

Oyediran, A. B. O. O., Abayomi, I. O., Akinkugbe, O. O., Bohrer, S. P. and Lucas, A. O. (1975): Renographic studies in vesical schistosomiasis in children. Am. J. Trop. Med. Hyg., 24 (2): 274-279.

Pan, C. T., Williams, R. R., Ritchie, L. S. (1954): The penetration-time for cercariae of Schistosoma japonicum. Am. J. trop. Med. Hyg. 3: 136-138.

Paperna, I. (1969): Study of an outbreak of schistosomiasis in the newly formed Volta Lake in Ghana. Z. Tropenmed. Parasitol., 21 (4): 411-424.

Parent, M. and Lietar, J. (1955): Contribution à l'étude de la biologie des mollusques a jadot ville. Ann. Soc. belge Méd trop. 35: 59.

Pesigan, T. P., Farooq, M., Hairston, N. F., Jaurequi, J. J. Garcia, E. G., Santos, A. T. B. C., Besa, A. A. (1958a): Studies on Schistosoma japonicum in the Philippines. I. General considerations and epidemiology. Bull. WHO., 18: 345-455.

Pesigan, T. P., Farooq, M., Hairston, N. F., Jaurequi, J. J., Garcia, E. C., Santos, A. T. B. C., and Besa, A. A. (1958b): Studies on Schistosoma japonicum in the Philippines. 2. The molluscan host. Bull. WHO., 18: 481-578.

Pimentel, D., Gerhardt, C. E., Williams, E. R., White, P. C. Jr., Ferguson, F. F. (1961): Aspects of schistosomal endemicity in three Puerto Rican watershed. Am. J. Trop. Med. 10: 523-529.

Pi-Sunyer, F., Gilles, H. M. and Wilson, A. M. M. (1965): Schistosoma haematobium infection in Nigeria. I. Bacteriological and immunological findings in the presence of schistosomal infection. Ann. Trop. Med. Parasit. 59: 304-311.

Pitchford, R. J. (1959): Natural schistosome infections in South African rodents. Trans. roy. Soc. trop. Med. Hyg., 53: 213.

Pitchford, R. J. (1970): Control of bilharziasis by rural management. Centr. Afr. J. Med. 23: 31-33.

Pitchford, R. J. (1977): African schistosomes, distribution, final hosts. J. Helminth. 51: 252-299.

Prentice, M. A., Panesar, T. S. and Coles, G. C. (1970): Transmission of Schistosoma mansoni in a large body of water. Ann. Trop. Med. Parasit. 64: 339-348.

Propert, A. J. (1965): Studies on larval trematodes infecting the freshwater molluscs of Llangorse Lake, South Wales. J. Helminth. 39 (1): 35-52.

Pugh, R. N. H. (1978): Malumfashi Endemic Diseases Research Project, V. Concurrent single dose metrifonate and niridazole in urinary schistosomiasis. Ann. Trop. Med. Parasit. 72 (5): 495-497.

Pugh, R. N. H. (1979a): Periodicity of output of S. haematobium eggs in the urine. Ann. Trop. Med. Parasit. 73 (1): 89-90.

Pugh, R. N. H. (1979b): Malumfashi Endemic Diseases Research Project; VII. The importance of young males from the Malumfashi area, Northern Nigeria, in the transmission of Schistosoma haematobium infection. Ann. Trop. Med. Parasit. 73 (2): 189-190.

Pugh, R. N. H. and Gilles, H. M. (1979c): Malumfashi Endemic Diseases Research Project, VIII. Follow-up intravenous urograms of boys infected with Schistosoma haematobium from the Malumfashi area. Ann. Trop. Med. Parasit. 73 (2): 191-192.

Pugh, R. N. H. and Gilles, H. M. (1979): Malumfashi Endemic Diseases Research Project. III. Urinary schistosomiasis: a longitudinal study. Ann. Trop. Med. Parasit. 72: 471-482.

Pugh, R. N. H., Jakubowski, A. W. and Gilles, H. M. (1979d): Malumfashi Endemic Diseases Research Project. VI. Urinary schistosomiasis: abnormal urograms in infected males from the Malumfashi study area, northern Nigeria. Ann. Trop. Med. Parasit. 73 (1): 37-44.

Pugh, R. N. H., Schillhorn van Veen, T. W. and Tayo, M. A. (1980a): Malumfashi Endemic Diseases Research Project. XII. Schistosoma bovis and Fasciola gigantica in livestock. Ann. Trop. Med. Parasit. 74 (4): 447-453.

Pugh, R. N. H., Burrows, J. W. and Tayo, M. A. (1980b): Malumfashi Endemic Diseases Research Project. XIV. Increasing schistosomiasis transmission. Ann. Trop. Med. Parasit. 74 (5): 569-570.

