EPIDEMIOLOGY OF HUMAN INTESTINAL PARASITES IN QWA-QWA, SOUTH AFRICA

by

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FRONTISPIECE

View over Qwa-Qwa from Makhabane primary school at 2200m altitude - the highest rural community in South Africa.

ABSTRACT

This study investigated the prevalences and intensity of intestinal parasites and aspects of their epidemiology among children in the Qwa-Qwa region of the eastern Free State. Faecal samples of 1180 children differing socio-economic status from nine schools at altitudes varying from 1660m to 2200m were examined quantitatively by means of the formol-ether sedimentation technique. Socio-economic, and demographic characteristics for the communities served by the schools were obtained from the literature and from a questionnaire.

The study showed that, the area supports a markedly low diversity of parasite infections, and at lower intensities, than low-altitude areas such as the coastal plain of KwaZulu-Natal and Eastern Cape, the Northern Province, Mpumalanga and the Western Cape. The intestinal parasite fauna affecting children in Qwa-Qwa is dominated by protozoans with only few helminths and no hookworm or bilharzia.

The results indicated that factors which influence the transmission of intestinal parasites in Qwa-Qwa appear to be related primarily to social, economic and cultural aspects of the peoples' lifestyles. Climatic factors were not found important. There was a significant seasonal effect on the intensities of all parasite infection, except two protozoans, *Entamoeba coli* and *Endolimax nana*.

Water source, electricity, house-type and quality of meat were found to be the important socio-economic factors that influenced parasite transmission. These relationships were investigated by fitting logistic regression and generalized linear mixed models.

By documenting human parasitism (above 1700m) this study provided an endpoint to the altitudinal transect conducted in 1993 in KwaZulu-Natal by Appleton and Gouws (in press). Public health authorities and Primary Health Care personnel should find this study useful when designing and implementing nutrition and parasite control. Severe ascariasis has been reported from the study area. It will help focus PHC activities in Qwa-Qwa and in the wider context of Free State Province by demonstrating the value of proper personal and environmental hygiene in the home, thereby forming the basis for intestinal parasite control at the community level.

PREFACE

The research work described in this dissertation was carried out in the Department of Zoology and Entomology, University of Natal, from January 1994 to December 1995, under the supervision of Professor Chris C. Appleton.

These studies represent original work by author and have not otherwise been submitted in any form for any degree or diploma to any University. Where use has been made of the work of others it is duly acknowledged in the text.

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Chapter 1

INTRODUCTION

1.1 Introduction

The epidemiology of human intestinal parasites at high altitudes in South Africa has not been researched. This study aims to determine the effect of environmental, socio-economic and socio-cultural factors on the epidemiology of intestinal parasites in South Africa with special reference to Qwa-Qwa. The study area lies between 1600 and 2200m altitude and is the highest densely inhabited part of South Africa. It also forms an endpoint to the altitudinal transect conducted in 1993 in KwaZulu-Natal by Appleton & Gouws (in press).

Intestinal protozoans and nematodes have become adapted to practically all types of environment. Their cysts and eggs They are able to adjust to a wide range of temperatures, pH, salinity and nutriment. Moreover, species that secrete a thick, relatively impermeable cyst wall, are able to survive long periods of desiccation (Beaver et al., 1984).

Parasitic infection of human bowel is a world-wide phenomenon. *Ascaris lumbricoides* and *Trichuris trichiura* are the commonest. Stoll (1947) estimated that one person for every four, all over the world, was infected with the common roundworm and whipworm infected about 350 million people, both estimates still hold at the present time.

In 1964 the World Health Organization (WHO) suggested that in assessing the relative importance of helminths and the desirability of introducing control programmes and feeding schemes, and understanding the population dynamics and epidemiology of infectious disease agents was necessary (Anderson and May, (1992) and Ukoli, (1984). The factors of primary importance are those which affect transmission. The combined effects of these factors determine the distribution and prevalence of the parasites at any given time and place (Ukoli, 1984). Appleton and Kvalsvig (1994) support this concern noting that little is known of the geographical distribution of human intestinal parasites in South Africa. They point out that KwaZulu-Natal is the best documented province with regard to information on the prevalences and intensities of gastrointestinal parasitism. Remarkably little is known however about the actual routes of parasite transmission in these areas.

Surveys done during the last few decades were almost always on an *ad hoc* basis and thus cannot usefully be compared with one another. The study therefore represents the first detailed assessment of the prevalences, intensities, distribution and transmission routes of intestinal parasites in a defined area in South Africa. The only other study which investigated transmission routes was the one conducted by Mqoqi (1993) on urinary schistomiasis in the former Transkei.

A moment's thought on any disease reveals the truth that transmission rates combine many biological, social, and environmental factors and the best way to measure transmission is to examine these factors indirectly (Brown, 1969).

Many species of intestinal parasites have complex life cycles involving developmental stages that live in soil (cysts, ova and helminth larvae) or water (protozoan cysts and helminth eggs), or use various kinds of intermediate hosts, including invertebrates like insects, snails and vertebrates like pigs, rats and cattle (Beaver et al., 1984).

Crompton et al. (1989) explained two ways (direct and indirect) by which intestinal parasites can be transmitted.

1. Direct transmission involves the infective stages (egg or cyst) of parasites passing directly from one host to the next. Examples are all the intestinal protozoan, and nematodes. The latter include *Enterobius vermicularis*, *Trichuris trichiura* and *Ascaris lumbricoides*. The life-cycle of *E. vermicularis* follows the direct-faecal-oral route while those of *T. trichiura* and *A. lumbricoides* follows the faecal-soil-oral route. None of these parasites need an intermediate host. Hookworm and *Strongyloides* produce free living larvae which also have to develop outside the host.
2. Indirect transmission involves the infective stage passing through one or more intermediate hosts in order to complete its life cycle. *Plasmodium falciparum*, which causes malaria, needs the mosquito to complete its life cycle and *Schistosoma* needs a snail in which to produce its infective stages (cercariae).

Winbald and Kilama (1992) stress that while viruses, bacteria, protozoans and worms can be spread through direct contact as well as indirectly via food, water and soil or via mechanical vectors like flies and fleas. Protozoan diseases like amoebic dysentery and giardiasis and worm infections like ascariasis, trichuriasis and pinworm are transmitted through faecally contaminated food or drink.

The principles of ecology apply as much to parasitic organisms as to others, because epidemiology is the study of factors affecting the distribution and transmission of human parasitic diseases. Thus water, flies, soil and raw vegetables may be vectors for a variety of parasitic diseases especially those found in the present study area. A high degree of environmental contamination with eggs of *Ascaris* can result in their being found on the following sites in addition to soil and sewage: door handles, wash basins, furniture, dust in houses and transport), fruit, vegetables, pickles, insects, chopping boards, public baths, paper money, nail dirt, fingernails, nasal discharge, underclothes, coins and school rooms (Crompton et al, 1989). Viable pinworm eggs have been found in the following locations: bed linen, towels, furniture, windowsills, doorjambs and dust about the house (Beck & Davies, 1976; Beaver et al., 1984 and Ukoli, 1984).

Parasite prevalences are determined not only by the combined effects of ecological and climatic factors and their vectors, but human behaviour, cultural practices, customs and traditions, and

parasite

their socio economic situations can also play a part (Most, 1951; Horton-Smith, 1957; Jeon, 1973; Crompton et al., 1989; Holland et al., 1988; Edungbola et al., 1988; Kirkby, 1988; Watts, 1986; Pammenter, 1988; Kirky, 1988; Chandiwana, 1986; Piekarski, 1989; Iputo et al., 1992; Greenberg, 1993 and Sarti et al., 1994). However the ecological and climatic factors are by far the most important. It is therefore not surprising that many control programmes in the past have sought to eliminate vectors such as mosquitoes in the case of malaria or snails in the case of schistosomiasis and so prevent them from transmitting disease. It is because of the apparent failure of these approaches to achieve control that (Dunn, 1979; Holland et al., 1988 and Watts, 1993) have suggested that attention should be focused on the effect of socio-economic and socio-cultural factors as well. The chances of infection by parasites increase when the climate favours the survival and development of infective stages like eggs and cysts outside the primary host. In the case of South Africa this is most likely in KwaZulu-Natal, Mpumalanga and the Northern Province.

There is an important temperature difference between air and ground (Geiger, 1950). Wind effects generally ensure that temperatures will be more extreme close to the air/ground interface than above it. The transmission potentials of intestinal parasites with complex life cycles (e.g bilharzia, hookworm) are influenced by the temperature of the water and/or soil in which they are transmitted. Water, air and soil temperature can for example induce substantial changes in life.

expectancies of free living infective stages, such as L3 (third larval stage) of hookworms or the miracidia or cercaria of schistosomes (Anderson and May, 1992).

The eggs of hookworm, pinworm, and *Schistosoma* have transparent shells. For these eggs to hatch they need a warm climate to be able to develop quickley. Pitchford (1981) found that distribution of *Schistosoma* could be correlated with certain air temperature regimes.

Beaver et al. (1984) and Anderson & May (1992) concluded that high temperatures usually induce rapid parasite development and *vice versa*. According to Learmonth (1988) larval transmission of hookworm, which occurs via the skin of bare feet on damp ground polluted with infected faeces, is especially favoured in warm, humid climates and where there is decaying vegetation. One of the features responsible for the success of nematodes is the structure and chemical composition of their egg shells. This allows development of the embryo to occur even at low temperatures, Ukoli (1984). *Ascaris* is the more common in humans than any other helminth (Stoll, 1947). It is a cosmopolitan intestinal parasite, and the largest roundworm found in humans and also the most widespread. One feature which has a profound influence on the epidemiology of this parasite is its eggshell which is tough, light and adhesive. It also allows development of the embryo under adverse environmental conditions and can survive in the presence of chemicals like ether and formalin, both which are lethal to other parasite eggs like *Schistosoma*, hookworms and

Strongyloides (Crompton et al., 1989). If conditions are unfavourable for development of the larva the egg can lie dormant for a period of up to six years (Muller, 1953 in Crompton et al., 1989). The *Trichuris* egg becomes fully embryonated after 3½ weeks at 26°C and remains infective for 4 to 4½ weeks at this temperature, high rainfall and humidity, dense shade and in moisture retaining soil (Schimdt & Roberts, 1985; Cheesbrough, 1991; Garaguso, 1981; Beaver et al., 1984; Fullerborn, 1923 in Anderson, 1992).

Another factor that contributes to the success of nematodes is their high productivity of transmission stages which offsets the low probability that any one infective stage gains entry to a new host. *Ascaris* is didelphic and each female is capable of laying up to 200 000 eggs per day, *Trichuris* is monodelphic and lays 10 000 to 30 000 eggs per day. It has been estimated that each female contains 4572 - 16 888 eggs. After laying the eggs she perishes (Beaver et al., 1984 and Anderson, 1992)

The major diseases transmitted through water are schistomiasis, amoebiasis and giardiasis (Winbald & Kilama, 1992 and Meyer, 1992. Transmission of these parasites can occurs directly via the faecal-oral-route, ingestion of contaminated food, person to person contact and also by consumption of contaminated drinking water. Sophisticated water supply systems may also be contaminated and result in urban epidemics of amoebiasis; such as an outbreak at the Chigago World Fair during the 1930s, resulting in approximately 100 deaths. Most of these epidemics were brought about by faecal contamination of faulty water-supply systems, since routine chlorination as employed in modern city waterworks does not destroy the cysts of *Entamoeba histolytica* (Beck & Davies, 1976). These cysts succumb readily to desiccation and high temperatures however (Beaver et al., 1984). The cyst of *Giardia intestinalis* may according to Meyer (1990), survive in water for up to three months but they are also highly vulnerable to desiccation and temperature of ≥50°C. They may survive in a watery or faecal sample. Studies in Nigeria by Edungbola et al., (1988) and Watts (1986) showed that a village, protected boreholes helped in controlling guineaworm diseases while unprotected ones facilitated transmission.

Interaction between parasite and host in general depends to a considerable extent on the nutritional state of the host (Anderson & May, 1992). The high incidence of amoebiasis in the tropics is attributable chiefly to poor sanitation (Beck & Davies, 1976). According to Ukoli (1984) and Winbald and Kilama (1992), transmission is associated with a low level of sanitation in which food and water are very easily contaminated with human faeces. Poverty and ignorance combine to inhibit adequate treatment and purification of food and drink. Amoebiasis is also highly endemic in areas with good sanitation in temperate zones. People here may be asymptomatic while prevalences are high. This can be explained by the degree of resistance by the infected host and the good nutritional state and general good health of these people who live under generally high socio-economic conditions Kirkby (1988). A poorly nourished child or individual will usually be more susceptible to infection, slower to mount an effective immune response and more likely to die of severe infection, than a well fed host. Studies on human gastrointestinal parasites in malnourished human communities have shown repeatedly that even light infections contribute to the host's nutritional deficiencies and this has been confirmed by Crompton et al. (1986). Parasitism contributes directly to malnutrition, which in turn reduces resistance to infection. Polyparasitism may be caused by undernutrition, malnutrition and even starvation (Ukoli, 1984).

Most helminthic infections are the results of human activities. Stratification by age is of significant importance since age reflects time; changes in prevalences with the hosts' age therefore represent the rate at which individuals acquire infection (i.e. the force of transmission) Anderson & May, (1992). Children playing in yards close to the house, frequently show a high incidence of soil transmitted parasites in endemic areas, because of contact between their invariably dirty hands and their mouths. In areas where night soil is used as fertilizer, infections are transmitted by eating raw vegetables. The severity of disease is determined by the extent to which man pollutes his environment with his own excreta (Meyer, 1990).

Education generates the capacity in the people to seek solutions to their own problems. Schimdt & Roberts (1985) have suggested that there is very little hope of eliminating the vast amount of helminthic diseases from the world without drastic changes in human behaviour. Holland et al. (1988) reported that *Ascaris lumbricoides* occurred more frequently in children who resided in relatively crowded areas and whose mothers had minimal formal education. Holland (1989) also discovered in Nigeria that the prevalences of single and multiple helminthic infections were higher in children living in houses made of wood or bamboo than in those living in houses built in concrete blocks.

Ukoli (1994) pointed out that diseases thrive where there was poverty and ignorance. He suggested that there was a need to adjust the imbalance in the socio-economic order and provide reasonable environmental quality especially in rural areas. Watson (1978) went as far to say that parasitic diseases probably contribute most to the retardation of socio-economic development.

Chapter 2

LITERATURE REVIEW

There is a great lack of information on the prevalences, distribution and economic consequences of intestinal parasite diseases in South Africa. This fact, which was recognized more than a decade ago by F.M.A. Ukoli, a Nigerian parasitologist, in his book on parasitology in tropical Africa (1984), does not seem to have been accepted by the National Department of Health in Pretoria. Such information is vital before any steps can be taken to introduce control measures at either the national or regional level. At present, KwaZulu-Natal is by far the best researched province in the country from the parasitological point of view but even here the numerous surveys carried out during the 1970s and 1980s were not done in a planned way so that they are of limited value. This has recently been corrected by the development of a method of combining altitudinal transect surveys and Geographical Information Systems to produce maps of parasite distribution (Appleton & Gouws, in press; Appleton & Kvalsvig, 1994).

For the purpose of this review, the South African landmass is divided into several altitudinal regions. These are dominated by the highveld plateau which is separated from the lowlands to the north, east and south by the Drakensburg mountains. This latter includes much of the present study area, Qwa-Qwa, and the Kingdom of Lesotho. Few parasite studies have been done on the highveld plateau; most were done, as noted above, on the coastal plain of

KwaZulu-Natal. A smaller number has been done in the Western Cape (Cape Town), with one-off studies in other provinces such as the Eastern Cape (Transkei/Ciskei and Port Elizabeth), the northern Cape and the lowveld of Mpumalanga and the Northern Province. This review will collate relevant reports first for the lowlying areas and then for the higher altitudes.

KwaZulu-Natal is, according to the available data, the province most seriously affected by intestinal parasites, probably followed by Mpumalanga though this cannot be stated for certain. Within KwaZulu-Natal, the coastal plain is the worst affected area since infection rates of the common nematodes (*Trichuris trichiura*, *Ascaris lumbricoides*, *Necator americanus*, and *Strongyloides stercoralis*) decrease with increasing altitude and in the case of *N. americanus* and *S. stecoralis* with increasing south latitude as well (Appleton & Gouws, in press; Appleton & Kvalsvig, 1994). The present study in Qwa-Qwa allows the altitude transect on which these trends are based to be extended beyond the limit of ±1700m in the Drakensberg foothills (Appleton & Gouws, in press) to 2200m. Thus we can now see a pattern of decreasing prevalence of, for example *A. lumbricoides*, from ±70% on the KwaZulu-Natal coast to ±4% at an altitude of 2200m in the Drakensberg mountains and *T. trichiura* from ±80% on the coast to zero above 1990m. Hookworm (*N. americanus*) and *S. stecoralis* are prevalent (>±30% and >2% respectively) only along the coastal plain of KwaZulu-Natal to about 200m altitude. Prevalences of these two helminths also decline with increasing south latitude from ±90% and ±10% close to the Mozambique border in the north to

±45% and <1% respectively near the Umzimkhulu river in the south (Maurihungirire, 1993).

These patterns are supported by surveys done along the coastal plain by Schutte et al., 1977; 1981). A study at Umkomaas on this same plain (Kirkby, 1988) confirmed what is already assumed, that black children constitute the great reservoir for these parasites. Kirkby (1988) attributes these high parasites loads to inadequate housing, lack of piped water supplies, poor general hygiene and ineffective/non-existent sewerage and suggests that a deworming programme would have little effect.

Protozoan parasites are also common but generally do not show altitude-related distribution patterns. An exception is the amoebae *Endolimax nana* which seems to be most common at higher altitudes in man (Appleton & Gouws, in press).

Little is known about the effects of the high infection rates of these geohelminths recorded in KwaZulu-Natal. Complications of ascariasis undoubtedly occur and frequently present as intestinal obstructions (i.e bolus formation) which may have to be removed surgically. Bradely & Buch (1994) reported seven such cases within a 14 month period at a hospital in KwaZulu-Natal midlands and the present study recorded one in Qwa-Qwa (Dr J.S. Moloi, Manapo Hospital, Phuthaditjhaba, personal communication). Cysticercosis, due to infection by larval *Taenia solium*, occurs in KwaZulu-Natal but is rare, particularly in the north-eastern part (0.2%) (Pammenter et al., 1987).

Further south in the Eastern Cape Province, the few data that are available show that in the former Transkei, several helminth species are present (*T. trichiura, A. lumbricoides* and *Hymenolepis nana*). Van Niekerk et al., (1979) found an overall parasite infection rate of 97.0%. *Trichuris* was the commonest with prevalence of 89.9% followed by 71.0% *Ascaris* in Guguletho children and 32.0% *Trichuris* in Tsolo children and 23.0% *Ascaris*. The former Transkei and Ciskei are "hotspots" for cysticercosis and Pammenter et al., (1987) estimated a prevalence of 2.5% for these areas. In the Port Elizabeth area, high prevalences were again encountered more in coloured than black school children living in the area served by Livingstone Hospital (Freeman & Grunewald, (1978). They recorded 57.0% *T. trichiura* in coloured chidren than 36% in black children. Prevalences for *A. lumbricoides* in coloured and black children were 55.0% and 41.0% respectively.

Several surveys have been done on the Cape Flats near Cape Town, Western Cape; a sandy area with a high water table and much poverty. Millar et al. (1989) reported an overall parasite infection rate of 45.6% amongst children from Mitchell's Plain. *Trichuris trichiura* was present at 30.7%, *A. lumbricoides* at 27.7% and *Giardia intestinalis* at 7.9%. *Enterobius vermicularis* was also present, but was not quantified. Gunders et al., (1993) reported an infection rate in pre-school children of 54.0% due largely to *T. trichiura* and *A. lumbricoides* at 36.6% and 33.9% respectively. *Hymenolepis nana* was present but uncommon (<6.0%)

as was *Enterobius vermicularis* though, again, its infection rate was not quantified. Another study (Bester et al., 1993) showed considerably lower prevalences, *Giardia intestinalis* 14.3%, *T. trichiura* 4.2%, *A. lumbricoides* 4.1% and *H. nana* 0.2%. A surprising result was the unusually low rate of *Entamoeba coli*, viz 2.7%. In the only estimate of *E. vermicularis* infection done in South Africa, Leary et al., (1974) used the "Scotch tape" method and reported prevalences between 26.0% and 38.0%.

The only study done to date in the semi-arid Northern Cape (Scaaf et al., 1989) showed prevalences of parasitism in school children to be low, 3.0% and 2.0% for *T. trichiura* and *A. lumbricoides* respectively. Low infection rates are perhaps to be expected in arid climates where eggs and cysts will be subject to severe desiccation, but the finding of a prevalence of 21.0% for *Giardia intestinalis* is interesting. This and the 23.0% reported from Lesotho (Esrey et al., 1989 - see below) are the highest yet reported for *G.intestinalis* from South Africa.
Few data are available for the Northern Province either. The only published report is that by Roodt et al., (1995) who examined adults only. The fact that only adults (>19 years) were sampled probably explains the low prevalences of most parasites normally regarded as common in children, viz: *A. lumbricoides*, 0.8%, hookworm (reported as *Ancylostoma duodenale*), 0.2%, *Taenia* sp., 4.4%, and *Giardia intestinalis*, 0.6%. Two species, both classified as commensals by most textbooks, *Entamoeba coli* and *Blastocystis hominis*, infected 50.4% and 30.8% respectively. This is the only published report of *B. hominis* from South Africa but

it is undoubtedly much more common and widespread. Its absence from other studies is probably due to a lack of familiarity with the morphology of its cysts by microscopists.

In Mpumalanga Province, parasitism by helminths was investigated in three different environments between 1200m and 1400m, resettlement, farming and urban, by (Evans et al., 1987). Generally, the spectrum of parasites recorded and their prevalences were similar to those in KwaZulu-Natal at comparable altitudes. The prevalence of *Ascaris lumbricoides* was highest in the urban environment (22.7%), *T. trichiura* was uncommon in all three, with maximum of 3.7%, also in the urban setting as was hookworm (not identified) and *Strongyloides stercoralis* at 22.7% and 5.3% respectively. Tapeworm infections were most frequent in the resettlement and urban areas; an unidentified taeniid reached a high prevalence of 9.0% in the former while *H. nana* was equally common, 3.8% and 3.7% in both.

The mountainous highlands of Lesotho represent a distinctive region and the survey by Kravitz et al., (1993) showed that helminthic infections were very rare, <1.0%, while prevalences of protozoan are not dissimilar to those recorded in other parts of the subcontinent. An earlier study by Esrey et al., (1989) reported an alarmingly high prevalence of *Giardia intestinalis*, 23.6% in the rural areas of that country. Esrey et al., (1989) concluded that it was not the quality of water that played a primary role in giardiasis transmission, but the amount of water used for personal and domestic hygiene.

Chapter 3.

THE STUDY AREA

3.1 Introduction

Figure 1 (Vrey and Smith, 1980) shows Qwa-Qwa in its provincial context. Qwa-Qwa is situated between latitudes 28° and 30° south and longitudes 28° and 30° east. It is bounded to the south by Lesotho and by KwaZulu-Natal on the east. Qwa-Qwa is in the north-eastern Free State, called region C by Erasmus (1991).

The estimated population of Qwa-Qwa was 342 400 (Central Statistical Services, 1991), and is the third largest district, following Bloemfontein and Welkom in the province. The district covers an area of 655 km² and had population density of 282 persons per km² and a growth rate of 5.8% from 1985 to 1990 (Erasmus, 1991). Of this total, 29 000 lived in urban areas and the remainder in semi-urban and rural areas (Central Statistical Services, 1991). There were 293 300 Africans (151 550 males and 190 850 females) the rest were Asians, Whites and Coloureds.

3.2 Topographic and climatic factors

Data are available on several physical factors, e.g topography, rainfall, environmental temperature, sunshine, relative humidity, wind, frost and soil types. It is necessary to describe these because many parasites recorded from Qwa-Qwa have stages, either cysts or eggs, which have to survive periods of time outside their hosts, i.e in the external environment, and are thus

QWAQWA

LOCATION WITH REGARD TO ADJOINING AREAS AND TRAFFIC ROUTES

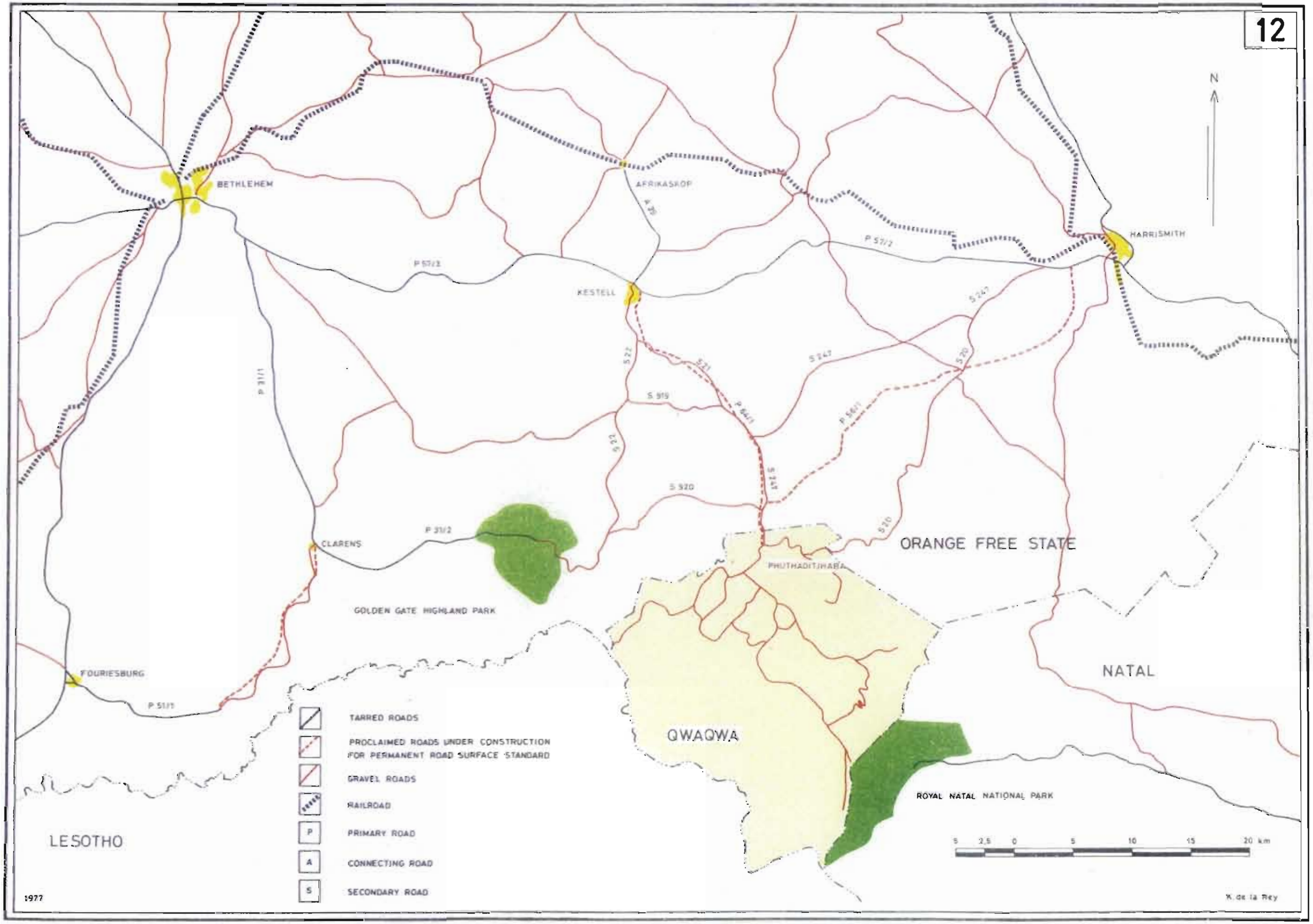


Figure 1. Qwa-Qwa in its National context.
Extracted from Vrey and Smith (1980).

subject to climatic stresses. It is not possible to discuss transmission of these parasites without a knowledge of the environmental variables their free living stages have to withstand.

