An epidemiological study of soil-transmitted helminthiases in rural Nigeria.

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Apart from the acknowledgements stated above, I declare that this is my original work.

I dedicate this thesis to Mum and Dad.

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SUMMARY

A total of 1412 faecal samples were collected in March 1989 from four rural villages in Oyo State, Nigeria. The overall percentage prevalences of *Ascaris lumbricoides, Trichuris trichiura* and hookworm (assumed to be *Necator americanus*) were 70.0%, 69.2% and 59.1% respectively. There were significant differences between the infection prevalence values and host age groups for each helminth. Children were found to be highly infected, particularly those aged between 5 and 9 years. Significant sex-related differences were observed between hosts. A lower prevalence of hookworm infection was found in females compared with males. There was a strong positive association found between *Trichuris trichiura* and hookworm infection. Triple infections (*Ascaris lumbricoides, Trichuris trichiura* and hookworm) were seen to be more prevalent than single infections in all four villages. Significant differences in infection intensity were detected between various age groups for each helminth species. The frequency distribution of numbers of worms per host was investigated for each species of helminth in each village on the basis of faecal egg counts. Evidence was obtained to show that *A. lumbricoides and T. trichiura* were overdispersed in all 4 villages and that hookworm showed some degree of overdispersion in Alakowe and Akeredolu.

GENERAL INTRODUCTION

Soil-transmitted helminths are major infections of humans in tropical and subtropical zones of the world. From a public health point of view, the morbidity caused by ascariasis, trichuriasis and hookworm infection has been grossly underestimated in the past; mortality is urgently in need of investigation. These infections persist in insanitary conditions and they affect the lives of about one quarter of the world's population. Further investigation into the biology of soil-transmitted helminths is essential to enable realistic control programmes to be set up to alleviate suffering in many developing countries.

RESEARCH OBJECTIVE

The first section of this dissertation discusses the morbidity caused by the parasites and control programmes that have been developed to counteract this problem. Following from this, the situation found in Nigeria is discussed, where intestinal helminth infections are a serious health problem. Difficulties arise when trying to control these infections, because of the behavioural and cultural habits of the people and the socio-economic status of the country.

The second section describes the project to which I contributed, entitled "Treatment Tactics with Anthelmintics in Ascariasis Control Programmes", which took place from March 1989 to April 1990 and involved rural communities in Oyo State, Nigeria. The specific aim of this project was to compare the effects of 3 different tactical uses of an anthelmintic drug on the intensity of infections of *Ascaris lumbricoides*, hookworm (*Necator americanus*) and *Trichuris trichiura* in rural human communities. Before this could be undertaken, the epidemiology of the helminth species had to be investigated first, as is set out in section 2. My role was to assist with fieldwork and the analysis of the base-line data.

SECTION 1

CHAPTER 1

SOIL-TRANSMITTED HELMINTHIASES

1.1 INTRODUCTION

The majority of metazoan parasites living in or on vertebrate hosts are representatives of 2 particular phyla, the Platyhelminthes and the Nematoda, although there are a few species of the phylum Acanthocephala and other groups which also infect humans. These parasites are known as "helminths" and can be agents of debilitating, deforming and killing diseases of humans and domesticated animals. Helminths are diverse in their body structure, life cycle strategies, nutritional physiology and behaviour. The helminth infections discussed here are causes of several major human diseases: 1) ascariasis (commonly known as roundworm disease) caused by *Ascaris lumbricoides*; 2) trichiuriasis (commonly known as whipworm disease) caused by *Trichuris trichiura*; 3) hookworm disease which results from infections with either *Ancylostoma duodenale* or *Necator americanus*. Each of these nematode species has a direct life cycle and is soil-transmitted in the sense that eggs or larvae responsible for transmission become infective after an obligatory period of development in the soil. Similarities in transmission and in geographical distributions of such helminths result in many individuals experiencing single, double or multiple infections (see Section 2, Chapter 3 [3.1.4]).

1.2 ASPECTS OF THE BIOLOGY, EPIDEMIOLOGY AND MORBIDITY OF SOIL-TRANSMITTED HELMINTHS

1.2.1. *ASCARIS LUMBRICOIDES*

Ascaris lumbricoides is a cosmopolitan parasite and is probably the best-known nematode parasite of humans. A recent estimate of its global prevalence is 1008 million people, representing about 22% of the world population with the infection known from 153 out of 218 recognised countries (Crompton, 1988). Infection with

A. lumbricoides occurs in temperate as well as tropical and subtropical environments where its occurrence is largely determined by poverty, high population density, poor sanitary practices, and climatic conditions which favour the survival and development of transmission stages.

According to Peters (1978) about 73% of all *A.lumbricoides* infections have been estimated to be present in Asia, while about 12% are thought to occur in Africa and 8% in Latin America. In the Philippines, Indonesia, Myanmar (formerly Burma) and other Southeast Asian countries, prevalences in rural village populations are often greater than 50%, and in some areas over 90% of children harbour the infection (WHO, 1969; de Silva, 1957; Beaver *et al.*, 1984; Thein-Hlaing, 1985). In Africa, *A. lumbricoides* infects an estimated 25% of Kenyans, 21% of rural people in Southern Nigeria, and has been reported from almost all African countries (Stephenson *et al.*, 1980a; Nwosu, 1981: Crompton and Stephenson, 1985). The prevalence of ascariasis in Kenya has apparently not decreased in over 60 years (Chunge *et al.*, 1985).