Pugh, R. N. H., Bell, D. R. and Gilles, H. M. (1980c): Malumfashi Endemic Diseases Research Project. XV. The potential medical importance of bilharzia in northern Nigeria: a suggested rapid, cheap and effective solution for control of Schistosoma haematobium infection. Ann. Trop. Med. Parasit. 74 (6): 597-613.

Purnell, R. E. (1966): Host parasite relationships in schistosomiasis. II. The effects of age and sex on the infection of mice and hamsters with cercariae of Schistosoma mansoni and of hamsters with cercariae of Schistosoma haematobium. Ann. Trop. Med. Parasit. 60: 94.

Ramsey, G. W. (1934): A study on Schistosomiasis and certain other helminthic infections in Northern Nigeria. W. Afr. Med. J., 8 (2): 2-10.

Ritchie, L. S., Radke, M. G. and Fergusson, F. F. (1962): Population dynamics of Australorbis glabratus in Puerto Rico. Bull. WHO; 27: 171-181.

Rowan, W. B. (1957): A simple device for determining population density of Schistosoma mansoni cercariae in infected waters. J. Parasit. 43: 396-697.

Rowan, W. B. (1958): Daily periodicity of Schistosoma mansoni cercariae in Puerto Rican waters. Am. J. Trop. Med. Hyg. 7: 374-381.

Rowan, W. B. (1959): Seasonal effect of heavy rains on the population density of Australorbis glabratus in a Puerto Rican watershed. Am. J. Trop. Med. Hyg. 8: 570.

Rowan, W. B. (1964): Sewage treatment and schistosome eggs. Am. J. Trop. Med. Hyg. 13: 572-576.

Rowan, W. B. (1965): The ecology of Schistosoma Transmission Foci. Bull. WHO., 33: 63-71.

Rowan, W. B. and Gram, A. L. (1959): Relation of water velocity to Schistosoma mansoni infection in mice. Am. J. Trop. Med. Hyg. 8: 630-634.

Ruyssenaars, J., Van Etten, G. and M^{c}Cullough, F. (1973): Population movements in relation to the spread and control of schistosomiasis in Sukumaland, Tanzania. Trop. Geog. Med. 25 (2): 179-186.

Saladin, B., Saladin, K., Dennis, E. and Dégremont, A. (1980). Preliminary epidemiological survey of schistosomiasis in central and southern Liberia. Acta Tropica; 37: 53-62.

Schillhorn van Veen, T. W., Shonekan, R. A. O. and Fabiyi, J. P. (1975): A host parasite check-list of helminth parasites of domestic animals in Northern Nigeria. Bull. Anim. Hlth. Prod. Afr., 23: 269-288.

Schwetz, J. (1954): On two Schistosomes of Wild Rodents of the Belgian Congo, S. rodhaini Brumpt, 1931 and S. mansoni var rodentorum Schwetz, 1953 and their relationship to S. mansoni in Man; Trans. roy. Soc. trop. Med. Hyg., 48: 89-100.

Shaw, A. F. and Ghareeb, A. A. (1938): The pathogenesis of pulmonary schistosomiasis in Egypt with special reference to Ayerza's disease. J. Path. Bact. 46: 401-424.

Shiff, C. J. (1964a): Studies on Bulinus (Physopsis) globosus in Rhodesia. I: The influence of temperature on the intrinsic rate of natural increase. Ann. Trop. Med. Parasit., 58 (1): 94-105.

Shiff, C. J. (1964b): Studies on Bulinus (Physopsis) globosus in Rhodesia. III: Bionomics of a natural population existing in a temporary habitat. Ann. Trop. Med. Parasit., 58: 240.

Shiff, C. J. (1968): Location of Bulinus (Physopsis) globosus by miracidia of Schistosoma haematobium. J. Parasit. 54: 1133-1140.

Shiff, C. J. (1974): Seasonal factors influencing the location of Bulinus (Physopsis) globosus by miracidia of Schistosoma haematobium in nature. J. Parasit. 60 (4): 578-583.

Shiff, C. J. and Clarke, V. de V. (1967): The effect of snail surveillance in natural waterways on the transmission of Schistosoma haematobium in Rhodesia. Centr. Afr. J. Med. 13: 133-137.

Siegal, F. M. (1968): Schistosomiasis haematobia in pre-school children of Ibadan, Nigeria. Am. J. Trop. Med. Hyg. 17 (5): 737-742.

Smith, V. G. F. (1975): The effects of pollution in a small stream near Samaru in Northern Nigerian Savanna, Vol. 4 (2): 155-172.

Smithers, S. R. (1956): On the ecology of Schistosome vectors in the Gambia with evidence of their role in transmission. Trans. roy. Soc. trop. Med. Hyg., 50: 354.

Smithers, S. R. and Terry, R. J. (1965): The infection of laboratory hosts with cercariae of Schistosoma mansoni and the recovery of adult worms. Parasit. 55: 695.