3.2.1 Topography

Qwa-Qwa is predominantly mountainous and forms part of the Drakensberg mountain range (see Frontispiece). Mountains rising to altitudes of 1500m and 3000m above sea level and the southern and south-western boundaries of Qwa-Qwa are formed by the Drakensberg mountains and Caledon River respectively. Figure 2 (adapted from Vrey and Smith, 1980) indicates the gradients of the slopes in Qwa-Qwa. It is clear from this that the bulk of the area is rocky which means that urban development is restricted to areas with gradients below 1:7.

3.2.2 Rainfall

Qwa-Qwa receives its main rainfall during summer. In the low-lying central area the average annual rainfall of 700-800 mm falls during the months of October to March (data from Weather Bureau, Pretoria, 1995) and higher up in the mountains it increases to more than 1200mm per annum. Figure 3 (adapted from Kritzinger, 1987) shows the distribution of rainfall isolines in Qwa-Qwa. Hail storms are common and occur four to five times per year. Snowfalls occur in the high lying southern region, with the heaviest falls towards the end of June.

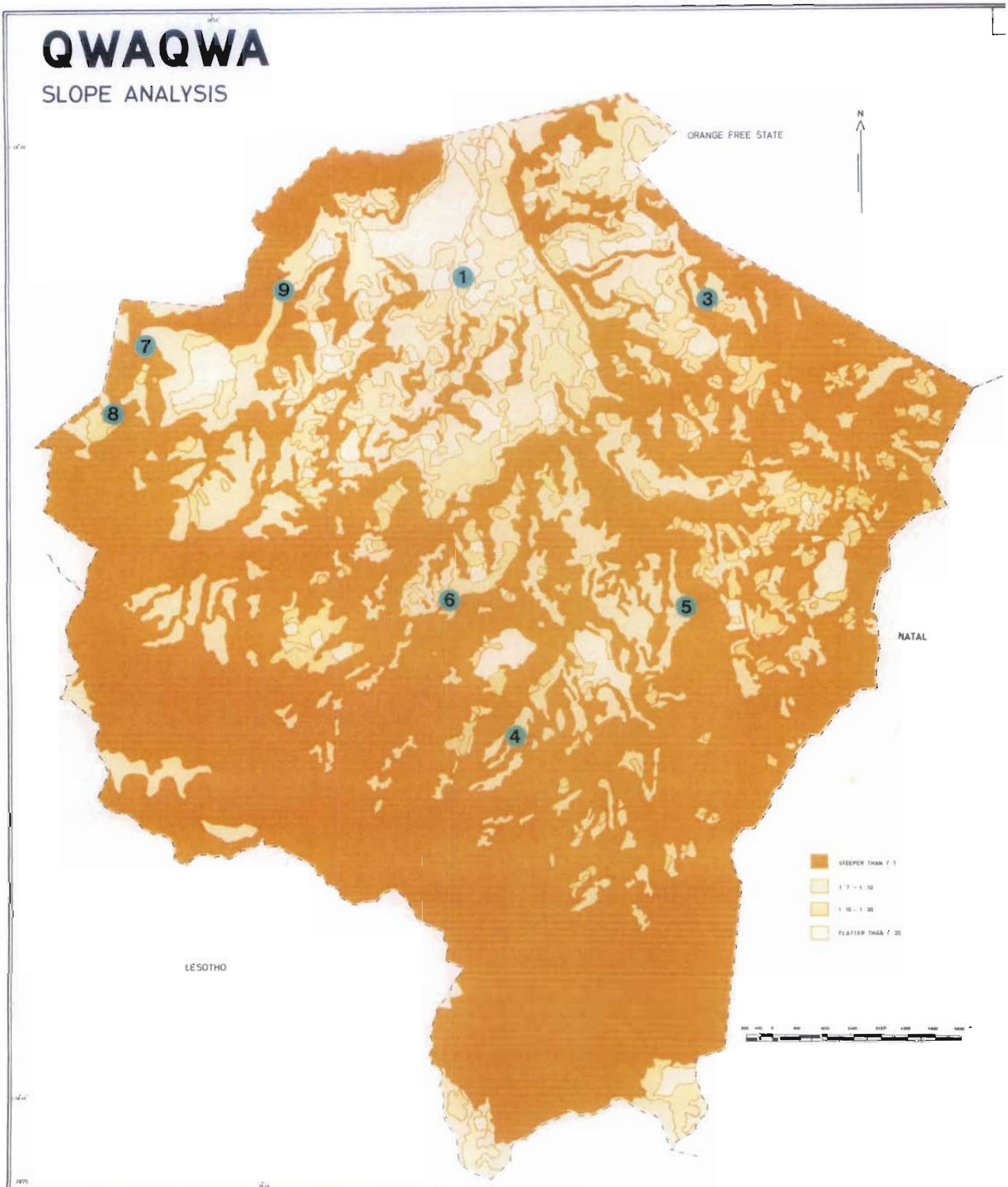


Figure 2. Map of Qwa-Qwa indicating gradients of slopes.
Adapted from Vrey and Smith (1980).
(●) represent sampling sites.

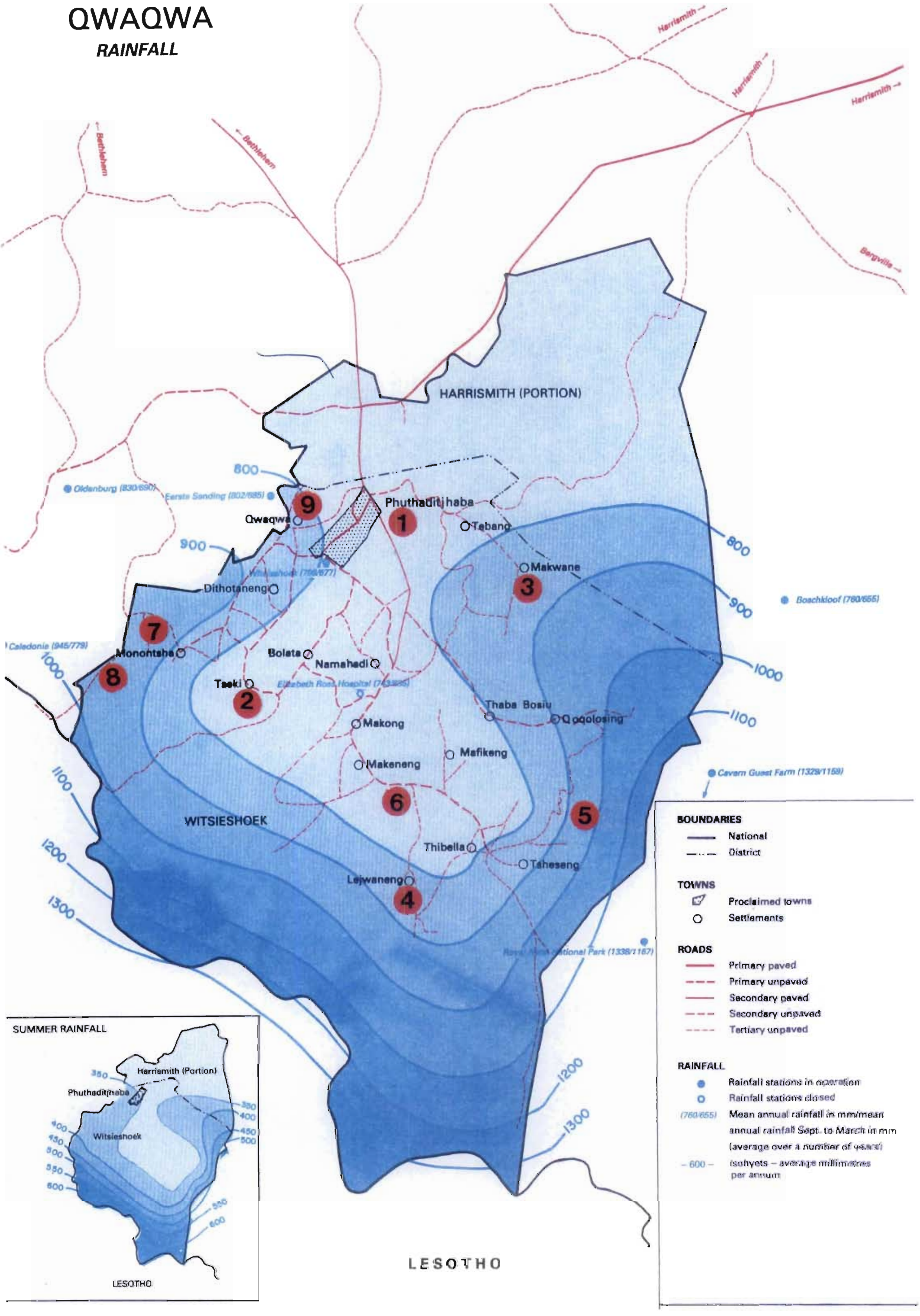


Figure 3. Map of Qwa-Qwa showing distribution of rainfall
patterns in the area. ( ) represent

3.2.3 Environmental temperature

The environmental temperature of the study area may be described as being cool to moderately warm. Daily maximum temperatures during mid-winter (July) range from -1.5°C to 15.3°C with an average of 6.9°C. Mid-summer (January) temperatures range from 12.9°C to 25.5°C with an average of 19.2°C. Cold spells, that is drops in temperature >5°C, can occur 30 times a year. Hot spells, that is increases in temperatures of >35°C, occur for four to five days per year.

3.2.4 Sunshine

Qwa-Qwa receives between 60% to 70% of possible sunshine per year: 53% in spring, 55% in summer, 65% in autumn and 75% in winter. On average, there are 10 completely overcast days per year, 35 days with ≤10% sunshine and 240 days that can be regarded as sunny, i.e with ≥50% possible sunshine.
Average annual evaporation according to the class A method measured 1750 mm in the lower lying areas, 31% in spring, 32% in summer, 21% in autumn and 16% in winter.

3.2.5 Relative humidity

The relative humidity varies between 38% to 45% during May to October and 47% to 51% from November to April. This is the result of the plentiful sunshine and relatively strong winds.

3.2.6 Wind

Wind is characteristic of very high altitudes. It aggravates the cold dry conditions by lowering surface temperatures and increasing evaporation (Irwin and Irwin, 1992).

3.2.7 Frost

The average first and last days of frost in Qwa-Qwa are 1st May and 20th September respectively, resulting in a frost period of 150 days per annum.

3.2.8 Soil types

The distributions of different soil types are shown in Figure 5. These pertain however to an area of only approximately 9 200 hectares or 18% of the total area of Qwa-Qwa. There is no information available on the rest of the region. The scale of this map (Figure 4) (adapted from Kritzinger et al., 1987) is too large to relate meaningfully to the schools in question. Further, the catchment area of these schools are not well known and consequently cannot be mapped. Properties of these soil types are explained in Table 1.

3.2.9 Flood plains

The high rainfall in Qwa-Qwa coupled with factors such as the topography causes large flood plains to develop along rivers.

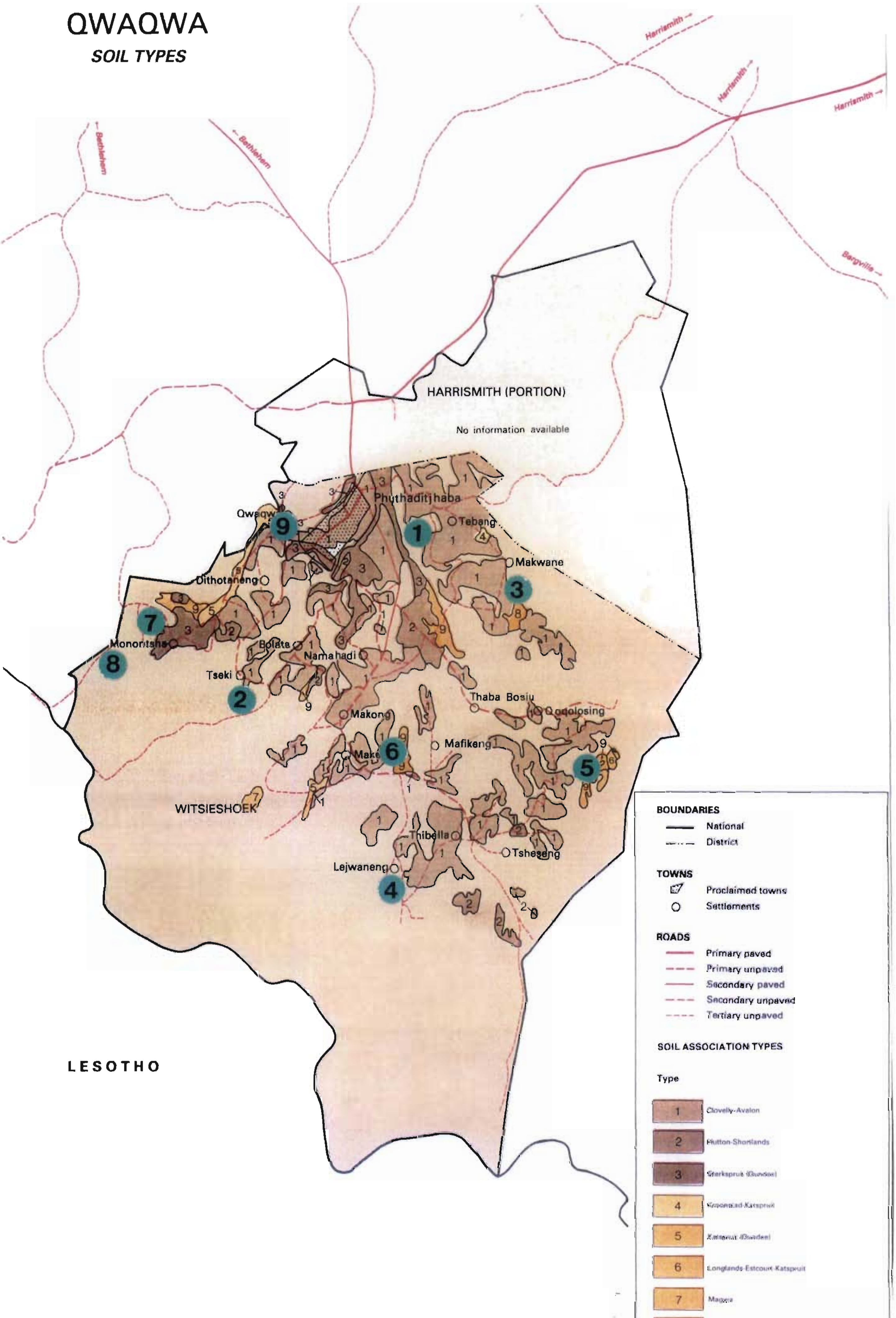


Figure 4. Map of Qwa-Qwa showing distribution of different soil

Table 1

Description of soil types in Qwa-Qwa (descriptions given by Prof. J. Hughes, Department of Agronomy, University of Natal PMB).

SOIL TYPE	DESCRIPTION
Sterkspruit	Sandy topsoil (A horizon) Clayey subsoil (B horizon)
Shortlands	Generally clayey in both A & B horizons, often > 40% clay in both more in B horizon - orchid A red, fertile, well drained indicates a dry climate.
Kroonstad	Sandy topsoil, sandy E horizon often clayey G horizon - indicates wet conditions at least seasonally.
Katspruit	Generally moderately clayey, also wet in G horizon, can be wet close to surface at times
Dundee	Variable as laid down by river
Longlands	Sandy topsoil, sandy E horizon, clayey plintic material indicates a fluctuating water table
Escourt	Sandy topsoil (if present often eroded), E horizon sandy, very strongly structured subsoil often sodic (rich in Na^+) - generally clayey
Magwa	Often a deep, black rich topsoil - clayey but well drained, acts as a sand with an organic carbon content < 2%. Yellow - brown apedal B horizon - again clayey but acts as a sand
Willowbrook	Base-rich, very fertile clay-rich. Strongly structured black, clay rich topsoil - melanic A. Wet subsoil (G horizon)
Clovelly	Brownish topsoil version of Magwa (less organic matter in Clovelly than Magwa)
Hutton	Red subsoil version of Clovelly. Both Hutton and Clovelly can have a wide range of textures from sand to clayey. Apedal B horizons indicate good drainage even if clayey
Avalon	Sandy topsoil (not always) yellow brown apedal B horizon - more clayey than topsoil, soft plintic B , clayey, indicating fluctuating water table.

3.2.10 CHARACTERISTICS OF THE SCHOOLS SAMPLED

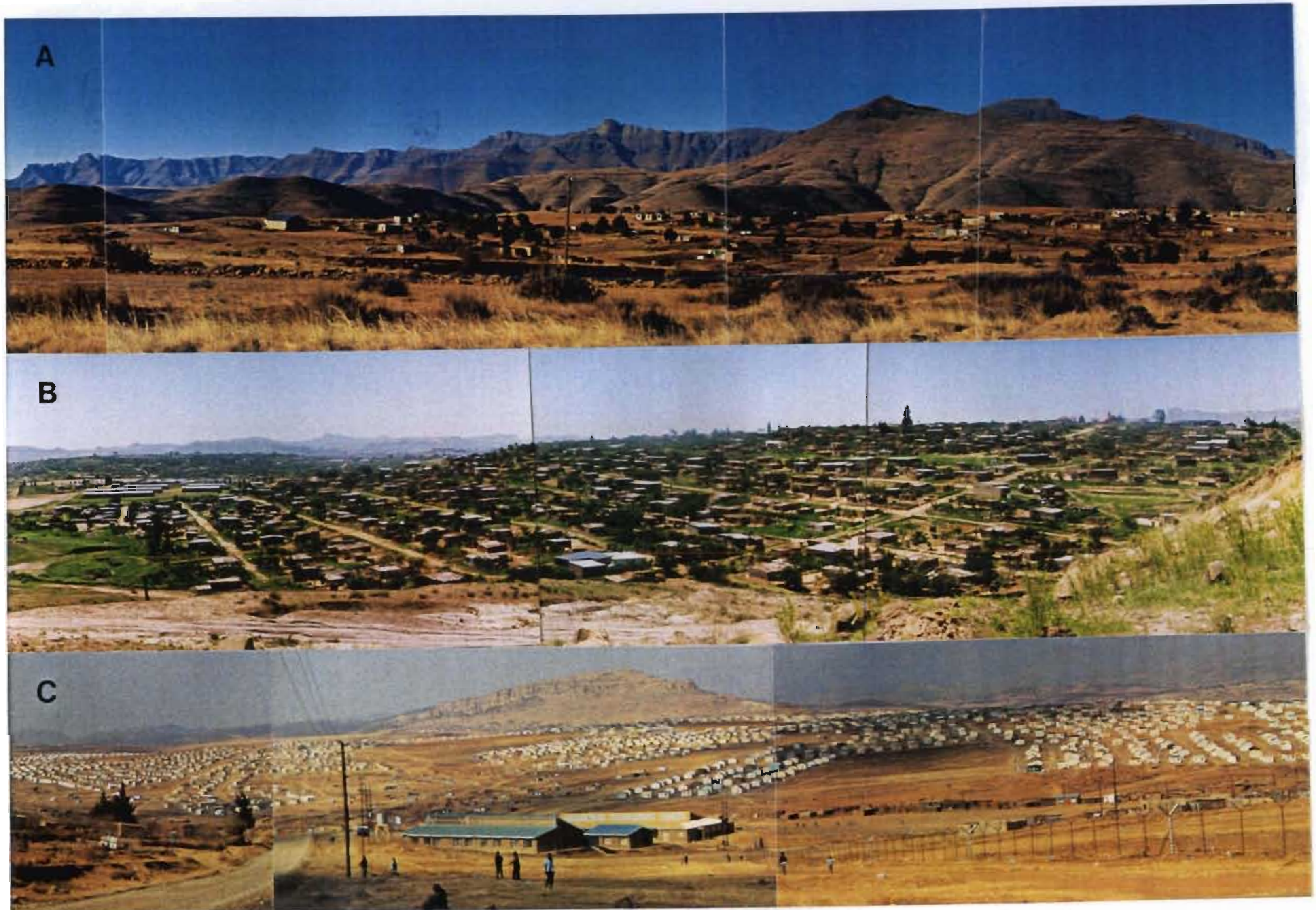
Socio eco. status

The nine schools sampled were grouped into those serving the low socio-economic and higher socio-economic sectors of the community. The former schools, Letlotlo, Mafika-ditshiu, Teboho, Makhetheng, Mohlakaneng, Makeneng, Sehlajaneng and Makhabane, served children living mostly in houses and shacks. Their homes have no electricity, proper sanitation or readily available water source. The parents or guardians of these children have household incomes of less than R600 per month and little formal education. They do not have access to medical aid schemes and do not get adequate health education when visiting local General Practitioners, clinics or hospitals. Many of them still prefer traditional healers' to western medical doctors.

Schools serving the low socio-economic section of the community were further divided according to the number of houses per km² in the areas they serve. Makhabane, Sehlajaneng, Makhetheng and Mohlakaneng are located in low density areas (0 - 10 houses per km²) (see Plate IA). These schools will be referred to as Group 1. Teboho, Makeneng, Mafika-Ditshiu serve semi-rural areas (20 -40 houses per km²) with predominantly mud houses and shacks. There are a few brick houses. These were grouped with Letlotlo which serves the urban area with >50 houses per km². Residents in this area live in small two-roomed houses or in shacks. These schools will be referred to as Group 2 (see PLATE IB and IC).

Sentinel school is the only primary school serving children whose parents are educated, have an income of >R1 000 p.m. and can afford medical aid schemes. Their houses are of brick, have electricity, piped water, flush toilets and eat graded meat. They have educated parents and live in brick houses. No children attending this school lived in either a shack or mud house. These parents however parents still visit traditional healers and still slaughter animals for their traditional customs. They also do not get any education on intestinal parasite transmission from their local general practitioners. This school was therefore used as a control.

PLATE I VIEWS OF SETTLEMENTS IN QWA-QWA



A = Low housing density (0-9 people/ha) without either sanitation or electricity.
B = High density housing (20-30 people/ha) without either sanitation or electricity.
C = Highest density housing (>50 people/ha) with latrines but no electricity.

Chapter 4

METHODOLOGY

4.1 Introduction

Cluster sampling was used to choose nine primary schools for this study (Figure 5, adapted from Vrey and Smith, 1980)), eight serving the lower socio-economic portion of the community and the one and only school serving the higher socio-economic section. The schools chosen were between 4.1km and 17.0km apart (mean 9.4km ±3.9 SD) and are listed in Table 2 with altitudes, population densities and the number of children sampled in each.

Primary schools were chosen as sampling sites rather than whole settlements for three reasons. Firstly, because it was easier for the researcher to come back for further samples from the same children. Secondly, because the school infrastructure enabled the collection the ancillary data needed, e.g. age and socio-economic data. Lastly, school children constituted the section of the population at greatest risk of parasite infection and children between the ages two to 10 years are the most co-operative. The schools selected were located at altitudes between 1660 to 2200m above sea level and are situated in the urban, semi-rural and rural areas of Qwa-Qwa (see Plate I). Permission to conduct research at schools, clinics and the hospital was obtained from the Secretary for Health and Director of Education.

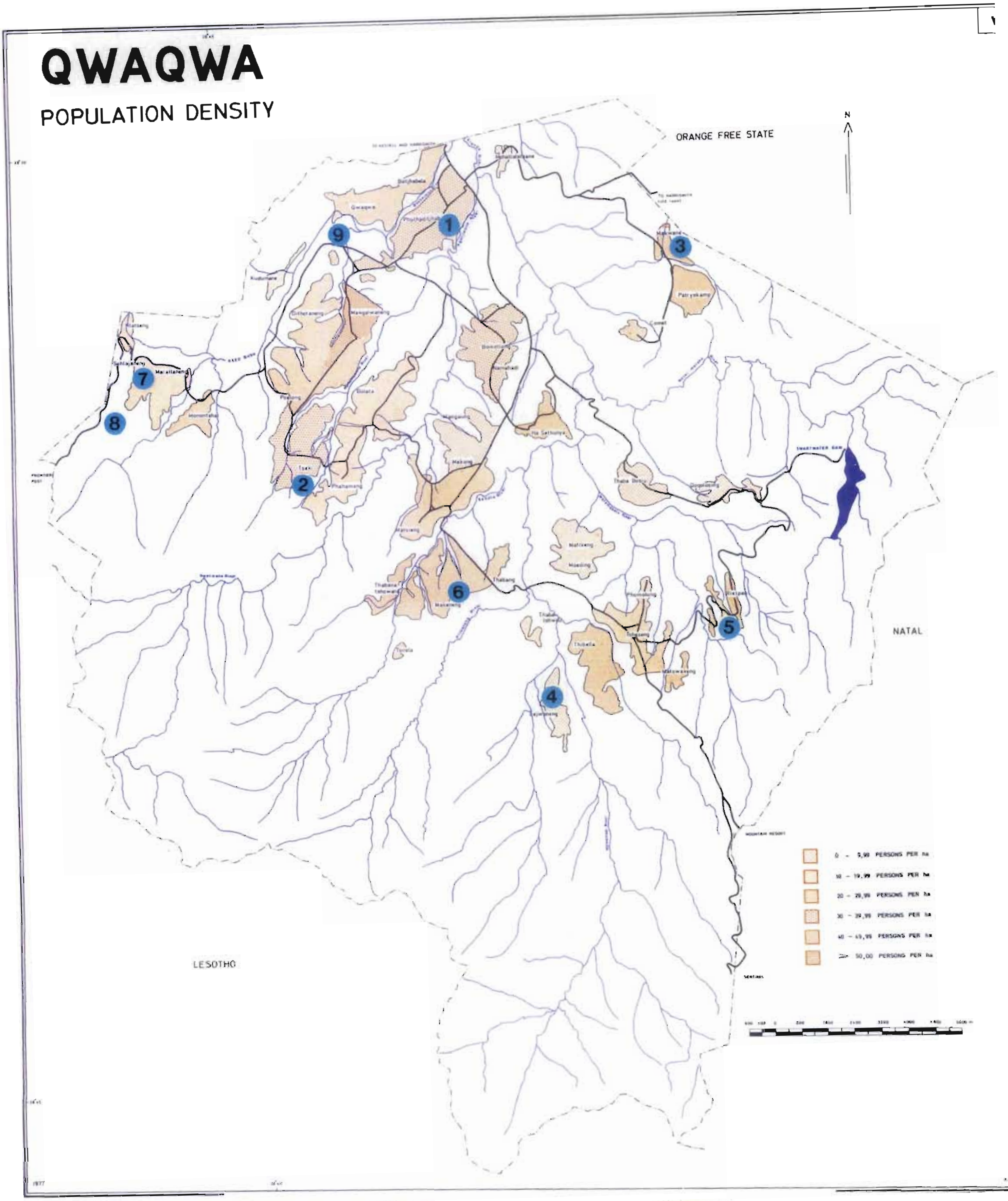


Figure 5. The study area showing settlements with corresponding schools (1-9), and indicating population densities in each settlement served by the schools (●).

4.2 Stool collection and analysis.

A total of 2583 stool samples was collected from the nine schools (see Table 2). During the mid-winter month of July duplicate samples were collected from each of the 969 X 3 children in the eight schools serving lower socio-economic communities. Single samples were collected in summer. Duplicate samples were also taken from 211 X 2 children in summer at the Sentinel School (No 9) serving the higher socio-economic sector of the community. This was used as a control school in the subsequent analysis of the parasitological data.

Once collected, samples were taken to Manapo Hospital laboratory in Phuthaditjhaba for sub-sampling, weighing and preservation. The mean weight ±SD of the samples to be analysed was 0.86 ±0.13g. The stool consistency classification and coding procedure developed at Tulane University Tropical Medicine Clinic (1948) was used to grade individual specimens from hard to watery. The weighed specimens were then preserved with 10 ml of 5% formalin, and taken to the Department of Zoology and Entomology, University of Natal, Pietermaritzburg for processing, staining and analysis.

A modified version of Merthiolate-iodine-formaldehyde concentration technique (MIF) of Sapero and Lawless (1953), was used for processing stool samples (see Appendix A).

Table 2.

Altitude [metres above see level], population density and number of samples taken in summer and winter at the nine schools {positive responses}.

