TRANSMISSION OF *SCHISTOSOMA MANSONI* IN AN ENDEMIC AREA OF KENYA WITH SPECIAL REFERENCE TO THE ROLE OF HUMAN DEFAECATION BEHAVIOUR AND SANITARY PRACTICES

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Thesis submitted in accordance with the
requirements of the University of Liverpool
for the Degree of Doctor in Philosophy

March 1987

This thesis is dedicated to my late father

Transmission of Schistosoma mansoni in an endemic area of Kenya with special reference to the role of human defaecation behaviour and sanitary practices

John H. Ouma

The transmission of Schistosoma mansoni was investigated in an endemic area of Kenya (the Kangundo Schisto project area, situated 78 Km east of Nairobi) between June 1984 and July 1986. Studies were carried out on (a) the general transmission pattern by means of (i) prevalence, intensity and incidence studies and (ii) monitoring infection in the snail intermediate host, and (iii) measurement of cercarial densities; (b) human water contact behaviour; (c) human contaminative behaviour and other sanitary practices in relation to transmission of S. mansoni; (d) the role of other animals in transmission; (e) the pattern and measurement of contamination of transmission sites with S. mansoni eggs.

S. mansoni was confirmed to be highly endemic in Matithini, which was the main village chosen for the study (prevalence 67.1%) with transmission continuing throughout 1985. Continued transmission is thought to be linked to poor sanitary facilities and practices.

Human water contact monitored by direct observations in several study sites revealed that a proportion of the residents and more particularly school age children (5-19 years old) and women of all ages often came into contact with infected waters for various purpose. Bathing, playing and swimming usually regarded as contaminative activities accounted for only 7.6% of the observed total number of water contact activities in Matithini, but were more commonly observed in the nearby villages.

Using faeces collected from each person during a 24 hour period to estimate the number of S. mansoni eggs excreted daily by individuals and by the community, it was confirmed that 5-19 year olds were responsible for the bulk of eggs released daily. Eggs per gramme data based on single stool specimens compared well with eggs per day data in providing estimates of relative contribution by different age groups.

Studies on defaecation behaviour involving direct observations and questionnaires revealed that toilets were present in most of the households but they were inadequately used particularly by children and teenagers. The same group were shown to be defaecating near water bodies and carried eggs in their perianal region which they could introduce into water during bathing, swimming or playing.

The role of other animals in the transmission of S. mansoni in the area studied was investigated by trapping and examining various rodent species for S. mansoni infections and by examining dog faeces. Few rodents (1.6%) were found naturally infected as shown by recovery of adult worms but they were thought to be unimportant in transmission. Many dogs were however found passing S. mansoni eggs (40.5%) possibly through spurious infections. In the laboratory, puppies fed on infected human faeces passed viable eggs capable of infecting B. pfeifferi snails with the implication that dogs may be important in disseminating transmission.

An attempt was made to study the pattern of infection in transmission sites by the weekly monitoring of maturation of 'prepatent' infections in B. pfeifferi and the results indicated that contamination of transmission sites largely occurs discontinuously.

Measurement of miracidial density in water was attempted by using the differential filtration technique since laboratory investigations revealed that miracidia can be recovered and recognised. Although miracidia were also recovered in artificial outdoor ponds attempts to recover them from natural habitats failed. Further improvements for use in natural habitats are suggested.

The combined results of these studies emphasises the importance of the role of human behaviour in the transmission of schistosomiasis from snail to man and cals for better approaches and emphasis on health education which might help to modifiy people's behaviour and help to reduce transmission.

ACKNOWLEDGEMENTS

I would like to thank Professor G. S. Nelson for his valuable suggestions, encouragement and support and for allowing me to use the facilities of the Department of Parasitology during my study period in Liverpool.

I would like to express my sincere appreciation to the Ministry of Health of the Government of Kenya for allowing me time off to pursue this study. Particularly, I would like to thank Dr. T. K. A. Arap Siongok, Senior Deputy Director of Medical Services, for his advice and encouragement; Dr. Davy K. Koech, formerly Head of Division of Vector Borne Diseases, and Mr. A. M. Ngindu, who is presently heading the Division, for putting the facilities of the Division at my disposal during my field work in Kenya.

I am very grateful to my supervisor, Dr. J. M. Jewsbury, for all his support and guidance throughout the study and for his helpful criticisms of drafts during the writing up of this thesis. I should also like to thank Professor G. K. Kinoti for useful advice during my field work in Kenya.

I would like to acknowledge the support given to me by all the people involved with the studies in immunity to schistosomiasis mansoni within the chemotherapy programme in Machakos and especially Dr. A. E. Butterworth (the project leader) for facilities and allowing me to work in the study area and for letting me refer to some of the information and to use rainfall figures;
Dr. R. F. Sturrock for his useful advice and discussions;
Dr. R. Klumpp for taking some of the photographs; Dr. H. Kloos and the late Dr. P. Dalton for their advice on sociological aspects of the study; Mr. Omondi-Odhiambo for mapping and demographic data collection; Mr. H. C. Kariuki and Mr. F. W. Thiongo for their dedicated technical assistance and for helping organise field studies; and all who assisted me in many ways.

I am equally grateful to Matithini residents and residents of the other areas referred to in the study for their cooperation.

I would like to thank the staff of the Statistics section of the Department of Tropical Paediatrics in the Liverpool School of Tropical Medicine, for all their help in computing and analysis. Particularly, I should like to thank Miss S. Macfarlane for all her patience in guiding and discussing the analysis of the data and for reading some of the chapters, and Mr. B. Moody for help in computer analysis. Earlier on, I benefitted from the help of Professor Roy Anderson of Imperial College, in whose Department part of the analysis was carried out and with whom I had very valuable discussions. I should like to express my appreciation to Dr. R. Bensted-Smith, formerly working with Professor Anderson and who assisted with part of the data handling and also made very useful suggestions for the analysis, and Dr. G. Tingley who later took over from Dr. Bensted-Smith.

I should like to thank Mrs. D. Steedman for keeping me informed about the Department of Parasitology whilst I was in Kenya, and for all the keenness, care and hard work she put into the typing of this thesis in between her busy daily schedule, and to Miss C. Chadwick for helping her. The help given by the Department of Medical Illustrations in preparing figures and with photographs is fully appreciated.

I would like to thank my family for bearing with me while I was deeply absorbed in the work and while I was away, especially my dear wife Joyce who not only took the heavy burden to run the family but also contributed to the typing of the thesis.

Finally, I should like to thank the British Council of Great Britain for financial support while in the UK, to both the Edna McConnell Clark Foundation and the European Economic Commission for financial support for field studies in Kenya.

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CHAPTER 1

INTRODUCTION

1.1 SCHISTOSOMIASIS

1.1.1 Definition and global situation

Schistosomiasis (Bilharziasis) is a disease of various mammals, including man and domestic livestock, caused by 'blood flukes' of the genus Schistosoma. It is one of the most widespread parasitic infections of man and is second only to malaria in socio-economic and public health importance in tropical and sub-tropical areas (Iarotski and Davis, 1981). It is estimated that more than 200 million persons in 74 countries of the world (see Table 1.1 and Figs 1.1a and 1.1b) are infected and that between 500-600 million persons are exposed to infection because of poverty, ignorance, poor housing, substandard hygienic practices, and the availability of few, if any, sanitary facilities (WHO, 1985). In Africa alone, the total number infected has been estimated as at least 150 million (WHO, 1965). The figure could be higher by now in view of new water schemes spreading all over Africa.

1.1.2 Historical aspects

The history of the disease dates back to the 16th Century BC, and the Ebers papyrus of this period contains what may be a reference to its treatment or prevention (Pfister, 1912). But it was not until 1851 that Theodor Bilharz first recovered S. haematobium worms from the mesenteric veins during the postmortem examination of a patient in Cairo, and associated it shortly afterwards with endemic haematuria. He also observed schistosome eggs in the intestines and associated them with dysentery. The next essential step was to determine the life cycle. Egypt remained the focal point for this research but confusions arose as there occurred

TABLE 1.1

Geographical distribution of schistosomiasis by species by WHO Region (WHO, 1985)

Country or area	S. mansoni	S. haematobium	S. intercalatum
African Region			
Algeria		+	
Angola	+	+	
Benin	+	+	
Botswana	+	+	
Burkina Faso	+	+	
Burundi	+		
Cameroon	+	+	+
Central African Republic	+	+	+
Chad	+	+	+
Congo	+	+	+
Ethiopia	+	+	
Gabon	+	+	+
Gambia	+	+	
Ghana	+	+	
Guinea-Bissau	+	+	
Guinea	+	+	
Ivory Coast	+	+	
Kenya	+	+	
Liberia	+	+	
Madagascar	+	+	
Malawi	+	+	
Mali	+	+	
Mauritania		+	
Mauritius		+	

TABLE 1.1 (continued)

Country or area	S. mansoni	S. haematobium	S.intercalatum
Mozambique	+	+	
Namibia	+	+	
Niger	+	+	
Nigeria	+	+	
Rwanda	+		
Sao Tome and Principe		+	
Senegal	+	+	
Sierra Leone	+	+	
South Africa	+	+	
Swaziland	+	+	
Togo	+	+	
Uganda	+	+	
United Republic of Tanzania	+	+	
Zaire	+	+	+
Zambia	+	+	
Zimbabwe	+	+	
Region of the Americas			
Antigua	+		
Brazil	+		
Dominican Republic	+		
Guadeloupe	+		
Martinique	+		
Montserrat	+		
Puerto Rico	+		
Saint Lucia	+		
Suriname	+		
Venezuela	+		

TABLE 1.1 (continued)

Country or area	S. mansoni	S. haematobium	S. intercalatum
Eastern Mediterranean Region			
Democratic Yemen	+	+	
Egypt	+	+	
Iran, Islamic Republic of		+	
Iraq		+	
Lebanon		+	
Libyan Arab Jamahiriya	+	+	
Oman	+	+	
Saudi Arabia	+	+	
Somalia		+	
Sudan	+	+	
Syrian Arab Republic		+	
Tunisia		+	
Yemen	+	+	
European Region			
Morocco		+	
Turkey		+	
South-East Asia Region	S. japonicum		
Indonesia	+		
Thailand	+		
India	(S. haematobium?)		
Western Pacific Region	S. japonicum		
China	+		

TABLE 1.1 (continued)

Country or area	S. mansoni	S. haematobium	S. intercalatum
Western Pacific Region (cont.)			
Democratic Kampuchea	(S. mekongi)		
Lao People's Democratic Republic	+		
Malaysia	+		
Philippines	+		

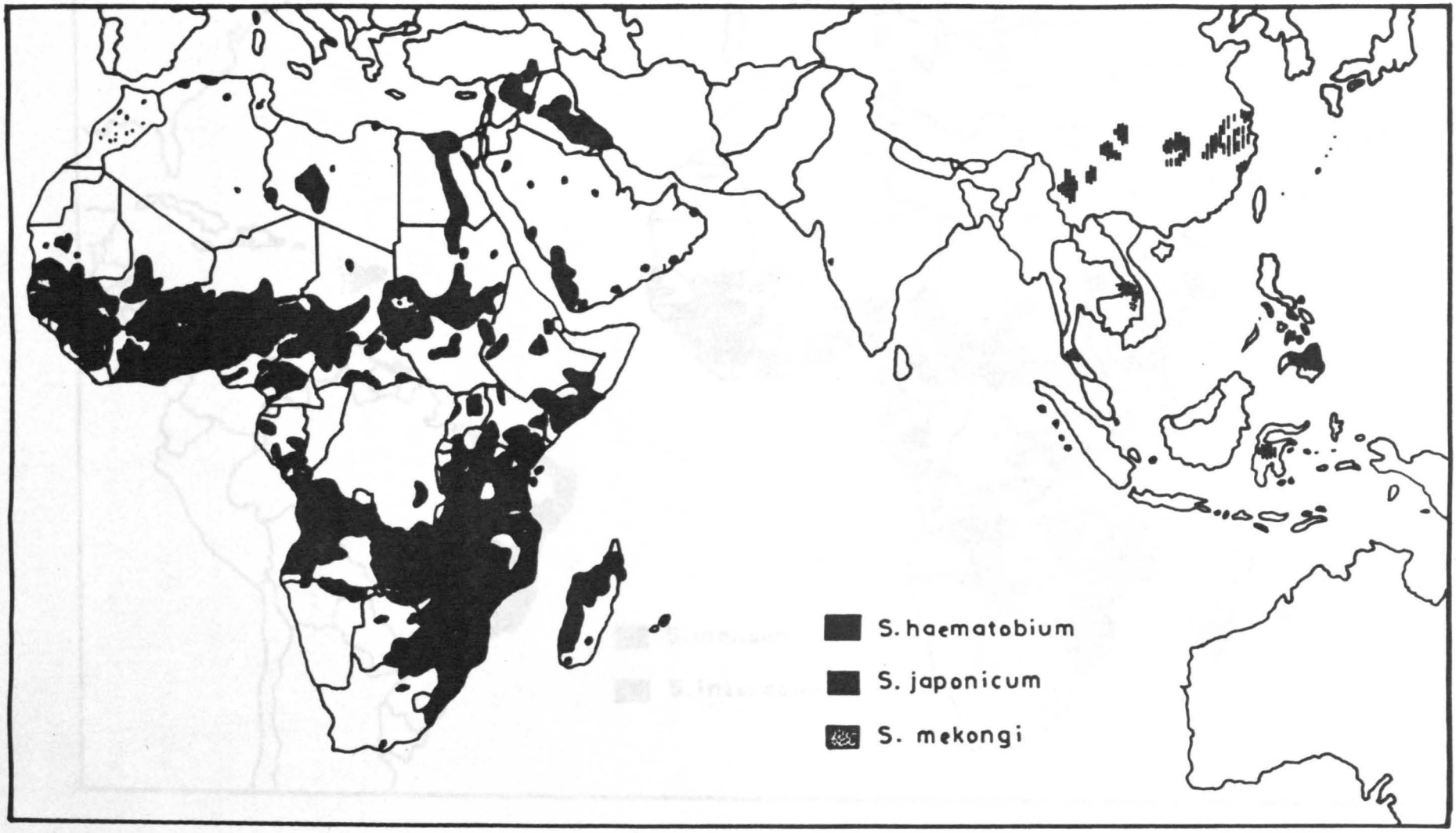

FIGURE 1.1a Global distribution of Schistosoma haematobium, S. japonicum and S. mekongi (from WHO, 1985)

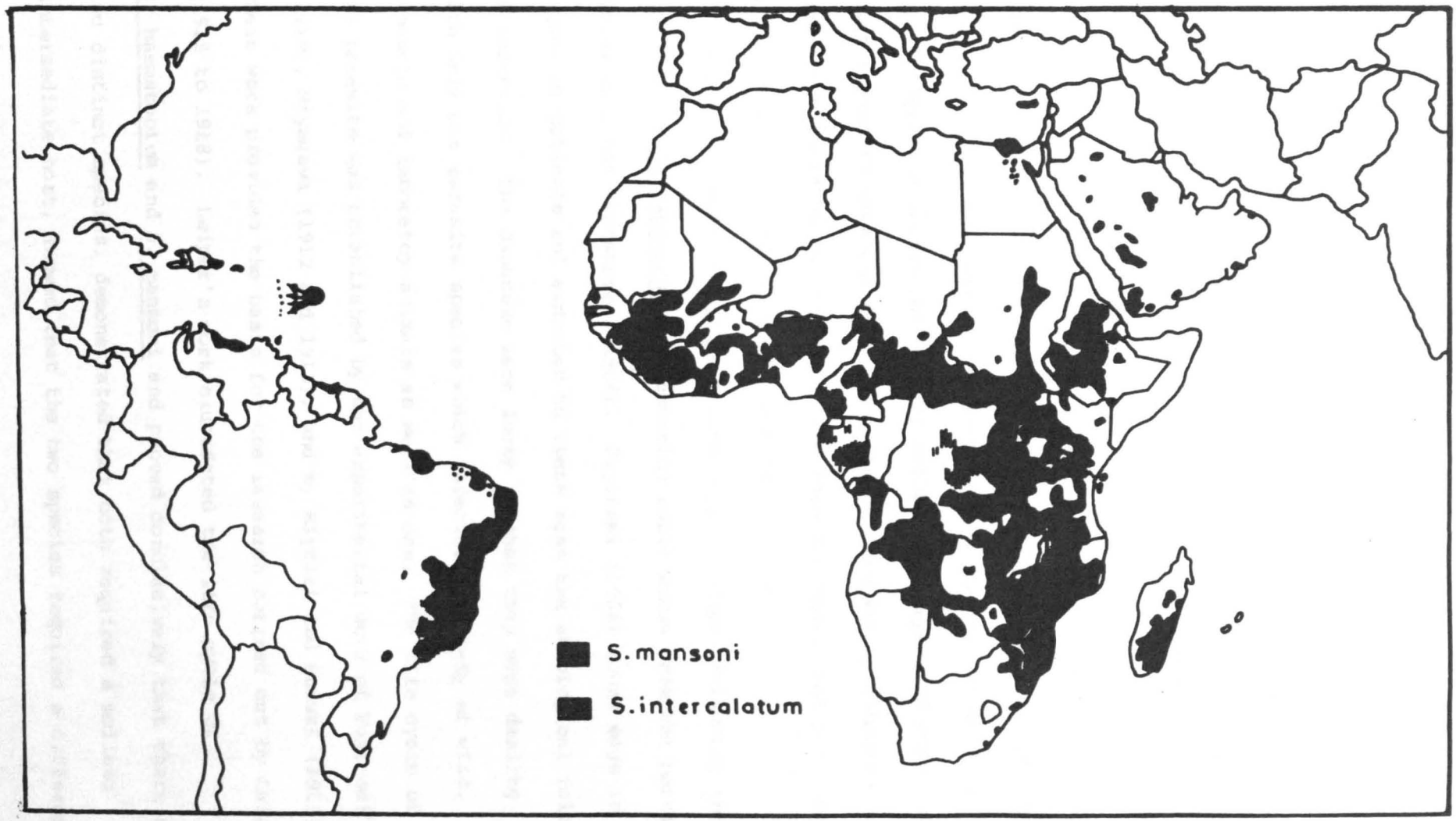

FIGURE 1.1b Global distribution of schistosomiasis due to S. mansoni and S. intercalatum (from WHO, 1985)

two different species of major schistosomes of man, one attacking the urinary tract and the other the intestinal tract. The principal clue was a striking difference in the structure of the eggs, one having a terminal spine and the other a lateral spine. Unfortunately, Bilharz had written that he had seen an egg with a lateral spine in the anterior part of the oviduct of the female worm, in which the posterior oviduct contained eggs with terminal spines.

It was not until 1902 that Sir Patrick Manson, who had observed only eggs with lateral spines and intestinal disease in his patients from West Indies suggested the possibility of having two species. Back in Egypt, a German pathologist Arthur Looss spent 20 years in Cairo trying to work out the life cycle but mistakenly concluded that the miracidium was the infective form for humans and postulated an intermediate stage of development in the liver.

The scene switched abruptly from Egypt to Japan following the discovery of S. japonicum by recovering adult worms from the portal system of a cat (Katsurada, 1904). Fujinami (1904) found eggs in organs of patients and ascribed to these eggs the etiological role of infection. The Japanese were lucky in that they were dealing with only one parasite species which infected a variety of wild, domestic and laboratoy animals as well as man. The life cycle of the parasite was established by the experimental work of Fujinami (1910), Miyagawa (1912 and 1913), and by Miyairi and Suzuki (1913). Their work provided the basis for the research carried out by Leiper (1915 to 1918). Leiper's work elucidated the life cycle of S. haematobium and S. mansoni and proved conclusively that there are two distinct species, demonstrated that both required a mollusc intermediate host, showed that the two species required a different

snail host and proved that the host-parasite relationships were specific. A description of the life cycle as it is known now is given in the next section.

1.2 HUMAN SCHISTOSOMES AND THEIR LIFE-CYCLE

The human schistosomes or bloodflukes are digenetic trematodes belonging to the Superfamily Schistosomatoidea. They are characterised by having no mascular pharynx and they produce non-operculated eggs. Three species commonly affecting man are S. mansoni, S. haematobium and S. japonicum. Infection with S. mekongi which is regarded as a close relative of S. intercalatum, has been reported from at least six Central African countries (WHO, 1985).

All species commonly infecting man have similar life cycles involving a sexual generation in the vertebrate host, and an asexual phase in a fresh water molluscan host. Figure 1.2a summarises the life cycle for the three main species. Except where mentioned, the remainder of this section considers S. mansoni only. In order to fully appreciate the contribution of this study to the epidemiology, detailed descriptions have been given in relevant stages of the life cycle.

Man is the principal host of S. mansoni although there are increasing reports of new hosts (see section 1.4). The adult female worm is held in the gyncaephoric canal of the male and the paired worms are normally found in the mesenteric veins. The adult worms may live for 20-30 years with a mean life span of 3-8 years (Jordan and Webbe, 1982). Each worm pair produces 100-300 eggs or more per day (WHO, 1985). The yellowish eggs are non-operculate and have a lateral spine. The miracidium develops inside the egg over a period of six days. Eggs passing through the intestinal wall each contain

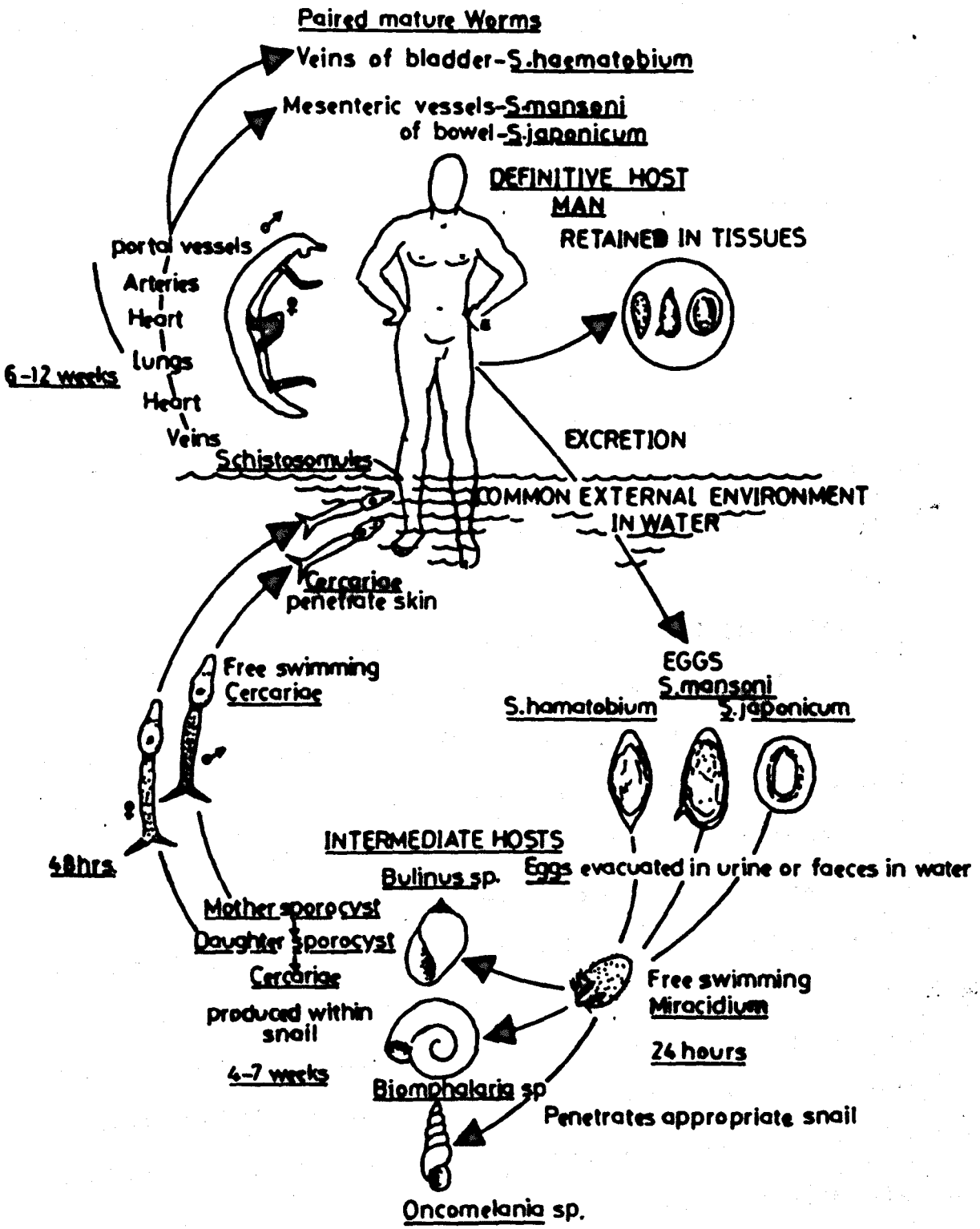

FIGURE 1.2a The life cycle of schistosome species (from Jordan and Webbe, 1969)

an embryo which is usually visibly mobile and ready to hatch when passed in faeces. Not all the eggs laid are successful in achieving this passage, some are carried back in the venous blood and become lodged in the liver or other organs where they can survive for 11-12 days, before forming granulomas. It is generally agreed that formation of egg granulomas is the principal process responsible for severe forms of the disease. Eggs which are passed in faeces hatch if they come in contact with fresh water and the process is stimulated by warmth and light. The miracidia become active and emerge from the egg shell through slits caused by a combination of osmotic effects and movement of the larvae. Free living miracidia measure approximately 160 x 60 μm (Ottolina, 1957).

The published essential morphological features of the miracidium as summarised by Pan (1965) are: (a) the anterior papilla (tere bratorium); (b) the epidermal plates heavily invested with cilia; (c) the subepithelium lined by a continuous row of arched cells; (d) "primitive gut"; (e) a pair of lateral (cephalic) penetration glands; (f) neural mass; (g) two pairs of flame cells; (h) a group of germinal cells (Fig. 1.2b).

Once free the miracidia swim actively; they respond positively to stimulus of light and are negatively geotropic. There is evidence that the ecology of miracidia is related to the ecology of their snail intermediate hosts (Webbe, 1962; Prentice *et al.*, 1970). Miracidia remain infective to their snail intermediate hosts for some 8-12 hours, swimming randomly in long sweeping lines. The continuity of the parasite's life cycle depends on these miracidia finding a snail intermediate host to which they are probably "naturally" directed (Chernin, 1974). The mechanism by which the molluscan hosts of schistosomes (*Biomphalaria*, *Bulinus* and *Oncomelina*) are located by miracidia continues to be investigated.

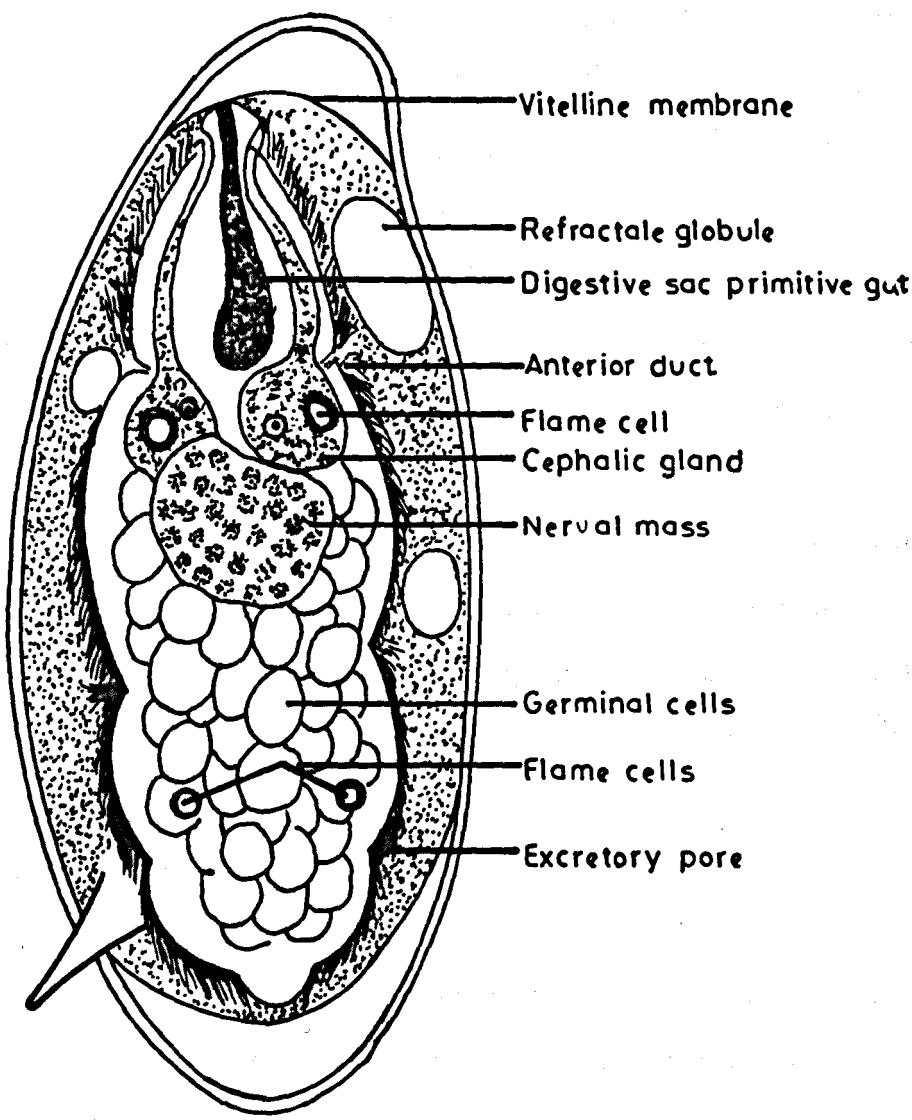

FIGURE 1.2b

An egg of S. mansoni containing a mature miracidium (from Gordon et al., 1934)

Penetration of the miracidium occurs when the larva becomes attached to the body surface of the snail by the secretion from the apical gland cells (Wajdi, 1963, 1966, 1972). When penetration is complete, the ciliated surface of the larva disappears and, within a few days, provided that a suitable snail host is found, in this case the genus Biomphalaria, development into mother sporocyst takes place near the point of penetration. It is not clear at the moment how many miracidia enter the snail host and develop further but work by Pan (1963, 1965) showed that only a small proportion develop to mature mother sporocysts. A single miracidium will result in the development of thousands of cercariae all of the same sex and produced as a result of asexual multiplication within mother sporocysts and by daughter sporocysts. It takes 3-5 weeks from the time of miracidial penetration to the time of production of mature cercariae - the actual period depending upon environmental temperature (reviewed by Anderson and May, 1979). The cercaria of the principal human schistosomes are all alike, being furcocercous and lacking eye spots or pharynx. They are small but visible to the naked eye. S. mansoni cercariae measure approximately 520μm in total length (Faust et al., 1934).

Mature cercariae escape from the daughter sporocysts and emerge from the snail when stimulated by light and usually at temperatures between 10°C and 30°C. The peak cercarial shedding in natural water in Tanzania was shown to occur between 10.00 and 14.00 hours (Webbe and Jordan, 1966). Slight variations may occur from place to place. For example in Kenya, Prentice and Ouma (1984) showed that the peak cercarial density was maintained between 13.30 and 15.30 hours. The number of cercariae produced by African Biomphalaria spp. is about 500 per day or less and rarely exceeds 1500 per day (Sturrock, 1965; Chu and Dawood, 1970; Sturrock and Sturrock,

1970b; Klumpp and Chu, 1977). Snails can continue producing cercariae for several months the total number produced depending on different species of snail hosts. For example, Frandsen (1979) found that the number produced in the entire life-span varies between 2900-20250 in Biomphalaria sudanica and B. glabrata respectively.

Cercariae of S. mansoni which are free-living non-feeding stages can survive while swimming in water for up to 48 hours. People or animals become infected when they come in contact with water containing a suspension of cercariae. The cercariae penetrate the skin of the definitive host with the assistance of lytic substances from the penetration glands. The tail is usually left behind and the main body of the cercaria transforms to a schistosomulum just under the skin where it stays for two days before it begins to migrate via the lungs, liver and portal veins where the adult worms pair before finally entering the mesenteric veins. The cycle is repeated when the egg laying by the female begins. The length of the prepatent period may vary between geographical strains of the same species (Hsu and Hsu, 1958). The incubation period in man is not known accurately but a period of 30-40 days is commonly quoted.

From a knowledge of the life cycle, it can be clearly seen that measures directed towards control of schistosomiasis will have to take into account the human definitive host and any reservoirs, the snail intermediate host and the parasite specifically in relation to its eggs, miracidia and cercariae. These measures are described in the next section.

1.3 GENERAL ASPECTS OF CONTROL

The objectives of schistosomiasis control are to prevent serious disease (i.e. to reduce morbidity), and to reduce transmission substantially. Eradication is not possible with present methods. However, it is now believed that control of morbidity and transmission is now feasible especially if carefully and appropriately planned in endemic areas through their primary health care programmes (WHO, 1985).

Broadly speaking transmission and progressively morbidity control can be achieved by reducing the level of environmental contamination with schistosome eggs. Various measures exist to attempt to achieve this directly or indirectly and Jordan and Webbe (1982) have put them in two categories of 'disease-specific' and 'non-specific'. Disease specific methods include control of the molluscan intermediate host by means of environmental control, and biological and chemical control, as well as chemotherapy. Using environmental control by modification of transmission sites, reasonable success has been reported in Philippines (Pesigan et al., 1958) and in Japan (Yokegawa, 1972). Biological control of snails has been advocated for many years, but the results of various field trials have generally been unsatisfactory (Ferguson, 1977). Chemical control has been widely used in the past but is now recommended to be used to support other measures such as chemotherapy. Use of chemicals alone did not succeed in controlling schistosomiasis in the Gezira (Fenwick, personal communication). Chemotherapy suffered previously from unavailability of safe drugs but its use is now becoming increasingly preferred due to discovery of better drugs in the last 10 years. Bina and Prata (1970) reported low prevalence of S. mansoni three years after treatment in Brazil using hycanthone. In St. Lucia, Christie and Upatham (1977) reported no infected

sentinel snails or wild snails two years after a selective chemotherapy campaign. In Kenya Ouma et al. (1985) reported low prevalence and intensities of infection with S. mansoni four years after treatment using hycanthone. Chemotherapy campaigns are now being encouraged after discovery of praziquantel which is a single-dose oral, non toxic drug which can cure infections with all the three major human schistosomes. 'Non-specific' methods include reduction of exposure by provision of safe water supplies, fencing transmission sites and prevention of contamination by provision of latrines, all of these approaches being re-enforced by community involvement and health education through primary health care programmes. The first serious attempt at controlling transmission by reducing exposure to infected water was made in South Africa (Pitchford, 1970a). Contact was prevented by fencing as well as the provision of piped water and simple swimming pools. Provision of individual household water supplies supplemented by communal laundry and shower units and simple swimming pools lead to reduced transmission in St Lucia (Jordan et al., 1975; Unrau, 1975). The widespread use of improved latrines would, in the long term, have an effect on transmission, although in the short term this is unlikely (WHO, 1985). Limited trials in the Philippines by Pesigan et al. (1958) showed that infection rates in nearby snail colonies fell when latrines were provided. In the Brazilian national schistosomiasis campaign, improved sanitation and water supplies as a supplement to chemotherapy and snail control reduced transmission (Barbosa et al., 1971). Health education is considered useful in the long term particularly in places where improvement in sanitation and water supply have taken place. Our approaches at the moment are limited due to insufficient knowledge of aspects of the life cycle

concerned with both exposure to infective waters and contamination of the environment with schistosome eggs. This is discussed further in the next section dealing with epidemiology.

1.4 GENERAL ASPECTS OF EPIDEMIOLOGY

Success of the control measures outlined above depends on a profound understanding of the epidemiology of the disease complex. This involves a study of the biology, ecology and distribution of the parasite, its snail intermediate hosts and mammalian reservoir hosts. A thorough knowledge of the role of man in transmitting and maintaining the infection is also important. Specifically, we need to study community contact with and usage of water, incidence of new infections and prevalence and intensity of infection in the definitive host (or hosts). These factors are related to socioeconomic and cultural patterns of the human population and influence the free living stage of the parasite and its complex relationship with the intermediate host. A knowledge of morbidity in relation to prevalence and intensity of infection is also essential.

A comprehensive and to quite an extent up to date information on the epidemiology of schistosomiasis is contained in Jordan and Webbe (1982). It will suffice here to highlight those aspects which are less understood, some of which are the subjects of the present study.

Although the life cycle of S. mansoni was finally understood in 1915, it is only in the last few years that the importance of the role of human behaviour has been realized. Transmission of schistosomiasis requires contact with water. Infection of human populations occur where behavioural patterns result in exposure to cercariae. Studies involving human water contact may lead in part

to a better understanding of questions relating to the stability of egg excretion levels in different age groups, the cause of declining prevalence rates in older persons and possible development of resistance. Recent ongoing studies parts of which have been reported by Butterworth et al. (1984) and Wilkins et al. (1984) are beginning to yield promising results.

Another aspect of behavioural studies involves contamination of water with faeces or urine containing schistosome ova. In most areas endemic for schistosomiasis mansoni the prevalence and intensity of infection is generally greatest in the 10-14 year old age group. In St Lucia, 5-14 year old children were calculated to be potentially responsible for 55% of contamination of the environment (Jordan et al., 1980). Although we can identify the group responsible for the bulk of contamination, very little information exists to show how schistosome eggs are transferred into snail infested waters. In addition, few behavioural studies exist to show the patterns of faecal and urinary contamination (WHO, 1980). Such studies together with those concerned with human contact with infected waters, already referred to above are of use in planning control stategies and in designing safe water and sanitary facilities (Husting, 1983). These studies and particularly contaminative behaviour of humans and other hosts form the basis of this thesis.

1.4.1 Animal reservoirs

Of the three species of schistosome infecting man, animal reservoirs are important and better studied in the epidemiology of S. japonicum. Transmission is clearly maintained by either man or animals.

Although some species of rodents and monkeys are known to be good hosts of both S. haematobium and S. mansoni in the laboratory it is an accepted dogma that the parasites were maintained entirely by interhuman transmission (Nelson, 1983). However, in recent years many animals have been found to be infected, especially in Africa and South America. Examples include gerbils and Nile rats in Egypt, rodents in South America and Zaire, many species of rodents and other wild mammals, as well as cattle, in Brazil, and baboons, rodents and dogs in East Africa (WHO, 1979).

To date, it is still not absolutely clear whether any of the animals mentioned above can maintain the infection in their own communities independent of re-infection from man. Part of work reported here is concerned with possible role of rodents as well as dogs in transmission of S. mansoni in Kenya. Information gained in studies such as this could add on to information needed for proper planning and implementation of control programmes not only in Kenya but also other endemic areas with similar conditions. A discussion on how the results of various aspects of investigations made could help to achieve this is to be found in the final chapter of this thesis.

1.5 THE PROBLEM IN AFRICA

1.5.1 History

Schistosomiasis is an old disease in Africa. Probably both Schistosoma mansoni and Schistosoma haematobium originated somewhere in Africa, possibly in Central Africa (Wright, 1966; Nelson et al., 1962). It probably spread to other parts of the world during the Slave Trade period. The earliest record of schistosomiasis in Africa dates back to about 1000 BC when calcified schistosome eggs were found in Egyptian mummies (Ruffer, 1910).

1.5.2 Species and their distribution

As already mentioned in section 1.1.1, an estimated number of 150 million in Africa are infected with either S. mansoni or S. haematobium which are endemic in most countries of Africa. Recently, infection with S. intercalatum has been reported in Cameroon and Gabon and there are also unconfirmed reports of the infection in Central African Republic, Chad and Congo (WHO, 1985).

1.5.3 Epidemiology and Control

Whatever the reason for the increased world population over the past few decades, in developing countries and particularly in Africa, it has created a need for dams to supply hydroelectric power for industralisation and water for irrigation for increased crop production. Schistosomiasis is accepted as a potential problem of such developments in the tropics where the need for hydroelectric power and increased food production are of paramount importance (Jordan, 1975). For example, the prevalence of schistosomiasis is known to have increased tremendously following the completion of the Kariba and Volta Dams in Zambia and Ghana respectively (Hira, 1969; Paperna, 1970). Another example in the Gezira Scheme in Sudan where schistosomiasis is known to have increased after it was opened in 1925 (Gaddal, 1985). Many more examples exist but the main problem is that very little is being done to control the situation due to limited resources. Hence there is a need for further research to find the economically accepted means of control.

1.6 EPIDEMIOLOGY IN EAST AFRICA

1.6.1 General

Both S. mansoni and S. haematobium are endemic in East Africa but a reliable assessment of their distribution is lacking at the present time. Relatively more work has been done recently in Kenya and for

the rest of this section, the epidemiological situation in Kenya is described and reference is made to the other East African countries only where appropriate.

1.6.2 Current knowledge on epidemiology of schistosomiasis in Kenya

1.6.2.1 Distribution, prevalence and intensity.

Both S. mansoni and S. haematobium are present in Kenya. In addition S.bovis, S.rodhaini and S. mattheei have been recovered from other animals (Nelson et al., 1962).

Estimates based on figures which were available ten years ago indicated that one million people were infected (Highton, 1974a). With the present high rate of population growth in Kenya (3.8%), in addition to current environmental changes involving development of irrigation schemes and dams this figure is likely to have doubled by now.

The distribution of schistosomiasis in Kenya is given in Figure 1.3. It is based on prevalence studies by various authors plus unpublished reports of Vector Borne Diseases of the Ministry of Health. For details of prevalence range by province and district, refer to Table 1.2.

For reasons still unclear, only S. haematobium is found along the Coastal Plain including the Lower Tana Basin. Elsewhere, it is found in scattered foci in Eastern, Central, Western Nyanza and North Eastern provinces.

S. haematobium infrequently occurs within the same area as S. mansoni, however it does happen in Taveta, Kitui, Machakos and the lower elevations of Kiambu and Murang'a districts and Western Kenya (Highton, 1974a).

S. mansoni is sporadically distributed. It occurs along the shores of lake Victoria including its islands and extends over most of Nyanza Province except Kisii district. The prevalence ranges

FIGURE 1.3 Distribution of schistosomiasis in Kenya
(improved from Highton, 1974a)

TABLE 1.2

Distribution and range of prevalence of schistosomiasis by Province and District

Province/District	Prevalence % S.mansoni	Prevalence % S.haematobium	Population 1979
Coast Province			
Kilifi	-	>66	446,000
Kwale	-	>66	298,000
Tana River		46 - 65	98,000
Taita-Taveta	26 - 45	46 - 65	152,000
Mombasa	-	6 - 25	352,000
Lamu	-	6 - 25	45,000
N.E. Province			
Garissa	-	26 - 45	44,000
Wajir	-	6 - 25	56,000
Mandera	-	<5	26,000
Eastern Province			
Machakos	46 - 65	6 - 25	1,061,000
Kitui	6 - 25	6 - 25	479,000
Embu	6 - 25	<5	274,000
Isiolo	6 - 25	<5	45,000
Meru	<5	<5	858,000
Marsabit	<5	<5	102,000
Central Province			
Kirinyaga*	6 - 66	-	300,000
Kiambu	6 - 25	<5	712,000

TABLE 1.2 (continued)

Province/District	Prevalence % S.mansoni	Prevalence % S.haematobium	Population 1979
Muranga	6 - 25	<5	673,000
Nyeri	-	-	501,000
Nyandarua	-	-	240,000
	* Includes Mwea Irrigation Scheme		
Nairobi Province	<5	-	869,000
Western Province			
Busia	6 - 25	-	310,000
Bungoma	<5	-	523,000
Kakamega	<5	-	1,060,000
Nyanza Province			
South Nyanza	6 - 25	46 - 66	835,000
Kisumu	6 - 25	26 - 45	491,000
Siaya	6 - 25	6 - 25	485,000
Kisii	-	-	892,000
Rift Valley Province			
No known endemic areas, but some cases amongst immigrant workers.			

from 4% inland (Kinoti, 1971) to 80% in the island of Lake Victoria (Wijers and Munanga, 1971). S. mansoni is also common in Machakos and Kitui districts (Mutinga and Ngoka, 1971; Ouma and Waithaka, 1978). Elsewhere the parasite is found in lower parts of Kiambu, Muranga and Kirinyaga districts. Limited foci are found in Embu, Meru and Isiolo districts where transmission is associated with small scale irrigation units.

Recent reports by Kinoti (personal communication) indicate the presence of the parasite in Kajiado district especially in the area to the south of Lake Magadi.

Urban transmission of schistosomiasis is known to occur in various major towns. In Nairobi transmission of S. mansoni is known to be taking place especially on the eastern part of the City according to recent survey (Anguka, personal Communication). In Mombasa transmission of S. haematobium has been observed in peri-urban areas (unpublished records of Division of Vector Borne Diseases) In Kisumu transmission of both S. mansoni and S. haematobium exists (Masaba, 1980). Transmission is also known to be taking place in Machakos, Kitui, Isiolo and Homa Bay townships (Ouma, personal observation).

As can be seen in Table 2-2 the prevalence rate range of both types of schistosomiasis varies from district to district and the same is true within each endemic district. Intensities of infection also vary from place to place and can be very high in some places. In Lower Nduu, Siongok et al. (1976) recorded a female patient with an egg count of 10,400 egg/g - the highest ever recorded anywhere for S. mansoni. In areas studied considered to be typical of stable S. mansoni transmission, there is a rapid build up of prevalence and intensity during the first two decades of life, followed by a stabilisation and then a gradual decline in the older age groups

with males showing higher prevalence and intensity than females (Siongok et al., 1976; Ouma et al., 1985; Sturrock et al., 1987). In fishing communities especially around Lake Victoria, the situation is rather different with both prevalence and intensity increasing throughout life in the males, while remaining static in females with only a slight decrease after the age of 24 suggesting that males are more exposed during fishing (Smith et al., 1979).

The situation with S. haematobium is less clear as most studies have concentrated on school children with limited age range (Kinoti, 1971; Siongok et al., 1978; Ouma and Waithaka, 1978). However studies by Katamine et al. (1978) appear to suggest that in Taveta area of Kenya, prevalence of S. haematobium increases with age and reaches a peak between the ages of 5 and 14 but unlike S. mansoni, the decline is more rapid after this. They did not find much difference in prevalence between males and females.

1.6.2.2 Vectors

The vectors for S. mansoni and S. haematobium in Kenya belong to species of snails of the genus Biomphalaria and Bulinus respectively. Generally speaking their distribution is similar to the distribution of the parasite which is shown in Figure 1.3. Detailed account of the distribution of species responsible for transmission of schistosomiasis is given by Brown et al. (1981). In Kenya, Biomphalaria is represented by three species all of which are capable of transmitting S. mansoni. Biomphalaria pfeifferi (Martens) occurs generally within the altitude range 300-2000m and can be found in nearly all districts of Kenya breeding in a variety of permanent habitats ranging from small pools to dams, canals, furrows, ditches, rivers and streams. It is absent in the coastal strip. A report by Haller (1974) of Biomphalaria occurring near Mombasa was based on the mistaken identification of a species

Helisoma, a genus of American origin known from other localities near the Kenyan coast (Frandsen and Madsen, 1979; Brown, 1980). B. sudanica (Martens) is confined to swamps near Lakes Jipe and Victoria and possibly Naivasha while B. choanomphala is restricted to the open shores of Lake Victoria. B. pfeifferi and B. sudanica are together thought to be responsible for all transmission of S. mansoni in Kenya. B. choanomphala has only been collected a few times on the Kenya side of Lake Victoria and it is therefore unlikely to play a major role in transmission.

S. haematobium is specifically transmitted by members of B. africanus group. B. africanus and B. nasutus are the commonest of the species, the former being associated with permanently filled dams, whereas the latter occurs usually in seasonal rain pools and dams. B. globosus, though widespread, seems to be comparatively rare away from the coast, B. ugandae (not found naturally infected so far) is confined to the shores of Lake Victoria, and B. hightoni is known to occur only near Galole (Brown et al., 1981).

1.6.2.3 Transmission

Few studies have been done in Kenya to show fluctuations in snail densities and infection rates with time. Recent studies in Machakos by Butterworth et al. (1984) show that B. pfeifferi populations reach their peak densities and infection rates during January to February and July to September both periods marked by little or no rainfall. The converse is true during March to May and October to December when there is rainfall. It would appear that transmission is confined to the dry periods of the year. On the other hand in Mwachiga Village in Coast Province, Bulinus africanus and B. globosus are more commonly found in large numbers with quite a few infected during periods immediately

following the start of rains implying that transmission of S. haematobium takes place soon after rains start (Shimada, personal communication).

1.6.2.4 Other animal hosts

In Kenya, apart from the humans several animals have been found to be naturally infected with either S. mansoni or S. haematobium. They include rodents of the genus Otomys, Mastomys and Dasymys (Nelson et al. (1962) - all of which were shown to be naturally infected with S. mansoni. Other S. mansoni infections were reported in baboons (Miller, 1959, 1960; Strong et al., 1961; Nelson et al., 1962) and in monkeys (Else et al., 1982). Infections of other animals with S.haematobium have received very little attention although Webbe et al. (1974) showed that Kenya baboons are good laboratory hosts of S. haematobium. Early work by Nelson et al. (1962) showed that four out of 15 baboons from the Tana river district were infected with S. haematobium. They also found one monkey out of 20 from the same place infected with S. haematobium. More recently Else et al. (1982) found S. haematobium in three out of 36 Cercopithecus aethiops from Tana River district.

Of the other animals there are only reports of light infections of S. mansoni in dogs (Nelson et al., 1962). Elsewhere in East Africa, Mango (1971) found light infections of S. mansoni in 8.8 percent of 160 dogs from Mwanza, in Tanzania.

Despite reports of infections of various animals with schistosomes, no work has been done in Kenya to prove their possible involvement in transmission. This has been strongly suggested by Nelson, (1983).

1.6.2.5 Morbidity

While schistosomiasis may not be a proven major cause of mortality, it ranks high as a cause of morbidity as assessed by

hospital attendances in Kenya. In addition, various workers have recently associated infections with S. mansoni and S. haematobium to morbidity (Siongok et al., 1976; Warren et al., 1979; De Cock et al., 1982; Masaba et al., 1983). Fortunately, evidence is accumulating to show that treatment with modern drugs will considerably reduce morbidity (Mahmoud et al., 1983; Stephenson et al., 1985). A pilot scheme for control of morbidity due to S. haematobium by treatment of infected school children is now underway in Msambueni, Coast Province and preliminary results are suggesting considerable improvements (Mahmoud, personal communication).

1.6.2.6 Socio-economic and environmental factors in relation to transmission.

Nordbeck et al. (1982) attempted to relate infections with S. mansoni in Machakos to some socio-economic and other environmental factors but only found strong positive correlation with altitude suggesting that distance from transmission sites is an important factor in transmission. Sturrock et al. (1983) working in Machakos discovered that prevalence and intensity were indirectly related to the distance between the child's home and transmission site.

1.6.2.7 Behavioural studies

For sometime now, water contact studies have been going on in Kenya and the general finding is that contact with water increases sharply with age reaching a peak between the ages 10 and 14 in males and 20 and 29 in females and thereafter declined (Butterworth et al., 1984). This has led to detailed studies on whether it is an acquired resistance which accounts for stabilisation of egg counts in the middle age groups rather than change in the pattern of contact with water. Studies by Butterworth

et al. (1985) have confirmed the existence of an age-dependent acquired resistance to re-infection, distinguishable from age-dependent changes in exposure. More work is in progress to discover the nature of resistance.

Of equal importance are behavioural studies which would lead to discovering how schistosome eggs reach snail infested waters. Ouma and Van Ginneken (1980) in a preliminary study showed that children in the age groups 5 to 14 are most often observed defaecating indiscriminately near transmission sites in Machakos implying that they are the most important group in ensuring eggs reaching water bodies. No detailed studies were however conducted to relate defaecation behaviour to potential contamination of the environment with schistosome eggs and how the eggs eventually reach snail infested waters. This information could be of use in implementing a recent WHO consultant recommendation of intensive water and sanitation campaigns and health education as part of a national programme for schistosomiasis control in Kenya.

1.7 CHOICE OF THE STUDY AREA

Using the above information and with the aims of the study described in the next section in mind, it was possible to choose an appropriate area in Kenya. Matithini Village in northern division of Machakos district (Fig. 1.4) was selected. The selection of this area depended on a number of things. Obviously, the area had to be endemic for S. mansoni. A nearby school, Iietune (Fig. 1.4) had been earlier shown by Butterworth et al. (1984) to have high prevalence (97%) and intensities of infection (geometric mean, 130 eggs per gram of faeces). Preliminary investigations on snail infection rates and cercariometry suggested intensive transmission in this area. For a closer look at people's behaviour, it was

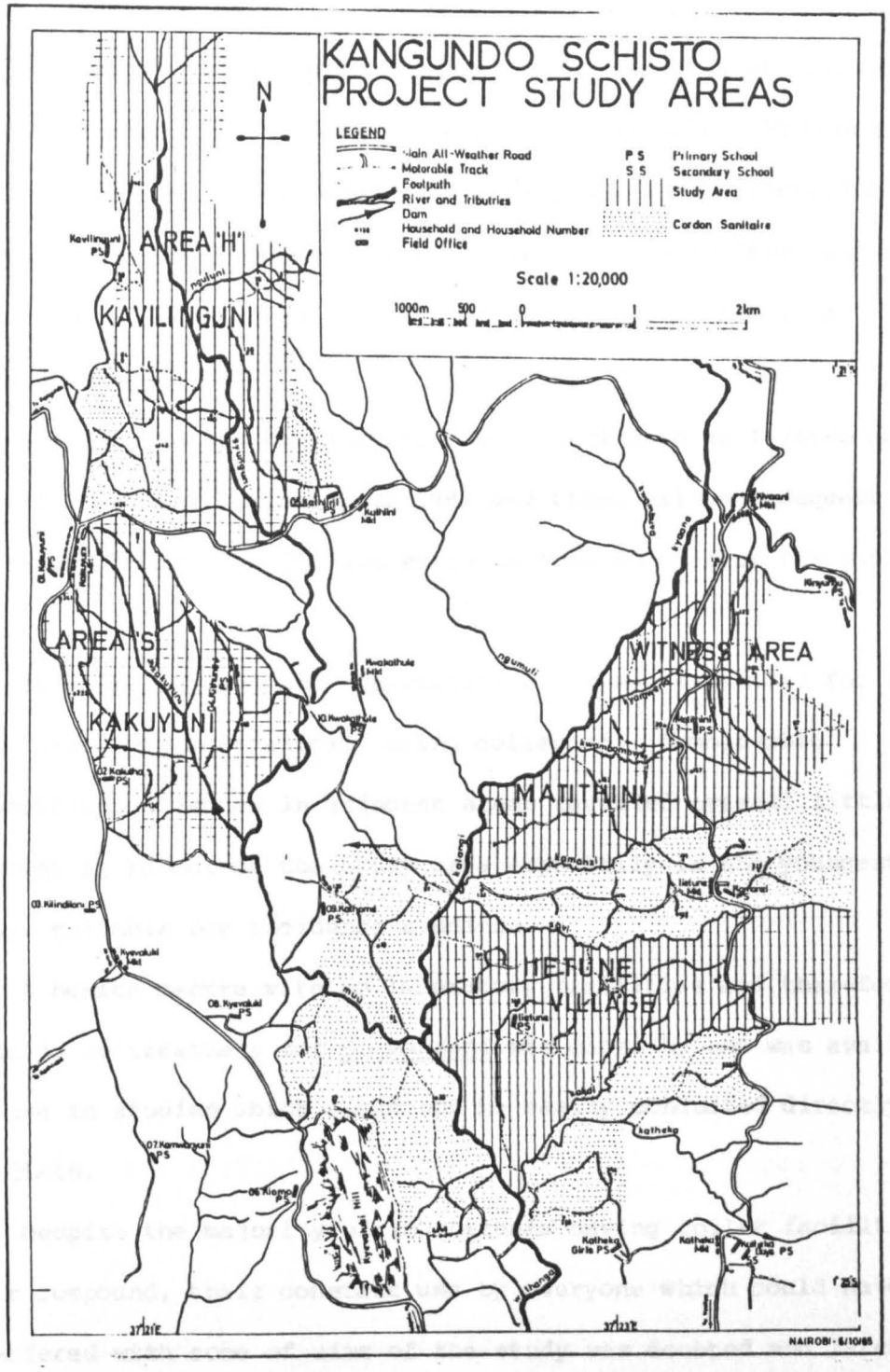

FIGURE 1.4

Kangundo schistosomiasis project study area

necessary to choose an area where transmission was restricted to a limited number of places visited by the majority of the residents. Matithini residents were confined to Kwa myeno stream and to some extent Kyaana river (Fig. 1.4). In a study like this, accessibility to the area and ultimately to the people is essential. This was the case with Matithini which is located only 80 km east of Nairobi. Shared transport to and from the area was available. From nearby areas where other studies were underway (Fig. 1.4) cooperation of the people through local meetings popularly know as "barazas" had already been established. Direct contact existed with local administrators.

A field station had already been established at Iietune market (Fig. 1.4) at the beginning of 1981 and there existed adequate laboratory facilities in Tala which is just 20 km from the study area.

Data on rainfall and temperature which are essential for a study like this were already being collected. Demographic information collected in adjacent areas revealed overall little movement in an out of the study area especially in the youngest age groups suitable for incidence studies.