Ascaris lumbricoides is the largest of the intestinal nematode parasites of man. The simple life cycle involves the egg, four larval stages separated by moults, immature worms and adult worms of both sexes. An adult female worm living in the small intestine is considered to produce on average 240,000 eggs per day for about a year, these being passed out with the faeces (WHO, 1967). The unembryonated eggs develop in the soil within 10-15 days given the presence of oxygen, moisture, cover from direct sunlight and an appropriate temperature. The eggs have a highly variable survival time and they have been found to survive up to 15 years (Storey and Phillips, 1985).

The first stage larva (L_1) moults to the L_2 stage inside the egg shells in the soil to produce an infective egg. Humans contract *A.lumbricoides* infection by ingestion of embryonated eggs. This commonly occurs through faecal contamination of hands, food and water, or cooking utensils. Embryonated eggs ingested by the host hatch in the duodenum to release L_2 larvae which migrate via the hepatic portal system to the liver and then to the lungs where they develop further for 1-2 weeks (the larvae moult twice). L_4 larvae ascend the trachea and are swallowed to re-enter the small intestine where they mature to adult male and female worms which copulate in the small intestine. Two morphological forms of the eggs may be identified. These are fertilised eggs (Plate 1) and unfertilised eggs, which tend to predominate when young adult females are present or when relatively few males are available (Janssens, 1985). The cycle, from ingestion of infective eggs to the release of eggs from the adult worms, takes approximately 60-70 days. The adult worms continue to grow in length and width throughout their normal lifespan of one year with adult male worms measuring from 150 to 200 mm and females measuring from 200 to 350 mm in length.

The symptoms associated with *A.lumbricoides* infection or ascariasis are many and can be divided into separate categories according to the stage of the infection. The severity of the morbidity is related to the intensity of *A.lumbricoides* infection and as described by Pawlowski and Arfaa (1984), larval migration, presence of adult worms in the small intestine, allergic reactions and complications comprise the syndrome known as ascariasis. The migration of larvae through the liver and lungs has been shown to initiate pneumonitis, asthma, coughing, substernal pain, fever, skin rash and eosinophilia (Coles, 1985). There is little information available on the impact of *A.lumbricoides* infection and respiratory problems, hence the public health significance of pulmonary ascariasis remains unclear. Studies of this kind are particularly important, because respiratory infections are possibly one of the major causes of morbidity and mortality in preschool age children in developing countries.

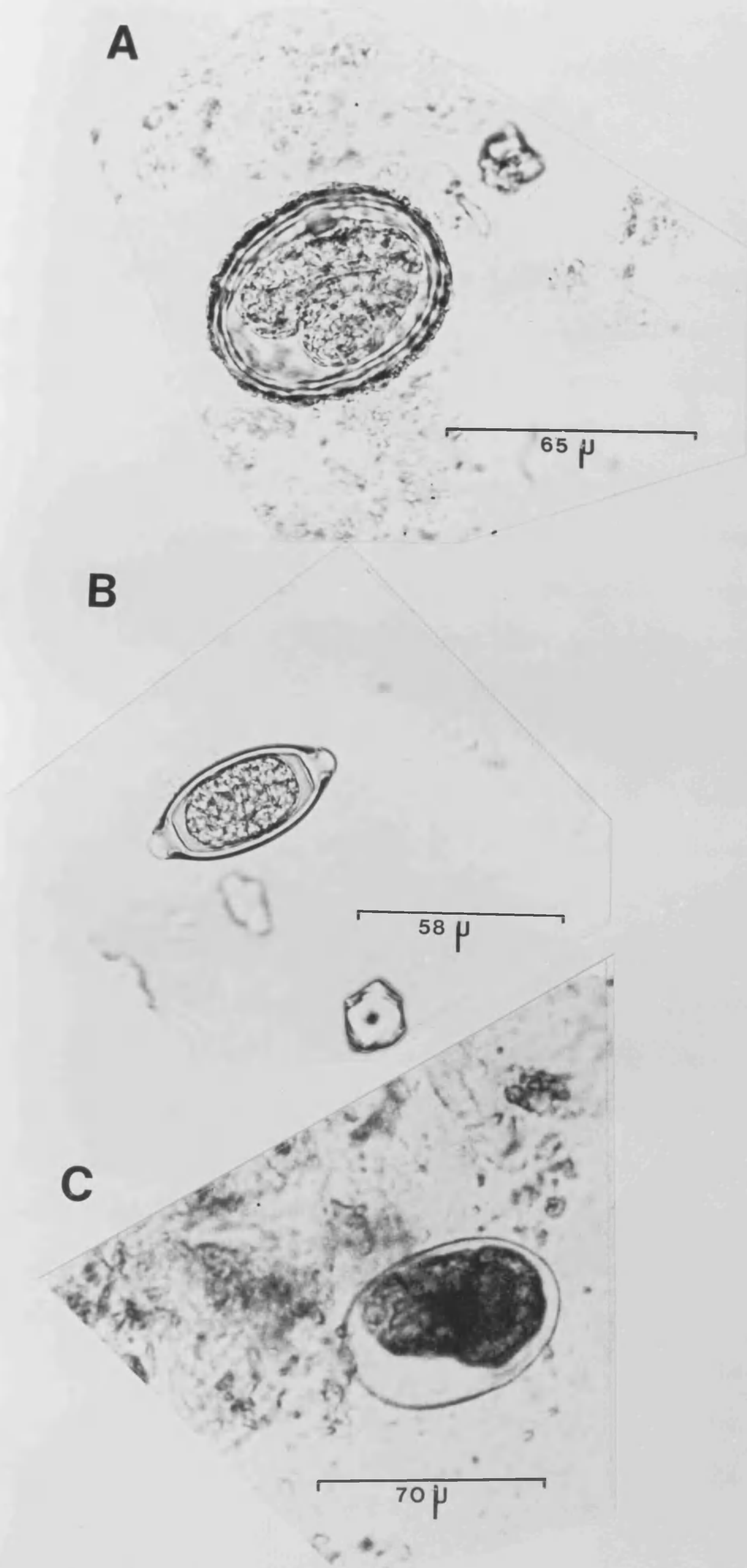
Effects of the presence of adult worms in the small intestine has received more attention, because it is at this stage where various complications arise to give deleterious effects in the individual. Numerous reports mention symptoms of nutritional significance including abdominal pain, nausea, anorexia, diarrhoea and nutrient malabsorption. The most serious complications are due to intestinal obstruction by a bolus of worms or to the migration of the adult worms into the hepatic duct, the appendix, a surgical wound or pancreatic duct (WHO, 1981). These complications represent one of the main causes of acute abdominal emergencies in