Sodeman, W. A. (1979): A longitudinal study of schistosome vector snail populations in Liberia. Am. J. Trop. Med. Hyg., 28 (3): 531-538.

Southwood, T. R. E. (1977): Habitat, the templet for ecological strategies? J. anim. Ecol. 46: 337-365.

Soyanwo, M. A. O. (1973): Studies on the prevalence of renal disease and hypertension in relation to schistosomiasis. M. D. Thesis. University of Ibadan.

Sturrock, B. M. (1966): The influence of infection with Schistosoma mansoni on the growth rate and reproduction of Biomphalaria pfeifferi. Ann. Trop. Med. Parasit. 60: 187-197.

Sturrock, R. F. (1965): Studies on the biology of Biomphalaria angulosa Mardahl-Barth and on its ability to act as an intermediate host of Schistosoma mansoni. Ann. Trop. Med. Parasit. 59: 1-9.

Sturrock, R. F. (1973): Control of Schistosoma mansoni transmission: strategy for using molluscicides on St. Lucia. Intl. J. Parasit., 3.(6): 795-801.

Taylor, A. N. (1932): An enquiry into the origin of an Outbreak of Schistosomiasis among Europeans at Kagoro, Northern Nigeria. W. Afr. Med. J., 5: 61.

Tayo, M. A. and Jewsbury, J. M. (1978): Malumfashi Endemic Diseases Research Project. IV: Changes in snail populations following the construction of a small dam. Ann. Trop. Med. Parasit. 72 (5): 483-487.

Tayo, M. A., Pugh, R. N. H., Bradley, A. K. (1980): Malumfashi Endemic Diseases Research Project. XI: Water-contact activities in the Schistosomiasis study area. Ann. Trop. Med. Parasit. 74 (3): 347-354.

Teesdale, C. (1962): Ecological observations on the Molluscs of significance in transmission of Bilharziasis in Kenya. Bull. WHO., 27: 759-782.

Unrau, G. O. (1975): Individual household water supplies in rural St. Lucia as a control measure against Schistosoma mansoni. Bull. WHO., 52: 1-8.

Upatham, E. S. (1972a): Exposure of caged Biomphalaria (Say) to investigate dispersion of miracidia of Schistosoma mansoni Sambon in simulated field and field habitats in St. Lucia, West Indies. J. Helminth. 46: 297-306.

Upatham, E. S. (1972b): Observations on the effect of unsusceptible aquatic animals on the capacity of the miracidia of Schistosoma mansoni Sambon to infect Biomphalaria glabrata (Say) under field simulated conditions in St. Lucia, West Indies. J. Helminth. 46: 277-283.

Upatham, E. S. (1973): Location of Biomphalaria Glabrata (Say) by miracidia of Schistosoma mansoni Sambon in natural standing and running waters on the West Indian Island of St. Lucia., Int. J. Parasit., 3: 289-297, Perganon Press, Great Britain.

Upatham, E. S. (1981): Studies on the transmission of Schistosoma haematobium and the bionomics of Bulinus (Ph.) abyssinicus in the Somali Democratic Republic. Ann. Trop. Med. Parasit. 75 (1): 63-69.

Upatham, E. S. and Sturrock, R. F. (1973): Field investigations on the effect of other aquatic animals on the infection of Biomphalaria glabrata by Schistosoma mansoni miracidia. J. Parasit. 59 (3): 448-453.

Upatham, E. S., Sturrock, R. F., Cook, J. A. (1976): Studies on the hatchability of Schistosoma mansoni eggs from a naturally infected human community on St. Lucia, West Indies. Parasit., 73: 253-264.

Upatham, E. S., Koura, M., Ahmed, M. D. and Awad, A. H. (1981): Studies on the transmission of Schistosoma haematobium and the bionomics of Bulinus (Ph.) abyssinicus in the Somali Democratic Republic. Ann. Trop. Med. Parasit., 75 (1): 63-69.

Van Someren, V. D. (1946): The habitats and tolerance ranges of Lymnae (Radix) Caillaudi the intermediate snail host of liver fluke in East Africa. J. Anim. Ecol., 15: 170-197.

Waddy, B. B. (1975): Research into the health problems of man-made lakes with special reference to Africa. Trans. roy. Soc. trop. Med. Hyg., 69: 39-50.

Warren, K. S. (1973): Regulation of the prevalence and intensity of schistosomiasis in man. Immunology or ecology? J. inf. Dis. 127: 595-609.

Warren, K. S. (1978): The pathology, pathobiology and pathogenesis of schistosomiasis. Nature 273 (5664): 609-612.

Warren, K. S. and Jane, J. A. (1967): Comparative susceptibility of Schistosoma mansoni of the squirrel monkey, the slow loris and the tree shrew. Trans. roy. Soc. trop. Med. Hyg. 61: 534.