A health centre with no laboratory facilities and therefore offering no treatment for S. mansoni was close by and was available for use in studies which could not be easily conducted directly in the field.

Despite the majority of inhabitants having toilet facilities in their compound, their constant use by everyone which could have interfered with some of aims of the study was doubted and later confirmed by preliminary talks to a few individuals.

In summary, the project area was highly endemic for S. mansoni, the place was accessible and the co-operation of the villagers had

already been established, other relevant informations were already available or being collected and limited laboratory facilities existed within easy reach from the field.

1.8 PURPOSE OF THE STUDY

The main aim of the present study has been to contribute to a better understanding of the transmission of Schistosomiasis mansoni in Kenya with a view to recommending improved measures for control. Special attention has been given to human behavioural aspects which lead to contamination of the environment with S. mansoni eggs. Possible involment of other animals in transmission has been looked at as well.

The specific objectives of the project were as follows:-

1) to study transmission pattern in a selected area of Machakos, Kenya by gathering data on prevalence, intensity and incidence of infection in all individuals available in the study area and also by collecting information on snail infection rate cercariometry and latrine use;
2) to study water contact behaviour of the people paying special attention to those activities which are likely to contribute to contamination of the water by schistosome eggs;
3) to monitor human defaecation behaviour by direct and indirect (questionnaire) observations in order to find out frequency, total amount of faeces and consequently total number of eggs produced per day and where defaecation takes place by age and sex and by looking closely at those aspects of behaviour which are relevant to transmission of S. mansoni;
4) to study the role of other animals in transmission of S. mansoni;

5) to study the nature and pattern of contamination of the sites, i.e. whether it is random or non-random, continuous or discontinuous;

6) to discover whether humans carry S. mansoni eggs in their perianal region and whether the eggs are likely to be introduced to transmission sites during bathing, swimming or playing;

7) to study possible new methods of evaluating contamination by attempting direct recovery of miracidia from water.

The initial studies for differential filtration technique for recovery of miracidia in natural waters was done in Liverpool during October 1983 to May 1984. The rest of the studies were carried out in Kenya between May 1984 to May 1986.

This Chapter saves the reader looking on the shelves in the library to remind him or herself of the basic facts on schistosomiasis. Since most of the work was done locally, an attempt has been made to give a concise account of the situation of schistosomiasis in Kenya in order to appreciate the efforts to achieve the above objectives.

An introduction to the study area is given in the following Chapter. Chapter 3 gives a general picture of transmission of S. mansoni in Matithini and Chapters 4, 5, 6 and 7 describe detailed studies on various aspects of transmission. Finally Chapter 8 discusses conclusions from the results and their relevance in improving measures aimed at control of S. mansoni in Matithini and other endemic areas in general.

CHAPTER 2

THE STUDY AREA

2.1 GEOGRAPHY, CLIMATE AND THE PEOPLE OF KENYA

2.1.1 Position

Although most people will be aware about the geography of Kenya, it is considered useful to outline those features which may be relevant to transmission of schistosomiasis. Details are given where relevant for later discussion.

The Republic of Kenya is located on the eastern part of the vast continent of Africa and forms an important part of East Africa. It is lies approximately between latitudes 4° 21'N and 4° 28'S; and between longitudes 34° and 42°E. It is almost bisected both by the Equator and by longitude 38°E.

2.1.2 Size

With an area of 224,960 square miles (583,000 Km^2), Kenya is about 2.4 times as large as the United Kingdom. Water or swamp occupies about 2.3% (14,000 Km^2) of the area of the country, thus leaving 56900 Km^2 of dry land, of which about two-thirds is either semi-desert or desert.

2.1.3 Administrative units

The largest administrative units are Provinces each headed by a Provincial Commissioner. There are seven Provinces altogether, the largest being Rift Valley. The other Provinces in order of size are: Eastern, in part of which this study took place, North Eastern, Coast, Nyanza, Central, Western and Nairobi Extra-Provincial district. Provinces are further subdivided into districts which are in turn subdivided into divisions. Divisions are further subdivided into locations which are finally divided into sublocations which represent the smallest administrative units.

2.1.4 Relief and Drainage

Kenya's landscape is an environment of great topographic diversity and contrasts, rising from sea level at the coast to 5,200 metres at the summit of Mount Kenya. Ojany (1974) estimates that 38% of the country lies below an altitude of 500 metres. Much of the land from about 150 metres to 1000 metres is a semi-arid to arid region of extensive interior plains in which water shortage and intense isolation place a serious constraint on the development and land use. The government is presently trying to introduce various water schemes in the dry areas and this according to Highton (1974b) poses a threat of transmission of schistosomiasis and other water borne or related diseases.

Kenya's drainage system is relatively simple. All the main rivers are consequents on the great dome formed by the Central highlands or on the foothhills of the Ethiopian highlands. The main rivers consisting of Tana, Athi, Mara, Nzoia, Turkwell, Ewaso-Ngiro, Yala, Sondu, Melawa and Voi therefore radiate from these highlands to give one of the greatest systems of a radial pattern known. The rivers are characterised by very high stream density but it must be pointed out that apart from Rivers Nzoia, Yala, Mara and the main courses of the Tana and the Galana, all the rivers and tributaries are seasonal, so that water shortage is experienced in most parts of Kenya as already pointed out. Transmission of schistosomiasis and particularly schistosomiasis mansoni is known to be mostly taking place in the majority of the seasonal rivers and streams.

Despite the high network of rivers and streams, the main waterbody is the portion of Lake Victoria that lies within the territorial waters. The other lakes consist of Rudolf, Baringo, Naivasha, Magadi, Hannington, Nakuru and Elementeita, all in the Rift Valley and except for Baringo and Naivasha, are salty.

Outside the Rift Valley are Lakes Amboseli, Jipe, Kanyaboli and much smaller ones in the Lower Tana Basin. As already mentioned (see Section 1.6.2.1) transmission of schistosomiasis is common along the shores of Lake Victoria. There is no evidence yet for transmission around Lake Naivasha (Pamba and Roberts, 1979) and in Lake Baringo (Ouma, personal observations).

2.1.5 Climate

Mean temperatures in Kenya are closely related to ground elevation. The highest temperatures are recorded in the arid regions of the North Eastern Province along the Somalian Coast and to the west of Lake Rudolf where the night minimum may be as high as 29°c during rainy seasons. Coldest are naturally, the tops of mountains where frost occurs above 10,000 feet and permanent snow or ice cover above 16,000 feet (Mt. Kenya). Annual temperature variations are generally small (less than 5°C) throughout Kenya.

Humidity is highest in areas with vegetation with a miximum exceeding 90% and in arid areas it fluctuates between 60-70%. Sunshine is generally high throughout the country with one exception: Eastern-Central and Southern areas experience prolonged cloudiness during the period June-September.

The annual rainfall follows generally a strong seasonal pattern with long rains from March to May and short rains from October to December. The seasonal variations are strongest in the dry low lands of the north and east, weakest in the humid highlands of the Central and Rift Valley areas. Areas in the Western Kenya receive rainfall nearly all the year round. Most of the rest of country hardly gets more than 760 mm of rainfall per annum which is considered to be the minimum for economical agriculture without irrigation. It is therefore not surprising to find a close relationship between mean annual rainfall and the population density in Kenya.

2.1.6 Agriculture and economy

Despite unfavourable weather for agriculture in most parts of Kenya, nevertheless the greatest asset is land which supports the crops, livestock and wildlife on which the economy of the country depends. Agricultural products together amount to 60% of total exports consisting mainly of coffee, tea and sisal fibre. the staple food is maize which is ground and baked to be eaten together with vegetables and meat. Mixed farming is the commonest type of land use by 90% of the population who live in rural areas. Large farms are mainly run by a few wealthy individuals and by cooperative societies.

The national cattle herd comprises nine million beasts of which eight million are unimproved Zebu cattle, half a million are temperate breeds and the other half million crosses between temperate breeds and the Zebu.

To boost agricultural production several irrigation projects such as Mwea-Tebere, West and East Kano, Bunyala, Perkerra, Bura and Hola have been developed and several more are under plan together with hydro-electric power schemes through creation of dams along the main rivers, especially Tana system. The anticipated increase in schistosomiasis in these areas has already been referred to (see section 1.6.2.1).

2.1.7 The people

Kenya's population according to the last Census in 1979 was just in excess of 16.5 million, with 51.5% in the 0-14 year age group and a growth rate of 4%, the highest anywhere. The population is unevenly distributed and as already mentioned in section 2.1.5 follows the rainfall pattern. Very high density regions consist of the Lake Basin and Central Province while medium

density regions are parts of Machakos, Kitui, Coast and Kitale areas. Low density regions include most of the dry areas in the northern part of Kenya.

For the tribal distribution of Kenya, refer to Table 2.1. The biggest group are the Kikuyus followed by the Luos, Luyhas and Kambas. The Kambas occupy the two big districts of Machakos and Kitui which together form Ukambani. This study was conducted in part of Machakos district inhabited by the Kambas who are very well known for their welcoming attitude towards visitors. Details of Kamba life is given in the next section.

2.2 THE STUDY VILLAGES

2.2.1 Location of the study villages

The main study village (Matithini) is shown in Figure 2.1. Its location in relation to other study areas is given in Figure 1.4. It lies approximately 78 km east of Nairobi and is typical of many other rural communities in Machakos District with individual household compounds comprising two to four huts (Fig. 2.2) scattered all over the village. The terrain is hilly and the altitude ranges from 1350 m along Kalangi river to 1550m at Malandi Kyawalawa Hills. The area is served by one primary school (Matithini) which is situated approximately in the centre of the village. All weather roads connect the village to Iietune Market on one side (Fig. 1.4) and Kivaani on the other. Our field station was situated at Iietune market and the nearest health centre was Kivaani. Kivaani also served as a market with shops providing basic requirements. From Kivaani, people can get means to travel to Kangundo where the main hospital is situated. The rest of the communication network consists of few motorable tracks and several footpaths. The other villages used for or referred to for some of the studies consisted

TABLE 2.1

Tribal distribution (Ojany and Ogendo, 1973)

MAIN GROUP	TRIBES
Central Bantu	Kikuyu, Embu, Meru, Mbere, Kamba and Tharaka
Western Bantu	Luhya, Kisii and Kuria
Coastal Bantu	Mjikenda, Pokomo/Riverine, Taveta, Taita, Swahili/Shirazi, Bajun and Boni/Sanye
Nilotic	Luo
Nilo-Hamitic (Kalenjin Speaking)	Nandi, Kipsigis, Elgeyo, Marakwet, Pokot, Sabaot and Turgen
Other Nilo-Hamitic	Masai, Samburu, Turkana, Iteso, Nderobo and Njemps
Eastern Hamitic (Somali speaking)	Gasha, Hawiyah, Ogaden, Ajuran, Gurreh, Degodia and other Somali
Western Hamitic	(Rendille, Borana, Gabbra, Sakuye, Orma and Galla speaking)

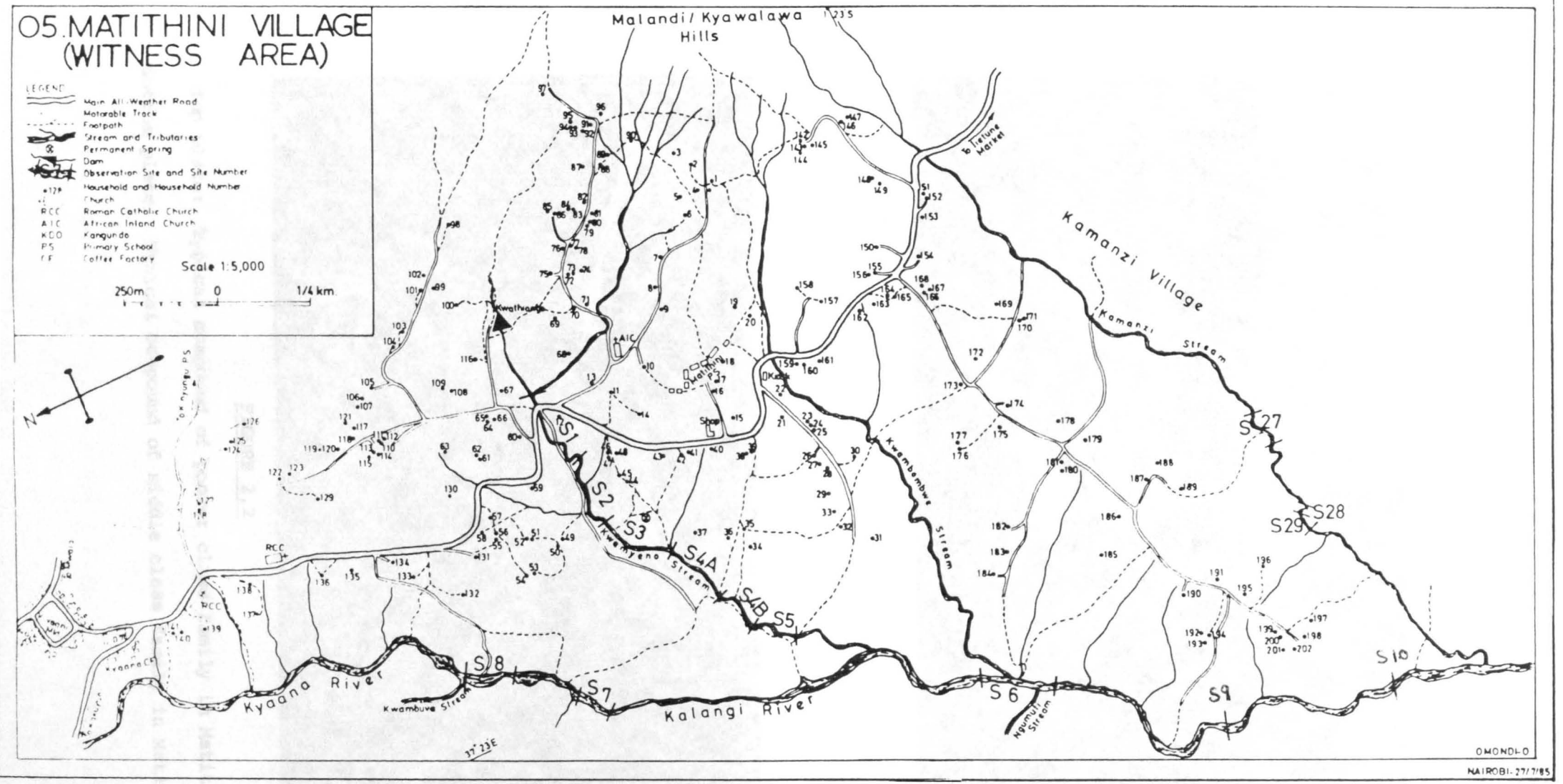

FIGURE 2.1 Matithini village map

FIGURE 2.2

Top plate: Typical compound of poorer class family in Matithini

Bottom plate: Typical compound of middle class family in Matithini

of Iietune, Kakuyuni and Kavilinguni (Fig. 1.4). Altogether, the villages formed the study area for a project dealing with immunological studies in human schistosomiasis within a chemotherapy control programme. Matithini village represented the control or 'witness' area for the main study and as such transmission was not interfered with in any way.

In order to have a better understanding of transmission of schistosomiasis mansoni and more particularly those aspects of transmission which formed the subject of the study (see section 1.8), it was considered necessary to collect as accurately as possible demographic information and vital statistics as well as some information on socio-economic and socio-cultural characteristics of the population and on the general environmental hygiene. The methodology used in collecting this information and the results are reported in the next section.

2.2.2 Mapping, demographic, socio-economic and socio-cultural charasteristics of the population and environmental hygiene

2.2.2.1 Mapping and methods of collection of vital statistics, socio-cultural, socio-economic and environmental hygiene data

After the selection of the village described above using the criterion described in section 1.7, each household was given a number which was printed on the door or window-frame. For the purposes of this study a household was defined as a group of people habitually eating and sleeping together on the same compound. A sketch map of the village was drawn inserting all the houses by their numbers in their approximate locations. Maps were later refined using the 1977 aerial photographs obtained from Survey of Kenya department.

Every person considered to be a member of each household was listed and given number by a trained local field worker who knew everyone in the village. The form used for this exercise is given

in Appendix 2.1a. An attempt was made to determine year of birth as accurately as possible and when proof records were not available, an estimate was made by use of calender of events specially prepared for the area (see Appendix 2.1b). After the initial registration of members of each household was completed, bi-monthly visits were made to each household to record vital events that had occurred and also to record presence or absence statuses of each individual.

For socio-economic, socio-cultural and environmental hygiene information, a special questionnaire (Appendix 2.2a) was constructed and pre-tested before being used to collect data from 50% of randomly selected households in Matithini. The questionnaires were administered by a local fieldworker in the local language and according to instructions given in Appendix 2.2b. Completed forms were thoroughly checked and re-visits were made whenever necessary. The other cultural observations especially on village life were based purely on my experience of the area during the two years of my close contact with the people of Matithini. The results of these investigations are given in the next section in a rather detailed form since the information will be of use in discussions of some of the Chapters.

2.2.2.2 Results of demographic survey

Matithini village had a de jure population of 1,470 inhabitants (703 males and 767 females giving sex ratio of 92: 100) in November, 1985 living in 202 households with an average of 7.27 persons per household. The inhabitants of the village are predominantly Akamba, a Bantu linguistic stock and the fourth largest ethic group in Kenya. The distribution of the population is shown in Figure 2.3 and the details are given in Appendix 2.3.

Like any other Third World configuration, the Matithini population pyramid has a very broad base (48% of the population

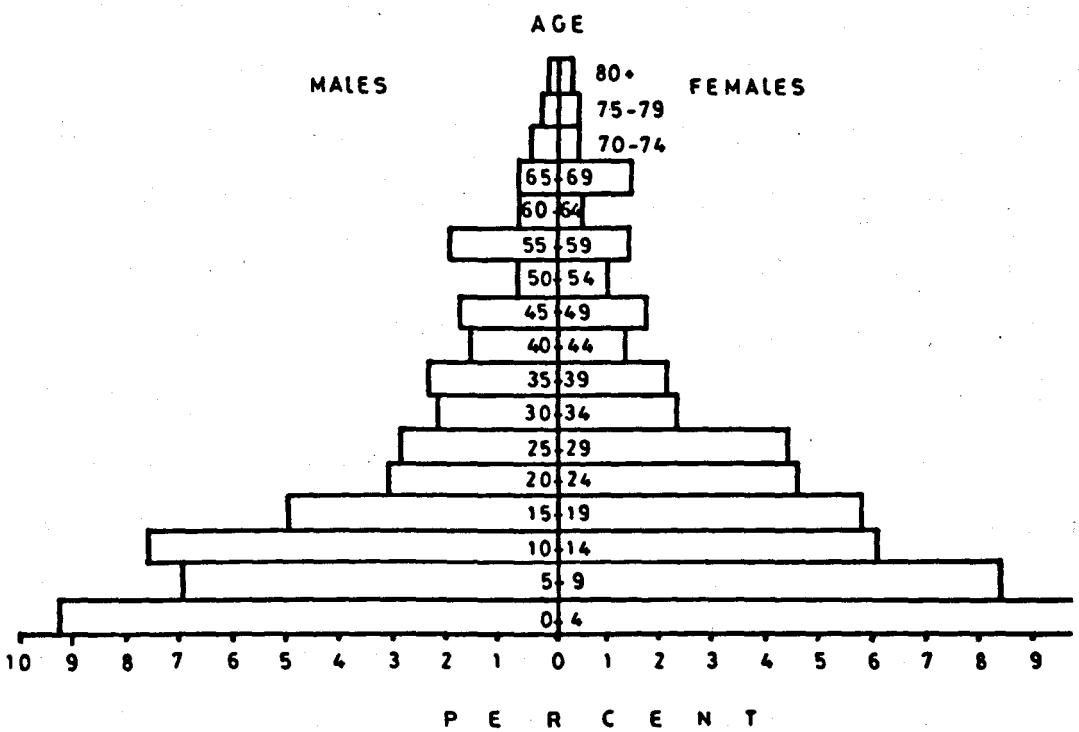

FIGURE 2.3 Matithini village de jure age-sex population pyramid November 1985

under 15 years) indicative of high fertility. The pyramid narrows very sharply particularly in the 15-34 age bracket suggestive of high migration of mainly teenage and adult males compared to females. There is a very small proportion of elderly persons (9%) in the population, a factor attributed to high rate of mortality after the age of 50. The village therefore has a low median age, a high dependancy ratio and a relatively "young" population.

The village has crude birth and death rates of 41 and 10 per thousand population respectively. The infant mortality rate (usually a measure of the health status of the population) is particularly low at 50 per thousand live births. These figures are slightly lower than the national average. The migration figures on the other hand, are very high. The village records an in-migration rate of 53 per thousand. The out-migration data generated may not be very reliable since a substantial number of individuals in the village are registered as absentees but may have actually moved out permanently. An inspection of the presentee-absentee data revealed that on average 16% of the population are absent from the village at any given point in time and that about 5% are absent continuously. Assuming that this latter group had actually moved out permanently, then the out-migration rate would stand at 53 per thousand.

Two important observations were made from the data on absenteeism (another form of migration). Firstly, the majority are teenage and adult males and secondly, about one third are male heads of households within the village. These individuals may be termed as temporary migrants because their absence is largely due to either schooling, jobseeking, visiting or to gainful salaried employment in the neighbouring towns of Nairobi, Thika and Machakos. However they often go home at weekends or month-ends for one or two days.

The two streams of migration into and out of Matithini village are characterised by localised short-distance movements. The in-stream in particular is dominated by females aged between 15 and 29 years of age accompanied by their infants possibly for marriage and other family related reasons. Such movements are typical within Machakos district. Migration within a village, on the other hand, is quite negligible at a rate of 4 per thousand.

The demographic implications of the findings described above suggest that Matithini village is growing at a rate of 3.34% per annum with natural increase contributing more to this growth (30.6/1000). If the population continued growing at the above rate, then it will double in 21 years time. Overall the demographic profile of Matithini village is typical of areas in the Third World that are beginning to grow rapidly as a result of marked reduction in infant and child mortality but which have not yet reduced their fertility. The relevance of the above findings to transmission of schistosomiasis mansoni in Matithini will be discussed under relevant sections.

2.2.2.3 Sources of water

All the 95 households interviewed said their main source of water was Kwa myeno and Kamanzi streams or Kyaana river (Fig. 2.1). There is a small dam (Kwathu) which is mainly used for cattle to drink. All these water sources are seasonal. Kwa myeno stream however has water most of the year and is considered to be the main focus for S. mansoni transmission. No piped water is available.

2.2.2.4 Occupation, education, religion and source of income

The majority of the various heads of household interviewed (65%) were peasant farmers while the rest were in salaried employment within or outside the area. 36% of heads of

households had no education at all while an equal proportion had primary education leaving only 28% who had secondary and above education. 40% of various heads of households were Catholic. Nearly all the rest were Protestants belonging either to African Inland Church or Salvation Army. Eight persons said they had no religion at all. Farming and salaried employment were two main sources of income in the area. Some of these variables will be discussed in relation to having or not having latrines.

2.2.2.5 Possession of latrines

It was rather suprising that 73 out of 95 or 76.8% had latrines all of the pit type in their compounds and they all claimed to use them regularly and nearly all claimed they constructed them because they felt there was need for them. It was however gathered that only 23.3% of those who had latrines contructed them within one year of establishment of the household. The rest built latrines in periods ranging between 2 to 20 years. Both level of education and main source of income influenced possession of latrines (Tables 2.2 and 2.3).

The majority of the latrines 62% were constructed within 10-20 m from the nearest building, 18% were within less than 10 m and the rest more than 20 m. A look at the type of toilet buildings revealed that 59% of the toilets had complete buildings with a roof and only 70% of these had permanent buildings with plastered walls and floor (Fig. 2.4). 22% of the latrine buildings were temporary buildings either with grass, paper or plastic walls (Fig. 2.4). Whether permanent or temporary buildings, only 40% had temporary or permanent doors and this could have contributed to their lack of use because of lack of privacy and particularly in the older age groups.

TABLE 2.2

Presence or absence of toilet in relation to level of education
91 households surveyed in Matithini

LEVEL OF EDUCATION	LATRINE PRESENT	LATRINE ABSENT
None	23	10
Primary	31	2
Secondary and above	19	6
TOTAL	73	18

(x^2 = 10.23 df 2; $P < 0.001$)

TABLE 2.3

Presence or absence of toilet in relation to source of income
91 households surveyed in Matithini

MAIN SOURCE OF INCOME	TOILET PRESENT	TOILET ABSENT
Farming	46	13
Salaried employment	27	5
TOTAL	73	18

(x^2 = 33.58 df = 2; $P < 0.001$)

FIGURE 2.4

Top plate: Temporary pit latrine building in Matithini

Bottom plate: Permanent pit latrine building in Matithini

An inspection of latrines revealed that 40% of them were dirty and smelly in the opinion of the fieldworker while the rest were clean. Only 22% of the latrines had a cover for the hole.

When people were asked whether they were aware of the advantages of having and using a latrine, except for one person all claimed they were and that the main reason was to avoid spread of diseases like diarrhoea, schistosomiasis and eye infections (see also section 4.3.2).

Every respondent said young children could not use latrines because of the danger of falling inside. Instead they either went to the bush or garden (25%) or they used the latrines indirectly, i.e. defaecating outside and then transferring the faeces to the toilet. The mean age at which children began to use toilets was 4.1 years.

As for the 18 households which had no latrines, the main reason given for not having one was because they had access to the neighbour's. Only three persons said they could not afford one while one person said he was not aware of the benefit of having one. Nearly all the persons who had no latrines used their neighbour's. The rest used the bush. All persons including the one who said he was not aware of the benefits of using a latrine said they were prepared to use a latrine if it was provided in their compound.

2.2.2.6 Village life in the Akamba society with special reference to Matithini and surrounding areas.

From Figure 2.1 it can be seen that people live close to one another and in general not far from water sources. Interspersed between households are small farms averaging 2-3 hectares and bushes and open grasslands mainly used for grazing cattle. Most of the land has been consolidated and as a rule

individual farms are next to individual households. Several farms are close to the river or stream valleys and especially in these, there is a tendency to irrigate the land with water drawn from the river or stream. This happens especially when there is prolonged lack of rain.

Details of Akamba life have been described elsewhere (Ndeti, 1972). Here only a brief summary will be given and the major emphasis will be on those aspects of the village life which are relevant to the aims of this study as outlined in section 1.8.

The smallest corporate unit in Akamba society is "musyi" which is equivalent to a household or homestead. The next corporate unit is "Utui" or village such as Matithini. Each village is headed by a local elder. Several of the villages form a sub-location (see section 2.1.3) which is the smallest administrative unit and is headed by an Assistant Chief. As a rule, each village is self contained in terms of primary schools, churches, sources of water, coffee factories, higher learning schools and markets.

Each household is headed by a man as a rule except when the man is not available mostly due to death when a woman takes over. Akamba society shows a high proportion of females to men within the home region as observed by Kabwegyere and Mbula (1979) and Matithini and nearby areas are no exceptions (see section 2.2.2.2. and Table 2.4). According to Ndeti (1972) this disproportion of "man to woman may have been constant in Akamba population and may well be one of the causes of polygamy in the society." In Matithini it is evident that men are mostly out in towns supplementing their earnings while women stay at home to take care of the land. Land is generally prepared before the rains in March and October of each normal year. People spend long hours during day time preparing land. Oxen are used in ploughing especially by those who keep cattle. Since

TABLE 2.4

Sex ratio in the selected locations in Machakos District, Kenya (Census of Kenya, 1969)

LOCATION	TOTAL POPULATION	MALE	FEMALE	SEX RATIO MALE: FEMALE
Kangundo	39,998	19,249	20,749	93: 100
Mitaboni	36,660	17,013	19,647	87: 100
Mwala	17,533	8,311	9,222	90: 100
Masii	18,369	8,626	9,743	89: 100

primary education is free in Kenya, all school age children go to school and infants have to accompany their parents when they are out in the farms. After a long day preparing land, people generally bathe in nearby water sources before going home. Looking after cattle which used to be a male's job, especially teenagers, is now shared by women since most men are away or are in school. Making bricks is commonly seen among the older men and this usually takes place not far from water sources. All the various activities described above involve spending quite a bit of time away from the households and it is not unusual for people to defaecate indiscriminately in bushes near streams or rivers as evidenced by finding faeces in the said places (Fig. 2.5) even though the majority of the people have access to latrines. This is discussed further in section 4.3.2.

Most people own dogs mainly for security reasons but even though they claim to feed them, this is unlikely since the majority of people have just enough food for the family. Most people are accompanied by their dogs while out in the gardens or looking after cattle and the dogs are frequently seen in water bodies, a fact which led to a decision to investigate them for their role if any in schistosomiasis mansoni transmission. This is reported in section 6.3.

Means of communication within the village or across to the other villages is predominantly on foot forcing residents to take shortcuts which usually cross rivers or streams. Naturally, they tend to stop and bathe in river or steam after walking to or from wherever they go. Before bathing, it is not uncommon for people to empty their bowels and river or stream valleys are suitable for this since they are hidden and have bush around them (see section 4.3.1.3). As such, crossing sites become important in transmission

FIGURE 2.5

Human faeces near Kivii stream in Kivii village

not only in connection with increasing chances of contact with contaminated water but also increases chances of potential and possible direct contamination of transmission sites.

2.2.2.7 Schistosomiasis in Matithini and the surrounding areas

Machakos district is known to be a schistosomiasis mansoni area and Ngoka and Mtinga (1971) showed that the prevalence is highest in Northern division in which Matithini Village is situated. It is also part of the same general area where Butterworth et al. (1984) recorded high prevalence and intensity of infection. It was in fact on this basis that Matithini was thought in part to be suitable for this study. Schistosomiasis haematobium has not been reported from the village according to information gathered from the health centre. This was later confirmed by the absence of intermediate hosts belonging to the genus Bulinus. It was therefore not surprising that people are generally unaware of schistosomiasis because schistosomiasis mansoni has no obvious visible signs or symptoms as opposed to schistosomiasis haematobium which is associated with urinating blood. Few persons who associated bathing in the streams with contacting schistosomiasis were those who had either been treated by us or attended "baraza" which is a local meeting organized from time to time to explain our activities. However, according to recent work by Kloos et al. (1986) there is a widespread knowledge of the occurrence of transitory itching and skin rash (aikundu unguw) after contact with stream water which is most likely to be swimmer's itch, known to be caused by especially 'non-human' schistosome cercariae which, as shown later, were present in the area (see section 3.3.2.4).

Snail vectors are predominantly Biomphalaria pfeifferi. In fact the only other snails collected were Lymnaea natalensis which is known to transmit liver fluke in Kenya and a few Bulinus

forskalii were found especially during periods following rains. Full details of the vector situation as well as the parasite is given in Chapter 3.

2.3 LOCATION OF TRANSMISSION SITES, RAINFALL AND TEMPERATURE IN THE STUDY AREA

2.3.1 Transmission sites

Like many other places in Machakos, where transmission of schistosomiasis mansoni is known to occur, transmission sites are usually located along seasonal rivers and streams. In Matithini Village, preliminary observations indicated that the bulk of transmission took place along Kwa myena stream and specially in the sites which are shown in Figure 2.1. Two other sites are shown along Kyaana river which is considered important in transmission although mostly in the other villages. Usually many Biomphalaria pfeifferi snails were seen in all sites a while after the rains had stopped.

SITE 1 - (Fig. 2.6). This was next to the main road from Iietune to Kivaani and was quite a busy one in terms of water contact as people stopped to bathe parts of their bodies when hiking to or from Kivaani. There was a brick making activity near this site which was another reason for its frequent use. The site remained a lateral pool for most parts of the year except during rains when it was flowing. It dried out some of the time especially during the dry months.

SITE 2 - (Fig. 2.7). This was an important site for crossing especially for children going to Matithini Primary School. It was for most parts of the year a lateral pool along Kwa myena stream but it dried out completely when it became very dry. Iron scum frequently formed on the water surface. It was surrounded by a

FIGURE 2.6 Site 1 in Kwamyena stream in Matithini village (used for water contact and cercarial density studies

FIGURE 2.7 Site 2 in Kwamyena stream in Matithini village (used for water contact and cercarial density studies)

FIGURE 2.8 Site 3 in Kwamyena stream in Matithini
(used for water contact and cercarial density studies)

FIGURE 2.9 Site 5 in Kwamyena stream in Matithini
(used for water contact and cercarial density studies)

thick bush of Lantana which provided cover and as such bathing was common.

SITE 3 - (Fig. 2.8). This was a lateral pool during most parts of the year except when it rained when it became a slow moving part of the stream. It never completely dried out during the two years of the study. It was mostly used for drawing water in addition to bathing and crossing activities. It was also commonly used to irrigate nearby gardens.

SITE 4A (= Site 6 for water contact observation). This was a lateral pool which rarely dried out completely and was commonly used for drawing water, crossing and irrigation. Iron scum often formed on top of otherwise clear water.

SITE 4B (= Site 7 for water contact observation). This was another lateral pool not far from site 4A and like 4B, it had water throughout the year. Drawing water was the commonest activity with some bathing taking place as well.

SITE 5 - (Fig. 2.9). This consisted of several lateral rocky pools of different sizes but all except one survived drought to have water throughout the year. It was one of the busiest bathing sites and was also much used for watering cattle.

The rest of the sites (8, 9 and 10) were all along Kalangi and Kyaana Rivers and were busy sites for washing clothes and bathing but except for snail sampling, they were not observed for water contact or sampled for cercariometry. All the sites mentioned above were surrounded with vegetation for most parts of the year. More will be said about the sites in the sections dealing with defaecation habits and water contact.

2.3.2 Rainfall and temperature in the study area

Rainfall data was taken from records obtained from Iietune Primary School (Fig. 1.4) where a rain gauge was installed in

December 1980. As can been seen from figures given in Table 2.5 annual total rainfall figures ranged from 609.8 mm (1985) to 1593.1 mm (1982) that is ignoring annual figures for 1984 since data for December are missing. There appears to be no clear pattern but in general more rain is experienced during March to May and October to December. Yearly variations in monthly rainfall figures are quite great. 1984 and 1985 were generally dry resulting in most of the sites referred to in section 2.3.1 remaining dry for sometime during the two year period. This may explain why there were no marked changes in S. mansoni prevalence and intensity figures for Matithini during the 1984 and 1985 survey periods. For more discussion on this see section 3.

Temperature records were kept at Iietune field station. Daily measurements of maximum & minimum room temperatures were recorded daily using a maximum and minimum thermometer. Table 2.6 and Figure 2.10 represents monthly mean figures for temperature records in Iietune for 1984. This is typical of the rest of the years. Monthly temperature variations are very small. Except for June to August when maximum and minimum temperatures fall slightly, the rest of the months are fairly warm.

2.4 SUMMARY OF CHAPTER 2

1. A description is given of the geographical features of Kenya which are relevant to transmission of schistosomiasis.
2. The main study village (Matithini) and other villages studied are located 78 Km east of Nairobi and are part of the study area for a project dealing with immunological studies in human schistosomiasis within a chemotherapy control programme.
3. The villages are inhabited by Kambas whose demographic characteristics are marked by a low median age, relatively "young" population and high out migration especially of adult teenage males.

TABLE 2-5

Iietune monthly and annual rainfal figures in millimetres between January 1981 and December 1985.

YEAR	MONTH AND RAINFALL FIGURES IN MILLIMETERS												
	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
1981	2.0	6.2	390.4	236.5	129.7	1.5	1.2	5.2	120.7	112	76.8	91.0	1173.2
1982	23.3	3.5	146.8	266.2	130.3	22.4	29.0	1.0	16.3	198.4	671.8	84.1	1593.1
1983	16.6	245.1	25.5	114.0	4.2	1.4	0	5.1	0.4	0	79.2	247.1	738.6
1984	25.8	0	51.0	0	0	3.5	1.5	0	0	206.0	271.0	?*	558.8
1985	12.0	77.2	59.1	157.7	4.0	0	1.0	0.3	0	73.0	170.0	55.5	609.8

*Figures missing.

TABLE 2-6

Mean Monthly maximum & minimum temperatures during 1984 in Iietune

MONTH	MEAN MAXIMUM TEMPERATURE IN °C	MEAN MINIMUM TEMPERATURE IN °C
January	32.7	20.4
February	30.8	20.6
March	33.2	20.3
April	32.4	20.1
May	31.5	19.9
June	28.6	17.4
July	27.7	15.1
August	27.0	16.5
September	30.2	18.5
October	29.5	18.0
November	28.5	19.0
December	28.9	19.3

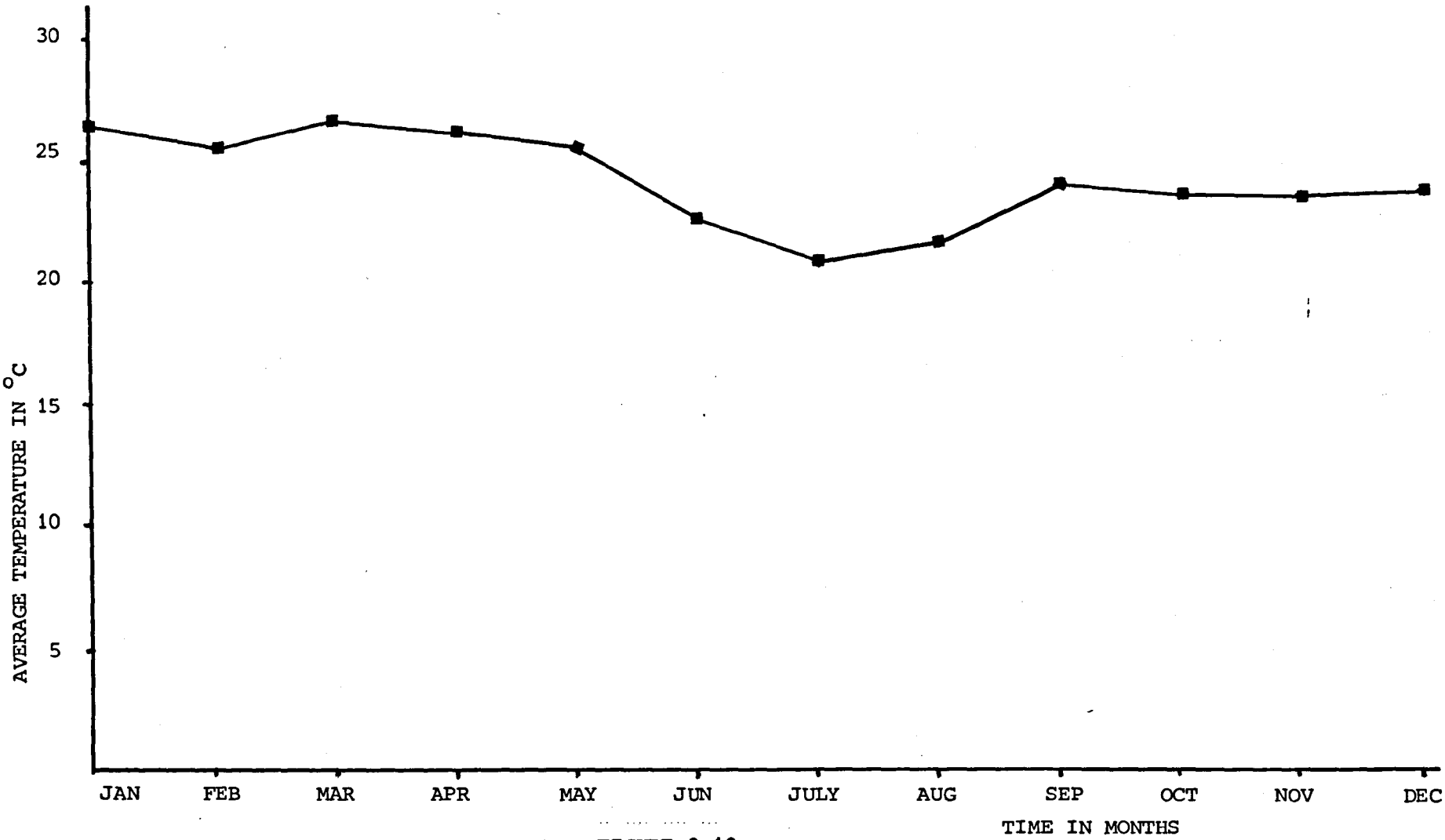

FIGURE 2.10

Mean temperatures in Ietune during 1984

4. Sanitary facilities are mostly poor. No piped water is available and latrines if present are inadequately used. As a result most people use snail infested waters for bathing and washing activities and it is not uncommon to come across faecal contamination in the environment particularly in valleys with streams. Most people own dogs which are known to feed on human faeces.

5. Most people in the area are unaware of the problem of schistosomiasis which is harboured by the majority of them.

6. The main focus for transmission is a side stream in which several lateral pools form, and which are popularly used for water contact activities,

7. Weather conditions although variable and unpredictable largely favour transmission of S. mansoni.

CHAPTER 3

GENERAL ASPECTS OF TRANSMISSION OF S. MANSONI IN THE STUDY AREA

3.1 GENERAL INTRODUCTION

The general situation of schistosomiasis in Matithini and the surrounding area has already been outlined in Section 2.2.2.7. Other information relevant to transmission of schistosomiasis has also been given in Chapter 2 which also describes the population studied.

At the beginning of these studies, various investigations were initiated in order to collect information on the important epidemiological indicators of S. mansoni transmission such as prevalence and intensity and incidence of infection, snail numbers and their infection rates, cercariometry and human contact with water.

Investigations such as these are usually necessary in epidemiological studies of schistosomiasis and have been used to provide baseline data required before any control measures can be applied and to allow evaluation of such measures (Jordan, 1985; Gaddal, 1985). In addition, information obtained from these investigations is now being found useful in studies designed to investigate the nature and mechanisms of immunity in man (Butterworth et al., 1984, 1985; Wilkins et al., 1984).

Whereas data on prevalence, intensity, incidence and snail vectors have been commonly collected in the past, it is only in the last few years that cercariometry and water contact observations have become recognised as useful in the epidemiological studies of schistosomiasis.

The use of cercariometry in monitoring transmission is now possible after recent developments in the technique (Theron, 1979; Kloos et al., 1982; Blumenthal and Jewsbury, 1983; Prentice, 1984;

Blumenthal, 1985-PhD thesis) and can be complementary to measurement of snail infection (Theron, 1986). The same technique has now been used with only minor modifications to recover miracidia from water (see Chapter 7).

In the past water contact studies have been concerned mainly with identification of those aspects of human behaviour which are relevant to transmission and more particularly those behavioural aspects which bring humans in contact with water containing cercariae (Husting, 1968; Dalton, 1976; Tayo et al., 1980; Kvalsvig and Schulte, 1984; Blumenthal, 1985). Although reference has been made to activities which could lead to contamination of water bodies with schistosome eggs (Cheesmond and Fenwick, 1981; Kloos et al., 1983) very little has been done to look at such activities closely. The present study included water contact observations partly to provide some information on how people become infected but mainly to identify those activities which could possibly lead to introducing S. mansoni eggs into water.

Therefore the objectives of the present investigations were:

1) to provide data on prevalence, intensity and incidence of S. mansoni for the main study area (Matithini),

2) to monitor transmission during the period of the study using both cercariometry and snail infection rate studies,

3) to monitor water contact behaviour of the people and to identify and study those activities which are likely to lead to contaminating natural waters with schistosome eggs.

The methods used in these studies some of which apply to studies described in the other chapters are given in the next section.

3.2 METHODS OF INVESTIGATION

3.2.1 Public meetings 'barazas' to explain the purpose of project

Prior to the start of the studies, a public meeting was arranged through the local administrator and in this meeting, a careful explanation was given concerning the purpose of the study and what was expected of the community in general terms. These meetings were organised later from time to time as and when it became it necessary.

3.2.2 Stool collections

Individually labelled stool containers (polypots), were left at each house after asking members of the household to fill them with stool (preferably the first stool of the morning). The filled containers were collected the following day from the houses. Those which were empty were left behind for a second or even a third visit. Those who were present but did not provide a specimen for a third time were considered to have refused. Usually 15 households with a total of approximately 80 persons were visited daily. Stool specimens were virtually collected on the spot from school children in their schools or from hospital patients.

3.2.3 Parasitological techniques

3.2.3.1 Formal-ether concentration technique

A portion of stool (2 g) was homogenised in 10 ml of 4% formal saline and the suspension strained through two layers of wet surgical gauze into a centrifuge tube. After centrifuging, the supernatant fluid was pipetted off and the residue repeatedly resuspended in formal saline and centrifuged until the supernatant was clear. Finally, the residue was mixed with 10 ml of 4% formal saline and allowed to stand for 5 mins, 3 ml of ether was added and the mixture capped and shaken vigorously, then centrifuged at 1500 r/min either for 2 mins in an electric centrifuge or for 5 mins in a

hand centrifuge. The plug of faecal debris and the fat layer was freed from the sides of the tube and carefully decanted. The sediment was placed on a glass slide and examined under the microscope.

3.2.3.2 Kato technique

1) A small portion of stool was pressed through 105-mesh stainless-steel bolting cloth (W. S. Tyler Co., Cleveland, Ohio) soldered to a metal loop to facilitate handling.

2) 50mg of faeces was then placed on a clean glass slide by means of a stainless steel template (Siongok et al., 1976) which is designed to contain the 50 mg of faeces on a volumetric basis.

3) Faeces were then covered by a cellophane cover slip (No. 124PD, E. I. Du Pont deNemours Inc., Film Department, Wilmington, Delaware) impregnated with glycerol in which 3% of malachite green was added to improve visibility of eggs.

4) The slides were inverted and pressed on to a bed of filter paper, turned face up and left for at least 48 hours to allow eggs and faecal matter to clear.

5) The eggs were then counted under a microscope. Two slides were usually prepared from each stool sample. The two slides were counted by two different individuals. If big differences occurred, e.g. of five eggs or more, the slides were re-checked again and eventually a repeat stool was collected if necessary.

3.2.3.3 Hatching test

Eggs were extracted from rodent livers by macerating the live tissue through a No. 60 mesh steel gauze, 250 microns, washing in 0.85% saline into a urine flask followed by sedimentation in darkness for 20 minutes. This was repeated three times with a final wash in filtered spring water at room temperature. Sediments were poured into petri dishes and exposed to artificial light in the

laboratory. Petri dishes were checked periodically for hatched miracidia. Miracidia were picked out by means of a pipette and counted before exposing to snails.

For hatching S. mansoni eggs from human or animal faeces, the procedure was the same as above except that 500 microns mesh sieves were used for sieving after emulsifying faeces in saline. For hatching more time was allowed (up to 2 days) before no hatching was recorded.

3.2.3.4 Treatment of heavily infected individuals

A decision was made at the beginning of the study to only give treatment to those found to be heavily infected. An arbitrary cut off point of 800 epg and above was decided upon. About 90 such people were recorded after the July 1984 survey and 65 who were available were treated in March 1985. The drug used was praziquantel given orally as a single dose of 40 mg/kg body weight. Patients were observed for two hours for any immediate side effects before being allowed to go home. The treated persons were re-examined again together with all the others during the second survey. Isolated cases of those who appeared sick from the infection were also treated even if they did not record 800 epg and above. Pregnant women were excluded from the treatment.

3.2.4 Biological techniques

3.2.4.1 Method of infecting snails

Biomphalaria pfeifferi snails (5-10 mm diameter) were exposed individually in haemagglutination plates containing 1.5 ml of filtered spring water in each chamber. Miracidia were picked up with a pipette under a dissecting microscope and six of them were introduced into each well before adding one snail, after which the plate was covered with a sheet of glass and maintained at room temperature (21°C) for up to 4 hours.

3.2.4.2 Sampling of snail population

A total of six sites (two on the river and four on the stream) were sampled in Matithini. The four sites on the stream were on the section of the stream observed for water contact and were close to but not the same sites as sampled for cercariometry. Snails were collected fortnightly from each site between January and December 1985. The sampling procedure was a one man, fixed-time search (10 mins for each site) by means of a standard scoop. Snails from each site were put in plastic bags and taken to a field laboratory by 10 am. Snails were measured and individually examined for cercarial shedding after exposure to daylight for at least four hours in 3 x 1" specimen tubes partly filled with filtered river water. Records were made in specially designed forms (see Appendix 3.1) of all the Biomphalaria pfeifferi snails per site according to size and whether they shed 'human' or 'non-human' cercariae. A record was also kept of other snail species found. All snails were subsequently returned to their respective collection sites.

Confirmation that 'human' cercariae were indeed those of S. mansoni was obtained by exposing mice to them during the initial stages of the study and identifying adult worms recovered later by perfusion.

3.2.4.3 Sampling for cercariometry

The details of the procedure used have been previously described (Prentice, 1984) and can be summarised as follows:-

The field filtration apparatus (Fig. 3.1) consisted of the following parts: two plastic graduated buckets of 5 and 20 litres capacity, for use as a measuring and fixing vessels respectively; a pair of pre-filters which fit over either bucket; a receiver of 5 litre capacity which tapers to fit the filter carrier; a filter

FIGURE 3.1 Cercariometry apparatus

carrier for the Nytrel TI filter cloth; a light but rigid camera tripod to support and level the filter carrier and a plastic baler for collecting water samples.

Except for the tripod, all of the above equipment, plus a supply of formalin, a stirring rod, measuring syringe, towel and rubber gloves, could be carried in the 20 litre bucket. Additional requirements included a supply of Whatman GF/A microfibre filters, plastic petri dishes, recovery filters and stain (0.01% solution of light green in a 2% acetic acid) and these were carried in a separate small box.

The sampling procedure was:

1) Once at the site to be sampled, the filter carrier and receiver were assembled, mounted on the tripod and levelled.

2) Water was then baled from the habitat and poured through the pre-filter assembly into the calibrated fixation vessel.

3) The sample was then stirred and formalin solution (40%) was added at the rate of 5 ml l^{-1}; the mixture was then stirred gently and continuously for 1-3 mins after which it was poured into the receiver. Stirring was continued in the fixation vessel until the filtration was complete.

4) The Nytrel disc was removed and placed onto a stain-loaded glass microfibre support in a plastic petri dish and returned to the laboratory for reading under a dissecting microscope and using a counter guide.

The apparatus were thoroughly cleaned after use.

3.2.5 Water contact observations

After the initial preliminary investigations to identify the most common water contact sites, five sites were selected along Kwamyena stream . A local fieldworker who knew the people well was used for regular observations which started in June 1984. Three

blocks (four months each) of observation were made. Each site was observed twice a month. A field worker stayed in the site between 06.00 and 18.00 hours and recorded in specially designed forms (see Appendix 3.2a) who went to the site, their ages and sexes, what they did in the site, what time they went to and left the site and the degree of water contact. At the end of every block of observation, information was summarised in Form 2 (see Appendix 3.2b) and individual data coded in the field according to instructions given in Appendix 3.2c. The forms were taken to Nairobi and the coding checked before entering the data in an Apricot micro computer using a spreadsheet designed for water contact data.

3.2.6 Records and analyses

The investigations covered in the present studies involved a lot of data and good record keeping was of prime importance.

Raw data from the field (vital statistics, stool examination results, snail and cercariometry results) were all thoroughly checked before being sent to Nairobi where thorough checks were repeated. Water contact data were coded in the field and were also thoroughly checked. Questionnaire forms were coded in Nairobi and checked afterwards for accuracy of coding.

For each set of data, a spreadsheet was created using a SuperCalc3 programme and giving each set of data a heading and file name. Using these spreadsheets, data was entered daily and stored on tape by means of an Apricot computer. Each set of data was printed from time to time and entries carefully checked for correctness. All discs were brought to Liverpool for main frame computer analysis. The statistical package used was Statistical Package for Social Science (SPSS(X)) on an IBM 3083 main frame computer.

3.2.6.1 Statistical treatment of stool data

The following indices of infection were calculated.

Prevalence rate: the percentage of persons found infected at a given time, calculated for specific age or sex groups or overall.

Intensity of infection: relates to the worm burden of infected individuals or groups of people and is measured indirectly by the number of schistosome ova being excreted. It is usually expressed as eggs per gramme (epg) of an infected individual or mean epg of all examined calculated for specific age or sex groups or overall. Egg counts were transformed to $\log_{10}(x+1)$ to normalise the variance and to allow the inclusion of zero egg counts and enabling geometric mean to be calculated. Arithmetic mean was used in calculations involving index of potential contamination.

Index of potential contamination (IPC): straight IPC is the sum of the products of prevalence and intensity of infection for each age group and gives a 'crude' index. Adjusted IPC takes into consideration the proportional contribution of each age group to the total population (Farooq and Samaan, 1967). Mean weight of faeces (per 24 hours) for specific age groups or overall were used to calculate the total eggs produced by each age group and by the entire population and from this relative percent contribution was calculated.

Incidence rate (of new infections): this is a measure of the level of transmission in an area over a given period and shows the percentage of children who are negative at one survey but are infected at a subsequent survey. It is calculated as $i = 100(p/n)$, where n = number of uninfected children at one survey re-examined at a later survey and p = number of children positive at the second survey.

3.2.6.2 General

Treatment of other data are obvious or explained in relevant sections. Standard statistical tests described by Snedecor and Cochran (1967) were used where considered appropriate.

3.3 RESULTS

3.3.1 Parasitological

3.3.1.1 Prevalence, intensity and incidence of S. mansoni in Matithini

All the registered residents of Matithini who could be found during July 1984 and again in September 1985 were used for the study. In 1984, 1076 of 1311 registered residents were examined giving a coverage of 82.1%. In 1985, 1189 out of 1470 or 80.9% were examined. A total of 874 persons or 66.7% were examined in both 1984 and 1985. People who were missed for stool examination were absent from the area at the time of stool collection. No refusals were reported.

Figure 3.2 summarises the data on age-specific prevalence and intensity curves for the whole population between 1984 and 1985. The overall figures for 1984 were relative higher (prev. 67.0%; Geometric Mean (GM) 28.5) than 1985 (prev. 60.7%; GM = 14.3 eggs/gramme of stool). Otherwise the pattern is typical of a stable S. mansoni transmission with a rapid build up of prevalence and intensity during the first two decades of life reaching a peak in the 15-19 year olds before declining gradually.

Details of age-specific prevalences and intensities by sex are summarised in Figures 3.3 and 3.4. The overall figures for males were higher (prevalence 68.2% and 63.7%; GM 33.2 and 18.3 epg) than for females (prevalence 66.1% and 58.6%; GM 23.6 and 12.1 epg) for 1984 and 1985 respectively. The reduced prevalence and intensity figures for the two years were as a result of treatment given in April 1985 to 65 residents who according to the 1984 survey, had 800 epg of stool or more.

Prevalences in the other areas referred to in the study were respectively 52.9%, 61.4% and 67.1% in Iietune, Kavilinguni and Kakuyuni.