PLATE 1. Photomicrographs showing the egg stage:-

A. *Ascaris lumbricoides*

B. *Trichuris trichiura*

C. Hookworm


A
65 μ
B
58 μ
C
70 μ

children in Kenya and Myanmar (Ochola-Abila and Barrack, 1982; Thein-Hlaing, 1985). Acute complications have a high case fatality rate (Pinus, 1985) and are expensive and difficult to treat, especially in developing countries.

Many of the clinical features of ascariasis are associated with malnutrition in certain infected individuals. Studies with *Ascaris suum* in pigs (used as a model for *A. lumbricoides*) have shown that *A. suum* infection is associated with decreased food consumption, decreased efficiency of feed utilisation and a reduced rate of body weight gain (Forsum *et al.*, 1981). Malabsorption of the three macro-nutrients (protein, fat and carbohydrate) has been demonstrated in *A. suum* infected pigs (Nesheim, 1985). Nitrogen absorption improved and retention decreased after deworming. Fat absorption was also observed to be reduced; this is important not only for energy balance but also because the bioavailability of fat soluble vitamins such as vitamin A would be impaired. Decreased lactose tolerance and depressed levels of intestinal lactase activity have been found in infected as compared with uninfected pigs (Forsum *et al.*, 1981).

Evidence from a series of clinical and community studies with children infected with *A.lumbricoides* indicates that the helminth is associated with decreased absorption and retention of nitrogen (Brown *et al.*, 1980), steatorrhea, abnormal absorption of D-xylose and accompanying villus atrophy (Tripathy *et al.*, 1972). After anthelmintic treatment, the degree of impairment is decreased. It has been proven that lactose maldigestion is associated with *A.lumbricoides* infection (Taren *et al.*, 1987). In Panama, *Ascaris*-infected preschool children exhibited a marked decrease in lactose digestion measured indirectly by breath hydrogen output as compared with age- and sex-matched control subjects. Breath hydrogen output returned to normal about three weeks after deworming. Ascariasis interferes with vitamin A absorption and may be a contributory factor in xerophthalmia with its associated morbidity, blindness and mortality. Mahalanabis *et al.* (1976) observed malabsorption of vitamin A in over 70% of infected patients, judging from serum levels, after a radioactive dose. Soon after deworming, vitamin A absorption improved.

A number of community-based longitudinal studies have concluded that ascariasis can contribute to growth retardation in pre-school children and that periodic deworming can improve growth (Gupta, 1977; Willett *et al.*, 1979; Stephenson *et al.*, 1980a). However, other studies have failed to demonstrate such findings. Stephenson (1987) has reviewed these extensively and comments that their failure to demonstrate growth improvement after deworming may be due to aspects of experimental design such as choice of population, sample size, success of the deworming treatment and data analysis. Successful drug treatment is particularly important and in a number of studies *A. lumbricoides* had not been completely eradicated from the infected children at the time that growth assessment was undertaken (Gupta and Urrutia, 1982; Greenberg *et al.*, 1981). Interestingly, Cerf and co-workers (1981) examined the relationship between the intensity of *A. lumbricoides* infection and percent weight for age in three Balinese hamlets and their findings indicated that the interaction between *A. lumbricoides* and child nutrition was influenced by socio-economic factors. This work underlines the importance of evaluating the additional socio-economic and dietary variables in a community that may influence the relationship between ascariasis and malnutrition there. It has recently been recognised that intestinal parasites contribute significantly to poor nutritional status. In fact WHO now recommends that in areas where the prevalence of mild-moderate underweight in children is greater than 25%, and where parasites are known to be widespread, high priority should be given to anthelmintic programmes for treatment of parasites (ACC/SCN, 1989).

1.2.2. *TRICHURIS TRICHIURA*

Trichuris trichiura, like *A.lumbricoides,* is a cosmopolitan infection, although it is most common in the warm, moist tropical and sub-tropical countries, where prevalences can be as high as 90%. Some authors estimate that between 500 and 700 million people are infected worldwide and the morbidity rate has often been cited as 0.2 per 1000 infected people (Walsh and Warren, 1979), others report that up to

1000 million may harbour the infection (Bundy, 1986). About 63% of the infected persons are found in the tropical regions of Asia, about 11% in Africa and about 14% in the Americas (Pawlowski, 1984). Transmission efficiency of the infection is broadly similar to that of *A. lumbricoides* and the occurrence of the 2 species together is common.