Warren, K. S., and Peters, P. A. (1967): Quantitative aspects of exposure time and cercarial dispersion on penetration and maturation of Schistosoma mansoni in mice. Ann. Trop. Med. Parasit. 61: 294-301.

Webbe, G. (1960): Observations on the seasonal fluctuation of snail population densities in the Northern Province of Tangayinka. Ann. Trop. Med. Parasit., 54: 54-59.

Webbe, G. (1962a): The transmission of Schistosoma haematobium in an Area of Lake Province, Tangayinka. Bull. WHO., 27: 59-85.

Webbe, G. (1962b): Population studies of Intermediate hosts in relation to transmission of bilharziasis in East Africa. In Bilharziasis: Ciba Foundation Symposium, P. 7, London: Churchill.

Webbe, G. (1964a): Biology of Intermediate hosts of Schistosomiasis with particular reference to control of transmission. Ann. Trop. Med. Parasit. 58 (2): 228-232.

Webbe, G. (1964b): Control of transmission of Schistosoma mansoni (Sambon) in the Mirenge River. East. Afr. Med. J., 41: 508-519.

Webbe, G. (1965a): Transmission of Bilharziasis. I. Some essential aspects of snail population dynamics and their study. Bull. WHO., 33: 147-153.

Webbe, G. (1965b): Transmission of Bilharziasis. II. Production of cercariae. Bull. WHO., 33: 155-162.

Webbe, G. (1974): Molluscicides in Schistosomiasis Control. Ed. T. C. Cheng. Academic Press Inc., pp. 41-50. New York and London.

Webbe, G. and Msangi, A. S. (1958): Observations of three species of Bulinus on the east coast of Africa. Ann. Trop. Med. Parasit., 52: 302-314.

Wilkins, H. A. and El-Sawy, M. (1977): Schistosoma haematobium egg counts in a Nile delta community. Trans. roy. Soc. trop. Med. Hyg. 71 (6): 486-489.

William, N. V. (1970): Studies on aquatic pulmonate snails in Central Africa. I. Field distribution in relation to water chemistry. Malacologia, 10: 153-164.

World Health Organization (1953): Expert Committee on Bilharziasis. First Report, Tech. Rep. Ser., No. 65.

World Health Organization (1954): Bilharzia snail vector identification and classification. Tech. Rep. Ser., No. 90.

World Health Organization (1957): African Conference on Bilharziasis. Tech. Rep. Ser., No. 139.

World Health Organization (1965): Expert Committee on Bilharziasis. Third Report., Tech. Rep. Ser., No. 299.

World Health Organization (1967a): Measurement of Public Health Importance of Bilharziasis. Tech. Rep. Ser., No. 349.

World Health Organization (1967b): Epidemiology and Control of Schistosomiasis. Tech. Rep. Ser., No. 372.

World Health Organization (1972): Community Water Supply Programme: Progress report by the Director General. Twenty-fifth World Health Assembly. A 25/29, Geneva; 24 pp.

World Health Organization (1973a): A field guide to African Freshwater Snails. I: West African species; WHO. Snail Identification Centre. Danish Bilharziasis Laboratory.

World Health Organization (1973b): Schistosomiasis Control. Tech. Rep. Ser. No. 515.

World Health Organization (1980): Epidemiology and Control of Schistosomiasis. Tech. Rep. Ser. No. 643.

Wright, C. A. (1956): A note on the ecology of some molluscan intermediate hosts of African Schistosomiasis Ann. Trop. Med. Parasit. 50 (4): 345-349.

Wright, W. H. (1973): Geographical Distribution of Schistosomes and their Intermediate Hosts. In 'Epidemiology and Control of Schistosomiasis (Bilharziasis)'. Edited by Ansari.S. Karger; pp. 42-137.

APPENDIX

A. Distribution of study population by age and sex.

B. Form on the distribution of wells in the villages.

C. Snail collection record.

D. Soil survey form.

E. Physical features of the low earth dams.

F. Physical features of Ruwan Sanyi dam.

G. Man-water contact study questionnaire form.

H. Man-water contact study observation form.

I. Analysis of soil samples from survey sites.

J. Chemical examination of water collected from snail habitats.

K. Growth of laboratory bred B. (P.) globosus.

L. Distribution of S. haematobium and S. mansoni infections in snails collected from 22 ponds.

M. Distribution of S. haematobium and S. mansoni infections in snails collected from 22 river sites.

N. Distribution of S. haematobium and S. mansoni infections in snails collected from 8 stream sites.

O. Distribution by size of infected B. (P.) globosus from natural habitats.

P. Proportion by size of infected B. (P.) globosus.

Q. Cercarial shedding by different size groups of B. (P.) globosus.

R. Daily pattern of output of S. haematobium cercariae from B. (P.) globosus.

S. Diurnal shedding of S. haematobium cercariae by B. (P.) globosus.

Appendix A: Distribution of study population by age and sex.