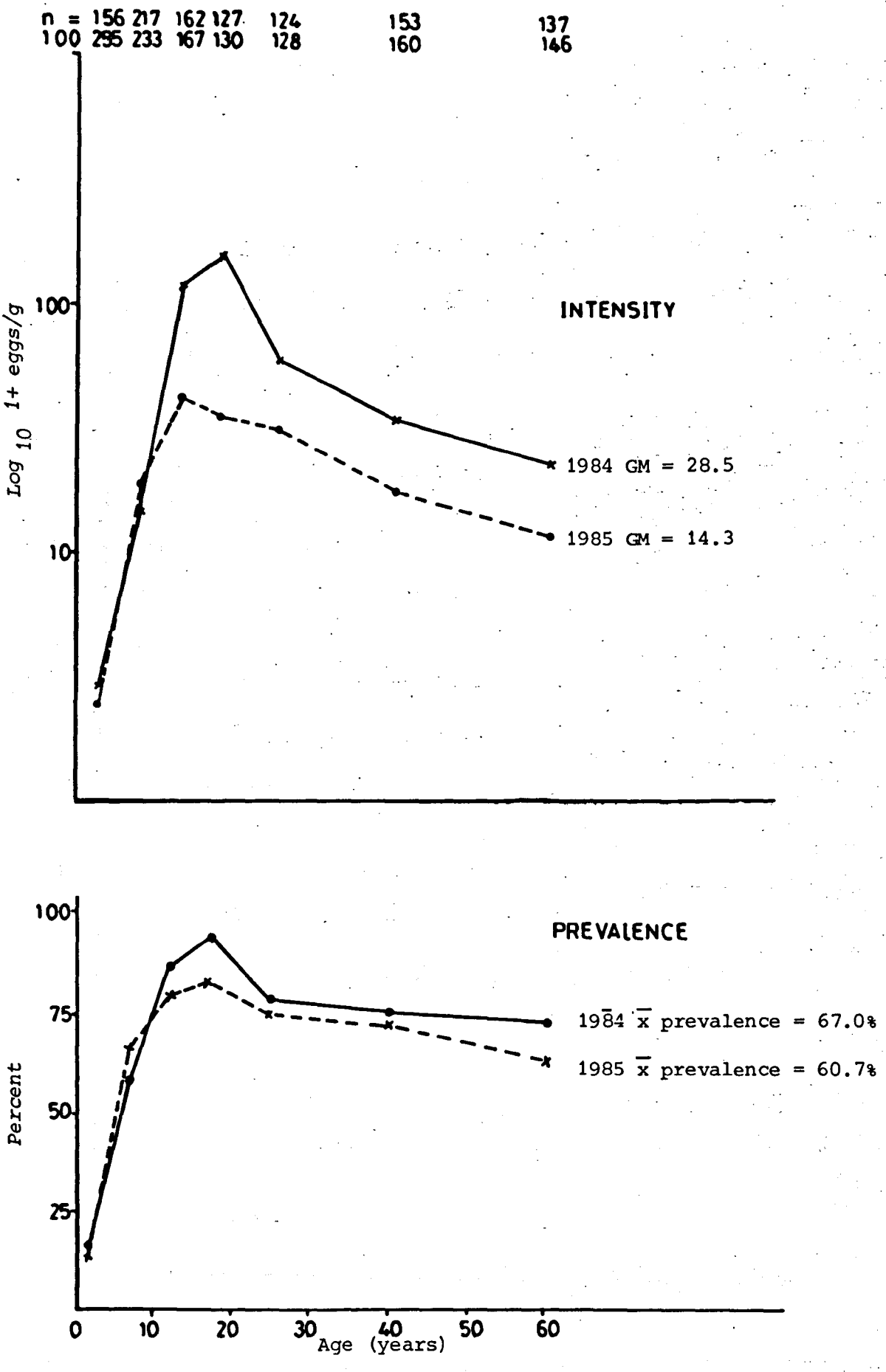

FIGURE 3.2

Age-specific curves for S. mansoni prevalence (%) and intensity (GM eggs counts) based on all subjects by sex for all Matithini residents examined in July 1984 and again in September 1985

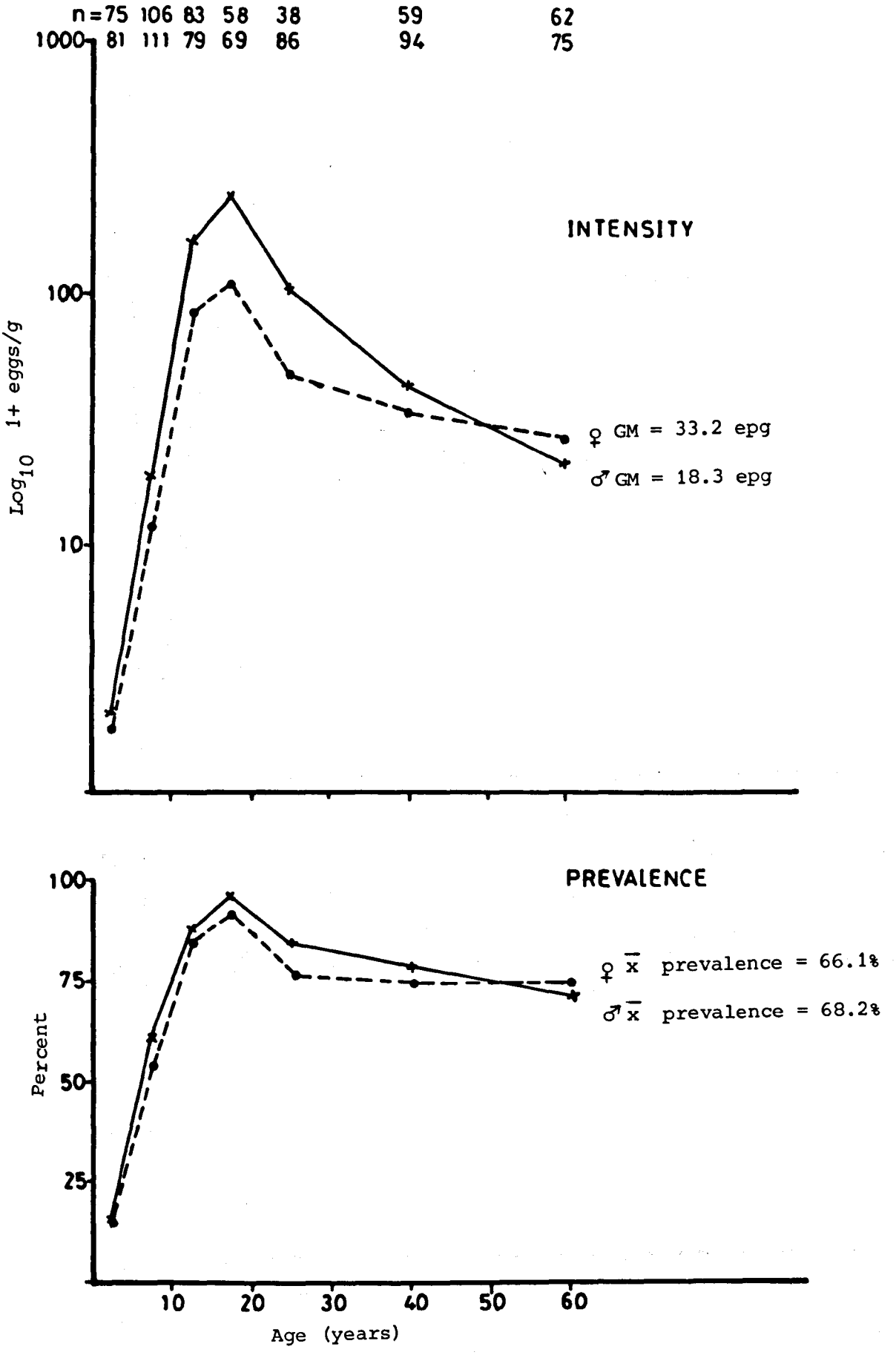

FIGURE 3.3

Age-specific curves for S. mansoni prevalence (%) and intensity (GM eggs counts) based on all subjects by sex for all Matithini residents examined in July 1984

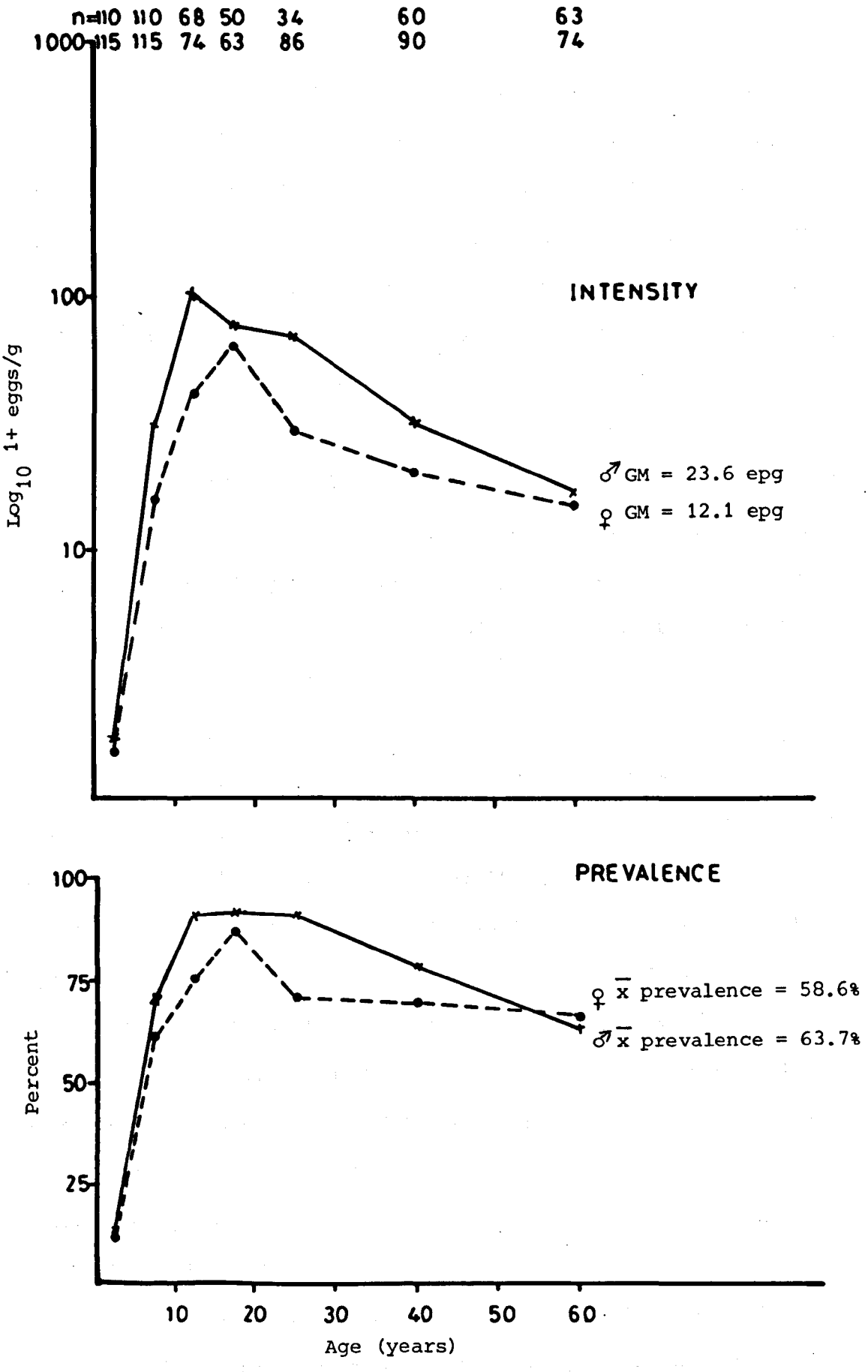

FIGURE 3.4

Age-specific curves for S. mansoni prevalence (%) and intensity (GM eggs counts) based on all subjects by sex for all Matithini residents examined in September 1985

3.3.1.2 Index of potential contamination

The relative index of potential contamination with S. mansoni eggs is given in Table 3.1. The total number of eggs produced daily per 100 infected individuals was estimated to be 3,093,770 in July 1984. Considering the whole population of 1076 (of whom 67% or 721 were infected) the total number of eggs produced daily would be 22,306,082. Teenagers 10-19 year olds were together responsible for 62.3% of the eggs making them a very important group in transmission.

As shown in Table 3.2 treatment of only 65 individuals who were excreting 800 epg or more and representing only 9% of all infected individuals according to the 1984 survey resulted in a 50% reduction in the total daily number of eggs produced. 80% of those treated were below 20 years of age.

3.3.1.3 Incidence

Table 3.3 gives age-specific incidence by sex between July 1984 and September 1985. The overall incidence was 25.6% with males showing a higher figure (31.5%) than females (21.2%). The males showed a more normal pattern with incidence increasing with age to a peak in the 10-14 year olds and declining thereafter. The females showed a similar pattern in the younger age group but reached a peak in the 15-19 year olds and thereafter gave a rather distorted picture declining in the 20-29 year olds before rising again in the older age groups.

3.3.2 Biological

3.3.2.1 Snail species

The sole vector for S. mansoni in the area was B. pfeifferi which was found in plenty throughout much of the study area. Lymnaea natalensis which transmits liver fluke in cattle was also present but not common. Bulinid snails were absent except for Bulinus forskalii which was found but rarely after rains.

TABLE 3.1

Relative index of potential contamination with S. mansoni eggs by age in Matithini during July 1984

Age group (years)	Population structure (1)	Prevalence % (2)	Intensity arithmetic mean epg (3)	Index of potential contamination* (1x2x3/100)=4	Average weight of faeces** (5)	Total no. of eggs/day (5x4=6)	Relative contribution (%)
0- 4	19.3	15.4	30	89	100	8900	0.2
5- 9	15.2	57.6	156	1366	180	245880	4.0
10-14	13.7	86.4	533	6309	320	2018880	33.0
15-19	10.8	93.7	514	5202	345	1794690	29.3
20-29	14.9	78.2	327	3810	330	1257300	20.5
30-49	11.5	75.8	210	1831	350	640850	10.5
50+	10.6	73.0	132	1021	150	153150	2.5
TOTAL				19628		6119650	100.0

* Total number of eggs excreted daily in 1 gm of faeces for a representative sample of 100 persons per population

** Average weight of stool taken from Kivii data

TABLE 3.2

Changes in prevalence and intensity of infection of S. mansoni following treatment of very heavily infected individuals in Matithini

AGE GROUP	JULY 1984			SEPTEMBER 1985		
	Prevalence (%) (1)	Intensity (epg)* (2)	Potential contamination** (1x2)	Prevalence (%) (1)	Intensity (epg)* (2)	Potential contamination** (1x2)
0- 4	15.4	30	462	12.4	21	260
5- 9	57.6	156	8986	65.7	158	10381
10-14	86.4	533	46051	79.0	274	21646
15-19	93.7	514	43162	82.3	212	17448
20-29	78.2	327	25571	74.2	176	13059
30-49	75.8	210	15918	71.9	120	7308
50+	73.0	132	9636	63.0	116	
Total potential contamination			154786			70102

* Arithmetric mean
** Eggs/day in 1 gm faeces of all infected individuals per 100 population

TABLE 3.3

Age-specific incidence of S. mansoni infections for Matithini community between July 1984 and September 1985.

Excluded are persons who were treated in April 1985

AGE GROUP (years)	INCIDENCE (%)					
	MALES		FEMALES		ALL	
	No. neg.[a]	% inc.[b]	No. neg.[a]	% inc.[b]	No. neg.[a]	% inc.[b]
0- 4	54	13.0	56	8.9	110	10.9
5- 9	37	54.1	45	24.4	82	37.8
10-14	9	77.8	12	25.0	21	47.6
15-19	2	50.0	5	100	7	85.7
20-29	2	50.0	14	14.3	16	18.8
30-49	9	44.4	22	22.7	31	29.0
50+	17	5.9	17	29.4	34	17.6
ALL	130	31.5	171	21.1	301	25.6

a Number negative at first survey (July 1984) and re-examined again in second survey (September 1985)

b Percentage positive at second survey

Note: Although the above gives an indication that transmission transmission was continuing, the figures should be treated with caution since both 1984 and 1985 examinations were based on examination of duplicate Katos from single stool specimens only.

3.3.2.2 Snail population and infection rates

Table 3.4 summarises details of snails collected in 1985 according to their size and those infected. A total of 1,753 B. pfeifferi snails were collected between January and December 1985. The majority of snails collected (1,323 or 75%) and of those which were infected (28 or 57%) were in the medium (5-10 mm) size group, followed by the largest size group 10 mm with 326 (19%) collected and 18 (37%) infected. Few snails less than 5 mm were collected and only few of them were infected. Overall, the highest infection rates (5.5%) was found in the largest snails followed by the smallest snails (2.9%) and then medium sized snails (2.1%).

Figure 3.5a summarises data on snails collected (total and infected transformed to $\log_{10}$ (x+1) to include zero counts in relation to rainfall from January to December 1985.

In general, total numbers of snails collected as well as those infected dropped, sometimes dramatically during periods of heavy rainfall but increased gradually after the rains stopped. Although many snails were collected between middle of July and middle of September 1985 virtually none was infected. The October-November and December rains were generally gentle and did not result in flooding which could wash snails downstream and it is not surprising that both total numbers of snails collected and those infected were not greatly affected. For a more general transmission picture of the general area and covering a longer period, refer to Figure 3.5b.

3.3.2.3 Cercariometry results

Top graph in Figure 3.5a summarises data on total number of cercariae per litre of water collected from all sites between January to December 1985. Although cercariometry data were collected from different sites but ones which were very close to snail sites, the pattern was the same as that of snails with numbers

TABLE 3.4

Summary of the numbers of snails collected and their infection rate by size in Matithini between January and December 1985

SIZE	TOTAL SNAILS No.	Proportion	INFECTED SNAILS No.	Proportion	INFECTION RATE %
< 5 mm	104	0.06	3	0.06	2.9
5-10 mm	1323	0.75	28	0.57	2.1
>10 mm	326	0.19	18	0.37	5.5
TOTAL	1753	1.00	49	1.00	2.8

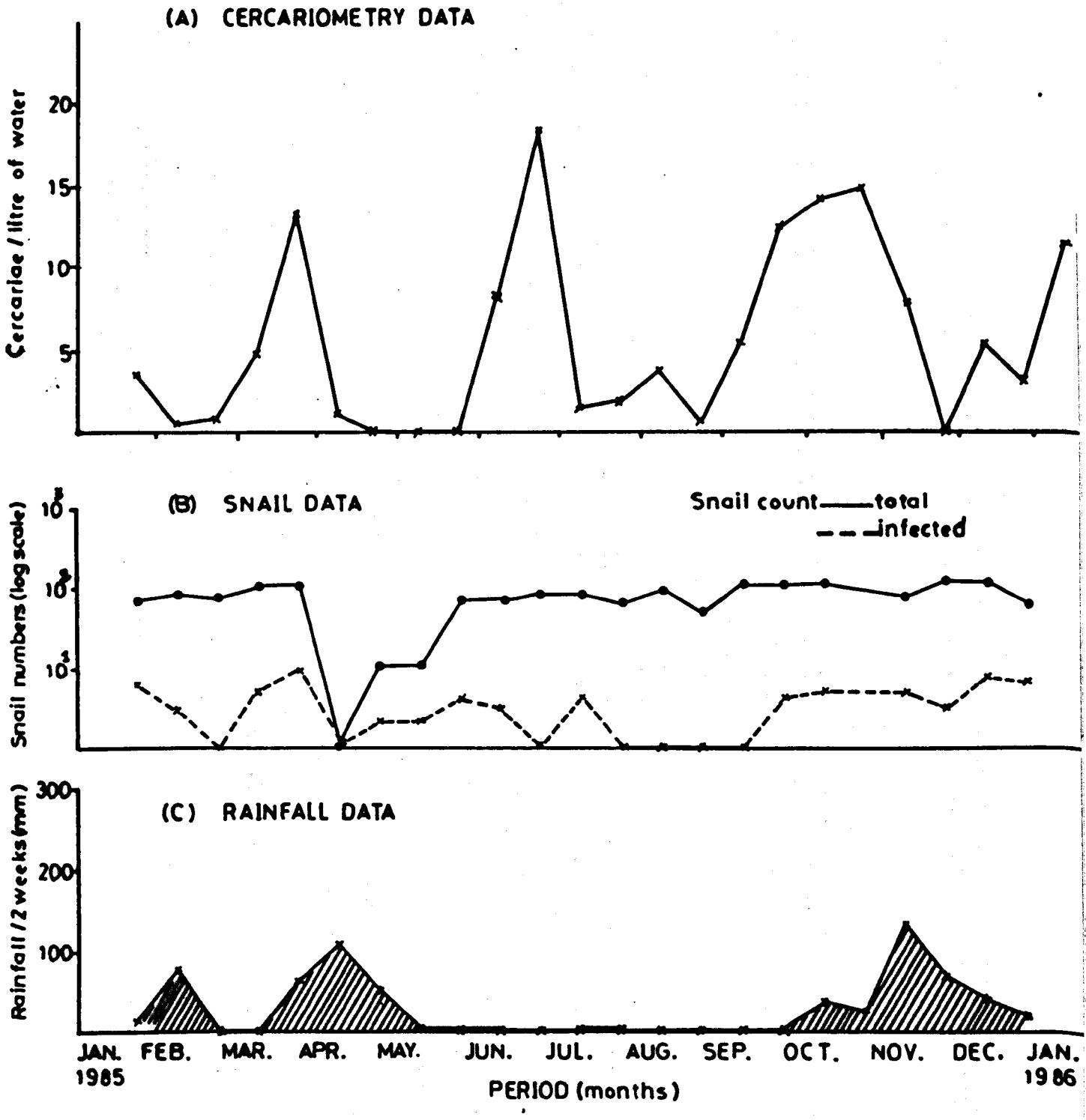

FIGURE 3.5a

S. mansoni transmission data from stream sites in Matithini in 1985 showing the seasonal fluctuations in numbers of snails, their *S. mansoni* infection rates and cercarial densities obtained from routine fortnightly sampling

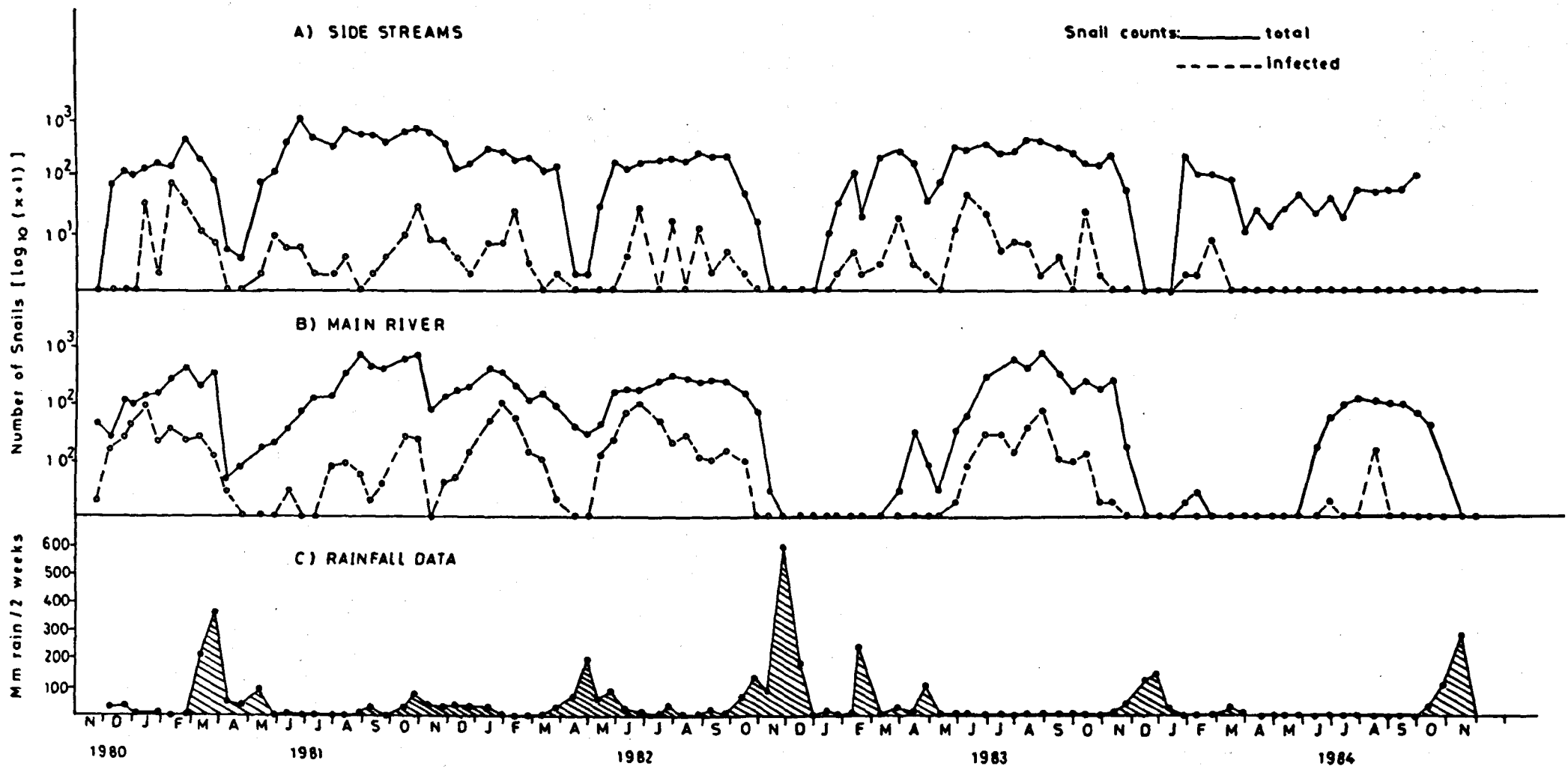

FIGURE 3.5b

S. mansoni transmission data from stream and river sites in Matithini between 1980 and 1984 showing seasonal fluctuation in numbers of snails and their S. mansoni infection rates obtained from routine sampling fortnightly (from Ouma et al. submitted)

of cercariae/litre falling with the rains. The fall in figures of infected snails during July and August was as a result of prolonged drought which resulted in some of the sites which usually recorded infected snails becoming dry. Details of monthly cercariometry data are given in Table 3.5.

3.3.2.4 Other trematode parasites

Among other common larval trematodes recovered from Biomphalaria pfeifferi during shedding and from cercariometry were Xiphidiocercariae (Fig. 3.6a), Strigea cercariae (Fig. 3.6b). Others also seen often included Echimostomes and Gymmocephalous cercariae.

3.3.3 Water contact data

3.3.3.1 General

Only five sites were observed between June 1984 and May 1985. One observer spent a total of 208 days to cover the sites. Altogether 1,157 contacts by 319 persons (22% of the population) were observed.

3.3.3.2 Pattern of water contact according to age and sex

The total number of water contacts for the Matithini community divided into sex and broad age groups is given in Figure 3.7. The total contact increased with age and in the case of males reached a peak in the 10-14 year olds and thereafter dropped considerably then remained stable before showing a slight increase in the oldest age group (50 years plus). In the case of females, the number of contact reached a peak in the 20-29 year olds and thereafter remained high but dropped in the oldest age group.

3.3.3.3 Pattern of water contact according to activity performed and according to site preference by activity

Definition of activities is given in Table 3.6. For the purposes of these studies, they have been classified into seven categories as shown in the same Table by combining some of the

TABLE 3.5

Monthly total numbers of cercariae per litre of water in Matithini collected between January and December 1985

Each value represents recovery during two sampling occasions. Means on the last row are calculated on the number of samples taken for each site during the year. Means on the last column represent the monthly average from all sites.

MONTH	SITE						MONTHLY	
	1	2	3	5	6	7	Total	Mean
January	0.2	0.6	1.6	0.7	0.1	0.3	3.5	0.6
February	0	0	0.4	0.1	0.7	0.2	1.4	0.2
March	2.6	1.1	5.4	1.8	1.3	7.2	19.4	3.2
April	0	0	0	0	0	0	0	0
May	0	0	0	0	0	0	0	0
June	1.6	4.8	5.6	3.9	5.3	5.3	26.5	4.4
July	0.5	0.5	0.9	0.3	0.6	0.4	3.2	0.5
August	0.4	Dry	1.0	0.7	1.5	0.7	4.3	0.7
September	0.5	Dry	4.7	3.0	2.9	5.9	17.0	2.8
October	Dry	Dry	2.8	8.8	4.5	11.8	27.9	4.7
November	Dry	Dry	2.0	3.1	1.6	0.9	7.6	1.3
December	0	0	0	0	0	0	0	0
Total	5.8	7.0	31.3	22.4	18.5	32.7	110.8	9.2
Mean	0.6	0.9	2.6	1.9	1.6	2.8		

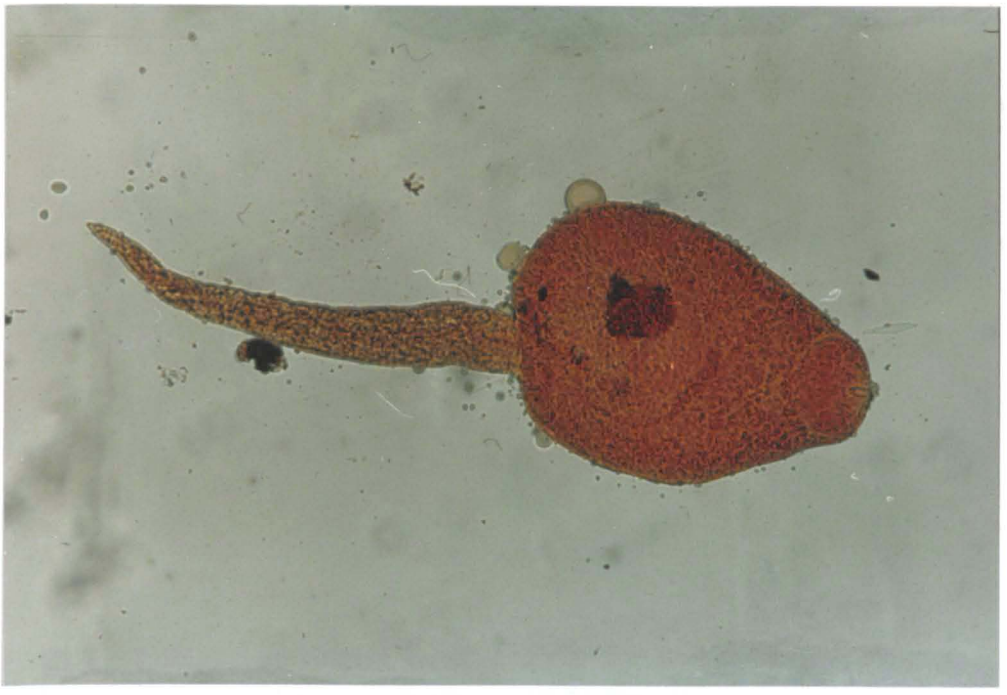

FIGURE 3.6a Xiphidiocercariae (recovered from B. pfeifferi)

FIGURE 3.6b Strigea cercariae (recovered from B. pfeifferi)

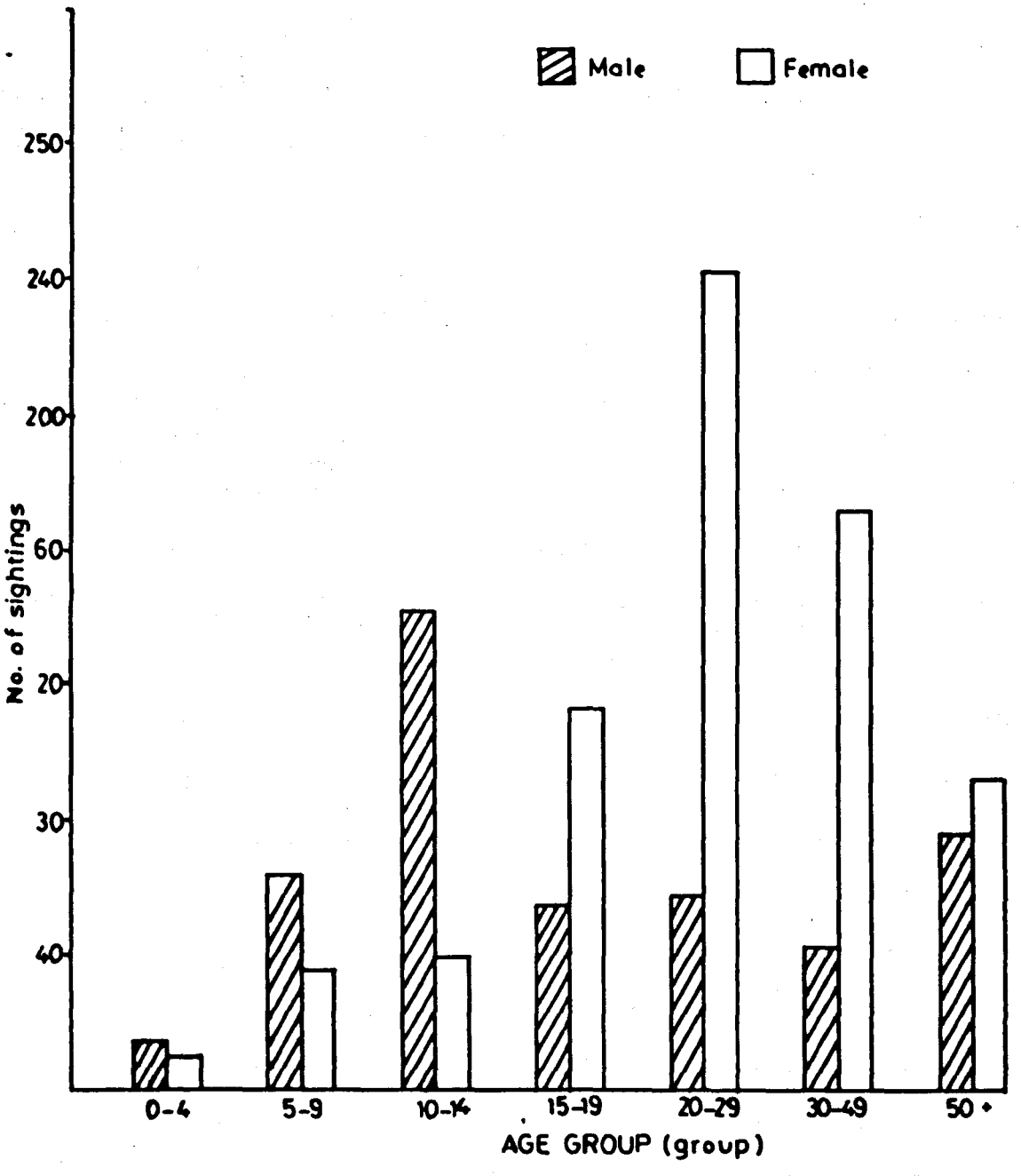

FIGURE 3.7

Pattern of water contact in Matithini between June 1984 and May 1985 according to age and sex

activities on the basis of whether they involved total body exposure (swimming, playing, bathing) or whether they were usually performed in a sequence (walking in water before bathing parts of the body or washing clothes and then utensils). Under 'others' come watering cattle and drinking. Drinking was observed only on very few occasions.

Overall, drawing water was the most frequent activity accounting for 34.9% of total contacts followed closely by crossing (28.4%) and then walking in water and bathing parts of the body (15.7%). Playing, bathing and swimming which are regarded as contaminative activities only accounted for 7.6%. Very little washing of clothes and utensils was observed (3.3%) and equally little observed was watering cattle and drinking (3.1%).

The numbers of water contact according to age, sex and the activities performed is given in Table 3.7. Bathing, swimming and playing were common among those below 20 years of age for both sexes but decreased thereafter. Very young females (4 years or less) were not observed bathing, swimming or playing in water. Crossing and washing parts of the body were generally common among all ages for both males and females. Only few persons (mostly females aged 20-29 years) were observed washing clothes or utensils (Figures 3.8) but this was not surprising since washing clothes mainly took place in the main river (Kyaana and Kalangi - see Figure 2.1) and river sites were not included in our observation schedule in Matithini. Drawing water was predominantly female activity with all ages involved although few males between 10 and 29 years also took part. Watering vegetables (irrigation) was mostly an activity of adult males although females also took part. Other activities which consisted mainly of watering cattle or fording (Fig. 3.9) were predominantly male activities and more particularly involving older children (5-9) and teenagers (10-14 years).

TABLE 3.6

Definition of activities

ACTIVITY	DEFINITION
Bathing	Bathing whole body
Swimming	Swimming in water naked
Playing	Playing in water naked (mainly children)
Crossing	Passing through water to go to the other side of river or stream
Walking in water	Walking along river or stream
Washing parts of the body	Washing feet, hands or head
Washing clothes and utensils	Washing clothes or cooking utensils directly in water
Drawing water	Collecting water to take home
Watering vegetables	Drawing water and using it to irrigate small vegetable farms along river or stream
Watering cattle	Taking cattle to drink and then coming in contact with water in the process
Drinking	Drinking directly from water body using hands to take water to the mouth

FIGURE 3.8 Women washing clothes and accompanied by children in Kyaana stream

FIGURE 3.9 Watering cattle by children at a site in Kwamyena stream in Matithini

TABLE 3.7

Number of water contact according to the activity performed, age and sex.

Top table: males - bottom table: females. Values represent number of contacts; the percentage of the total contacts of each age group for each activity is given in brackets:-

BATHE/SWIM/PLAY = Bathing whole body, swimming or playing in water;
WA WAPB = Walking in water and Washing parts of the body;
WAC U = Washing clothes and Utensils; OTHERS = drinking and fording.

ACTIVITY	AGE GROUP 0-4	5-9	10-14	15-19	20-29	30-49	50+	ALL AGES
PLAY/BATHE/SWIM	5(33.3)	14(22.2)	16(12.0)	10(17.9)	1(2.0)	2(4.7)	4(5.2)	52(11.9)
CROSSING	3(20)	19(30.2)	37(27.8)	19(33.9)	20(40.8)	19(44.1)	35(45.5)	152(34.7)
WA WAPB	4(26.6)	14(22.2)	33(24.8)	7(12.5)	5(10.2)	10(23.3)	21(27.3)	94(21.5)
WAC U	0	3(4.6)	4(3.0)	1(1.8)	3(6.1)	0	1(1.3)	12(2.7)
DRAWING WATER	1(6.7)	10(15.4)	18(13.5)	9(16.1)	10(20.4)	0	2(2.6)	50(11.4)
IRRIGATION	0	0	7(5.3)	9(16.1)	10(20.4)	11(25.6)	12(15.6)	49(11.2)
OTHERS	2(13.3)	5(7.7)	18(13.5)	1(1.8)	0	1(2.3)	2(2.6)	29(6.6)
ALL ACTIVITIES	15(3.4)	65(14.8)	133(30.4)	56(12.8)	49(11.2)	43(9.8)	77(17.6)	438(100)

ACTIVITY	AGE GROUP 0-4	5-9	10-14	15-19	20-29	30-49	50+	ALL AGES
PLAY/BATHE/SWIM	-	4(11.1)	6(15)	5(4.4)	15(6.2)	5(6.2)	1(1.1)	36(5.1)
CROSSING	1(10)	5(13.9)	8(20)	39(34.2)	42(17.4)	39(22.5)	36(38.7)	170(24)
WA WAPB	2(20)	7(19.4)	13(32.5)	17(14.9)	13(5.4)	29(16.8)	6(6.5)	87(12.3)
WAC U	-	-	-	4(3.5)	17(7.0)	5(2.9)	-	26(3.7)
DRAWING WATER	5(50)	13(36.1)	11(27.5)	47(41.2)	141(58.3)	88(50.9)	48(51.6)	353(49.9)
IRRIGATION	-	5(13.9)	2(5)	2(1.8)	13(5.4)	6(3.5)	1(1.1)	29(4.1)
OTHERS	2(20)	2(5.6)	-	-	1(0.4)	1(0.6)	1(1.1)	7(1.0)
ALL ACTIVITIES	10(1.4)	36(5.1)	40(5.6)	114(16.1)	242(34.2)	173(24.4)	93(13.1)	708(100)

Table 3.8 shows activites by site. Bathing, swimming and playing occurred mostly in sites 2, 3 and 5 but also to a lesser extent in sites 6 and 7. Crossing was commonest in sites 2, 3 and 5 while walking in water and washing parts of the body were commonly observed in sites 1, 3 and 7. Washing clothes and utensils mainly took place in sites 1, 2 and 3. More than 50% of drawing water activities were observed in site 3 which also recorded the highest number of contacts due to watering vegetables. Contact due to watering cattle was observed predominantly in sites 3 and 5.

Table 3.9 shows site preference by age. Site 3 was popular for all ages otherwise there was no obvious site preference.

3.3.3.4 Pattern of water contact according to day of the week

The distribution of number of contacts as well as activities by day of the week is given in Table 3.10. There did not seem to be much difference in the total number of contacts throughout the week. Playing, bathing and swimming were more commonly observed on Mondays and Tuesdays. Except for washing clothes and utensils which were observed mostly on Fridays and over the weekend, the rest of the activities were well spread throughout the week.

As shown in Table 3.11, it would seem that contacts with water were more or less equally observed in all sites throughout the week. There were preferences for sites 1 and 5 on weekends, site 2 on Tuesday and sites 4, 6 and 7 on Fridays.

3.3.3.5 Pattern of water contact according to time of the day

The number of contacts according to time of the day by age is given in Figure 3.10. Contacts during the mornings (6-11a.m.) increased with age and were highest in the 20-29 year olds and thereafter remained high for the rest of the age groups. Contacts during the middle of the day (11.01-15.00) increased with

TABLE 3.8

Number of activities and mean cercarial densities by site in Matithini between July 1984 and May 1985

Values in brackets represent percentages of totals for each activity

ACTIVITY	SITES 1	2	3	5	6	7	All sites
Cercariae/litre of water	0.13	0.10	1.20	1.20	0.80	0.70	0.70
Play/bathe/swim	1(1.1)	20(22.7)	20(22.7)	31(35.2)	6(6.8)	10(11.4)	88(7.7)
Crossing	49(15.0)	64(19.6)	81(24.9)	58(17.8)	25(7.7)	47(14.5)	325(28.5)
Walking in water and washing parts of body	55(30.4)	16(8.8)	44(24.3)	25(13.8)	4(2.2)	37(20.4)	181(15.8)
Washing clothes and utensils	8(21.6)	8(21.6)	13(37.1)	1(2.7)	n.o.	7(18.9)	37(3.2)
Drawing water	44(11.2)	9(2.3)	209(53.0)	8(2.0)	82(20.8)	42(10.7)	394(34.5)
Irrigation	1(1.2)	n.o.	30(37.0)	19(23.5)	17(21.0)	14(17.3)	81(7.1)
Others	1(2.8)	1(2.8)	6(16.7)	22(61.1)	2(5.6)	4(11.1)	36(3.2)
All activities	159(13.9)	118(10.3)	403(35.3)	164(14.4)	136(11.9)	161(14.1)	1142(100)

TABLE 3.9

Number of contacts in Matithini according to age and site

Figures in brackets refer to percentages of totals for each group

AGE	SITES						
	1	2	3	5	6	7	All sites
0- 4	4(16)	4(16)	8(32)	5(20)	n.o.	4(16)	25 (2.2)
5- 9	19(18.8)	6(5.9)	28(27.7)	25(24.88)	7(6.9)	16(15.8)	101(8.9)
10-14	38(22.2)	19(11.1)	39(22.8)	47(27.5)	3(1.8)	25(14.6)	171(15.1)
15-19	39(23.1)	17(10.1)	51(30.2)	32(18.9)	8(4.7)	22(13.0)	169(15.0)
20-29	25(8.9)	39(13.9)	115(41.1)	15(5.4)	55(19.6)	31(11.1)	280(24.8)
30-49	18(8.4)	19(8.8)	84(39.1)	15(7.0)	46(21.4)	33(15.3)	215(19.0)
50+	15(8.9)	11(6.5)	73(43.2)	24(14.2)	17(10.1)	29(17.2)	169(15.0)
All	158(14.0)	115(10.2)	398(35.2)	163(14.4)	136(12.0)	160(14.2)	1130(100)

TABLE 3.10

Frequency pattern of water contact according to day of the week and activit

Figures show number of contacts observed per activity for each day of the week. Figures in brackets represent percentages of totals for each activity for each week

ACTIVITY	DAY OF THE WEEK					
	MONDAY	TUESDAY	FRIDAY	SATURDAY	SUNDAY	ALL DA
Play/bathe/swim	25(28.4)	29(33.0)	11(12.5)	12(13.6)	11(12.5)	88(7.
Crossing	58(17.6)	61(18.5)	75(22.8)	79(24.0)	56(17.0)	329(28.
Walking in water and washing parts of body	31(17.0)	37(20.3)	32(17.6)	36(19.8)	4(25.3)	182(15.
Washing clothes and utensils	7(13.2)	3(7.9)	9(23.7)	11(28.9)	8(21.1)	38(3.
Drawing water	97(24.0)	62(15.3)	95(23.5)	56(13.9)	94(23.3)	404(34.
Irrigation	14(17.3)	15(18.5)	14(17.3)	21(25.9)	17(21)	81(7.
Others	7(19.4)	6(16.7)	9(25.0)	8(22.2)	6(16.7)	36(3.
All activities	239(20.6)	213(18.4)	245(21.2)	223(19.3)	238(20.6)	1158(10(

TABLE 3.11

Pattern of water contact according to day of the week.

Figures show number of contacts observed per site and per day of the week. Percentage of the total contacts of each day of week and for each site is given in brackets.

SITE	MON	TUE	FRI	SAT	SUN	TOTAL
1	35(22.0)	23(14.5)	14(8.8)	42(26.4	45(28.3)	159(13.7)
2	21(17.8)	34(28.8)	27(22.9)	16(13.6)	20(16.9)	118(10.2)
3	91(22.5)	78(19.3)	76(18.8)	73(18.1)	86(21.3)	404(34.9)
4	3(20)	2(13.3)	7(46.7)	1(6.7)	2(13.3)	15(1.3)
5	26(15.9)	30(18.3)	35(21.3)	31(18.9)	42(25.6)	164(14.2)
6	31(22.8)	19(14.0)	46(33.8)	26(19.1)	14(10.3)	136(11.8)
7	32(19.9)	26(16.1)	39(24.2)	34(21.1)	30(18.6)	161(13.9)
ALL SITES	239(20.7)	212(18.3)	244(21.1)	223(19.3)	239(20.7)	1157(100)

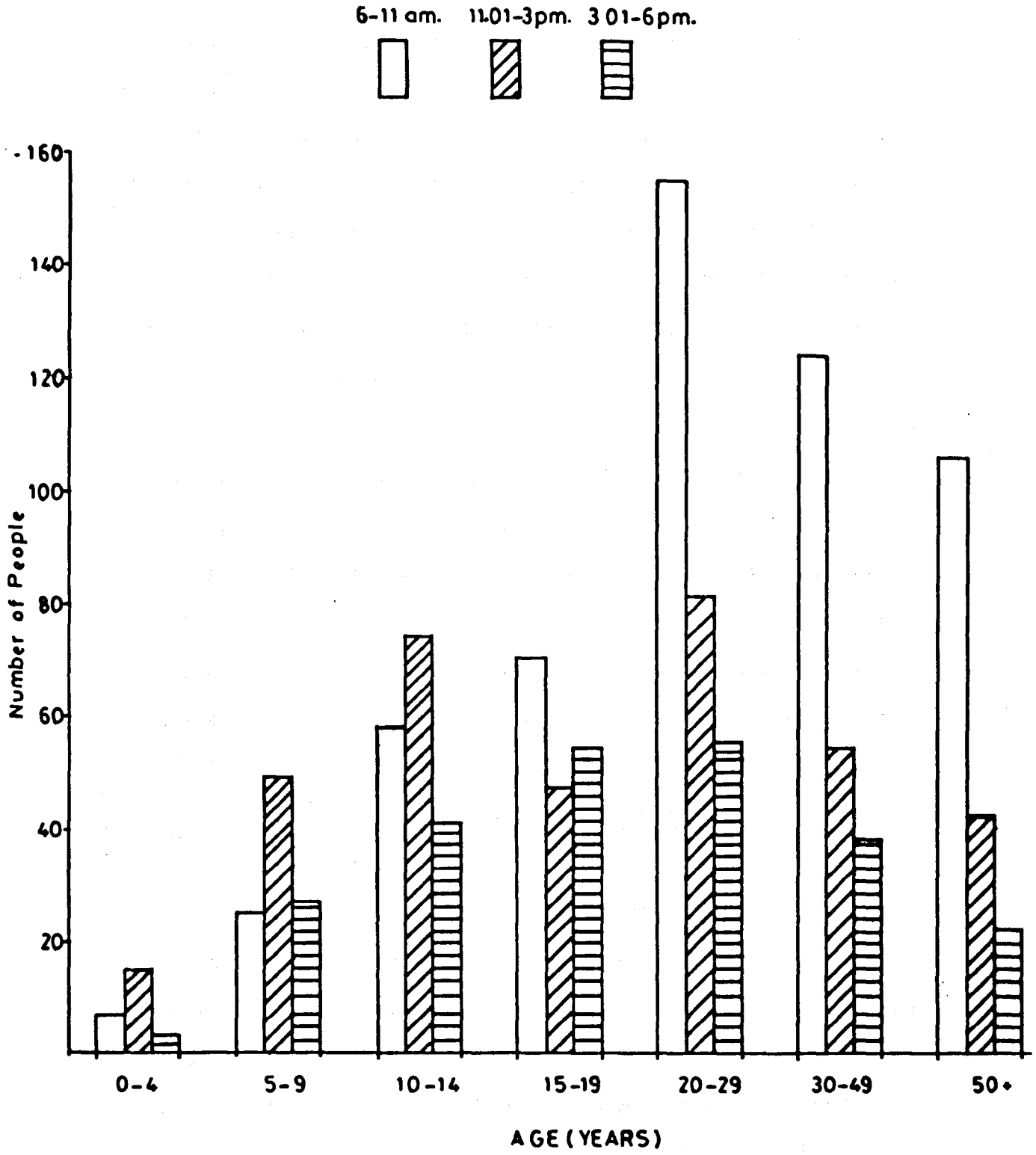

FIGURE 3.10

Pattern of water contact in Matithini between June 1984 and May 1985 according to age and time of day

age until 10-14 year olds and then dropped before rising again to reach a peak in the 20-29 year olds before decreasing gradually. Contact during the rest of the day (15.01-18.00) increased with age and also reached a peak in the 20-29 year olds before dropping gradually.

The number and mean duration of contact by sex is given in Table 3.12. In both sexes, the number of contacts was greatest during the mornings and then decreased during the rest of the day although both sexes spent on average more time in water during the middle of the day and overall, males spent more time in water compared to females.

The activities according to time of the day are shown in Table 3.13. Playing, bathing and swimming were most commonly observed during the middle of the day and so were washing clothes and utensils. Other activities (mainly watering cattle) also took place mostly during the middle of the day. Crossing, washing parts of the body, drawing water and watering vegetable were mostly morning activities but they were also observed to varying extents for the rest of the day.

3.3.3.6 Pattern of water contact according to season

Pattern of water contact according to season is summarised in Table 3.14. Seasons in Kenya are not very well defined and strictly speaking depend on rainfall. The period covered in the analysis could be divided roughly into four on the basis of being wet or dry. As can be seen from the table, there was not much difference in monthly observed contacts by season but people on average spent more time in water during the first dry period (June to September 1984) and less time during February to May 1985 wet period. The reverse is true with the wet period (October -November 1984) and the dry period (December 1984 - January 1985).

TABLE 3.12

Number and mean duration of contact in Matithini by sex according to time of the day

TIME	MALES		FEMALES	
	No.	Mean duration* (mins)	No.	Mean duration* (mins)
06.00-11.00	175	17.6	376	10.8
11.01-15.00	173	21.6	194	18.4
15.01-18.00	102	17.4	139	11.9
ALL TIME	450	19.1	709	13.1

TABLE 3.13

Number of activities by time of the day in Matithini

Values in brackets represent percentages of totals for each activity observed

ACTIVITY	TIME			
	06.00-11.00	11.01-15.00	15.01-18.00	ALL TIMES
Play/bathe/swim	18(20.5)	52(59.1)	18(20.5)	88(7.6)
Crossing	176(53.5)	94(28.6)	59(17.9)	329(28.4)
Walking in water and washing parts of body	71(39.0)	59(31.9)	52(28.6)	182(15.7)
Washing clothes and utensils	4(10.5)	20(52.6)	14(36.8)	38(3.3)
Drawing water	234(57.9)	105(26.0)	65(16.1)	404(34.9)
Irrigation	37(45.7)	21(25.9)	23(28.4)	81(7.0)
Others	11(30.6)	16(44.4)	9(25.0)	36(3.1)
All activities	551(47.6)	367(31.7)	240(20.7)	1158(100)

TABLE 3.14

Number of contacts by activity according to period of the year

ACTIVITY	MEAN MONTHLY NUMBER OF CONTACTS			
	6.84-9.84 (Dry)	10.84-11.84 (Wet)	12.84-1.85 (Dry)	2.85-5.85 (Wet)
Play/bathe/swim	4.3	4.5	9	11
Crossing	4	33.5	41.5	40.8
Walking in water and washing parts of body	7.8	19.5	19.5	18.3
Washing clothes and utensils	1.8	3	3	4.8
Drawing water	60	20	8	27.5
Irrigation	12.5	1	7	3.8
Others	2.8	7.5	4.5	0.3

On average more contacts due to playing, bathing and swimming were observed during the long rains in 1985 (February - May) followed by the short dry period of December 1984 to January 1985. Relatively few contacts were observed during the dry period of June to September 1984 and during the wet period immediately following. As for the rest of the activities, watering vegetable was the only clearly defined seasonal activity with more contacts during the dry periods as compared to the wet periods. More contacts due to drawing water were observed during the long dry spell in 1984 but was very low in the next dry period of December 1984 to January 1985. Surprisingly very few contacts due to crossing were observed in the first few months of the beginning of the study and so was walking in water and bathing parts of the body. This is almost certainly due to the fact that the fieldworker had not become fully familiar with everyone in the area.

3.4 DISCUSSION

The initial survey in Matithini in July 1984 revealed that S. mansoni was endemic (prevalence = 67%; intensity, GM = 28.5 epg). Prevalence reduced slightly (60.7%) in September 1985 but intensity dropped considerably (GM = 14.3 epg) as a result of treatment in April 1985 of the 65 heavily infected individuals (800 epg or more). This represented only 9% of the total number (721) infected in 1984. Total number of eggs produced per day was also reduced by half (see Table 3.2). Nevertheless transmission continued as is evident from incidence figures (Table 3.3) and from both snail and cercariometry data (Fig. 3.5a). Males had a slightly higher prevalence rate than females but differences in intensities were much more marked with males especially in the initial survey in July 1984 showing higher intensities (GM = 33.2 epg) than females

(GM = 23.2 epg). The tendency of males to show higher prevalences and intensities as compared to females has been observed elsewhere in Kenya (Siongok et al., 1976; Ouma et al., 1985; Sturrock et al., 1987).

No vectors of human schistosomes other than Biomphalaria pfeifferi were found in the area. This meant that the typical 'human' cercariae emerging from snails or observed in cercariometry samples were likely to be those of S. mansoni especially since no other animal species of schistosome transmitted by the same snail (S. rodhaini and S. mattheei) was found in the preferred rodent hosts examined from the area (see section 6.2.3.2). Bulinus forskalii, which is known to transmit S. bovis in East Africa (Southgate and Knowles, 1975) were only found in very small numbers and none shed any type of cercariae.

Transmissison of S. mansoni in the field was measured by monitoring snail infection rates and by cercariometry. 1985 was generally a dry year and had only moderate rainfall as was 1984 compared to the previous years (Table 2.5). It was not surprising therefore that only relatively few numbers of snails were collected. Some of the sites also dried out.

As expected, the greatest S. mansoni infection rates were observed in the largest snails but, because of their greater abundance (see Table 3.4) medium sized snails clearly play an important role in transmission. The smallest sized snails were undoubtedly undercollected, and only 3 of them were found shedding 'human' cercariae and although the overall infection rate was slightly higher than that of medium sized snails, they were unlikely to be playing a major role in transmission. Similar observations were made in Iietune (Ouma et al., submitted) and so was the pattern of transmission in which the total number of snails and of those

infected fluctuated according to rainfall. The failure to find infected snails between August and September and the reduction in number of cercariae collected (Figure 3.5a) could possibly in part be due to the effect of treatment of heavily infected persons in April (number of eggs excreted daily reduced by half - see Table 3.2) but this is unlikely since treatment of heavily infected individuals has in the past been shown to have little effect on transmission (Polderman and Manshande, 1981; Ouma et al., 1985).

The results of cercariometry show a similar pattern as snail infections (Fig. 3.5a) implying that cercariometry can be reliably used in monitoring transmission but because of complexity of situations encountered in the field, in terms of varied hydrodynamic conditions, it is still largely at the experimental stage (Theron, 1986).

The area initially chosen for the study had to be extended to satisfy the wish of the area administrator and although everyone registered was included in the analysis of other sets of data, water contact data collection was only confined to a smaller section of the village and covering mainly the first 100 households. Observations were limited to only five sites on Kwamyena stream and it is therefore not surprising that only 319 persons representing only 22% of the entire population were observed between June 1984 and May 1985. Some of the people presumably visited sites not covered in the observations. In Iietune where many more sites were observed, 65% of the population were covered in the observations (Butterworth, personal communication).

The number of water contacts increased with age for both sexes and then dropped considerably in males over 14 years remaining relatively low but contact persisted at high levels in females after reaching a peak in the 19-29 year olds mainly because of household

duties. This difference between males and females was not reflected by higher prevalence or intensities of infection in females, as seen in community surveys in 1984 and 1985 (Figures 3.3 and 3.4). Similar observations were made in a nearby village of Iietune (Butterworth et al., 1984) and in The Gambia by Blumenthal (1985).

As referred to in the Introduction, the main reason for studying water contact behaviour of the people was to identify and learn more about activities observed and more particularly those activities which could lead to contamination of water with faeces containing S. mansoni eggs. There is no doubt that bathing, swimming and playing are important contributing to contamination of water bodies since they involved total body exposure including extremities. Yet in Matithini, these activities combined formed only 7.6% of total observed contacts in contrast to their widely reported predominance (Husting, 1983; Kloos et al., 1983; Blumenthal, 1985; Kvalsvig and Schulte, 1986). It is possible that these particular activities were under-reported because some people may have changed their places for bathing especially after probably realising that they were being observed even though they denied this. One thing in common with the findings by others referred to above is that these activities involved the younger generation. For example in Matithini nearly 70% of the observed activities due to bathing, swimming and playing were of those less than 20 years of age. This same group had the highest intensities of S. mansoni and were potentially responsible for nearly 70% of the total number of eggs produced daily (see Table 3.1). The three activities just referred to were most commonly observed between 11.00 and 15.00 when cercarial densities were also high (Prentice and Ouma, 1984) and this could be important for deciding the best time field health educators should go to important transmission sites to discourage

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was commonly used for this purpose showed on average high numbers of cercariae per litre of water but this may as well have been as a result of bathing, swimming and playing activities also observed at the site. Careful evaluation of the importance of watering cattle in transmission is necessary on a wider scale before any conclusion can be made. It is worth noting that looking after cattle was mostly an activity of younger persons (5-14 years) and involved long periods of staying away from home making it more likely to result in defaecations in the bush away from home.

It is unlikely that the rest of the activities washing clothes and utensils, drawing water and watering vegetables could play a part in potential contamination of the environment. Washing clothes directly in river or stream may have added few S. mansoni eggs into water from faeces remaining in the underpants (Chernin and Antolics, 1973) but this was not investigated.

Drawing water involved only very short periods of time and people usually drew water and went back straight home. Most of the people drawing water were adult females and were unlikely to defaecate in bushes near transmission sites. They were also not noticed bathing before or after drawing water although they did so at other times.

Only few people were observed watering vegetable and more than half of them were adults who were less likely to defaecate near the sites or bathe directly in water.