Trichuris trichiura is an unusually shaped nematode of about 40 mm long with an extremely long, thin, pharyngeal region and a wider posterior section containing the rest of the gut and reproductive organs. The buccal cavity contains a small stylet with which the worms disrupt the caecal mucosa. The anterior part of the body lies embedded in the mucosal surface with the posterior part free in the lumen of the large intestine. The life history of *T. trichiura* is fairly similar to that of *A. lumbricoides*, but there is no known tissue migration. Unembryonated eggs are passed out in the faeces of the host and develop in the soil for 15-30 days to the L_1 larva stage. Infective eggs (Plate 1) containing L_1 larvae are ingested by humans from contaminated food, water, soil or hands. The eggs hatch to release L_1 larvae in the small intestine where they penetrate the mucosa and then re-enter the caecal lumen. The L_1 to L_4 stages and L_4 to adult stages take place in the caecum. Adults develop in 60 to 90 days and after copulation the females start to lay eggs.

The morbidity associated with *T. trichiura* is due to the unique mode of attachment of the adult worms in the mucosa of the small intestine. The severity of the morbidity is dependent on the intensity of infection, but also the state of the host, including age, general health and iron resources (Pawlowski, 1984). Many infections tend to be regarded as asymptomatic, but others produce abdominal pain, diarrhoea, vomiting, weight loss and anaemia in malnourished children, while obviously heavy infections have been associated with severe anaemia (Layrisse *et al.*, 1967), protein-energy malnutrition (Gilman *et al.*, 1983), chronic diarrhoea and dysentery (Cooper *et al.*, 1986), rectal prolapse (Ramirez-Weiser, 1971), and clubbing of the fingers (Kamath, 1973). A decrease in food intake and increase in nutrient excretion are likely to occur during this infection.

Trichuris trichiura infections associated with childhood malnutrition have received the most attention. There is evidence that heavy *T. trichiura* infections cause enough blood loss to produce anaemia and even death in certain vulnerable children. Layrisse *et al.* (1967) measured faecal blood loss in 9 heavily infected Venezuelan children and estimated that the blood loss caused per worm was approximately 0.005 ml per day, which is 10% to 15% of that attributed to *Necator americanus*, and 2% to 3% of blood lost to *Ancylostoma duodenale*. However, blood loss per child was 0.8 to 8.6 ml per day, which is significantly more than was found for uninfected individuals (Roche *et al.*, 1957). The authors concluded that infections of over 800 worms can cause iron deficiency anaemia in children. Clearly more field studies are needed to examine the relationship between *T. trichiura* infection, blood loss and anaemia in different environments.

Recent studies have provided strong evidence that heavy infections of trichuriasis contribute to protein-energy malnutrition in children and that growth rates improve after treatment. Gilman *et al.* (1983) studied children with heavy *T. trichiura* infections and uninfected children of similar socio-economic status. All of the children with heavy infections had chronic dysentery, 51% had prolapsed rectum, 18% had oedema, 12% had clubbing of the fingers and anaemia was common. Their growth was also significantly poorer compared with that of the control subjects. Bowie *et al.* (1978) observed striking increases in weight gain and regression of clubbing after treatment for *T. trichiura* infection and they concluded that malabsorption is an unlikely factor in the infection and that the increase in weight was due to the cessation of diarrhoea, improvement in appetite after treatment for anaemia and the improved diet in the hospital.

Heavily infected children often suffer from chronic diarrhoea which has been associated with rectal prolapse and rectal bleeding (Gilman *et al.*, 1983). The quantities of nutrients lost due to chronic diarrhoea and dysentery do not appear to have been studied, but since Cooper and Bundy (1986) have found an association between *T. trichiura* egg counts ($>$ 20,000 eggs per gram of stool) and stunting in St. Lucian children with dysentery, the need for further investigation into nutrients lost is obvious. Iron deficiency anaemia reportedly reduces appetite and food intake and is associated with heavy infections of *T. trichiura*; this could be one explanation for the evidence for chronic protein-energy malnutrition.

A quote by Cooper et al. (1986b)" the gross underestimation of morbidity rate has given a falsely benign impression of the whipworm's importance in world public health and the association of dysentery itself with stunting implies that whipworm infestation may be a major determinant of chronic malnutrition in children " sums up the trichuriasis problem particularly well.

1.2.3. HOOKWORM INFECTIONS

Human hookworms appear to infect more than 900 million people, representing over one-fifth of the world's population (Schad and Banwell, 1984). *Ancylostoma duodenale* and *Necator americanus* are by far the most common hookworms and will be discussed here. Both species are extensively distributed in the tropical and subtropical zones of the world. The prevalence can vary from 80 to 90% in rural insanitary conditions in the moist tropics to 10 to 20% in relatively dry insanitary areas such as Iran and parts of Pakistan (Schad and Banwell, 1984). It is convenient to consider the two species of hookworm together in this section because of the similarities between them.

Hookworms are transmitted to humans by a skin-penetrating L_3 larva that arises subsequent to L_1 and L_2 development in the soil. *Necator americanus* larvae must penetrate the skin, but *Ancylostoma duodenale* larvae can penetrate the skin and can be swallowed, or can pass the placenta as a means of transmission. There is also some evidence of transmammary transmission, that is, transmission from an infected mother to her infant via breastmilk (Brown and Girardeau, 1977). The eggs are passed out in the faeces and if they are deposited in a warm and humid environment (protected from direct sunlight) they will hatch within 24 h. *Ancylostoma duodenale* has been estimated to produce an average of 20 000 eggs per female worm per day and *Necator americanus* about half that number.