Age group (in years)	Males	Females	Total	% Total
0-4	1,558	1,461	3,019	24.0
5-9	1,069	1,071	2,140	16.7
10-14	628	503	1,131	8.9
15-19	434	743	1,177	9.2
20-29	850	1,283	2,138	16.7
30-39	659	710	1,369	10.7
40-49	546	433	979	7.7
50-59	282	179	461	3.6
60-69	162	80	242	1.9
70-79	59	27	86	0.67
80-89	13	1	19	0.15
90-99	10	2	12	0.09
100+	3	1	4	0.03
Total	6,278	6,499	12,777	100.00

Appendix B: Form on the distribution of wells in the villages. Date:

NUMBER	NAME	VILLAGE	DRY	HAS WATER	COVERED	NOT COVERED	CEMENTED	NOT CEMENTED

Appendix C: Snail collection record.

Date: ..... Time: ..... Village: .....

Waterbody: PERMANENT, STAGNANT, SEASONAL, RUNNING

Type: ..... Name: ..... Code: .....

Nature of bottom: ROCK, SAND, CLAY, HUMUS, DECAYING MATTER

Aquatic vegetation: DENSE, LIGHT

Type: .....

Sun exposure of the habitat FULL/HALF/NOT EXPOSED

Colour of water: CLEAR, MUDDY, GREEN

Temp. of habitat: ..... Temp. of microhabitat: .....

Air temperature: .....

Aquatic birds or mammals: .....

Contact with and use by population: .....

Distance of water from hamlet: .....

Climate: DRY, RAIN, FLOOD PERIODS

Other information: .....

Water analysis:

SNAILS COLLECTED

Type:	BULINUS			BIOMPHALARIA			OTHERS		
Size division	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Total No.									
Total No. alive									
Total No. dead									
Total No. with cercariae									
Total No. without cercariae									

Type of cercariae: .....

Appendix C: (Cont'd)

SNAIL:- Information

COLLECTED:- DATE OF COLLECTION:-

CODE:- SIZE:- SPECIES:-

CECARIAE: INFORMATION

1. MOVEMENT: Rapid
   Slow
   Moderate

2. ENCYSTMENT ON GLASS: Does
   Does not

3. PRESENCE OF EYES: Present
   Not present

4. SUCKERS:- Anterior present/Not present
   Caudal present/Not present
   Central present/Not present

5. TAILS
   A. SHAPE: Bifurcate
   Single
   B. LENGTH: Short
   Long
   Medium
   C. THICKNESS: Stout
   Slender
   Moderate

6. GLANDS:- Pre - Acetabular gland present/not present
   Post - " " " / " "

7. STYLET:- Present
   Not present

8. SPINES:- Present
   Not present

9. HOOKS:- Present
   Not present

10. BODY:- (A) Length: Short
    Long
    Medium
    (B) Thickness: Stout
    Slender
    (C) DRAW SHAPE

Appendix E: I

Dam	Local Govt. Area	Capac FSL ac.ft
Tandama	Funtua	108.0
Kabomo	"	40.0
Camji	"	85.8
Sabua	"	200.0
Gidan Sambo	"	559.3
Tafoki	"	600.6
Kakumi	"	59.6
Sheni	"	76.2
Kankara	Malumfashi	47.7
Kankara town	"	40.7
Yargoje	"	46.3
Malumfashi	"	150.9
Dayi	"	231.6
Ruwan Sanyi	"	203.5
Dutsin Kura	"	85.1
Ganzago	"	37.0
Rigoji	"	64.0
Gurbi	"	33.0
Gundawa	"	78.0
Dan Narabau	"	140.0
Average		51.2
Range		33-
		600.6

Appendix D: Soil survey form.

SURVEY AREA TRAVERSE POINT DATE SAMPLED DATE ANALYSED

CLASSIFICATION:

IDENTIFICATION			MECHANICAL COMPOSITION								pH		BASE EXCHANGE						CALCULATED VALUE			
Bag No.	Depth cm	Lab. No.	Clay 2	Fine Silt 2-20	Coarse Silt 20-50 M I	Fine Sand 50-200 C R O	Coarse Sand 200 M S	% Stones	F:C Sand	H_2O	$CaCl_2$	Org. C.	Na	K	Ca+Mg	Total	CEC/ 100g Soil	Base Sat %	CEC/ 100g Clay	

Appendix F: Physical features of Ruwan Sanyi dam.

Physical features	Imperial unit	Metric Unit
Catchment area	1624 acres	657 hectares
Flooded area	30 acres	12 hectares
Maximum throwback	2800 feet	853 metres
Wall length at full supply level	980 feet	299 metres
Maximum depth	20 feet	6 metres
Depth at end of dry season	14 feet	4.3 metres
Full storage capacity	55×10^6 gallons	250×10^6 litres
Designed capacity at end of dry season	12.5×10^6 gallons	56.0×10^6 litres

Appendix G: Man-water contact study questionnaire form.