Further implications of the results of these studies in the transmission of S. mansoni in Matithini and the surrounding area are discussed in Chapters 4, 5 and the Overall Discussion.

3.5 SUMMARY OF CHAPTER THREE

1) General methods used in the investigations are described.

2) The first parasitological survey in July 1984 revealed a prevalence of 67.0% and intensity (GM = 28.5 epg) of *S. mansoni*. The second survey in September 1985 revealed a slightly lower prevalence (60.7%) but much reduced intensity (GM = 14.3 epg). In both cases males had slightly higher prevalences and intensities. The lower figures in 1985 were attributed to treatment given to a small proportion of the most heavily infected individuals during March 1985. However, transmission continued (incidence = 25.6%).

3) *Biomphalaria pfeifferi* was the sole vector of *S. mansoni* in the area studied. The overall infection rate for the period January 1985 to December 1985 was 2.8%. Transmission fluctuated with rainfall being low during periods of rain and high when rains stopped as revealed by both snail infection rates and cercariometry data.

4) Water contact observations revealed that:

a) Contact with water increased with age dropping after 14 years of life in males but remaining high in females throughout.

b) Drawing water was the most frequent activity (mostly by females) followed by crossing. Walking in water or bathing parts of the body were also fairly common. Contaminative activities (bathing, swimming and playing) accounted for only 7.6% of all activities but was commonly observed in the under twenties.

c) Site preference was observed in all activities but there was no obvious preference shown by different age groups.

d) People visited all sites more or less equally throughout the week but most people visited the sites during the middle of the day for purposes of swimming, bathing, playing, washing clothes and utensils and watering cattle. There were no obvious seasonal differences in frequency of contact.

CHAPTER 4

DEFAECATION BEHAVIOUR AND POTENTIAL CONTAMINATION OF THE ENVIRONMENT WITH SCHISTOSOME EGGS

4.1 GENERAL INTRODUCTION AND LITERATURE REVIEW

The level of environmental contamination with Schistosoma mansoni eggs which potentially can hatch and infect snails is important in understanding the epidemiology of the disease in a particular area. In the absence of control measures, this level will largely depend on defaecation habits of the people especially when this is considered in relation to presence or absence and use of sanitary facilities. Our knowledge of defaecation habits and latrine use is very limited at the moment.

From the data on prevalences, intensities and population structures, estimates of the level of contamination and which age groups are responsible for the bulk of contamination have been made (Jordan, 1963, 1985; Farooq and Samaan, 1967) but they did not take into account differences in mean faecal weight contributed by each age group.

4.1.1 Defaecation behaviour and latrine use

Although there is an accumulation of data on behavioural aspects of humans in relation to water (e.g. Dalton and Pole, 1978; Husting, 1983; Kloos et al., 1983) there have been remarkably few studies on human behaviour as it relates to contamination of the environment with schistosome eggs. WHO (1980) has stressed the need for studies directed at determining the pattern of faecal and urinary contamination in communities. Anderson and May (1985) emphasised that behavioural factors, particularly those associated with personal hygiene and defaecation habits, are likely to play a role in determining exposure to infection.

Faeces are frequently found on rocks or in bushes adjacent to or near river banks (Jordan, 1985; Polderman, 1974) but it is not known who is responsible for this, how often they do it and why they do it. Studies by Husting (1968) briefly looked at some aspects of human excretory behaviour relevant to transmission in Rhodesia (now Zimbabwe). Husting noted that latrines if present were not often used but he did not go into details for both practical and ethical reasons. The first attempt to look at defaecation habits in some detail was a preliminary study by Ouma and Van Ginneken (1980) who working in Lower Nduu, Machakos, Kenya (previously shown by Siongok et al. (1976) to be highly endemic for S. mansoni) found out that people, mostly children, very often defaecated near water bodies (Table 4.2). They also found that contaminative activities (bathing whole body, swimming and playing) constituted 25% of the activities observed post defaecation (Table 4.5b) and that most of the defaecations took place very close to water source, mostly in the morning hours.

Cheesmond and Fenwick (1981) using discrete observation and the interpretation of circumstantial evidence studied excretory behaviour of resident and migrant labourers in Gezira, Sudan and found that 93% of defaecations occurred in sites far removed from any water body and that after excretion 31% of the people washed themselves in water. Their results showed that privacy is a more important consideration than proximity of water in the selection of a site for excretion and suggested that there is only limited regular contamination by S. mansoni eggs under the observed conditions. However, the situation may be different in other areas as in the Gezira which is flat and has relatively little vegetation to provide cover for privacy.

It is generally agreed that provision of latrines could create a long term impact on transmission not only of schistosomiasis but also of other faecally transmitted diseases (WHO, 1985). The prediction made by Macdonald (1965) that sanitation will not reduce transmission was based on the false assumption that water bodies were 'saturated' with miracidia (Jordan and Webbe, 1982). However at present we have very little knowledge of reasons for not having or using latrines and how these relate to individual defaecation behaviour. Most observations tend to indicate that people may be having latrines but that they may not necessarily use them or if they do, only a section of the population may do so. For example, Gaud (1955) stated that latrines in Guinea Bissau, Ghana and Zaire were failures because only a few people used them. Farooq et al. (1966b) observed that in the Egypt-49 project area, latrines were not used by some members of the household especially younger children, mainly for fear of falling inside. Green (1985) studied factors relating presence and use of sanitary facilities in rural Swaziland and found that older people and small children were least likely to use a latrine - the former for attitudinal reasons and the latter for fear of falling inside.

Even if latrines are used, it is unlikely that people working away from their homesteads are likely to walk back home merely to defaecate (communal toilets are hardly available in most developing countries) and as expressed by Jordan et al. (1980) people working in their fields will defaecate there for convenience. In Kenya, Ayuka (personal communication) observed that in Kibwezi area of Machakos District, it was considered a matter of prestige to have a latrine irrespective of whether it was being used or not.

In the area studied during the present work, preliminary investigations had shown that the majority of households had toilets

and this was later confirmed (see section 2.2.2.5). It was therefore cosiderd relevant to find out why transmission of schistosomiasis mansoni continued despite presence of latrines which if adequately used, could result in considerable reduction of transmission.

4.1.2 Environmental contamination

In conjunction with studies on defaecation behaviour, it was considered necessary to obtain a better estimate of the total number of eggs excreted daily by individuals and by the community since as mentioned in the beginning of the chapter, previous estimates by other workers were based on daily mean faecal weights from hospital patients who may not have been truly representative.

Studies involving 24 hour faecal collection have been used mainly as a means of estimating daily egg production from infections with various helminths to determine worm burden or fecundity (Croll et al., 1982; Martin and Keymer, 1983; Anderson and Schad, 1985; Keymer and Hiorns, 1986). Results so far have been inconclusive mainly because of variability of egg counts within samples, between samples and between hosts (human or animals) and through time. Hall (1982) speculated on several factors which may lead to sources of these variabilities. He reasoned that eggs may be diluted by faeces depending on the daily output which is related to the amount and nature of the food eaten. He further reasoned that eggs may be unevenly mixed leading to sampling errors and that time may be an important determinant of degree of mixing of intestinal contents. He also argued that the size of the host may influence eggs counts as this often determines the amount of food eaten. For example, he reasoned that samples collected from children may have abnormally high egg counts, possibly because they produce relatively small amounts of stools in which the eggs will be concentrated. Although

the 24 h faecal collection study was primarily to collect data needed to make a relatively more accurate estimate of the number of eggs getting into the environment daily, the design provided an opportunity for a look at some of the above possibilities.

Therefore the present work looked at

1) Human defaecation behaviour using both observations and questionnaire with a view to identifying by age and sex who defaecates, where, when and what they do before and after defaecation.

2) Availability, awareness and pattern of latrine use in the community

3) Information necessary to get a better estimate of S. mansoni eggs being produced daily by individuals and by the community at large and to study age related factors affecting estimates of individual daily S. mansoni egg output and transmission in general.

4.2 MATERIALS AND METHODS

4.2.1 Defaecation behaviour

Studies on defaecation behaviour involved direct observations in the field, 24 h stool collections, and questionnaire studies to supplement information on defaecation behaviour and more particularly in relation to latrine use and bathing habits.

4.2.1.1 Direct observations

The main study area was Matithini but both Iietune and Kakuyuni villages (Fig. 1.4) were also used.

Observations on defaecation behaviour were done simultaneously with those of water contact. The general procedure was the same as already explained for water contact (see section 3.2.5). The observers who knew nearly everyone in the study area used a form

provided (see Appendix 4.1) to record who defaecated, their ages and sexes, time of defaecation, where defaecation took place in relation to water body and activities before and after defaecation. That defaecation had taken place was confirmed shortly after the person had gone away and the place of defaecation was plotted on a sketch map provided. This helped to trace the stool the following day to see if it had been washed away by rain or partly eaten by animals , especially dogs. The maps were also later used to approximate the distance of defaecation in relation to the water body.

4.2.1.2 24 hour faecal collection

This was a rather sensitive exercise and, as such, a separate small village (Kivii - see Fig. 1.4) with a defacto population of 240 persons living in 34 households was used. The village was mapped and demographic data collected as already explained (see section 2.2.2.1). Baseline data on prevalence and intensity of infection with S. mansoni was collected in May 1985 and transmission studies involving cercariometry were started at the same time using the methods already described in section 3.2.

A 24 hour stool collection programme was started in the first week of August 1985 and was completed at the end of October. This coincided with the beginning of the school holidays to ensure that everyone was generally at home. When schools opened, collections were only done on weekends. The procedure used involved the following stages:

a) On Day 1 a household was visited by a field worker in the company of a senior person in our team and a careful explanation was given about the purpose of the study.

b) The following day a field worker went back to the same household at 7 am carrying large plastic cups with lids, 1 x 1 foot polythene sheets, strings and labels. Each person present in the

household at the time was issued with three labelled plastic cups, three pieces of polythene and three strings. A careful explanation was given to everyone to provide separately all faeces excreted between 8 am that day to 8 am the following day. They were told to empty their bowels in polythene sheets each time they were naturally called upon to do so, fold up the sheet and tie with the string before placing in the appropriately labelled cup and noting the time of excretion on the label. A field worker stayed in the household most of the time to supervise the operation. Only one household was done at a time.

c) On the third day, a field worker visited the household again, just before 8 am, once more in the company of a senior person. At exactly 8 am all the residents were asked to hand over all the specimens produced during the previous 24 hours. At the time of handing over, each person was weighed and interviewed mainly to find out if they had collected all their stools during the previous 24 hours and whether the numbers of stools produced was their daily norm. They were also asked what they had eaten the previous day and whether they had any problems associated with the stomach.

All the stools handed over were carefully sorted and each stool specimen was weighed using a simple spring balance (Fig. 4.1). All individual records were entered in the individual forms provided (see Appendix 4.2). Details of age and sex were obtained from the records of demographic survey.

A portion of each stool was placed in a labelled polypot and these were taken to Kangundo laboratory where they were examined for consistency before making four instead of the usual two Kato preparations as described in section 3.2.3.2. Except for those specimens which were to be used for dog feeding experiments (see section 6.3.2.4). The rest were discarded in the nearest toilet before leaving the compound.

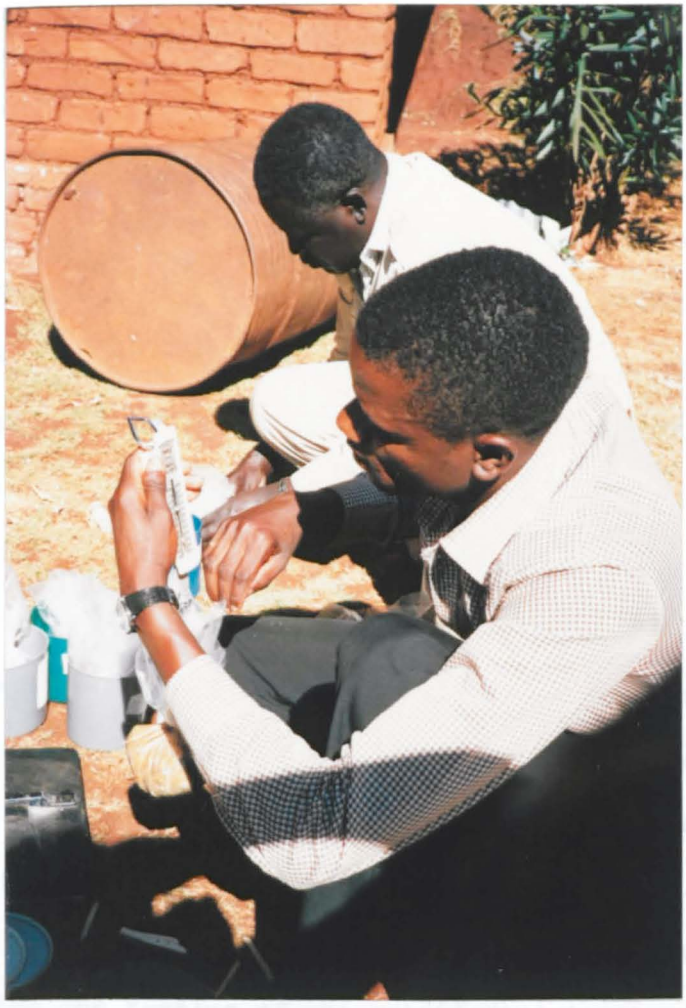

FIGURE 4.1

Weighing of stool in Kivii village during
24 hour faecal sample survey

d) All the four slides were read not later than five days after preparation and the results entered in the individual forms. Counts on baseline Katos were also entered on the same forms. The forms were thoroughly checked for completeness of information before sending to Nairobi for further processing of data.

The above procedures were repeated for each household. Re-visits were made later for those who were missing during the first visit. Those who were present but consistently failed to produce specimens were considered to have refused and were excluded from the study.

4.2.1.3 Questionnaire study

A questionnaire was designed (see Appendix 4.3a) to investigate defaecation behaviour in relation to latrine use in Matithini village. Two local interviewers, one of each sex, and who knew the people were used for this purpose. After initial training to understand the questionnaire, it was extensively tested in a nearby village before use for the main study population in Matithini. An instruction sheet was prepared (see Appendix 4.3b) and this was carried all the time by the interviewers. The interviews were conducted using the local language following a careful introduction in which the purpose of the study was explained. All persons who could be found in the 50% random sample of households in Matithini formed the study population and were interviewed individually between January and March 1986. For children aged two years or less, the mothers were interviewed instead. During the testing of the questionnaire, it was discovered that some questions were sensitive to older women being interviewed by a man. It was therefore decided that people be interviewed by a field worker of their own sex and especially for the older people of 30 years and above. The interviews were closely supervised except

when it was thought that the presence of a supervisor would influence the answers given. At the end of each day, completed questionnaires were carefully checked and those which had mistakes or were incomplete were later discussed with individual interviewers before revisits were made to correct the mistakes. Inter-observer checks to test the consistency of data produced by the two interviewers was not thought necessary since both of them were always present in each household at the same time during the interviews and they often consulted one another. All completed questionnaires were sent to Nairobi where they were finally checked and coded before preparing a spread sheet to facilitate storage on computer disks and subsequent analysis.

4.3 RESULTS

4.3.1 Defaecation studies

Studies on defaecations involved direct observations, 24 hour faecal collection and a questionnaire. Direct observations were made in Matithini, Iietune and Kavilinguni with a total population of approximately 4000.

The 24 hour faecal collection studies which also included investigations on estimates of total numbers of eggs produced daily by individuals and by the community in the environment (see section 4.3.3) were based at a small village (Kivii) and involved all the residents registered and who could be found at the time of the study.

In addition to investigations involving individual defaecation behaviour, questionnaire studies also looked at latrine use by the Matithini residents (see section 4.3.2). The study population consisted of about 500 residents living in a 50% random sample of households.

For convenience and ease of comparisons, the results of all aspects of studies relating to the same subjects are brought together irrespective of the method used in collecting the information.

4.3.1.1 Defaecation pattern by age and sex - direct field observations

All together 126 acts of defaecation were observed (a total of 87 observation days) in Matithini, Kakuyuni and Iietune between June 1984 and December 1985. Another 112 acts of defaecations were observed but the defaecators were not from the study area and were unknown to the observers and were therefore excluded from the analysis. Table 4.1 summarises defaecation patterns by age and sex in the three villages. By coincidence the same number of males and females were observed. The majority of people seen to be defaecating were in the age group 10-19 years for both males and females and thereafter numbers declined but surprisingly rose again in age group 50 year and above. The children and teenagers (0-19 years) formed nearly half (48.4%) of those observed defaecating. The same pattern was observed in Lower Nduu (see Table 4.2) where many more acts of defaecation were observed compared to the present areas. In both cases, age and sex distribution are not necessarily typical of the area in general (see Appendix 2.3) since the analysis was based on the number of defaecations rather than the number of persons.

4.3.1.2 Preferred time of defaecation

Field observation results on periods of the day people were seen defaecating in Matithini and Kakuyuni are summarised in Table 4.3a. People were most frequently seen defaecating in the morning hours with a few later in the day. Very few were seen defaecating during the middle of the day (10.00 to 14.00 hours). The results of the 24 hour faecal collection gave

TABLE 4.1

Defaecation pattern by age and sex in Matithini, Kakuyuni and Iietune. Percentage values are based on total number observed.

AGE GROUP (years)	NUMBER AND PERCENTAGE DEFAECATING					
	Males		Females		Males + Females	
	No.	Percentage	No.	Percentage	No.	Percentage
0 - 9	16	12.7	9	7.1	25	19.8
10 - 19	21	16.7	15	11.9	36	28.6
20 - 29	7	5.6	9	7.1	16	12.7
40 - 49	3	2.4	2	1.6	5	4.0
50 +	9	7.1	11	8.7	20	15.9
ALL	63	50	63	50	126	100

TABLE 4.2

Number of defaecation by age and sex in Lower Nduu during February to June 1980 - 42 days of observation (Ouma and Van Ginneken, 1980)

AGE GROUP (years)	MALES		FEMALES		TOTAL	
	Number	Percent	Number	Percent	Number	Percent
0 - 4	31	3.9	47	5.9	78	9.8
5 - 9	105	13.2	188	23.6	293	36.9
10 - 14	139	17.5	54	6.8	193	24.3
15 - 19	46	5.8	7	0.9	53	6.7
20 - 24	13	1.6	22	2.8	35	4.4
25 - 29	13	1.6	26	3.3	39	4.9
30 - 34	8	1.0	8	0.9	14	1.8
35 - 44	7	0.9	4	0.5	11	1.4
45 - 54	9	1.1	41	5.2	50	6.3
55 - 64	3	0.4	11	1.4	14	1.8
65 +	2	0.3	11	1.4	13	1.6
TOTAL	376	47.3	419	52.7	795	100
AVERAGE AGE	14.1		17.5		15.9	

TABLE 4.3a

Time of defaecation in Matithini and Kakuyuni villages

Results of direct observation study

PERIOD	NUMBER OF DEFAECATIONS	PERCENTAGE OF TOTAL
06.00-08.00	20	47.6
08.01-10.00	16	38.1
10.01-12.00	0	0
12.01-14.00	2	4.8
14.01-18.30	4	9.5
ALL PERIOD	42	100.0

similar picture (Fig. 4.2) with most defaecations taking place by 9.00 hours and there after a decline until 16.00 hours in the afternoon. Only few defaecations were recorded after 20.00 hours. The questionnaire study gave relatively similar results as above (Table 4.3b). Most people said they defaecated in the morning hours with progressive reductions thereafter. Again very few defaecations were said to have taken place after dark. It is regretted that in the questionnaire analysis the coding of the data did not take into account the details of hourly or two hourly intervals so that exact comparison with the results of field observations and 24 hour faecal collection is not possible.

4.3.1.3 Place of defaecation

Generally speaking, few people were observed defaecating and most of them defaecated near a river or stream since these were usually shielded by vegetation or deep valleys which provided the necessary cover. According to the results of the observations, 44.4% of the people defaecated within 5 metres of a river or stream (Fig. 4.3), 20.6% defaecated within 5-10 metres and only 4.8% defaecated beyond 10 metres (Table 4.4a). As for the rest (30.2%) it was not indicated in the maps where they had defaecated.

The results of the questionnaire study (Table 4.4b) revealed that of the 119 persons (mostly children) who said they normally defaecated before bathing in a river or stream, 21% defaecated within 5 metres, 41.2% between 5-10 metres and the rest (37.8%) defaecated beyond 10 metres.

4.3.1.4 Activities before and after defaecating

The most common activity before defaecation as revealed by direct observations was walking in water along a stream or river (presumably looking for a good spot) followed by crossing. After defaecating, crossing was more important followed by walking in water (Table 4.5a). In the Lower Nduu study, ignoring those who went straight home, the most frequent

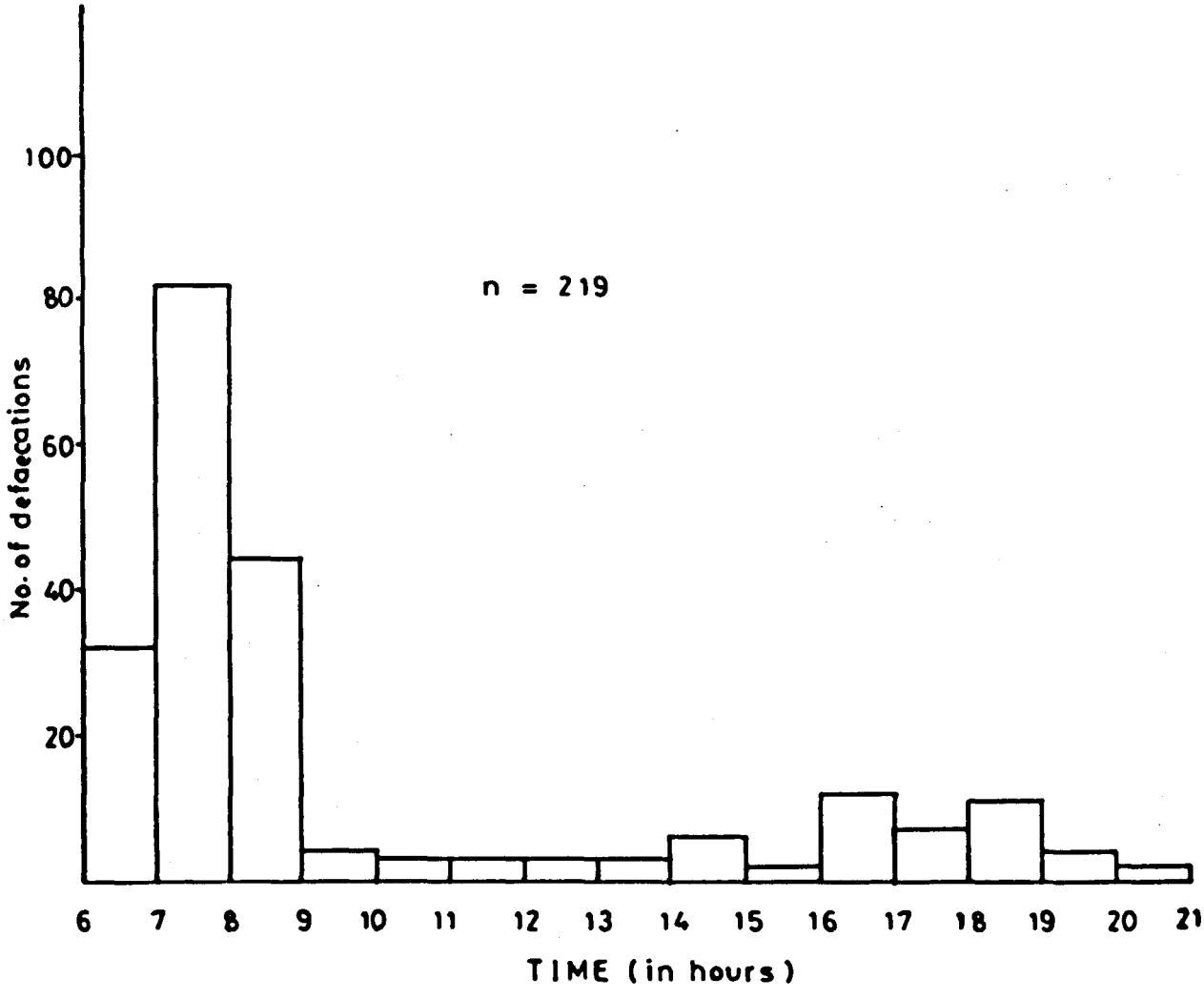

FIGURE 4.2

Preferred time of defaecation in Kivii in 1985 as obtained from 24 hr faecal survey

FIGURE 4.3

Human faeces next to Kivii stream in Kivii village

TABLE 4.3b

Time of defaecation in Matithini

Results of the questionnaire study

(N = 496)

PERIOD	NUMBER OF DEFAECATIONS	PERCENTAGE OF TOTAL
06.00-10.00	459	43.5
10.01-14.00	318	30.1
14.01-18.30	221	20.9
After 18.30	57	5.4
TOTAL	1055	99.9

TABLE 4.4a

Distance of defaecation in relation to river or stream in Matithini, Kakiyuni and Iietune
(Direct observations)

DISTANCE	NUMBER	PERCENTAGE
On the edge (< 5 m)	56	44.4
Near the edge (5-10 m)	26	20.6
Far (> 10 m)	6	4.8
Not indicated	38	30.2
ALL	126	100.0

TABLE 4.4b

Distance of defaecation from river or stream by age
(Questionnaire study)

AGE GROUP (years)	n	NUMBER (AND PERCENTAGE) DEFAECATING 5 metres	5-10 metres	10 metres
0- 4	7	4 (57.1)	2 (28.6)	1 (14.3)
5- 9	35	14 (40.0)	12 (34.3)	9 (34.3)
10-14	29	5 (17.2)	17 (58.6)	7 (24.1)
15-19	16	-	8 (50.0)	8 (50.0)
20-29	14	1 (7.1)	4 (28.6)	9 (64.3)
30-49	7	-	3 (42.9)	4 (57.1)
50+	11	1 (9.1)	3 (27.3)	7 (63.6)
ALL	119	25 (21.0)	49 (41.2)	45 (37.8)

activity after defaecation was playing followed by bathing the whole body (Table 4.5b). Unfortunately, activities before defaecation were not observed.

4.3.1.5 Frequency of defaecation

Data on frequencies of defaecation as actually happened and what is considered normal by the people as revealed by the 24 hour study are summarised in Table 4.6a and 4.6b. The overall mean frequency of actual defaecation was 2.2 defaecations per person per day as compared to 2.4 of what the people said was normal with peaks of 2.4 and 2.6 in the age groups 10-14 years in both cases respectively. For females and males respectively, the mean frequencies were 2.1 and 2.4 for actual defaecation and 2.2 and 2.5 of what was considered by the people to be normal. In both cases, females peaked in the age groups 10-14 years while males peaked in the oldest age group of 50 years and above in both cases.

The results of the questionnaire study in Matithini are summarised in Tables 4.6c and 4.6d. People were asked how many times they defaecated during the last 24 hour period and how many times they normally defaecate daily. The overall mean frequency of defaecation during the period 24 hours before the interview was 2.4 as compared to 2.2 of normal which compares well in "reverse" with the results of the 24 hour faecal survey. Overall peak frequencies of 2.8 and 2.7 occurred in the children 0-4 for actual and normal defaecations respectively. The next overall highest frequencies were 2.7 in age group 15-19 years for actual and 2.4 in age group 5-9 years for what was considered normal. When both sexes are considered, there appears to be no clear pattern in both males and females with regard to actual defaecations (Table 4.6c) but the

TABLE 4.5a

Activities before and after defaecating in Matithini and Kakuyuni. Values relate to those who were observed defaecating.

ACTIVITY	NUMBER OF TIMES OBSERVED	
	Before defaecation	After defaecation
Walking in water	21	8
Crossing	16	25
Drawing water	1	2
Bathing	0	1
Fetching firewood	1	1
Watering vegetables	2	2
Unspecified	1	3
ALL	42	42

TABLE 4.5b

Activities after defaecating in Lower Nduu by sex and average age during March to July 1980 - 35 days observation (Ouma and Van Ginneken, 1980)

ACTIVITY	MALE		FEMALE		TOTAL	
	Number	Mean age	Number	Mean age	Number	Mean age
Went straight home	96	14.1	106	14.9	202	14.6
Bathing whole body	28	19.5	22	19.8	50	19.6
Bathing parts of the body	40	14.4	39	11.5	79	12.9
Crossing	12	18.2	16	22.0	28	20.4
Washing clothes and utensils	1	23.0	5	31.6	6	30.2
Drawing water	23	13.0	35	13.2	58	13.4
Swimming	2	8.0	3	7.0	5	7.4
Playing	37	7.9	59	4.8	96	6.1
Collecting firewood	7	9.6	26	34.3	33	29.1
Other	24	14.1	4	39.2	28	17.1
ALL	270	13.9	315	15.2	585	14.1

TABLE 4.6a

Frequencies of defaecating by age and sex as obtained by collecting 24 hours stool specimen in Kivii Village

AGE GROUP (years)	MEAN FREQUENCIES OF DEFAECATION AND STANDARD DEVIATIONS								
	FEMALES			MALES			ALL		
	N	Mean frequency	SD	N	Mean frequency	SD	N	Mean frequency	SD
0 - 4	23	1.8	0.7	15	1.8	0.9	39	1.8	0.7
5 - 9	23	2.2	0.7	17	2.1	0.8	40	2.2	0.7
10 - 14	20	2.5	0.7	11	2.3	0.8	31	2.4	0.7
15 - 19	17	2.4	0.7	12	2.0	0.9	29	2.2	0.8
20 - 29	13	2.2	0.9	6	2.5	0.8	19	2.3	0.9
30 - 49	14	2.1	0.8	10	2.4	0.7	24	2.2	0.8
50 +	15	2.1	1.0	5	2.8	0.4	20	2.3	0.9
ALL	125	2.1	0.8	76	2.2	0.8	201	2.2	0.8

TABLE 4.6b

Frequencies of what is considered normal defaecation by age and sex as obtained from answers given during 24 hours stool collection in Kivii Village

AGE GROUP (years)	MEAN FREQUENCIES OF DEFAECATION AND STANDARD DEVIATIONS								
	FEMALES			MALES			ALL		
	N	Mean frequency	SD	N	Mean frequency	SD	N	Mean frequency	SD
0 - 4	23	2.3	0.6	15	2.3	0.6	38	2.3	0.6
5 - 9	23	2.4	0.6	17	2.5	0.6	40	2.5	0.6
10 - 14	20	2.7	0.5.	11	2.5	0.5	31	2.6	0.5
15 - 19	17	2.5	0.7	12	2.3	0.5	29	2.4	0.6
20 - 29	13	2.5	0.7	6	2.7	0.5	19	2.5	0.6
30 - 49	14	2.4	0.5	10	2.5	0.5	24	2.4	0.5
50 +	15	2.2	0.9	5	2.8	0.4	20	2.4	0.8
ALL	125	2.4	0.6	76	2.5	0.6	201	2.4	0.6

TABLE 4.6c

Frequencies of actual defaecation by age and sex as obtained from questionnaire study in Matithini village

AGE GROUP (years)	MEAN FREQUENCIES OF DEFAECATION AND STANDARD DEVIATIONS								
	FEMALES			MALES			ALL		
	N	Mean frequency	SD	N	Mean frequency	SD	N	Mean frequency	SD
0 - 4	48	2.8	1.0	43	2.8	0.9	91	2.8	1.0
5 - 9	50	2.8	0.9	47	2.5	1.0	97	2.6	1.0
10 - 14	42	2.5	0.8	37	2.7	0.8	79	2.6	0.8
15 - 19	26	2.6	0.6	18	2.8	0.9	44	2.7	0.7
20 - 29	48	2.0	1.0	18	2.7	0.9	66	2.2	1.0
30 - 49	46	1.9	1.0	22	2.1	0.9	68	2.0	1.0
50 +	30	1.9	1.0	21	2.0	0.7	51	1.9	0.9
ALL	290	2.4	1.0	206	2.5	0.9	496	2.4	1.0

TABLE 4.6d

Frequencies of normal defaecation by age and sex as obtained from questionnaire study in Matithini village

AGE GROUP (years)	MEAN FREQUENCIES OF DEFAECATION AND STANDARD DEVIATIONS								
	FEMALES			MALES			ALL		
	N	Mean frequency	SD	N	Mean frequency	SD	N	Mean frequency	SD
0 - 4	48	2.7	0.8	43	2.7	0.7	91	2.7	0.8
5 - 9	50	2.4	0.7	47	2.3	0.8	97	2.4	0.7
10 - 14	42	2.3	0.6	37	2.4	0.6	79	2.3	0.6
15 - 19	26	2.2	0.5	18	2.3	0.8	44	2.2	0.6
20 - 29	48	1.9	0.8	18	2.3	0.6	66	2.0	0.8
30 - 49	45	1.7	0.7	22	1.8	0.7	67	1.7	0.7
50 +	30	1.4	0.6	21	1.8	0.5	51	1.6	0.6
ALL	289	2.1	0.8	206	2.3	0.7	495	2.2	0.8

analysis of what was considerd normal gave a more expected general trend with peaks in the youngest age groups and there after dropping gradually with age (Table 4.6d).

4.3.1.6 Cleanliness after defaecation

71.6% of the people interviewed claimed they cleaned themselves always after defaecating while 20.6% mostly children, claimed they cleaned themselves only sometimes. The rest (7.8%), all children except one adult, claimed they did not clean themselves at all. Very few people (7.9%) said they used toilet paper to clean themselves. The rest used leaves or old newspapers (see Table 4.7).

4.3.1.7 Defaecation habits and bathing activities

The distriubtion of bathing places according to age is given in Table 4.8. 64.5% (320) representing all ages claim they bathe at home, while 34.1% (169) mostly teenagers and the oldest persons claimed they bathed directly in the rivers or streams. Few (1.4%) drew water to bathe by the riverside. 161 persons said they bathed directly in rivers or streams after defaecating nearby or elsewhere and 52% of them did so immediately, 16.8% bathed after half an hour and the rest (22.4%) bathed at least two hours after defaecating (Table 4.9). The proportion of people who bathe immediately after defaecation drops with age up to age group 30-49 years and then rises again. There seems to be no clear pattern in time of bathing by age with regard to the other time intervals.

80.8% of the people who defaecate before bathing claimed they cleaned themselves before doing so while 19.2% mostly children, claimed they do not bother to clean themselves at all because they considered they would be doing so while bathing (Table 4.10).

TABLE 4.7

Material for use in wiping after defaecation by age.

Values represent numbers and percentages of each age group.

AGE GROUP (years)	n	MATERIAL USED									
		Nothing		Toilet Paper		Leaves		Newspaper		Others	
		No	%	No	%	No	%	No	%	No	%
0 - 9	187	35	18.6	5	2.7	72	38.3	68	36.7	7	3.7
10 - 19	123	0	0	7	5.7	24	19.5	92	74.8	0	0
20 - 29	66	0	0	13	19.7	12	18.2	41	62.1	0	0
30 +	119	1	0.8	14	11.8	40	33.6	63	52.9	1	0.8
ALL	496	36	7.3	39	7.9	148	29.8	265	53.4	8	1.6

TABLE 4.8

The distribution of bathing places by age. Figures in brackets are percentages of total number(n) in each age group

AGE GROUP (years)	n	PLACES OF BATHING At home	Directly in river	Others
0 - 4	91	83(91.2)	7(7.7)	1(1.1)
5 - 9	97	51(52.6)	45(46.4)	1(1.0)
10 - 14	79	33(41.8)	45(57.0)	1(1.3)
15 - 19	44	20(45.5)	22(50.0)	2(4.5)
20 - 29	66	46(69.7)	18(27.3)	2(3.0)
30 - 49	68	56(82.4)	12(17.6)	0
50 +	51	31(60.8)	20(39.2)	0
TOTAL	496	320(64.5)	169(34.1)	7(1.4)

TABLE 4.9

Time of bathing after defaecation.

Values represent numbers and percentages for each group of all those who went to bathe after defaecating near bathing site or elsewhere.

AGE GROUP (years)	n	NUMBER BATHING (PERCENTAGE BATHING) Immediately	Between ½-1hr	Between 1-2hrs	After 2 hrs
0 - 4	8	6(75)	1(12.5)	-	1(12.5)
5 - 9	44	27(61.4)	6(13.6)	4(9.1)	7(15.9)
10 - 14	40	23(57.5)	7(17.5)	1(2.5)	9(22.5)
15 - 19	23	11(47.8)	4(17.3)	2(8.7)	6(26.1)
20 - 29	18	8(44.4)	3(16.7)	4(22.2)	3(16.7)
30 - 49	11	2(18.2)	5(45.5)	-	4(36.4)
50 +	17	8(47.1)	1(5.9)	2(11.8)	6(35.3)
ALL	161	85(52.8)	27(16.8)	13(8.1)	36(22.4)

TABLE 4.10

Cleaning or not cleaning before bathing.

Values represent numbers and percentages of each age groups.

AGE GROUP (years)	n	NUMBER and (PERCENTAGE) cleaning before bathing	cleaning while bathing
0 - 4	5	0	5(100)
5 - 9	43	26(60.5)	17(39.5)
10 - 14	39	35(89.7)	4(10.3)
15 - 19	23	21(91.3)	2(8.7)
20 - 29	18	18(100)	
30 - 49	11	10(90.9)	1(9.1)
50 +	17	16(94.1)	1(5.9)
ALL	156*	126(80.8)	30(19.2)

*5 persons were excluded for no answer.

4.3.1.8 Total weight of faeces produced in 24 hours in Kivii in relation to age and sex

The smallest single stool specimen was 5 gm from a female aged two years. The largest single stool specimen weighed 590 gms produced by a female aged 16 years who also recorded the highest daily output of 1060 gms. Details of mean weight of faeces by age and sex are given in Table 4.11. The mean faecal weight for females and males were comparable at 244.7 and 245.5 gms per day respectively. Females however showed a peak of 356.8 gms in the age group 15-19 years, while males showed a peak of 407.0 in the age group 30-49 years. Due to skewness and kurtosis, the geometric mean of daily weight of faeces in different age groups was calculated and the distribution is given in Fig. 4.4. There is a sharp rise in faecal weight with age reaching a peak in the 14-19 year olds followed by a stabilisation and then a second peak in the 30-49 year olds before declining gradually. As shown by confidence intervals, there is a definite significant difference in mean stool weights of the youngest age groups as opposed to the rest.

4.3.1.9 The relationship between faecal weight and body weight

The relationship between faecal weight and body weight is shown in Fig. 4.5. The correlation coefficient was low but differed significantly from zero ($r = 0.3$, $df = 199$; $P < 0.0001$). The correlations were calculated separately for each age group and the results showed no correlations except in the youngest age group of 0-4 years ($r = 0.40$; $df = 36$; $P < 0.01$). The results can be interpreted to mean that in general there is no marked relationship between faecal weight and body weight.

4.3.2 Latrine use

500 persons (207 males and 293 females) living in 100 randomly selected households in Matithini were interviewed. This figure is reduced in some of the tables depending on missing

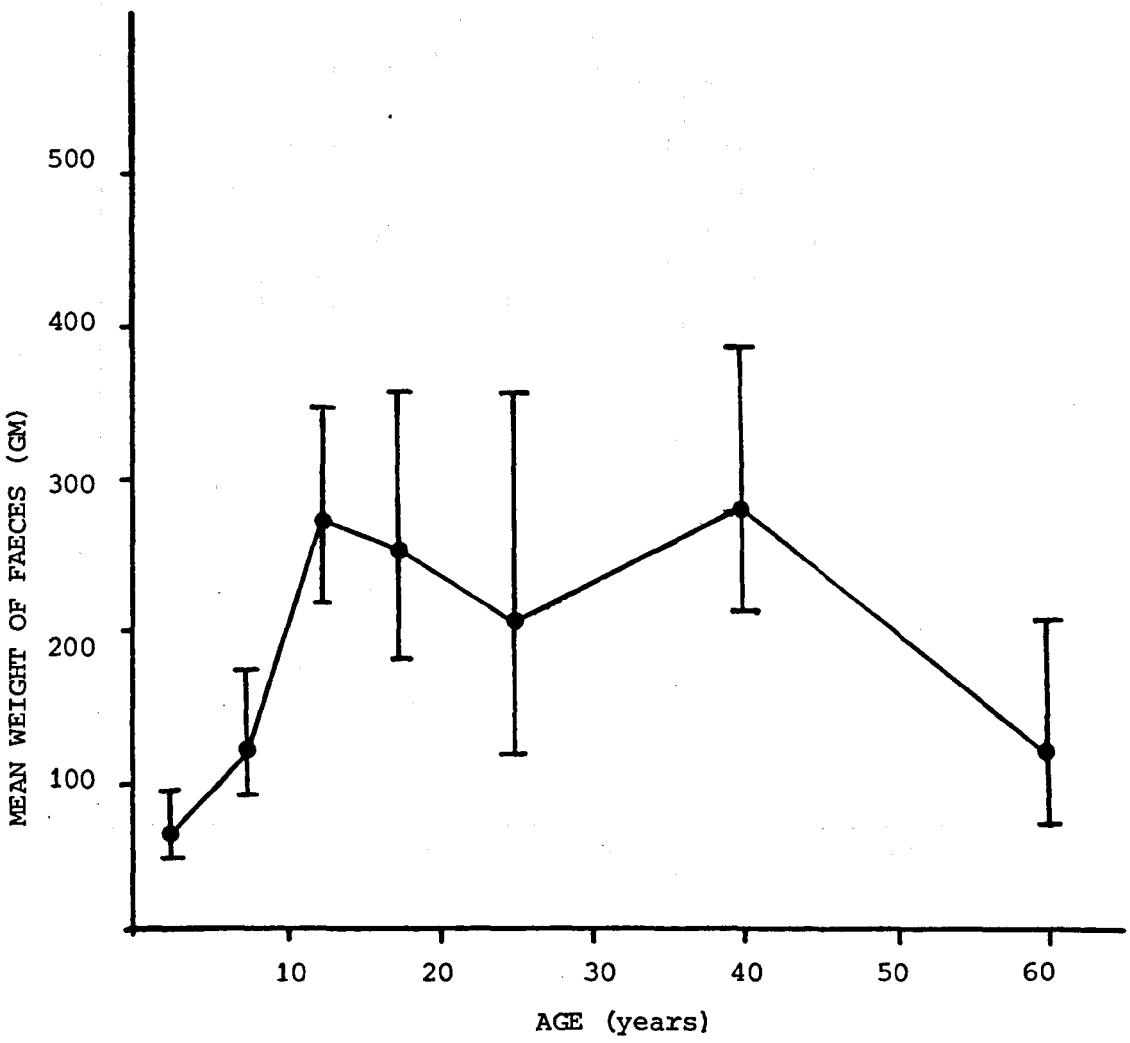

FIGURE 4.4

Mean faecal weight in relation to age in Kivii residents in 1985

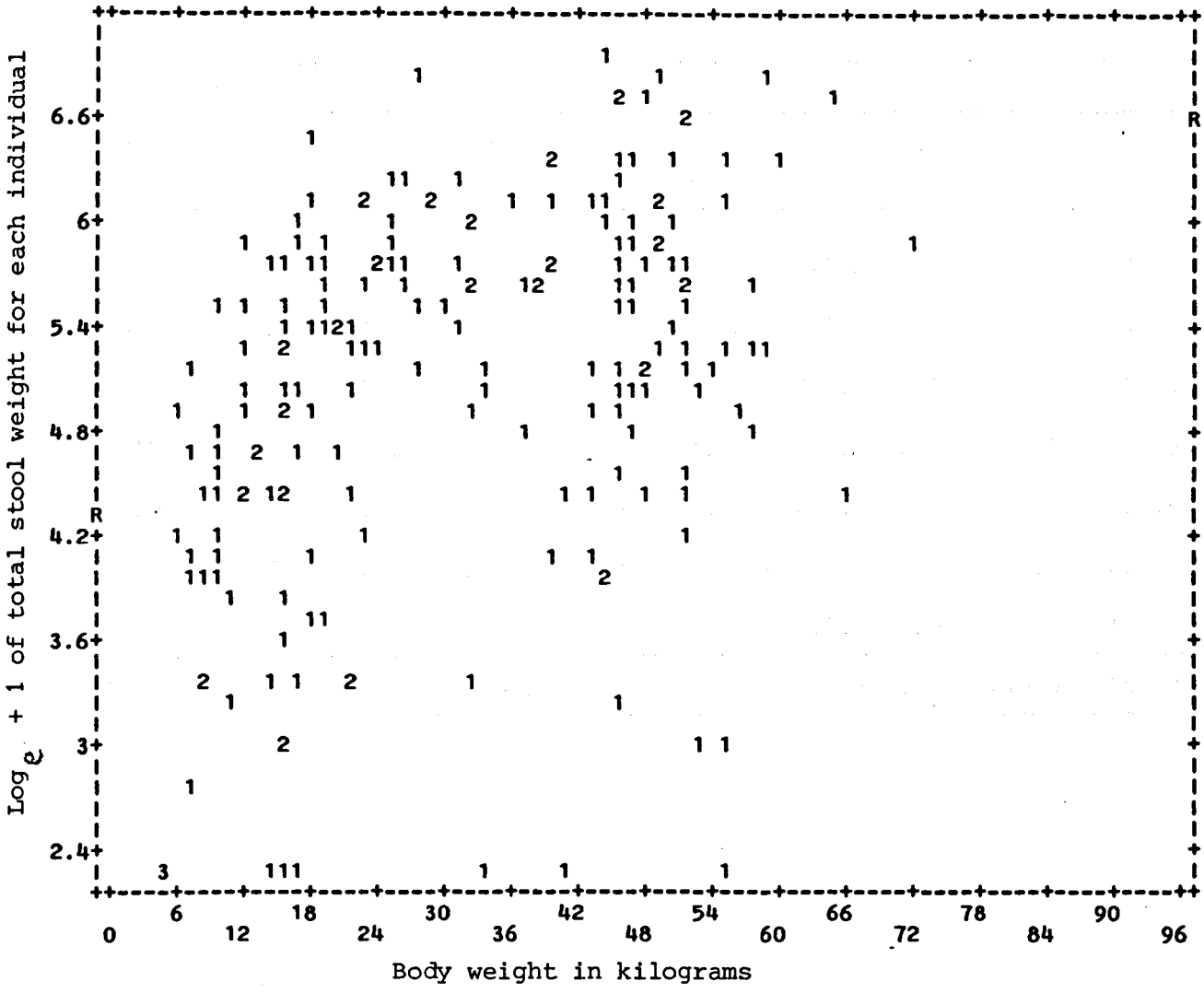

FIGURE 4.5

The relationship between the logarithms of total stool weight (SW) and body weight (BW) for 201 persons examined in Kivii in 1985. The numbers refer to cases

$$r = 0.369 \quad (P < 0.0001)$$

$$\text{Log}_{10}\ (SW) = 4.310 + 0.024 \times (BW)$$

TABLE 4.11

Mean weight of faeces and their standard deviation in Kivii residents by age and sex

AGE GROUP	FEMALES			MALES			ALL		
	n	Mean wt (gms)	S.D.	n	Mean wt (gms)	S.D.	n	Mean wt (gms)	S.D.
0- 4	23	99.1	78.8	15	100.3	111.5	38	99.6	91.6
5- 9	23	201.5	156.6	17	147.1	93.5	40	178.4	134.8
10-14	20	295.8	130.4	11	357.3	223.1	31	317.6	168.1
15-19	17	356.8	275.9	12	325.0	223.0	29	343.6	251.5
20-29	13	328.5	290.7	6	330.8	213.7	19	329.2	262.8
30-49	14	313.6	205.4	10	407.0	280.0	50	352.5	238.2
50+	15	202.0	185.5	5	172.0	131.1	20	194.5	170.7
ALL	125	244.7	205.6	76	246.7	212.5	201	245.5	207.7

variables. The general household information regarding presence and use of latrine has already been given in Section 2.2.2.5. Details of individual defaecation behaviour have also been given in section 4.3.1. This section summarises results of information on individual latrine use by the people.

4.3.2.1 Diet of the people and general health conditions

The typical diet here is a mixture of maize and beans used by 84.7% of the residents. The rest (15.3%) mainly children, fed on maize meal, vegetables or rice. The majority of the people (81.3%) said they fed three times a day while 6.7%, mainly adults, fed twice a day and the rest (12%), mainly children, fed more than three times a day.

Surprisingly, 97% claimed they defaecate normally, while only 3% claimed to sometimes have diarrhoea, constipation or stomach ache.

4.3.2.2 Presence and frequency of use of toilets

Out of 493 persons interviewed, only five said they had no access to a toilet. Except for young children of three years and less, the majority of the females and males (83.9% and 84.1% respectively) said they always used toilets. The number using toilets always increased with age in both sexes until about 50 years, and then dropped slightly in the age group 50 years and above. 10.3% of the females and 15.3% of the males use toilets only sometimes and these figures increased with decreasing age. Very few persons (0.8 and 0.5% of females and males respectively) claimed they did not use the toilet at all.

4.3.2.3 Alternative places of defaecation by some members of the household when at home and when away from home

People were questioned where they defaecate when away from home and these were compared to where they said they defaecated when at home. The results are summarised in Fig. 4.6.

Most people claim they use their own toilet when at home. When out in the gardens (not usually far from homesteads) the majority claimed they used the bush while quite a few claimed they walked back home to defaecate; a few said they went to the nearest toilets or used other means.

Virtually everybody used the bush (usually near water bodies) while out looking after cattle. The majority of the school age children used their nearest toilets (e.g. in schools) while at school, while most people claimed they used the nearest toilets, presumably those of their hosts while on a visit.

4.3.2.4 Awareness of advantages of using toilets

73% of the people claimed they were aware of the advantages of using toilets while 27%, mostly children, claimed they were unaware. Although more females (45%) seemed to be aware of the advantages compared to only 28% of males, the difference was not statistically significant ($x^2 = 0.26$; df = 1; P 0.05).

4.3.2.5 Reasons for using toilet facilities

Table 4.12 summarises information on what reasons people gave for using toilet facilities. Most of the people representing all ages (77.5%) claimed they used toilets for health reasons. 19.6%, mostly adults, claimed they used toilets to improve cleanliness while only 1.1% said they used them for privacy. 1.8% said they used them for both health and cleanliness.

4.3.2.6 Sources of information for awareness of toilet use

Table 4.13 gives the breakdown of sources of information for awareness of toilet use. 78.5% of the people claimed they had learnt about the advantages of toilet use at school. Few (4.5%) claimed they learned from parents while 6.2%, mostly adults, said they learnt through administration in public

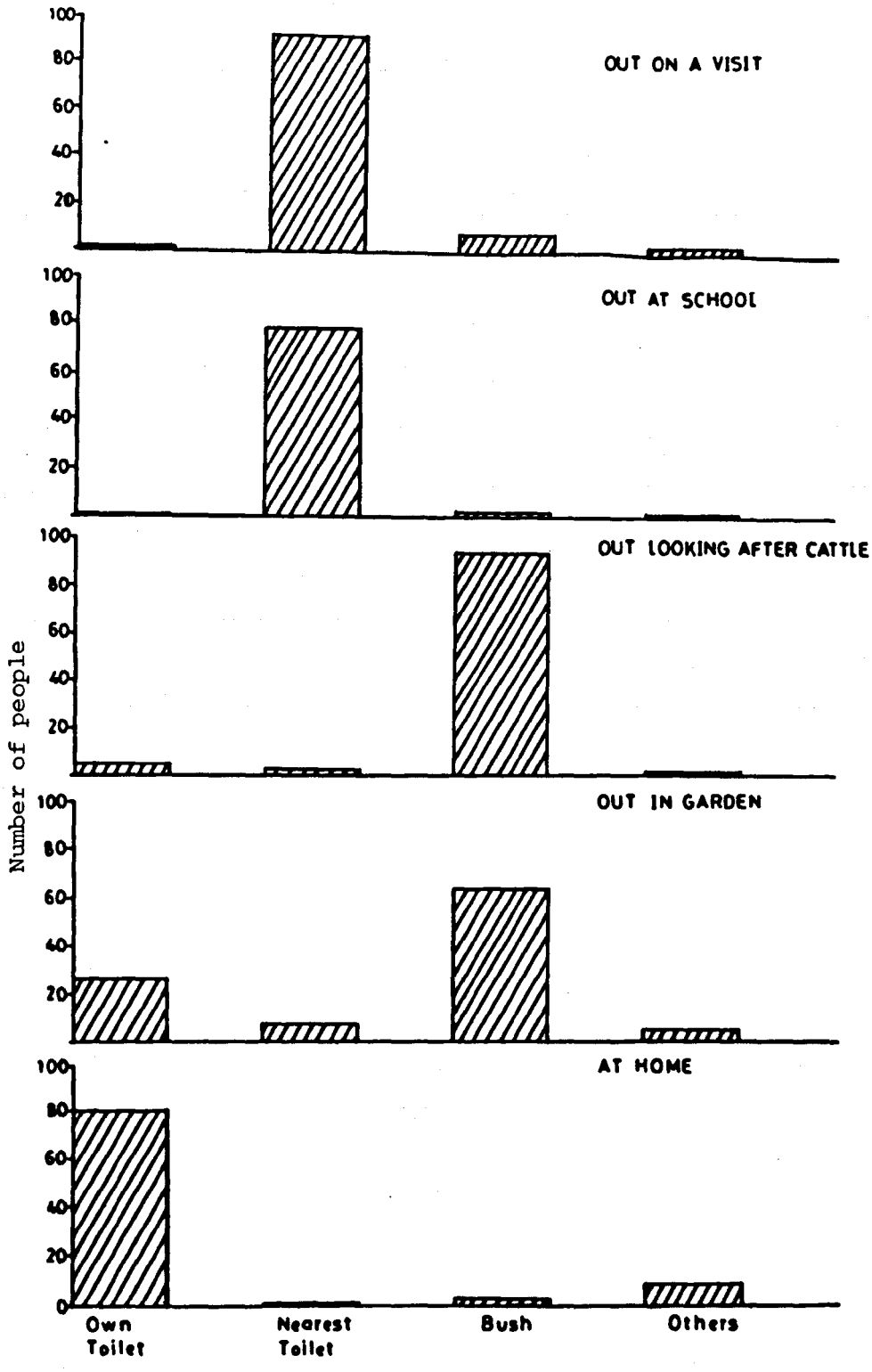

FIGURE 4.6

Places of defaecation by people in Matithini

TABLE 4.12

Reasons for using toilet facilities.

Values represent number of people using toilet facilities for reasons under each heading. Percentage for each age group is given in brackets.

AGE GROUP (years)	n	REASONS			
		Health	Privacy	Cleanliness	Health and Cleanliness
2 - 9	16	15(93.8)	0	1	0
10 - 14	54	46(85.2)	1(1.9)	7(13.0)	0
15 - 19	44	38(86.4)	0	5(11.4)	1(2.3)
20 - 29	62	45(75.6)	1(1.6)	14(22.6)	2(3.2)
30 - 49	66	50(75.8)	1(1.5)	14(21.2)	1(1.5)
50 +	38	23(60.5)	0	14(36.8)	1(2.6)
TOTAL	280	217(77.5)	3(1.1)	55(19.6)	5(1.8)

TABLE 4.13

Sources of information for awareness of advantages of latrine use by age.

Values are for both sexes.

AGE GROUP (years)	N	PERCENTAGE LEARNED THROUGH					
		Teaching at School	Parents	Meeting "Baraza"	Health Worker	Teaching Church	Others
0 - 9	19	89.5	10.5	0	0	0	0
10 - 14	56	96.4	1.8	1.8	0	0	0
15 - 19	44	97.7	2.3	0	0	0	0
20 - 29	62	95.2	1.6	0	1.6	1.6	0
30 - 49	67	73.1	10.4	2.9	10.4	1.4	0
50 +	41	9.8	2.4	36.6	34.1	2.4	14.6
ALL	289	78.5	4.5	6.2	7.6	1.0	2.4

meetings and 7.6% through health workers. Few persons (1.0%) learnt about the advantages through the church.

4.3.3 Estimates of total number of eggs produced per day

4.3.3.1 Comparison of the results of the four Kato counts

The relationship between variances and means of measures of egg output has been commonly used to determine variability in helminth egg output within a single specimen or between several specimens (Croll et al., 1982; Anderson and Schad, 1985; Keymer and Hiorns, 1986). For all the four Kato counts, the relationship between log variance and log mean is a linear function (Fig. 4.7) with a gradient of 1.4 which is well above the unity value. This implies that there is a fair amount of variability in the counts suggesting that the negative binomial probability distribution may be a good empirical model of the observed distribution (for a negative binomical model the value of the gradient will be more than one and the closer it is to two, the higher the variability (Elliott, 1977).