The first larval stage, a rhabditiform larva, lives in the soil for about 12 days during which time, it moults twice to give rise to the third larval stage, the infective or filariform larva. The infective larva does not discard the second larval cuticle which serves as a protective covering. The L_3 larva penetrates human skin, usually on the feet, enters the circulatory system and migrates via the heart to the lungs. From the alveoli of the lungs they pass into the bronchi then to the trachea, up the pharynx from where they are swallowed. Maturation is completed in the small intestine where the larvae moult twice and develop to mature worms.

Adult male and female worms attach to the villi in the jejunum and duodenum and the eggs of *A. duodenale* first appear in the faeces between 43 and 105 days post infection; those of *N. americanus* appear between 40 and 60 days after the initial infection (Schad and Banwell, 1984). The late larval stages and adults abrade the surface of the gut with cutting plates (*Necator*) and "teeth" (*Ancylostoma*) in well-developed buccal capsules and feed on blood. *Ancylostoma duodenale* has 2 pairs of hook-shaped "teeth" whilst *N. americanus* has a pair of semi-circular cutting plates. Adult worms are stout, cylindrical nematodes, off-white or rusty red in colour. *Ancylostoma duodenale* is the larger worm, measuring 5-10 mm for males and 10-18 mm for females. *Necator americanus* males measure about 5-9 mm and females 10 mm in length.

The clinical severity of hookworm disease is closely related to worm burden and the condition of host, including iron resources, pregnancy, iron needs, iron intake and bioavailability, and general state of health. The first stage of infection, cutaneous invasion of the larvae, results in a transient dermatitis and associated symptoms (blisters, macules and papules) referred to as "ground itch". Larvae migrating through the lungs to the oesophagus can cause coughing, wheezing and bronchitis (clinical features adapted from Banwell and Schad, 1978). The most important impact of the infection on the host is the blood and iron loss caused by the intestinal stages of the adult worms (Schad and Banwell, 1984). In acute hookworm infection, nausea, vomiting, diarrhoea and abdominal pain occur (Cline *et al.*, 1984), accompanied by decreased food intake and increased excretion of nutrients. Chronic hookworm disease has been most thoroughly studied, especially in relation to iron loss. Layrisse and co-workers (1964) found a highly significant relationship between circulating haemoglobin levels and hookworm egg counts in some rural Venezuelan communities. Haemoglobin levels were significantly lower in women and children passing more than 2000 eggs per gram of faeces and in men passing more than 5000 eggs. Mean haemoglobin levels decreased linearly as egg count increased. Anaemia associated with hookworm infection usually responds to the oral administration of ferrous sulphate or other suitable iron compound, and haemoglobin levels return to normal in a matter of weeks. A single *N. americanus* causes a loss of approximately 0.03 ml of blood per day, and one *A. duodenale* causes about 5 times as much, or about 0.15 ml per worm per day (Miller, 1979). A person who passes 2000 hookworm eggs per gram of faeces (a moderate infection) probably loses an estimated 1.3 mg of iron per day in the faeces for *N. americanus* infections and about 2.7 mg of iron per day in an infection with *A. duodenale* (Layrisse *et al.*, 1961).

Studies of the absorption of fat, carbohydrate, vitamin A, vitamin B_{12} and folic acid have been undertaken in hookworm-infected individuals. Results from the majority of the studies showed that most infected patients did not suffer from a malabsorption syndrome and that the structural and functional abnormalities found in the gut were more likely to be due to protein-energy malnutrition (Layrisse *et al.*, 1964). Several studies have shown that certain patients with heavy hookworm infections are protein deficient (judged by low serum albumin levels), exhibit villus atrophy and decreased fat and D-xylose absorption (Mayoral *et al.*, 1967). Protein deficiency could occur because of a decreased intake, decreased absorption, increased excretion or a combination of these and hookworm infection may contribute to the resulting deficiency.

Another important aspect of hookworm infection is its possible association with growth stunting. Protein loss, nutrient malabsorption, and anorexia could be causes, but these remain unstudied or controversial. However, Stephenson *et al.* (1985)

working in Kenya, observed significant improvements in growth rates of children following treatment with metrifonate for infections of *Schistosoma haematobium*. The degree of improvement correlated well with decrease in hookworm egg count after treatment. There have not yet been well-controlled longitudinal studies to demonstrate whether hookworm infections retard child growth and thus contribute to protein-malnutrition. However, there is overwhelming evidence that heavy hookworm infections are an important cause of anaemia in many developing countries today as they were in North America and regions of Europe earlier this century.

1.3 PREVENTION AND CONTROL STRATEGIES

The control of intestinal helminth infections appears to be more feasible now than ever before owing to the discovery of safe and efficacious drugs, the improvement and simplification of some diagnostic procedures, and advances in knowledge of helminth population biology. The control of diseases in many developing countries can be quite a sensitive issue owing to the association of parasitic infections and socio-economic status. In some countries, parasite control has proved a useful entry point for other primary health care services, as will be described later.

Prevention and control programmes have both short- and long- term objectives. The main short-term objective is to reduce the intensity of infection to levels at which harmful effects on the nutritional status are reduced. This can be achieved by community-based chemotherapy (Stephenson *et al.*, 1983). The approaches for prevention and control of intestinal helminths differ for each infection and each area, depending on the local public health importance of the infection, local health priorities, political will, manpower and economic resource, and the potential for combined or integrated programmes involving parasite control and other major health programmes, for example, diarrhoeal disease control, sanitation, and child care.