HAMLET:

HD. NO.

ETH. GP.

W1 W2 W3

01

AGE

PRIM. SCHOOL NOW?

MIGRATION

KNOWLEDGE

TREATMENT

WATER CODE

B O B O B O B O B O B O B O B)

WELLS USED

Appendix C; (Cont'd)

Schistosomiasis - Man-water contact study

	MAIGIDA	WIVES	OTHERS
OCCUPATION			
Occupation: COLLECTION OF WATER/SITE			
REASONS FOR SITE BATHING 2 TO 3			
REASONS FOR AVOIDANCE AT SITE			
BATHING:			
Details			
Time of day			
Season			
REASONS FOR COLLECTION AT SITE 2 TO 3			
IMMERSION + OTHER ACTIVITY ON COLLECTION			
USES OF SITE COLLECTED WATER BACK IN COMPOUND			
OTHER ACTIVITY AT SITE 2 TO 3			
Washing dishes			
Washing clothes			
Washing animals			
Religious			
EXCRETA DISPOSAL/ URINATION AT SITES			

Appendix G: (Cont'd)

MIGRATION:

Regularity
Season
Duration
Destination
Description
Activity
Etc.

KNOWLEDGE +
DETAILS

Traditional remedies or
practices?

DEFINITE CONVENTIONAL
TREATMENT DETAILS

SPECIFIC, FURTHER AND CONFIRMATORY INFORMATION

Appendix H: Man-water contact study observa

GENERAL INFORMATION:

Observer: Out of sight

In view

Season: Damuna

Agazari

Dari

Rani

Bazara

PERSON	1	2	3	
SEX: MALE				
FEMALE				
NAME				
NAME OF HOUSEHOLD/COMPOUND HEAD				
SAMPLE NO OF PERSON				
OBSERVED AGE				
0-4: ON MOTHER'S BACK				
ON FOOT				
5-9				
10-14				
15-24				
25+				
AGE RE-ENUMERATION				
TIME CONTACT WITH WATER BEGAN				
TIME CONTACT WITH WATER ENDED				

Appendix I: Analysis of soil samples from survey sites

Site	Pond		Stream	River	
	Control	Test	Test	Control	Test
Snail collection over 12 months	-	803	569	-	96
Chemical Composition					
Clay (in microns)	13	12	13	11	9
Fine silt "	8	4	4	3.3	5.5
Coarse silt "	34	22	20	32	32
Fine sand "	39	49	47	40	44
Coarse sand "	6.6	13.2	14.5	14.5	10.5
% stones	0.4	0.8	6.0	0	0
pH (water)	5.3	6.1	5.7	5.5	5.7
Organic carbon (%)	1.18	0.75	0.33	0.26	0.53
Base exchange					
Na (milliequivalent/100g)	0.17	0.22	0.29	0.047	0.04
K "	0.64	0.22	0.18	0.25	0.08
Ca + Mg "	2.66	3.19	3.0	2.3	2.16
Total "	3.45	3.64	3.47	2.54	2.3
CEC/100g soil "	8.5	7.5	6.4	4.6	4.1
Calculated value					
Base Saturation (%)	40.4	45.5	54.3	55.0	61.0

CEC = Cation (or base) exchange capacity.

Appendix J: Chemical examination of water collected from snail habitats.

	Pond		Stream		River	
	Wet Season (W.S.)	Dry Season (D.S.)	W.S.	D.S.	W.S.	D.S.
pH	7.4	7.2	6.6	7.2	7.2	7.3
Electrical conductivity at 25°C (microhms/cm)	112.9	16.7	27.8	22.2	126.6	20.9
Total alkalinity as $CaCO_3$ (ppm)	62.0	98.0	26.0	104.0	78.0	101.0
Total hardness as $CaCo_3$ (ppm)	42.0	40.0	8.0	48.0	54.0	52.0
O_2 absorbed from $KMnO_4$ in 3 hrs. at 37°C (ppm)	2.8	2.9	3.1	1.4	3.0	1.6
Total solids (ppm) dried at 180°C for 1 hour	104.0	494.0	683.0	172.0	758.0	146.0
Total solids after gentle ignition (ppm)	46.0	192.0	558.0	74.0	614.0	86.0
Organic matter (ppm)	58.0	302.0	125.0	98.0	144.0	60.0
Total dissolved solids dried at 180°C for 1 hour (ppm)	96.0	276.0	240.0	136.0	392.0	66.0
Suspended solids (ppm)	8.	218.0	443.0	36.0	366.0	80.0