4.3.3.2 Total number of S. mansoni eggs produced per day

Estimates were made of the number of eggs produced on a daily basis by individuals and by the community as a whole. Estimates were made for each individual by multiplying the calculated number of eggs per gramme of stool (based on Kato results) by the total weight of stools that each individual produced in 24 hrs. Of 197 persons who had been examined both during baseline and 24 hr faecal collection surveys and from whom complete data were available, 23 or 11.7% were consistently negative when all the stools they produced during the 24 hour period were examined for S. mansoni eggs. For those who were positive (88.3%) estimates of individual 24 hr egg production ranged between 200 and 981,850 with

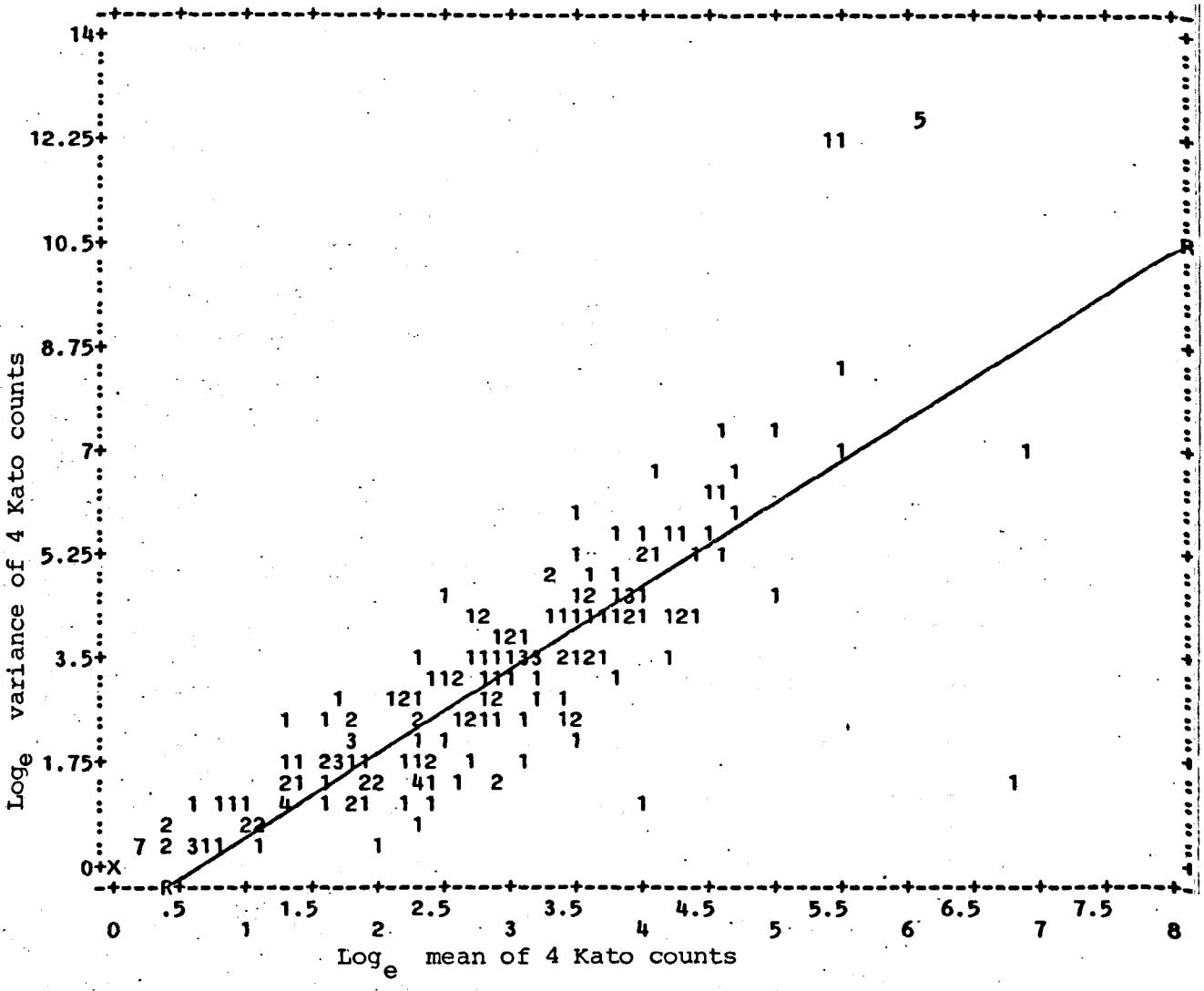

FIGURE 4.7

Variability in egg counts in 4 Kato counts from the same stool specimen. The relationship between the logarithms of variance (V) and mean (M) eggs per Kato slides for 224 Kivii residents examined in 1985. The numbers refer to frequencies. For symbols refer to Appendix 4.4

$$r = 0.869 \quad (P < 0.0001)$$

$$\text{Log}_{10} \text{ (V) Kato counts} = 0.516 + 1.365 \text{ log (M) Kato counts}$$

33% of individuals each excreting more than 100,000 eggs per 24 hr period. From figures of daily mean faecal weight, daily mean e.p.g. and the proportions infected, total number of eggs excreted by different age groups in 24 hrs for males and females and for all were calculated and these are shown in Table 4.14. Kivii residents numbering just about 200 persons produced an estimated 22,035,124 S. mansoni eggs during the 24 hour period. Overall, females were responsible for 57% of the eggs produced daily compared to 43% of males. School age children (5-19 years) were responsible for 70.6% of the eggs produced.

Calculations of daily egg production by Kivii residents was repeated using the method described by Jordan et al. (1980). Figures for mean e.p.g., prevalences and population structure as at the time of baseline survey (three months before 24 hr stool collection) were used but the calculations were extended by using figures for mean weight of faeces (corrected to the nearest figure) for each age group as obtained during the 24 hr survey (see Table 4.11). It is assumed that 24 hour stool production and intensity remained stable within the three month period. The relative total number of eggs produced in 24 hrs and contribution percent per 100 population is shown in Table 4.15. Given that Kivii residents numbered approximately 200, the total number of eggs arrived at in this calculation was (11,124,460 x 2 = 22,248,920). As might be expected this figure compares with the calculations based on the 24 hr faecal collection shown in Table 4.14. However a closer look at the results of the relative index of potential contamination (calculated before stool weight is considered) and relative contribution after allowing for stool weight revealed minor differences in all age groups except in the 5-9 year olds which

TABLE 4.14

Total number of eggs produced per 24 hours by age and sex and relative percent contribution by age for totals in Kivii Village

AGE GROUP (years)	TOTAL NUMBER OF EGGS PER 24 HOURS						RELATIVE CONTRIBUTION %
	MALES		FEMALES		ALL		
	n	No.eggs	n	No.eggs	n	No.eggs	
0- 4	15	117350	22	233825	37	351175	1.6
5- 9	17	1520300	21	2038575	38	3558875	16.2
10-14	11	1957233	20	3690425	31	5647658	25.6
15-19	12	3667000	17	3679283	29	6346283	28.8
20-29	6	888225	13	687900	19	1576125	7.2
30-49	9	2207025	14	1289150	23	3496175	15.8
50+	5	110850	15	947983	20	1058833	4.8
ALL	75	9467983	122	12567141	197	22035124	100.1

TABLE 4.15

Calculation of index of potential contamination (IPC), total number of eggs produced per day and relative contribution by age for Kivii residents

Calculations are based on infected persons per 100 population

Age group (years)	Population structure (1)	Prevalence % (2)	Intensity x eggs/gm of faeces (3)	Index of potential contamination (1x2x3/100)=4	Average weight* of faeces (gms) (5)	Total no. of eggs/day (4x5)	Relative contribution (%)
0- 4	14.7	47.2	80.6	562 (1.4)**	100	56200	0.5
5- 9	18.0	95.0	574.8	9833 (25.0)	180	1769940	15.9
10-14	15.5	100.0	556.5	8634 (22.0)	320	2762880	24.8
15-19	14.0	100.0	515.6	7224 (18.4)	345	2492280	22.4
20-29	15.5	93.3	358.7	5192 (13.2)	330	1713360	15.4
30-49	14.0	95.8	429.2	5754 (14.6)	350	2013900	18.1
50+	10.1	89.5	232.6	2106 (5.4)	150	315900	2.8
OVERALL				39305 (100)		11124460	99.9

* Mean figures obtained from 24 hour collection of stools (see Table 4.11)

** Relative contribution (%) as calculated from index of potential contamination figures

showed a difference of 9.1% (Table 4.15) implying that mean stool weight may be an important consideration in calculating index of potential contamination in the age groups between which big differences in mean stool weight occur.

4.3.3.3 Comparison of eggs per day, baseline eggs per gramme and eggs per gramme calculated from daily stool output by age

Fig. 4.8 summarises information on eggs per day, baseline eggs per gramme (based on single stool examination three months before 24 hour stool collection) and eggs per gramme of stool calculated by dividing total number of eggs produced by total weight of stool produced per 24 hour period by persons representing each age group. Data on eggs per day and e.p.g. are transformed to log scale. Eggs per day increases with age and reaches a peak at age group 15-19 years and then a drop in age group 20-30 followed by a small increase again in age group 30-49 and then a small drop in the older age groups. Eggs per gramme as calculated from the baseline survey when stools were collected three months prior to 24 hour collection follow a similar pattern to the distribution of eggs per day as described above. The curve for the distribution of eggs per gramme calculated by dividing total number of eggs and total weight of stool for each age group run very close to the baseline e.p.g. curve and follows a similar pattern to it except in the 20-30 year olds when there is a very slight decrease instead of a small increase in the same age group observed in both eggs per day and baseline e.p.g. patterns. The practical implication of these results is that calculations of e.p.g. based on single stool specimens from individuals are sufficient to give a reliable age related picture of intensity of infection with S. mansoni in a community and that it is not necessary to collect 24 hour stool samples for this.

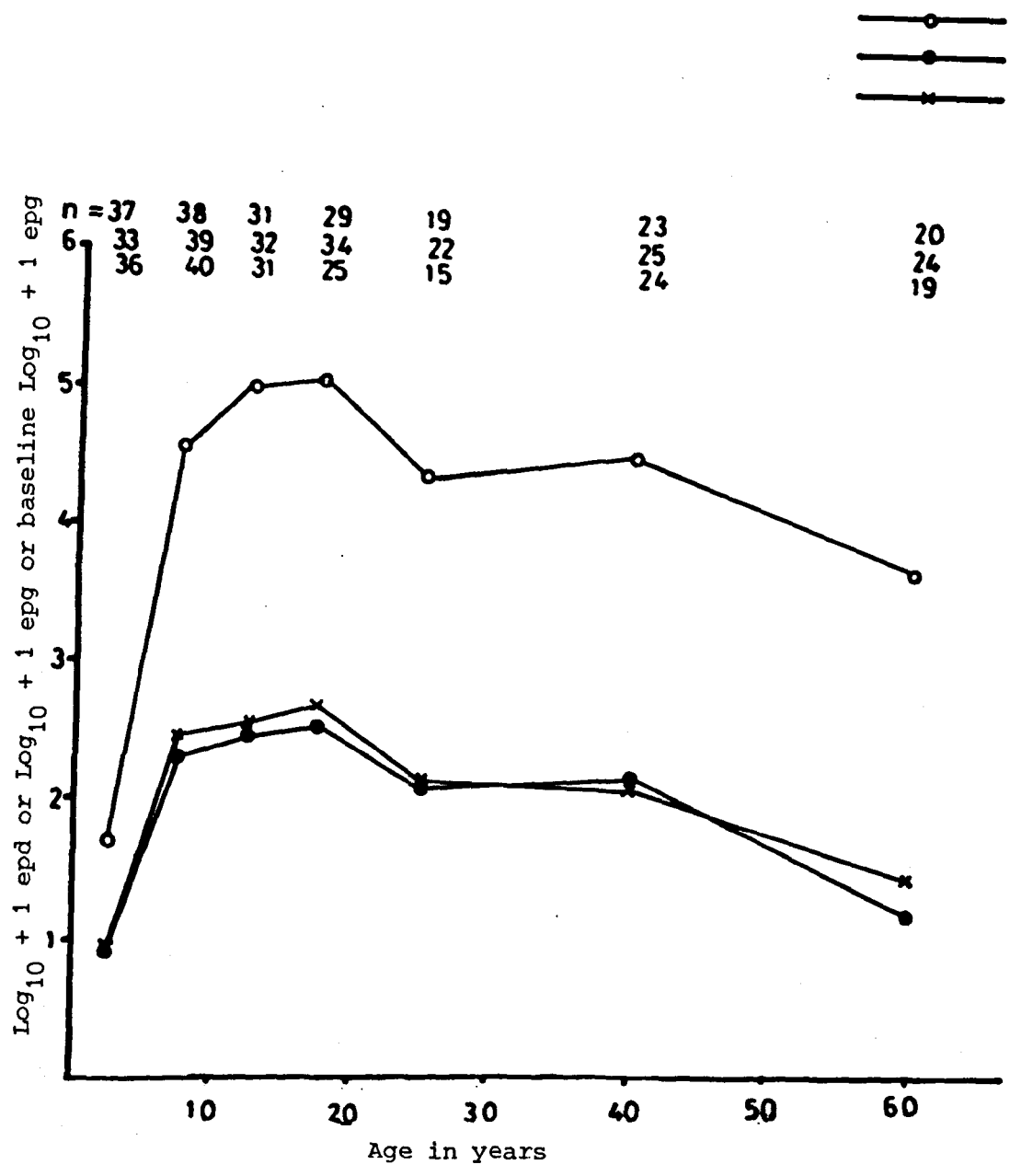

FIGURE 4.8

Age specific intensity curves for S. mansoni for all Kivii residents examined in 1985

$\log_{10}$ + 1 eggs/day (calculated from 24 hr faecal specimen)

$\log_{10}$ + 1 egg/g (calculated from the total eggs per day divided by the total weight of faeces)

$\log_{10}$ + 1 baseline egg/g (calculated from a single stool specimen, collected 3 months prior to 24 hr faecal collection)

4.3.3.4 Relationship between eggs per gramme and faecal weight

In order to see if there was any relationship between epg and weight of faeces between individuals, overall log epg (total epd/weight of faeces) were plotted against total weight of faeces for individuals and tested for correlation. As shown in Fig. 4.9 there was a weak but significant positive correlation between log epg and total individual stool weight for everyone examined ($r = 0.27$; $P < 0.001$). Results of the analysis of correlations between e.p.g. and total stool weight in different age groups revealed no obvious correlations.

4.3.3.5 Relationship between eggs per gramme and time interval between stools

Multiple regression analysis was carried out on e.p.g. of stools produced by the same individuals taking into account the time intervals between each stool and there was no evidence that time had an effect on the numbers of eggs produced.

4.3.3.6 Daily stool to stool variability in egg output

At least 80 persons produced more than two stools within 24 hour period. The relationship between log variance and log mean is a linear function with slopes of 1.8 (Fig. 4.10) reflecting a high degree of varability in egg output per stool and per individual within 24 hours suggesting that the negative binomial probability distribution is a good empirical model of the observed distribution. For the negative binomial model the value will be approximately 2.0 (Elliott, 1977). Linear relationships between logarithms of variances and means hold true for all ages suggesting that age has no effect on the variability of egg count per stool per day for each individual.

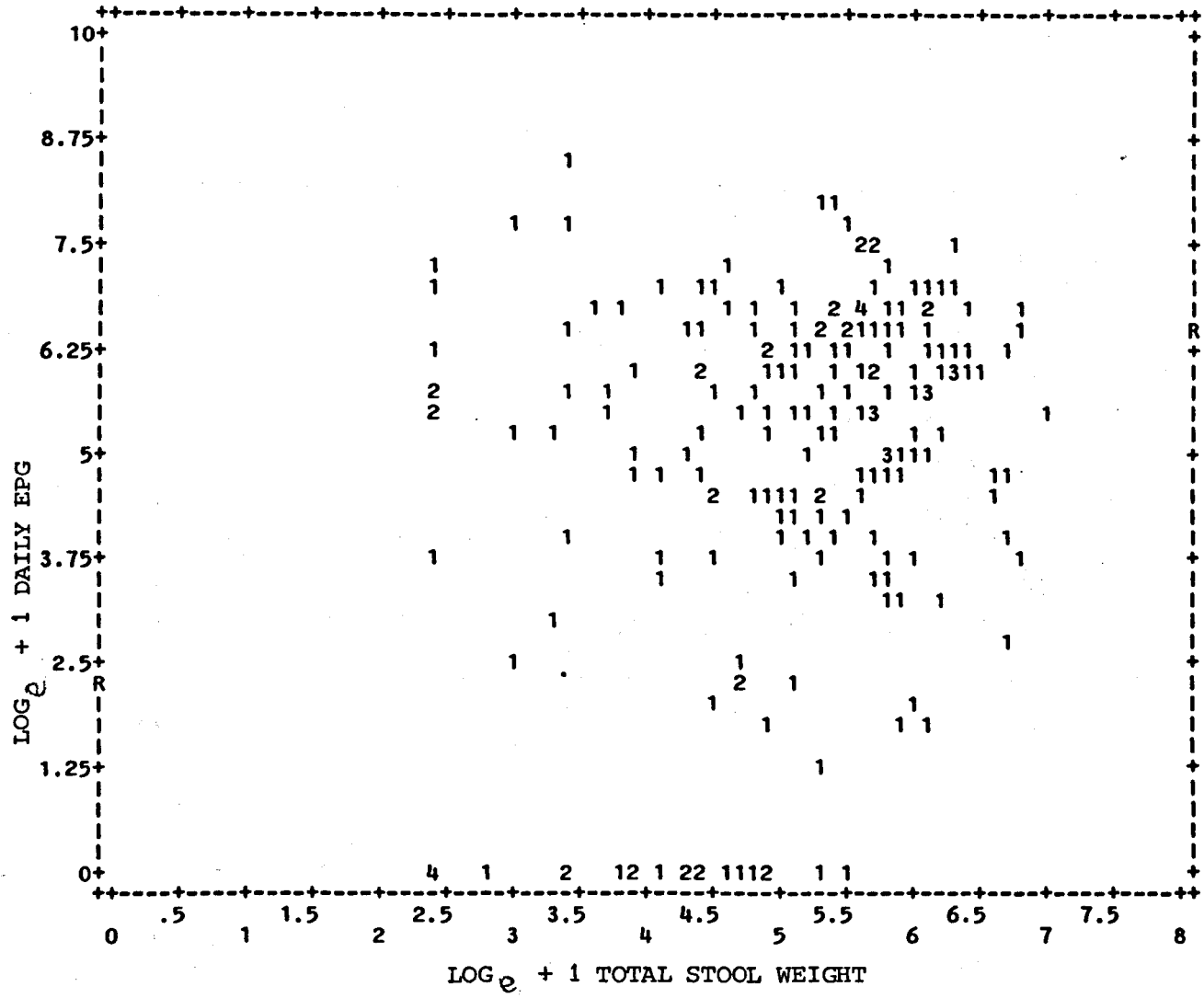

FIGURE 4.9

Relationship between the logarithms of total number of eggs produced daily by each individual and log total weight of stool in 207 residents examined in Kivii in 1985

$r=0.27$ ($p<0.0001$)

Log_{10} epg=2.172 + 0.537 log stool weight

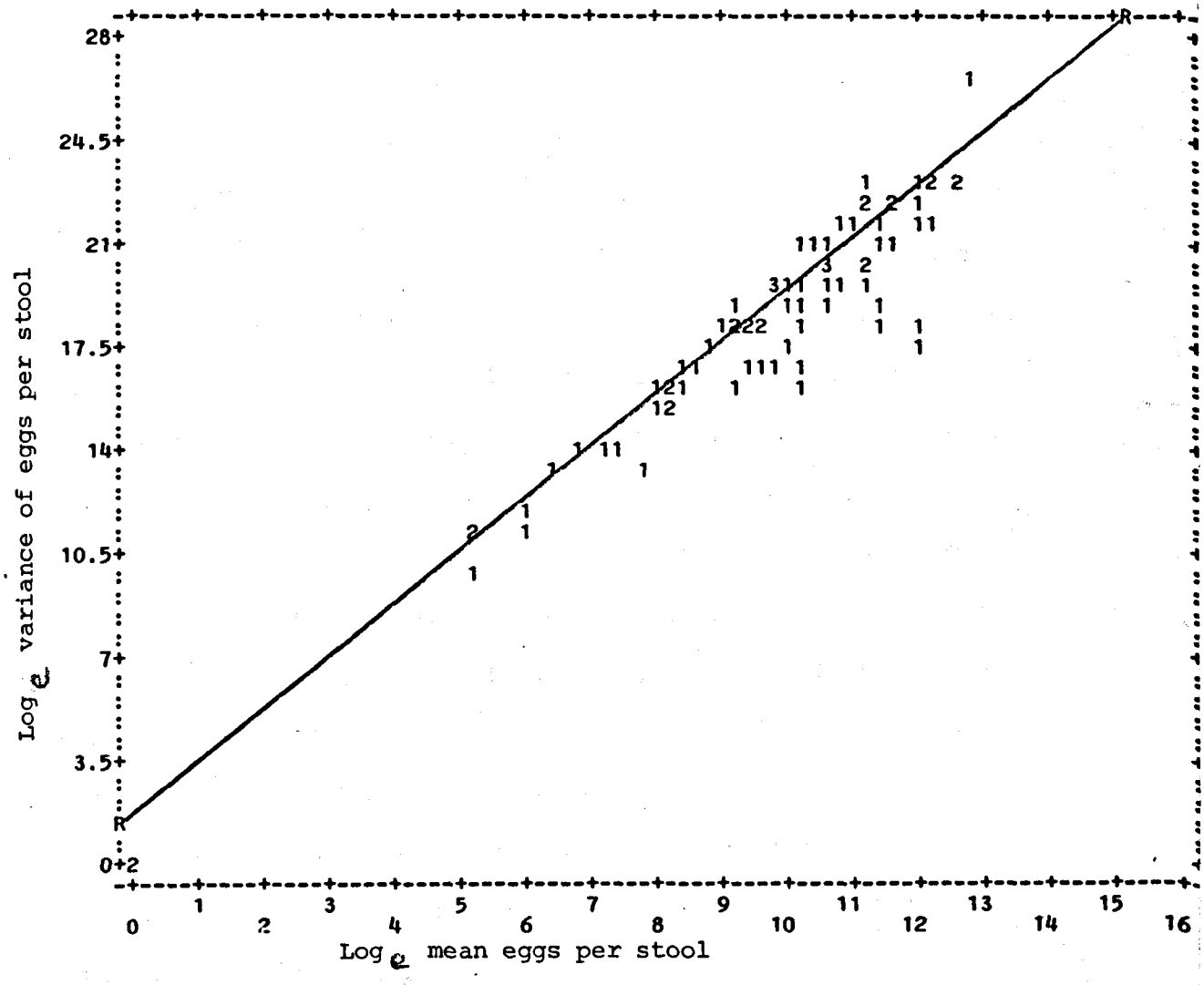

FIGURE 4.10

Variability in egg output from daily stools of the same individual. The relationship between the logarithms of variance (V) and mean (M) eggs per stool for 80 Kivii residents examined in 1985. The numbers refer to frequencies.

$$r = 0.954 \quad (P < 0.0001)$$

$$\text{Log}_{10}\ (V) = 1.248 + 1.752 \log\ (M)$$

4.4 DISCUSSION

4.4.1 Defaecation behaviour

The defaecation habits of the people is one aspect of human behaviour of which very little is known and yet which is believed to be important in transmission of S. mansoni. Some of the few studies done so far have met with difficulties associated with observer interference and importance attached to privacy in the act of defaecation (Husting, 1968; Cheesmond and Fenwick, 1981). In the present study, different approaches involving direct observations, collection of 24 hour faecal specimens and interviews have been used to gather as much data as possible on people's defaecation behaviour relevant to transmission of S. mansoni in the area studied.

In a period of one and a half years involving a total of 84 days of observation by 3 different persons in 3 areas with a total population of approximately 4000 persons, only 126 acts of defaecation some of which may have come from the same individuals were observed. As judged from many faeces which were frequently seen along river or stream banks, this figure is obviously too low even considering another 112 acts of defaecation observed in non-residents. Moreover, in Matithini alone, about one third of the population said they often defaecated near the river or stream before bathing (see Table 4.9). It is possible that observer interference as well as difficulties in spotting those who were defaecating were responsible for the low figure. Nevertheless it was possible to get a general picture from the few defaecations observed. Nearly half of the defaecations (48%) were observed in the 0-19 year olds with males giving equal contribution as females and implying that both are important in potentially contaminating the environment. Earlier studies in Lower Nduu in which many more

acts were observed, revealed that the 0-19 year olds were responsible for 78% of the defaecations (Ouma and Van Ginneken, 1980).

As shown in Tables 4.3a and b as well as Fig. 4.2, direct observations, 24 hour faecal collection and questionnaire studies revealed that defaecations occurred mostly in the early morning hours with relatively less during the rest of the day. This has also been observed by other workers (Farooq and Mallah, 1966; Cheesmond and Fenwick, 1981).

The chances of schistosome eggs reaching water depends on how far from water bodies infected persons defaecate. No-one was observed defaecating directly in water. As shown in Tables 4.4a and b, more than 50% of the defaecations occurred within 10 metres from the rivers or streams. In Egypt, Farooq and Mallah (1966) observed that men and women defaecated and urinated within 0.5m-2m of the water. In Zimbabwe, Husting (1968) noted that defaecations occurred very close to water and this has been recently confirmed by Chandiwana (1986) who suggested that defaecation should be limited to areas far removed from water bodies so as to reduce chances of S. mansoni eggs being washed in when it rains.

A knowledge of activities which take place before and after people defaecate is essential if health education is to be used to discourage them from contaminating the environment. In the areas studied, the most important activities observed both before and after defaecation were walking along water and crossing. Although only one bathing activity was recorded after defaecation, 33% of the people (mostly aged 5-19 years) said they bathe directly in the river immediately or soon after defaecation near the river bank (see Table 4.9). In the Lower Nduu study, bathing, playing and

swimming formed 26% of the activities post defaecation (see Table 4.5b). In the Gezira in Sudan, 31% of the people wash themselves after defaecation (Cheesmond and Fenwick, 1981) while in the Egypt-49 project area, no water contact activity was involved in defaecation or urination except ablution (Farooq and Mallah, 1966) although the opposite was true in El Ayaisha village in Upper Egypt (Kloos et al., 1983). As discussed in the next chapter, all these activities increased the chances of S. mansoni eggs getting into water in one way or another and should be discouraged as much as possible in order to reduce transmission.

A knowledge of how frequently people defaecate could be important in predicting the overall number of defaecations which could be important in transmission. For example, if we know that people normally defaecate twice in a day, there is every chance that one of the defaecations will be in the bush. Pitchford (1970b) believed that the Bantus in South Africa defaecated as often as 3 or 4 times daily. In the present study, the 24 hour faecal collection programme revealed that people in Kivii defaecated 2.2 times daily on average although a slightly higher figure of 2.4 was reported to be what normally takes place. The peak frequency was observed in the 10-14 year olds which is surprising since younger children would under normal circumstances defaecate more often. It is possible that some of the defaecations by the younger children were missed especially when their mothers were away from home. The questionnaire study confirmed that this may have been the case for overall peak frequencies occurred in the 0-4 year olds. As for the rest of the age groups, the questionnaire study was generally in good agreement with the results of the 24 hour faecal collection. If we ignore the youngest age group, the fact that the peak frequencies of defaecation occurred in the middle age groups

increases their chances of defaecating in the bush and near water bodies. It is this same group that are responsible for the bulk of contamination as discussed later.

Daily output of faeces is related to the amount of food eaten, to its fibre and water content, and diarrhoeal disease (Hall, 1982) and may vary with time and place and between individuals. The people of Kivii fed mainly on maize, beans and vegetables (see Section 4.3.2.1) and plant foods are good sources of fibre (Paul and Southgate, 1978). Relative amounts of faeces produced daily by different age groups will allow a reasonable estimate of the total number of eggs contributed daily by the same age groups. In Kivii village, people produced an average of 245.5 gms of faeces in a day with males and females producing more or less the same amount (see Table 4.11). This figure is high compared to other quoted average daily figures of 125 gms in hospital patients (Jordan, 1985), 158.8 gms in Egypt (Farooq and Samaan, 1967) and 100-200gms in Europeans (Burkitt, 1973). The observation that females showed peak weight of faeces in the age group 15-19 years while males showed a peak in 30-49 year olds is difficult to explain but could in part be due to some abnormally large single stools. Repeated collection of 24 hour stools for several days before taking the mean figures may help to confirm this. Overall, as shown in Figure 4.4, the distribution of mean weight of faeces by age show a similar pattern as prevalence and intensity curves (Fig. 4.8) rising to a peak in the 15-19 year olds with a slight drop and then a slight rise before decreasing gradually implying that people with the highest intensities and prevalences also produce the largest stools and therefore the greatest number of eggs.

Hall (1982) suggested that the size of the host may influence the amount of stool produced. As shown in Figure 4.5, there appears to be a relationship between body weight and total stool weight but the relationship is rather too weak to make any conclusion.

4.4.2 Latrine use

The basic reason for transmission of schistosomiasis is the low level of sanitation found in endemic areas with the result that faecal matter and urine containing schistosome eggs get into the water containing fresh water snails susceptible to infection (Jordan et al., 1980). According to WHO (1976) only 15% of rural people in developing countries were estimated to have adequate excreta disposal facilities. Even if latrines are present, they are not usually used by all members of the community especially younger people (Farooq et al., 1966b).

If everyone in Matithini had access to toilet facilities which 99% of them claim to have there would be very little transmission of S. mansoni in the area. However, having access to toilet facilities does not necessarily mean using them and although 85% of the people of Matithini claimed that they used toilets all the time, this is doubtful. That this is not so was confirmed when the majority of people claimed they used the bush when away from home (see Fig. 4.6). Even though the majority of people defaecated in the early part of the morning when they were still likely to be at home and were more likely to use toilets if present, quite a number of defaecations were still observed during the rest of the day when people were likely to be away from home (see Section 4.3.1.2). Even during morning hours, quite a number of people were still likely to detour into the bush and defaecate when they are on their way to school or gardens. Crossing rivers or streams was identified as an

important activity associated with defaecation (see Table 4.5a). Children would not normally use latrines until they are about 4 years (see Section 2.2.2.5).

One obvious reason for non use of toilet if available would be unawareness of the advantages of doing so. Jordan and Webbe (1984) mention particularly fly and odour problems. In Swaziland reasons for non use of toilets by some people were fear of sorcery and of possibility of pit caving in and danger of falling in by the children (Green, 1984). In Matithini 73% of the people said they were aware of the advantages of toilet use and that the main reasons were quoted as health (78%) and cleanliness (20%). Only 1% mentioned privacy as a reason for using toilet and this is surprising since it is generally accepted that privacy especially among women comes first in determining whether to use a toilet or not. For example in the Sudan, privacy had priority over everything else in the act of defaecation (Cheesmond and Fenwick, 1981). The fact that people believe or rather say that latrines are used for health reasons is useful and could be exploited in any health education programme since health matters are usually taken seriously by the people. It was therefore disappointing to note that only a few people (7.6%) learnt the advantages of using toilets through health or social workers, few of which are provided by the Kenya Government each to cover very large areas. It is possible that the majority of the people are not easily reached by health workers. In a way, the fact that few people said they used toilets for health reasons shows that our presence (the research team) did not influence answers given.

While it is unlikely that the majority of the people learnt about the advantages of use of toilets at school as they said, they may not necessarily have taken it seriously for even though education seemed to have influenced latrine ownership (Table 2.2) in practice, things learnt at school are usually regarded to be for examination purposes. From my experience in the area and other parts of Kenya, people seem to take things more seriously if they are told by their parents in the case of children or from the pulpit in case of churchgoers or generally if they are told in public meetings by administrators and health workers. I would strongly recommend that these media be fully utilized for purposes of health education be it directed to schistosomiasis or other health concerns. It might also help to consider introducing public toilets in various strategic places so that people may have access to toilets as much as possible from wherever they are.

4.4.3 Estimates of total number of S. mansoni eggs produced per 24 hour period

Various methods (see Muller, 1975) have been used in qualitative and quantitative diagnosis of helminth ova in general. In the past, filtration staining method - Bell's technique (Bell, 1963) has been commonly used in the quantitative diagnosis of S. mansoni but modified Kato technique (Katz et al., 1972) is now recommended because it is quick and relatively accurate (WHO, 1985).

In the present study, the Kato technique was used as described in Section 3.2.3.2, with the only modification that 4 instead of the usual 2 slides were prepared from each specimen. This was partly to increase sensitivity in light infections and mainly because it would allow a measure of the amount of variation of S. mansoni eggs in each 50mg of the same stool. Such information was necessary to be borne in mind while making estimates of the total number of eggs

produced per 24 hour period. Although Martin and Beaver (1968) and Woodstock et al. (1972) showed that S. mansoni eggs are randomnly distributed in faecal specimens the results of the present study showed that this is not the case (Fig. 4.7). Uneven distribution of other helminth eggs in faeces has also been reported by other workers (Hall, 1981; Anderson and Schad, 1985).

While it is accepted that day to day variation in the output of S. mansoni eggs in stool exists (Jordan and Webbe, 1982) variations in the number of S. mansoni eggs in stools passed within a 24 hour period has not been reported. Over such a short time, very little variation should be expected since the worm burden would remain the same. However very high variations were found between stools of the same individual (Fig. 4.10). Variations between individuals could not be explained adequately by differences in stool bulk (Fig. 4.9) nor by the time between stools (see Section 4.3.3.5) as suggested by Hall (1981).

Even though there were some variations in egg counts from the same stool, it was assumed that this would little affect an estimate of the overall eggs per day on the basis of total weight stool produced. The observation that one individual could excrete as much as close to one million eggs in one day and that one third of the population were each excreting 100,000 or more eggs per day is significant for it implies that even if a good proportion of the people used toilets to dispose of their faeces, the few that do not would still be responsible for several thousands of eggs getting into the environment daily with the chances that some of the eggs reach snail infested waters. In situations like this, it will be mandatory to treat everyone infected besides other control measures such as provision of latrines.

At community level, the usefulness and reliability of a single stool rather than 24 hour stool specimen in measuring intensity in the community has been confirmed in this study (Fig. 4.8). Both eggs per day and eggs per gram curves follow similar patterns. Moreover, eggs per gram data based on a single stool specimen compares reasonably well with eggs per day data in identifying the important group in transmission (Tables 4.14 and 4.15). This compares well with calculations by Jordan (1963) and Farooq and Samaan (1967) although minor variations are apparent in percentage contribution by different age groups because allowances have been made for differences in mean stool weights (see Table 4.11 and Fig. 4.4).

The observation that in Kivii females contributed overall more eggs than males is important especially in considering the fact that males had on average slightly higher intensities than females. This emphasises the importance of movement by the people in transmission of schistosomiasis. For example in Matithini, the majority of those absent (see Section 2.2.2.2) were teenage and adult males and overall there were more females than males (92 males for every 100 females). In Kivii where females contributed more eggs as referred to above, the sex ratio was much lower with only 85 males for every 100 females.

4.5 SUMMARY OF CHAPTER FOUR

1) Sanitary behaviour was studied by means of direct observation and questionnaire, with particular reference to use of latrines and bathing activities.

2) The majority of people observed defaecating in the morning hours and very close to rivers or streams were in the age group 5-19 years.

3) The most common activities before and after defaecating were crossing and walking along streams or rivers. Some people also bathed directly in the river after defaecating.

4) The overall frequency of defaecation was about 2.4 per 24 h period and younger people tended to defaecate more frequently compared to the adults.

5) Children (0-9 years) admitted not cleaning themselves after defaecating and especially if they were going to bathe immediately afterwards.

6) Despite nearly everybody having access to toilet facilities and being aware of their benefits quite a number, mostly children, never used them regularly and nearly everybody used bush when they were out in the fields.

7) Mean weight of faeces produced per 24h period by each individual was about 245gms and apart from the youngest and oldest persons, there was very little difference in faecal weight in the middle age groups. There was little relationship between faecal weight and body weight.

8) Millions of eggs were produced daily with about one third of the population each excreting more than 100,000 eggs per 24 hours.

9) There was very good agreement in estimates of total number of eggs produced by the community based on 24 hour faecal collection and just one single collection. There was also very good agreement in the pattern of infection with age in both epg and eggs per day.

10) Variability in egg counts were noted in the 4 Katos and separate daily individual stools.

11) There was no relationship between epg and stool weight and epg and time interval between stools.

CHAPTER 5

STUDIES ON CONTAMINATION OF WATER WITH SCHISTOSOMIASIS MANSONI EGGS

5.1 INTRODUCTION AND LITERATURE REVIEW

The continuity of the life cycle of S. mansoni depends on eggs reaching water inhabited with snail intermediate hosts. The way that this is achieved is probably the least understood part of the life cycle of the parasite (Jordan, 1985). Many workers have favoured the hypothesis that infected stools are washed into the rivers and dams by heavy rains or by floods scouring areas which are normally above water level but this if it occurrs can only account for infection of snails during a few months of the year, i.e. during and immediately after the rainy season (Husting, 1965). One obvious additional possibility would be direct defaecation at the sites which seems unlikely (Jordan, 1985). As observed in St Lucia by Jordan et al. (1980), in Ethiopia by Polderman (1974) and in Machakos (see section 4.3.1.3, Fig. 4.3), faeces are frequently found on the riverine rocks or on the river banks. The greatest amount of contamination is probably from faecal matter deposited behind bushes or in tall grass on river banks for reasons of privacy and which is subsequently washed into water bodies. There is evidence that the infection rate of sentinel snails (Christie and Upatham, 1977) and of wild snails (Chandiwana, 1986) increases with the onset of the rains and this could be attributed to wash-in of the faeces deposited by rain. Polderman (1974) tried to recover S. mansoni eggs in rainwater being washed downstream but only recovered a few Ascaris lumbricoides and many hookworm eggs suggesting an intense contamination of water by faeces being washed into the stream. He also suggested that seasonal fluctuations of

snails infection rates could be explained by the seasonal pattern of rainfall. However, exposure of faeces containing schistosome eggs to direct or indirect sunlight will decrease longevity of eggs (Maldonado et al., 1949). For example, in Kenya, S. mansoni eggs were found hatching though in small numbers in faeces which had stayed in the bush where they were deposited for up to three days. Whether the eggs hatched or not and how many hatched depended on whether the stool was under shade or exposed to direct sunlight (Ouma, unpublished data). Clearly the longer that S. mansoni eggs can survive then the greater is their chance of being washed in by rain or transferred by other means to water bodies. While rainfall may lead to an increase in the number of infected snails by facilitating transfer of eggs into water, it may have the opposite effect of flushing snails out of habitats where they had been abundant (Hairston, 1973). This is often the case in situations such as Matithini where transmission is concentrated in streams or rivers which are subject to flash flooding rather than pools or ponds. Both total numbers of snails and those infected are reduced by rainfall (see section 3.3.2.2, Fig 3.5a,b) but the numbers of both build up soon after the rain stops and reach a peak towards the end of the dry period implying that exposure of snails to miracidia continues even in the absence of rainfall. How then do the eggs reach water in the absence of rainfall? Several possibilities have been suggested.

Overflowing latrines may facilitiate the spread of the parasites (Maldonado et al., 1949) and in some situations treated sewage may be the source of contamination. In Puerto Rico it was found that 83% of S. mansoni eggs were removed when sewage was treated by primary sedimentation and decantation and 99.7% by trickling filter and activated sludge plants (Rowan, 1964).

However, in spite of the high rates of eggs removed, it was estimated that from the activated sludge plant investigated, over 130 million S. mansoni or miracidia per year were discharged. The epidemiological significance of this contamination was unknown.

Sewage stabilization ponds have been accepted as economical and practical in developing countries. Their potential in transmission of S. mansoni was investigated by Kawata and Kruse (1966) who found that the deep, heavily loaded anaerobic pond will curtail the hatching of eggs, the survival of miracidia and of Biomphalaria glabrata. Aerobic and facultative stabilisation are more likely to significantly affect miracidia or snails. However in field and laboratory trials in Brazil, both the infection of B. glabrata with S. mansoni and the growth of non-infected snails was lower in water taken from aerobic stabilisation ponds than in local tap water (Bunnag et al., 1978). Thus transmission may be reduced as a result of this type of stabilisation pond.

Jordan et al. (1980) quotes Prentice as saying that cattle walking through favourite defaecation sites at Entebbe near the shores of Lake Victoria carried human faeces into the lake in their hooves. Previous observations in another part of Machakos noted that not only cattle but also poultry stepped on human faeces near the water bodies and it is possible that some of the faecal material was transferred into water whenever cattle or poultry came in contact with water (Ouma, unpublished data).

The role of fomites in the transmission of certain diseases has been well described, particularly for scabies (Gulati et al., 1977; Mellanby, 1944; Burkhart, 1983), conjunctivitis (Patriarca et al., 1982; Hossain et al., 1983), impetigo, the "common cold" and fungal infections (Benenson, 1981). Laboratory evidence supports a possible role of fomites in the spread of Giardia (Rendtorff,

1954). Chernin and Antolics (1973) investigated the role of fomites in the transmission of S. mansoni and concluded that washing of faecally contaminated clothing could add small numbers of schistosome eggs to the water.

Animate vectors such as flies and cockroaches are capable of transmitting Shigella (Dupont, 1979; Nelson et al., 1967). Flies and beetles are commonly seen in faeces near waters and their role in transferring eggs into water has not been investigated.

In areas where Moslems live and ablution is practised, it is possible that small numbers of S. mansoni eggs may get into water (Cheesmond and Fenwick, 1981).

Prentice et al. (1970) suggested that eggs adherent to the perianal skin of children and youths may be washed into water during their regular bathing and playing. Earlier, Husting (1965) in the only investigation of its kind so far demonstrated the presence of schistosome eggs in the perianal area of 12 boys out of 25 aged between 5-15. He also suggested that as the eggs will be washed off the perianal skin whenever the infected person bathes in snail infected water, transmission will occur throughout the year and will not depend on fortuitous washing of infected faeces into the water during the rainy season. In Gezira in the Sudan, Cheesmond and Fenwick (1981) reported that six out of ten water contact sites in which contaminative activities were concentrated also had snails infected with S. mansoni. In contrast only five out of 20 sites in which no contaminative activity had been observed were there infected snails but these five sites were all close to human dwellings and it is possible that activities leading to contamination of water with schistosome eggs occurred outside the hours of observation. Ahmed et al. (1985) found a strong positive correlation between the numbers of infected snails found in

transmission sites and the human contact activities, some of which were contaminative. Chandiwana (1986) did not find a positive correlation between exposure indices for complete contact and prevalence of infection in B. pfeifferi but he did observe a few infections in the hot dry period when rain could have played no part. Chandiwana suggested that infections may in part have come from eggs remaining on perianal skin after defaecation.

The present study has examined further the possibility that eggs adherent into the perianal region may contribute to the transmission of S. mansoni. The possible role of insects, mainly flies in transmission, was briefly looked at.

5.2 MATERIALS AND METHODS

5.2.1 Demonstration of presence of eggs in the perianal region

Patients attending Kakuyuni Health Centre between August, 1984 and January, 1986 were used for this study. The first part of the study consisted of finding the best technique for examining the perianal region. At first, a scotch tape was used by placing it on the perianal region and then putting it on a slide for direct examination of ova under a miscroscope as described for examination of Enterobius vermicularis (Muller, 1975). This proved unsuccessful. Cotton swabs were then prepared in the laboratory and these were used to clean the perianal region of each patient. The swabs were washed in water which was then centrifuged and the deposit examined under a microscope. This proved very successful but it was not possible to prepare standard swabs in the laboratory. It was then decided to use commercial cotton buds.

Patients of all ages and both sexes were referred to us by the enrolled nurse if they were complaining of stomach problems. Each

person was supplied with a stool container, in which they were instructed to put a portion of their stools before taking their perianal swabs. The name, age and sex of each individual was recorded. A perianal swab was then taken from the patients in a standard way by cleaning the perianal area up and down three times. Patients who objected were excluded from the study. Each swab taken was immediately washed in approximately 3 mls of filtered spring water in a 3 x 1 inch specimen tube (Fig. 5.1). Each tube was then whirled and the contents transferred to a centrifuge tube before centrifuging by means of a hand centrifuge. The deposits were examined for presence of eggs and cysts of intestinal parasites. For S. mansoni, all the eggs in the deposit were counted and observations were made directly under the microscope for viability and hatching during the examination.

Stool specimens collected were examined using both modified formol ether technique (see section 3.2.3.1) and Kato method (see section 3.2.3.2). For both these methods, examination of the slides were done by persons who had no prior information on the results of the swab examination.

During July 1986, investigations involving the presence or absence of S. mansoni or other intestinal ova helminth was repeated as already described above but this time school children (6 - 15 years old) from a nearby school were used. This served the purpose since we had no knowledge of whether the children examined had complaints associated with the stomach or not. The investigation was extended to include the taking of perianal swabs before and immediately after providing stool specimen and a record was made of the times the bowels were emptied prior to the taking of the first swab. The investigation was also extended to include a check on the efficiency of the method by examining the contents of a second rinse of the swab by people who had no prior knowledge on whether the swabs had been examined earlier.

FIGURE 5.1

Examination of swab specimens in Kakuyuni Health Centre

Except for data collected during July 1986 which were analysed by hand, all the other data were compiled onto spreadsheets for the the Apricot microcomputer (see section 3.2.6). The analysis was carried out using the main frame computer in Liverpool.

5.2.2 Snail infection rates and water contact observations

Snail infection rates and water contact observations were done as already explained in sections 3.2.4.2 and 3.2.5 respectively. Since preliminary data had already shown that several persons were carrying S. mansoni eggs on their perianal skin, it was thought possible that contaminative water contact activities (swimming, bathing and playing) would enhance transmission. Relevant data on water contact and snail studies were therefore compiled together and a regression analysis carried out to see if there was any association between overall snail infection rate and frequency of contaminative activities by site. Data from Iietune, Kavilinguni and Kakuyuni were used.

5.2.3 Collection of various fly species found feeding on faeces and examination of them to detect if they were carrying any S. mansoni or other intestinal helminth ova or protozoan cysts

Flies found resting on faeces were disturbed and collected using hand nets. Others found dead on top of water were also collected. At first, they were shaken in water in a closed tube to rinse off any contamination from faeces. They were then removed and the water centrifuged. The deposits were examined for presence of ova and cysts. Later, it was decided to examine each fly caught more thoroughly by examining parts of the legs and mouth and by dissecting the gut. Any ova or cyst seen were recorded.

5.3 RESULTS

5.3.1 Population studied

A total of 920 patients of all age groups were referred to us at Kakuyuni Health Centre between August 1984 and January 1986. Of these, 38 were either too old or pregnant and were excluded from the study. An additional seven (0.8%) patients consisting of five females (mean age 19.3) and two males aged 17 and 25 years refused to have a swab taken and were also excluded from the study. The remaining 875 completed various examination procedures and were all included in the final analysis of the data except when data on their ages or sexes were missing. Age and sex distribution of the population studied is given in Table 5.1. Excluding four persons whose sex was not recorded, the rest showed close to equal distribution between sexes with 52.4 and 47.6% consisting of males and females respectively.

As an extension of these studies, an additional 71 school children of both sexes and aged between 6-15 years were examined in July 1986.

5.3.2 Prevalence and intensity of S. mansoni in the samples studied

The overall prevalence for the main study group as given by Kato results was 53.9%. Details of prevalence figures by age and sex are summarized in Table 5.5 together with the results of concentration and swab methods. Data on intensity of infection (Kato method) is summarised in Figure 5.2. In general, it shows a typical pattern, intensity increasing with age with a peak in the age group 14-19 years and then a sharp drop in age group 20-30 years followed by a steady decline in the older age groups.

TABLE 5.1

Distribution of population of Kakuyuni patients studied by age and sex

AGE GROUP (years)	MALES		FEMALES		ALL	
	No.	%	No.	%	No.	%
0- 4	48	10.7	56	13.9	104	12.2
5- 9	89	19.9	73	18.1	162	19.0
10-14	95	21.3	129	31.9	224	26.3
15-19	59	13.2	69	17.1	128	15.0
20-29	105	23.5	36	8.9	141	16.6
30-49	42	9.4	21	5.2	63	7.4
50+	9	2.0	20	5.0	29	3.4
ALL	447	100.0	404	100.0	851	100.0

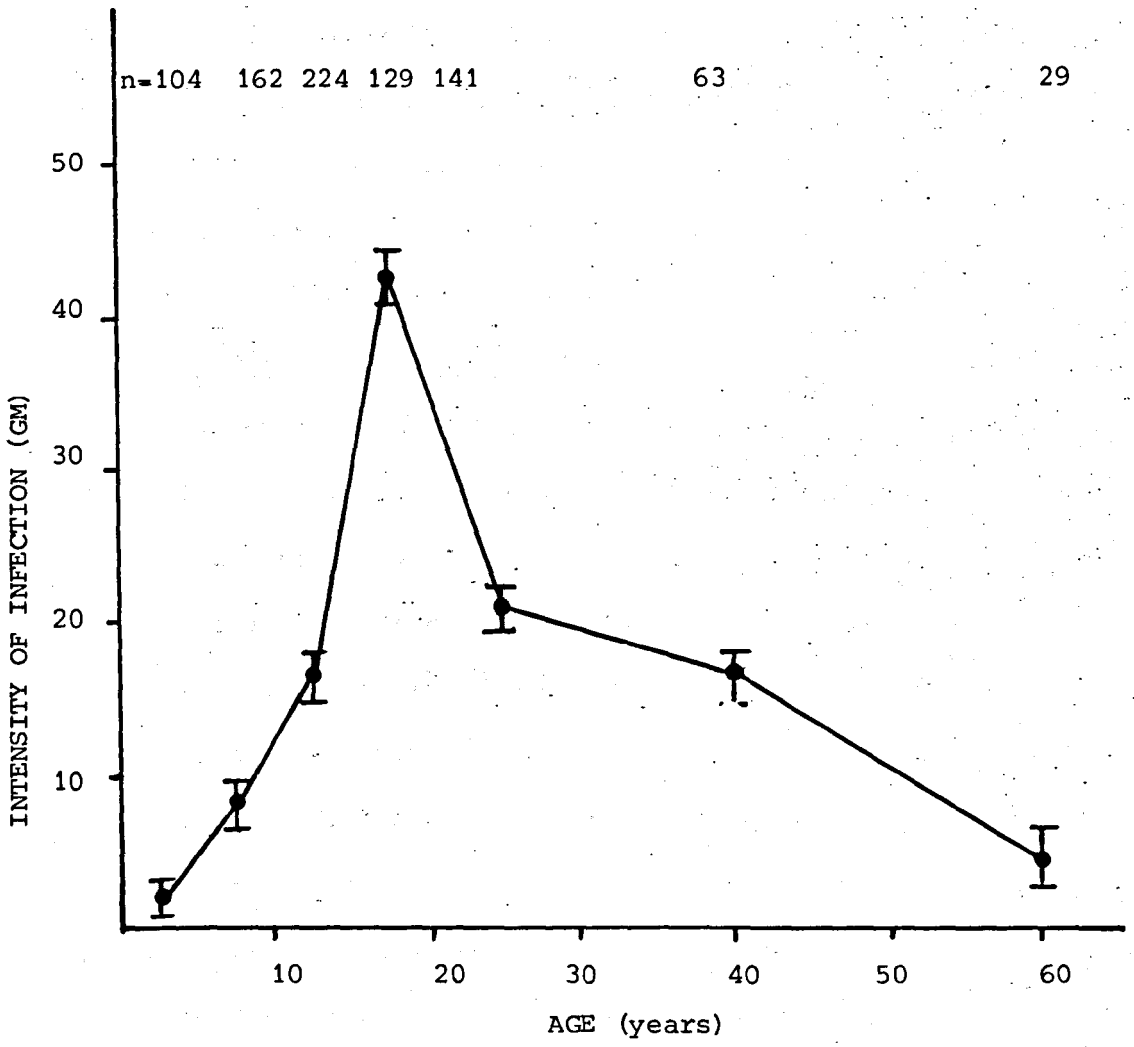

FIGURE 5.2

Age intensity curve for S. mansoni for patients examined in Kakuyuni health centre and included in perianal swab study. Intensity is based on the G.M. of egg counts of all examined.

5.3.3 Efficacy of swab technique in detecting S. mansoni eggs and comparison with Kato and concentration methods

Of the three methods used, the swab was the least sensitive and gave a prevalence rate of 20.4% compared to 39.2% for the concentration method and 53.9% for the Kato method (Table 5.5). Compared to Kato both swab and concentration techniques detected significantly fewer eggs of S. mansoni (see Tables 5.2 and 5.3) and sensitivity of swab was only 35% while that of concentration was 66% implying that swab is least efficient. Compared to the concentration technique, the swab technique was relatively more sensitive (sensitivity = 46.8% - see Table 5.4), but again the two methods differed significantly in detecting S. mansoni eggs. Total figures in the above tables are slightly different from the rest of the tables since missing variables (age and sex) were not considered in determining who is positive or negative.

5.3.4 Reliability of the swab method

In order to assess if some of the eggs remained in the cotton swab after rinsing, swabs which had been rinsed were re-examined by an independent group of technicians who had no previous knowledge of the results of the first examination. Of the 71 swabs taken immediately after giving specimens, 18 were found positive in the first examination but of the 71, none had S. mansoni eggs when they were reexamined. However, three check swabs had Enterobius vermicularis eggs in both examinations implying that the rinsing process may leave some eggs on the swab. One swab which gave negative results for E. vermicularis gave positive results in the check swab implying that it is possible to get false negatives.

5.3.5 Comparison of swab results before and immediately after defaecation

Of the 71 school children examined, eight had no S. mansoni eggs detected by the Kato method and no S. mansoni eggs were found

TABLE 5.2

Comparison of Swab and Kato techniques for detecting S. mansoni ova from some of the patients attending Kakuyuni Health Centre

SWAB	KATO		
	Positive	Negative	Totals
Positive	166	12	178
Negative	303	393	696
Totals	469	405	874

(x^2 = 138.95; df: 1; P $<$0.001)

Sensitivity = 35%

TABLE 5.3

Comparison of concentration and Kato techniques for detecting *S. mansoni* ova from patients attending Kakuyuni Health Centre

CONCENTRATION	KATO		
	Positive	Negative	Totals
Positive	311	32	343
Negative	158	373	531
Totals	469	405	874

(x^2 = 308.53; df: 1; P $<$ 0.001)

Sensitivity = 66%

TABLE 5.4

Comparison of Swab and concentration techniques for detecting *S. mansoni* ova from patients attending Kakuyuni Health Centre

SWAB	CONCENTRATION		
	Positive	Negative	Totals
Positive	161	18	179
Negative	183	513	696
Totals	344	531	875

(x^2 = 239.12; df: 1; P $<$0.001)

Sensitivity = 46.8%

in their swabs taken just before (first swab) and immediately after defaecation (second swab) on the day of examination.

Of the remaining 63, 18 or 28.6% had defaecated earlier the same day of examination were found with S. mansoni eggs in the first swab only and a similar number were found with eggs in the second swab only while a total of eight or 12.7% were found with S. mansoni eggs in both first and second swabs while the rest were negative for either the second or first swab. Among those who had no S. mansoni eggs detected in the first swabs were eight persons who had defaecated the day prior to taking the first swab and four of them were positive for S. mansoni eggs on the second swab.

5.3.6 Prevalence of S. mansoni by age and sex - Kato, concentration and swab results compared

The Kato and concentration methods are dependent on 'indirect' examination of the individuals by examining stool specimens provided while swab technique although basically the same as concentration is a more 'direct' method to determine whether bits of faeces are carried in the perianal area in addition to detecting eggs of S. mansoni and eggs or cysts of other intestinal parasites. The cleanliness of various individuals after defaecation was thought to depend on age or sex. When the results of the three methods were compared (Table 5.5 and Fig. 5.3), they showed that the trends in prevalence by age in the three methods were the same with peaks in the teenage age groups implying that age is not directly important in determining those who may become positive when swab method is used. Multiple regression analysis confirms tnat both age and sex are not important in determining whether a swab becomes positive for S. mansoni eggs or not ($p < 0.001$).