1.3.1 CHEMOTHERAPEUTIC CONTROL

Several methods of chemotherapy can be used in helminth control programmes: mass treatment, selective treatment and targeted treatment. Mass treatment is when a community is treated irrespective of age, sex, worm burdens or other social characteristics of the individuals in that population. For example, mass treatment was the control strategy used in different areas in Iran, Myanmar and Kenya (Arfaa and Ghadirian, 1977; Thein Hlaing *et al.*, 1987; Stephenson *et al.*, 1983) and the results indicated that the prevalences and intensities of *A.lumbricoides* were reduced after treatment, but they were only short-term, because anthelmintics (drugs used against helminths) do not prevent a person from reinfection. Reinfection in these areas is inevitable, thus periodic treatment of at least once every 3 months is a more ideal strategy. As demonstrated by Stephenson *et al* (1983), periodic mass treatment combined with health education appear to be the best way of starting to control soil-transmitted helminths in Kenya. The benefits of chemotherapy are generally popular and can serve as an entry point into a community to encourage the village people to change their behavioural habits needed to improve environmental sanitation and personal hygiene (Stephenson *et al.*, 1980; Trainer, 1985). These are short-term effects of anthelmintics aimed at lowering the intensity of infection quickly, which is crucial if the support and cooperation of the community are to be secured.

Long-term objectives are to reduce the prevalence, intensity and severity of intestinal helminths to levels at which they cease to be of public health significance. This may take from one to two decades, because the stability of helminths to perturbations by human activities or climatic factors and the resistant properties of the free-living stages in the environment are remarkable. Humans elicit immune responses to infection, which may help to limit parasite survival, but acquired resistance fails, therefore reinfection tends to be rapid following treatment. In the case of *A.lumbricoides* and *T.trichiura,* intensities of infection tend to return to their pre-treatment levels 9 to 12 months after treatment. Annual mass treatment in endemic areas is therefore of little value in the long term elimination of helminths.

Extensive studies in Japan, Thailand, Korea and Myanmar have demonstrated that bi-monthly treatment intervals are optimal for the long term control of *A.lumbricoides* (APCO, 1980a, 1980b).
Mathematical models of parasite transmission, have pointed to the need for frequent mass treatment maintained over long periods of time (Anderson and May, 1985).

Selective treatment is based on those individuals in the community who are heavily infected (high worm loads). This is time-consuming and costly, because it requires the identification of the wormy individuals (in each age class) at each round of treatment. One feature of the population biology of helminths makes selective treatment an attractive option in theory, because the frequency distributions of worm numbers per person is highly aggregated (or overdispersed) such that most people harbour a few worms and a few people harbour most of the total parasite population (Croll *et al.*, 1982; Martin *et al.*, 1983; Bundy *et al.*, 1988; Holland *et al.*, 1989). Therefore treating the so-called "wormy" fraction of a community ought to relieve the morbidity for vulnerable individuals (given that worm load and morbidity are positively correlated) and reduce the number of transmission stages reaching the environment. In economic terms, this method of control clearly reduces the amount of drug used, but in practical terms, the extra cost entailed in identification of those to be treated within a population can be quite excessive. Studies are needed to quantify the costs of selective treatment.

Targeted treatment is specific to groups or individuals in the community classified by age, sex, or worm load. For example, 4 to 15 year old children may be targeted with treatment in a given community. This approach (choosing the most heavily infected age group) has practical advantages in the sense that such individuals, because they are at school, are accessible with respect to the administration of treatment. The "Treatment Tactics project 1989-1990" in Nigeria (Asaolu, Crompton, Fraser, Holland, and Stoddart, unpublished results) investigated the use of anthelmintic treatment in the community in the three ways as described above (mass, selective and targeted), to control soil-transmitted helminths.

1.3.2. SANITATION CONTROL

Improved, affordable sanitation and faecal management and disposal and improved drinking-water supplies and personal hygiene are measures which will serve to interrupt the transmission of soil-transmitted helminths. The provision of sanitary facilities for excreta disposal and their proper use are necessary components of any programme aimed at controlling intestinal parasites (Crompton *et al.*, 1989). Many studies have been carried out which assess the impact of improved sanitation (Chandler, 1954; Henry, 1988). The results of encouraging people to build latrines, improve wells or attend health education classes have not yet led to decreases in the transmission of soil-transmitted helminths because behavioural changes by people does not always happen and people are still living in contaminated environments. However, every new latrine built, every litre of clean water and every health education session conducted are small but positive contributions in the effort to control intestinal helminths.

The provision of safe water and sanitation facilities to a community does not necessarily protect the population from contamination of disease (Mason *et al.*, 1986; Chunge *et al.*, 1985). The entire community needs to make sure *all* stools passed are deposited in a latrine, otherwise people who do regularly use latrines can still be infected by their neighbours and relatives who do not use them. Improved sanitation exists in many African countries, such as Zimbabwe (Kilama, 1985), Latin American countries, and Asian countries, such as Myanmar (Crompton *et al.*, 1989). Sanitary control measures are generally not successful in the short term in decreasing parasitic infection in the community. Only deworming programmes can make a major short term impact on the prevalence and intensity of soil-transmitted helminths (Latham, 1984). The most effective and beneficial way is, a combination of chemotherapy, environmental sanitation and health education. These control measures are welcomed by communities and have a strong psychological impact. When people actually see the expelled worms wriggling around in their faeces, it is a startling sight to them.

The costs of control measures can be variable from very low to unrealistically high. Programmes based on mass treatment alone are likely to be the least expensive, although they have only short term benefits. Their costs include the cost of drugs used plus the cost of a delivery system (Stephenson *et al.*, 1983). Soil-transmitted helminth control programmes which include sanitation, water supplies and health education are likely to be much more expensive than chemotherapy, but, if successful, will have much larger and more permanent health benefits due to controlling other important diseases.