Name of school (abbr) [Alt]	Polpn. densty. no/km²	No of children sampled		Total number of samples
		Summer	Winter	
1. Letlotlo (Le) [1660m]	>50	146 {129}	146 {129 X 2}	387
2. Mafika-ditshiu [1740m] (MF)	30 - 39	123 {97}	123 {74 X 2}	245
3. Teboho (Te) [1800m]	40 - 49	105 {91}	105 {76 X 2}	243
4. Makhaleng (Ma) [1800m]	0 - 9	104 {97}	104 {75 X 2}	247
5. Mohlakaneng (Mhl) [1860m]	20 - 29	120 {117}	120 {100 X 2}	317
6. Makeneng (Mk) [1990m]	20 - 29	116 {71}	116 {62 X 2}	195
7. Sehlajaneng (Se) [2000m]	10 - 19	140 {128}	140 {114 X 2}	356
8. Makhabane (Mkh) [2200m]	0 - 9	115 {83}	115 {106 X 2}	295
9. Sentinel control (Snt) [1660m]	>50	211 X 2 {149}	None	298

This procedure was used instead of the modified formal-ether concentration technique of Allen and Ridley (1970) which was widely used in previous parasitological surveys in KwaZulu-Natal, for the following reasons :

1. its simplicity and low cost of preparation.
2. its rapid (almost immediate) wet fixing and staining of both cysts and trophozoites of intestinal protozoan and of helminth eggs, and
3. its preservation qualities which allow field, home or hospital ward collections of stools to be kept in the freshest possible state.

This procedure results in the sedimentation of helminth eggs and protozoan cysts at the bottom of a centrifuge tube. This concentrate is sub-sampled using a Pasteur pipette onto a slide and examined under 400X using a compound microscope. The intensity of infection of both protozoans and helminths was determined as indicated in Table 3. The identification of these parasites was made after the author had been trained in morphological diagnosis using light microscopy by a qualified and highly experienced instructor.

4.3 Chemotherapy

School principals, the nearest clinic and the primary health care doctor were provided with a list of all children diagnosed as having pathogenic parasites and treatment was requested. Before treatment, a consent form was signed by an each child's parents (see Appendix B). Worm infections were treated with of Mebendazole (Vermox) at 100mg per dose every 12 hours for five days regardless of child's age and weight. Those who had amoebiasis were treated with Metronidazole (Flagyl) given at

Table 3

Intensities of infections was assed for helminths by calculating the number of eggs per gram stool and for protozoans by scoring the number of cysts per field of vision at 40X objective (dilution method).

Protozoans

Intensity	Number of cysts per field of vision at 40X objective	Mean in 40 fields	Standard deviation
Occasional	1 cyst every second field	0.6	0.52
Scanty	2 cysts every second field	1.1	0.99
+	3 cysts per field	2.4	0.84
++	4-5 cysts per field	4.1	0.88
+++	6-8 cysts per field	7.1	0.88
++++	Field full of cysts with little spaces between.	20.9	0.88

Helminths

(Egg-count classification for both Ascaris and Trichuris)

Scheme used for *Ascaris*

Light infection	<10 000 eggs per gram (epg)
Moderate infection	10 000 - 40 000 epg
Heavy infection	>40 000 epg

For *Trichuris*

Light infection	<2 000 epg
Moderate infection	2 000 - <7 000 epg
Heavy infection	>7 000 epg

Adapted from Ashford et al., (1981) and Singh et al., (1994).

20mg/kg/day in two or three doses for five successive days. After five days a post-treatment stool was collected, preserved, processed and analysed as described in Appendix A. No further post-treatment analyses were carried out.

4.4 Questionnaire

A questionnaire designed by author (see Appendix C) was personally administered in one-on-one interviews with the parents or guardians of the children sampled. The purpose was to undertake a household economic survey to investigate possible social causes of parasite infection. Questions covered the following socio-economic and demographic parameters:

Socio-economic factors

* sanitation
* education
* nutritional deficiencies
* distance from nearest water source
* literacy
* unemployment
* income/poverty
* availability of electricity
* personal and environmental hygiene
* source of meat
* quality of meat eaten
* distance from health facility
* quality of housing

Demographic factors

* age and sex profiles
* migrant labour
* overcrowding
* household size
* number of houses per km^2

Several socio-cultural factors were also investigated:

* religious taboos
* traditional healers
* traditional leaders
* eating habits

The principals organized meetings for this purpose with the parents at each school. It was necessary for this study to give consideration to the following additional questions which relate to in planning the human side' of the project:

(a) what was the state of readiness of the community with respect to the proposed intestinal parasite survey?

(b) are infections by intestinal parasites really of concern to the people?

(c) do the people feel the diseases caused by these intestinal parasites could or should be controlled?

(d) do western-style control procedures arouse culturally determined fears in `traditional healers´? For example, they might feel threatened because they enjoyed authority among rural people in the past and might now feel they are no longer in control. They will also lose money.

3.3.3 Statistical Analysis.

Associations between selected sociodemographic factors and overall intestinal parasites (classified as present or absent) were investigated using chi-square tests. A number of significant associations were found, but this approach has two drawbacks viz:

(a) there was the possibility that some false positive associations might be found due to the fact that many tests were carried out. Furthermore many of the socio-demographic variables were highly correlated with each other (e.g there was a very strong association between mother's education and mother's income). A multivariate approach was then used to see which socio-demographic factors were the most important determinants of parasite transmission.

(b) the second approach ignored the fact that cluster sampling was used, with the schools forming clusters of children. It became apparent however that this led to an overestimate of the evidence for relationships in the data. Thus, a method was needed that took into account the structure of the sample (that are children being clustered into schools).

The following procedures were used to overcome this problems:

(a) multiple logistic regression models were fitted (separately for summer and winter) to assess the effects of socio-economic (in these models schools were fitted as " fixed effects" i.e. an approach used by Holt and Scott (1982).

(b) To take account of the cluster sampling, Generalized Linear Mixed Models were fitted, using the Genstat Library Procedure GLMM (Schall, 1991 and Breslow and Clayton, 1993.

These models were fitted using the explanatory variables identified as potentially important in (a) as fixed effects, and using the schools as random effects.

These fitted models in both (a) and (b) provide us with parameter estimates that can be interpreted as log of the odds ratio (for two levels of the explanatory factor) e.g. they allow us to say how much more likely a child is to be infected if his/her mother has low income than if she has a high income.

Chapter 5

RESULTS

5.1 Introduction

A total of 13 parasite species was recorded. This diversity included protozoans and helminths. Among the protozoans there were two flagellates viz:

(a) *Giardia intestinalis* Felice, 1952 a pathogenic parasite, and *Chilomastix mesnili* (Wenyon, 1910) which is non-pathogenic (see Plate II).

(b) the only pathogenic amoeba recorded was *Entamoeba histolytica* Schaudinn, 1903. *E. histolytica* is recorded here as the only pathogenic amoeba. It is however recognised that invasive amoebiasis is now widely considered to be due to another species, *E. dispar* Brumpt, 1928, while *E. histolytica* is regarded as a non-invasive commensal. Separation of these two species was beyond the scope of this study. Four other commensal species were also present, viz: *Entamoeba coli* (Grassi, 1879) *Entamoeba hartmanni* von Prowazek, 1912, *Endolimax nana* (Wenyon and O'Connor, 1917) and *Iodamoeba büetschlii* (von Prowazek, 1911) (see Plate III). What was interesting was that at the highest altitudes unidentifiable immature precysts were found which lacked the usual diagnostic structures. These precysts were separable into two groups: small ones (designated SPA - small precystic amoebae) similar in size to *E. hartmanni*, and the larger ones (designated MSPA - medium sized precystic amoebae) similar in size to *E. histolytica* and *E. coli*.

The diversity of helminths found in the survey comprised :

(a) three cestode species, viz: an unidentified taeniid tapeworm presumably either *Taenia solium* Linnaeus, 1758 or *Taeniarhynchus saginatus* (Goeze, 1782) *Hymenolepis diminuta* (Rudolphi, 1819) and *Hymenolepis nana* (Stiles, 1906) (see Plate IV). Because most textbooks on medical parasitology refer to *H. nana*, I have used this name but it should be noted that Schimdt (1986) has placed it into synonomy with *Vampirolepis nana* (Siebold, 1852);

(b) three nematode species, *Trichuris trichiura* (Linnaeus, 1771), *Enterobius vermicularis* (Linnaeus, 1758) and *Ascaris lumbricoides* (Linnaeus, 1758). Hookworm and *Strongyloides* were not present (see Plate V). Trematodes were also absent.

The overall helminth infection rate was highest at group II two schools (Table 4.1 and 4.2). In most cases prevalences were lower in winter than in summer.

5.2 PREVALENCES OF INTESTINAL PARASITES.

Tables 4.1 and 4.2 show the prevalences of the 13 parasites species (including SPA and MSPA) during summer and winter and also of the uninfected children (NPS - no parasite seen).

These data show that prevalences of intestinal helminths are generally low and that the most common parasites in all groups were *E. coli* and *E. nana*, both protozoans.

The overall prevalences of helminths and protozoans in the whole

Table 4.1
Seasonal effect on the prevalence of protozoan parasites in eight schools (school 9 was only sampled in summer).

Sch	Le	Mf	Te	Mkh	Mhl	Mk	Se	Mkh	Snt (C)
Num	1	2	3	4	5	6	7	8	9
Alt (m)	1660	1740	1800	1800	1860	1990	2000	2200	1660
N	146	123	105	104	120	116	140	115	211
Giardia intestinalis									
Prev	%	%	%	%	%	%	%	%	%
Sum	3.4	2.4	2.8	1.9	0.8	5.0	2.8	0.0	12.5
Win	12.8	1.2	7.4	1.3	2.0	11.0	6.1	1.9	-
Ave	8.1	1.8	5.1	1.6	1.4	8.0	4.4	1.0	-
Chilomastix mesnili									
Sum	13.0	17.0	9.5	29.0	13.0	13.0	12.8	15.0	9.2
Win	12.0	7.1	13.5	7.9	10.0	15.3	4.4	1.0	-
Ave	12.5	12.1	11.5	18.4	11.5	14.2	8.6	8.0	-
Entamoeba histolytica									
Sum	0.0	0.8	0.95	0.0	0.0	0.0	3.6	0.0	0.6
Win	0.85	2.4	2.4	0.0	5.0	3.0	2.6	0.0	-
Ave	0.42	1.5	1.7	0.0	2.5	1.5	3.1	0.0	-
Entamoeba coli									
Sum	50.7	47.0	51.0	59.0	58.0	37.0	53.0	36.5	29.0
Win	71.0	56.0	67.0	59.0	45.0	61.5	51.0	61.0	-
Ave	60.8	51.5	59.0	59.0	51.5	49.2	52.0	48.4	-
Entamoeba hartmanni									
Sum	9.6	6.5	10.5	2.8	2.5	7.0	13.6	3.5	3.9
Win	7.7	5.0	8.6	3.9	5.0	4.6	2.6	4.7	-
Ave	8.6	5.8	9.6	3.4	3.8	5.8	8.1	4.1	-
Endolimax nana									
Sum	22.6	14.6	15.0	12.5	26.0	11.0	17.8	20.0	11.0
Win	24.0	13.0	28.0	9.2	22.0	17.0	16.7	26.0	-
Ave	23.3	13.8	21.7	10.8	24.0	14.0	17.3	23.0	-
Iodomoeba bütschlii									
Sum	7.5	2.4	7.6	3.8	2.5	0.7	3.6	2.6	1.9
Win	0.85	2.4	1.2	1.3	1.0	0.0	0.0	0.0	-
Ave	4.2	2.4	4.4	2.6	1.8	0.35	1.8	1.3	-
Small unidentified pre-cystic amoeba									
Sum	0.7	1.6	0.0	0.0	0.0	0.7	2.1	0.0	0.0
Win	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	-
Ave	0.35	0.8	1.2	0.0	0.0	1.8	1.5	0.0	-
Medium sized unidentified pre-cystic amoeba									
Sum	6.8	4.0	3.8	4.8	8.3	4.3	5.6	5.2	0.0
Win	5.1	7.4	8.6	0.0	0.0	3.0	0.0	0.0	-
Ave	5.9	5.4	6.2	2.4	4.2	1.8	2.8	2.6	-

Le = Letlotlo
Mf = Mafika-ditshiu
Te = Teboho
Ma = Makhetheng
Mhl = Mohlakaneng
Mk = Makeneng
Se = Sehlajaneng
Mkh = Makhabane
Snt = Sentinel
C = Control school
SPA = Small unidentified precystic amoebae
MSPA = Medium unidentified precystic amoebae

Table 4.2

Seasonal effect on the prevalences of helminth parasites in eight schools (school 9 was only sampled in summer).

Sch	Le	Mf	Te	Mak	Mohl	Man	Se	Mkh	Snt (C)
Num	1	2	3	4	5	6	7	8	9
Prev	%	%	%	%	%	%	%	%	%
Alt (m)	1660	1740	1800	1800	1860	1990	2000	2200	1600
N	146	123	105	104	120	104	140	115	211
taeniid tapeworm									
Sum	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
Win	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	-
Ave	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	-
Hymenolepis diminuta									
Sum	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0
Win	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	-
Ave	0.0	0.0	0.0	0.0	0.4	0.0	0.5	0.0	-
Hymenolepis nana									
Sum	0.7	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
Win	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
Ave	0.35	0.0	0.5	0.5	0.0	0.0	0.0	0.0	-
Trichuris trichiura									
Sum	1.4	0.8	0.0	0.0	1.7	0.8	0.0	0.0	1.0
Win	0.85	0.0	0.0	0.0	1.0	0.0	0.0	0.0	-
Ave	1.1	0.4	0.0	0.0	0.85	0.4	0.0	0.0	-
Ascaris lumbricoides									
Sum	8.9	1.6	13.0	0.0	2.5	5.0	2.1	1.7	1.3
Win	6.1	0.0	6.1	0.0	2.0	1.5	1.0	0.0	-
Ave	7.5	0.8	9.55	0.0	2.25	3.25	1.55	0.85	-
No parasites seen in stool sample (NPS)									
Sum	23.3	27.0	26.0	31.0	35.0	15.0	28.6	20.0	66.0
Win	14.5	40.5	21.0	39.0	41.0	29.0	42.0	33.0	-

TABLE 5

OVERALL PREVALENCES OF INTESTINAL PARASITES IN QWA-QWA DURING SUMMER AND WINTER.

	Summer	Winter	Average
Parasite species	% Prev.	% Prev.	% Prev.
G. intestinalis	3.5	5.5	4.5
C. mesnili	14.6	8.9	11.8
E. histolytica	0.7	2.0	1.4
E. coli	46.7	58.9	52.8
E. hartmanni	6.6	5.2	5.9
E. nana	16.7	19.5	18.1
I. buetschlii	3.6	0.8	2.2
SPA	0.6	0.3	0.4
MSPA	5.2	3.0	4.1
taeniid tapeworm	0.1	0.1	0.1
H. diminuta	0.3	0.1	0.2
H. nana	0.3	0.0	0.2
T. trichiura	0.8	0.2	0.5
E. vermicularis	0.4	0.4	0.4
A. lumbricoides	3.8	2.1	2.9

Table 5.1a
Mean intensities of protozoan and cestode infections at the nine schools in summer (school 9 was only sampled in summer). Intensities were scored as: none, light, moderate or heavy according to Ashford et al (1981) and Singh et al (1994).

Sch	Le	Mf	Te	Ma	Mhl	Mk	Se	Mkh	Snt (c)
Num	1	2	3	4	5	6	7	8	9
Alt (m)	1660	1740	1800	1800	1860	1990	2000	2200	1660
N	146	123	105	104	120	116	140	115	211
Giardia intestinalis									
none	96.5	97.3	97.1	98.1	99.2	93.9	97.2	99.2	91.7
low	3.5	2.7	2.9	1.9	0.8	6.1	2.8	0.8	4.4
mod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9
heav	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chilomastix mesnili									
none	97.2	81.1	91.3	70.9	86.9	88.7	86.5	85.0	93.3
low	2.4	16.2	3.9	17.5	9.0	5.2	6.4	10.5	2.9
mod	0.0	2.7	3.9	9.7	1.6	3.5	6.4	2.6	2.9
heav	0.0	0.0	0.9	1.9	2.5	2.6	0.7	1.7	0.9
Entamoeba histolytica									
none	100	100	99.1	100	100	99.1	97.2	100	100
low	0.0	0.0	0.9	0.0	0.0	0.9	2.8	0.0	0.0
mod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
heav	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Entamoeba coli									
none	50.0	50.4	45.6	42.7	40.5	63.5	45.7	61.4	83.4
low	33.0	36.9	35.0	24.3	34.7	23.5	37.8	26.3	10.7
mod	15.5	10.8	13.6	28.1	18.2	11.3	15.0	10.5	3.9
heav	1.5	1.9	5.8	4.9	7.6	1.7	1.5	3.9	1.9
Entamoeba hartmanni									
none	90.8	95.5	89.3	97.1	98.4	93.1	87.2	95.6	97.2
low	9.2	4.5	8.9	2.9	1.6	6.9	12.1	4.4	1.9
mod	0.0	0.0	0.9	0.0	0.0	0.0	0.7	0.0	0.9
heav	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0
Endolimax nana									
none	79.7	86.4	87.4	89.3	77.0	91.4	85.1	80.7	91.8
low	16.1	11.7	7.8	5.8	16.5	6.9	12.8	11.4	5.4
mod	1.4	1.8	4.8	4.9	4.9	0.0	2.1	6.1	1.9
heav	2.8	0.0	0.0	0.0	1.6	1.7	0.0	1.8	0.9
Iodamoeba buetschlii									
none	92.3	97.3	91.4	96.1	97.6	99.2	97.2	98.4	98.5
low	6.3	1.8	7.7	3.9	1.6	0.8	2.8	0.8	1.5
mod	1.4	0.9	0.9	0.0	0.0	0.0	0.0	0.8	0.0
heav	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0
Small unidentified pre-cystic amoeba									
none	100	100	100	100	99.2	98.2	97.9	100	100
low	0.0	0.0	0.0	0.0	0.8	1.8	2.1	0.0	0.0
mod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
heav	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Medium sized unidentified pre-cystic amoeba									
none	94.4	96.4	96.1	95.2	91.8	95.7	94.3	94.8	100
low	5.6	2.7	3.9	4.8	7.4	4.3	4.3	0.0	0.0
mod	0.0	0.9	0.0	0.0	0.8	0.0	1.4	0.0	0.0
heav	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
taeniid tapeworm									
none	100	100	100	99.1	100	100	100	100	100
low	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
mod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
heav	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hymenolepis diminuta									
none	100	100	100	99.1	99.2	100	100	100	100
low	0.0	0.0	0.0	0.9	0.8	0.0	0.0	0.0	0.0
mod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
heav	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hymenolepis nana									
none	99.3	100	99.1	100	100	100	100	100	100
low	0.7	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0
mod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
heav	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 5.1b
Mean intensities of protozoan and cestode infections at the nine schools in winter (school 9 was only sampled in summer). Intensities were scored as: none, low, moderate or heavy according to Ashford et al (1981) and Singh et al (1994)

Sch	Le	Mf	Te	Ma	Mhl	Mk	Se	Mkh
Num	1	2	3	4	5	6	7	8
Alt (m)	1660	1740	1800	1800	1860	1990	2000	2200
N	146	123	105	104	120	116	140	115
Giardia intestinalis								
none	91.6	93.9	94.2	99.1	98.4	99.1	94.3	98.1
low	7.7	6.1	5.8	0.9	1.6	0.9	5.7	1.7
mod	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
heav	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chilomastix mesnili								
none	90.2	91.5	89.4	93.4	92.6	97.3	96.4	93.6
low	7.0	6.0	5.8	4.8	5.8	0.9	3.6	3.5
mod	2.1	1.7	3.9	0.9	1.6	1.8	0.0	2.9
heav	0.7	0.8	0.9	0.9	0.0	0.0	0.0	0.0
Entamoeba histolytica								
none	99.3	98.2	97.3	100	98.2	98.2	97.2	99.1
low	0.7	0.9	1.8	0.0	0.9	1.8	2.8	0.9
mod	0.0	0.9	0.9	0.0	0.9	0.0	0.0	0.0
heav	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Entamoeba coli								
none	42.4	66.9	77.6	56.5	61.9	61.3	58.6	43.9
low	45.0	21.7	27.2	30.0	29.7	32.4	35.7	50.0
mod	10.5	8.8	18.4	12.6	7.4	4.5	4.3	6.1
heav	2.1	2.6	4.8	0.9	0.8	1.8	1.4	0.0
Entamoeba hartmanni								
none	95.1	97.4	93.3	97.1	97.5	95.5	97.2	96.5
low	3.5	2.6	5.8	2.9	2.5	4.5	2.8	3.5
mod	1.4	0.0	0.9	0.0	0.0	0.0	0.0	0.0
heav	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Endolimax nana								
none	81.7	91.4	79.6	94.5	81.0	90.1	87.9	78.9
low	14.8	6.9	14.6	4.8	15.7	9.9	11.4	20.2
mod	2.8	1.7	5.8	0.7	2.5	0.0	0.7	0.0
heav	0.7	0.0	0.0	0.0	0.8	0.0	0.0	0.9
Iodamoeba buetschlii								
none	99.3	100	99.1	99.1	99.2	98.2	100	100
low	0.0	0.0	0.0	0.0	0.8	1.8	0.0	0.0
mod	0.7	0.0	0.9	0.9	0.0	0.0	0.0	0.0
heav	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SPA								
none	100	100	99.1	100	100	100	100	100
low	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0
mod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
heav	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSPA								
none	97.2	99.1	96.3	99.1	99.1	100	100	100
low	2.8	0.9	3.7	0.9	0.9	0.0	0.0	0.0
mod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
heav	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
taeniid tapeworm								
none	100	100	100	99.1	100	100	100	100
low	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0
mod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
heav	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hymenolepis diminuta								
none	100	100	100	100	100	100	99.3	100
low	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0
mod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
heav	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hymenolepis nana								
none	100	100	100	100	100	100	100	100
low	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
heav	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

study area were 0.7% and 11.2% respectively (see Table 5). Prevalences of *A. lumbricoides* were considerably less during winter at six schools: Letlotlo, Teboho, Mafika-ditshiu, Makeneng, Mohlakaneng and Sehlajaneng. Prevalences of *T. trichiura* by contrast, varied little between season and the parasite was absent from the two highest schools (2000 to 2200)m. *Enterobius vermicularis* was excluded from analysis of the data. The reason for this was that faecal examination does not give a true reflection of its prevalence. The most reliable diagnostic technique for this helminth is the cellophane tape swab (see discussion, chapter six). SPA occurred with a prevalence of 0.4%. They were similar in shape and size to *E. hartmanni* and *E. histolytica* but lacked diagnostic features characteristic of either species. MSPA were also present with an overall prevalence of 4.1%.

5.3 INTENSITIES OF INTESTINAL PARASITES

The mean intensities of protozoans and cestodes in winter and summer are given in Tables 6.1a and 6.1b. Those for nematodes are given in Table 7. Amongst the protozoans, prevalences were generally light. Exceptions were *E. coli, E. nana* and *C. mesnili* where each have considerable numbers of moderate infections and even a few heavy ones. This is particularly so in summer. Cestodes were rare in summer and virtually absent in winter. Generally there was a trend amongst all the parasites towards lower prevalences and intensities in winter, compared to the summer values. Exceptions were *E. coli* and *E. nana* which were

Table 6.1a
Mean intensities of protozoan and cestode infections at the nine schools in summer (school 9 was only sampled in summer). Intensities were scored as : none, light, moderate or heavy.

Sch	Le	Mf	Te	Ma	Mhl	Mk	Se	Mkh	Snt (c)
Num	1	2	3	4	5	6	7	8	9
Alt (m)	1660	1740	1800	1800	1860	1990	2000	2200	1660
N	146	123	105	104	120	116	140	115	211
Giardia intestinalis									
none	96.5	97.3	97.1	98.1	99.2	93.9	97.2	99.2	91.7
low	3.5	2.7	2.9	1.9	0.8	6.1	2.8	0.8	4.4
mod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9
heav	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chilomastix mesnili									
none	97.2	81.1	91.3	70.9	86.9	88.7	86.5	85.0	93.3
low	2.4	16.2	3.9	17.5	9.0	5.2	6.4	10.5	2.9
mod	0.0	2.7	3.9	9.7	1.6	3.5	6.4	2.6	2.9
heav	0.0	0.0	0.9	1.9	2.5	2.6	0.7	1.7	0.9
Entamoeba histolytica									
none	100	100	99.1	100	100	99.1	97.2	100	100
low	0.0	0.0	0.9	0.0	0.0	0.9	2.8	0.0	0.0
mod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
heav	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Entamoeba coli									
none	50.0	50.4	45.6	42.7	40.5	63.5	45.7	61.4	83.4
low	33.0	36.9	35.0	24.3	34.7	23.5	37.8	26.3	10.7
mod	15.5	10.8	13.6	28.1	18.2	11.3	15.0	10.5	3.9
heav	1.5	1.9	5.8	4.9	7.6	1.7	1.5	3.9	1.9
Entamoeba hartmanni									
none	90.8	95.5	89.3	97.1	98.4	93.1	87.2	95.6	97.2
low	9.2	4.5	8.9	2.9	1.6	6.9	12.1	4.4	1.9
mod	0.0	0.0	0.9	0.0	0.0	0.0	0.7	0.0	0.9
heav	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0
Endolimax nana									
none	79.7	86.4	87.4	89.3	77.0	91.4	85.1	80.7	91.8
low	16.1	11.7	7.8	5.8	16.5	6.9	12.8	11.4	5.4
mod	1.4	1.8	4.8	4.9	4.9	0.0	2.1	6.1	1.9
heav	2.8	0.0	0.0	0.0	1.6	1.7	0.0	1.8	0.9
Iodamoeba buetschlii									
none	92.3	97.3	91.4	96.1	97.6	99.2	97.2	98.4	98.5
low	6.3	1.8	7.7	3.9	1.6	0.8	2.8	0.8	1.5
mod	1.4	0.9	0.9	0.0	0.0	0.0	0.0	0.8	0.0
heav	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0
Small unidentified pre-cystic amoeba									
none	100	100	100	100	99.2	98.2	97.9	100	100
low	0.0	0.0	0.0	0.0	0.8	1.8	2.1	0.0	0.0
mod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
heav	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Medium sized unidentified pre-cystic amoeba									
none	94.4	96.4	96.1	95.2	91.8	95.7	94.3	94.8	100
low	5.6	2.7	3.9	4.8	7.4	4.3	4.3	0.0	0.0
mod	0.0	0.9	0.0	0.0	0.8	0.0	1.4	0.0	0.0
heav	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
taeniid tapeworm									
none	100	100	100	99.1	100	100	100	100	100
low	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
mod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
heav	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hymenolepis diminuta									
none	100	100	100	99.1	99.2	100	100	100	100
low	0.0	0.0	0.0	0.9	0.8	0.0	0.0	0.0	0.0
mod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
heav	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 6.1b
Mean intensities of protozoan and cestode infections at the nine schools in winter (school 9 was only sampled in summer). Intensities were scored as : none, low, moderate or heavy.