TABLE 5.5

Distribution of patients attending Kakuyuni Health Centre according to age and sex and prevalence of schistosomiasis mansoni as determined by Concentration, Kato and Swab methods

AGE GROUP (years)	NUMBER POSITIVE FOR SCHISTOSOMIASIS MANSONI/ NUMBER EXAMINED (PERCENTAGE)					
	CONCENTRATION		KATO		SWAB	
	MALES	FEMALES	MALES	FEMALES	MALES	FEMALES
0- 4	6/48 (12.2)	3/56 (5.4)	10/48 (20.8)	9/56 (16.1)	1/48 (2.1)	2/56 (3.6)
5- 9	31/89 (34.8)	25/73 (34.2)	44/89 (49.4)	33/73 (45.2)	16/89 (18)	8/73 (11)
10-14	42/95 (44.2)	47/129(36.4)	51/95 (53.7)	70/129(54.3)	20/95 (21.1)	36/129(27.9)
15-19	29/59 (49.2)	43/69 (62.3)	42/59 (71.2)	54/69 (78.3)	18/59 (30.5)	25/69 (36.2)
20-29	56/106(52.8)	21/36 (58.3)	64/105(61)	27/36 (75)	26/106(24.5)	11/36 (30.6)
30-49	14/42 (33.3)	9/21 (42.9)	28/42 (66.7)	14/21 (66.7)	4/42 (9.5)	4/21 (19)
50+	3/9 (33.3)	5/20 (25)	4/9 (44.4)	9/20 (45)	2/9 (22.2)	1/20 (5)
ALL	181/448(40.4)	153/404(37.9)	243/447(54.4)	216/404(53.5)	87/448(19.4)	87/404(21.5)

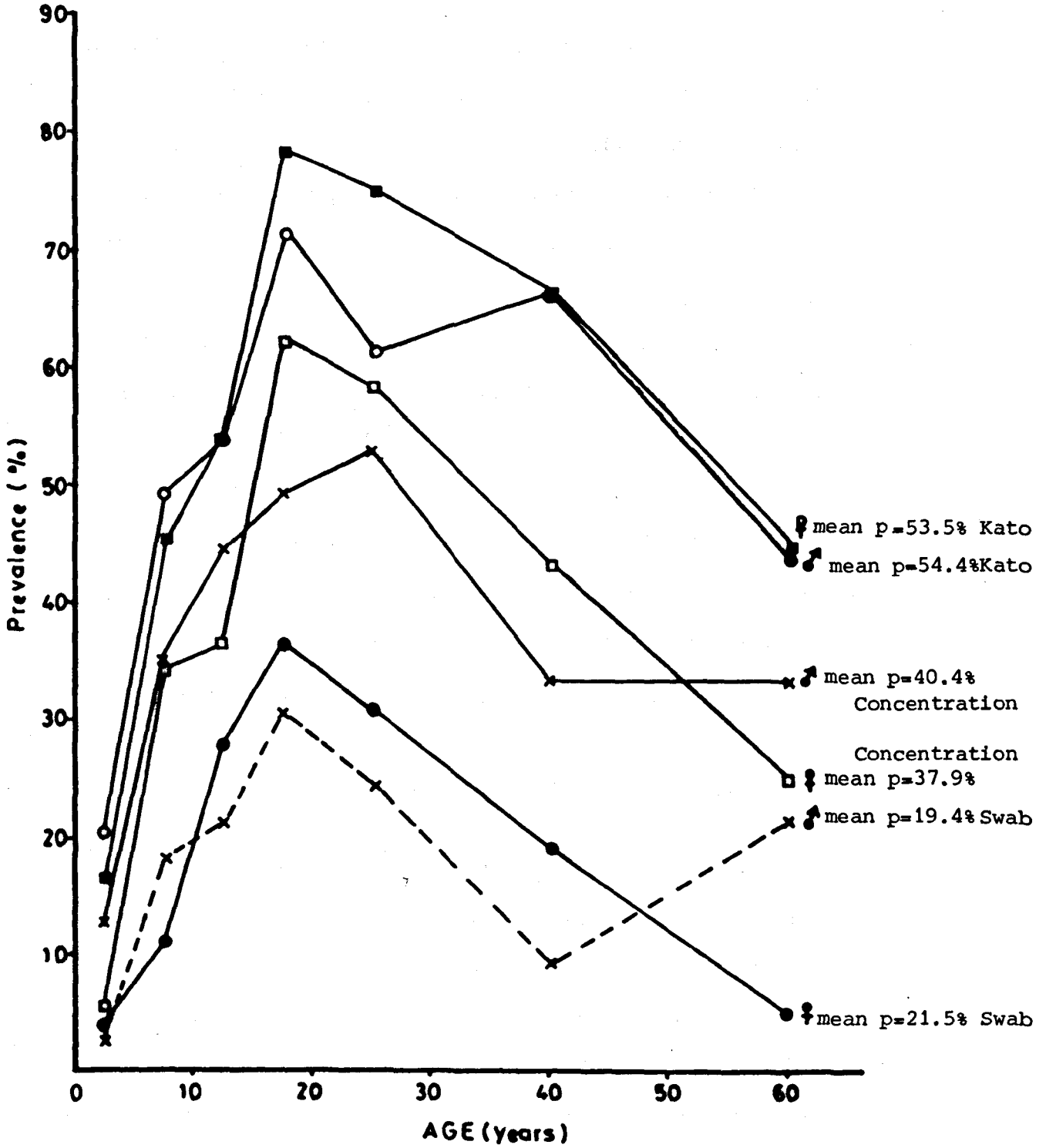

FIGURE 5.3

Prevalence of S. mansoni in Kakuyuni patients according to age as given by Kato, concentration and swab techniques

5.3.7 Presence of S. mansoni eggs in the perianal area in relation to intensity of infection

The number of S. mansoni eggs found in each swab examined ranged between 1 and 36. The finding of eggs in the perianal area increases with intensity of infection as is clearly demonstrated in Table 5.6 and Figure 5.4. For example considering those with light infections (10-99 eggs), only 17% were found with eggs in the perianal area and this figure is tripled (52%) in those with heavy infections (500-999 eggs). The trend is more or less the same for both sexes.

5.3.8 Relationship between swab scores and Kato scores

A regression analysis of the swab scores against Kato scores on a log scale revealed a significant positive correlation (see Figure 5.5; $r=0.51$, $p<0.001$). The relationship is however a weak one as only 26% of variation in the swab scores can be explained by Kato scores ($R^2=0.26$). When age was considered, all age groups showed significant positive correlations between the scores with the strongest correlation in the age group 10-14 years ($r=0.57$; $R^2=0.33$, $p<0.001$) with the rest of the age groups being in between the two extremes.

5.3.9 Viability of S. mansoni eggs recovered from the perianal region

Of the 178 persons who had S. mansoni eggs in the perianal region, at least some of the eggs were viable or hatched in 75 or 43.1% of them. Unfortunately, observation on the viability of eggs in the extended study of 71 school children was overlooked. It would have been interesting to compare viability in S. mansoni eggs recovered from swabs before and immediately after defaecation.

TABLE 5.6

Relationship by sex between presence of one or more *S. mansoni* eggs in the Swab (Swab technique) and intensity of infection in eggs per gram (Kato technique)

EGG COUNT RANGE	NUMBER POSITIVE/NUMBER EXAMINED (% +ve)		
	Males	Females	All
0 -10	8/209 (4)	4/194 (2)	12/403 (3)
10-99	16/110 (14)	19/100 (19)	35/210 (17)
100-499	42/101 (42)	35/ 74 (47)	77/175 (44)
500-999	7/ 14 (50)	15/ 28 (54)	22/ 42 (52)
1000+	15/ 22 (68)	16/ 19 (84)	31/ 41 (76)

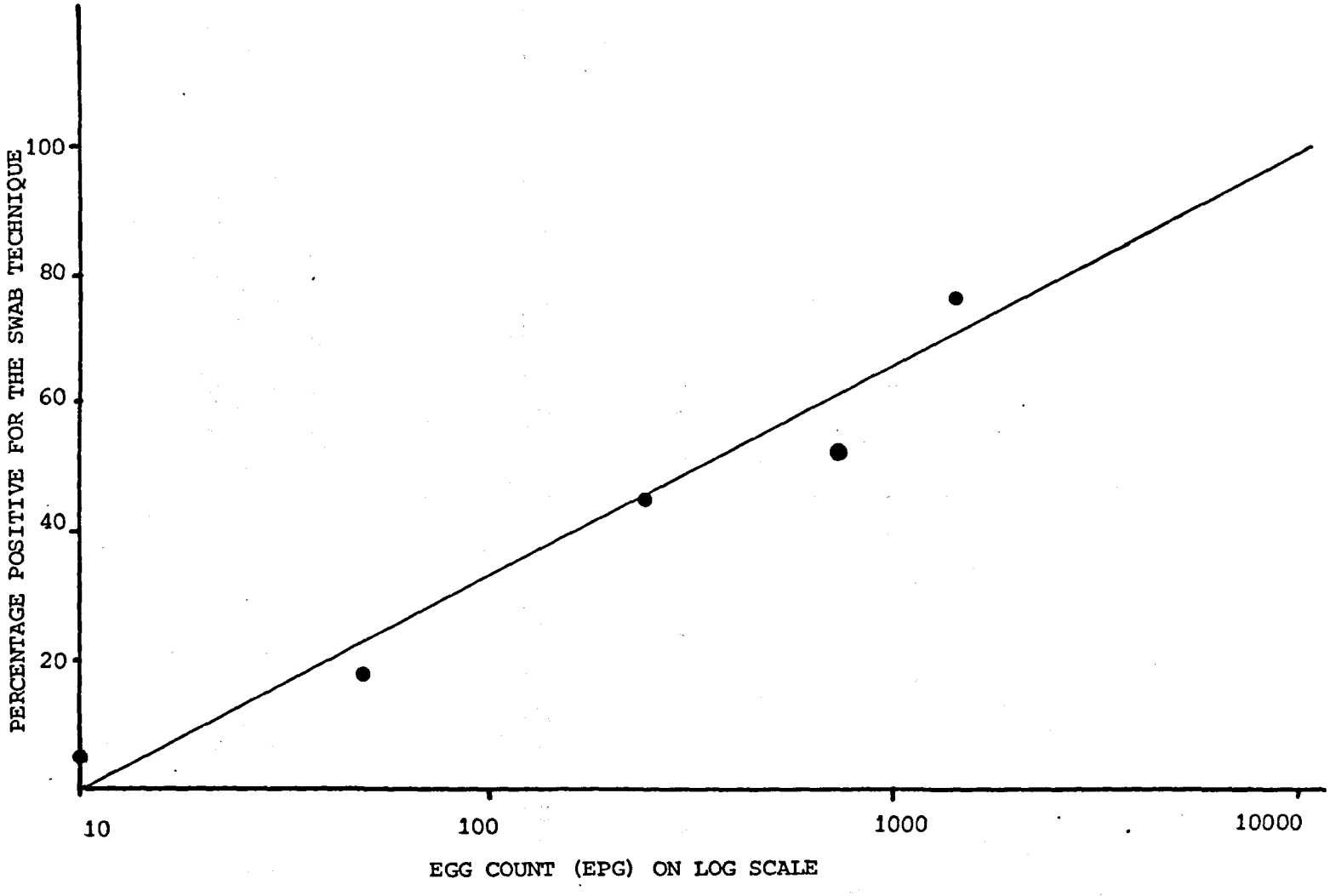

FIGURE 5.4

Relationship between the proportion of people positive for S. mansoni by swab examination and the intensity of infection (Kato method) for Kakuyuni health centre patients.

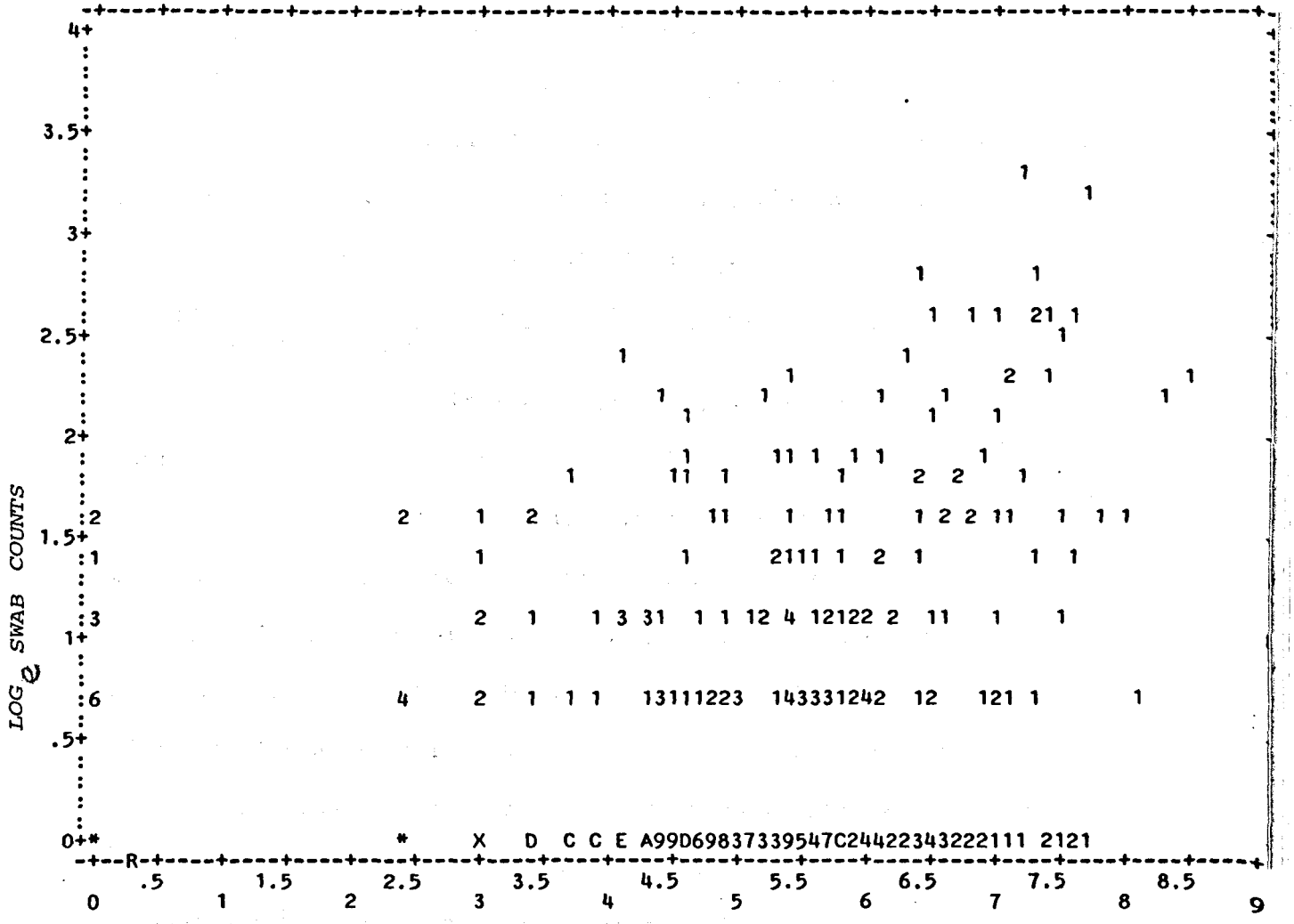

FIGURE 5.5

Relationship between swab scores and Kato (epg) in 874 patients examined in Kakuyuni health centre. Numbers refer to frequencies. For symbols refer to Appendix 4.4 r=0.51 (p<0.0001)

5.3.10 Comparison of swab and concentration methods in detecting other intestinal parasites

The other intestinal helminth parasite most frequently detected by the concentration method was hookworm with a prevalence of 18.7%. Others were Ascaris lumbricoides and Enterobius vermicularis with prevalences of 3.4% and 2.1% respectively. Protozoan cysts were often seen but not recorded.

When concentration and swab methods were compared the latter gave better results in detecting E. vermicularis as would be expected (see Table 5.7). The swab method was also fairly efficient in detecting A. lumbricoides (sensitivity 41.2%) but was rather poor in detecting hookworm (sensitivity 19.25%).

5.3.11 Relationship between contaminative activities and snail infection rates

In order to see if there are relationships between various activities considered to be contaminative (bathing, swimming and playing) and snail infection rates in sites used for both snail and water contact observation data from three different areas (Iietune, Kavilinguni and Kakuyuni - see Fig. 1.3) were compared and these are summarised in Tables 5.8a, b, c. Regression analysis of percentages of infected snails against numbers of contaminative contacts revealed no significant correlations in both Iietune and Kavilinguni ($r = -0.10$ and $r = -0.14$ respectively) but a positive significant correlation was found in Kakuyuni ($r = 0.64$) which was significant at the 5% level (Figs. 5.6a, b, c). It is noted that while the majority of the observation sites in both Iietune and Kavilinguni were flowing sites for most of the period, all of the sites in Kakuyuni were static except for very short periods when there were heavy rains.

5.3.12 Results of possible role of flies in transmission of S. mansoni

Various flies were frequently observed feeding on faeces deposited near water bodies and then landing on water from time to

TABLE 5.7

Comparison of Swab and Concentration techniques for detecting *Enterobius vermicularis* ova from patients attending Kakuyuni Health Centre

SWAB	CONCENTRATION		
	Positive	Negative	Totals
Positive	21	10	31
Negative	18	826	844
Totals	39	836	875

Sensitivity = 53.8%

TABLE 5.8a

Total number of contacts due to bathing, playing and swimming snail number and their infection rates in Iietune from November 1981 to October 1982.

SITE NO.	TOTAL NO. OF CONTACTS	NO. OF CONTACT DUE TO BATHE/PLAY AND SWIM	NO. OF SNAILS +VE / NO. COLLECTED	PERCENTAGE POSITIVE
1	212	8	1/117	0.9
2	100	5	45/283	15.9
3	386	30	1/136	0.7
4	255	22	1/136	0.7
5	358	23	7/187	3.7
6	394	27	0/30	0
7	268	0	92/411	22.4
8	189	20	56/499	11.2
9	182	15	11/148	7.4
10	62	19	135/793	17.0
11	571	41	19/440	4.3
12	166	22	0/11	0
13	107	29	5/123	4.1
14	110	26	0/3	0
15	355	35	142/509	27.9
16	72	7	0/7	0
17	28	2	72/254	28.3
18	107	0	4/218	1.8
19	204	10	39/1328	2.9
20	236	3	15/469	3.2
22	142	25	10/1032	1.0
24	52	6	2/163	1.2
25	326	30	85/1002	8.5
26	96	2	0/1	0

TABLE 5.8b

Total number of contacts due to bathing, playing, swimming and snail numbers and their infection rates in Kavilinguni from April to March, 1985.

SITE NO.	TOTAL NO. OF CONTACTS	NO. OF CONTACTS DUE TO BATHE/PLAY AND SWIM	NO. OF SNAILS +VE / NO. COLLECTED	PERCENTAGE POSITIVE
4	160	34	1/1498	0.1
6	95	7	0/363	0
7	44	20	0/128	0
8	18	6	17/107	15.9
9	71	21	0/7	0
10	73	28	0/15	0
11	121	64	0/210	0
12	47	10	20/273	7.3
13	110	15	0/17	0
14	74	17	0	0
15	200	43	1/106	0.9
18	19	4	70/875	8
25	131	38	43/187	23

TABLE 5.8c

Total number of contacts due to bathing, playing and swimming and snail numbers and their infection rates in Kakuyuni from April 1984 to March 1985.

SITE NO.	TOTAL NO. OF CONTACTS	NO. OF CONTACTS DUE TO BATHE/PLAY AND SWIM	NO. OF SNAILS +VE NO. COLLECTED	PERCENTAGE POSITIVE
1	64	0	$\frac{32}{2761}$	1.2
2	18	1	$\frac{18}{539}$	3.3
3	95	0	$\frac{9}{171}$	5.3
6	336	16	$\frac{68}{618}$	11.1
7	409	96	$\frac{443}{2034}$	21.8
8	305	102	0	0
9	418	158	$\frac{193}{1736}$	11.1
10	108	17	$\frac{0}{8}$	0

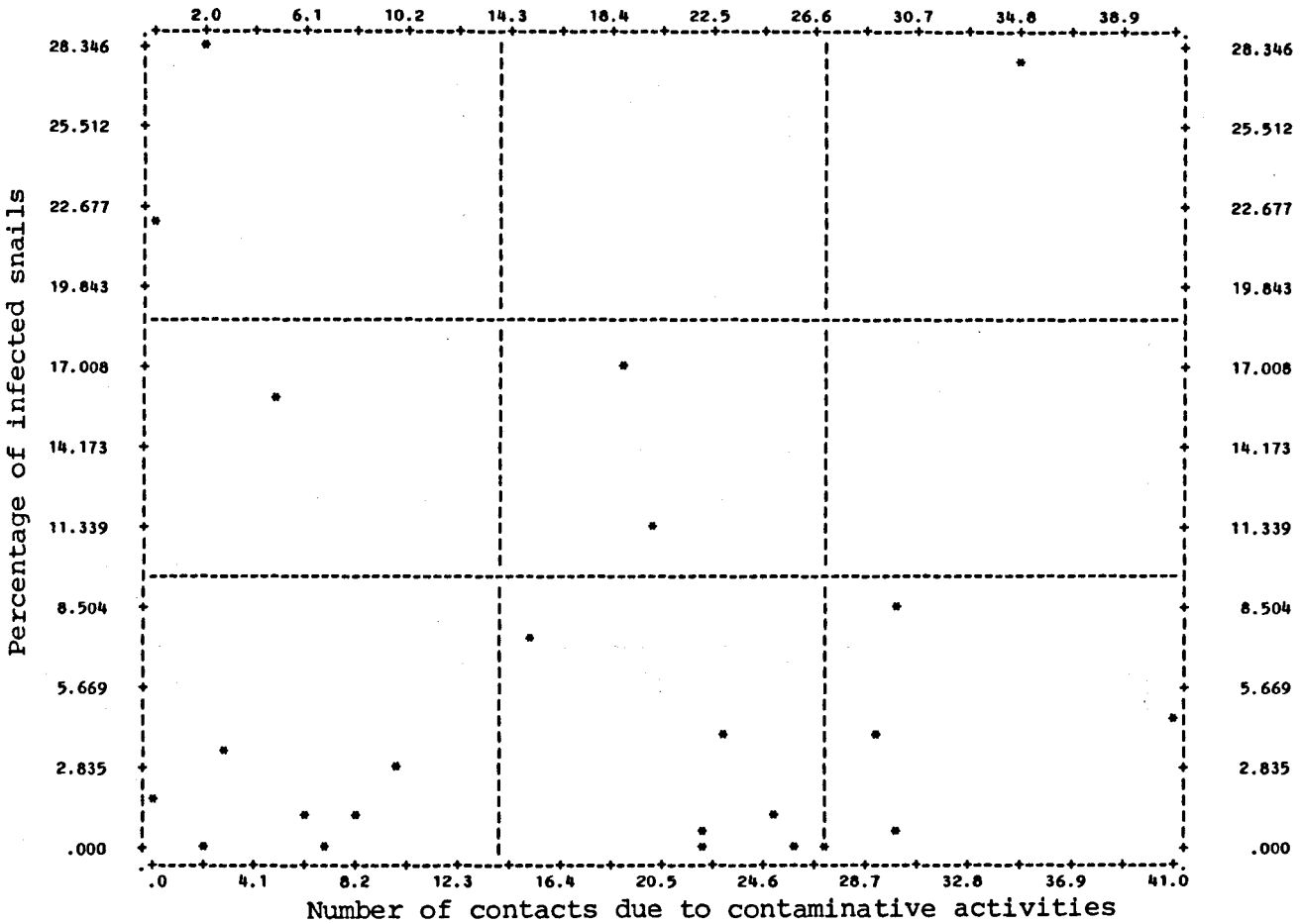

FIGURE 5.6a

Relationship between infection rate of snails and frequency of contaminative activities from 22 sites in Iietune duri 1985

$r = -0.10$ $(p>0.01)$

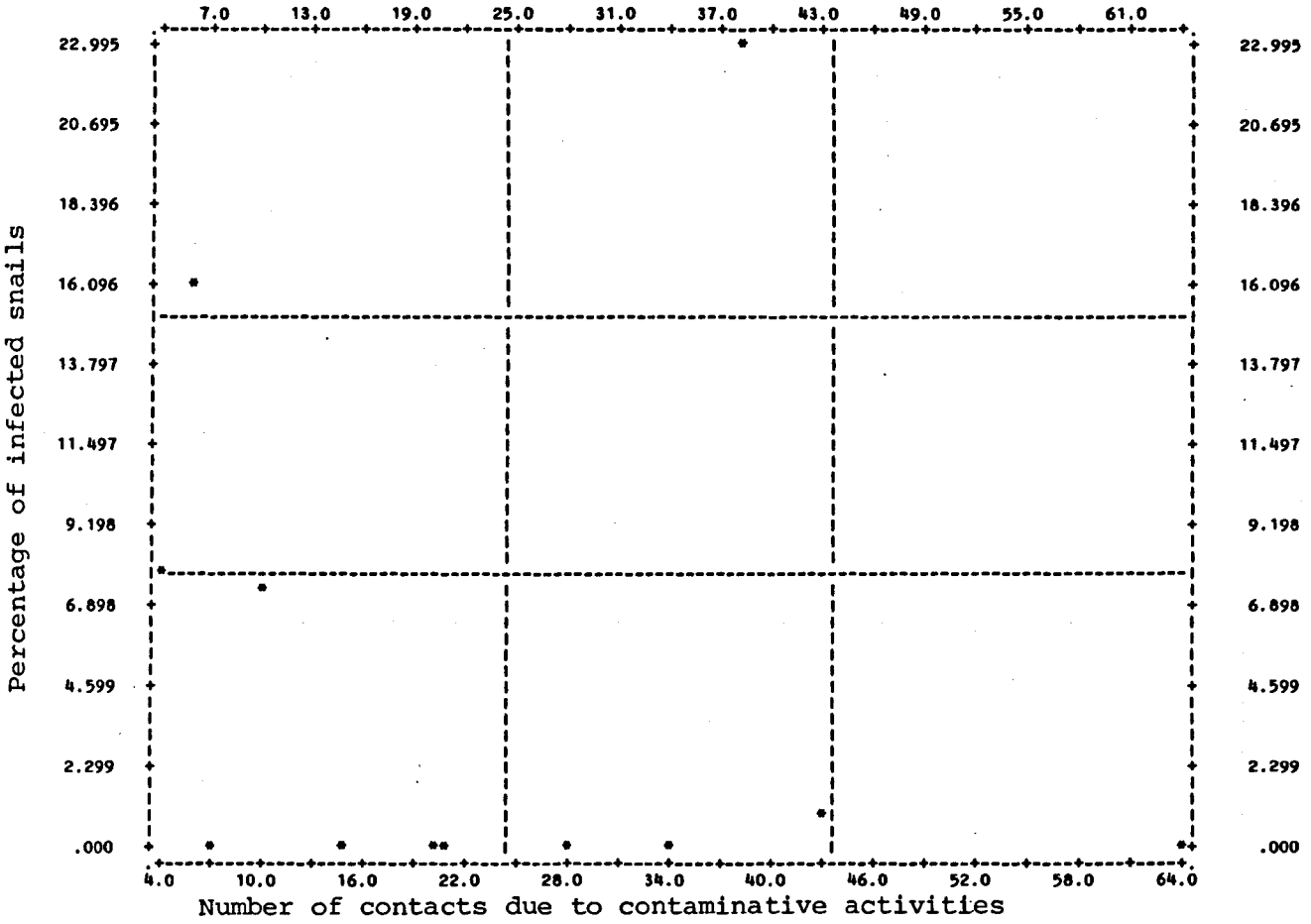

FIGURE 5.6b

Relationship between infection rate of snails and frequency of contaminative activities in 12 transmission sites in Kavilinguni in 1985

r = -0.4273 (p>0.01)

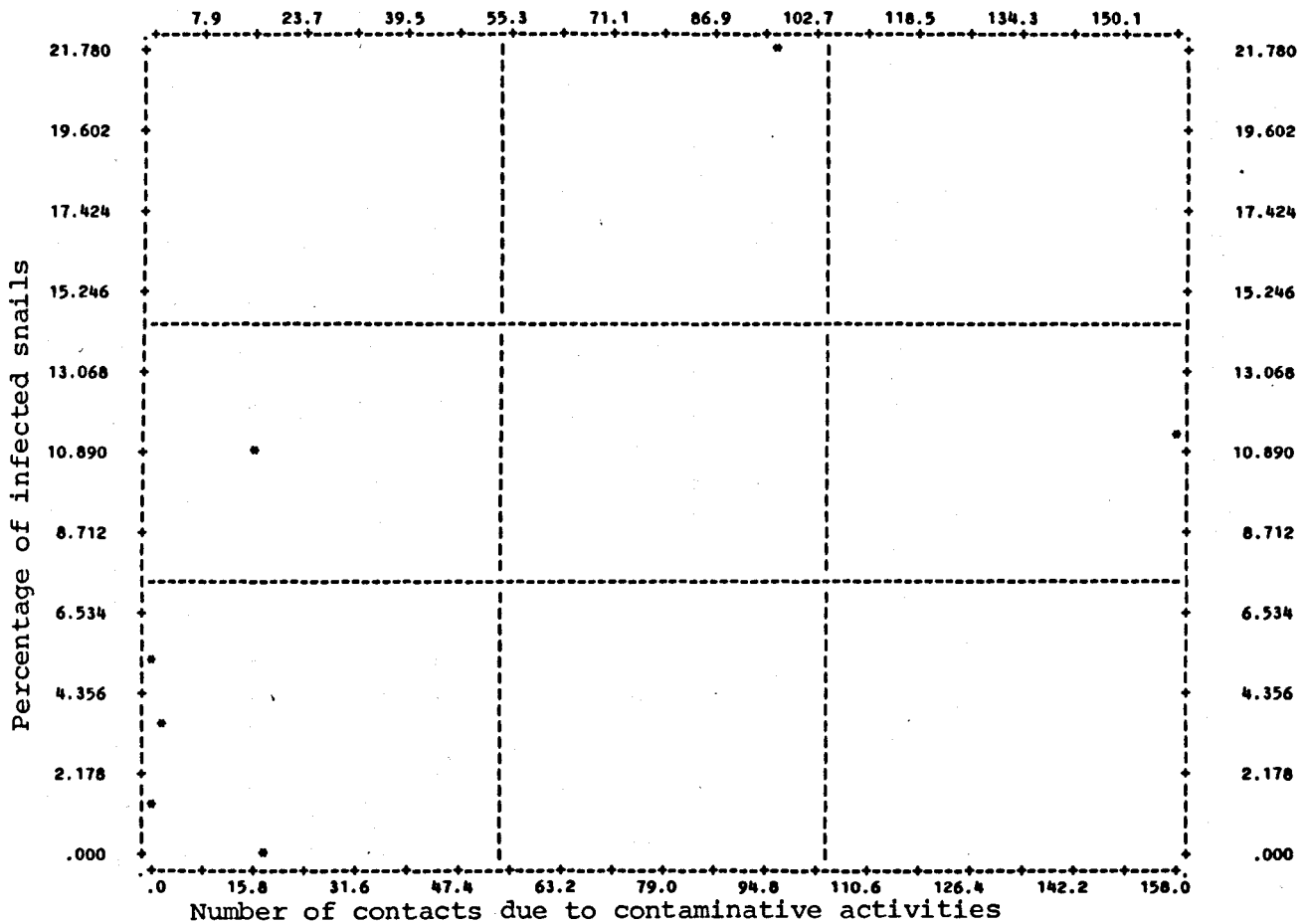

FIGURE 5.6c

Relationship between infection rate of snails and frequency of contaminative activities in 7 transmission sites in Kakuyuni in 1985

$r = 0.64$ ($P < 0.05$)

time. Preliminary investigations to reveal if they became contaminated with S. mansoni eggs or other ova and cysts revealed only eggs of hookworm and cysts of E. coli. However, recently a few flies have been found contaminated with S. mansoni eggs on either their legs or mouthparts (Thiongo, personal communication). The various species have been identified as Chrysomya chloropyga (Calliphoridae), Bercaea sp. (Sarcophagidae) and Anthrax sp. (Bombyliidae). Their role in transmission of S. mansoni continues to be investigated.

5.4 DISCUSSION

In the foregoing chapter, we have seen how the environment gets contaminated and the magnitude of the daily contamination with S. mansoni eggs as well as which groups of people are responsible for the bulk of this contamination. We have also looked at various aspects of human behaviour which influence the level of environmental contamination. The eggs being excreted daily into the environment are important in transmission only if they reach snail infested waters. It is generally believed that most eggs will be washed into water during rains. Chandiwana (1986) found that the peak prevalences of S. mansoni infection in B. pfeifferi occurred during the rainy and post-rainy seasons. He also noticed that a few infections still occurred in B. pfeifferi in the hot dry period when rain could have played no part and like Husting (1965) and Prentice et al. (1970) he suggested that eggs remaining in the perianal area after defaecation and washed into water during bathing or swimming may have been responsible for the infections. Several other theories have been put forward as reviewed in section 5.1. The present study has looked further into the possible role of S. mansoni eggs adhering to the perianal area and the results though

not conclusive seem to support the perianal area theory. Investigations involved two steps. Firstly, an attempt was made to discover if, who and what proportion of the people normally carry S. mansoni eggs in their perianal area. Secondly, we tried to see if there is any evidence for these eggs reaching water.

Demonstration of presence of eggs in the perianal area is not a simple matter for it involves personal hygiene of the people. Whatever reason for doing it, it must be seen as part of the vital diagnostic procedures necessary before the correct treatment can be given for whatever complaint. This is why the study population had to be restricted to those who came to Kakuyuni health centre for treatment of various illnesses and as such they were unlikely to depict a true picture of the population structure of the people (see Table 5.1).

The swab technique has been used (Graham, 1941) and is generally recommended for diagnosis of E. vermicularis (Muller, 1975) because the adult worms migrate during the night to lay eggs next to the anus but nowadays, transparent adhesive tape (Sellotape or Scotch tape), which can be stuck onto a microscope slide is more commonly used. Husting (1965) used cotton swabs to cleanse the perianal area and demonstrated presence of S. mansoni as well as hookworm eggs but had to abandon it because he thought the cotton fibres were retaining many of the eggs and thus giving biased results. Instead he used a blunt rounded steel spatula to scrape the perianal area. In the present study, Scotch tape was used initially but it is not surprising that it did not work since faeces might adhere firmly onto perianal hairs thus making it not possible to pick any eggs easily. The cotton swabs were successfully used in taking perianal swabs in the present study and contrary to what Husting (1965) thought, there was no evidence that the cotton swabs

were retaining S. mansoni eggs (see section 5.3.4). However, E. vermicularis eggs were retained in a few cases and this could be attributed to the stickyness of the outer albuminous layer of the eggs mentioned by Muller (1975). Although the swab technique was less sensitive in detecting S. mansoni eggs as compared to Kato and concentration methods, it must be realised that as also suggested by Husting (1965) the positivity of the swab technique depended on the personal hygiene of the people which may be different from person to person. For example we have seen in section 4.3.1.6 that not everyone cleaned themselves always after defaecating. Even if they did, the majority did not have toilet paper and used newspapers or leaves which may have only helped to spread S. mansoni eggs evenly around the perianal area. Another possibility is that the right part of the perianal area was missed at times during swabbing because some of the patients became nervous in the process. People were not generally told in advance whether a swab was going to be taken after providing a stool but it is likely that some of them learned this from patients already examined and this could have resulted in them cleaning themselves more thoroughly. It therefore seems reasonable to suggest that under normal circumstances, more people than were found (20.4%) could be carrying S. mansoni and other helminth eggs in their perianal area. If we consider those who were revealed to be passing S. mansoni eggs by the concentration technique, the swab picked 46.8% of the cases which compares well with 48% (12 out of 25 confirmed cases of S. mansoni by the same method) shown by Husting (1965) to be having eggs in their perianal area.

The observation that finding eggs in the perianal area depended on intensity of infection (see Figure 5.3) rather than age implies that personal hygiene does not improve with age. The implication

here is that people with S. mansoni infections are more likely to be carrying eggs in their perianal area irrespective of age and sex as well. However, the number of eggs carried depended on intensity of infection (Fig. 5.4). There was a significantly positive correlation between the swab scores against the Kato scores ($r = 0.51$; $P < 0.001$). It is possible that we could have obtained an even better correlation for even though the Kato results were based on eggs per gramme of stool, the swab results could not be standardised. Future use of swab technique should take into account the weight of the cotton swab before and after it is taken so that a rough estimate can be made of the amount of stool and hence eggs per unit weight of stool. This would improve the prediction of the swab scores on the basis of Kato scores and allow a reasonable estimate of the number of S. mansoni eggs possibly being introduced each day in a particular transmission site by people who bathe, play or swim provided their Kato results are known.

From the results of examination of the swabs before and immediately after providing stool specimens, we saw that a good number of school children had S. mansoni eggs in their perianal region several hours before and immediately after defaecation. For these eggs to be important in transmission of S. mansoni, it is necessary that people expose their extremities directly into natural waters during ablutions or during bathing, swimming or playing, activities which are regarded by Kloos et al. (1983) to be contaminative. Unlike the Gezira Scheme in the Sudan and the Egypt 49 project area (Cheesmond and Fenwick, 1981; Farooq and Mallah, 1966) ablution was not observed in the study area and is not known to be practised in Machakos District as a whole. However, bathing, swimming and playing were observed in Matithini and although they accounted for only 7.6% of all the other activities combined (see

Table 3.10), they were mostly observed in the age group 5-19 years - the same age group observed to be having the highest intensity (Figure 3.1). Bathing activity was commonly observed after defaecation in Lower Nduu in Machakos and the same activities are known to represent 20% of all activities in Area S (Kakuyuni - see Fig. 1.4) (Butterworth, personal communication).

About half the number of people interviewed and who admitted bathing directly in the river or stream (mostly aged 5-19 years) said they normally do so immediately after defaecating (see Table 4.9), the other half said they normally do so sometime later.

According to the above observations, those who bathe directly in the river or stream immediately after defaecating may be important in introducing a small amount of viable S. mansoni eggs into water. For example 43.1% of the people had viable S. mansoni eggs in their perianal region soon after defaecation (see Section 5.3.9). In the absence of information on the viability of S. mansoni eggs which have remained in the perianal area for several hours after defaecating, it is not possible to make a definitive statement on the possible role of such eggs although we know that the other half of the people who admitted they bathed directly in the river or stream did so a while after defaecating. However, it is unlikely that eggs remaining in the perianal region for several hours will get destroyed since moist and warm conditions in the perianal region favour their survival (Husting, 1965).

The amount of eggs getting into natural waters via the perianal region whether able to hatch or not will depend on the faecal egg load and if and how well people clean themselves after defaecating and before they go to bathe, swim or play in water. From the results of the questionnaire survey on personal hygiene after defaecation (see section 4.3.1.6, Table 4.10) it was observed that

the 0-19 year olds cleaned themselves less regularly after defaecation and quite a good proportion (19.2%) did not bother to clean themselves at all when they defaecated just before bathing. It is therefore possible that the above age group were introducing a substantial amount of S. mansoni eggs in water when bathing, swimming or playing. Moreover there is a fair chance that quite a good proportion of the eggs were viable since Upatham (1976) and Upatham et al. (1976) demonstrated that hatching rate of S. mansoni eggs increased with people's age as well as the intensity of infection.

All in all, the total number of S. mansoni eggs getting into water via perianal region may be small compared to those for example washed in by rain. But as implied by Jordan and Webb (1982) only a small number of S. mansoni eggs needs to reach the water in order to ensure that transmission continues.

A more direct way of proving if S. mansoni eggs from the perianal area reach the water would be by using dyes which can be given to people by food and then detecting if such dyes will show in water in sites used for bathing, swimming or playing. Dyes are known to have been used in India in connection with diarrhoeal studies (Jordan, personal communication). As the same water is used in the area for all purposes, it was thought that such approach would lead to spoiling the co-operation of the people which we were already enjoying.

If it is true that S. mansoni eggs reach water when people expose their perianal region directly into water during bathing, swimming or playing, it seems reasonable to suggest that water sites commonly used for these activities would have more infected snails than those used for non-contaminative activities. In order to check this, we tested to see if there was any correlation between snail

infection rates and frequency of contaminative activities. As shown in the results (see section 5.3.11, Figs. 5.6a, b, c) no correlations were found in two of the three areas tested but in one of them (Kakuyuni) a strong positive correlation was found ($r = 0.64$) which was significant at the 5% level. In this particular area, all transmission sites were static most of the time and any eggs introduced or hatched miracidia in them were unlikely to be washed away as opposed to the other two areas (Iietune and Kavilinguni) in which most sites had water flowing for most part of the year. Chandiwana (1986) in a study just published failed to find any correlation between exposure indices for complete contact and prevalence of infection in B. pfeifferi.

From these observations, it is concluded that in the area studied, up to about one third (mostly school age children) of the people infected with S. mansoni as shown by Kato technique normally carry S. mansoni eggs in their perianal area and that it is possible to reliably detect these eggs by taking and examining the contents of a cotton swab of the perianal area. Although we have some evidence that these eggs were important in transmission in one of the villages (Kakuyuni) studied (snail infection rates in different sites correlated with a number of contaminative contacts in the same sites) more careful observations are needed to take into consideration the condition of the sites, the details of the users by age and sex before any general conclusion can be made. As an additional evaluation technique, perhaps we can use sentinel snails to expose them in sites used for contaminative activities and compare the results with those exposed in sites not used often for contaminative activities.

Another possible route of transmission of S. mansoni briefly looked at was the role of various fly species. The earlier

observations that flies carry hookworm eggs and E.coli cysts and later observation that the same carry S. mansoni eggs as well (Thiongo, personal communication) are striking. These flies are often seen landing on water particularly during the dry periods and it is possible that they introduce S. mansoni eggs into the water in this way. If proved, this will be yet another possible method of transmission of S. mansoni particularly in water sites in which transmission cannot be explained by contaminative activities in the absence of obvious routes such as rainfall water.

The possibilities of eggs reaching water via other animal hosts is discussed in the next chapter.

5.5 SUMMARY OF CHAPTER FIVE

1) Presence of S. mansoni eggs in perianal region was demonstrated in 20.4% of the population examined using swabbing technique and in 35% and 46.8% of those respectively shown to be positive by Kato and concentration methods. There was a high positive correlation between number of eggs observed in the swabs and number of eggs per gram of stool. 43.1% of those positive for the swab had viable eggs.

2) There was no age difference in the prevalence pattern as revealed by the three methods implying that presence of eggs in the perianal region is not age dependent - it was expected that personal hygiene may improve with age. But there was a linear relationship between swab positive and intensity of infection implying that people with heavy infections are more likely to be having eggs in their perianal region.

3) Ova of other intestinal parasites particularly Enterobius vermicularis were also found in the perianal region as revealed by the swabbing technique.

4) Only one area out of three showed a positive correlation between contaminative activities and snail infection rates in the sites observed implying that there is yet little evidence for eggs getting into water during bathing, swimming or playing in water bodies.

5) Preliminary studies showed that various fly species may be involved in the transmission of S. mansoni but that their role is still to be studied.

CHAPTER 6

STUDIES ON ANIMAL HOSTS OF *SCHISTOSOMA MANSONI*

6.1 GENERAL INTRODUCTION AND LITERATURE REVIEW

6.1.1 General introduction

For the purposes of this thesis, reservoir hosts of schistosomiasis include all animals which are directly or indirectly involved in the transmission of infections to man. They can be either the maintenance hosts responsible for the natural cycle of the infection or they can be secondary hosts which may be essential for the organism reaching man.

In Chapter 1, section 1.4 reference has been made to animal hosts of human schistosomiasis in general. A more detailed review of the literature is given below and special emphasis has been placed on natural infections with *S. mansoni* with references made to infections with *S. haematobium* and other animal schistosomes only where relevant.

Although schistosomiasis due to *S. japonicum* infection has always been regarded as a zoonosis, it is only in the past few years that animals have been seriously considered as possible reservoir hosts of *S. mansoni*, *S. haematobium* and *S. intercalatum* (Nelson, 1975). Animals so far found with natural infections of either *S. mansoni* or *S. haematobium* can be grouped as follows.

6.1.2 Primates other than man

The first record of an infection with *S. mansoni* in an animal was by Cameron (1928) in the West Indies where he found five out of eight *Cercopithecus* monkeys infected. Porter (1938), in South Africa, observed that in the faeces of the monkey *Cercopithecus aethiops* there were eggs which seemed to be from *S. mansoni*, and concluded: "Such possible sources of molluscan infection as

naturally infected monkeys need to be borne in mind". Much later, natural infections of S. mansoni were reported from baboons (Papio spp) from East Africa (Miller, 1959, 1960; Nelson, 1960; Strong et al., 1961; Nelson et al, 1962; Fenwick, 1969), and from Vervet monkeys (Cheever et al., 1970; Else and Sturrock, 1982). In Ethiopia, Papio anubis has been found naturally infected as well as the grivet monkey (C. aethiops) (Fuller et al., 1979). There is one report by Swellengrebel and Rijpstra (1965) of a squirrel monkey (Saimiri sciureus) found with S. mansoni eggs four months after it was brought to Holland from Surinam.

While there is a call for more studies, it is now believed that baboons in Africa may be playing an important role in maintaining the transmission of S. mansoni (WHO, 1979a). For example, Fenwick (1969) had no difficulty in finding S. mansoni eggs in baboon faeces collected around rock pools in Northern Tanzania and the same author observed that 15 people were heavily infected with S. mansoni after bathing in the same rock pools which were situated in uninhabited areas. Nelson (1983) quotes Barnleyas saying that he found S. mansoni eggs in baboon faeces in Uganda. Else and Sturrock (1982) argue that the monkeys they found with natural infections of S. mansoni from Lake Naivasha area of Kenya could be maintaining transmission by themselves in their restricted home range since according to Pamba and Roberts (1979) no inter-human transmission has yet been proven in this area.

Infections of primates with S. haematobium have been recorded on very few occasions. Nelson et al. (1962) reported natural infections in baboons and monkeys from Tana river area of Kenya and more recently Else and Sturrock (1982) reported natural infections of S. haematobium in Sykes monkeys (C. mitis) from the same area. Elsewnere natural infections of S. haematobium been recorded in

baboons, monkeys and chimpazees in West Africa (De Paoli, 1965; Taylor et al., 1972). It seems likely that these are no more than incidental infections which can be of little importance. For example so far, only a total of four primates have been found naturally infected.

6.1.3 Other wild animals

Few reports exist of natural infections with S. mansoni in wild animals other than primates and rodents (see section 6.1.5 below). S. mansoni was found in the Insectivore, Crocidura luna by Stijns (1952) in the Congo and by Kuntz (1958) in Eqypt. Pitchford et al. (1974) recorded natural infection of S. mansoni in waterbuck. In South America there are reports of natural infections with S. mansoni in the Oppossum (Travassos, 1953; Martins et al., 1955).

With regard to S. haematobium, there is an unconfirmed record of a large wild boar (Sus scrofa) from Nigeria being naturally found passing S. haematobium eggs by Hill and Onabimiro (1960) and of an African Cape buffalo (Syncerus caffer) from South African from which Basson et al (1970) recovered only one male S. haematobium

6.1.4 Domestic animals other than dog

Barbosa et al. (1962) found S. mansoni adults in 4 cows in Brazil and ova in faeces of one of them. Mackenzie (1970) reported natural infection of both S. haematobium and S. mansoni in sheep in Rhodesia. Recently Karoum and Amin (1985) reported natural infections of S. mansoni in two out of 98 cattle examined in the Sudan but could not find infections in sheep or goats. Natural infection in dogs is reviewed in section 6.3.1.

6.1.5 Rodents

Small mammals were first incriminated as natural hosts of schistosomes in Africa by Stijns (1952) when he found Crocidura spp.

infected with S. rodhaini in the Belgian Congo. The same year rodents were first found infected in the wild in Egypt when a gebril was found with S. mansoni (Kuntz, 1952). Extensive surveys of the wild rodent population in South Africa revealed natural infections with S. mansoni in Mastomys and Otomys (Pitchford, 1959) but they were thought to be of very little importance in transmission. During further observations in the Eastern Transvaal by Pitchford and Visser (1962) Lemniscomys griselda was once found with natural infection of S. mansoni and twice with S. mattheei. They also found it to be a good laboratory host. In the Congo, Dasymys, Pelomys, Lophuromys and Oenomys were found with S. mansoni var rodentorum by Schwetz (1956) but it is likely that these were S. mansoni infections (Teesdale and Nelson, 1960; Pitchford and Visser, 1962). In the Sudan the Nile rat (Arvicanthus niloticus) has been reported to be naturally infected with S. mansoni (Karoum and Amin, 1985). Natural infections of Nile rats have been previously recorded by Mansour (1973) in Egypt and by Polderman (1974) in Ethiopia. In Kenya, Nelson et al. (1962) found natural infections of S. mansoni in Otomys sp., Mastomys and Dasymys. He argued that most of the animals examined were Savannah rats and emphasised the importance of discovery of infections of S. mansoni in Dasymys incomtus and Lophuromys flavopunctatus, two species of rodents which are closely associated with water. Kawashima et al. (1978) working in the Taveta area in Kenya found 18 out of 41 Pelomys sp. infected. This "creek rat" passed viable eggs in its faeces and with an infection rate 40 per cent it must be a good candidate as a reservoir host of S. mansoni. Elsewhere in East Africa, McMahon and Baalawy (1967) found three out of 47 rats (unspecified species) from Mwanza, Tanzania with high infections of S. mansoni.

While the significance of rodents in transmission of S. mansoni in Africa remains unclear, recent findings suggest that they may be important in maintaining transmission of S. mansoni in South America. Nelson (1983) quotes Da Silva as saying that rodents and possibly other wild and domestic animals are important reservoir hosts in Brazil but further studies are necessary. In areas where human prevalence of infection was high, 8.5 percent of rats were found to be infected with S. mansoni. Nectomys squamipes, Holochilus sciureus and Oxymycterus angularis are probably most important (Amorim et al., 1954). Rattus frugivorus was examined in the Pernambuco district of Brazil and 16 out of 27 were found infected (Barbosa et al., 1953). In Guadeloupe, Rattus rattus and R. norvegicus have been found naturally infected with S. mansoni, but their role in transmission was considered to be negligible (Theron et al., 1978). However later work by Combes and Imbert-Establet (1980) and Imbert-Establet (1982) have revealed that Rattus rattus may be important in transmission of S. mansoni. Nelson (1983) suggested that isoenzyme studies are necessary to determine if isolates from man and animals in the same area are the same. Rollinson et al. (1986) made enzymatic comparison between isolates of S. mansoni from rats and humans in Guadeloupe and found no differences. They concluded that S. mansoni is circulating through R. rattus and man in the natural habitat.

The only record of a possible natural infection of S.haematobium in rodents is that of Pitchford (1959) when he reported having found eggs indistinguishable from those of S. haematobium in Otomys rats.

6.2 STUDIES ON POSSIBLE ROLE OF RODENTS IN TRANSMISSION OF SCHISTOSOMA MANSONI

6.2.1 Introduction

Both domestic and wild rodents are well known for their role in the damage they do to our grain crops. Rodents are also known for their role as reservoirs of certain diseases. In Kenya, outbreaks of sylvatic plague have been associated mainly with Arvicanthus niloticus and Paraomys natalensis (Roberts, 1974). De Geus (1974) mentioned the bush rat (Aethomys kaiseri) as being the main reservoir for Leptospira grippotyphosa with gerbils, Tatera robusta and the spring mouse, Acomys wilsoni being involved as well. Wijers (1974) referred to rodents as possible reservoirs of kala-azar in Turkana, West Pokot and Baringo districts in Kenya but to date this has not been confirmed. As already pointed out in section 6.1.4, Nelson (1962) and Kawashima et al. (1978) reported finding natural infections of S. mansoni in wild rodents from two different parts of Kenya. Both authors sounded a warning about possible role of rodents as reservoirs of S. mansoni but until the present project, no more work was carried out on the subject. The present study was aimed at not only humans as the source of contamination of the environment with S. mansoni eggs but also possible contribution to contamination by other animals. Rodents were chosen on the basis of previous records associating them with infections with S. mansoni in Kenya and elsewhere as referred to earlier. In addition, they were frequently seen near transmission sites in the study area. The only other animal suspected to be of importance for the same reasons was the dog and studies on its possible role in transmission of S. mansoni is reported in section 6.3.

The main aim for this particular study was to discover if various rodent species in the area were naturally infected with S. mansoni and whether they were likely to contribute significantly to transmission.

6.2.2 Materials and Methods

6.2.2.1 Trapping of rodents and identification of parasites recovered

Rodents were trapped in the study area between February 1985 and August 1986 near known transmission sites. The trap used was a multicatch wire gauze cage (Fig. 6.1) and the bait was baked maize meal mostly but sometimes we used roasted maize flour. At least 10 traps were used each time and they were set along identified rodent routes in the bushes near the river valleys in the mornings of each day. The following morning, they were checked and those containing rodents were emptied and reset again while those found empty were moved to new locations. Rodents caught were taken to Tala laboratory where they were perfused using the method described by Smithers & Terry (1965). The perfusate was thoroughly checked for presence of any schistosome worms. Contents of the intestine were thoroughly checked for presence of helminth ova especially ova of schistosomes. Preliminary identification was made of any ova seen. Later it was realised that some ova from the faecal contents of the intestine were difficult to identify to species so it was necessary to collect actual worm specimens by cutting through the intestines and carefully removing any worm seen. This was done immediately after perfusion. All the worms collected from the alimentary canal were washed in normal salive (8.5gm NaCl in 1000ml of distilled water) to remove mucus and other host debris before fixing. For nematodes 70% alcohol was used as fixative. For trematodes and cestodes, 4% formaldehyde was used.

FIGURE 6.1 Multi-catch wire gauze cage used in trapping rodents in Matithini

FIGURE 6.2 Mastomys natalensis

Screw-cap bottles were used for keeping the specimens which were carefully labelled and sent to the Commonwealth Institute of Parasitology, St. Albans, UK for identification. The results were compiled according to rodent species.

In addition to examining contents of the alimentary canal, the liver was examined for the presence of ova. This was done mainly when the livers were spotted or if schistosome worms were recovered from a particular rodent perfused. If the eggs were detected in the liver, a hatching test was performed by macerating the tissue and treating the macerated tissue as described for stools in section 6.3.2.1. If miracidia hatched, medium sized B. pfeifferi were individually exposed to 6 miracidia as already explained in section 3.2.4.1. They were then kept in the laboratory and checked for infection from day 21 post exposure.

6.2.2.2 Estimate of the densities of various rodent species.

The capture - recapture method was used to estimate the relative abundance of different species of rodents caught. In doing this, an area of roughly 50 m^2 in Matithini was selected and 20 cages were set as already explained in section 6.2.2.1. Cages were checked the following day for any catches. All the rodents caught were identified, counted, recorded and marked with a yellow dye before releasing them. Traps were then re-set again and all the rodents caught were similarly treated. An additional record of numbers recaptured was introduced. Trappings were done continuously for one week in May 1986 and again for the same period in July 1986. Populations of each rodent species (P) were calculated from the simple Index used by Lincoln (1930). The equation for this is $P = \frac{an}{r}$ where n = total number of individuals in the second sample, a = total number marked and r = total recaptures. The following assumptions are usually made (Southwood, 1966):

1) The marked animals are not affected by being marked and the marks will not be lost.

2) The marked animals become completely mixed in the population.

3) The population is sampled randomly with respect to its mark status.

4) Sampling must be at discrete time intervals and the actual time involved in taking the samples must be small in relation to the total time.

5) The population is a closed one.

6) There are no births or deaths in the period between sampling.

7) That the trapping method is not selecting sub-populations of rodents attracted to the specific type of bait.

6.2.3 Results

6.2.3.1 Rodent species and estimates of their populations

The predominant rodent species caught in traps during routine trapping was Tatera robusta (Table 6.1) which was collected every month between February 1985 and July 1986. The next most common species caught was Mastomys natalensis commonly known as (multimammate rat) (Fig. 6.2). They were also collected every month throughout the period of collection except for September 1985. The third most common species collected was Lemniscomys striatus also known as punctated grass-mouse (Fig. 6.3). Apart from February, April and December of 1985 and May 1986 - they were also collected for the rest of the months. Aethomys kaiseri (Fig. 6.4) were also collected nearly every month except for August, November and December 1985 but in much smaller numbers. The last species, the Elephant shrew was very rarely found throughout the collection period, only five being caught.

It must be pointed out that the figures given in Table 6.1 are by no means comparable since in some occasions, the number of traps set were less after some were stolen.

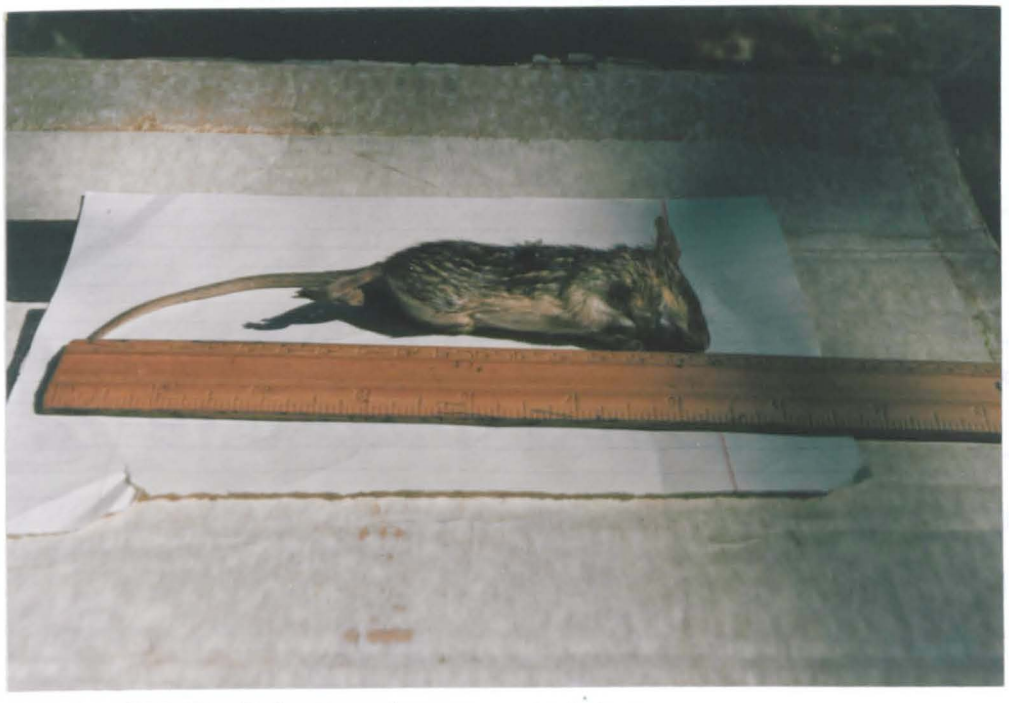

FIGURE 6.3 Lemniscomys striatus

FIGURE 6.4 Aethomys kaiseri

TABLE 6.1

Species of rodents collected according to the period of the year and according to whether they were positive for schistosomiasis mansoni infections. No trapping was done in January 1986.

Values in brackets represent numbers found positive for S. mansoni.