Appendix K: Growth of laboratory bred B.(P.) globosus

Age of Cohort (in weeks)	No. of snails	Average size (in mms)	Survivorship
1	400	1.5	1.00
2	376	2.3	0.94
3	353	3.4	0.88
4	350	4.6	0.87
5	350	5.8	0.87
6	340	6.7	0.85
7	333	7.8	0.83
8	330	8.5	0.82
9	330	9.3	0.82
10	317	10.0	0.79
11	309	10.9	0.77
12	301	11.7	0.75
13	298	12.5	0.74
14	276	13.3	0.69
15	262	13.8	0.65
16	261	14.2	0.65
17	260	14.35	0.65
18	254	14.55	0.63
19	250	14.6	0.62
20	243	14.75	0.60
21	237	14.8	0.59
22	235	14.8	0.58
23	230	14.85	0.57
24	207	14.86	0.51
25	201	14.88	0.50
26	201	14.91	0.50
27	190	15.0	0.47
28	178	15.05	0.44
29	150	15.1	0.37
30	136	15.09	0.34
31	120	15.1	0.30
32	113	15.18	0.28
33	92	15.2	0.23
34	81	15.22	0.20
35	71	15.23	0.17
36	60	15.24	0.15
37	58	15.25	0.14
38	53	15.25	0.13
39	52	15.3	0.13
40	45	15.31	0.11
41	42	15.32	0.10
42	38	15.33	0.09
43	35	15.33	0.08
44	34	15.34	0.08
45	30	15.35	0.07
46	28	15.38	0.07
47	28	15.40	0.07
48	26	15.40	0.06
49	24	15.42	0.06
50	24	15.45	0.06
51	22	15.48	0.05
52	20	15.50	0.05

Appendix L: Distribution of S. haematobium and S. mansoni infections in snails collected from 22 ponds.

Site	No. of snails	B. globosus	B. forsk.	B. pfei.
1	23	23 (1)		
2	19	19		
3				
11	104	104(8)		
12	95	81 (1)	14	
13	189	149 (16)		40 (1)
14				
16	3		1	2
17	9		9	
22	119	117	2	
23	78	78		
25	28	28		
27	59	27 (1)	32	
30	35	30	5	
33	87	87 (2)		
36	42	42 (3)		
37	16	15	1	
42				
43	95	85 (10)	7	3 (1)
48				
49	6	6		
50	63	52 (1)	11	
Total	1070 (45)	943 (43)	82	45 (2)

( ) parenthesis refers to numbers infected.

Appendix N: Distribution of S. haematobium and S. mansoni infections in snails collected from 8 stream sites.

Site	No. of snails	B. globosus	B. forsk.	B. pfei.
5				
6				
7	6			6 (4)
8	14			14 (3)
9	10			10
19	143		43	100 (5)
20	159		36	123 (7)
21	39		1	38
Total	371 (19)		80	291 (19)

( ) parenthesis refers to number infected.

Appendix O: Distribution by size of infected B.(P.) globosus from natural habitats.

Snail size(in mm)	Frequency	% Frequency
5.1-6	23	4.6
6.1-7	32	6.4
7.1-8	45	9.0
8.1-9	36	7.2
9.1-10	123	24.6
10.1-11	36	7.2
11.1-12	45	9.0
12.1-13	50	10.0
13.1-14	32	6.4
14.1-15	55	11.0
15.1-16	14	2.8
16.1-17	5	1.0
17.1-18	4	0.8
Total	500	

Appendix F: Proportion by size of infected B.(P.) globosus.

	1976-77										
	Jun.	J.	A.	S.	O.	N.	D.	J.	F.	M.	A.	M.
Young (0-7.5mm)		.22	.3	.39	.3	.35	.18					.38
Adult (7.6-15.0mm)	1.0	.6	.46	.57	.59	.56	.82	1.0				.62
Old (15mm)		.18	.24	.04	.11	.09						

	1977-78										
								.07			
Young	.05	.12					1.0	.93	1.0	1.0	
Adult	.76	.88	.50	1.0							
Old	.19		.50								

Appendix G: Cercarial shedding by different size groups of B. (P.) globosus.

Snail size group (in mms.)	No. of snails		Average No. of cercariae
	Exposed	Examined	
5.1-6.0	10	6	90
6.1-7.0	10	7	130
7.1-8.0	10	9	230
8.1-9.0	10	8	350
9.1-10.0	10	9	280
10.1-11.0	10	10	440
11.1-12.0	10	10	370
12.1-13.0	10	8	410
13.1-14.0	10	10	460
14.1-15.0	10	10	460

Appendix R: Daily pattern of output of S. haematobium cercariae from B.(P.) globosus.