1.3.3. INTEGRATED CONTROL PROGRAMMES

Another emerging strategy for controlling soil-transmitted helminths is to incorporate parasite control programmes and primary health care into rural development plans (Trainer, 1989). This appears to be a viable approach because using the people's interest in health services, such as family planning, enhances the level of community participation that is required for a mass control programme. In this way, family and environmental hygiene may be achieved more quickly. Parasite control in Asia is largely committed to such integrated projects (Yokogowa, 1985); that is integration with family planning. By 1986, eight Asian countries were committed: Bangladesh, Indonesia, Korea, Malaysia, Nepal, the Philippines, Sri Lanka and Thailand. In other Western Pacific countries, control programmes have been launched in conjunction with priority health programmes. In Japan, where parasite control became the key factor in the improvement of community health, almost complete eradication of parasitic worms has been achieved within 20 years and this is via an integrated strategy. Such projects, like the Japanese one, now exist in Latin America and Africa, where mass examination and mass treatment are used to stimulate people's interests in family planning and in environmental and family hygiene.

Therefore, eradication is a realistic goal in the near future. As stated by the most recent WHO Expert Committee (1987) on the prevention and control of intestinal parasitic infections: "Countries in which intestinal parasitic infections and diseases constitute a significant health problem should consider adopting a national policy for their prevention and control. Where there is political will on the part of the government to respond to the people's expressed need to be rid of their worms, considerable success and benefit to the population can be confidently expected"

1.3.4 SUMMARY

The morbidity of soil-transmitted helminths has been discussed mainly in terms of clinical pathology and clinical expression of the infections. *Ascaris lumbricoides*, *Trichuris trichiura* and hookworm infections have an important impact on the health of human beings. Ascariasis is associated with malnutrition, decreased growth rate, and structural abnormalities of the mucosa of the small intestine particularly in children. Trichuriasis is associated with chronic dysentery, rectal prolapse, anaemia, poor growth and clubbing of the fingers. Hookworm infections cause anaemia, through the loss of blood and iron, malabsorption and intestinal protein loss. Evidence continues to accumulate that soil-transmitted helminthiases influence the health of people, particularly children, in the developing countries.

The control of soil-transmitted helminthiases is now considered to be a worthwhile public health measure. In view of the widespread and harmful effects of these infections on large sections of the world's population, the WHO Expert Committee (1987) has agreed that the problems call for effective action to prevent and control intestinal parasitic infections at the community level through active and well-designed national programmes. Virtual eradication of intestinal parasites has been achieved in Japan, South Korea and Israel, demonstrating that control is an achievable objective.

SECTION 2

CHAPTER 1.

SOIL-TRANSMITTED HELMINTHS IN NIGERIA: A REVIEW

1.1 INTRODUCTION

"The helminth problem is an insidious one, not dramatic in its morbidity as is malaria, but one which slowly and quietly saps the strength of the afflicted population to a state of debility that renders them incapable of sustaining economic activities at the level necessary to foster development of the villages" (Nwosu, 1983). This quote portrays a dismal picture of rural life in Nigeria. Rural villages remain economically poor, partly because of the poor health status of the villagers and, in this state of poverty and ignorance, little can be done to improve the situation. The crucial question is how to break this cyclical situation.

In Nigeria, the major helminth infections are the triad of nematodes, (*Ascaris lumbricoides, Trichuris trichiura*, and hookworms especially *Necator americanus*) which occur throughout the country (Fisk, 1939; Nnochiri, 1968; Hinz, 1968) and *Dracunculus* and *Onchocerca* species and tapeworms and intestinal schistosomiasis. In order to consider which parasitic diseases would be expected to occur in different areas of Nigeria, it is important to understand their general distribution throughout the country.

Nigeria is a large country with a total area of 356,605 square miles and lies between latitudes 4°21' and 14°00' north and longitudes 2°20' and 14°30' east (Bartholomew, 1987). It is bounded on the north by Niger, on the west by Benin and on the east by Cameroon and by Chad. The Gulf of Guinea lies to the south. The distribution of some helminths is influenced in many cases by the topography of the country, in others by the climate and by the vegetation. The climate is tropical with some variation between the south which is hot and wet, and the north which is hot and dry. The mean minimum temperatures range from 21°C in the south to 13°C in the north and the mean maximum temperatures range from 32-35°C in the south and 38-41°C in the north. Factors which are known to influence the prevalence and dissemination of *Ascaris lumbricoides* include overcrowding, poor housing, insanitary conditions, inadequate methods of disposal of human excreta and public refuse, low economic status and ignorance about health matters particularly among the people and their families. These factors provide a suitable environment for the persistence and transmission of *Ascaris lumbricoides* and *Trichuris trichiura* which are acquired by the ingestion of viable eggs containing infective larvae. Their life-cycles are direct, infection being from human to human. No reservoir or intermediate hosts are therefore necessary for their transmission.