PERIOD (months)	NUMBERS OF VARIOUS RODENT SPECIES COLLECTED AND PERFUSED AND NUMBERS POSITIVE FOR SCHISTOSOMIASIS MANSONI				
	Tatera robusta	Mastomys natalensis	Lemniscomys striatus	Aethomys kaiseri	Totals
Feb. '85	2	3	-	3	8
March '85	48	24	14(1)	5	91(1)
April '85	30	36	-	3	69
May '85	29	30	11(1)	11	81(1)
June '85	21	27	17	7	72
July '85	17(1)*	29(3)	25(2)	4	75(6)
August '85	3	9	14	-	26
Sept. '85	37(1)	-	13(1)	4	54(2)
Oct. '85	14	10	3	5	32
Nov. '85	17	17	11	-	45
Dec. '85	22	5	-	-	27
March '86	2	9	3	1	15
April '86	3	4	1	4	12
May '86	1	4	-	2	7
June '86	15	9	2(1)	1	27(1)
July '86	10	6	5	9	30
TOTAL	271(2)	222(3)	119(6)	59	671(11)
Percentage Positive for S.mansoni	0.7	1.4	5.2	0	1.6

*Only male worms were recovered and it was not possible to confirm the identification of the Schistosome species.

In estimating the population of rodent species in the area, two periods were used. The period May 1986 represented the time before the grain harvest when the rodent populations were expected to be low. The period July 1986 represented the period after the grain harvest when the rodent populations were expect to be high. As shown in Tables 6.2a and b, total number of rodents caught per 50 km^2 in July was almost twice the number caught in the same area during May. The two tables also show that Tatera robusta was the most abundant species caught followed by Lemniscomys striatus and Mastomys natalensis. Aethomys kaiseri was the least abundant.

6.2.3.2 Prevalence of S. mansoni in rodents

Prevalence of S. mansoni in various rodent species caught is given at the end of Table 6.1. The overall prevalence in all rodent species caught was 1.6%. Lemniscomys striatus had the highest prevalence of 5.2% followed by Mastomys natalensis (1.4%) and Tatera robusta (0.7%). None of the Aethomys kaiseri caught was found infected. Except in one Mastomys natalensis, in which many S. mansoni worms were recovered (21 males and 15 females) the rest of the rodent species found with infections had few worms. In the M. natalensis which had many worms the liver was spotted and miracidia were hatched from eggs trapped in the liver. Of the ten B. pfeifferi exposed to miracidia which hatched five survived and all shed "human" cercariae from day 34 post infection. Two L. striatus species which had adult schistosome worms (Fig. 6.5) had their livers slightly spotted. Only very few eggs hatched and it was not possible to infect snails. In the rest of the rodents in which adult schistosome worms were recovered, no hatching of the eggs was observed. One of the Tatera robusta had two male and two female S. mansoni worms and the liver was spotted. In the other Tatera robusta found infected, only male worms were recovered and it was not possible to confirm the identification.

TABLE 6.2a

Estimates of population of various rodent species in Matithini during May 1986.

Species	Total No. marked	Total No. in second sample	Total recapture	Population estimate
Tatera robusta	15	16	6	40
Mastomys natalensis	19	21	12	33
Lemniscomys striatus	14	18	7	36
Aethomys Kaiseri	14	9	7	18
ALL	62	64	32	127

TABLE 6.2b

Estimates of population of various rodent species in Matithini during July 1986.

Species	Total No. marked	Total No. in second sample	Total recapture	Population estimate
Tatera robusta	22	21	5	92
Mastomys natalensis	37	19	13	54
Lemniscomys striatus	16	13	3	69
Aethomys Kaiseri	10	11	4	28
ALL	85	64	25	243

FIGURE 6.5

Male and female S. mansoni worms recovered from L. striatus

6.2.3.3 Other parasites recovered from rodents

Few species of helminths were recovered from the gut and other tissues of rodent species described above and these are listed in Table 6.3.

6.2.4 Discussion

WHO (1979a) suggested further studies on the significance of murine infection in the epidemiology of human infections with schistosomiasis. This followed earlier work in South America in which high infection rates of S. mansoni (more than 50%) had been reported (Barbosa et al., 1953; Amorin et al., 1954; Martins et al., 1955). More recently, studies by Rollinson et al. (1986) have provided evidence for circulation of S. mansoni between man and Rattus rattus. In Africa however, the earlier records of natural infections in rodents were regarded as incidental infections of no significance in transmission of the parasite to man (Nelson, 1975). More reports by Kawashima et al. (1978) and Karoum and Amin (1985) seems to suggest that the "creek rat" Pelomys sp. and the "Nile rat" Arvicanthus niloticus may be involved in transmission.

In the present study, three different species of rodents were found with natural infections of S. mansoni. These were Lemniscomys striatus, Mastomys natalensis and Tatera robusta (see Table 6.1). It can be reasonably assumed that the male worms recovered from one of Tatera robusta were those of S. mansoni. For example no other schistosome species was recovered from the rest of the animals examined. This is rather surprising since elsewhere in Kenya, S. bovis and S. rodhaini were recovered from various species of rodents (Nelson et al., 1962).

Nelson et al. (1962) working in Kenya examined among other rodent species, 145 L. striatus, two L. griselda and 134 Tatera robusta collected in the field and found none of them infected.

TABLE 6.3

Helminths other than schistosomes recovered from various rodent species from Matithini

RODENT SPECIES	HELMINTHS RECOVERED		
Tatera robusta	Nematodes	-	*Rictularia* sp., *Trichuris* sp., *Welcomia* sp.
	Trematodes	-	*Sudaricoria taterae*
	Cestodes	-	*Inermicapsifer madagascariensis*
Mastomys natalensis	Nematodes	-	*Rictularia* sp.
	Cestodes	-	*I. madagascariensis* *Skrjabinotaenia occidentalis*
Lemniscomys striatus	Nematodes	-	*Rictularia* sp.
	Trematodes	-	*Neoglyphe* sp.
	Cestodes	-	*I. madagascariensis*
Aethomys kaiseri	Nematodes	-	*Rictularia* sp.

In the present study six out of 119 or 5.6% of L. striatus were found infected and in two of them, a few viable eggs were recovered. This is the first time that L. striatus and T. robusta have been found naturally infected with S. mansoni in Africa. There is one report of a natural infection of L. griselda with S. mansoni from South Africa (Pitchford and Visser, 1962).

The recorded natural infection of S. mansoni in Mastomys natalensis confirms an earlier report by Nelson et al. (1962). In addition to S. mansoni, this rodent species has been listed by Pitchford (1977) as having been found naturally infected with other schistosome species and it is considered by Campos et al. (1984) to be a good model for experimental studies on schistosomiasis mansoni. In fact it was in this species that we recovered several adult male and female worms and in which liver and faeces contained viable eggs which hatched and infected B. pfeifferi snails. Although the highest infection rate was found in L. striatus they are likely to be poor hosts since the infections were light and only very few of the eggs found in their faeces or intestinal walls hatched. Only one Tatera robusta was confirmed to be infected with S. mansoni and therefore they are unlikely to be excellent hosts.

From Table 6.1, it is evident that the three species of rodents which were found with infections of S. mansoni were predominant in the area. This was confirmed by estimates of population using mark and recapture technique. Estimated populations of rodents in July 1986 was nearly double those in May (Table 6.2a, b) presumably due to the fact that June being a grain harvesting month, there was plenty of food for rodents to eat which could have resulted in increased breeding in July. It must be said though that estimates of populations were only based on one week trappings during each period and only a limited number of traps were used. Better

estimates could have been obtained if more traps had been used and at least for two weeks.

Although the three rodent species found with natural infections were commonly found in the area, the infection rates were very low. Apart from Mastomys natalensis, the other two species L. striatus and T. robusta were probably poor hosts as already explained. With the information available in this study, it would seem reasonable to suggest that rodents are unlikely to play a significant role in transmission in the area. Future studies should look at detailed observations on the behaviour of various rodent species towards water. Experimental laboratory infections of the local rodent species with the local strain of the parasite should be done in order to learn which species are good hosts and the quantities of S. mansoni eggs passed out.

6.3 STUDIES ON POSSIBLE ROLE OF DOGS IN TRANSMISSION OF SCHISTOSOMA MANSONI

6.3.1 Introduction and literature review

In section 2.2.2.6, it was pointed out that several Matithini residents own dogs mainly for security reasons. People are generally aware of the potential dangers of dogs acting as reservoirs of certain diseases. In Kenya, dogs are well known for their role in the transmission of hydatid disease in Turkana as reported by Nelson (1983). Another important disease in which dogs are involved in transmission to man is rabies. According to Sang (personal communication), a few dogs have been found positive for visceral leishmaniasis in Kenya but their role in transmission of this disease is still to be acertained. Elsewhere domestic animals including dogs have long been known as reservoirs of great epidemiological importance for Schistosoma japonicum, one of the three principal species of the schistosome parasites of man

(Martins, 1958). However, very little is known about the role of domestic animals in the transmission of the two other major schistosomes of man, S. mansoni and S. haematobium. A general review of literature on the role of domestic animals other than dogs in transmission of the two species just mentioned has been given in section 6.1.4. Here we confine ourselves to dogs.

No successful experimental or natural infection of dogs with S. haematobium has been reported. The dog (Canis familiaris) was considered resistant to various strains of S. mansoni by Cram and Files (1947), Stirewalt et al. (1951), and more recently by Mango (1971) and Karum and Amin (1985), but was infected by Kuntz et al. (1953) and Pinto and Almeida (1948), who state that puppies are easily infected, passing viable eggs with the faeces about 80 days after the penetration of cercariae.

The first report of natural infection of S. mansoni in dogs was by Nelson et al. (1962) who working in Kenya found light infections in two out of nine dogs examined. Mango (1971) working around Mwanza in Tanzania recovered a few eggs of S. mansoni from faeces of 8.8 percent of the 160 dogs examined. He also showed that dogs would readily ingest infected human faeces and later excrete a small number of eggs within the first few days but that all the eggs were non-viable. He did an autopsy on one of the dogs but could only recover one dead egg in the liver tissue. He concluded that dogs are refractory to the Mwanza "strain" of S. mansoni and are unlikely to be playing any significant role in transmission of S. mansoni in that area. Recently Karoum and Amin (1985) working in the Blue Nile project area in Sudan failed to find any S. mansoni eggs in the faeces of 55 stray dogs but they recovered adult worms and eggs in the tissues of 15 out of the 55 dogs examined (27.3%). They were unsuccessful in hatching any of the eggs recovered from the tissues

and they too concluded that dogs are unlikely to play a major role in S. mansoni transmission in Northern Gezira in the Sudan.

As part of the investigations on the epidemiology of S. mansoni in Machakos, it was decided to re-examine the role of dogs since they were frequently seen to be in contact with water and they were also frequently noticed eating human faeces. The aim of the study was to discover if dogs naturally pass viable S. mansoni ova irrespective of whether the infection is active or spurious and what role if any they play in transmission of S. mansoni in Matithini. Since it became difficult to convince dog owners to offer them for autopsy and stray dogs were unavailable due to rabies control more emphasis was placed on investigations related to spurious infections. The methodologies used for various investigations are described in the next sections followed by the results and discussion.

6.3.2 Materials and Methods

6.3.2.1 Collection and examination of dog faeces

A list was compiled of all dogs in both Matithini and Kakuyuni villages by recording their local names against each household number. Stool specimens were then collected from all dogs which could be traced between January and December 1985. Labelled containers were left in each household with dogs and the owners were requested to put a portion of faeces from each dog in them. A local field worker visited the households from time to time and collected available specimens. In case of doubt about the labelling, the specimen was ignored and a repeat collection arranged. The collection of specimens took quite a while since it was not always easy to catch a dog while defaecating and most of the dogs were not confined. Labelled specimens were then transported to Kakuyuni field laboratory. Kato preparations were made in duplicate for each

specimen using the method already described in section 3.2.3.2. The slides were later examined quantitatively for presence of S. mansoni ova. The remaining specimens were quickly screened for the presence of S. mansoni and other heminths ova using formal ether concentration technique (see section 3.2.3.1).

6.3.2.2 Hatching test for faeces..

Specimens which were positive for S. mansoni were taken to Tala laboratory and a hatching test was performed on each of them, using the method already explained in section 3.2.3.3.

6.3.2.3 Susceptability of young puppies to S. mansoni

Four young puppies were acquired locally and were used in the series of experiments described below. At the beginning of the study, each of them was exposed to 300 S. mansoni cercariae, obtained from naturally infected B. pfeifferi. The method used for infection was paddling as described by Webbe and James (1971). Plastic basins wide enough to accommodate each of the puppies were used. 30 minutes exposure time was allowed for each puppy. The stools of the puppies were checked for S. mansoni ova from week five after exposure and thereafter once every week for four months. One of the puppies died 4 weeks after exposure to S. mansoni cercariae and a postmortem was done to discover if it had taken the infection. One other puppy was sacrified after 123 days and a careful search was made of S. mansoni worms from the mesenteric veins and from the liver tissues. The other two puppies were taken back by the owner at his request and we had no objection since their stools recorded negative results for S. mansoni ova throughout the period of their captivity.

6.3.2.4 Feeding experiments for the puppies.

During the 4 week period prior to exposing the dogs to S. mansoni cercariae, two categories of feeding experiments were performed. The first was concerned to discover if dogs will pass viable S. mansoni ova after feeding on faeces from a heavily infected individual. The entire stool specimens of previously known infected individuals were obtained during the 24 hour collection of stools (see section 4.2.1.2). The specimens were delivered at Kakuyuni laboratory by 10 a.m each day of the experiment. At Kakuyuni, the specimens were quickly screened for S. mansoni eggs by means of a direct smear method. After confirmation of the presence of eggs, five portions of 10 gms each were weighed. Four portions were each fed to the puppies (Fig. 6.6) usually at 11.00 each day of the experiment. The fifth portion (control specimen) and any other remains were taken to Tala laboratory for a hatching test and Kato preparations. In the meantime, the puppies, which were usually locked away separately after feeding on faeces, were checked every hour for stool specimens. It became apparent that they never defaecated until usually about 5 to 6 p.m. and overnight. It was therefore decided to restrict our collection of stool specimens to the above times. Stool specimens collected from the puppies were screened for the presence of S. mansoni ova using the formal ether concentration technique described in section 3.2.3.1. Some of the stool specimens were used to prepare two Kato slides while the rest were taken to Tala laboratory for hatching. A separate hatching test was carried out on all specimens. Specimens for hatching were usually kept in normal saline. The hatching test was performed at the same time for all the specimens including the control specimen referred to earlier. Usually the hatching test was performed the following day after the delivery of the overnight specimens from

FIGURE 6.6

Young puppy feeding on human faeces

puppies. The procedure was as described in section 3.2.3.3. It was not always easy to count all the miracidia when they hatched and it was decided to use three categories of quantification. "None" was recorded when no miracidia was seen, "few" was recorded when between 1 to 10 miracidia could be seen in a petri dish, and "many" was recorded when more than 10 miracidia could be immediately seen in the petri dish. When many miracidia hatched, they were used to infect Biomphalaria. Snails used for this purpose were laboratory bred and measured 5-7mm in diameter. Snails were individually exposed to 6 miracidia in small tubes and at room temperature. They were then kept as described by Webbe and James (1971), and checked for infection from day 21 onwards up to day 70. As a control, miracidia which hatched from the human specimen (source specimen) used for feeding the puppies were treated similarly. If snails became infected and cercariae were produced, an arrangement was made to infect mice. The paddling method described by Webbe and James (1971) was used. Mice were then perfused eight weeks later as described by Smithers & Terry (1965). Recovered adult worms were identified by examining the eggs in the uterus of the female worms.

The second experiment was concerned to find out if dogs could introduce S. mansoni eggs in water when they drink after feeding on faeces from an infected person. This was done in the course of the feeding experiment just described. After dogs had been fed on faeces at 11 a.m., they were allowed to drink water in a bowl. The bowl was removed before they finished all the water. The remaining water was then taken to the laboratory, centrifuged and examined for the presence of S. mansoni eggs and to see if they were viable. Ten such experiments were performed on different days.

6.3.2.5 Experiment to show if "confined" dogs continued to pass S. mansoni eggs in their stool

It was not possible to convince the people whose dogs were continuously passing S. mansoni ova to hand them to us for sacrificing to look for S. mansoni worms. It was therefore decided to confine a few of them in a condition in which they could not be exposed to infected human faeces. They were examined for the presence of S. mansoni eggs in their stools on the day of confinement and thereafter every day for seven days. The formol ether concentration technique as described in section 3.2.3.1 was used.

6.3.2.6 Feeding behaviour of dogs and their relationship with water

A questionnaire study was conducted to find out whether people normally feed their dogs, what they feed them on and whether it is normal for them to eat human faeces even if they are regularly fed. We also enquired whether dogs normally come in contact with water especially after eating human faeces. For convenience the questionnaire used (Appendix 2.2a) was included in the section of the questionnaire dealing with household latrine use. The instruction sheet for the questionnaire is to be found in Appendix 2.2b.

6.3.3 Results

6.3.3.1 Prevalence of S. mansoni eggs in dogs

Table 6.4 summarises the prevalence of S. mansoni eggs (Fig. 6.7) in the faeces of dogs from both Matithini and Kakuyuni. 242 out of 310 (78.1%) registered dogs were examined. The number of missed cases was due to difficulty in collecting specimens from dogs. Few of the registered dogs died during the period of collection.

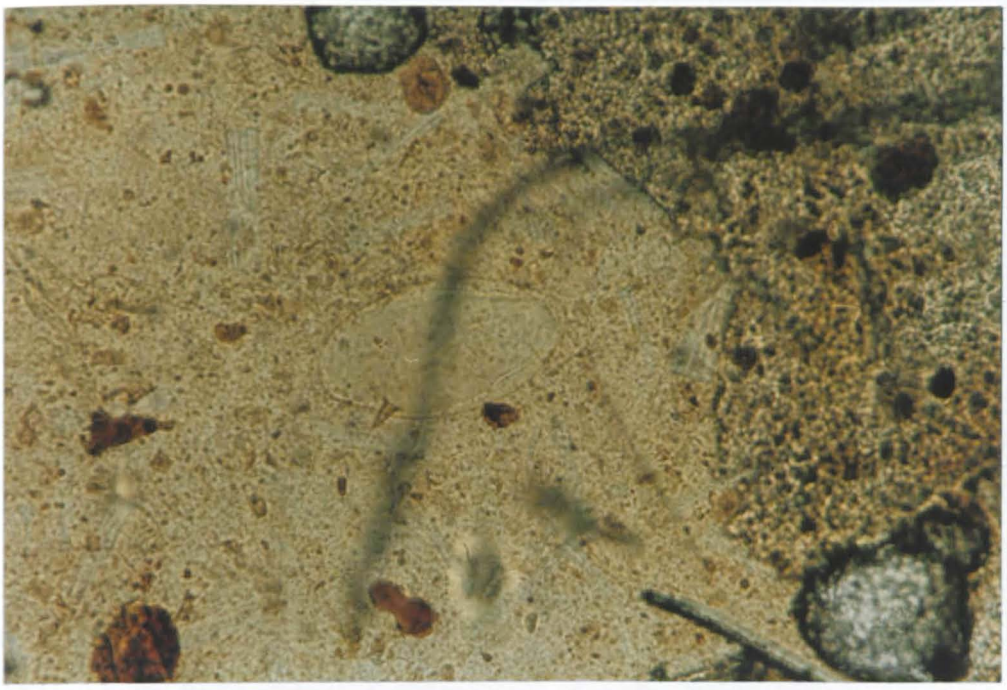

FIGURE 6.7

S. mansoni egg recovered from dog faeces

The overall prevalence in the two villages was 40.5%. Matithini showed a higher prevalence rate of 44.7% compared to Kakuyuni with 36.7%.

6.3.3.2 The intensity of S. mansoni in dogs

The results of the Kato examination of dog faeces are given in Table 6.5. The reduced number in those examined using the Kato method was due to introducing it slightly later in the programme. 13 slides out of 142 i.e 9.2% were too dark and could not be read, and were therefore excluded from the analysis. The overall prevalence of S. mansoni eggs in dogs using the Kato technique for stool examination was 39.5% which compares well with the results of the concentration method (40.5%). Eggs per gramme of stool ranged from 10 to 690. Of the 51 dogs which were positive for S. mansoni when the Kato method was used, 54.9% had light infections (10-49 epg), 11.8% had relatively moderate infections (50-99 epg) while the rest (33.3%) had relatively heavy infections i.e. 100+epg.

Apart from S. mansoni, hookworm eggs were detected in 85% of the dogs examined and the hookworm species was identified as A. caninum after a few dogs were dewormed and the specimens examined. Toxocara canis eggs were detected in 13% of the dogs examined. Other parasite eggs were rarely seen and included Taenia spp and Trichuris spp.

6.3.3.3 The hatching test results on dog faeces collected during the prevalence survey

Surprisingly no eggs of S. mansoni were observed to be viable or to hatch from all the specimens tested. Even after repeated collections from the positive dogs, no hatching was observed.

6.3.3.4 Susceptibility test.

None of the puppies exposed to 300 cercariae excreted S. mansoni eggs from day 30 up to day 123 after being exposed except

TABLE 6.4

Number of dogs from Kakuyuni and Matithini passing *S. mansoni* eggs

VILLAGE	NO. REGISTERED	NO. EXAMINED	NO. POSITIVE	PERCENTAGE POSITIVE
Matithini	140	114	51	44.7
Kakuyuni	170	128	47	36.7
TOTAL	310	242	98	40.5

TABLE 6.5

Number and intensity of *S. mansoni* eggs passed by dogs from Kakuyuni and Matithini

EGG COUNT RANGE (Eggs per grame)	NUMBER OF DOGS (AND PERCENTAGE) IN		
	Matithini	Kakuyuni	ALL
0 - 9	36(53.7)	42(67.7)	78(60.5)
10 - 49	17(25.4)	11(17.7)	28(21.7)
50 - 99	4(6.0)	2(3.2)	6(4.7)
100 +	10(14.9)	7(11.3)	17(13.2)
ALL	67(100)	62(99.9)	129(101)

of course when they were fed on infected human faeces and this was mostly done before day 35 after they were exposed. No worms were recovered from the dog which died after four weeks and the dog which was sacrificed on day 123 after exposure to S. mansoni cercariae was negative.

6.3.3.5 Results of the feeding experiments

When we collected the puppies from the owner, they were just 3 weeks old and it was confirmed that they had not come in contact with natural waters. Repeated examination of stool specimens before the feeding experiment began only revealed ova of Toxocara canis in each of the dogs. They were consequently treated for this infection.

A total of eight feeding experiments was conducted as already explained in section 6.3.2.4.

The dogs were normally fed on commercial dog feed bought from the shops. At the beginning of the experiments infected human faeces (hereafter referred to as the source specimen) were mixed with the dog feed but later it was discovered that they readily ate human faeces, especially when they were light or yellowish in colour. Dark stools were not preferred and had to be given mixed with dog feed. It was of interest to note that when both dog feed or yellowish coloured source specimens were offered to the dogs separately at the same time, they first went for the source specimen. Whatever they were given to eat they preferred to eat it outside rather than inside their confinement cubicles. After confinement for more than five hours, they readily defaecated when released. It was very rare for them to defaecate in their cubicles except at night.

Of the eight feeding experiments performed, five were incomplete since not enough miracidia to infect snails hatched from the dog faeces excreted after feeding on the source specimen. Completed parts of each of the five experiments gave similar results which can be summarised as follows:

A good proportion of S. mansoni eggs were recovered from dog faeces from five hours after they were fed with a source specimen from heavily infected individuals. Out of a total of 39 stool specimens collected from the dogs after feeding on the human faeces, only nine failed to produce S. mansoni eggs as detected by the concentration and the Kato methods. In four of the experiments, the source specimen contained eggs which produced many miracidia and at least eight of 23 dog faecal specimens collected more than five hours after feeding produced a few miracidia implying that some of the S. mansoni eggs consumed passed unharmed through the guts of the dogs. In one of the experiment in which the source specimen produced only a few miracidia, all the specimens collected from the dogs were negative for miracidia although they contained S. mansoni eggs. For both the detection of S. mansoni eggs and the hatching from dog faeces, it did not seem to matter whether the specimens were collected later in the evening on the day of infection or overnight.

In at least three experiments, some of the specimens collected from the dogs produced many miracidia which were then used to infect snails. The results of the three experiments are summarised in Table 6.6. Like the other experiments referred to above, eggs were detected in the majority of the specimens collected from dogs post feeding and in several of the specimens few eggs hatched into miracidia. In at least three specimens, many eggs hatched and in two of them some B. pfeifferi were successfuly infected although the

TABLE 6.6

A summary of results of feeding experiments to demonstrate spurious infection in dogs and whether transmission of *S. mansoni* can be recycled this way

Experiment No.	Dog No.	Time of specimen collection	Results of concentration method	Kato results (eggs)	No. of eggs hatching	No. of snails exposed	No. of snails surviving	No. of snails positive
5	1	5.30pm	+ve	0	Few	-	-	-
		5.35pm	-ve	0	Many	14	5	3(after 60 days)
	2	5.00pm	-ve	0	Nil	-	-	-
		5.30pm	+ve	20	Nil	-	-	-
	3	5.15pm	-ve	0	Nil	-	-	-
	4	5 pm	-ve	10	Nil	-	-	-
		5.20pm	+ve	10	Nil	-	-	-
	Source* specimen (6.004.3)	morning	+ve	550	Many	14	8	6(after 32 days)
4	1	5.30pm	+ve	100	Few	-	-	-
		Night	-ve	20	Many	10	4	0(day 40)
	2	5.40	+ve	50	Nil	-	-	-
		Night	-ve	0	Nil	-	-	-
	3	5pm	+ve	0	Nil	-	-	-
		5.45pm	+ve	0	Nil	-	-	-
	4	6.05pm	+ve	70	Nil	-	-	-
		Night	+ve	0	Nil	-	-	-
	Source specimen (6.010.12)	morning	+ve	960	Many	10	7	6(day 34)
8	2	5pm	+ve	0	Nil	-	-	-
		5.30pm	+ve	0	Few	-	-	-
	3	5.07pm	+ve	140	Many	10	2	1(day 58)
		5.17pm	+ve	0	Few	-	-	
	4	5.10pm	+ve	0	Few	-	-	-
		Night	+ve	30	Few	-	-	-
	Source specimen (6.003.3)	Morning	+ve	1170	Many	10	6	5(day 29)

* - specimen used in feeding the dogs. Number in brackets refers to individual number whose faeces was used. Dash is put if nothing was done.

prepatent period was much longer than normal. No snails started shedding until day 58 after exposure to miracidia compared to day 29 in the source specimen. In experiment 4, only four snails survived but they all died after they were checked on day 40 possibly due to contamination by chemicals in the tubes used for exposure to light. Unfortunately, this was not discovered immediately so no check was made of the snails for daughter sporocysts. All the other snails which were negative in the other two experiments were crushed and they all proved to be negative for larval stages of S. mansoni.

From all the experiments, it was observed that the recovered eggs per gram of faeces for each of the specimens were within the same range as those obtained from the field surveys of dogs summarised in Table 6.5. The other thing worth pointing out is that none of the ova of the other human intestinal parasites found in the area were detected in dog faeces collected from puppies but we cannot make a good comparison because a thorough screening for them was omitted in the source specimens.

6.3.3.6 Possibility of introducing S. mansoni eggs in water while drinking

The results of the experiment to see if dogs can introduce S. mansoni eggs in water after feeding on human faeces are summarised in Table 6.7. Out of ten experiments, seven gave positive results for S. mansoni eggs and in at least five of the experiments, some of the eggs were viable.

6.3.3.7 Prevalence of S. mansoni in confined dogs

Four out of five dogs which had been shown to be passing S. mansoni eggs on three different occasions remained negative for S. mansoni throughout the seven days of confinement. One of the dogs had one egg on one Kato slide on the second day after confinement. This could have been an egg which passed

TABLE 6.7

Recovery of *S. mansoni* eggs in water left after being used for drinking by dogs which had just fed on infected human faeces.

SOURCE From individual No.	SPECIMEN Eggs per grame of faeces	NO. OF EGGS FOUND IN LEFT WATER	NO. VIABLE OR HATCHED
6-014-5	1330	0	0
6-016-5	120	2	1
6-013-1	590	0	0
6-011-1	690	3	0
6-004-3	550	4	2
6-008-4	780	5	3
6-007-7	570	0	0
6-007-8	470	2	0
6-010-2	960	4	1
6-003-3	1170	6	1

undigested after being eaten with infected human faeces since no S. mansoni egg was detected in the same dog for the rest of the confinement period. Other eggs detected from four of the five dogs prior to confinement included hookworm eggs and Toxocara canis eggs which were consistently found in stools collected and examined during the confinement period.

6.3.3.8 Questionnaire study on dogs.

6.3.3.8.1 Dog ownership

Of the 94 households interviewed, 54 or 57.4%, kept dogs and all said they did so for security. The average number of dogs per house was 1.9. There was no obvious relationship between keeping of dogs and the level of education but in general dog ownership was confined to well-to-do households.

6.3.3.8.2 Feeding behaviour of dogs

Of the 54 households which kept dogs 47 claimed they feed them regularly and only seven said they do so only sometimes. One household claimed they made special preparations for dogs to feed while the rest of the households claimed they feed their dogs on the same food they themselves eat and more especially if there are leftovers. Every respondent in the 54 households claimed they had seen dogs eating human faeces and 44 claimed they do so even if they are regularly well fed while 10 respondents claimed they do not eat human faeces if they are regularly fed. 26 respondents or 48.1% considered the eating of human faeces by dogs to be a usual event while the same numbers considered it to be unusual. Two respondents said it is accidental.

6.3.3.8.3 Dogs and their relationship with water bodies.

31 respondents or 57.4% claim they are accompanied by their dogs when out of their homesteads especially

when going to look after cattle or in the gardens while the rest said they are not normally accompanied by the dogs. Nearly every respondent, i.e. 53, claimed it is very usual to find human faeces near river or stream. Only one respondent claimed it is not. Of the 53 who claim it is usual to find human faeces near a river or stream, 52 of them have noticed dogs eating faeces found along stream or water bodies while only two claimed they have not noticed that happening. Of the 52 respondents who have noticed dogs eating human faeces near river or stream 33 or 63.5%percent of them have noticed dogs coming in contact with water bodies after eating faeces while only 21 or 36.5% claimed they have not seen that happening. 52 respondents out of those who own dogs claimed they have seen dogs in contact with water mostly drinking. Only two persons said they had not seen this happening.

During the period when the interviews were conducted, a fieldworker, observing for water contact and defaecation habits, noticed dogs drinking or playing in water (Fig. 6.8) on each of the 20 days special observation period. It was not possible for the observer to watch if dogs eat faeces before they went to drink water because this would have interfered with other observations.

6.3.4 Discussion

6.3.4.1 Prevalence, intensity and susceptibility studies

Natural infection of S. mansoni with adult worms have been reported in dogs by Nelson et al. (1962), and by Karoum and Amin (1985). Mango (1971) reported light infection of S. mansoni in dogs from Mwanza, Tanzania but was unable to conclude if the infections were active or spurious. Natural infections of S. rodhaini which is closely related to S. mansoni was reported in dogs from Ruanda Urundi by Deramee et al.(1953) and in Kenya by Nelson et al. (1962).

FIGURE 6.8

Dog near water body in Matithini

In the present study, ova of S. mansoni (Fig. 6.7) were detected in 40.5% of the 242 dogs examined in Matithini and Kakuyuni villages as revealed by the formal-ether concentration method (Table 6.1). Examination of some of the specimens using the Kato technique (Table 6.2) revealed that 39.5% were positive for S. mansoni. The figures are high compared to those previously reported (Nelson et al., 1962; Mango, 1971; Karoum and Amin, 1985). Moreover, 33.3% of the positive dogs were excreting many eggs, e.g. more than 100 eggs per gramme of stool but the comparison should be treated with caution since different methods were used in the diagnosis.

Although a high proportion of the Kenya dogs were passing S. mansoni eggs, this does not necessarily indicate that they are important in the transmission of the infection in the area studied. Attempts to infect puppies with the local strain of the parasite yielded negative results suggesting that dogs may not be good hosts of S. mansoni but relatively few cercariae were used in the exposure experiment compared to those used by other workers who produced positive results (Kuntz et al., 1953; Pinto and Almeida, 1948) and we know that very high cercarial densities do occur in our area. Also local dogs were not examined for schistosome adult worms. In their study, Karoum and Amin (1985) recovered S. mansoni adult worms from stray dogs but they did not detect eggs in dog faeces. On the other hand, Mango (1971) failed to find adult S. mansoni worms in one dog which consistently excreted S. mansoni eggs but could not find eggs in two dogs previously excreting S. mansoni eggs after confining them in the laboratory for up to six days. This is in agreement with the present study in which dogs previously shown to be passing S. mansoni eggs in more than one occassion remained

negative during the period in which they were confined and had no access to infected human faeces suggesting that they had no active S. mansoni infections (see section 6.3.3.7). Further work is required before conclusions can be made about possible role of dogs in transmission of S. mansoni through active infection with the parasite. This should consist of more work on susceptibility tests to include exposing dogs in transmission sites with known cercarial densities. Search for adult S. mansoni worms in dogs from the study area should also be included.

The other possibility in which dogs could be important epidemiologically in transmission of S. mansoni is by mechanical transfer of infected faeces through coprophagy or spurious infections. Mango (1971) suggested that S. mansoni eggs he detected from dogs from Mwanza in Tanzania could have been the result of spurious infections. This was thought likely to be the case in our study area (see section 6.3.3.7). As a result, more intensified investigations were carried out and the results are discussed separately in the next section.

6.3.4.2 Spurious infection

It has been stated by WHO (1964) that eggs of Ascaris and Trichuris trichiura are able to pass unharmed through the gut of coprophagous animals. Among domestic animals, pigs are known to consume human faeces (Clements, 1936). Jones (1976) working in Papua New Guinea observed that a large proportion of A. suum eggs ingested by a pig were able to pass unharmed through pigs guts and retained their viability whereas most of the hookworm eggs were destroyed. He concluded that pigs are likely to play a significant role in dissemination of human Ascaris infections in Papua New Guinea. In the present study, it has been experimentally observed that dogs will readily eat human faeces and if they contain

S. mansoni eggs, some of the eggs will pass through the dogs gut unharmed and hatch into miracidia capable of infecting B. pfeifferi snails and so continue the cycle. For reasons explained later, it is not known why viable S. mansoni eggs were not recovered from wild dogs. Mango (1971) observed that dogs could ingest and excrete a small number of S. mansoni eggs within the first three days but that the eggs which pass through the gastro-intestinal tract were rendered non-viable. In Mango's experiment, it was not clear how he fed the dogs with S. mansoni eggs but it is noted that the eggs he used (160-370) were much less than those used in the present study when each dog was fed with more than 4000 eggs during each experiment. The observation that some of the S. mansoni eggs recovered from the faeces of dogs hatched at least six hours after they were consumed and infected snails is of interest because this implies that dogs may be disseminating S. mansoni infection in Matithini and Kakuyuni. This indeed is likely to be the case since as is pointed out section 6.3.3.8.2, nearly everyone who own dogs claim they have seen them eating human faeces and half of them consider this to be normal event. According to Karoum (personal communication), dogs in the Gezira in the Sudan live in intimate association with man and it is possible that they occasionally eat human faeces although this has not been particularly observed. This could explain their failure to find S. mansoni eggs in dog faeces as already referred to.

Under normal circumstances in my own experience, dogs would eat several whole faeces containing several thousands of S. mansoni eggs. This means that the chances of getting many more eggs passing in a viable state is increased and if it is true as claimed by 52 out of 54 respondents who own dogs (see section 6.3.3.8.3) that dogs

are often seen in or around water bodies, it is possible that they excrete vaiable S. mansoni eggs directly in water or near it. In addition, they probably introduce some of the eggs into water while drinking (see section 6.3.3.6). For example, 63.5% of the people have noticed dogs drinking water immediately after eating human faeces near rivers or streams (see section 6.3.3.8.3).

The observation that the pre-patent stage in B. pfeifferi snails exposed to S. mansoni miracidia from dogs faeces is prolonged compared to the control experiment from human faeces (see Table 6.6) could be of epidemiological importance and needs further investigation.

Whether dogs are naturally or spuriously infected, proof of excretion of viable S. mansoni eggs which can eventually reach water containing the appropriate snail vectors is necessary before their significance in transmission of S. mansoni can be appreciated. That dogs can pass viable S. mansoni eggs after consuming human faeces containing the eggs has been shown experimentally. However, in these experiments, puppies of about 5 weeks old were used and and we have no evidence that older dogs would give similar results since none of faeces collected from them contained eggs which hatched. It is possible that age may be important in ensuring that eggs pass through the dog system unharmed. It is also possible that time is a factor to be considered in ensuring that some of the consumed eggs pass through the dog system unharmed. For example, it was not known when village dogs whose faeces were collected may have consumed infected human faeces.

6.3.4.3 Conclusions

From the above experiments, two things are clear. A high proportion of adult dogs from villages which are endemic for S. mansoni pass S. mansoni eggs in their faeces but none of the eggs

passed in their faeces was viable. Under experimental conditions, puppies would readily eat human faeces and if the faeces contain S. mansoni eggs, some of the eggs will pass through their gut unharmed and are able to hatch and infect B. pfeifferi snails.

Since eating of human faeces by dogs is widespread in the area studied, it is possible that dogs play a role in the dissemination of S. mansoni infection but further work is needed to confirm this. Conversely they may reduce faecal contamination of the environment with human faeces and in this way, they may reduce the level of transmission of diseases associated with faecal contamination in general.

6.4 SUMMARY OF CHAPTER SIX

1) Rodents and dogs were investigated for their possible role in the transmission of S. mansoni.

2) The overall prevalence of S. mansoni in rodents was very low (1.6%). Lemniscomys striatus was shown for the first time to be infected with S. mansoni and had the highest infection rate (5.2%). Other rodents found infected but in very small numbers included Mastomys natalensis (1.4%) and Tatera robusta (0.7%). Rodents are not thought to be important in the transmission of S. mansoni in the area.

3) The overall prevalence of S. mansoni eggs in dogs was 40.5%. None of the eggs was shown to be viable.

4) Experiments with young dogs in captivity revealed that S. mansoni eggs can pass unharmed through the dog's gut and since most dogs are known to be commonly eating human faeces it is thought that dogs may be important in disseminating S. mansoni eggs through coprophagy. However, their role in transmission of S. mansoni is yet to be clarified.

CHAPTER 7

PATTERN AND EVALUATION OF FAECAL CONTAMINATION IN S. MANSONI TRANSMISSION SITES

7.1 GENERAL INTRODUCTION

Although the main purpose of these studies was to understand factors involved in contamination of the environment with schistosome eggs, limited studies were done to provide information on the pattern of faecal contamination in snail habitats and also possible methods of monitoring such contamination.

7.2 PATTERNS OF FAECAL CONTAMINATION OF SNAIL HABITATS

7.2.1 Introduction

At any given time the proportion of snails infected with schistosomes depend upon a complex interaction of different factors including: the relative susceptibility to infection of a particular snail intermediate host, climatic factors such as temperature and rainfall, and above all the distribution and behaviour of definitive hosts who are responsible for contamination of the waterbodies with schistosome eggs. Neither the distribution of waterbodies, the distribution of snail populations within them, nor their contamination by man or other animals are random; nor is human water contact (Sturrock, 1986). This complex epidemiological transmission picture has so far defied attempts to mimic it completely with mathematical models (Barbour, 1982). In the preceeding chapters, reference has been made to various aspects of human behaviour which may lead to contamination of the waterbodies with schistosome eggs. The main purpose of this particular study was to collect information necessary to find out if contamination of the snail habitats occurs regularly or irregularly in different habitats and in different seasons. This was done by collecting

B. pfeifferi in several transmission sites and shedding them at weekly intervals to see the pattern of maturation of 'prepatent' infections. This would give an indication of whether the snails collected from the same transmission points were all infected at the same time and from the same source of contamination or whether few of the snails became infected continuously or discontinuously at different times and from different contaminations.

7.2.2 Materials and methods

7.2.2.1 Field snail collections

Collections for the first group of snails were made in 11 sites along Kyaana stream on various days between March and May 1985. Collections for the second group of snails were made along Kivii stream (sites used in Kyaana stream dried out) between June and August 1985. In both cases, snails were collected by means of metal scoops. The sites were scooped until at least 100 B. pfeifferi were collected. The snails were placed in damp vegetation in metal trays and carried by car to Nairobi (100 km away) within one hour of collection.

7.2.2.2 Examination for S. mansoni infection

On arrival in the Nairobi laboratory, all snails from each collection were kept in five litre glass aquaria at room temperature (at least 10 snails per litre) and fed on lettuce over a night. The following day, they were examined individually for cercarial shedding as already explained in Section 3.2.4.2. All the dead snails were counted, recorded and removed. Snails which shed S. mansoni cercariae were also removed from each collection. The rest of the snails were put back into the aquaria. The procedure was repeated at weekly intervals for the following seven weeks.

7.2.3 Results

Tables 7.1a and b summarise the results of weekly observation of the shedding of *S. mansoni* cercariae by *B. pfeifferi* collected from 11 and seven different field sites between March and May (rainy period) and June and August 1985 (dry period) respectively. During the initial shedding (week 0) ten of the 11 sites from which snails were collected during the rainy period had varying numbers of snails shedding *S. mansoni* cercariae with infection rates ranging between 1% and 60.3%. One of the sites (7) recorded no infected snails during the initial shedding. The overall infection rate when snails were first shed (week 0) was 12.7% (189 out of 1491). The 189 infected snails were removed and 170 of them died leaving a total of 1132 of which another 5.3% (60 out of 1132) shed *S. mansoni* cercariae during the seven weeks holding period denoting the presence of 'prepatent' infections at the time of collection. Based on the total number of snails during week 0, the overall infection rate was therefore 16.7% or (249 out of 1491) - an increase of 4%.

The cumulative totals of snails starting to shed were 27, 43, 55, 57, 59 and 60 in weeks one to seven respectively. Although these figures indicate a steady rate of maturation of infection especially during the first three weeks holding period, examination of individual collection data showed that this was not generally the case except to some extent in sites 9 and 11 (Table 7.1a). In three sites (1, 8 and 10) no more snails shed *S. mansoni* cercariae beyond week zero. In five sites (2, 3, 4, 6 & 7), snails shed only once more and except in site 6 where nine more snails shed, the rest had only one additional snail shedding from each of them. Sites 5, 9 and 11 recorded new infections continuously at least for the first 1-3 weeks holding period indicating a continuity of

TABLE 7.1a

Weekly observations on *S. mansoni* cercarial shedding of *B. pfeifferi* collected from 11 different field sites in Machakos between March and May 1985

Site No	Total number of snails examined and number shedding *S. mansoni* cercariae in week 0 T*(No+ve)**	1 T(No+ve)	2 T(No+ve)	3 T(No+ve)	4 T(No+ve)	5 T(No+ve)	6 T(No+ve)	7 T(No+ve)
1	250 (2)	202	167	147	120	90	58	50
2	105 (9)	74	74	65	65	60(1)	54	48
3	100 (1)	83 (1)	80	80	70	66	57	43
4	121 (12)	87 (1)	85	80	80	79	77	68
5	120 (18)	85 (1)	72 (2)	68 (1)	59(1)	51	51	47(1)
6	103 (1)	97 (9)	74	66	57	53	44	40
7	70	68	68	64 (1)	64	60	57	53
8	213 (3)	198	170	150	130	114	82	65
9	68 (10)	48 (3)	47(10)	37 (2)	30	26	9	6
10	127 (4)	118	118	94	81	75	32	15
11	214(129)	72(12)	72 (4)	40 (8)	24(1)	22(1)	20	18
Total	1491(189)	1132(27)	1027(16)	891(12)	780(2)	696(2)	541	453(1)
Cumulative no. of infected snails***		27	43	55	57	59	59	60

* Total number of snails examined (diminishing numbers are due to snail mortality as well as removal of snails which progressively started shedding during the holding period).

** Number becoming positive during each week

*** Cumulative number of infected snails based on the total number infected in week 1

maturation of infection. Altogether 54.7% (619 out of 1132) snails died within the seven weeks holding period.

With regard to seven sites in which the snails were collected during the dry period (Table 7.1b) the initial overall infection rate was 18.3% (165/904). The 165 snails were removed like in the snails observed during the rainy period and another 62 died leaving 677 of which 17% (115 out of 677) became positive for S. mansoni cercariae during the holding period. This brought the total overall infection rate to 31% (280 out of 904) once more denoting the presence of prepatent infections at the time of collection. A total of 215 or 31.8% of the snails died between week one and week seven.

As shown in Table 7.1c, the details of the results revealed minor differences compared to the results of snails collected during the rainly period. Three sites recorded snails shedding in pulses while another three sites recorded a somewhat steady maturation of the infections between week 1-5 holding period. Only one site recorded positive snails one more time after week zero. The difference in the overall and initial infection rates was greater e.g. 12.7% compared to only 4% in the sites in which snails were collected during the rainy season.

7.2.4 Discussion

Discontinuities in the contamination of the snail populations could have important implications for mathematical modellers (Fine and Lehman, 1977), particularly if taken in conjunction with the observation that not all snail colonies within an endemic area of schistosomiasis are involved in transmission (Sturrock, 1973).

The results of the present study show no clear evidence that contamination of snail populations happens continuously. Out of

TABLE 7.1b

Weekly observations on *S. mansoni* cercarial shedding of *B. pfeifferi* collected from 11 different field sites in Machakos between June and August 1985

Site No	Total number of snails examined and number shedding *S. mansoni* cercariae in week 0 T*(No+ve)	1 T(No+ve)	2 T(No+ve)	3 T(No+ve)	4 T(No+ve)	5 T(No+ve)	6 T(No+ve)	7 T(No+ve)
1	105 (24)	80(10)	70 (1)	65 (2)	59	58	52	51
2	120 (54)	6 (1)	64	62	61	60	59	53
3	113 (29)	79(15)	60 (2)	58(12)	45(10)	35	34	29
4	175 (32)	137(14)	118 (1)	115	114 (1)	108	101	78
5	116 (6)	108 (2)	104	98 (7)	87	88 (1)	87	72
6	145 (6)	112	100(10)	80	48	45 (3)	44	43
7	130 (14)	95(18)	63 (2)	28 (1)	27 (1)	22 (1)	21	21
Total	904(165)	677(60)	579(16)	506(22)	441(12)	416 (5)	398	347
Cumulative no. of infected snails based on no. infected in week 1		60	76	98	110	115		

* Total number of snails examined (diminishing numbers are due to snail mortality as well as removal of snails which progressively started shedding during the holding period).

** Number becoming positive during each week

*** Cumulative number of infected snails based on the total number infected in week 1

TABLE 7.1c

Comparison of the results of serial shedding for S. mansoni cercariae during rainy (March-May) and dry (June-August) periods

Figures in brackets refer to the actual sites

Description of the pattern of shedding by snails	Number of sites (actual sites) Rainy period March-May (Table 3.1a)	Dry period June-August (Table 3.1b)
Positives found only during the initial shedding (week 0)	3 (1,8,10)	0
Positives found one more time after week 0	5 (2,3,4,6,7)	1 (2)
Positives found in pulses	1 (5)	3 (4,5,6)
Positives found continuously		
Week 1-3	1 (9)	1 (1)
Week 1-4		1 (3)
Week 1-5	1 (11)	1 (7)

11 sites sampled between March and May 1985 (rainy period) only three indicated some degree of continuity in their contamination as judged by the pattern of maturation of 'prepatent' S. mansoni infections while the rest showed discontinuity (Tables 7.1a and c). Three out of seven sites (Tables 7.2b and c) sampled between June and August 1985 (dry period) indicated some degree of continuity but in two of them (sites 1 and 7) only few additional snails shed weekly after the first week of holding in the laboratory and it may well be that these few snails took infections at the same time with those that had previously shed but took longer to become patent possibly because of their age or the number of miracidia which infected them. Both age and the number of miricidia infecting snails have been shown to influence the prepatent period (Chu et al., 1966a, b; Moore et al., 1953) although Sturrock and Sturrock (1970a) found no direct relationship between length of prepatent period and age. The picture may also have been distorted by the death of prepatent snails before they started to shed (53.8% and 31.8% of the snails died respectively during the holding periods in snails collected during the rainy and dry periods). Lifespan of infected snails is generally shorter than that of uninfected ones (Berrie, 1970).

The results of these studies agree with limited observations by Sturrock et al. (1979) who working in Kenya, observed that maturation of prepatent infections occurred in pulses with the implication that contamination of snail habitats occurred irregularly.

In view of the focal nature of schistosomiasis transmission (Bradley et al., 1967; Bradley, 1972; Polderman, 1974; Ahmed et al., 1985) there is no doubt that contamination of transmission

sites occurs non-randomly in endemic areas for S. mansoni but whether some of these sites are contaminated regularly or irregularly will depend on various sources of contamination which are little understood at the moment and which in themselves may change daily, weekly, monthly or annually depending mainly on weather conditions but also on changes associated with environmental modifications. For example, pollution of the sites as a result of washed in water by rain will only be regular when rain falls every day. As discussed in Chapter 5, the most likely way S. mansoni eggs reach water in the absence of rainfall is through contamination from bathing, playing or swimming by infected people and these appear to occur regularly especially during warm weather. In such cases, contamination of the sites used for such activities can be expected to occur on a regular basis. From the few sites observed in this study, it is not possible to compare the result of the pattern of contamination during the rainy and dry periods and especially since the same sites were not used during the two investigation periods for reasons already explained. Nor can we draw any conclusions about the pattern of contamination in bathing, swimming or playing sites as compared to sites used for other activities since water contact observations were not made in the sites from which snails were collected.

Furthermore elaborate investigations are suggested in areas endemic for schistosomiasis and if the same procedure is used, results from such areas can be compared. In addition to providing information on the pattern of contamination, we shall obtain data on the 'actual' proportion of snails infected which is usually lower when based on shedding once. For example, judging by the results of the present study and those of Sturrock et al. (1979) in which additional snails were shown to be infected with S. mansoni,

'total' infection rates could well be much higher in some, at least, of snail colonies because prepatent infections are excluded. This information could improve models of snail population dynamics and transmission of infection in snails and help to devise more efficient means of snail related transmission control. At the moment, all existing models assume the snails to inhabit a spatial uniform world, yet the excretion of eggs into water by humans, and consequent patterns of exposure for the snails, depend a lot on the local geography of water supplies and the spatial patterns in their usage (Anderson and May, 1985).

7.3 DIFFERENTIAL FILTRATION TECHNIQUE FOR RECOVERY OF MIRACIDIA IN WATER

7.3.1 Introduction and literature review

Faecal pollution of water can be detected by bacteriological examination of water samples for faecal coliforms (FC) and faecal streptococci (FS) using membrane filtration methods (Geldreich et al., 1965). The technique has been used in conjunction with diarrhoeal studies (Faechem, 1975; Gracey et al., 1976; Barrell and Rowland, 1979). Such a technique would be useful in studies of the epidemiology of schistosomiasis in as far as it will give an indication of whether faecal matter is present in snail habitats. However, it will not provide information on presence and relative abundance of miracidia in different habitats.

Caged laboratory bred snails were used in Tanzania by McClelland (1965) in an attempt to determine the extent of miracidial infection in natural pools. Upatham (1972a, b) developed the technique further in St. Lucia and sentinel snails were used to assess the reduction in numbers of miracidia as a means of assessing the efficacy of chemotherapy (Jordan, 1985).

The main problem with the technique was very low numbers of infected sentinel snails (0.15 to 0.22%) were recorded in flowing streams (Upatham, 1973). Prentice et al. (1981) suggested improvements of the technique after achieving high infection rate (3.7%) by using many cages each with a maximum of five snails instead of twenty snails all squeezed in one cage. The technique was later successfully introduced into the WHO/UNDP/World Bank Programme on Lake Volta in Ghana (Chu et al., 1981). Although WHO (1980) recommended the use of sentinel snails for monitoring contamination, few people have used the method possibly because of the difficulties and the workload involved in raising large numbers of sentinel snails and keeping them in the laboratory after they are exposed and before they can be examined for infections.

In Chapter 3, section 3.1 reference has been made to recent developments in cercariometry techniques which now permit their successful use in the field as a direct means of measuring cercarial densities to complement information obtained from measurement of snail infection rates. The technique involves essentially recovering cercariae in cloth mesh filter size 30 um-50 um. Although as mentioned in Section 1.2, cercariae are small but visible to the naked eye (less than 1 mm in length) there is no reason to suppose that any organism which is bigger than 30 microns will fail to be recovered in the same way as cercariae. Therefore an attempt was made in the laboratory to test if miracidia which measure 0.160 mm in length and 0.062 mm in width or 160 μm x 62 μm (see section 1.2) would be recovered in a similar way as cercariae. If successful, the technique may be developed further for use in the field to determine miracidial densities in transmission sites.

7.3.2 Materials and methods

7.3.2.1 Laboratory studies on a differential filtration technique for the recovery of schistosome miracidia from natural waters

The initial experiments were performed in Liverpool between February and April 1984. Using exactly the same techniques described for cercariometry in Section 3.2.4.3 an attempt was made in the laboratory to recover miracidia from water and whether they could be easily distinguished from other organisms present in tank water in the laboratory. At first, formalin was not added as a killing agent but later when it was added at a concentration of 5 ml/lire miracidia were easily recovered from water when a nylon recovery filter with mesh size 25 um was used.

The next step was to determine which filters were most convenient and efficient for recovery of miracidia. Nylon filters with different mesh sizes (30 μm, 40 μm and 50 μm) were used in the laboratory in Nairobi between June and August 1984. Bewteen 20 and 50 miracidia were introduced in five litres of water and poured into different recovery filters as explained for cercariometry. Filters were read later after staining with 0.01% of light green in 2% acetic acid and all the miracidia seen were counted and recorded. A total of twelve measurements were taken. Using the 30um pore size filter, the sensitivity of the method was tested by attempting to recover 30, 15, 7, 3 and 1 miracidia from five litres of water.

7.3.2.2 Evaluation of differential filtration technique for recovery of schistosome miracidia from artificial ponds

Two artificial ponds (1.5m^2 by 0.5m deep) were dug within the compound of Kakuyumi health centre. Several experiments were performed between January 1985 and February 1986 to recover

miracidia from the ponds. Each day of the experiment, the ponds were filled with water up to 0.25m deep after lining them with large polythene sheets to prevent water from draining into the soil. Miracidia were hatched from stools collected from heavily infected individuals as already described in Section 3.2.3.3. Miracidia were then introduced directly into the water in the ponds usually around midday. One hour was allowed for them to settle before sampling various positions (edge, corner and centre) of the ponds. It was not possible to estimate the exact numbers of miracidia introduced each time but it was ensured that more than 200 were used. It was important to sample around midday to ensure that the sun was overhead as this would ensure equal distribution of light all over the ponds. Light is known to attract miracidia (see Section 1.2). Each position was sampled 2-3 times and the experiment was repeated ten times on different days.

Finally the experiments were repeated with snails introduced into some of the positions on the ponds before sampling to detect if presence of snails affected the distribution of miracidia. Ten snails were put into each of the two cages and cages put in water in corners A and C. More than 200 miracidia were introduced and two hours were allowed before sampling each of the four corners and the centre positions by drawing five litres of water and pouring in filtration apparatus as already described. Each position was sampled three times. The experiment was repeated five times.

7.3.2.3 Field trial of different filtration technique for recovery of miracidia from natural habitats

Five transmission sites in Kivii were sampled regularly between July 1985 and February 1986 in an attempt to recover miracidia directly from them. The five sites were known to be potentially highly contaminated as judged by faeces seen around them and by the number of cercariae per litre recovered from them.

7.3.3 Results

7.3.3.1 Laboratory evaluation of differential filtration technique in the recovery of miracidia

For the general morphology of a miracidium, refer to section 1.2 and Figure 2.1a. Figure 7a and 7b show miracidia as recovered from 30 um filter.

Miracidia can be easily identified by the round neural mass situated centrally and by the 'primitive gut' which is round or oval in shape and is situated close to the anterior margin. Both neural mass and primitive gut are acidophilic and stain conspicuously with light green stain.

The results of tests of the efficiency of different mesh sizes in the recovery filter are summarised in Table 7.2. No miracidia were recovered unless formalin was added to kill them first. 50 µm pore size recovery filter gave the poorest results with only between 3.3 to 20% of the miracidia recovered. Both 30 µm and 40 µm pore size filters give good results and can be used depending on the turbidity of water. Recovery rates range between 70 and 90% and 63.3 to 86.7% in 30 µm and 40 µm pore size nylon filters respectively.

7.3.3.2 Sensitivity of differential filtration technique for recovery of miracidia

Recovery of miracidia according to the number added is shown in Table 7.3. Sensitivity appears to decrease with numbers added. The recovery of one miracidium experiment was repeated ten times and the one miracidia was recovered in at least six of the experiments.