Days of shedding	No. of snails	Average no. of cercariae shed				Total
		7-11a.m.	11-3p.m.	3-7p.m.	7-11p.m.	
1	40	60	200	100	70	430
2	40	60	240	130	70	500
3	40	80	260	140	80	560
4	40	80	240	150	100	570
5	40	80	280	200	120	680
6	36	90	300	240	140	770
7	36	100	380	300	150	930
8	35	100	400	300	160	960
9	34	90	420	330	150	990
10	30	100	400	310	130	940
11	30	100	420	330	160	1010
12	30	100	420	340	200	1060
13	30	100	410	330	190	1030
14	30	100	420	330	180	1030
15	29	50	410	300	200	960
16	29	70	400	280	180	930
17	28	60	380	290	160	890
18	28	70	360	300	140	870
19	27	60	390	300	100	850
20	27	60	400	290	90	840
21	27	50	380	280	80	790
22	27	60	350	260	80	750
23	26	50	300	220	90	660
24	25	70	300	200	80	650
25	24	60	260	200	80	600
26	24	50	270	180	70	570
27	20	50	250	180	70	550
28	20	30	250	160	60	500
29	20	30	220	150	50	450
30	20	20	200	140	30	390
Mean cercariae output		69	330	242	115	

Appendix S: Diurnal shedding of S. haematobium cercariae by B. (P.) globosus.

	Mean number of cercariae shed			
	7-11a.m.	11-3p.m.	3-7p.m.	7-11p.m.
Field snails	140	483	80	10
Lab. snails	69	330	242	115

STUDY OF THE ECOLOGY AND DISTRIBUTION OF THE SNAIL INTERMEDIATE HOST OF *SCHISTOSOMA HAEMATOBIUM* IN RELATION TO LOCAL TRANSMISSION IN THE MALUMFASHI AREA OF NORTHERN NIGERIA

By

MARGARET ARIBIYO TAYO

B.Sc. Combined Honours, Aston, England, 1974

M.Sc. London, 1975

AN ABSTRACT OF A THESIS

Submitted to

Ahmadu Bello University

in partial fulfillment of the requirements

for the degree of

DOCTOR OF PHILOSOPHY

Department of Community Medicine

May, 1982

ABSTRACT

A three year study on the transmission of Schistosoma haematobium was carried out in an area of Malumfashi Local Government, with a population of 12,777, spread over 250 Km^2. The area is in the Sudan Savanna of northern Nigeria with a mean annual rainfall of 965mm. The investigation included the study of distribution and bionomics of snail intermediate hosts in relation to local transmission, as well as certain human behavioural factors associated with transmission. Some recently constructed dams were also investigated.

The investigations revealed the presence, in the study area, of Bulinus (Physopsis) globosus, Bulinus (Bulinus) forskalii, Biomphalaria pfeifferi, Lymnaea natalensis, Bulinus truncatus rohlfsi,. and Ferrisia eburnensis. Of these, B. (P.) globosus was the most abundant and widespread, accounting for approximately 80% of the collections. A similar result was obtained in the survey of 22 newly constructed low earth dams in the area. Eighty five per cent of all snails were collected in temporary habitats which dry up between December and April. Snails were collected more often in temporary than permanent habitats and around edges than in depths of habitats. Snail densities increased during the rainy season. Two peaks were observed in the snail densities; one between June and August and the other about October. Laboratory and field observations showed that B. (P.) globosus is the main intermediate host of

S. haematobium in the study area. A seasonal fluctuation was observed in the infection rates of these snails with a peak in March, coinciding with peak dry season. Although, there was no significant difference in the densities of snails in the three habitats studied (pond, stream, river), there were however, significant differences in the infection rates of snails dependent on the habitats, with ponds having the highest. Transmission sites were focally distributed and were predominantly streams and ponds. Mice exposures in these habitats indicate that transmission occurs between June and January. The snail intermediate hosts of schistosomiasis were collected throughout the year from the low earth dams.

A diurnal pattern was observed in the shedding of S. haematobium cercariae by B. (P.) globosus with peak shedding between 11a.m. and 3p.m. Shedding during this period accounted for approximately 35% of the daily output. The maximal human-water contact was also observed during this period, with males having greater contact than females. No child less than 5 years old was recorded at the water sites. Contact with water is mainly recreational for the younger age group while it is domestic, economic and religious for the older ones. Migration in the area is seasonal and mainly for employment. Females migrated more than males. Seventy five per cent of migration took place within a radius of 9.6Kms. from the study area; therefore attempt at controlling schistosomiasis in the area must take this into account. The absence of safe and potable water supply compels the people to

turn to surface water for their domestic and recreational needs. There is a low level of sanitation in the area, out of 134 compounds investigated, only 74 had latrines; and of those questioned about their urination and defecation habits, approximately 40% admitted to excreting near water sources. Furthermore 4% of water contact activities are accounted for by defecation and urination alone. The indiscriminate excretion results in contamination of the water sites, thus favouring infection of the snail intermediate hosts. The presence of snail intermediate hosts all year round in the low earth dams would appear to favour continual and increased transmission of schistosomiasis in the area. The most appropriate time to intervene based on the ecology of the snails has been discussed.