Sch	Le	Mf	Te	Ma	Mhl	Mk	Se	Mkh
Num	1	2	3	4	5	6	7	8
Alt (m)	1660	1740	1800	1800	1860	1990	2000	2200
N	146	123	105	104	120	116	140	115
Giardia intestinalis								
none	91.6	93.9	94.2	99.1	98.4	99.1	94.3	98.1
low	7.7	6.1	5.8	0.9	1.6	0.9	5.7	1.7
mod	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
heav	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chilomastix mesnili								
none	90.2	91.5	89.4	93.4	92.6	97.3	96.4	93.6
low	7.0	6.0	5.8	4.8	5.8	0.9	3.6	3.5
mod	2.1	1.7	3.9	0.9	1.6	1.8	0.0	2.9
heav	0.7	0.8	0.9	0.9	0.0	0.0	0.0	0.0
Entamoeba histolytica								
none	99.3	98.2	97.3	100	98.2	98.2	97.2	99.1
low	0.7	0.9	1.8	0.0	0.9	1.8	2.8	0.9
mod	0.0	0.9	0.9	0.0	0.9	0.0	0.0	0.0
heav	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Entamoeba coli								
none	42.4	66.9	77.6	56.5	61.9	61.3	58.6	43.9
low	45.0	21.7	27.2	30.0	29.7	32.4	35.7	50.0
mod	10.5	8.8	18.4	12.6	7.4	4.5	4.3	6.1
heav	2.1	2.6	4.8	0.9	0.8	1.8	1.4	0.0
Entamoeba hartmanni								
none	95.1	97.4	93.3	97.1	97.5	95.5	97.2	96.5
low	3.5	2.6	5.8	2.9	2.5	4.5	2.8	3.5
mod	1.4	0.0	0.9	0.0	0.0	0.0	0.0	0.0
heav	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Endolimax nana								
none	81.7	91.4	79.6	94.5	81.0	90.1	87.9	78.9
low	14.8	6.9	14.6	4.8	15.7	9.9	11.4	20.2
mod	2.8	1.7	5.8	0.7	2.5	0.0	0.7	0.0
heav	0.7	0.0	0.0	0.0	0.8	0.0	0.0	0.9
Iodamoeba buetschlii								
none	99.3	100	99.1	99.1	99.2	98.2	100	100
low	0.0	0.0	0.0	0.0	0.8	1.8	0.0	0.0
mod	0.7	0.0	0.9	0.9	0.0	0.0	0.0	0.0
heav	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SPA								
none	100	100	99.1	100	100	100	100	100
low	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0
mod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
heav	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSPA								
none	97.2	99.1	96.3	99.1	99.1	100	100	100
low	2.8	0.9	3.7	0.9	0.9	0.0	0.0	0.0
mod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
heav	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
taeniid tapeworm								
none	100	100	100	99.1	100	100	100	100
low	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0
mod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
heav	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hymenolepis diminuta								
none	100	100	100	100	100	100	99.3	100
low	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0
mod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
heav	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hymenolepis nana								
none	100	100	100	100	100	100	100	100
low	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mod	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 7

Geometric mean egg counts (epg) for the nematode parasites at the nine schools in summer and winter (school 9 was only sampled in summer).

Sch	Le	Mf	Te	Ma	Mhl	Mk	Se	Mkh	Snt
Num	1	2	3	4	5	6	7	8	9
Alt (m)	1660	1740	1800	1800	1860	1990	2000	2200	1660
N	146	123	105	104	120	116	140	115	211
Trichuris trichiura									
none	98.6	99.1	100	100	98.4	99.1	100	100	98.6
Sum	409	19	0	0	391	4	0	0	34
Win	478	0	0	0	253	0	0	0	
Ascaris lumbricoides									
none	91.5	98.2	86.4	100	97.5	94.1	97.1	98.2	98.5
Sum	791	265	1314	0	4419	430	124	857	413
Win	2255	0.0	1524	0	671	307	98	0	0.0

more common and more intense in winter.

5.4 POLYPARASITISM

5.4.1 Frequencies of overall polyparasitism per child in the nine schools in summer.

Table 8.a

Overall frequencies of numbers of parasites per child.

Number of Parasites	Frequecy	Percentage	Cumulative percentage
0	353	35.4	35.4
1	326	32.7	68.1
2	190	19.1	87.2
3	98	9.8	97.0
>4	30	3.0	100.0

In general, the majority of children (87.2%) have two or fewer parasites. Tables 8.a & 8.b indicate that polyparasitism is not a problem in summer and winter respectively in the study area.

Table 8.b Frequencies of polyparasitism per child by school.

		Number of parasite per child					
Sch	Alt(m)	0(%)	1(%)	2(%)	3(%)	>4(%)	Total
Le	1660	36 (28.8)	45 (36.0)	17 (13.6)	20 (16.0)	7 (5.6)	125
Te	1800	26 (28.3)	28 (30.4)	26 (28.2)	10 (10.9)	2 (2.2)	92
Mf	1740	19 (26.0)	30 (41.1)	14 (19.2)	6 (8.2)	4 (5.5)	73
Mk	1990	36 (35.6)	37 (36.3)	17 (16.7)	7 (6.9)	5 (4.8)	102
Mhl	1860	40 (33.6)	41 (34.4)	22 (30.2)	12 (10.1)	4 (8.4)	119
Ma	1800	31 (31.6)	31 (31.6)	25 (25.5)	9 (9.2)	3 (2.1)	98
Se	2000	39 (30.0)	45 (34.6)	29 (22.3)	14 (10.8)	3 (2.0)	130
Mkh	2200	25 (30.1)	29 (34.9)	17 (20.5)	11 (13.2)	1 (1.3)	83
Snt (C)	1660	90 (60.0)	33 (22.0)	19 (12.7)	7 (4.7)	1 (0.6)	150

5.4.2 Frequencies of overall polyparasitism per child in eight schools in winter

Table 9a

Frequencies of overall polyparasitism per child in eight schools in winter.

Number of parasites	Frequency	Percentage	Cumulative percentage
0	247	32.9	32.9
1	303	40.3	73.2
2	133	17.7	90.9
3	57	7.6	98.5
>4	11	1.5	100

In winter 90.9% of children had two or fewer parasites, therefore polyparasitism is not important in winter as shown in Tables 9a & 9b. There is no statistical difference between the frequencies of polyparasitism between summer and winter.

Table 9b

Frequencies of polyparasitism in the eight schools sampled in winter, per child by school.

		Number of parasites per child					
Sch	Alt(m)	0(%)	1(%)	2(%)	3(%)	>4(%)	Total
Le	1660	18 (15.7)	55 (48.2)	24 (21.0)	16 (14.0)	1 (1.1)	114
Te	1800	16 (20.2)	30 (28.1)	21 (26.6)	8 (10.1)	4 (5.0)	79
Mf	1740	19 (30.1)	27 (42.8)	8 (12.7)	7 (11.1)	2 (3.3)	63
Mk	1990	33 (41.8)	31 (39.2)	10 (12.7)	3 (3.7)	2 (2.6)	79
Mhl	1860	43 (42.1)	35 (34.3)	17 (16.7)	5 (4.9)	2 (2.0)	102
Ma	1800	30 (39.5)	32 (42.1)	10 (13.2)	4 (5.2)	0 (0.0)	76
Se	2000	49 (42.2)	43 (37.0)	17 (14.6)	7 (6.2)	0 (0.0)	116
Mkh	2200	36 (33.9)	44 (41.5)	20 (18.9)	6 (5.7)	0 (0.0)	106

5.5. Morphology and diagnostic features of cysts and eggs of intestinal parasites found in the study area.

5.5.1 THE PROTOZOANS

5.5.1.1 The Flagellates

Giardia intestinalis (Plate II A)

The cyst is oval in shape and measures 8 to 12μm in length and 7 to 10μm in width. The cytoplasm is clear, with a distinct central axostyle, flagellum curled up and has 2 to 4 nuclei and usually 2 retracted vacuoles or "eyes". When stained with iodine the cyst is normally yellow or light brown.

Chilomastix mesnili (Plate IIB)

The cyst is characteristically lemon shaped, they measure 7 to 10μm in length by 4 to 10μm in width. It has a very thick wall, an axostyle down the middle and sometimes with a curled-up flagellum. A dense granular cytoplasm appears separated from the wall at the narrow end and forms a distinct nipple. Stains yellow with iodine.

PLATE II

Cysts of intestinal protozoan parasites (flagellates)

A. *Giardia intestinalis*, , oval shaped cyst with curled up axonemes of flagella (ax) and two or four nuclei, (seen with 1000X objective).

B. *Chilomastix mesnili*, pear shaped cyst with one nucleus and a characteristic nipple (n) (seen with 1000X objective).

5.5.1.2 The Amoebae

Entamoeba histolytica (Plate IIIA)

Usually spherical in shape with a prominent dark "pencil lead" outer wall. It is 10 to 20μm in diameter. It has granular cytoplasm with 1 to 4 nuclei and round-ended chromatoidal bars and does not retract from the cyst wall. The karyosome is central within the nucleus. Stains light yellow with iodine.

Entamoeba coli (Plate IIIB)

The cysts vary in shape, and measure between 10 and 33 μm in maximum diameter. It has 1 to 8 nuclei sometimes more, clear cytoplasm, when immature some are almost full of glycogen. They are very large, and in some cases the cytoplasm has retracted from the cyst wall. Nucleolus is eccentric and has spindle-ended chromatoidal bars. Stains yellow to orange with iodine.

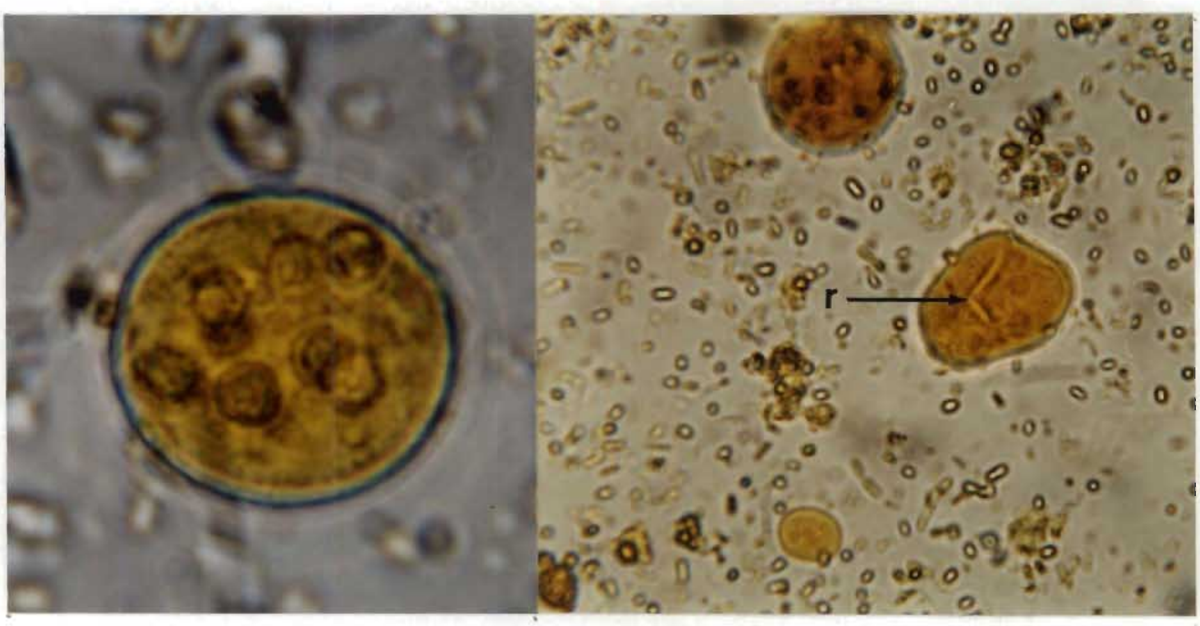
Entamoeba hartmanni (Plate IIIC)

This is a very small, round cyst measuring 5 to 10μm in diameter. The cytoplasm is granular with 1 to 4 nuclei, a central nucleolus and rounded-ended chromatoidal bars. It stains orange to brown with iodine.

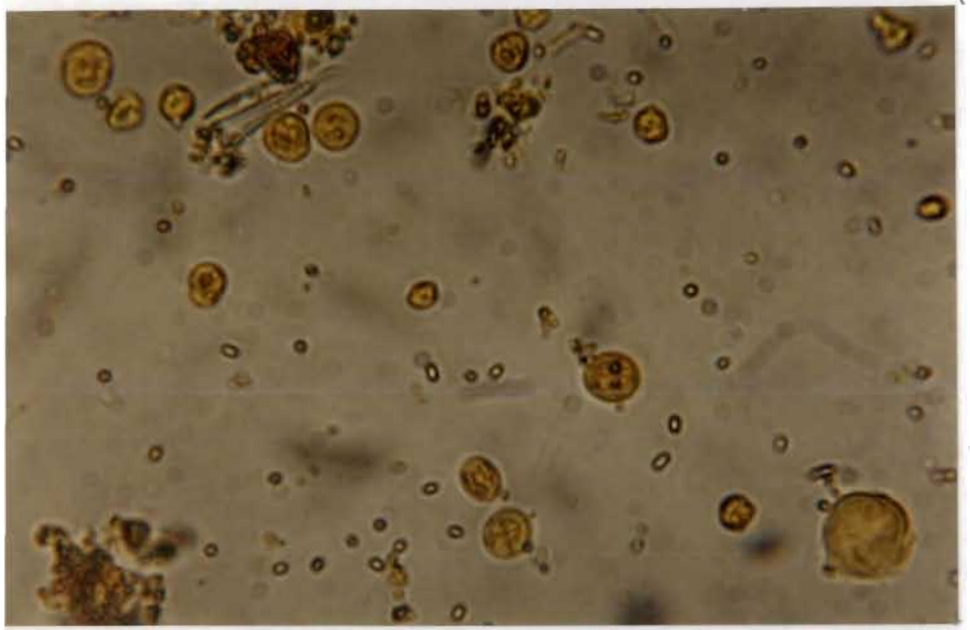
PLATE III

Cysts of intestinal protozoan parasites (amoebae).

A. *Entamoeba histolytica*, cyst with central nucleolus (1-4 nuclei), showing rod-shaped chromatoidal bars (r), (seen with 1000X objective).

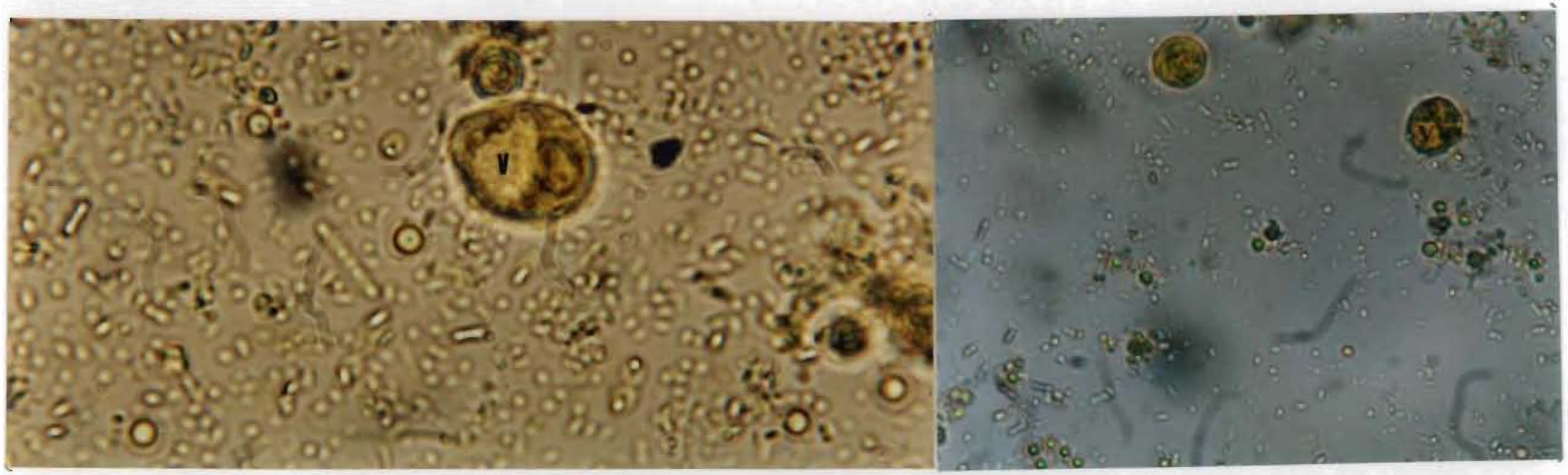


B. *Entamoeba coli*, cyst with eccentric nucleolus (1-8 nuclei) showing splinterlike chromatoidal bars (r) and eight nuclei, (seen with 1000X objective).



C. *Entamoeba hartmanni*, spherical, cyst with granular cytoplasm and one nucleus, (seen with 1000X objective).

D. *Endolimax nana*, oval shaped cyst with and four nuclei, (seen with 1000X objective).



E. *Iodamoeba büetschlii*, compact glycogen vacuole (v) and one nucleus, (seen with 1000X objective).

Endolimax nana (Plate IIID)

The shape of the cyst is spherical or ovoid, with a clear cytoplasm containing refractile vacuoles. It measures 5 to 14μm in diameter and has 1 to 4 indistinct nuclei. Stains pale green with iodine.

Iodamoeba büetschlii (Plate IIIE)

The cyst varies in shape, viz: round, oval, elliptical, rhomboidal etc. It measures between 5 to 20μm. It has a granular cytoplasm, one nucleus with a well defined glycogen vacuole. The nucleolus is surrounded by granules. Typically stains dark brown with iodine.

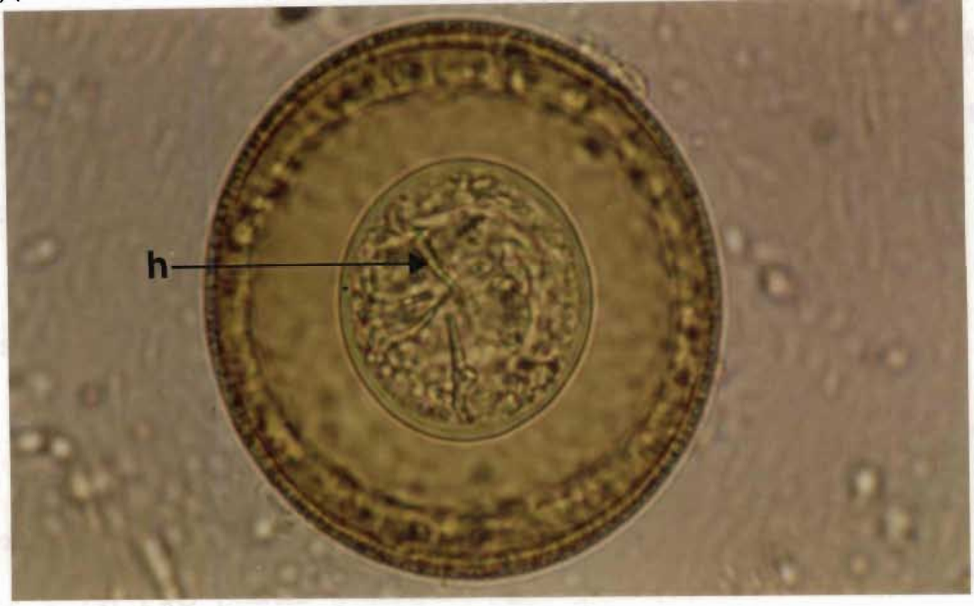
5.5.2 The Cestodes

Taeniid tapeworm (Plate IV A)

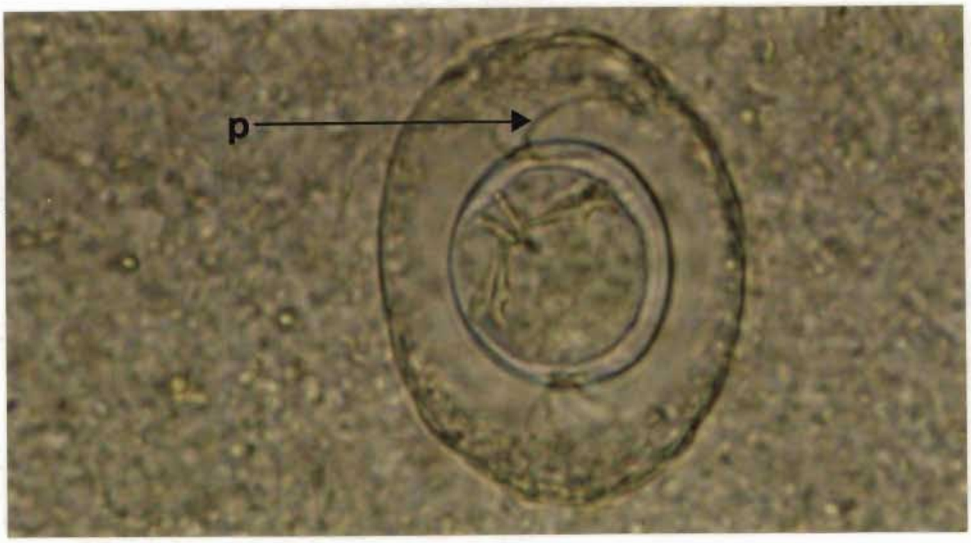
The fully embryonated egg, which is almost mature when it leaves the uterus. The eggs are spherical, measure 31 to 43μm in diameter, the shell is thick-walled, consisting of many truncated prisms cemented together. Within a shell is a fully developed onchosphere which, in *Taenia solium* that has three pairs of hooklets. These cannot usually be seen so that *T. saginatus* and *T. solium* eggs are very difficult to separate.

PLATE IV Cestode eggs

A. Fully embryonated, spherical, egg of (Pork tapeworm) *Taenia solium* hatching to release hexacanth embryo with three pairs of hooklets (h),and thick radially striated shell,(seen with 400X objective).



B. Rat tapeworm (*Hymenolepis diminuta*) fully embryonated, spherical egg with three pairs of hooklets (h) similar to *H.nana* but no polar filaments, seen with 400X objective).



C. Dwarf tapeworm (*Hymenolepis nana*) fully embryonated, oval shaped egg, contain onchosphere enclosed with polar thickenings from which polar filaments arise (p). Onchosphere has three pairs of hooklets, (seen with 400X objective).

Hymenolepis diminuta (Plate IV B)

The eggs are spherical or subspherical, measure 60 to 79μm by 72 to 86μm, and have the onchosphere with three pairs of hooks and no polar filaments between embryo and outer shell.

Hymenolepis nana (Plate IV C)

The egg is spherical to oval in shape, measures 30 to 47μm in diameter and contains an onchosphere that is enclosed in an inner envelope with two polar thickenings, from each of these arise 4 to 8 polar filaments.

5.5.3 The Nematodes

Trichuris trichiura (Plate V A)

In *Trichuris trichiura* the outer eggshell is fully formed and deeply tanned while in the uterus. The egg is barrel-shaped, and in addition to a vitelline membrane, has a triple layered shell, the outer layer is dark brown. They have bipolar, unstained mucoid plugs. The eggs measure 50 to 54μm by 22 to 23μm.

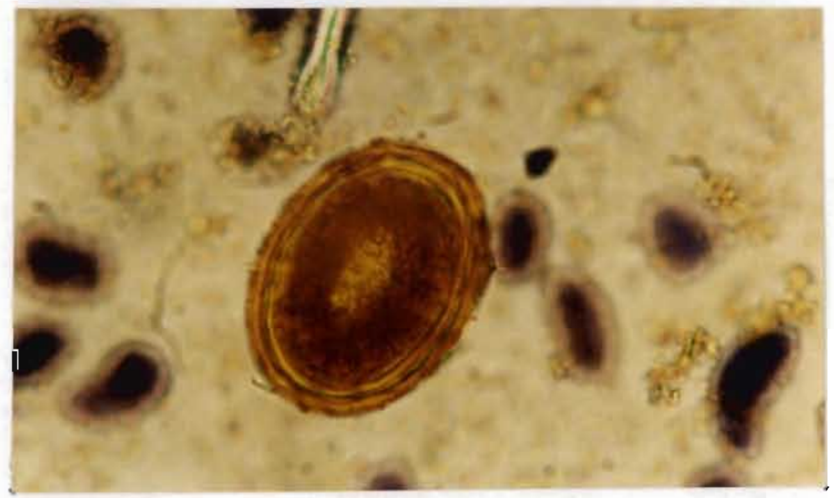
Enterobius vermicularis (Plate V C)
The egg contains an infective L1 stage larva when laid. The eggs are elongate-ovoidal, flattened on one side, and measure 50 to 60μm by 20 to 30μm. The shell is relatively thick and colourless. They are sticky.

PLATE V

Nematode eggs

Whipworm *(Trichuris trichiura)*, barrel shaped fertilized egg, triple layered shell in addition to vitelline layer, bipolar, unstained, mucoid plugs (seen with 400X objective).

] B. *Trichuris trichuris* egg, containing first stage infective larva (seen with 400X objective).



D. Common roundworm (*Ascaris lumbricoides*) broadly ovoidal, normal fertilized,embryonated egg, a complex egg shell made up of four layers (seen with 400X objective)

Pinworm (*Enterobius vermicularis*) elongate ovoidal, distinctly flattened laterally eggs from a dissected worm, contains an infective first stage larva. Shell thick and colourless (seen with 400X objective).

Ascaris lumbricoides (Plates VD, VIA-D)

The egg is extremely tough and very adhesive. Three structurally different types of eggs are commonly found, especially in heavy infections. Fertilized eggs (Plate VD and VIC) measure over the range 50-70 by 40-50μm in length. These eggs are broadly ovoid in shape. Unfertilized eggs measure up to 60-100 by 40-60μm. Infertile eggs (Plate VIA) confused with plant cells. Decorticated eggs (Plate VIB) sometimes be confused with hookworm eggs. Plate VID shows the L2 (second stage) hatching from the egg.

5.6 STATISTICAL ANALYSIS

As noted in Chapter 4 to overcome the confounding effects of schools models were fitted to determine the most important socio-economic variables.

5.5.1 Introduction

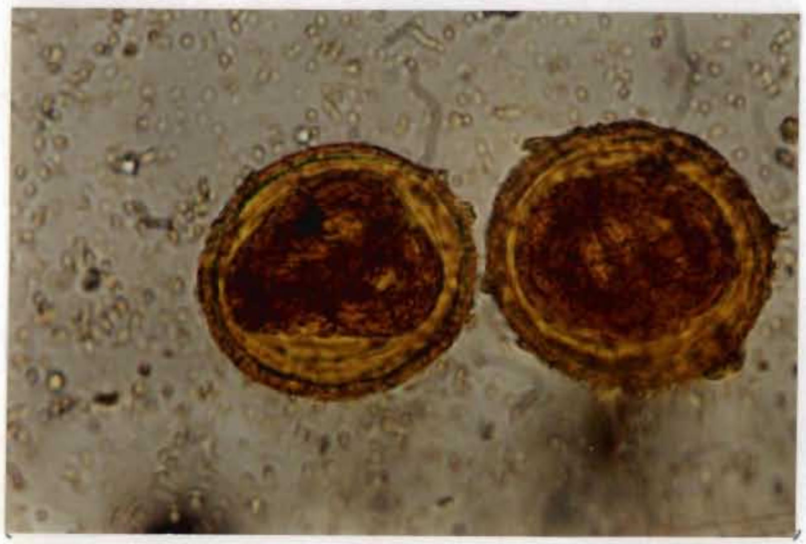
Socio-economic factors were considered one at a time, i.e. chi-squared tests were used to determine whether transmission of parasites appears to be related to each socio-economic factor. In addition to the unadjusted chi-square test, a Mantel-Haenszel stratified approach was used for those socio-economic factors with two levels, e.g. gender, with the schools as strata to remove the confounding effect of the schools themselves as socio-economic variables.

PLATE VI

Ascaris lumbricoides eggs

Normal unfertilized egg, with mammillated albuminoid layer (seen with 400X objective)

B. Decorticated (lost the mammillated layer), ~~not~~ embryonated fertilized egg, (seen with 400X objective)



Embryonated egg containing an infective second stage larva (seen with 400X objective)

D. Hatching of infective second stage larva from the egg, (seen with 400X objective)

5.5.2 Relationships between prevalences and altitude

Figure 6 shows the percentages of uninfected children (NPS) at each school in summer. Winter data are not included because no winter data were available for school no. 9. There were no significant differences in total parasitism between schools at different altitudes from 1660 to 2200m . However there was a marked difference between the two schools at the same altitude 1660m, viz: Letlotlo (No 1) and Sentinel (No 9), ($\chi^2 = 11.80$, $p \leq 0.001$). Indeed reference to Figure 6 shows that whereas 23.0% of children at Letlotlo had no parasite infections, 66.0% at Sentinel school were uninfected.