7.3.3.3 Recovery of miracidia in artificial ponds

The results of recovery of miracidia in artificial ponds are given in Table 7.4. It is demonstrated that it is possible to recover miracidia from artificial ponds and it would

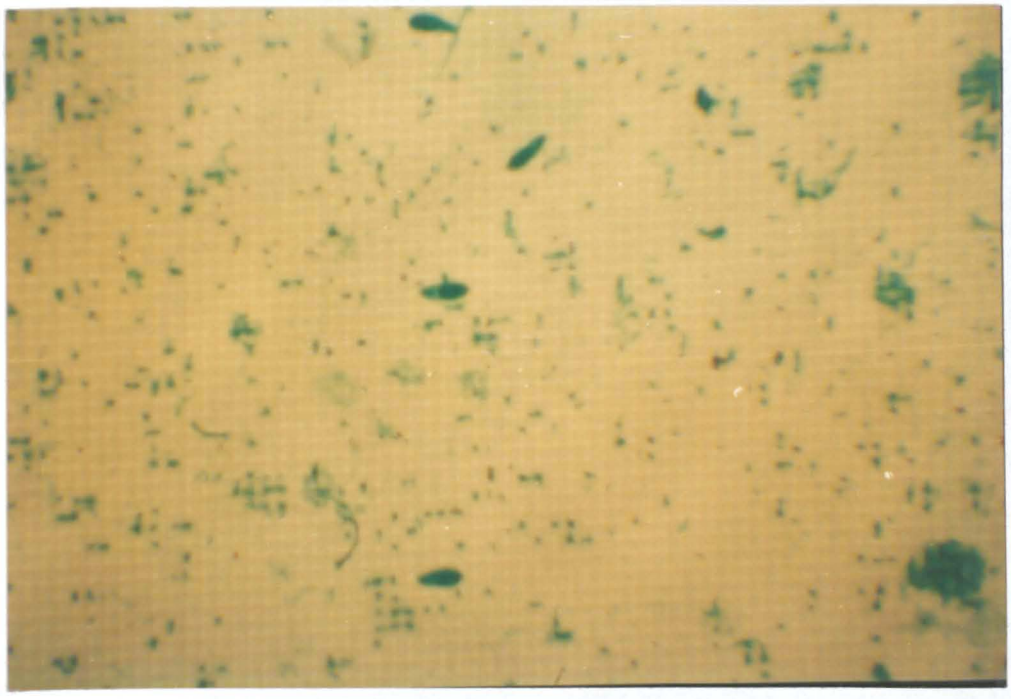

FIGURE 7a Miracidia recovered from water in the laboratory

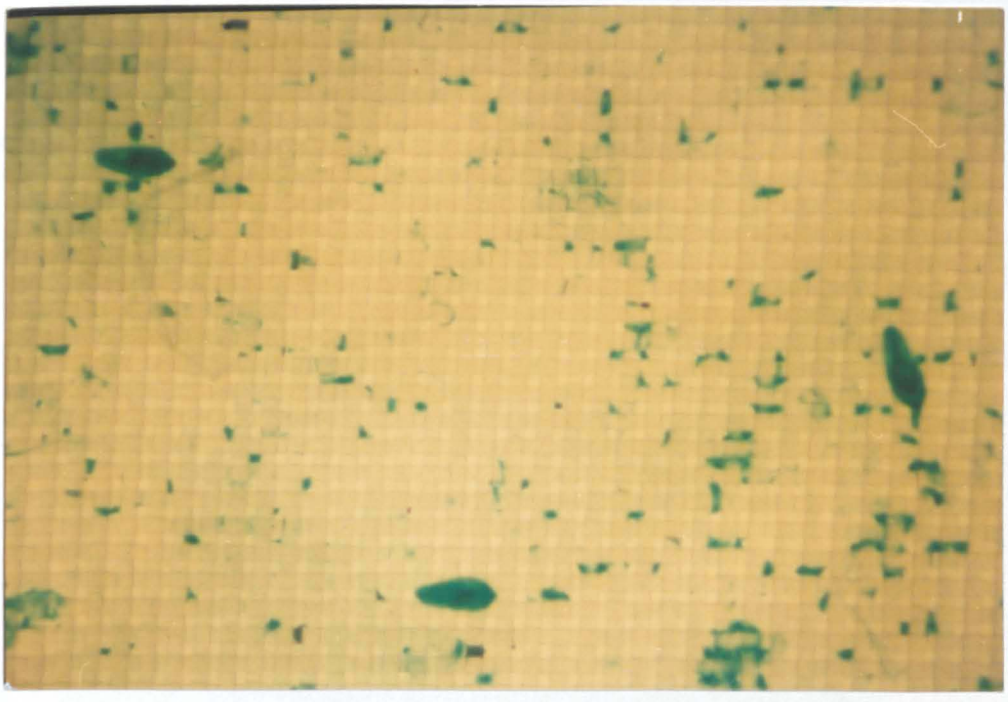

FIGURE 7b Miracidia recovered from water in the laboratory

TABLE 7.2

Recovery efficiency of miracidia with different pore size cloth mesh recovery filter

Replicate Number	No. miracidia introduced in 5 l water	Number and (percentage) recovered		
		30 µm pore size No.(%)	40 µm pore size No.(%)	50 µm pore size No.(%)
1	30	25(83.3)	21(70)	1(3.3)
2	30	23(76.7)	17(56.7)	2(6.7)
3	20	18(90)	15(75)	3(15)
4	20	18(90)	13(65)	2(10)
5	30	27(90)	17(56.7)	1(3.3)
6	30	23(76.7)	19(63.3)	0
7	20	18(90)	14(70)	1(5)
8	20	16(80)	13(65)	3(15)
9	30	25(83.3)	26(86.7)	5(16.7)
10	30	27(90)	22(73.3)	3(10)
11	20	17(85)	16(80)	4(20)
12	20	14(70)	13(65)	2(10)
Totals	300	251(83.7)	206(68.7)	27(9)

TABLE 7.3

Recovery of miracidia according to numbers added

Total cercariae in five litres	Number and percentage of miracidia recovered			
	First series		Second series	
	No.	%	No.	%
30	26	86.7	28	93.3
15	11	73.3	12	80.0
7	5	71.4	4	57.1
3	2	66.7	1	33.3
1	0	0	1	100

Each value is one determination

TABLE 7.4

The recovery of miracidia from different positions of experimental ponds

More than 200 miracidia were added during each sampling period.
Values refer to mean of 3-6 readings

Experiment No.	Mean number and (standard deviations) of miracidia					
	Centre		Edge		Corner	
	Mean No.	S.D.	Mean No.	S.D.	Mean No.	S.D.
1	4	(1.4)	1.5	(0.7)	1.5	(0.7)
2	0.33	(0.6)	4.7	(4.04)	4	(4.0)
3	1	(1.7)	3.5	(2.1)	7.3	(4.04)
4	39.7	(49.8)	17	(7.8)	13.3	(4.2)
5	2.7	(3.1)	4.3	(4.2)	15.3	(19.3)
6	1.7	(2.08)	2.7	(4.6)	44	(71.0)
7	3.7	(2.5)	8.5	(3.7)	12.5	(13.6)
8	3.5	(2.1)	29	(31.1)	16	(5.7)
9	1	(1.4)	3	(4.4)	3	(1.7)
10	4	(5.7)	1.5	(0.7)	1	(0)

appear that more miracidia are found either on the edge or in the corners and although more data would be needed for meaningful statistical comparisons since large variations occur in replicate samples as shown by individual counts. The same applies to data on Table 7.5 which compares numbers of miracidia recovered in corners with snails and those without snails. The variations are too great to make meaningful statistical comparisons.

No miracidia were recovered in natural transmission sites in Kivii although many cercariae were found (Table 7.6).

7.3.4 Discussion

If it can be done direct recovery of miracidia from natural waters would provide a quick, easy and more direct means of monitoring contamination of the environment with human schistosome eggs assuming of course that human schistosomes can be identified easily from other animal schistosome miracidia. The only method available to determine the extent of miracidial presence in water is by use of sentinel snails and although this was used to evaluate the effect of treatment in St Lucia (Jordan, 1985) it has not been popular possibly because of the amount of work involved in the procedure.

The results of the present study show that direct recovery of miracidia in the laboratory and in controlled field situations is possible - the miracidium being easily recognized by the deeply light green staining neural mass and primitive gut.

Failure to recover miracidia from natural waters may be due to several reasons:

a) Dilution factor: although schistosomes produce large numbers of eggs, only a fraction of the miracidia which hatch are ultimately available to snails in water (Jordan and Webbe, 1984). This means that miracidia may be present in water in such small

TABLE 7.5

The recovery of miracidia from artifical ponds in positions with and without *B. pfeifferi* snails
More than 200 miracidia introduced during each experiment

Experiment No.	Replicate No.	Number of miracidia recovered from									
		Corner A*		Corner B		Corner C*		Corner D		Centre	
		No. recovered	Mean No.	No. recovered	Mean No.	No. recovered	Mean No.	No. recovered	Mean No.	No. recovered	Mean No.
1	I	572	336	12	9.5	1	0	3	3.5	1	3.5
	II	100		7		0		4		6	
2	I	247	162.5	21	36	45	32	118	103	34	27.5
	II	78		51		19		88		21	
3	I	23	17.0	27	17	78	60.5	33	29.5	29	21
	II	11		7		43		26		13	
4	I	127	71	23	14.5	80	52.0	4	7.5	n.d.	
	II	15		6		24		11			
5	I	29	15.5	400	212.5	3	12	4	7.3	30	18.5
	II					11		3		7	
	III	2		25		22		15			

* = positions with snails
n.d. = not done

TABLE 7.6

Seasonal variation in cercarial density in sites in Kivii from June 1985 to May 1986

Values represent cercariae/litre of water

Month	Site 1	2	3	4	5
June 1985	0.9	2.4	4.1	7.0	1.5
July 1985	16.6	59.8	47.1	37.2	28.3
August 1985	30.5	16.3	44.1	33.1	72.3
September 1985	0	10.7	0.9	0.4	1.0
October 1985	0	0	0.01	15.8	0.01
November 1985	0	0	0.01	1.3	0.3
December 1985	0	0	4.0	34.6	8.2
January 1986	3.6	5.3	14.5	6.3	6.2
February 1986	0	0	7.5	4.1	1.0
March 1986	0	0	0.5	2.2	4.0
April 1986	0	0	0	0	0
May 1986	0	0	0	0	0.02

Please note that this survey was aimed especally at recovering miracidia but none was detected throughout the period.

quantities compared to cercariae which are present in large numbers (see Section 1.2) and although the cercariometry equipment can recover small numbers of miracidia in water (Table 7.3), the method in itself would have to be very sensitive to avoid filtering large quantities of water before hopefully recovering a few miracidia.

b) The problem of identification: although filtered miracidia can be easily recognized in the laboratory, this may not necessarily be so in natural waters where there are many other animals of approximately the same size. In addition, although miracidia of different species of schistosomes differ in sizes (see Loker, 1983) in several of the species the differences are too small to be easily recognised.

c) Distribution of miracidia in water: although there is evidence that behaviour of miracidia is related to the ecology of their snail intermediate host (Jordan and Webbe, 1982) and although it has been shown that miracidia tend to concentrate on the margin of a petri dish in the laboratory (Chernin and Dunovan, 1962) and on the margin of outdoor tanks and natural ponds (Upatham, 1972a), we still lack precise information on the distribution of miracidia in a wide range of different outdoor habitats. The results of the present studies have not added any new information in this respect.

Despite the above difficulties associated with direct recovery of miracidia in natural waters, there is much room for improvement directed to the identification of substances or chemicals which can attract miracidia before sampling is done. For example ammonia was shown to induce miracidia to increase their klinokinetic (turning) movements, thus restricting their dispersion (Mason and Fripp, 1976; 1977). Miracidia are also known to be attracted by a substance 'miraxone' coming from snails (Chernin, 1970) and it is said that miracidia will respond to 'snail conditioned' water even

in the absence of a concentration gradient (Mason and Fripp, 1976). Miracidia of S. haematobim are known to move from darkened cooler regions to that which is illuminated but warm (Shiff, 1974).

However, in the meantime the method of recovering miracidia directly from water in the laboratory could be of great use to researchers who are studying parasite vector relationships in the laboratory.

7.4 SUMMARY OF CHAPTER 7

1) Biomphalaria pfeifferi were collected from different field sites and kept in the laboratory for up to seven weeks to study the pattern of 'prepatent' infections after the initial shedding to detect 'patent' infections.

2) Many more snails started shedding S. mansoni cercariae during the seven weeks holding period denoting presence of prepatent infections at the time of collection but in general there was no steady rate of maturation of infections in snails from different sites indicating lack of continuous contamination of the sites.

3) The method of differential filtration technique for recovery of cercariae described by Prentice (1984) was used to try and recover miracidia in the laboratory and in artificial ponds.

4) Using 30um pore size cloth filter mesh, it was possible to recover miracidia which could easily be recognised by the neural mass which stained darkly with the light green dye. Miracidia were also recovered from the artificial ponds but further work is still needed before the method can be applied in the field.

CHAPTER 8

OVERALL DISCUSSION AND CONCLUSIONS

8.1 INTRODUCTION

The main purpose of the study was to contribute to a better understanding of the transmission of S. mansoni in Kenya with a view to recommending improved methods for the control of the diseases. The centre of interest was to determine the way in which the environment gets contaminated with schistosome eggs by humans and animals and the behavioural factors (humans or animals) that influence the degree of contamination and hence transmission of S. mansoni. To achieve this, several studies involving different approaches were performed between May 1984 and July 1986 in Matithini village of Machakos District of Kenya. These included observations on the general transmission pattern of S. mansoni in Matithini village, human water contact and defaecation behaviour and whether such behaviour influenced transmission of S. mansoni by regulating the number of eggs that eventually reach water and infect snails, presence and use of sanitary facilities, the role of other animals in transmission, nature and pattern of contamination of various transmission sites and monitoring of contamination. The various findings and conclusions have been extensively discussed in relevant chapters of the thesis; here the major findings are highlighted and discussed from the point of view of the whole study with particular emphasis on their relevance to the control of schistosomiasis in Kenya and the needs for on-going research.

8.2 THE SITUATION OF S. MANSONI INFECTIONS IN MATITHINI VILLAGE

S. mansoni was shown to be highly endemic in Matithini village having a prevalence of 67% and an overall high intensity. Males had slightly higher prevalences and intensities than females. Incidence, snail infection rates and cercariometry data confirmed that transmission of S. mansoni continued throughout the study period. The sole vector for S. mansoni in the area was B. pfeifferi. The endemicity and continued transmission are linked to both human water contact and contaminative behaviour of the people. For example, there is no safe water supply in the area so that most people used the rivers or streams directly for their water needs. This was confirmed during water contact observations. Toilets were available in the majority of the households but it was discovered that many of them were constructed only recently and their proper use by everybody was doubted. This was eventually confirmed, as explained later.

8.3 WATER CONTACT STUDIES

Water contact observations were primarily aimed at identifying those activities which were likely to contribute directly or indirectly to the contamination of snail inhabited water bodies. Generally speaking, contact with water increased with age in both sexes, dropping gradually after 14 years of age in males but remaining high in females throughout. The pattern of water contact with age is clearly reflected in the prevalence and intensity curves for males infected with S. mansoni but for unknonwn reasons to a lesser extent in females. These observations are similar to those obtained by others (Dalton, 1976; Husting, 1983; Kloos et al., 1983; Blumenthal, 1985). The most frequent water contact activities observed in the present study were drawing water,

crossing from one side or walking along the rivers or streams and bathing parts of the body. The latter two were observed to be linked to the defaecation habits of the people and were thought to contribute indirectly to contamination of water bodies. Bathing, swimming and playing were also considered to be contaminative since they are thought to lead to faecal contamination of water.

Total body exposure including extremities were not so commonly observed in Matithini perhaps because the observations were confined to a few sites but these activites are known to be commonly taking place in the surrounding areas (Butterworth, personal communication) and in Lower Nduu (Ouma and Van Ginneken, 1980). The main point however is that these water contact activities which were likely to lead to contamination of the water bodies were observed mainly in 5-19 year olds. While water contact activities likely to lead to contamination of water bodies have been identified for the area studied, there is need for further detailed studies to clearly demonstrate the importance of these particular activities in the transmission of S. mansoni before more practical recommendations can be made on measures to be taken to discourage those activities and reduce transmission.

8.4 THE ROLE OF HUMAN DEFAECATION BEHAVIOUR IN CONTRIBUTING TO POTENTIAL CONTAMINATION OF THE ENVIRONMENT WITH S. MANSONI EGGS

Detailed studies on the number of S. mansoni eggs produced daily revealed that many millions of eggs were excreted by individuals and by the community (Chapter 4). Observations on toilet use by the people confirmed that toilets were not adequately used by younger people in particular and by everyone especially when they were away from their compounds. It is therefore believed that a good proportion of the total number of eggs excreted daily in the

area were deposited in the open environment from where they could have been washed in by rain water or transported by other means to snail bearing waters, leading to the infection of snails. This is evident from data on snail infection rates (Fig. 3.5a) which show a build up in infected number of snails soon after the rains stopped. Similar observations have been made elsewhere (Jordan, 1985; Chandiwana, 1986).

According to Jordan (1963) and Farooq and Mallah (1967) the group of people responsible for potential contamination can be identified from figures of prevalence, intensity and population structure. As was revealed in their studies, 5-19 year olds were responsible for the bulk of S. mansoni eggs excreted daily (more than 60%) in Kivii and Matithini villages (see section 4.3.3.2).

The results of defaecation habit studies implicate 5-19 year olds in encouraging transmission of S. mansoni in the study area. For example, they were observed more often defaecating near water bodies, did not use toilet facilities adequately, carried eggs in their perianal regions and bathed most often directly in snail bearing water bodies. Control measures aimed at this particular age group would no doubt lead to a big reduction in the number of S. mansoni eggs eventually reaching water bodies and help to reduce transmission.

8.5 POSSIBLE ROLE OF TREATMENT IN REDUCING CONTAMINATION OF THE ENVIRONMENT WITH SCHISTOSOME EGGS

One way to reduce the number of eggs in the environment would be the treatment of infected individuals. Good drugs are now available (WHO, 1985) and can be used but acceptable cost delivery systems at community levels are yet to be worked out. Proposals have been made for treatment of school children (Jordan, 1963) and

heavily infected individuals (Warren and Mahmoud, 1976), both groups being responsible for a high proportion of potential contamination but the two approaches have not been evaluated for transmission control (Jordan and Webbe, 1982).

Current studies in Machakos of which Matithini village is a 'witness' or control area are aimed at comparing the above approaches and preliminary results have certainly confirmed the cost effectiveness of treatment of heavily infected individuals only (Butterworth, personal communication). In the present study, treatment of 65 heavily infected individuals (most of them under 20 years) in Matithini reduced the number of eggs excreted daily by half (see Table 3.2). The 65 persons represented only 9% of the total number infected, confirming the point made by Bradley (1972) that half the parasite eggs may be excreted by only a small proportion of the host population. This is emphasised by the realisation that one third of the population were excreting more than 100,000 eggs per person daily. Under these circumstances it is important that all the heavily infected persons are traced and treated, as missing only a few might still leave many eggs being excreted into the environment and possibly reaching water bodies. Even if all heavily infected individuals or all infected school children were treated, much will still depend on the general human defaecation behaviour of the people in the particular area. Theoretically, treatment of all infected school children should provide better results because as demonstrated in this study, children's behaviour favour transmission. In practice they soon become re-infected as a result of their water contact behaviour, especially since treatment of a proportion of infected individuals does not stop transmission (Polderman and Manshande, 1981; Ouma *et al.*, 1985). This calls for additional measures to help further

reduce environmental contamination with schistosome eggs by the proportion of the people not covered in the treatment campaign. This is discussed in the next section.

8.6 POSSIBLE ROLE OF IMPROVED SANITARY PRACTICES IN REDUCING CONTAMINATION OF THE ENVIRONMENT WITH SCHISTOSOME EGGS

As pointed out earlier, toilets present in the majority of the households in Matithini were inadequately used despite claims by the residents to the contrary. Detailed studies on defaecation behaviour revealed that the youngest children (under 5 year olds) did not use toilets for fear of falling inside and yet almost half these children were already infected with S. mansoni (see Chapter 3), and as already mentioned the rest of the people and particularly 5-19 year olds did not use toilet facilities regularly and often defaecated near water bodies. As was concluded by Farooq et al. (1966b) use of toilets by a small proportion of the people had no substantial effect on prevalence of S. mansoni in the Egypt-49 project area and this has been confirmed in the present study. In addition, it was demonstrated that about one third of the infected population consisting mainly of the younger age groups carry viable eggs in their perianal skin and it is possible that some of these eggs were introduced to water directly during bathing, swimming or playing - the activities which involved total body exposure. These activities were reported by Kloos et al. (1983) to have resulted in high infection rates of S. mansoni in Egypt. In Matithini, swimming and playing together with bathing were observed mostly in children but less common, although they were known to be taking place in other nearby areas referred to in the study. Transmission of S. mansoni in Matithini and in Iietune villages was known to have continued during most of the dry period (Figs. 3.5a, b) when

rainfall could not have been responsible for the transfer of S. mansoni eggs into water and as suggested by Husting (1965) and Chandiwana (1986) it is possible that part of the transmission in both Iietune and Matithini were likely as a result of contaminative activities which were predominant in the heavily infected group (5-19 year olds). This was confirmed in one of the villages (Kakuyuni) where a positive correlation was found in snail infection rates and contaminative activities but for reasons still to be investigated, no positive correlation was found in each of the other areas tested (see Chapter 5). Nevertheless, the observation that a good proportion of the infected population, consisting mainly of children, carried S. mansoni eggs some of which were viable in their perianal region and that their water contact behaviour favoured introducing the eggs into water bodies is of interest. The majority of these people do not or have no adequate means to clean themselves after defaecating. Toilet paper is not normally available in most rural areas in developing countries, including Kenya, and even if it were, very few people can afford it. Moreover there is a tendency for especially younger people to ignore cleaning themselves after defaecating if they know they are going to bathe, as was discovered in Matithini residents (Chapter 4). The implication here is that poor personal hygiene is likely to increase the chances of more eggs getting into water when people bathe, swim or play. One thing that needs to be considerd for future work is to approximate the amount of S. mansoni eggs which might be introduced into water through the perianal region in order to assess the importance of transmission this way. In the present study the highest number of eggs found in one swab specimen was about 35. However, the method used was not designed for making more accurate estimates of the eggs but it can certainly be improved and this is now being planned.

Eggs reaching water through bathing or such activites may be important not only in ensuring that transmission continues during dry periods, but could also ensure regular source of contamination, in particular transmission sites as discussed in Chapter 7 and this would make such sites infective practically all the time, provided they are continually used for contaminative activities and provided the snail hosts are present. As pointed out in Chapter 2, most of Kenya remains dry for a greater part of the year and it is possible that transmission through eggs in the perianal region may be one of the important sources of contamination in most parts of the country and for a good part of the year.

8.7 THE POSSIBLE ROLE OF WILD OR DOMESTIC ANIMALS IN TRANSMISSION

While humans remain the important reservoir hosts for S. mansoni, WHO (1979a) has emphasised the need for an awareness of possible animal hosts contributing to transmission. In the present study, a variety of rodents were examined for schistosome infections and although a number of them were found naturally infected including Lemniscomys striatus (reported so for the first time) the results of the present study provided no evidence that they were important in transmission (Chapter 6), although other studies elsewhere in Kenya suggest that baboons and monkeys (Nelson et al., 1962; Else and Sturrock, 1982), and the creek rat Pelomys may be important (Kawashima et al., 1978). Also studies in the Caribbean and South America suggest that murine infections may be important (Rollinson et al., 1986).

Many dogs were found excreting S. mansoni eggs and further studies revealed that the dogs may be important in the transmission of S. mansoni through coprophagy. For example it was shown experimentally that young puppies not previously exposed to natural

infections will pass viable S. mansoni eggs capable of hatching and infecting snails after feeding on infected human faeces. Since the eating of human faeces is common among dogs in the area and since most dogs move freely in villages, it is possible that they could be disseminating S. mansoni eggs this way and particularly if they eventually defaecate directly in water which was often observed or drink from water bodies immediately after feeding on infected faeces. While the role of dogs in transmission of S. mansoni possibly through coprophaghy should continue to be investigated, it would equally be useful to confirm if they become naturally infected and whether it is true that they are a dead end as suggested by Karoum and Amin (1985). It is also necesary to prove if adult dogs will pass viable eggs after feeding on infected human faeces.

Flies which are coprophagous are known to be involved in the transmission of other helminths (Lawson & Gemmell, 1985). Preliminary observations in our study area have shown that the flies can carry S. mansoni eggs in their bodies. This needs more careful study and investigations are currently underway in the Machakos area.

8.8 THE NEED FOR BETTER HEALTH EDUCATION

There is a need for better health education to change human behaviour in order to reduce contamination of the environment and minimise transmission of schistosomasis.

In the prevailing circumstances referred to, I would like to strongly recommend more practical and realistic approaches to health education programmes as a supplement to chemotherapy and other measures in reducing environmental contamination with schistosome eggs and hence the transmission of S. mansoni.

As recommended for most other health concerns, health education

involving schistosomiasis should form part of the primary health care approach now being advocated (WHO, 1983; Rhode, 1985; Mott, 1984). Emphasis should be placed on the importance of having and properly using toilets by everyone at all times. The importance of personal hygiene should be clearly and more carefully explained and people should be strongly advised not to bathe directly in open waters where, in addition to risking being infected, they are likely to introduce S. mansoni eggs in the process. Defaecation in the open and especially near water bodies should be discouraged even if this means providing communal toilets in strategic convenient places. It is well appreciated that the number of trained people available for health education is too few compared to the total population they are supposed to serve and it is suggested that the few trained personnel would better spend their time in concentrating at educating church leaders, local administrators, leaders of social organisations and even volunteers who can then join hands to effectively transfer knowledge to the population through community participation, or "harambee" as they call it in Kenya, as has been recommended by Sandbach (1975). Since the majority of the people responsible for the transmission of S. mansoni belong to school age children, it would be useful to consider modifying school syllabuses to adopt more practical rather than theoretical approaches in ensuring the understanding of the importance of good sanitary practices. While all these are going on it would be important to continue to investigate reasons behind lack of or improper use of sanitary facilities. As suggested by WHO (1979) and by Dun (1979) special attention should be given to the important neglected areas including traditional beliefs, people's attitudes, perceptions, social and psychological factors which might enhance or restrict the efforts of health educators to introduce innovations in behaviour to

minimise transmission.

Improved sanitary practices including provision and proper use of latrines, avoiding bathing directly in waters and better personal hygiene can be achieved through the suggested health education measures to help reduce the net flow of eggs into the habitat with which man has contact. As such it serves to reduce the value of the basic reproductive rate (Ro) of the parasite. The prediction made by Macdonald (1965) that sanitation will not reduce transmission was based on the false assumption that water bodies were saturated with miracidia (Jordan and Webbe, 1982) and ignored the fact that such a measure may not only have a long term effect but would also help in controlling other helminth and bacterial and viral infections as well. It is very much appreciated that practical difficulties arise in the implementation of such measures, primarily as a consequence of inadequate resources in developing countries, hence the need for identifying and better understanding such difficulties in order to devise simple and more acceptable solutions.

8.9 FINAL COMMENT AND RECOMMENDATION

Studies carried out on human behaviour and contamination of the environment have gone some way to understanding some of the gaps in the knowledge of the epidemiology of schistosomiasis. There is increasing optimism that schistosomiasis can be controlled by combining the use of molluscicides and chemotherapy and by providing alternative water supplies but none of these measures are likely to be effective without the full cooperation of the community and it is here where health education is so vital especially as long term control will depend on the participation of the community through the primary health care system rather than vertical control programmes imposed by the public health authorities.

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APPENDICES
(numbered according to chapters)

APPENDICES FOR CHAPTER 2

2.1a Form used for demographic data collection

2.1b Calender of events used for estimating ages when records of date of birth are unavailable

2.2a Questionnaire used for a survey of household latrine use and ownership and feeding of dogs

2.2b Instruction sheet for questionnaire on household latrine use and ownership and feeding of dogs

2.3 Table showing detailed data on de jure population of Matithini village

APPENDICES FOR CHAPTER 3

3.1 Form used for recording snail data

3.2a Form used for collection of water contact data

3.2b Summary sheet for water contact data

3.2c Instruction sheet for coding water contact data

APPENDICES FOR CHAPTER 4

4.1 Form used for collection of defaecation pattern behaviour data

4.2 Form used for data on 24 hour stool survey

4.3a Questionnaire used for a survey of individual latrine use and defaecation behaviour

4.3b Instruction sheet for questionnaire on individual latrine use and defaecation behaviour

4.4 Key for scatter diagrams

APPENDIX 2.1 (a)

MINISTRY OF HEALTH - KEMRI
SCHISTOSOMIASIS CONTROL THROUGH CHEMOTHERAPY-MACHAKOS PROJECT
BASELINE DEMOGRAPHIC FORM

Study Area Household No._____ Name of Household _____

Date of Registration _____ _____ Fieldworker's Name_____ Date Checked _____

NO.	HOUSEHOLD MEMBERS (NAMES)	RELATIONSHIP	RESIDENCE		SEX	AGE	PLACE OF BIRTH PREVIOUS RESIDENCE	DATE OF ARRIVAL
Give the names of every one in this household: both usual members and visitors starting with the head of household.		What is the relationship of this person to the head of the household and the rest of the other members of this household?	Did this person sleep here last night? YES/NO	Does this person usually live here? YES/NO	What is the sex of this person? M=Male F=Female	When were you born? When was this person born?	RESIDENTS - Where was this person born? NON-RESIDENTS-Where was this person living last before moving to this house? Write Location if born in Machakos and District if born elsewhere.	If born elsewhere write year of arrival to the village of registration DO NOT write year for person born in the village.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
01								
02								
03								
04								
05								
06								
07								
08								
09								
10								
11								
12								

Just to make sure I have a complete listing of memebers of this household (TICK APPROPRIATE BOX):

(i) Are there any other persons, such as small children or infants, that we have not listed here? YES (Add to the above listing) NO. (ii) Are there any usual members of this household who are temporarily absent? YES (Add to the above listing No. (iii) In addition, are there any other people who may not be members of this family, such as domestic servants, friends or lodgers who usually live in this household that we have not listed here? YES (Add to the above listing) No. (iv) Finally, are there any guest or visitors temporarily staying in this household? YES (Add to the above listing) No.

Calender of events used for estimating ages in Matithini

CALENDAR OF LOCAL HISTORICAL EVENTS

1.	Ngovo (famine of hides and skins)	1840-1843
2.	Kiasa (famine)	1845-1850
3.	Ngwambu (famine)	1858-1861
4.	Mutulungo (famine)	1865
5.	Ngeetele (famine)	1870
6.	Ndata (famine of star)	1878-1882
7.	Kyumbe (dance)	1884-1886
8.	Kitombo (dance)	1894-1898
9.	Muvunga (famine of rice)	1897-1901
10.	Yua ya Munyili (famine of livestock dysenty)	1898-1899
11.	Ngoma (dance)	1898-1899
12.	Mission Muisuni (founding of a mission at Muisuni)	1898-1900
13.	Mutambo-Konza (railway construction at Konza)	1899
14.	Ilovi yiyatukiwa (first construction of Nairobi)	1900-1904
15.	Kyesa (dance)	1906-1908
16.	Ivinda ya Chief Ntheketha (the reign of Chief Ntheketha) (Andu mambee kuma Mua) - first immigration to Mua Hills .	1909-1910
17.	Ndata ila yaumie (rising of a star to the East)	1910
18.	Timamu - Report (counting of natives by administrative officers)	1911
19.	Kuka kwa kilovia (introduction of Rupee as a currency) .	1912
20.	Yua ya malakwe (famine of beans)	1913-1914
21.	Kau wa Mathyaka (first world war fought with bow and arrows)	1914-1918
22.	Muimu wa Mavui (outbreak of lung disease-coughing)	1918
23.	Sukulu ya Lazima (forced or compulsory schooling)	1918-1919
24.	Kilolo (dance)	1920-1921

25. Kuka kwa silingi (introduction of a shilling as a currency). 1922-1923

26. Ndeke ya mbee (sighting of the first aeroplane) 1924-1925

27. Yila kwatukie (sun eclipse) ..... Jan 1926

28. Mithingitho (earth quake) ..... Jan 1928

29. Ngie syaya liu (crop invasion by locusts) 1928-1929

30. Nzalukangie (famine full of blinks due to expectation of food) 1929-1930

31. Momboleo (floods) 1930-1931

32. Uku atwika chief (The year Uku was installed as chief) 1938

33. Muindi Mbingu (the reign of Muindi-Mbingu) 1939-1940

34. Kau wa Italia (The second world war - war with Italians in Ethiopia) 1940-1944

35. Mbulung'u (Beans brought from Kikuyu during famine) 1942

36. Nthung'u (outbread of smallpox) 1943

37. Munyoloko upesi (famine of cassava) 1943

38. Yua ya Uimbi (famine of millet) 1943-1944

39. Kuakwa Itheka-kakumi (first land adjudication) 1945-1946

40. Kaawa wambee (introduction of coffee tree in Machakos) 1947-1948

41. Yua ya Makonge (famine of sisal) ..... 1949.

42. Silanga syambee (construction of the first dams) 1949-1950

43. Ivinda ya King'esi (the reign of King'esi) 1950-1951

44. Kanzeti ila ya Ngei (circulation of Paul Ngei's gazette) ... 1951

45. Mbua ya Kanzi (The rains that destroyed crops and the situation saved by an Asian businessman Kanzi who was supplying foodstuff) 1951-1952

46. Mau Mau iyambiia (the start of Mau Mau rebellion) 1952

47. Ikaoni ya Kapenguria (the trial of freedom fighters at Kapenguria 1953

48. General Kimanthi aikwatwa (arrest of General Kimathi) 1956

49. Andu mambee Leg coo (first African to the Legislative Council)..... 1957

50. Mau Mau uthela (end of Mau Mau rebellion) 1959-1960

51. Kenyatta, Ngei mailekwa (release of Mzee Kenyatta and Paul Ngei) 1960-1961

52. Yua ya ndeke (famine of aeroplane - which supplied food) 1960-1961

53. Uhuru (towards Kenya's independence) 1961-1963

54. Yua ya Atta (famine of Atta - distribution of reddish wheat flour) 1965-1966

55. Mboya sathwa (the assassination of Thomas Joseph Mboya ... 1969

APPENDIX 2.2a

QUESTIONNAIRE ON LATRINE USE AND OWNERSHIP AND FEEDING OF DOGS

Section A. (General)

1. Household No. _____ 2. No. in household _____

3. a) Head of household _____ b) Year of birth _____

   c) Sex _____ d) Person interviewed _____

4. Since when have you been living here _____

5. Level of education Not gone to school _____ Primary _____

   Secondary _____ University _____

6. Occupation (specify) _____

7. Religion (specify) _____

8. Main source of income Farming _____ Salaried employment _____

   Any others (specify) _____

9. Main source of water _____

10. a) Do you have toilet facility in this household Yes ____ No _____

    b) If yes, how many? _____

11. If yes, proceed to Section B

12. If no, proceed to Section C

Section B (Presence and use of toilet facility)

13. Type of toilet facility Pit latrine _____ Water borne _____

    Others (specify) _____

14. Distance from nearest building in metres Less than 10m. _____

    Between 10 - 20m _____ More than 20m _____

15. Estimated cost in K.shs. Less than K.shs.500 _____

    Between shs.500 - 1000 _____ More than shs.1000 ____

16. When was it constructed? _____

17. What led you into constructing it?

    a) Felt there was need for it _____

    b) Ordered by the administration _____

    c) Others (specify) _____

18. Types of toilet building

a) Complete building with roof Yes ____ No ____

b) With bricks and plastered floor Yes ____ No ____

c) With bricks and unplastered floor Yes ____ No ____

d) With earth wall as well as floor Yes ____ No ____

e) With sisal, plastic sheeting or paper wall and cemented floor Yes ____ No ____

f) Temporary or permanent door present Yes ____ No ____

g) Any other, (specify) _____

19. Toilet hole with cover Yes _____ No _____

20. Cleanliness of the toilet (inspect) very clean _____

Clean _____ Dirty _____

21. Odour of toilet Very smelly _____ Smelly _____

Very little or no smell _____

22. Is the toilet facility being used by all the family

all the time? _____ sometimes only _____ not at all _____

23. Is your toilet facility being used by other households?

Yes _____ No _____

List them _____

_____

24. If the answer to question No.23 is yes, how are you related to members of the household sharing the toilet facility with you?

_____

25. a) Total No. of persons using the toilet facility directly _____

b) Total No. of persons using the toilet facility indirectly _____

c) Total No. of persons not using the toilet facility at all _____

26. (Other than children) do all members of your and or other households if any share the same toilet facility

Yes _____ No _____

27. If no, what family members are not able to share

	Name	Indiv No.	Relation to H/H
i.	_____	_____	_____
ii.	_____	_____	_____
iii.	_____	_____	_____
iv.	_____	_____	_____

28. What are their reasons for not sharing?

i. _____

ii. _____

iii. _____

29. If members of the household cannot share the same toilet, have you provided a separate one for them? Yes _____ No _____

30. If no, where do they defaecate? Bush _____

Neighbours _____ Others (specify) _____

_____

31. a) At what age do your children begin to use toilet directly?

_____

b. How do they dispose of their feaces before the above age?

Bush _____ Garden _____ Indirect use _____

32. What are the reasons for not using toilet before the above age?

Danger of falling inside _____

Any other reason (specify) _____

_____

33. a) Are you aware of having a toilet facility in your compound

Yes _____ No _____

b) If yes, what are the advantages? For convenience _____

To avoid spread of certain diseases _____

Any other (specify) _____

34. Again, if yes what diseases are you aware of that are spread as a result of having no toilet facilities.

1. _____

2. _____

3. _____

4. _____

Section C. (Alternatives of toilet facility)

35. Why don't you have toilet facility?

Can't afford _____

Not aware of the benefit _____

Not thinking there is benefit ____

There is one already available in the neighbourhood _____

Any other reasons (specify) _____

36. What do you use as an alternative? Dig a hole _____

Bush _____ Neighbours _____

Any other (specify) _____

37. Are you prepared to use toilet facility if provided in this household? Yes _____ No _____

Section D. (Feeding of dogs on human feaces) (Section limited to dog keepers only)

38. Do you keep dogs in this household? Yes ___
No ___

39. If yes, how many _____

And

40. What is the reason for keeping dogs?

i. Security

ii. Pets

iii. Any other (specify) _____

41. Do you feed your dogs regularly _____ Sometimes _____

Not at all _____

42. If you feed them regularly or sometimes what do you feed them on?

Left food _____ Special food cooked for them _____

Same food prepared for family use _____ Others (specify)

_____

43. If the answer to No. 41 is not at all how do they get their food?

_____

44. Have you seen dogs eating human feaces Yes ____ No _____

45. If yes, do they eat human feaces even if they are well fed

Yes _____ No _____

46. If the answer to question No.44 is yes do you consider the eating of human feaces by dogs to be usual _____ Unusual _____

Accidental _____

47. If you are keeping dogs, do they usually accompany you?

i. when going to the garden Yes _____ No _____

ii. when looking after cattle along river valley Yes ___ No _____

48. Is it usual to find human feaces on the bush around river, stream or any other water body Yes _____ No _____

49. If yes, have you noticed your or any other dog eating feaces within the compound near a river or in bush near river Yes _____ No _____

50 Do dogs come incontact with the water after eating feaces

Yes _____ No _____

51. Do they do so any other time?

Yes _____ No _____

Interviewer _____ Date _____

APPENDIX 2.2b

INSTRUCTION SHEET ON HOUSEHOLD QUESTIONNAIRE ON LATRINE USE AND OWNERSHIP AND FEEDING OF DOGS

1. INTRODUCTION

1. Same as for instruction for individual questionnaire on latrine use and defaecation bahaviour. You have to realize that this is to be completed for each household in the study. Stickly speaking, the person to be interviewed should be the head of household or his wife.

2. INTERVIEW

2.1 General - same as for questionnaire on individual latrine use and defaecation behaviour.

2.2 Questions: Questions 1 to 3 can be filled from the original record book containing demographic information on households in the village.

Question 4 - you may need to use calender of events for this. The answer should be in the form of since 1969 for example and NOT say for 16 years.

Question 5 - Here we are referring to level of education of Head of household only and nobody else. Instead of taking the form of years of formal education - here we have three categories i.e. primary, secondary or university. For the purposes of this study primary will be taken to mean reaching and completing standard four. Included here are those who will have gone beyond standard four up to standard eight.

Secondary - will be taken to mean all those who reached and completed for two. Included here are those who will have gone beyond form two up to form six.

University - means going to university and completing successfully. It excludes those who were discontinued or dropped out in the middle.

Question 6 - The majority of the people will be farmers. Others will be say teachers, administratration, religious leaders etc.

Question 7 - We have several religious denominations in the area. Be specific. Remember that you are asking for the religion of the head of the household and not for the rest of the members of the households. Examples are Salvation army, A.I.C., S.D.A., Catholic etc.

Question 8 - Main source of income - be careful. You are not asking for the source of income but main source of income. For example you may be having salaried employment but still your main source of income could be farming or vise-versa. Again here you are referring to head of household only.

Question 9 - Main source of water - river, spring, piped water, rainwater tank, individual well etc. Be specific.

Question 10 - Some people may have more than two toilet facilities in which case tick under yes and put in bracket whatever number i.e. (2) or (3). Dont forget. If the answer is No - dont complete section B. If the answer is yes and more than one - you will have to complete more than one form for section B i.e. you complete section B for each toilet facility.

Section B

Question 14 - you may need to estimate by physically making steps. Nearest building means nearest building where at least some-one spends the night.

Question 15 - Crude estimate.

Question 17 - We are interested in whatever the toilet was built voluntarily or whether it was built as a result of an order from somewhere.

Question 18 - All questions a - e must hav e an answer either yes or no.

Question 20 - you must *inspect the toilet* and declare your own judgement on the cleanliness which refers to the cleanliness of the inside of the toilet and not the outside.

Question 21 - You can have an indication while inspecting.

Question 22 - Again inspect with torch to confirm its use.

Question 24 - Refers to relationship to head of households of those sharing the toilet facility i.e. brothers, uncle, father, grandfather etc.

Question 25 - Refers to all including members of other households if any. Using directly means going there physically and using it. Using indirectly means defaecating elsewhere and transferring faeces to the toilet afterwards. This may happen mostly with children. Toilet figure for 25a, b and c should fall with question 2 plus 'others from other households if any.

Question 26 and 27 - Here we are trying to find out if for some reasons other members of the households can not share same toilet facility. In some places it is commonly known that mothers or fathers in-law do not share same toilet with their sons or daughters in-laws.

Question 28 - Reasons can take the form of traditionally not allowed etc.

Question 31 a) - The answer to this will depend perhaps on the type of toilet facility and if it is pit latrine and whether the hole is made small or big. Remember indirect use is not regarded as use in this case.

Question 32 - Most likely all the answers should be danger of falling inside which is a good summary of all sorts of reasons which may be given such as being afraid, being too young etc.

Question 33 - This links up with question 17 i.e. some people may have been forced to build toilet facility without knowing the benefits or advantages.

Question 34 - Try to probe be specific on the answer given. Try to get at diseases themselves and not their complications. For example cholera rather than diorrhea etc.

Section C

- straight forward.

Section D - Question 41 - Be careful. You may not get the right answer. As far as I know most people do not feed their dogs regularly. You have to insist on confirming whatever answers is given.

Question 42 - Left food - means foor eaten by the family and left over. It is very unlikely that most people cook food for dogs but you just have to find out.

Question 43 - The expected answer is - they find their own way. I would like it to be framed like this in the answer.

Question 44 - You have to probe to find the correct answer. Same with question No. 45 and 46.

Question 48 - Again probe to get the correct answer. Same with the rest of the questions.

3. CHECKING QUESTIONNAIRE

Do as instructed in individual questionnaire on latrine use and defaecation pattern.

APPENDIX 2.3

Percent de jure population of Matithini village by age and sex (November 1985)

AGE	MALES		FEMALES		MALES & FEMALES	
	NO	%	NO	%	NO	%
0-4	136	19.3	148	19.3	284	19.3
5-9	100	14.2	124	16.2	224	15.2
10-14	111	15.8	90	11.7	201	13.7
15-19	74	10.5	85	11.0	159	10.8
20-29	87	12.4	132	17.2	219	14.9
30-39	67	9.5	65	8.5	132	9.0
40-49	51	7.3	44	5.7	95	6.5
50-59	40	5.7	35	4.6	75	5.1
60+	37	5.3	44	5.7	81	5.5
TOTAL	703	47.8	76.7	52.2	147.0	100.0

APPENDIX 3.1 Sample snail form used in the study area

MACHAKOS STUDIES - SNAILS SITE COLLECTION SHEET

EXTRA SITES - KAMANZI STREAM

COLLECTOR ----------
SITE ----------
DATE ----------
NO. +ve ----------

SITE

CONDITION NO FLOW
FLOWING
FLOODED/FLUSHED

WEATHER SUNNY WARM
CLOUDY COOL
RAINING
AIR TEMP.------
WATER TEMP. ---

	A 5mm.	B 5-10mm.	C 10mm.	TOTAL
SITE				
NO. INF.				
NO. COLL.				

NO.	SIZE	INFECTION	NO.	SIZE	INFECTION	NO.	SIZE	INFECTION	NO.	SIZE	INFECTION
1			11			21			31		
2			12			22			32		
3			13			23			33		
4			14			24			34		
5			15			25			35		
6			16			26			36		
7			17			27			37		
8			18			28			38		
9			19			29			29		
			20			30			40		

APPENDIX 3.2a Summary sheet for water contact data

WATER CONTACT

ORIGINAL OBSERVATION SHEET FORM 1

AREA: DATE: OBSERVER NUMBER: OBSERVATIONS STARTED AT:

SITE NUMBER DAY OF WEEK: OBSERVER NAME:

WEATHER:

NAME	ESTIMA-TED AGE	SEX	H/H CODE	DEGREE OF CONTACT	DURATION FROM TO	ACTIVITIES	REMARKS

APPENDIX 3.2b Water contact form used for recording water contact information in the study area

WATER CONTACT

SUMMARY SHEET

FORM 2

AREA:

NAME:

MONTH/YEAR

YEAR OF BIRTH (CHECK)

SEX:

H/H NUMBER (CHECK)

DATE	SITE NUMBER	DAY OF WEEK	WEATHER	DEGREE OF CONTACT	DURATION FROM TO	ACTIVITIES	REMARKS

CODING:

APPENDIX 3.2c Coding sheet for water contact data

CODING INSTRUCTIONS FOR ALL WATER CONTACT ACTIVITIES

	NAME	H.H. NO.	YEAR OF BIRTH	SEX	DATE	SITE	DAY OF WEEK	WEATHER	DEGREE OF CONTACT	TIME FROM	TIME TO	ACTIVITY	REMARKS
	NO	YES	YES	YES	YES	YES	YES	NO	YES	YES	YES	YES	YES
E.G.		01703	79	1	030485	04	2		5	0405	0406	04	0

CODE AS FOLLOWS:

Year of birth: Unknown = 99, 1899 or earlier = 98

Sex : Female = 0, Male = 1, Unknown = 9

Site : For Matithini:- Site 4A = 6, Site 4B = 7

: For Area H :- Site 22A = 22, Site 22B = 91, Site 25A = 92, Site 25B = 93.

Day of week : Wednesday = 1, Thursday = 2, Saturday = 3, Sunday = 4*

Degree of Contact	
Feet	1
Hands	2
Head or Face	3
Hands and Face	4
Hands and Feet	5
Head/Face, Hands and Feet	6
Whole body	7
(new type of contact appearing)	8
Unspecified	9

Activities	
Crossing	01
Walking in water	02
Grazing cattle	03
Drawing water	04
Drinking	05
Watering Veg./Nurseries	06
Bathing	
- with soap	07
- without soap	08
- not specified	09
Swimming	10
Playing	11

activities contd.	
Washing parts of body	
- with soap	12
- without soap	13
- not specified	14
Washing clothes or utensils	
- with soap	15
- without soap	16
- not specified	17
If activity unspecified or very rare	99

Remarks : Whenever the use of Kithima water is specified put 1. Otherwise put 0.

*Except for some earlier Matithini observations, for which Monday = 1, Tuesday = 2, Friday = 3, Saturday = 4, Sunday = 5.

APPENDIX 4.1 FORM FOR DEFAECATION STUDIES

AREA DATE OBSERVER NUMBER

SITE NUMBER DAY OF WEEK OBSERVER NAME OBSERVATIONS STARTED AT:

NAME	AGE	SEX	IND. CODE	ACTIVITIES BEFORE DEFAECATION	ACTIVITIES AFTER DEFAECATION	REMARKS

APPENDIX 4.2

INDIVIDUAL FORMS FOR TOTAL AMOUNT OF FEACES COLLECTED DURING A 24 HOUR PERIOD

a) Household information

Household No. _____ Total No. in household _____

Name of Head of household _____

Period of collection 8 a.m. on _____

to 8 a.m. _____

Date of collection by fieldworker _____

Name of fieldworker _____

Total No of persons providing all stools for a 24 hour period_____

Total No. of persons providing some of the stools for 24 hour period _____

b) Individual information

Individual No. _____ Name _____

Sex _____ Year of birth _____ H/H _____

Weight _____

All stools of the 24 hours period collected Yes/No _____

If no, how many? _____

Reasons for not providing the rest _____

If yes, how many specimens? _____

Is this the average daily number of stools passed normally Yes/No ____

If no, what is the average? _____

What did you eat during the last 24 hours _____

Have you any problem with the stomach? Yes/No _____

If yes (specify) _____

c) Detailed individual stool data

Please leave the last three main verticals for laboratory records.

Stool No.	Date	Time defecating	Weight of each specimen (in gms)	Kato readings (each slide 50 gm)				No. of egg/gm	Calculated No. of eggs for each specimen
				A	B	C	D		
1.									
2.									
3.									
4.									
5.									
6.									
TOTAL									

All specimens collected for kato Yes/No

Baseline kato counts _____ Calculated eggs/gm _____

Consistency

1. _____
2. _____
3. _____
4. _____

Colour

1. _____
2. _____
3. _____
4. _____

Any other remarks

Data form checked by _____ Date _____

APPENDIX 4.3a

INDIVIDUAL QUESTIONNAIRE ON LATRINE USE AND DEFAECATION BEHAVIOUR

Section A. (General)

1. Head of the household _____ 2. Individual No. _____

3. Name _____ 4. Year of birth _____

5. Sex _____ 6. Relationship to H/H _____

7. Person interviewed _____ 8. Years of formal education _____

9. Is there a toilet in the compound you are staying in Yes ____ No _____

10. If yes, do you use it always _____ Sometime only ____ Not at all____

11. If don't use it at all - why? Still young ____ Can't share _____

Do not see need _____

Any other (specify) _____

12. Where do you normally defaecate most of the time (check appropriate line)

	Own toilet	Nearest toilet	Bush	Any other (specify)
a) When at home	_____	_____	_____	_____
b) When in the shamba (garden away from home)	_____	_____	_____	_____
c) When looking after cattle	_____	_____	_____	_____
d) When at school	_____	_____	_____	_____
e) When gone for a visit in another household	_____	_____	_____	_____

13. Are you aware about the advantage of having and using toilet?

Yes ____ No _____ Under age _____

b) What are they? _____

_____

14. If yes, how did you learn about it for the first time?

a) Through teaching at school _____

b) Through a baraza by administrators _____

c) Through a health worker _____

d) Through teaching at church _____

e) Any other (specify) _____

Section B. (Defaecation Habits)

15. What is your diet? Maize and beans _____ Other (specify)_____

_____

16. How many times do you have a meal in a day? _____

17. Do you defaecate normally everyday? Yes _____ No _____

18. If no, what are the problems?

a) Constipation _____

b) Diarrhoea _____

c) Others (specify) _____

19. How many times did you defaecate during the last 24 hours? _____

20. Can you give the times for each defaecation

1. _____ 3. _____

2. _____ 4. _____

21. How many times do you normally defaecate in a day? Once _____

Twice _____ Three times _____ More than three times ___

22. Do you normally use anything to wipe yourself after defaecating?

Always _____ Sometimes only _____ Not at all _____

23. If "yes", what do you use mostly? Toilet paper _____ Leaves _____

Used newspapers _____ Any other (specify) _____

24. Where do you normally bathe or swim?

a) at home _____

b) directly in river, stream or pond _____

c) draw water and bathe near river, stream or pond _____

(if the answer to 24a) is yes STOP HERE. If the answer to b or c is yes proceed with the rest of the questions)

25. a) If yes, for 24b or c do you sometimes defaecate near the bathing site before bathing or swimming Yes _____ No _____

b) Or do you sometimes defaecate elsewhere i.e. toilet before going to bathe or swim Yes _____ No _____

26. If either b and c is yes, how far in relation to the river, stream or pond? Less than 5 metres ____ Between 5 - 10 metres _____ More than 10 metres _____

27. Do you normally go straight to bathe after defaecating either near bathing site or elsewhere Yes _____ No _____

28. If no, after how long do you usually go to bathe?

Between ½ hr. - 1 hr. _____ Between 1 - 2 hours _____

After 2 hours _____

29. If yes, do you normally wipe yourself anyway before bathing?

Yes _____ No _____

30. If no, why not? Because I will clean myself during bathing _____

Too young to bathe _____ Othes (specify) _____

APPENDIX 4.3b

INSTRUCTION SHEET ON INDIVIDUAL QESTIONNAIRE ON LATRINE USE AND DEFAECATION BEHAVIOUR

1. INTRODUCTION

1. Request if you are welcome in the household. Introduce yourself and whoever you might be with. Explain the purpose of the study i.e. to collect more information on latrine use and defaecation behaviour in order to be able to give proper future advice on how to control diseases associated with feacal contamination such as bilharzia. Emphasise that the answers given will be very confidential.

2. INTERVIEW

2.1. General: Make sure that you read and understand the questionnaire and this instruction sheet before hand. Make a tick in pencil for answers or write in pencil whatever information is requested for. For young children interview the mother. Leave out children under 1 year.

2.2. Questions: 1-6 can be filled from the original book containing demographic information on all households in the village.

Question 8 - years of formal education - ask specifically how many years spent learning. If adult education - still write number of years and indicate "adult". If no education at all - write zero (0).

Question 9 - apart from asking the questions - inspect the compound to verify if there is a latrine or if there is none.

Question 10 and 11 - It is important to get the right answer here. We are interested in direct use of toilet and not indirect use i.e. children defaecating elsewhere and feaces being collected to be taken to the toilet later.

For indirect use, the answer to question 10 is not at all.

Question 11 - you may come across a group of persons who are simply not interested in using toilet facilities. This will come under Any other (specify). Find out whether apart from not interested they see the need anyhow. The answer will be see the need but not interested or just not interested and this will come under Any other (specify).

Question 12 - There should be only one tick along a,b,c,d and e except when any of the questions does not apply to the person in which case there should be no tick at all against any of the questions. A good example is those not going to school. Indicate compound under Any other.

Question 13 - This question is linked with question 10. Remember a person can be aware of the advantages of having and using toilet facility but still do not see the need or is not interested. For children 6 years and below the answer to 13(a) should be generally under age. For 13(b) - try to summarize answers given i.e. to avoid contacting diseases, to maintain cleanliness in the compound etc.

Question 14 - Mostly school children will have been tought about advantages of using toilet at school. The adults have learnt this elsewhere i.e. baraza etc.

Section B (Defaecation habits)

Question 15 and 16 - main diet and main meals i.e. breakfast, lunch and supper or dinner. Do not include other meals which may be taken at other times. People generally eat only 3 meals a day but some may omit lunch or breakfast or both.

....3/

Main diet should be what is normally taken for more than 50% of the time.

Question 17 - implies defaecating normally in the sence that there is no diorrhea (more than 3 stools) or constipation.

Question 18 - add other complications i.e. diorrhea with blood etc.

Question 19 - more specific - to get information on frequency of defaecation. Dont simply ask during the last 24 hours. Instead ask since the same time (i.e. the time you are interviewing) yesterday.

Question 20 - Times for defaecation - if they remember the exact times to the nearest 1 hour - fine if they dont know just put early morning - late morning - early afternoon - late afternoon and during night time. For the purpose of this study early morning between 10.01 and 12 noon; early afternoon 12.01 to 2 p.m. late afternoon 2.01 p.m. to 6.30 p.m. and night - during darkness.

Question 21 - Same to question No.19 but more general.

Question 22 - Sensitive - frame it in a polite way especially a male interviewing an older lady.

Question 23 - Again referring to what is used mostly. Some people may be using both but only tick what is used mostly.

Question 24 - The word directly means bathing inside the river or water body and does not for example mean taking water with a bucket and bathing near the river. This may be common with mothers bathing their young children.

Question 25 - Remember the question emphasizes on defaecating sometimes before bathing and not defaecating always before bathing. You can have a positive answer for both a and b.

...4

Question 26 - 30 - are straight forward. Some people can still defaecate in latrine at home and go to bathe in a nearby water body in which case you should still indicate distance.

3. CHECKING QUESTIONNAIRE

To avoid qoing back to the compound for whatever question may have been forgotten, thoroughly check the questionnaire before leaving the compound. This you should do before filling your name and writing the date.

NB: Always remember to say "thank you" at the end of every questioning.

APPENDIX 4.4

Symbols used in scatter diagrams

Symbol	Frequency of observations
A	10
B	11
C	12
D	13
E	14
F	15
G	16
H	17
I	18
J	19
K	20
L	21
M	22
N	23
O	24
P	25
Q	26
R	27
S	28
T	29
U	30
V	31
W	32
X	33
Y	34
Z	35
*	36+