5.5.3 Relationship between prevalence and soil type

The scale of the soil type maps available (Fig. 4) (p.20) is too large to relate meaningfully to the schools in question. Further, the catchment areas of these schools are not well known and consequently cannot be mapped. The settlements in which the soil transmitted nematodes *A. lumbricoides* and *T. trichiura* occur, lie on soils basically very fertile clay rich area, viz: Clovelly-Avalon, Willowbrook and Kroonstad.Katspruit types. (Prof. J. Hughes, Department of Agronomy, University of Natal pers. comm.). The characteristics of the different soil types are described in Table 1 on (p.21).

Prevalences of helminths in group 1 schools ranged from 1.7% in summer to 0% at Makhabane in winter. At Sehlajaneng, the

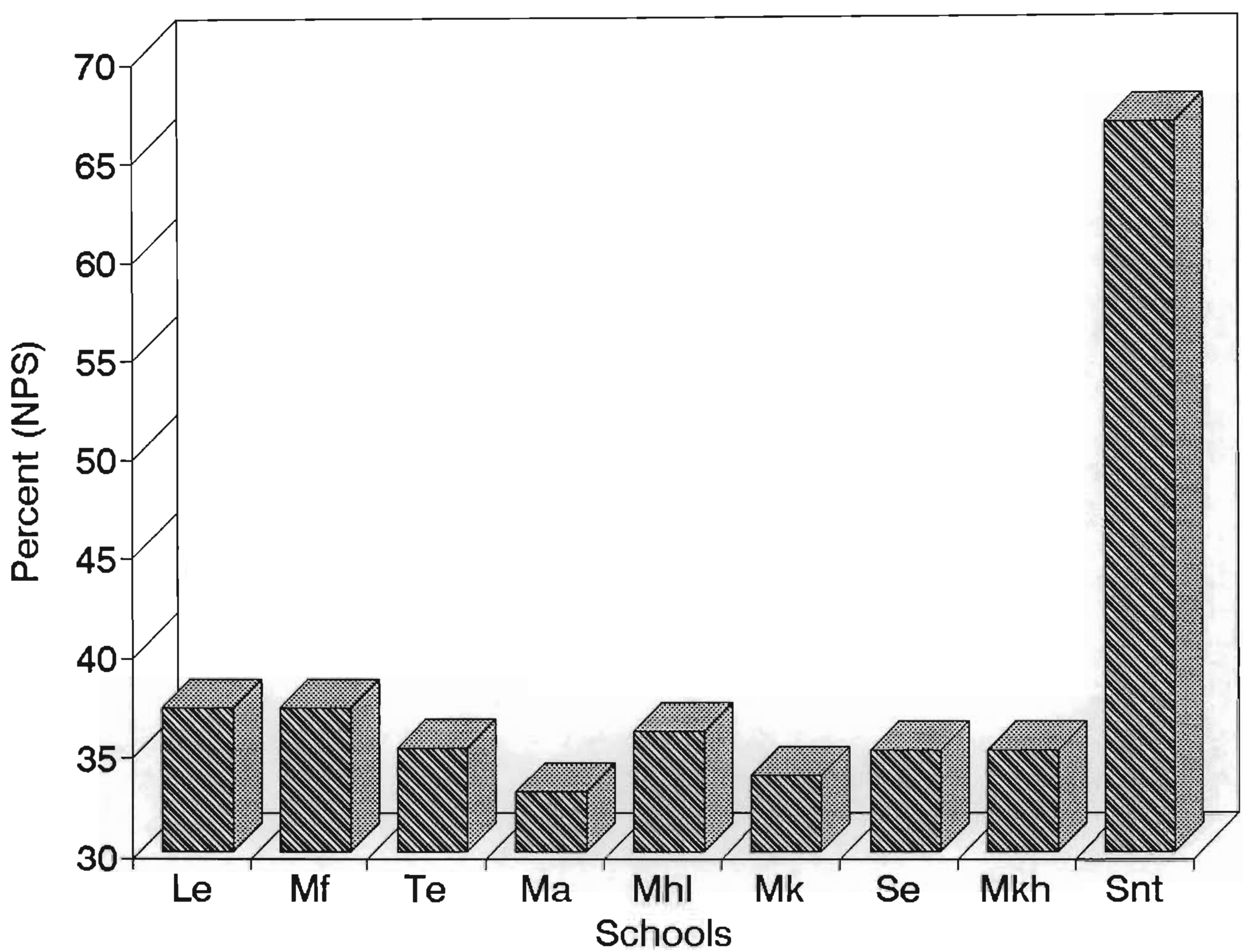


Figure 6 shows percentages of uninfected children during summer (NPS = No parasites seen in faecal sample).

prevalence decreased from 2.1% in summer to 1.0 in winter. Tapeworm infection was only found at Makhetheng where one child was infected. There was no seasonal effect on tapeworm infection in winter, ascariasis was also not recorded at the Makhetheng. At Mohlakaneng ascariasis decreased from 2.5% to 2.0% in winter.

In group 2 schools, ascariasis decreased from 5.0% at Makeneng to 1.5%, from 13.0% to 6.1% at Teboho and from 8.9% to 6.1% at Letlotlo.

E. coli and *E. nana* in group 1 and group 2 prevalences increased in winter, with prevalences increasing from 36.5% to 61% Makhabane (see Table 5.1 and 5.2 for seasonal effect on prevalences of intestinal parasites in all schools). Sentinel was sampled in summer only.

5.6 RELATIONSHIP BETWEEN PREVALENCES AND SOCIO-ECONOMIC FACTORS

5.6.1 GENDER PREVALENCE PROFILES BY SCHOOL

5.6.1.1 PREVALENCES IN MALES AND FEMALES

Gender-related parasite prevalence data are given for each school in Appendix D. Analysis of these data showed that there was no evidence of a difference in the infection rate for males and females in either winter or summer. This is shown in Figure 7. Pooling the data from all nine schools:

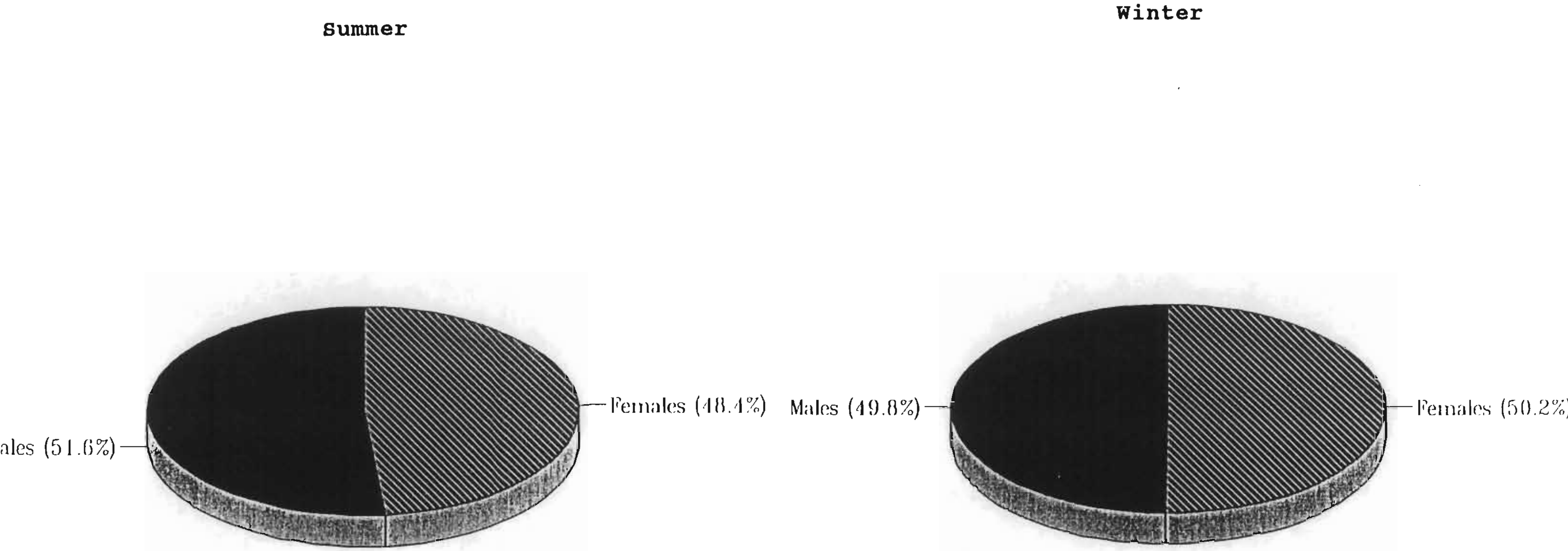


Figure 7

Relative frequencies of intestinal parasite infections among males and females - data pooled from all nine schools in summer and eight schools in winter.

$\chi^2 = 0.14$ on 1 d.f. ($p = 0.71$) (summer)

$\chi^2 = 0.11$ on 1 d.f. ($p = 0.74$) (winter)

Use of the Mantel-Haenszel approach to adjust for the possible confounding effect of "school" gave:

$\chi^2_{MH} = 0.04$ ($p = 0.85$)

$\chi^2_{MH} = 0.40$ ($p = 0.52$)

5.6.1.2 PREVALENCES IN DIFFERENT AGE CLASSES

Analysis of the age-related data in Appendix D showed considerable variation in parasite prevalences between schools.

$\chi^2 = 3.14$ on 2 d.f. ($p = 0.21$) (summer)

$\chi^2 = 4.89$ on 2 d.f. ($p = 0.087$) (winter).

For example it can be seen that in Figure 8, at Mohlakaneng and Mafika-ditshiu schools, prevalences in the < 5year age group in summer were 23.9% and 45.0% respectively. Similarly, in the 6-10 year age groups, prevalences of 50.5% and 86.7% were recorded at Teboho and Sehlajaneng schools respectively in summer. Variation was less in the <10 year age group, from 0.8% at Mohlakaneng to 31.3% at Makhabane in winter.

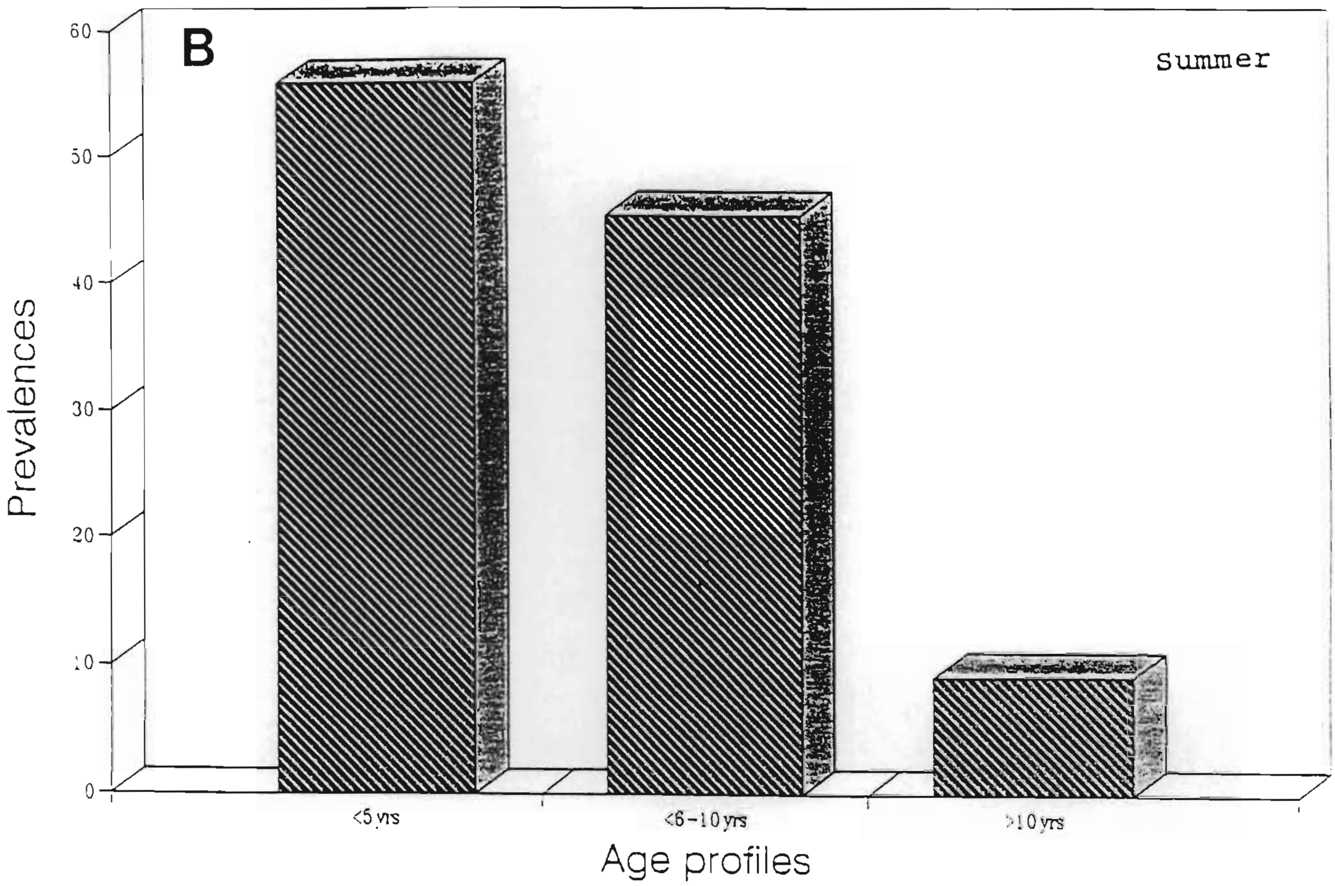
Two groups of children are most commonly infected by these parasites i.e the <5 year and the 6-10 year old groups (Figure 8). The >10 year group have generally low prevalences of parasite infections with the 6-10 year group being the most frequently infected age group followed by the <5 year old group.

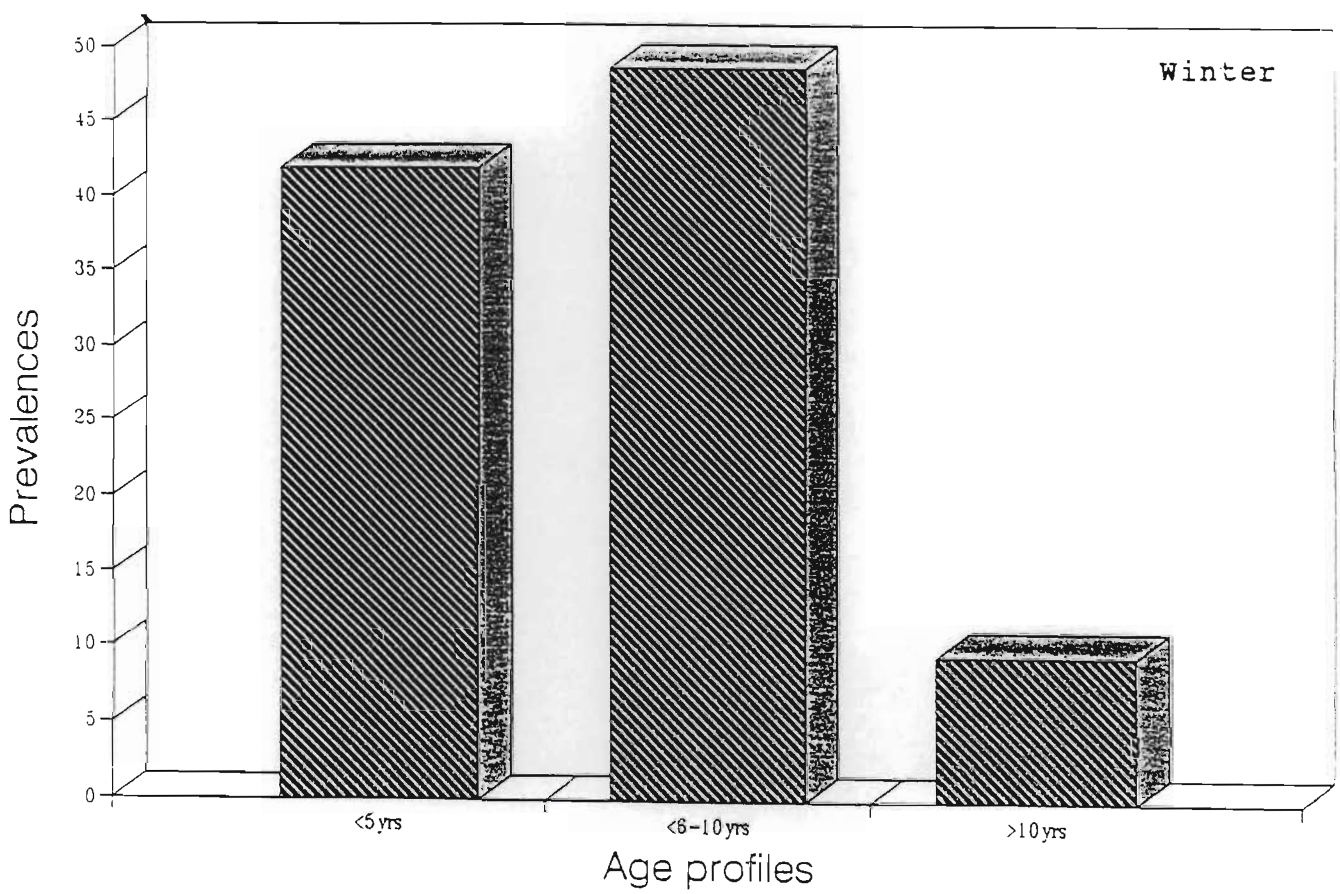
Mohlakaneng

Figure 8

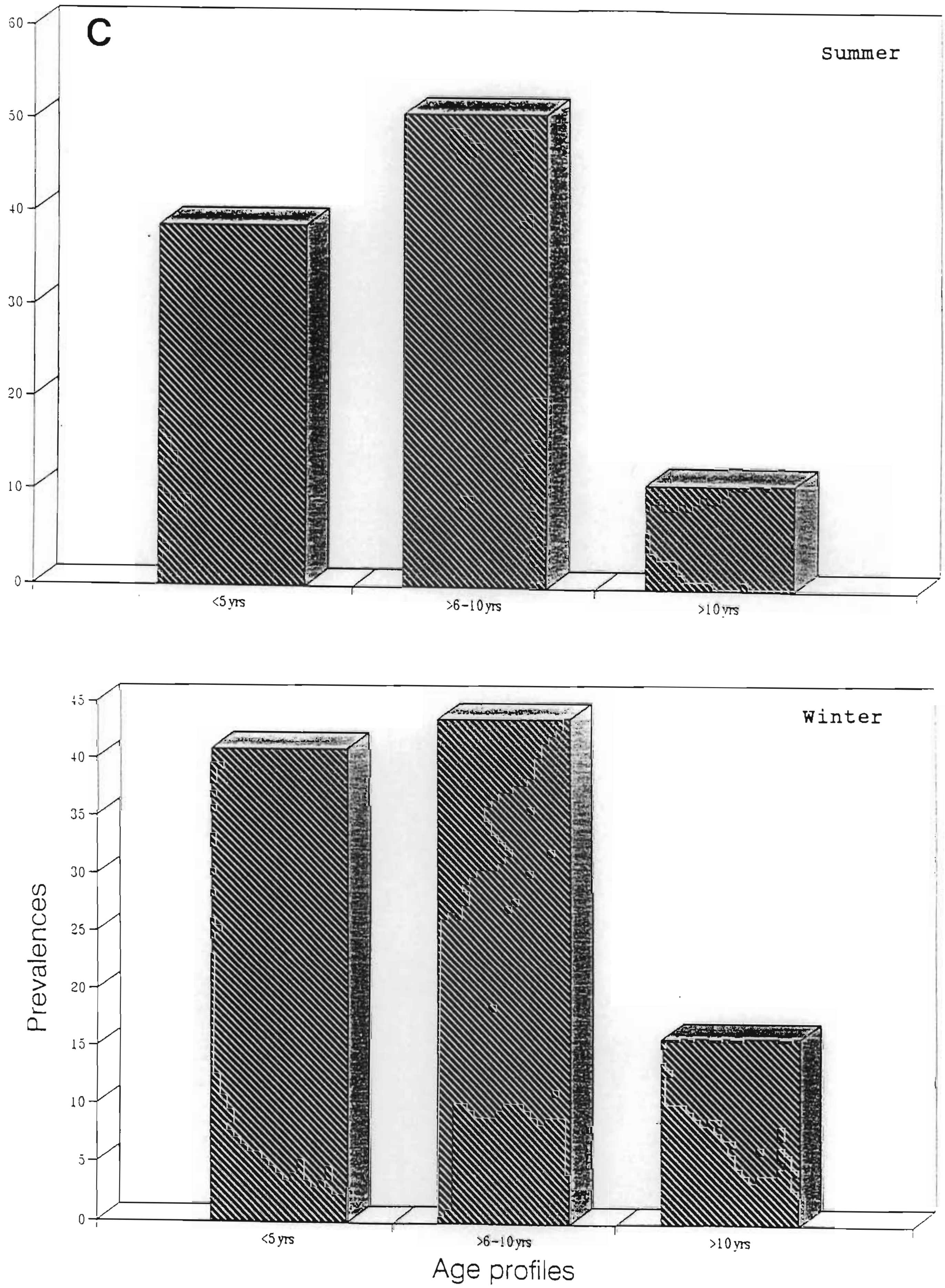
Prevalences of intestinal parasites infections in summer and winter in the three age classes at Mohlakaneng (A), Mafika-

Mafika-ditshiu

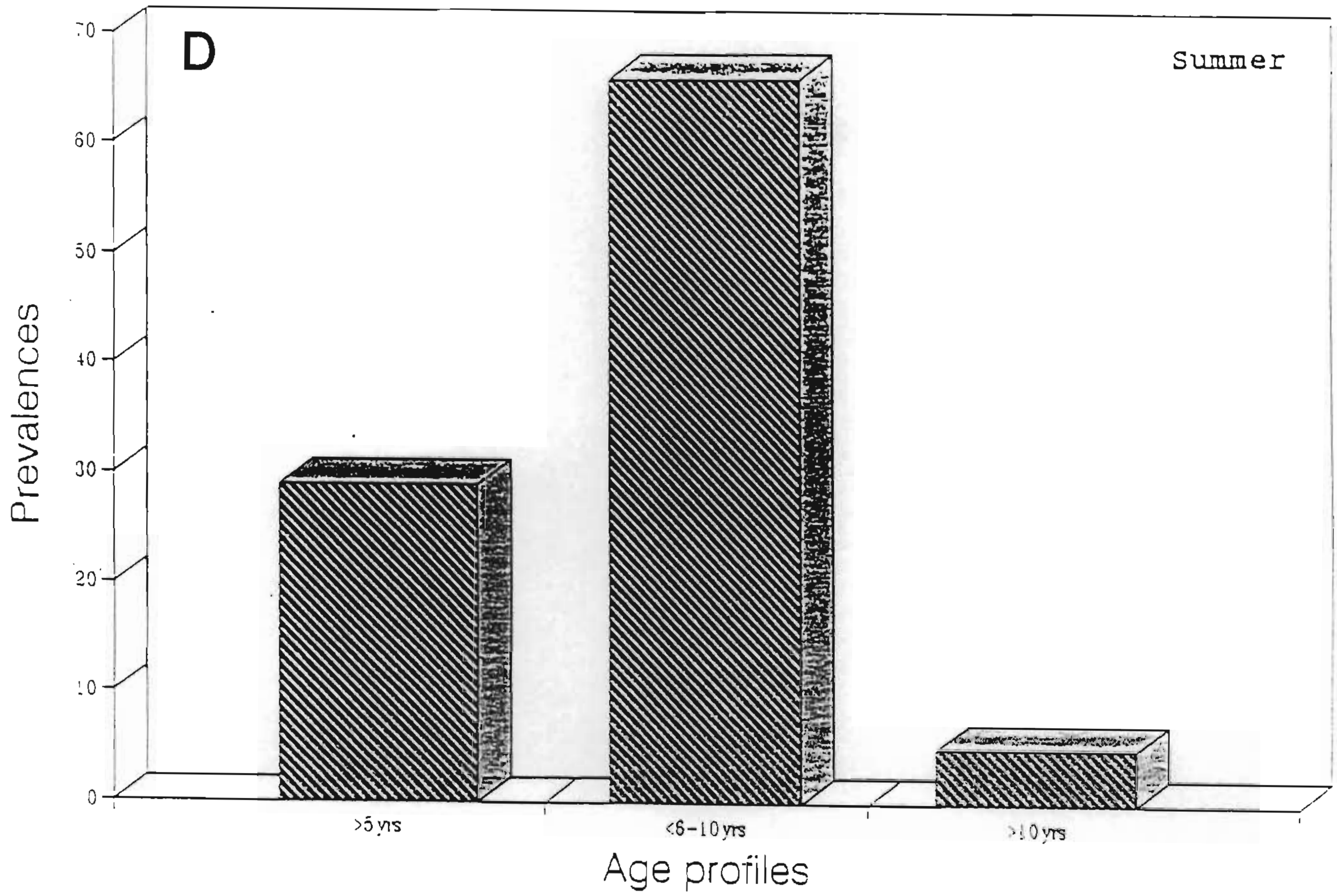




Teboho


C
Summer
60
50
40
30
20
10
0
<5 yrs
>6-10 yrs
>10 yrs
Winter
45
40
35
30
25
20
15
10
5
0
Prevalences
<5 yrs
>6-10 yrs
>10 yrs
Age profiles

Makhetheng


D
Summer
Prevalences
60
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30
20
10
0
>5 yrs
<6-10 yrs
>10 yrs
Age profiles


Winter
Prevalences
60
50
40
30
20
10
0
<5 yrs
<6-10 yrs
>10 yrs
Age profiles

The age of parents or guardians (usually grandparents) categorized as (i.e. <30, 31-40 and >40 years) did not have any significant effect on whether or not a child was infected. This was true regardless of the sex of the parent or guardian.

5.6.1.3 EFFECT OF HOUSEHOLD SIZE ON TRANSMISSION

The average household size in Qwa-Qwa is six to seven people. This increases according to the following trend: rural (see Plate IA) >urban (see Plate IC) >semi-rural (see Plate IB) (p.23). The largest average household size recorded was in Makwane with 8 to 12 people. The smallest household size (<5 people) was recorded. In the higher socio-economic sector of the Qwa-Qwa community. Interestingly, the highest ascariasis prevalence was recorded at Teboho school which serves the Makwane community. Trichuriasis was not recorded at Teboho school. However statistical results show that 41.0% of the children from small households, 38.0% from intermediate households and 39.0% for households with more than ten people were not infected. Household size did therefore not have a significant effect on parasite transmission:

χ^2 = 1.11 on 1 d.f. (p = 0.29) (summer)

χ^2 = 2.73 on 1 d.f. (p = 0.098) (winter)

Use of the Mantel-Haenszel approach to adjust for the possible confounding effect of "school" gave:

χ^2_{MH} = 0.01 (p = 0.85)

χ^2_{MH} = 1.57 (p = 0.21)

5.6.1.4 EFFECT OF LEVEL OF EDUCATION ON TRANSMISSION

The lowest levels of education were recorded at Makhabane, Lejwaneng and Rietpan even though educational institutions are evenly distributed within the study area. The heads of the households in these areas (Group 1) have only primary school education or no education at all. The results of the survey indicated that 66.0% of the children whose fathers possess a primary education qualification only, were infected. For children whose fathers had a higher primary, secondary or tertiary level of infection rates were 64.0%, 64.0% and 33.0% respectively. The highest level of infection (68.0%) was recorded among those children whose fathers had no formal education at all. There is strong evidence that the fathers level of education has a significant influence on the probability of his children being infected in summer, however in winter there is no evidence of the relationship:

$\chi^2 = 30.39$ on 4 d.f. ($p \leq 0.0001$) (summer)

$\chi^2 = 3.45$ on 4 d.f. ($p = 0.49$) (winter)

The present study shows that for children whose mothers had only attained a lower or higher primary qualification, infection levels were 65.0% and 71.0% respectively. Among children whose parents possessed secondary education the prevalence rate was 62.0% compared with 35.0% observed in those children whose mothers had tertiary education. This was only significant in summer.

$\chi^2 = 38.78$ on 4 d.f ($p \leq 0.0001$) (summer)

$\chi^2 = 1.54$ on 4 d.f ($p = 0.82$) (winter)

One possible reason for the different results in summer and winter is the exclusion of the control school in winter (since many parents in the control area had higher levels of education).

5.6.1.5 EFFECT OF LEVEL OF EMPLOYMENT OF PARENTS/GUARDIANS ON TRANSMISSION

Employment of the father has been shown to be significant in determining the probability of a child becoming infected in summer but not in winter. In summer, 60.0% of children whose fathers were unskilled were infected. whereas 50.0% of those whose fathers were skilled were infected. Children who were looked after by their grandfathers, were 67.5% infected.

$\chi^2 = 9.35$ on 3 d.f. ($p = 0.025$) (summer)

$\chi^2 = 3.10$ on 3 d.f. ($p = 0.38$) (winter)

Sixty eight percent of children whose mothers were unskilled were infected, while those whose mothers were skilled showed a 45.0% infection rate. Those children who were looked after by pensioners showed a 62.0% level of infection. Association of mother's employment and infection was found to be significant

$\chi^2 = 22.58$ on 3 d.f. ($p \leq 0.0001$) (summer)

$\chi^2 = 2.63$ on 3 d.f. ($p = 0.45$) (winter)

5.6.1.6 EFFECT OF HOUSEHOLD INCOME ON TRANSMISSION

The income of father played a significant role in parasite transmission in summer. Sixty six percent of children whose fathers earned less than R300 p.m. had intestinal parasites. Of those who earned between R301 - R600 p.m. 64.0% of their children were infected, and 40.0% of children whose fathers earned more than R1 000 p.m were infected. In winter there was no such relationship.

$\chi^2 = 24.39$ on 4 d.f. ($p \leq 0.0001$) (summer)

$\chi^2 = 4.62$ on 4 d.f. ($p = 0.33$) (winter)

The mother's income played an even more significant role in determining whether a child is likely to be infected or not in summer. Sixty five percent and 68.0% percent children whose mothers earned less than R300 p.m. and R301 - R600 p.m. respectively were infected. Only 35.0% of children whose had mothers earned more than R1 000 p.m. had infection:

$\chi^2 = 39.97$ on 4 d.f. ($p \leq 0.0001$) (summer)

$\chi^2 = 3.16$ on 4 d.f. ($p = 0.53$) (winter)

5.6.1.7 EFFECT OF HOUSING QUALITY ON TRANSMISSION

Levels of infections varied according to house quality.
Children living in brick houses were the least likely to be infected; 55.0% were infected followed by children liviing in mud houses where the prevalence was 65.0%. Children who lived in shacks had a 71.0% infection rate. The correlation between house

quality and parasite transmission was significant:

$\chi^2 = 9.86$ on 2 d.f. ($p \leq 0.01$) (summer)

$\chi^2 = 5.96$ on 2 d.f. ($p = 0.051$) (winter)

5.6.1.8 EFFECT OF KIND OF MEAT EATEN ON TRANSMISSION

There was no evidence for any significant association between parasite transmission and the kind of meat eaten. My survey showed that 55.0% ate beef, 36.8% ate both beef and pork, 5.5% ate goat meat, 2.4% ate pork only and 0.3% could not afford to buy meat at all. Note that the statistical results for this variable are unreliable due to a very large number of missing values and only 16 pork eaters.

5.7.1.9 EFFECT OF SOURCE OF MEAT ON TRANSMISSION

The association between source of meat and intestinal parasite transmission was found to be not significant. The results showed that 53.6% of children who ate meat bought from a butchery were infected. However 63.6% of children whose parents bought meat from the butchery and also slaughtered their own were infected. This provides some evidence that the inclusion of self-slaughtered meat in children's diets promoted parasite infection.

5.6.1.10 EFFECT OF QUALITY OF MEAT ON TRANSMISSION

There was statistical evidence that children coming from families that bought both graded and ungraded meat were infected significantly more often than those children whose families did not buy meat at all, 55.0% were infected. Of those who came from families who bought meat from vendors or slaughtered their own and thus ate uninspected meat, 67.0% were infected.

χ^2 = 13.58 on 2 d.f. ($p = 0.001$) (summer)

χ^2 = 7.57 on 2 d.f. ($p = 0.023$) (winter)

5.6.1.11 EFFECT OF DISTANCE FROM WATER SOURCE ON TRANSMISSION

Water source had a highly significant effect on parasite transmission in summer. Thirty five percent of children from households with taps available indoors, were infected. Those who had water sources further from the house were 65.0% infected while and those which had to fetch water more than a kilometre away had 72.0% of their children infected.

χ^2 = 57.67 on 3 d.f ($p \leq 0.0001$)(summer)

χ^2 = 6.14 on 3 d.f ($p = 0.11$) (winter)

5.6.1.12 EFFECT OF SANITATION ON TRANSMISSION

Only 32.7% of children who had flush toilets in their houses were infected; 86.0% of these children were from Sentinel school which serves the higher socio-economic sector of the community. Those who only had access to pit-latrines or buckets were 67.0% infected. This was a highly significant association. Pooling the data from all nine schools:

χ^2 = 57.51 on 1 d.f. ($p \leq 0.0001$) (summer)

χ^2 = 1.33 on 1 d.f. ($p = 0.72$) (winter)

Use of the Mantel-Haenszel approach we got:

χ^2_{MH} = 23.14 on 1 d.f ($p \leq 0.0001$) (summer)

χ^2_{MH} = 0.16 ($p = 0.48$) (winter)

The effect of sanitation is however likely to be confounded with other socio-economic variables such as water source, electricity and housetype.

5.6.1.13 EFFECT OF ELECTRICITY ON TRANSMISSION

The results show that 31.0% of children coming from homes with electricity were infected while 67.0% of those coming from homes without electricity were infected. There was strong evidence that the presence or absence of electricity in the home influenced parasite transmission:

χ^2 = 62.08 on 1 d.f ($p \leq 0.0001$) (summer)

χ^2 = 1.17 on 1 d.f ($p = 0.64$) (winter)

Use of the Mantel-Haenszel approach to adjust for the possible confounding effect of "school" gave:

χ^2_{MH} = 57.41 ($p \leq 0.0001$) (summer)

5.7 STATISTICAL MODELS

Logistic regression models were fitted, with parasite infection as the binary response. Explanatory variables considered were type of house, quality of meat, mother's employment level, gender, age, water source, electricity, sanitation and household size. School was fitted as a fixed effect .

The most important effects in summer were whether or not the household had electricity, quality of meat eaten and source of water. The results for summer are summarized in Tables 10a &10b which indicate that (adjusting for schools) children without electricity are 4.6 times more likely to be infected than those with electricity, those who eat either ungraded meat or both graded and ungraded meat are about twice as likely to be infected compared to those who have water supplied in the house.

Table 10a

Parasite infections corrected for control school, summer data.

Analysis of Deviance (Dev)

Source	df	Dev	Significance	
School	8	43.2	***	($p<0.001$)
Electricity	1	27.8	***	($p<0.001$)
Meat quality	2	8.7	**	($p<0.01$)
Water source	1	4.9	*	($p<0.05$)
Age	2	2.5	not significant	
Residual	426	542.9		

Interpreted Parameters

Parameter	est.	s.e.	Odds Ratio
No electricity	1.519	0.516	4.57
Ungraded meat	0.688	0.290	1.99
Both graded & graded meat	0.669	0.240	1.95
Water source	0.932	0.422	2.54

Key:

est. = estimate

s.e. = standard error

O.R. = Odds Ratio

n.s. = not significant

Table 10b

Parasite infections. Winter data - correct Denominator including mother's employment level.

Analysis of Deviance

Source	df	Dev	Significance
School	7	24.6	*** (p<0.001)
House type	2	10.7	*** (p<0.001)
Meat grade	2	2.5	n.s.
Water source	1	1.3	n.s.
Residual	321	409	

Interpreted Parameters

Parameters	Est.	s.e.	Odds Ratio
Housing quality 2 (shack houses)	-0.47.	0.386	0.625
Housing quality 3 (brick houses)	-1.068	0.391	0.343

A similar model was then fitted using the Genstat procedure GLMM for fitting Generalized Linear Mixed Models. This in general inflates the parameter estimates by allowing for the clustering effect of schools.

The following parameter estimates were obtained:

Parameter	est.	s.e.	O.R.	χ^2	Sig.
No electricity	0.9538	0.41	2.60	36.3	*** ($p<0.001$)
Ungraded meat	0.4979	0.25	1.65	6.3	* ($p<0.05$)
Both ungraded and graded	0.5816	0.25	1.79	6.3	* ($p<0.05$)
No water available in the house.	0.7243	0.37	2.06	3.8	n.s ($p = 0.05$)

Thus in this case ignoring the clustering effect of school leads us to an overestimate of the size of the effects of the socio-economic variables. In winter the most important variable was type of housing, with no other variable being significantly related to parasite infection at the 5.0% level. The results for winter are summarized in Table 10b. We see that children living in mud houses are 0.63 times as likely to be infected as children living in shacks, while children living in brick houses are only 0.36 times as likely to be infected as children from shacks (i.e children living in shacks are about 3 times more likely to be infected than children from brick houses).

The results from GLMM are summarized below:

Parameter	est.	s.e.	O.R.	χ^2	significance
Mud house	-0.4454	0.327	0.64	7.0	($p<0.05$)
Brick house	-0.8167	0.3282	0.44	7.0	($p<0.05$)

So again, ignoring the clustering effects of schools leads us to overestimate the size of the effects of socio-economic variables.

Variables such as economic status and level of education were not considered in these models due to the large number of missing values in these variables. When fitting GLMM the effect of altitude could be examined, but there was no evidence of change in infection rate with increasing altitude (in both summer and winter).

In conclusion the results for summer and winter were very different, with much stronger associations found in summer. This was partly due to the fact that there was no control school data in winter, but an analysis of the summer data excluding the control school still showed different results from winter.

Chapter 6

GENERAL DISCUSSION

This study has involved a detailed investigation into the diversity and transmission of human intestinal parasites infecting children at high altitudes, from 1600 to 2200m, their prevalences and intensities in relation to climatic, demographic and socio-economic factors. The results were compared to Kravitz et al., (1993) from neighbouring Lesotho (see Tables 15a and 15b). The two studies are almost similar.

People in Qwa-Qwa are not severely parasitised by worms and there is no hookworm or bilharzia as it has been established by Evans et al., (1987) and Pitchford (1981) that the *Schistosoma* endemic areas are below 1400m. The study has developed a model of intestinal parasite transmission at community level and lays a groundwork on which the Primary Health Care (PHC) and Public Health authorities can base the design and control programme for the area or any area in South Africa after taking into consideration the relevant climatic and socio-economic factors.

Data on intestinal parasites at high altitudes (Kravitz et al., (1993a&b) and this study) show that there is a very low prevalence and intensity of worm infection but a wide range of prevalences and intensities of protozoan infections. Kravitz et al., (1993b) attributed the absence of helminths, especially *Ascaris*, hookworm and *Trichuris* from Lesotho to cold, dry climate, which was unfavourable for the survival of eggs and, in

Table 15a
Comparison of the prevalences of intestinal protozoans in KwaZulu-Natal, Lesotho and Qwa-Qwa .

Study area	1	2	3	4		
Altitude (m.a.s.l)	50 - 1720	100 - 300	1650	1660 - 2200		
Number of children sampled	N = 693	N = 7569	N = 1611	N = 1180		
Parasite species	%Prev	% Prev	% Prev	Sum %	Win %	Ave %
Protozoans						
Giardia intestinalis	16.8	3.4	4.1	3.5	5.5	4.5
Chilomastix mesnili	1.3	4.2	6.1	14.6	8.9	11.8
Balantidium coli	0.7	0.7	0.0	0.0	0.0	0.0
Entamoeba histolytica	0.9	4.3	14.5	0.7	2.0	1.4
Entamoeba coli	40.2	60.5	53.2	46.7	58.9	52.8
Entamoeba hartmanni	0.0	4.3	6.7	6.6	5.2	5.9
Endolimax nana	2.1	7.0	3.7	16.7	19.5	18.1
Iodomoeba buetschlii	17.8	4.3	1.7	3.6	0.8	2.2
SPA	0.0	0.0	0.0	0.6	0.3	0.45
MSPA	0.0	0.7	0.0	5.2	3.0	4.1

Key:

1 = KwaZulu-Natal altitudinal transect study by Appleton and Gouws (in press)

2 = KwaZulu-Natal coastal community study by Schutte *et al.* (1981)

3 = Lesotho study by Kravitz *et al.* (1993)

4 = This study (1995)

m.a.s.l = metres above sea level

SPA = Small pre-cystic unidentified amoebae

MSPA = Medium sized precystic unidentified amoebae

Table 15b.

Comparison of the prevalences of intestinal helminths in KwaZulu-Natal, Lesotho and Qwa-Qwa.

Study area	1	2	3	4		
Altitude (m.a.s.l)	50 - 1720	100 - 300	1650	1660 - 2200		
Number of children sampled	N = 693	N = 7569	N = 1611	N = 1180		
Parasite species	%Prev	%Prev	%Prev	Sum %	Win %	Ave %
Helminths						
taeniid tapeworm	0.9	1.5	0.5	0.1	0.1	0.1
Hymenolepis diminuta	0.0	0.03	0.0	0.3	0.1	0.2
H. nana	2.8	0.6	0.1	0.3	0.0	0.15
Fasciola hepatica	0.25	0.3	0.0	0.0	0.0	0.0
Schistosoma haematobium	0.9	57.0	0.0	0.0	0.0	0.0
Strongyloides stercoralis	10.3	0.5	0.3	0.0	0.0	0.0
Trichuris trichiura	93.5	54.1	0.1	0.8	0.2	0.5
Enterobius vermicularis	2.8	0.9	0.0	0.3	0.4	0.35
Ascaris lumbricoides	84.1	50.4	0.9	3.8	2.1	2.95
Necator americanus	30.8	37.2	0.0	0.0	0.0	0.0

Key:

1 = KwaZulu-Natal altitudinal transect study by Appleton and Gouws (in press)

2 = KwaZulu-Natal coastal community study by Schutte *et al.* (1981)

3 = Lesotho study by Kravitz *et al.* (1993)

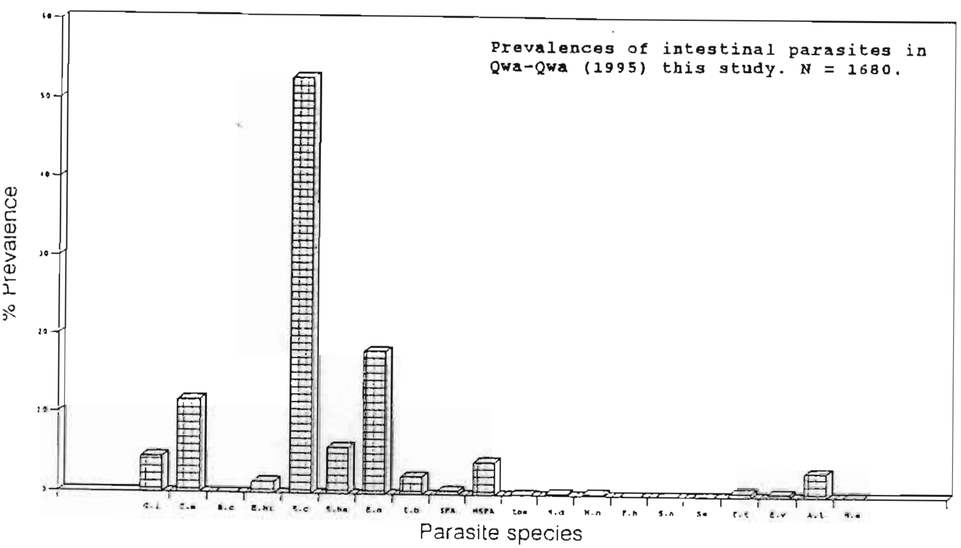
4 = This study (1995)

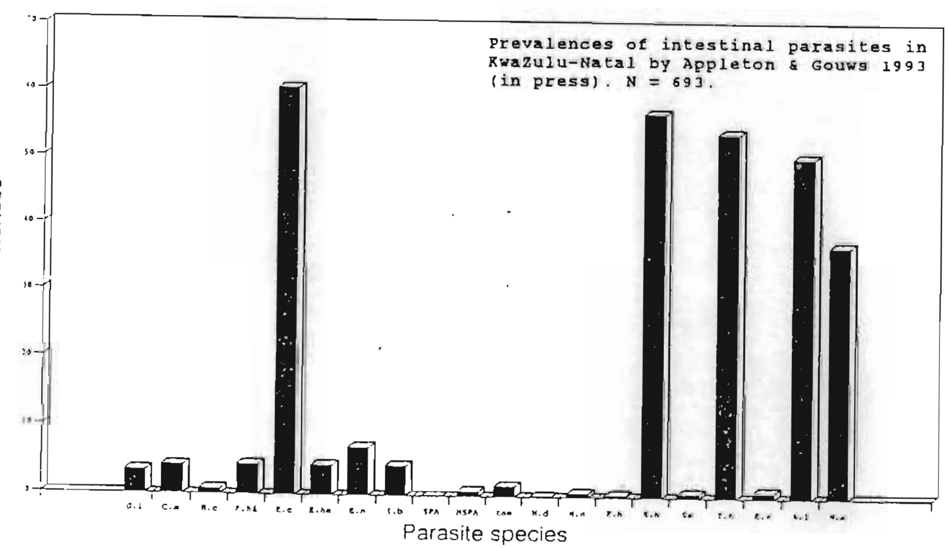
m.a.s.l = metres above sea level

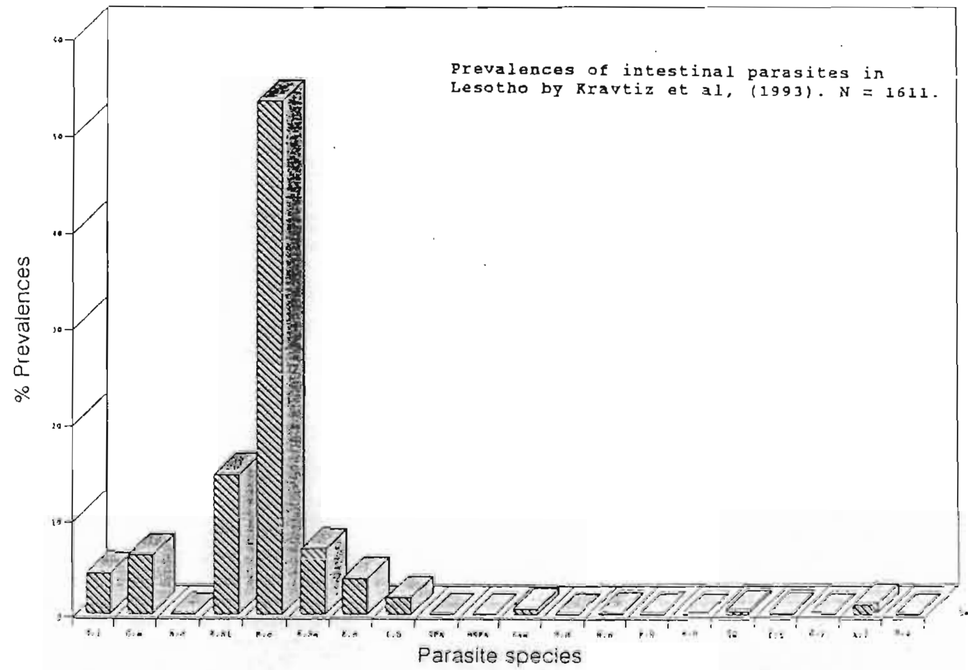
the case of hookworm the free-living larval stages. This is in contrast with studies conducted in KwaZulu-Natal by Appleton & Gouws (in press) and Schutte et al., (1981) which recorded a high diversity and prevalences of helminths infections (see Fig. 9). In studies across KwaZulu-Natal, Appleton and Gouws (in press) showed that there was a decrease in prevalence of human gastrointestinal parasites with increasing altitude from sea level to 1750m. These data from sea level to 1750m are tabulated together with data (1800, 2000 and 2200)m from this study in Table 16. The two studies show a clear decline in worm infections e.g from 84.1% *Ascaris* at sea level 1.7% at 2200m; *Trichuris* dropped from 93.5% at sea level to 0.0% above 2000m. In fact *Trichuris* seem to be just "hanging in there" in the study area, which might indicate that this is its upper limit. The absence of *Trichuris* at altitudes above 2000m can be explained by the fact that the egg is not mamillated and lacks the albuminous external layer that is found in the *Ascaris* egg (see Plate V for comparison of eggshell textures for the nematodes recorded in the study area) (p.42). It has been noted that the *Trichuris* egg survives better in areas of high rainfall, high humidity, dense shade and moisture retaining soils but the problem might be its sensitivity to desiccation (Garaguso, 1981; Beaver et al., 1984; Schimdt & Roberts, 1985 and Anderson, 1992). Although Qwa-Qwa has high rainfall, high humidity, with midwinter mean ambient temperature of 7°C and mean summer ambient temperature of 19°C, the whipworm egg might not be able to tolerate the dry climate long periods of sunshine. In addition, the bulk of the area is rocky and most of the soils do not hold moisture. *Schistosoma* is

Figure 9

Prevalences of intestinal parasites in Qwa-Qwa, Lesotho and KwaZulu-Natal. (A) this study (B) Lesotho study by Kravitz et al, 1993; (C) KwaZulu-Natal study by Appleton & Gouws, (in press) and (D) KwaZulu-Natal study by Schutte et al, (1981).


Prevalences of intestinal parasites in
Qwa-Qwa (1995) this study. N = 1680.
% Prevalence
Parasite species


Prevalences of intestinal parasites in
KwaZulu-Natal by Appleton & Gouws 1993
(in press). N = 693.
Parasite species


Prevalences of intestinal parasites in
Lesotho by Kravtiz et al, (1993). N = 1611.
% Prevalences
Parasite species

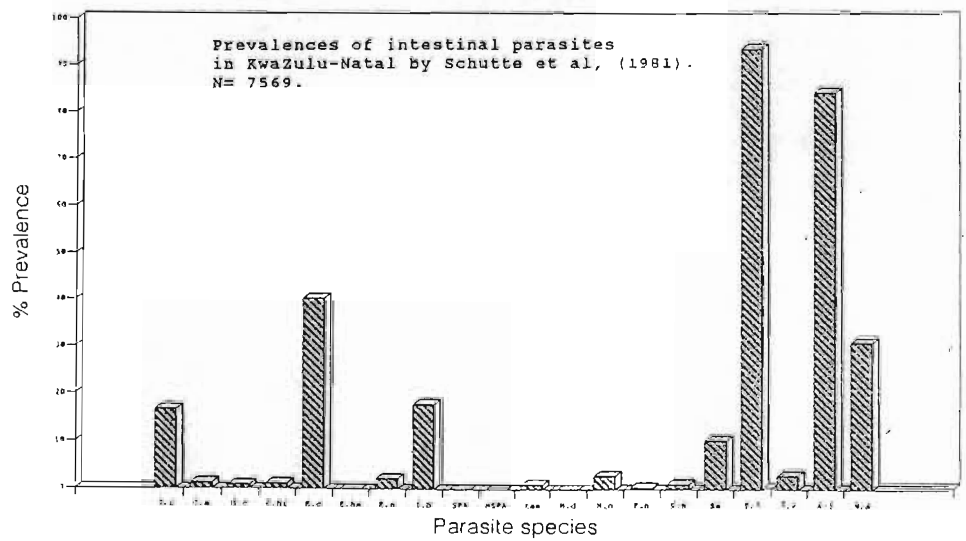

Prevalences of intestinal parasites
in KwaZulu-Natal by Schutte et al, (1981).
N= 7569.
% Prevalence
Parasite species

Table 16.

Comparisons of prevalences of parasites along an altitudinal transect between KwaZulu-Natal and this study.

Sch	Si	Bh	Em	Um	Do	Th	Te	Se	Mkh
Alt	50	480	860	800	1100	1720	1800	2000	2200
Spec	%	%	%	%	%	%	%	%	%
E.c	40.2	44.4	29.3	37.9	17.1	40.2	67.0	53.0	61.0
E.hi	0.9	0.7	2.7	1.7	1.3	2.2	2.4	3.6	0.0
I.b	17.8	3.5	3.4	4.3	4.0	5.8	7.6	3.6	2.6
E.n	0.0	0.0	2.0	2.6	1.3	6.6	28.0	16.7	26.0
G.d	16.8	7.8	7.5	4.3	4.0	8.0	7.4	6.1	1.9
C.m	0.0	0.0	1.3	0.0	0.0	0.0	13.5	12.8	15.0
B.c	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T.t	93.5	55.6	15.7	37.9	5.3	5.8	0.0	0.0	0.0
Ho	30.8	4.9	2.7	0.0	2.6	0.0	0.0	0.0	0.0
Str	10.3	0.0	1.3	0.0	0.0	0.7	0.0	0.0	0.0
E.v	2.8	0.7	0.0	0.9	0.0	0.7	1.0	0.2	0.0
A.l	84.1	59.9	29.9	67.2	44.7	12.4	13.0	2.1	1.7
F.h	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0
S.h	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

absent because there are no snails to host its intermediate stages.

An interesting parasite which shows an increase with altitude is *Endolimax nana*. It started to appear at 860m with prevalence of 2.0% and increased to 26.0% at the top school in Qwa-Qwa (2200m).

The survey was done in a small area, nine communities were investigated and the difference in altitude between them was 600m, i.e between the highest and lowest settlement. Interestingly there was a marked difference in parasite distribution but this was due more to socio-economic factors than to topographical factors.

A similar landscape epidemiological study was conducted in Kenya, by Ashford et al., (1993) over a smaller altitudinal range (15 to 225m). Prevalences varied between 24.0% and 75.0%. These clusters (20 individuals were randomly selected, each to indicate the centre of a cluster). These results showed that people living in drier areas, furthest from the coast were relatively free from intestinal nematodes and that human behaviour was at least as important as the major environmental factor in determination of parasite abundance. This was supported by other authors e.g (Nelson, 1966 Pampiglione & Ricciardi, 1974; Chunge et al., 1985) . In Ashford et al., (1993) study, the prevalence of *Ascaris* at 15m was 69.0% and 15.0% at 225m ascariasis prevalence was 15.0%, trichuriasis prevalence at 15m was 27% and at 225m trichuriasis prevalence was 11.0%. The only other South African study that reveal a decrease in prevalence of *Trichuris* from the coastal belt to higher altitudes ±300m was Schutte et al., (1979).

Generally there was a decreasing trend amongst all prevalences and intensities of infections in winter especially in worm infections. Cestodes were rare in summer and virtually absent in winter. Exceptions were *E. coli* and *E. nana* which were more common and more intense in winter. A possible explanation is the cold temperatures on the ground due to frost. The average ambient temperature during mid-winter in Qwa-Qwa is 7°C, the soil temperature can be even lower according to Geiger (1950). He found that soil condition changes with weather depending on the moisture content of the soil. He discovered that at depths beyond 1m the temperature becomes constant and above that soil temperatures fluctuate, and that if dry air moves up and down the atmosphere adiabatically, its temperature changed. In moving upwards it came into a region of lower air pressure, its volume increases and it became cooler. Descending air, on the other hand became warmer. Thermodynamics tells us that altitudinal temperature changes amount to 1°C per 100m difference in altitude. Perhaps that is why worm infections are low at Makhabane and Sehlajaneng with altitudes of 2000 and 2200m respectively although they have mean annual rainfall of 1000 to 1100m per annum and the protozoans were taking an advantage of the empty niche since they are not dependent on environmental temperature for their survival. There are no data available on ground temperatures and relative humidity in Qwa-Qwa.

Protozoans are more likely to be transmitted in winter than geohelminths because in winter many children (especially boys irrespective of age) wore the same clothes for many days, they don't wash and they sleep together to keep themselves warm. Girls wash regularly whereas boys of the 6-10 years age group wash their faces only. They play differently from girls of their age, they make wire cars and drive them around, some make animals with clay and sell them. When making this animals they use their saliva to smooth the clay surfaces of the animals and this habit may cause infection with soil transmitted parasites.

Another reason for possible transmission of faecal matter is that most rural people do not clean their hands before eating and after defecating. Most people do not use toilet paper, they either use stones, or old newspapers, children <6 years both boys and girls do not wipe themselves at all. Children are forced to sleep together especially because in rural areas children sleep on the floor while adults and visitors sleep on the bed. Blankets used by these children are washed once or twice a year depending on the general cleaniless of the family or whether there is enough soap to wash them. Sheets and use of toilet paper to clean the anus after defecating are luxuries. Water is used to wash children, in clean families only.

Schools are provided with toilet paper but it never reaches the pupil's toilets. Pupils in these school bring their own paper, some use newspaper, this leads to most of toilets at school becoming blocked and are not immediately unblocked by municipality. The only school which teaches children to use toilet paper is Sentinel. Here general assistants stand at the toilet's door during the interval. They give each child a piece of toilet paper and explain and demonstrate to each child what they are expected to do. This practice continues until the children get used to it.

Person to person infection can be another factor that causes transmission of protozoans in the area. The small amount of water used for personal hygiene, storage of water in open vessels and not cleaning the vessels frequently may lead to the vessels being the main source of contamination. In addition these vessels are used to brew "Mqomboti" during traditional feasts, which may result in an increase in bacterial and fungal growth and lead to increasing protozoan populations because most of the commensal, especially *E. coli* feed on bacteria (Fripp, 1979; Beaver et al., 1984 and Mims, 1992). The quantity of water used for personal hygiene was found to be the chief factor accounting for the high prevalences of giardiasis in Lesotho (Esrey et al., 1989). This was supported by (Jeon, 1973; Campell, 1982; Watts, 1986; Henry, 1990; Morgan 1990; Pinfold, 1990; Kravitz et al., 1993a&b and Lengerish et al., 1994).

Protozoan cysts can survive storage in refrigerator (4°C) for periods varying between 7 to 36 weeks (Neal et al, 1974). *Giardia* on the other hand is known to withstand chlorine (Gray et al., 1994).

Part of the life-cycles of *Trichuris* and *Ascaris* involve embryonation of their eggs which must take place outside the host environment. Under suitable conditions of temperature, moisture. O_2 content and soil texture (determined by grain size of the soil), embryonation proceeds to the infective first stage larva of *Trichuris* and to the infective second stage larva in *Ascaris*. Anderson (1992) gave the following rates of the development of *Trichuris trichiura* eggs at various temperatures: 120 days at 20°C; 57 days at 25°C; 17.5 days at 30°C; and 11 days at 35°C and its daily egg output is 3 000-20 000 (Faust et al., in Anderson, 1992; Maung (1978) in Anderson, 1992 and Needham & Lillywhite, 1994) reported considerable variability in the timing of the moults of *Ascaris lumbricoides* larvae, at 28°C L1 stage occurred in 15 to 24 days and the infective L2 stage after 17 days. Fully embryonated L2 larval stage of *Ascaris* can remain viable for up to six years under favourable conditions (Crompton et al., 1989).

Although prevalences and intensities of parasites found in the study area were low, a case of *Ascaris* forming a bolus has been reported in Qwa-Qwa from an 19 year old female (see Plate VIII). According to the report there was no evidence of worm infestations clinically. Findings at a laparotomy indicated a very tense and distended terminal (±10cm) part of the jejunum, packed with thick glittering *Ascaris lumbricoides*. About 10cm of the bowel segment was showing signs of devitalisation, i.e early necrosis. Milking of the worms was impossible without tearing off the necrotic luminal wall. The obstruction was complete at that point and the surgeon could see the worm moving in other part of

PLATE VIII

Intestinal bolus

Contrast X-ray of the abdomen of a 19 years old female, showing *Ascaris lumbricoides* forming a bolus (arrow).

(Courtesy of Dr. J. Moloi, Manapo Hospital, Qwa-Qwa).

the abdominal cavity. A 15cm piece of small bowel/necrotic bowel, was resected and an end-to-end anastomosis was performed. As the bowel recovered from surgery and a sausage of worms removed, the patient was put on Mebendazole orally and discharged from hospital after two weeks. Similar cases have been reported by Millar et al., (1989) at the Red Cross Hospital in Cape Town , Freeman & Grunewald (1980) at Livingstone Hospital in Port Elizabeth. Bradley & Bush (1994) reported seven children with intestinal obstructions to *A. lumbricoides* admitted to a Red Cross Memorial Children's Hospital in KwaZulu-Natal over a period of 14 months. It is known among Africans that pregnant women like eating soil (pica) (personal communication with nursing sisters at 27 clinics visited in Qwa-Qwa and people in general).

The most common protozoans found in the area are primarily considered as commensals and cause no disease. Their presence in the stool is however an important indicator that a child has ingested some faecal matter and therefore identification is of diagnostic value (Katz et al., 1988). Amoebic dysentery was diagnosed in 100 to 150 children per year in Cape Town (Watson et al, 1970 and Segal et al., 1981), found 7 cases out of 55 patients examined at Baragwanath Hospital in Soweto. Giardiasis has been confirmed as the main cause of travellers diarrhoea (Beaver et al., 1984; Ukoli, 1984 and Meyer, 1990).
E. histolytica normally feeds on the intestinal contents but may ingest blood sometimes feed blood, even the worms, particularly if they are present in large numbers (Sepulveda & Diamond, 1976 and Scrimshaw, 1984).

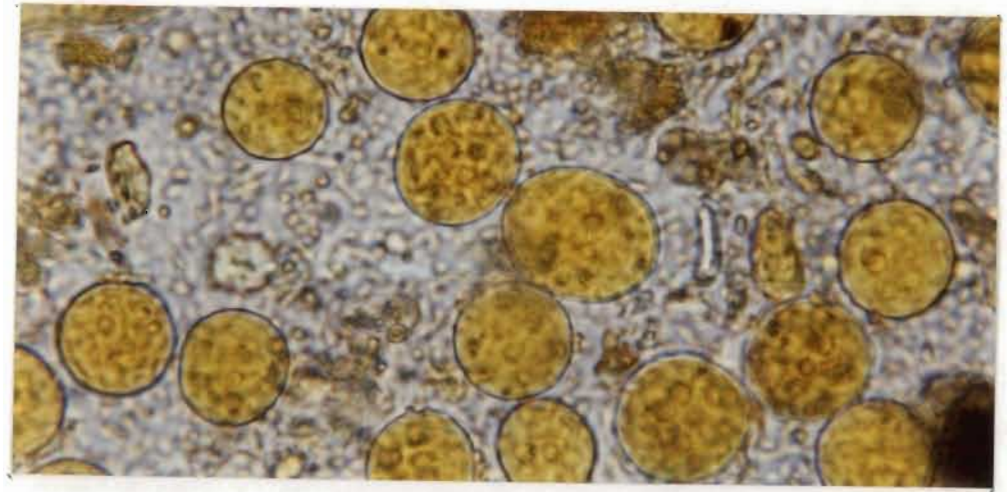
Protozoans, both pathogens and non-pathogens can reduce the absorptive area available for nutrient uptake if they are abundant (>+++) (see Plate VII). Important minerals and vitamins can also pass out with the stool possibly leading to malnutrition and diarrhoea (Garaguso, (1991). Heavy infections of ascariasis are known to be associated with granulomatous hepatitis and multiple liver abscesses (Anstey, 1966 & Louw, 1966 in Hendriks (1994). It has been noted that common parasite infections cause energy depletion and growth stunting in endemic areas and there is a suggestion that mental processes and school achievement can be affected as well (Kvalsvig et al., 1991).

Polyparasitism (the number of parasite species found per child) especially in case of worm infections, does not pose a public health problem in Qwa-Qwa. No child was found infected with more than one species of worm in the survey though there were multiple infections of protozoans. An example of a child with multiple protozoan infection is shown in Plate VII. Polyparasitism becomes important when multiple infections of diseases like schistomiasis, hookworm and malaria occur together with *Ascaris* and *Trichuris* as discussed by Gunders et al., (1993) in Cape Town. In any consideration of how much intestinal parasites contribute to undernourishment and malnutrition. Their contribution on nutritional deficiencies is not clearcut. There are many studies that show that *Ascaris* and *Giardia* for example, may exist in small numbers in a severely malnourished children without evidence of nutrient malabsorption. However, heavier infections unquestionably do cause nutrient losses (Gunzburg et

PLATE VII Qualitative measure of intensities of infection

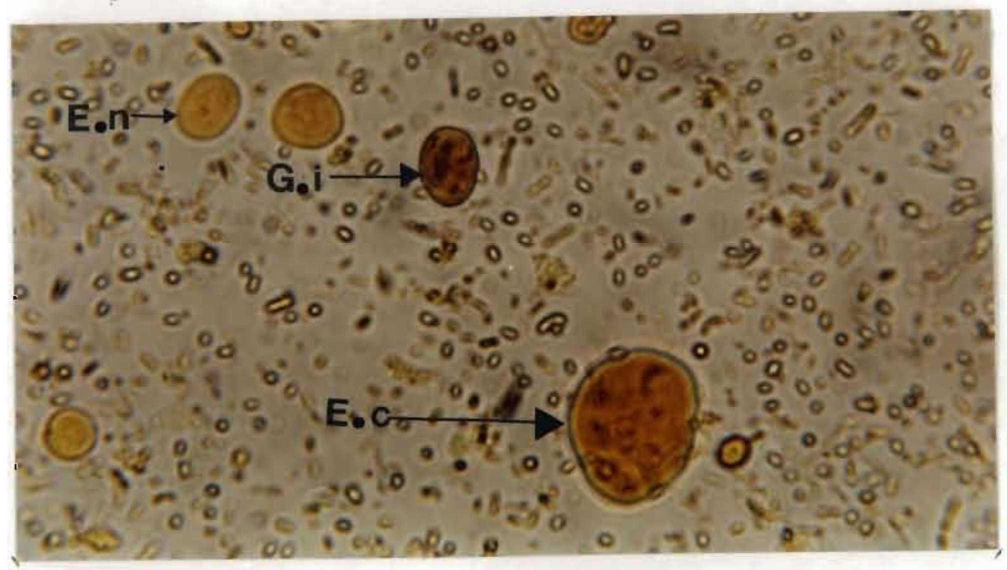
(C.m = *Chilomastix mesnili*, E.c = *E.coli*, E.n = *Endolimax nana*)

+ infection (*Entamoeba coli*)



+++ infection (*Entamoeba coli*)

++ infection (*Entamoeba coli*)



Multiple infection

al., 1992; Gracey, 1985; Solomons, 1982; Wright, 1979).

The most important socio-economic factors affecting parasite transmission in summer were whether or not the household had electricity; the quality of meat eaten and the proximity of the nearest water source. The reason might be that the analysis of the summer results included data from the control school and that caused the much stronger associations between variables and transmission in winter. In winter the only important socio-economic variable significantly associated with transmission was housing quality. But it should be remembered that only eight schools were sampled in winter, and these served the lower socio-economic sector of the Qwa-Qwa population

The models show that there is a 4.57/5 chance of a child without electricity being infected, and a 1.99/5 chance with respect to those children who eat both graded and ungraded meat. The presence or absence of electricity in the home influenced parasite transmission because the prevalent intestinal parasites found are transmitted through contaminated food or drink. In addition it is not possible to have electricity in a shack or mud house i.e. (quality of house), therefore resources to keep food cool in summer will be more expensive than in a house with an electric refrigerator. This results in less contamination of food or drink in a household with electricity.

Water source is important because the probability of a person having water available indoors means that he/she might have a flush toilet and therefore a greater possibility of having electricity within the household. This might be connected to income which is usually determined by a person's level of education and employment. Water source is also important in winter because people without taps available indoors use little water when bathing. Women are the only people who fetch water and most group 1 school which served extreme rural areas (see Plate IA) (p.23) they fetch it >1km away while those in Group 2 school areas (semi-rural and urban) fetch water from <1km. Hence overcrowding plays a more important part in parasite transmission in group 2 settlements (semi-rural and urban) (see Plate IB) than group 1 settlements (extreme rural) (see Plate IA).

Tapeworm is rare, because most people do not eat pork. The explanation for this is that most people do not eat pork because of their religious taboos, and they were not prepared to discuss the issue further during questionnaire interviews. Not eating pork could save them from being infected with *Taenia solium* but the possibility of getting *T. saginatus* still exists. Most children in the rural areas are not given meat, they eat pap and green vegetables (summer) or tea and bread or pap and beans in winter. Meat is only bought on Sundays or when there is a special visitor. The children may only get a chance of eating meat during a feast. Most boys eat rats and birds. This may explain the occurrence of the rat tapeworm *Hymenolepis diminuta* in boys than girls (see Appendix E).

The majority of people in Qwa-Qwa still perform their cultural customs and rituals. Part of this tradition is to slaughter the animal in the yard, the blood must spill there and this shows the respect you have towards your ancestors. The score for traditional customs in the model is low because, communities from all socio-economic sectors of the community eat both graded and ungraded meat. This shows that meat does not contribute much to the transmission of intestinal parasites, but here is an indication of the people's lifestyles. It shows a lack awareness of the dangers of slaughtering without a meat inspector checking the meat before it is consumed. Most Africans, urban or rural, do not or will not part with their traditions and customs and a lot them still use traditional medicines and visit traditional healers (Manganyi, 1974; Matseke, 1974; Tema & Sebego, 1990; Abdol Karim et al., (1994) Crawford, 1995). This compounds the problem of personal hygiene which is found to be a very important factor in protozoan parasite transmission in the study area.

People thought that it was normal that their children should have intestinal parasites, mothers showed concern, but the grandfathers and male guardians seemed not to be perturbed. They were more concerned about poverty and employment.

Their large positive response to allowing their children to comply, was because we promised to treat their children free of charge. Interviewing in their own language made it very easy for them to relax and answer most questions, communication between the interviewee and parents/patient in his/her own language is very crucial, this creates a better atmosphere between the two parties involved, this is supported by Nash, (1995). I tried not to write anything while I was interviewing because they usually think researchers like experimenting with them (i.e. treating them as guinea pigs). When designing the questionnaire I followed suggestions from (Katzenellenbogen, 1991; Lengeler et al., 1991; 1992) by asking less sensitive questions first and follow with more sensitive ones and end with something like "income and education". To get good results a self-administered questionnaire is preferable because the researcher is able to phrase questions such that they will elicit the desired answer in relation to the topic of the investigation. A teacher, for an example, may not be able to decide (or might not be sure) what level of employment applies to someone who is a domestic worker, thus resulting in her filling the incorrect category in the questionnaire. For instance those educated parents who filled-in questionnaires at home had to come to school for clarification, and I had to be there to answer questions relating to the context of the questionnaire. The accessibility of water may also be interpreted differently by subjects of rural origin which may expose the interpretation of data to the effects of subjective interpretation; the presence of the reseacher will aid in eliminating such effects.

Girls washed more frequently than boys, especially age <10 years, but their playing styles were different. Girls and boys <5 years (most of the rural areas children do not attend school until they are six years old and have no pre-schools). The age group <5 years liked playing with soil and some cooked soil as gravy; one coming from a richer family would and steal some mealie meal to make pap, they may start a fire or imagine it, and then start eating. The 6-10 years age group are more clever and careful, and do not eat soil or play with fire, because they know that fire is dangerous. In summer the girls play dolls, "Diketo" a game where they sit on the ground. In winter they play skipping, by making skipping ropes with grass, but they don't play on the ground because it is cold. The boys play soccer or make wire cars and drive around in summer but in winter they make clay cattle, sheep etc and use their tongues to smooth and make final touches of the surface the toys they make, most boys sell them to passing tourists. Because they use clayey soil they stand a good chance of getting *Ascaris* infections. In the higher socio-economic sector of the community, children play with real toys or teddy bears, but very seldom with soil. The study recorded high prevalences of parasitism in the <5 year and 6-10 year age groups.

In this study the overall prevalence of *E. histolytica* was 1.4% in contrast to the 14.0% in Lesotho (Kravitz et al., 1993b). However if the MPSA (3.0%) had been cultured, they could have been identified, possibly as *E. histolytica* and so increased the prevalence. Also the children sampled were <12 years old, whereas Jackson (1995) states that *E. histolytica* is most common in the 20 to 50 years age group.

It should be noted that *Enterobius vermicularis* was excluded from the analysis because it gave false results about the real prevalence of this parasite. Faecal examination gave a 0.4% prevalence of the 2583 samples examined of this parasite, whereas after treating 56 children for helminthic infections, 12 (22.0%) of the post treatment stools had live pinworms in them. The most reliable diagnostic technique to get a true reflection of this parasite is to conduct a cellophane swab technique. This involves the attachment of a piece of cellophane-tape to the peri-anal region overnight or in the morning before the child defecates or takes a bath. Clinically and medically it was not possible to do this in schools or clinics because there are not enough beds at clinics and nor is it to do it at schools.

Statistical analysis shows no difference in parasite transmission with respect to sex, and this has been found by many other authors (Chandiwana, 1989; Evans et al., 1987; Kvalsvig et al., 1991).

In Plate I (p.23) three kinds of settlement are shown, the rural, semirural and urban settlements. The statistical models show that children living in shacks and mud are about three times more likely to be infected than children from brick houses. Plate IA indicates rural areas which have <9 houses per km^2, and though they do not have proper sanitation, they have big yards and many bushes behind the houses where people can defecate, decreasing the chances of cysts and eggs contaminating the surrounding environment.

In rural or semi-rural areas (Plate IB,C) when a latrine is full it is filled up with soil, and after three years the occupants start planting in the area and they actually know that if you plant there the soil is very fertile and they claim to get very big carrots, potatoes, beetroot etc. They even call the area "Manyolong". When these vegetables are prepared they wash them with a little water and don't cook them well, in fact most rural people like the feel of soil when eating green vegetables "Moroho". *Ascaris* eggs can survive for more than two years if the second stage larva has already developed. The problem here is that most people including all traditional healers interviewed. associate intestinal parasites with either fruit, especially peaches, vegetables animals or even witchcraft. They do not associate parasitism with contamination.

When people are washing themselves, they use a small amount of water in a basin. In winter warm this same quantity and share it because they have no resources or electricity to warm more. Most children do not wash at all in winter or share the little water that was warmed depending on whether the family had enough resources to warm more for them. After washing, the dirty water is thrown at the back or front of the house because there are no drainage systems in the lower socio-economic sectors of the community. There is both an advantage and a disadvantage in throwing dirty water in front of the house. The advantage is that on windy days the water is thrown in front of the houses so that it can help settle the dust and prevent from coming into the house. The disadvantage is that a child playing in the same ground can drop a sweet, and picking it up, become infected with parasites like protozoans and geohelmiths, because cysts and eggs of these parasites can withstand any detergent. Personal experience while analysing the stool samples revealed many live infective L2 larvae of *A. lumbricoides* inside eggs in both ether and 5% formalin and even hatched (see Plate VID), to extent of seeing the L2 infective stage larva of *Ascaris* hatching from the egg (see Plate VID) (p.43) and also surviving well in ether and 5% formalin.

The increase in parasite prevalence and intensities in the semi-rural areas and urban areas is a result of high housing densities i.e overcrowding (see Plate IB & C). The consequences of used dish-washing water being thrown either in front of or behind houses may differ depending on the housing density. It may result in an increase in flies, especially in summer. The area with the highest ascariasis prevalence is next to a chicken farm and piggery, which results in more flies than any other place in Qwa-Qwa; the health inspectors consider the area an environmental nuisance. Flies may be important mechanical vectors, carrying eggs and cysts, which can contaminate food or drink with the parasites infective stages.

Most household do not cover food and have no refrigerators to keep the food cold because of the absence of electricity. Their level of income do not allow them to maintain paraffin or gas refrigerators.

Here is an example from personal interviews conducted by myself, of how people think about how worms are transmitted. Intestinal parasites are transmitted if you give your child powdered milk, eat peas, eat raw vegetables or fruit especially peaches. If you happen to eat raw maize, a small worm is hiding there, presumably the developing embryo mistaken for *Enterobius vermicularis* ("Tjobitjobi" or "Lenyonyo" in Sesotho) because most people know it and have seen it on a child at night. If you eat this maize by mistake, the small worm, after being swallowed, grows to be very big and pinkish (presumably *A. lumbricoides* ("Lenyoha"). If a child start passing worms, the local doctors or clinic may prescribe Albendazole or Mebendazole for the patient. Albendazole usually has the disadvantage that it completely destroys the worm while still in the bowel and it is partly absorbed. Mebendazole however is a purgative and paralyses the worm and it is not absorbed (Garaguso, 1981). What the parents see is a dead *Ascaris*. The string-like reproductive organs of these worms, and which fill most of the pseudocoelom, are perceived by both traditional healers and parents to be little *Ascaris*!

Chapter 7

CONCLUSIONS AND RECOMMENDATIONS

The present study not only gives a detailed account of intestinal parasitism at high altitudes but also completes the altitudinal transect of Appleton & Gouws (in press). As such it will make a contribution to public health planning at community level planning in South Africa.

Parasites found in Qwa-Qwa do not constitute a public health problem, therefore chemotherapy (deworming programme) cannot control be justified as a control measure. Rather control should rely on an improvement of personal hygiene, change in certain lifestyles and some traditions like slaughtering own meat, improving sanitation facilities and domestic environment by government through, refuse and sewage disposal. This has been supported by other authors e.g van Rensburg & Fourie, 1990; 1992; 1994; Oskowitz & McKenzie, 1993 and Kent, 1994). Human factors such as implementation of health education programmes are also necessary so that knowledge of the life cycles of parasites and their transmission routes can be taught to women.

It is not the researcher, or a microscope or nurses or teachers that will prevent people in this area from being infected with parasites. Affected communities must be involved in trying to implement control programmes themselves and must take the initiative in trying to improve their lifestyles and abandon some of their customs which might be difficult to do, and lastly improve their environment by collecting refuse.

The Government must try to uplift the socio-economic level of these people. Reconstruction and development programmes must create jobs by training people to be health workers, buy computers for each clinic and train people who can enter correct data in each clinic so that an accurate data base can be built up. Teachers and nurses must improve their medical and teaching ethic by taking time to educate the rural people and children to do basic things like washing hands before eating and after defecating and must keep their environment clean. The study has shown that transmission rates combine many biological, social, cultural and environmental factors and that these factors interact.

RECOMMENDATIONS

These are some recommendations that may improve the quality of life of the people of Qwa-Qwa:

* Introduction of health education in all school syllabi uses.
* Better recording of statistical data at clinics. At the 27 clinics visited, any stomach ailment except diarrhoea was recorded as gastroenteritis. Staff confirm that most children have intestinal parasites and realize that they are more prevalent in summer than winter but still they do not record them. Diarrhoea is only recorded only when there is an outbreak.

* Improve the quantity and quality of manpower in the clinics. There must be at least four doctors who can visit clinics twice a week; the situation now is that only one doctor is in charge of 24 functional clinics.
* There is shortage of doctors, This has led to the government bringing Cuban doctors to try and help in implementation of the new primary health care system. There is a concern that these foreign doctors will not be able to communicate with their patients. To expect such a doctor to explain the epidemiology of any disease to a patient is naive. If they do not know the language of their patients. Doctors have the capability and intellectual ability to learn any language, the hospital can organize tapes and oblige them to learn the local language, this is practised in provinces like Western Cape and KwaZulu-Natal. That can improve their knowledge of the peoples' culture and get a correct history of the patient background if their real aim is to get a maximum cure for a patient. Health education can never be implemented if it is conducted in a language that people do not understand.
* The health department must train health workers. to do simple test (like the Kato-Katz) to perform simple stool, blood or urine tests diagnoses. Diagnoses can be done immediately at the clinics and nursing sisters can get the results immediately or after only a few hours, sooner than relying on results that take a week come from the pathology laboratory.
* One nurse in every clinic must have a driver's licence.

* Selected clinics must have computers. One clerk can be taught in a week to enter data and collate data from the four to five nearest clinics. Data on infectious and preventable diseases given to the author by health authorities and clinics was very unreliable. This made it difficult to perform an epidemiological survey and impossible to compare data with prevalences of intestinal parasites during previous years.
* Hospital authorities should organize training tapes of simple conversations needed to get the background of a patient. People always think that you show respect by trying his/her language.
* Retired nurses and teachers can be used or may be asked to volunteer to conduct health education. If the government were to train them. These are the only people in our society who are willing to improve the quality of lives of their communities and are still respected by rural and semi rural communities.
* Government lacks the drive to implement proper research centres for infectious diseases in many provinces including the Free State. There must be proper infectious disease research centres in each province.
* Improvement of communication between communities and Department of Water Affairs and health and welfare. My personal experience in the area is that the water sometimes have chironomids and small nematodes in domestic water supplies. The water is sometimes brown and unpalatable and we can be without water for two weeks without the community

being given an explanation from the Department of Water Affairs department.

* There must be a formal link between Departments of Education and Health to design the health education curriculum for schools. Controlling diseases involves many parties, therefore if they plan together and evaluate progress regularly, then it will be real progress.
* Government must introduce pre-schools in rural and semi rural areas. The parents of most of these children go to work at 04h00 and come back at 22h00. This will make sure that the child does not go hungry because no one is there to look after them or cook for them. I have interviewed children who had not have a meal for three days. This may lead to malnutrition resulting in children getting all forms of infectious diseases because they eat from rubbish dumps as was the case in the first sampled school (Letlotlo). The government must also make sure that an abattoir is built, to serve the ±400 000 people in the area.
* Mass media (e.g radio) can be used to educate people about transmission routes of intestinal parasites, because people in rural areas cannot read or write. Radio is the best media to use because it can be operated by battery.
* Education on intestinal parasites and their complications, e.g liver abscess or *Ascaris* bolus can be reinforced extremely graphic posters in the streets, clinics, schools churches, traditional healers and by billboards with a huge unmistakeable public message.

In conclusion, the realities of the epidemiology of human intestinal parasites in the area will continue affecting them. People must however try to abandon, or at least modify, their lifestyles and improve their personal and environmental hygiene, if they wish to avoid being infected. The feasibility of providing suitable and acceptable alternatives seems remote, since it is a function of the socio-economic and cultural status of the community which can only be uplifted by the government.

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APPENDIX A

MODIFIED MERTHIOLATE-IODINE-FORMALDEHYDE CONCENTRATION TECHNIQUE

METHOD:

1. Pour the totally emulsified preserved stool sample through a double wetted gauze into 70ml paper cup.
2. Wash down any remaining stool sample with few drops of 5% formalin.
3. Tranfer the filtrate (strained fluid) into a labelled plastic centrifuge tube.
4. Centrifuge at 4 000 rpm for 1 minute. Remove excess supernatant. (leave 7-8ml)
5. Add 4ml ether and close tightly with a cork stopper.
6. Shake vigorously for 2 minutes.
7. Remove the cork stopper and centrifuge immediately at 5 000 rpm for 2 minutes.
8. After centrifuging four layers should have been formed (formol-ether, plug of faecal debris, formalin and sediment).
9. Using an "orange stick" carefully loosen around the debris layer between ether and formalin.
10. Return tube to upright position and tap the bottom of the tube to resuspend the sediment.
11. When about to examine add the 2 drops of Lugol's iodine to the sample, and transfer with pasture pipette onto the slide. Put coverslip on top and examine.

APPENDIX B

PARENT CONSENT FORM

PARENTS

The majority of children in your area have common parasite infections like intestinal worms and pathogenic protozoans. We would like permission to test and to treat your child if she/he has any of these infections. Medical staff will be present during treatment. Generally there are no problems but if you suspect that treatment has affected your child please contact the nearest clinic or hospital as soon as possible. There will be no charge, but without your permission we are unable to treat your child. The results of your child's tests will be made available to you if you contact your school or principal of the school that your child attends.

I,____,

a parent or guardian, give permission for my child

____,

to be treated by school nurses and doctor from the Department of Health if she/he is infected with intestinal parasites.

BATSWADI

Boholo ba bana ba moo le ahileng teng ba na le tshwaetso ya manyoha. Re kopa ke hona tumello ya ho hlahloba ngwana wa hao le mo alafa ebang a ena le tswaetso ya mofuta ona. Baoki le Ngaka ba tla ba teng ha ngwana a fuwa phekolo. Ha se phekolo e bakang mathata; empa ha o ka belaelwa hore ngwana hao o amehile ka tsela e itseng ke pheko eo o ka ikopanya le tliliniki e haufi.
Diteko le phekolo ha di lefellwe; empa re sitwa ho alafa ngwana wa hao ntle le tumello ya hao. Diphetho (results) tsa diteko tsa ho bona hore tshwaetso e teng kapa tjhe ngwaneng wa hao o ka di fumana ho mooki wa sekolo kapa mosuwehloho wa sekolo.

Nna,____,

motswadi, ke fana ka tumello ya hore ngwanaka,

____

a alafuwe ke mooki wa Lefapha la Bophelo ha eba a ena le tswaetso ya manyoha.

APPENDIX C

(X and Y codes are required by the Epi-Info programme)

QUESTIONNAIRE

NUMBER (NUM)	
NAME OF SHOOL	
ALTITUDE (Y2)	

SEX (X2)	♂	♀

AGE (X3)	< 5YRS	6 - 10 YRS	>10 YRS

STANDARD OF HYGIENE

MEAT EATEN (X4)	BEEF	PORK	BOTH	OTHER

SOURCE OF MEAT (X5)	BUTCHERY	OWN SLAUGHTER	BOTH

QUALITY OF MEAT (X6)	GRADED	UNGRADED	BOTH

WATER SOURCE (X7)	IN THE HOUSE	< 1 KM	> 1KM	TANKS	OTHER (RIVER) or BUSH)

SANITATION (X8)	PIT-LATRINE	FLUSH TOILET

ELECTRICITY (X9)	CONSTANT SUPPLY	OCCASIONAL	NONE

PUPIL'S BACKGROUND

PARENT/GAURDIAN'S AGE	
FATHER (X10A)	MOTHER (X10B)
< 30YRS	< 30 YRS
31 - 40 YRS	31 - 40 YRS
> 40 YRS	> 40 YRS

APPENDIX D

Table 6.1

Prevalences of intestinal parasites with respect to age and sex profiles in summer at Letlotlo primary school. Percentage children without any parasites = 23.3 %. Total number of children sampled = 146.

Letlotlo	Females	Males	<5yrs	6-10yrs	>10yrs
Number who complied [129]	77	52	23	85	21
Parasite species	% (num)	% (num)	% (num)	% (num)	% (num)
G.i	2.6 (3)	5.8 (3)	0.0 (0)	4.7 (4)	4.8 (1)
C.m	12.9(10)	17.3 (9)	8.6 (2)	18.8(16)	4.8 (1)
E.hi	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
E.c	62.3(48)	48.1(25)	30.4 (7)	61.2(52)	66.7(14)
E.ha	12.9(10)	5.8 (3)	8.7 (2)	10.6 (9)	9.5 (2)
E.n	28.6(22)	17.3 (9)	0.0 (0)	25.9(22)	42.8 (9)
I.b	5.2 (4)	13.5 (7)	4.3 (1)	9.4 (8)	9.5 (2)
SPA	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
MSPA	7.8 (6)	3.8 (4)	0.0 (0)	4.7 (4)	19.0 (4)
tae	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
H.d	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
H.n	0.0 (0)	1.9 (10	0.0 (0)	1.2(10)	0.0 (0)
T.t	1.3 (1)	3.8 (2)	0.0 (0)	1.2 (1)	9.5 (2)
A.l	9.9 (7)	11.5 (6)	17.4 (4)	10.6 (9)	0 (0)

Table 6.2

Prevalences of intestinal parasites with respect to age and sex profiles in winter at Letlotlo primary school. Percentage of children without any parasites = 14.5 %. Total number of children sampled = 146.

Letlotlo	Females	Males	<5yrs	6-10yrs	>10yrs
Number who complied [129]	77	52	23	85	21
Parasite species	% (num)	% (num)	% (num)	% (num)	% (num)
G. i	10.4 (8)	11.5 (6)	8.7 (2)	8.2 (7)	23.8 (5)
C. m	9.1 (7)	13.5 (7)	8.7 (2)	10.6 (9)	14.3 (3)
E. hi	0.0 (0)	1.9 (1)	4.3 (1)	0.0 (0)	0.0 (0)
E.c	59.7(46)	51.9(27)	43.5(10)	62.4(53)	47.6(10)
E.ha	3.9 (3)	3.8 (2)	0.0 (0)	4.7 (4)	4.8 (1)
E.n	18.2(14)	15.4(8)	0.0 (0)	22.4(19)	14.3(3)
I.b	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
SPA	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
MSPA	5.2 (4)	0.0 (0)	8.7 (2)	2.4 (2)	0.0 (0)
tae	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
H.d	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
H.n	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
T.t	0.0 (0)	1.9 (1)	0.0 (0)	1.2 (1)	0.0 (0)
A.l	6.5 (5)	5.8 (3)	8.7 (2)	5.9 (5)	4.8 (1)

G.i = *Giardia intestinalis*
C.m = *Chilomastix mesnili*
E.hi = *Entamoeba histolytica*
E.c = *Entamoeba coli*
E.ha = *Entamoeba hartmanni*
E.n = *Endolimax nana*
I.b = *Iodomoeba buetschlii*
SPA = Small pre-cystic amoeba
MSPA = Medium pre-cystic amoeba
tae = taeniid tapeworm
H.d = *Hymenolepis diminuta*
H.n = *Hymenolepis nana*
T.t = *Trichuris trichiura*
A.l = *Ascaris lumbricoides*

Table 7.1

Prevalences of intestinal parasites with respect to age and sex profiles in summer at Mafika-ditshiu primary school. Percentage of children without any parasites = 27.0 %. Total number of children sampled = 126.

Mafika-ditshiu	Females	Males	<5yrs	6-10yrs	>10yrs
Number [97]	43	54	44	44	9
Parasite species	% (num)	% (num)	% (num)	% (num)	% (num)
G.i	2.3 (1)	1.8 (1)	0.0 (0)	4.5 (2)	0.0 (0)
C.m	20.9 (9)	18.5(10)	18.1 (8)	20.4 (9)	22.2 (2)
E.hi	0.0 (0)	1.8 (1)	2.3 (1)	0.0 (0)	0.0 (0)
E.c	58.1(25)	50.0(27)	52.3(23)	50.0(22)	77.8 (7)
E.ha	9.3 (4)	1.8 (1)	6.8 (3)	4.5 (2)	0.0 (0)
E.n	13.9 (6)	16.7 (9)	22.7(10)	6.8 (3)	11.1 (1)
I.b	2.3 (1)	3.7 (2)	2.3 (1)	2.3 (1)	11.1 (1)
SPA	2.3 (1)	1.8 (1)	0.0 (0)	4.5 (2)	0.0 (0)
MSAP	6.9 (3)	1.8 (1)	4.5 (2)	2.3 (1)	11.1 (1)
tae	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
H.d	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
H.n	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
T.t	0.0 (0)	1.8 (1)	2.3 (1)	0.0 (0)	0.0 (0)
A.l	0.0 (0)	3.7 (2)	2.3 (1)	0.0 (0)	11.1 (1)

Table 7.2

Prevalences of intestinal parasites with respect to age and sex profiles in winter at Mafika-ditshiu primary school. Percentage of children without any parasites = 40.5 %. Total number of children sampled = 126.

Mafika-ditshiu	Females	Males	<5yrs	6-10yrs	>10yrs
Number who complied [74]	36	38	31	36	7
Parasite species	%(num)	%(num)	%(num)	%(num)	%(num)
G.i	2.8 (1)	0.0 (0)	3.2 (1)	0.0 (0)	0.0 (0)
C.m	2.8 (1)	5.2 (2)	6.4 (2)	2.7 (1)	0.0 (0)
E.hi	2.8 (1)	0.0 (0)	0.0 (0)	0.0 (0)	14.2 (1)
E.c	41.6(15)	63.1(24)	41.9(13)	55.5(20)	85.7(6)
E.ha	16.7 (6)	7.9 (3)	9.6 (3)	5.6 (2)	0.0 (0)
E.n	13.9 (5)	13.2 (5)	9.6 (3)	11.1 (4)	42.8 (3)
I.b	0.0 (0)	2.6 (1)	0.0 (0)	0.0 (0)	14.2 (1)
SPA	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
MSPA	0.0 (0)	2.6 (1)	0.0 (0)	2.7 (1)	0.0 (0)
tae	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
H.d	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
H.n	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
T.t	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
A.l	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)

Table 8.1

Prevalences of intestinal parasites with respect to age and sex profiles in summer at Teboho primary school. Percentage of children without any parasites = 26.0%. Total number of children sampled = 105.

Letlotlo	Females	Males	<5yrs	6-10yrs	>10yrs
Number who complied [91]	46	45	35	46	10
Parasite species	% (num)	% (num)	% (num)	%(num)	%(num)
G.i	8.7 (4)	2.2 (1)	0.0 (0)	2.2 (1)	0.0 (0)
C.m	8.7 (4)	11.1 (5)	17.1 (6)	4.3 (2)	10.0 (1)
E. hi	0.0 (0)	2.2 (1)	2.8 (1)	4.3 (2)	0.0 (0)
E.c	54.3(25)	62.2(28)	51.4(18)	58.7(27(	80.0(8)
E.ha	13.0 (6)	11.1 (5)	20.0 (7)	8.7 (4)	0.0 (0)
E.n	4.3 (6)	15.6 (7)	8.6 (3)	19.6 (9)	10.0 (1)
I.b	13.0 (6)	6.7 (3)	5.7 (2)	13.0 (6)	10.0 (1)
SAP	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
MSPA	2.2 (1)	6.7 (3)	5.7 (2)	2.2 (1)	10.0 (1)
tae	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
H.d	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
H.n	2.2 (1)	0.0 (0)	0.0 (0)	2.2 (1)	0.0 (0)
T.t	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
A.l	15.2 (7)	15.5 (7)	8.6 (3)	19.6 (9)	20.0 (2)

Table 8.2

Prevalences of intestinal parasites with respect to age and sex profiles in winter at Teboho primary school. Percentage of children without any parasites = 21.0 %. Total number of children sampled = 105.

Teboho	Females	Males	<5yrs	6-10yrs	>10yrs
Number who complied [76]	45	31	31	33	12
Parasite species	%(num)	%(num)	%(num)	%(num)	%num)
G.i	4.4 (2)	12.9 (4)	6.4 (2)	9.1 (3)	8.3 (1)
C.m	4.4 (2)	29.0 (9)	22.6 (7)	3.0 (1)	25.0 (3)
E.hi	2.2 (1)	6.5 (2)	3.2 (1)	6.1 (2)	0.0 (0)
E.c	44.4(20)	93.5(29)	67.7(21)	57.6(19)	75.0(9)
E.ha	2.2 (1)	19.4 (6)	9.7 (3)	6.1 (2)	16.6 (2)
E.n	24.4 (1)	29.0 (9)	29.0 (9)	21.2 (7)	33.3 (4)
I.b	2.1 (1)	0.0 (0)	3.2 (1)	0.0 (0)	0.0 (0)
SPA	2.2 (1)	3.2 (1)	0.0 (0)	6.1 (2)	0.0 (0)
MSPA	2.2 (1)	6.5 (2)	3.2 (1)	3.0 (1)	8.3 (1)
tae	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
H.d	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
H.n	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
T.t	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
A.l	4.4 (2)	9.7 (3)	12.9(13)	0.0 (0)	8.3 (1)

Table 9.1

Prevalences of intestinal parasites with respect to age and sex profiles in summer at Makhetheng primary school. Percentage of children without any parasites = 31.0 %. Total number of children sampled 104.

Makhethe -ng	Females	Males	<5yrs	6-10yrs	>10yrs
Number who complied [97]	47	50	28	64	5
Parasite species	% (num)	% (num)	% (num)	% (num)	% (num)
G.i	4.2 (2)	0.0 (0)	3.6 (1)	1.6 (1)	0.0 (0)
C.m	23.4(11)	36.0(18)	25.0(17)	34.3(22)	0.0 (0)
E.hi	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
E.c	48.9(23)	70.0(35)	53.6(15)	65.6(66)	20.0(1)
E.ha	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
E.n	8.5 (4)	14.0 (7)	10.7 (3)	9.3 (6)	40.0 (2)
I.b	6.4 (3)	2.0 (1)	3.6 (1)	4.7 (3)	6.2 (4)
SPA	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
MSPA	4.2 (2)	6.0 (3)	3.6 (1)	6.2 (4)	0.0 (0)
tae	2.1 (1)	0.0 (0)	0.0 (0)	0.0 (0)	20.0 (1)
H.d	0.0 (0)	2.0 (1)	0.0 (0)	1.6 (1)	0.0 (0)
H.n	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
T.t	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
A.l	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)

Table 9.2

Prevalences of intestinal parasites with respect to age and sex profiles in winter at Makhetheng primary school. Percentage of children without any parasites = 39.0 %. Total number of children sampled = 104.

Makhethe -ng	Females	Males	<5yrs	6-10yrs	>10yrs
Number who complied [75]	37	38	17	53	5
Parasite species	% (num)	% (num)	% (num)	% (num)	% (num)
G.i	0.0 (0)	2.6 (1)	0.0 (0)	1.9 (1)	0.0 (0)
C.m	13.5 (5)	5.3 (2)	11.8 (2)	9.4 (5)	0.0 (0)
E.hi	0.0 (0)	2.6 (1)	0.0 (0)	1.9 (1)	0.0 (0)
E.c	51.4(19)	68.4(16)	70.6(12)	60.4(32)	20.0 (1)
E.ha	0.0 (0)	7.9 (3)	5.9 (1)	7.5 (4)	0.0 (0)
E.n	2.7 (1)	10.5 (4)	5.9 (1)	7.5 (4)	0.0 (0)
I.b	0.0 (0)	2.6 (1)	0.0 (0)	1.9 (1)	0.0 (0)
SPA	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
MSPA	0.0 (0)	2.6 (1)	0.0 (0)	1.9 (1)	0.0 (0)
tae	2.7 (1)	0.0 (0)	0.0 (0)	0.0 (0)	20.0 (1)
H.d	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
H.n	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
T.t	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
A.l	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)

Table 10.1

Prevalences of intestinal parasites with respect to age and sex profiles in summer at Mohlakaneng primary school. Percentage of children without any parasites = 35.0 %. Total number of children sampled = 120.

Mohlakan -eng	Females	Males	<5yrs	6-10yrs	>10yrs
Number who complied [117]	53	64	28	88	01
Parasite species	% (num)	% (num)	% (num)	% (num)	% (num)
G. i	0.0 (0)	1.6 (1)	0.0 (0)	1.1 (1)	0.0 (0)
C.m	9.4 (5)	15.6(10)	17.8 (5)	11.4(10)	0.0 (0)
E.hi	3.8 (2)	0.0 (0)	0.0 (0)	2.3 (2)	0.0 (0)
E.c	52.8(28)	65.6(42)	57.1(16)	60.2(53)	100.0(1)
E.ha	3.8 (2)	0.0 (0)	0.0 (0)	2.3 (2)	0.0 (0)
E.n	22.6(12)	23.4(15)	17.8(5)	23.8(21)	100.0(1)
I.b	1.9 (1)	3.1 (2)	0.0 (0)	3.4 (3)	0.0 (0)
SPA	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
MSPA	13.2(7)	4.7 (3)	7.1 (2)	9.1 (8)	0.0 (0)
tae	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
H.d	0.0 (0)	1.6 (1)	0.0 (0)	1.1 (1)	0.0 (0)
H.n	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
T.t	1.9 (1)	1.6 (1)	0.0 (0)	2.3 (2)	0.0 (0)
A.l	3.8 (2)	1.6 (1)	3.6 (1)	2.3 (2)	0.0 (0)

Table 10.2

Prevalences of intestinal parasites with respect to age and sex profiles in winter at Mohlakaneng primary school. Percentage of children without any parasites = 41.0 %. Total number of children sampled 120.

Mohlakan -eng	Females	Males	<5yrs	6-10yrs	>10yrs
Number who complied [100]	43	57	24	75	1
Parasite species	% (num)	% (num)	% (num)	% (num)	% (num)
G.i	2.3 (1)	1.8 (1)	0.0 (0)	2.7 (2)	0.0 (0)
C.m	6.9 (3)	10.5 (6)	8.3 (2)	9.3 (7)	0.0 (0)
E.hi	2.3 (1)	7.0 (4)	4.2 (1)	5.3 (4)	0.0 (0)
E.c	44.2(19)	47.4(27)	33.3(8)	49.3(37)	100.0(1)
E.ha	0.0 (0)	5.3 (3)	0.0 (0)	4.0 (3)	0.0 (0)
E.n	16.3 (7)	26.3(15)	20.8 (5)	22.7(17)	0.0 (0)
I.b	0.0 (0)	1.8 (1)	0.0 (0)	1.3 (1)	0.0 (0)
SPA	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
MSPA	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
tae	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
H.d	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
H.n	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
T.t	0.0 (0)	1.8 (1)	0.0 (0)	1.3 (1)	0.0 (0)
A.l	4.6 (2)	0.0 (0)	0.0 (0)	2.7 (2)	0.0 (0)

Table 11.1

Prevalence of intestinal parasites with respect to age and sex profiles in summer at Makeneng primary school. Percentage of children without any parasites = 29.0 %. Total number of chidren sampled = 116.

Makeneng	Females	Males	<5yrs	6-10yrs	>5yrs
Number [116]	34	37	24	40	7
Parasite species	% (num)	% (num)	% (num)	% (num)	% (num)
G.i	8.8 (3)	10.8 (4)	8.3 (2)	12.5 (5)	0.0 (0)
C.m	17.6 (6)	18.9 (7)	16.6 (4)	22.5 (9)	0.0 (0)
E. hi	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
E.c	67.6(23)	51.4(19)	58.3(14)	62.5(25)	42.8(3)
E.ha	23.5 (8)	0.0 (0)	4.2 (1)	17.5 (7)	0.0 (0)
E.n	17.6 (6)	10.8(11)	8.3 (2)	12.5(5)	0.0 (0)
I.b	0.0 (0)	2.7 (1)	0.0 (0)	0.0 (0)	14.3 (1)
SPA	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
MSPA	11.7 (4)	2.7 (1)	4.2 (1)	10.0 (4)	0.0 (0)
tae	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
H.d	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
H.n	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
T.t	0.0 (0)	2.7 (1)	0.0 (0)	2.5 (1)	0.0 (0)
A.l	8.8 (3)	8.1 (3)	20.8 (5)	2.5 (1)	0.0 (0)

Table 11.2

Prevalences of intestinal parasites with respect to age and sex profiles in winter at Makeneng primary school. Percentage of children without any parasites = 29.0 %. Total number of children sampled = 116.

Makeneng	Females	Males	<5yrs	6-10yrs	>10yrs
Number who complied [62]	32	30	28	29	5
Parasite species	% (num)	% (num)	% (num)	% (num)	% (num)
G.i	6.2 (2)	16.7 (5)	14.2 (4)	10.3 (3)	0.0 (0)
C.m	9.4 (3)	23.3 (7)	17.8 (5)	13.8 (4)	20.0 (1)
E.h	3.1 (1)	3.3 (1)	3.5 (1)	0.0 (0)	20.0 (1)
E.c	68.8(22)	53.3(16)	67.8(19)	58.6(17)	40.0 (2)
E.ha	3.1 (1)	6.7 (2)	3.5 (1)	3.4 (1)	20.0 (1)
E.n	15.6(50)	16.7 (5)	14.2 (4)	10.3 (3)	0.0 (0)
I.b	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
SPA	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
MSPA	3.1 (1)	0.0 (0)	3.5 (1)	0.0 (0)	0.0 (0)
tae	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
H.d	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
H.n	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
T.t	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
A.l	3.1 (1)	0.0 (0)	3.5 (1)	0.0 (0)	0.0 (0)

Table 12.1

Prevalences of intestinal parasites with respect to age and sex profiles in summer at Sehlajaneng primary school. Percentage of children without any parasites = 28.6 %. Total number of children sampled = 140.

Sehlajan-eng	Females	Males	<5yrs	6-10yrs	>10yrs
Number who complied [128]	62	66	4	111	13
Parasite species	% (num)	% (num)	% (num)	% (num)	% (num)
G.i	1.6 (1)	4.5 (3)	0.0 (0)	2.7 (3)	7.7 (1)
C.m	9.7 (6)	15.2(10)	25.0 (1)	9.9 (11)	30. 7(4)
E.hi	6.4 (4)	0.0 (0)	25.0 (1)	2.7 (3)	7.7 (1)
E.c	56.4(35)	59.1(39)	100.0(4)	55.8(62)	61.5(5)
E.ha	20.9(13)	7.6 (5)	25.0 (1)	13.5(15)	15.4(2)
E.n	17.7(11)	15.2(10)	0.0 (0)	18.0(20)	7.7 (1)
I.b	3.2 (2)	3.0 (2)	0.0 (0)	2.7 (3)	7.7 (1)
SPA	1.6 (1)	1.5 (1)	0.0 (0)	1.8 (2)	0.0 (0)
MSPA	9.7 (6)	3.0 (2)	0.0 (0)	7.2 (8)	0.0 (0)
tae	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
H.d	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
H.n	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
T.t	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
A.l	4.8 (3)	0.0 (0)	0.0 (0)	2.7 (3)	7.7 (1)

Table 12.2

Prevalences of intestinal parasites with respect to age and sex profiles in winter at Sehlajaneng primary school. Percentage of children without any parasites = 42.0 %. Total number of children sampled = 140.

Sehlajan-eng	Females	Males	<5yrs	6-10yrs	>10yrs
Number who complied [114]	54	60	3	100	11
Parasite species	% (num)	% (num)	% (num)	% (num)	% (num)
G.i	3.7 (2)	8.3 (5)	0.0 (0)	6.0 (6)	9.1 (1)
C.m	1.8 (1)	6.7 (4)	0.0 (0)	5.0 (5)	0.0 (0)
E.hi	5.6 (3)	1.7 (1)	0.0 (0)	4.0 (4)	0.0 (0)
E.c	51.8(28)	46.7(28)	0.0 (0)	48.0(48)	72.7(8)
E.ha	7.4 (4)	0.0 (0)	0.0 (0)	4.0 (4)	0.0 (0)
E.n	16.7 (9)	13.3 (8)	0.0 (0)	16.0(16)	9.1 (1)
I.b	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
SPA	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
MSPA	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
tae	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
H.d	1.8 (1)	0.0 (0)	0.0 (0)	1.0 (1)	0.0 (0)
H.n	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
T.t	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
A.l	0.0 (0)	1.7 (1)	0.0 (0)	1.0 (1)	0.0 (0)

Table 13.1

Prevalences of intestinal parasites with respect to age and sex profiles in summer at Makhabane primary school. Percentage of children without any parasites = 20.0 %. Total number of children sampled = 115.

Makhabane	Females	Males	<5yrs	6-10yrs	>10yrs
Number who complied [83]	38	45	09	48	26
Parasite species	% (num)	% (num)	% (num)	% (num)	% (num)
G.i	2.6 (1)	0.0 (0)	0.0 (0)	0.0 (0)	3.8 (1)
C.m	21.0(8)	20.0 (9)	0.0 (0)	22.9(11)	23.1(6)
E.hi	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
E.c	44.7(17)	60.0(27)	55.6(5)	58.3(28)	42.3(11)
E.ha	7.9 (3)	4.4 (2)	11.1(1)	4.2 (2)	7.7 (2)
E.n	31.6(12)	22.2(10)	22.2(2)	25.0(12)	30.7(8)
I.b	5.3 (2)	0.0 (0)	0.0 (0)	2.1 (1)	3.8 (1)
SPA	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
MSPA	10.5 (4)	4.4 (2)	22.2(2)	4.2 (2)	7.7 (2)
tae	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
H.d	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
H.n	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
T.t	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
A.l	2.6 (1)	4.4 (2)	11.0(1)	4.2 (2)	0.0 (0)

Table 13.2

Prevalences of intestinal parasites with respect to age and sex profiles in winter at Makhabane primary school. Percentage of children without any parasites = 33.0 %. Total number of children sampled = 115.

Makhaba-ne	Females	Males	<5yrs	6-10yrs	>10yrs
Number who complied [106]	50	56	9	62	35
Parasite species	% (num)	% (num)	% (num)	% (num)	% (num)
G.i	4.0 (2)	0.0 (0)	11.1(1)	9.7 (6)	0.0 (0)
C.m	6.0 (3)	7.1 (4)	11.1(1)	9.7 (6)	0.0 (0)
E.hi	0.0 (0)	1.8 (1)	0.0 (0)	0.0 (0)	2.8 (1)
E.c	60.0(30)	60.7(34)	55.6(5)	56.4(35)	68.6(24)
E.ha	4.0 (2)	3.6 (2)	0.0 (0)	3.2 (2)	5.7 (6)
E.n	28.0(14)	17.8(10)	11.1(1)	24.2(15)	22.8(8)
I.b	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
SPA	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
MSPA	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
tae	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
H.d	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
H.n	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
T.t	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
A.l	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)

Table 14.

Prevalences of intestinal parasites with respect to age and sex profiles in summer at Sentinel primary school. Percentage of children without any parasites = 60.0 %. Total number of children sampled = 211.

Sentinel (control)	Females	Males	<5yrs	6-10yrs
Number who complied [149]	68	81	53	96
Parasite species	% (num)	% (num)	% (num)	% (num)
G.i	7.3 (5)	2.5 (2)	1.9 (1)	3.1 (3)
C.m	7.3 (5)	11.1 (9)	9.4 (5)	9.4 (9)
E.hi	0.0 (0)	1.2 (1)	1.9 (1)	0.0 (0)
E.c	22.0(15)	24.5(20)	24.5(13)	22.9(22)
E.ha	0.0 (0)	7.3 (7)	0.0 (0)	7.3 (7)
E.n	14.7(10)	8.6 (7)	11.3 (6)	11.4(11)
I.b	2.9 (2)	2.5 (2)	1.9 (1)	3.1 (3)
SPA	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
MSPA	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
tae	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
H.d	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
H.n	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
T.t	0.0 (0)	2.5 (2)	1.9 (1)	1.0 (1)
A.l	2.9 (2)	1.2 (1)	0.0 (0)	3.1 (3)

APPENDIX E

SMALL CYSTS

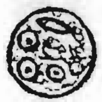
Amoebae :

1. *Endolimax nana*

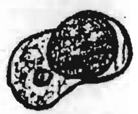
Smooth cytoplasm
4 nucleii (dots)
oval or round shape

Round in shape
Granular cytoplasm
1 - 4 nucleii with
central nucleolus
Round-ended chromatoidal bars

2. *Entamoeba hartmanni*



3. *Iodamoeba buetshlii*



All shapes
very distinct glycogen vacuole
unstained it is clean ; stained with iodine it is brown

Flagellates

4. *Chilomastix mesnilli*

Pear- shaped
Axostyle don middle,
sometimes with curled up flagellum
characteristic " nipple "
1 or 3 nucleii

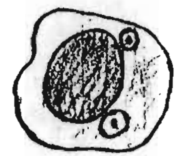
MEDIUM CYSTS

Amoebae

1. *Entamoeba histolytica*

"pencil" outer wall
round in shape
1 - 4 nucleii with
central nucleolus
round-ended chromatoidal bars

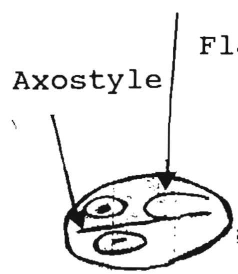
2. *Iodomoeba buetschlii*



All shapes
distinct glycogen vacuole

Flagellates

3. *Giardia intestinalis*

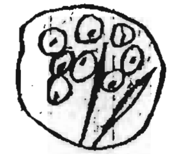


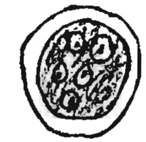
small cytoplasm
oval shape
central axostyle
Flagellum curled up
2 - 4 nucleii
usually 2 " eyes "

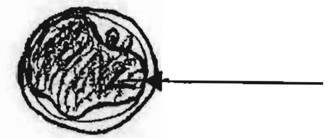
LARGE CYSTS

Amoebae

1. *Entamoeba coli*







Vary in shape
Very large usually
some smaller
some retracted from cyst wall
some almost filled with
glycogen - immature

As before
but as large as *E.coli*

2. *Iodomoeba buetschlii*