1.2 EPIDEMIOLOGICAL SURVEYS OF PREVALENCE AND INTENSITY DATA CONCERNING THE "TRIAD" OF NEMATODES IN NIGERIA

Basic epidemiological information on the prevalence and intensity of soil-transmitted helminths in Nigeria exists, but is fragmentary. It is often published in rather inaccessible literature and results are rarely comparable due to the lack of standardisation in obtaining and reporting information. Most surveys have been cross-sectional and carried out on a single occasion (Ayanwale, 1982; Adeyeba and Dipeolu 1984). Differences in factors such as geographical area, rural/urban setting, sample size and host characteristics all contribute to the observed prevalence variability. *Ascaris lumbricoides, Trichuris trichiura* and hookworm are distributed throughout the country. Their prevalences do vary considerably in different categories of people from different regions. The prevalences of these infections tend to be lower in urban and suburban communities than in rural villages (Okpala, 1956). The prevalence of *Ascaris lumbricoides* appears to be higher in the south (Obiamiwe, 1977) than in the north of Nigeria (Collard, 1962). The climate of Northern Nigeria is a likely influence on the lower prevalence of helminths in that region. Developmental stages of the helminths are inhibited by the dry, arid climate and there is a possible lower degree of contamination of food and water in the Northern States, although faecal contamination of the soil is probably as common as in other parts of the country. Hookworm appears to be higher in the Northern States of Nigeria. For example in Katsina State, hookworm prevalence was found to be 59%

(Collard, 1962) and in the Malum Fashi area (Kaduna State), hookworm (*Necator americanus*) was the most common intestinal helminth with a prevalence as high as 89% in adult males from one farming community, although the intensities were low (Pugh *et al.*, 1981). There is still a need for more recent data on *Ascaris lumbricoides* from the Northern States of Nigeria.

Many more surveys have been carried out in the south of Nigeria. For example in Oyo State, *A.lumbricoides* prevalence was found to be 70% in the suburban quarters of Ibadan, hookworm prevalence was 46% and *T.trichiura* was 4% (Ayanwale *et al.*, 1982). In Ondo State, 2 large rural villages and a large urban slum near Lagos were examined for intestinal helminths (Fashuyi, 1988). The results agree with Cowper (1967) that the three common species of helminth are universal in south-western Nigeria, but the prevalence and intensity of *A.lumbricoides* were higher in the large slum area than the rural farming communities; interestingly this does not conform with the previous findings where soil-transmitted helminths are more prevalent in the rural areas than the city areas. Perhaps the huge population concentration coupled with the unplanned nature of the settlement and the absence of facilities like drainage, water supply and refuse disposal contribute to the increased levels of infection.

In a more up-to-date survey of gastrointestinal helminths in southwest Nigeria (Reinthaler *et al.*, 1988), *A. lumbricoides* was the most common intestinal helminth found (40% of 479 hospital specimens), followed by *T. trichiura* (23.2%) and hookworm (19.2%). Children were mostly affected, particularly those aged between 2 and 5 years old, in that 65% had *A.lumbricoides.* This conforms with the results of a survey at Enugu hospital, south Nigeria, where the highest prevalence (74%) of *A. lumbricoides* infection was found in children between 3 and 7 years old, and the lowest rate (4%) was found in 1 and 2 year olds (Aguagua, 1983). In Benin City, Bendel State, the most common helminths were *Necator americanus* (16.8%), *A. lumbricoides* (19.5%) and *T. trichiura* (5.9%). The prevalence of these helminths remained steady throughout the rainy and dry seasons, indicating that factors other than rainfall operate to maintain high levels of infections, the most likely being inadequate disposal of human excreta in the environment causing a continuous pattern of infection (Obiamiwe, 1977).

Prevalence rates of soil-transmitted helminths have also been observed to be high in the central states of Nigeria. In Plateau State (where a study was carried out at Jos University), the highest prevalence rates were found in the staff of the university (77.5%) and the lowest rates occurred in medical students (21.28%) (Azikiwi, 1984). *Ascaris lumbricoides* and hookworm were the most common infections in the groups examined. This high prevalence is important in view of the family size of the subjects (mean family size is approximately 6.9); it is most likely that the other family members are as infected as the ones examined in the study and therefore appropriate control measures should be carried out (Azikiwi, 1984).

In the west of Nigeria the prevalence of soil-transmitted helminths is also seen to be high. In a population of 3232 people in the rural Kainji Lake area, Kwara State, the prevalence of *A.lumbricoides* was 44.17% and *Ancylostoma* species was 40.33% (Okaeme, 1985). This may be a reflection of the inadequate health and veterinary facilities and overcrowdedness in the Kainji Lake area. More recently Holland *et al.* (1989) found the prevalence of *A.lumbricoides* and *T.trichiura* to be high in children living near the town of Ile-Ife (88.5% and 84.5% respectively).

The variability of prevalences of soil-transmitted helminths in different regions of Nigeria makes it difficult to draw firm conclusions. In 1986, a report on the prevalence of *A.lumbricoides* in Africa, submitted to W.H.O., singled out Nigeria for special comment: 15 million Nigerians are estimated to harbour *A.lumbricoides*. Crompton and Tulley (1987) found more information on ascariasis in Nigeria than in any other African country, but despite this they concluded that many of the studies lacked appropriate controls and that the data were incomplete. As we have seen, the Nigerian data is collected from various sources and dates back to earlier this century:- Okpala, 1956 (school children); Okpala, 1961 (government workers); Cowper and Woodward, 1961 (hospital patients). Biased estimates of prevalence may result from surveys of people who present themselves for examination, since they are more likely to harbour *A.lumbricoides* than those who do not volunteer. Another factor to contribute to the variability of prevalences is the variety of methods used in diagnosis and in determining the helminth egg counts. From the simple qualitative faecal smears to the quantitative McMaster, Kato-Katz and ether concentration methods, varying results are obtained (Hall, 1981).

Few studies provide information on the intensity of infection, a measure that is essential for the accurate assessment of the dynamics of infection, the morbidity and mortality rate associated with soil-transmitted helminthiases and the effectiveness of control measures. Nwosu (1981) carried out a long-term study of soil-transmitted helminth infections of two rural villages in southern Nigeria involving 6842 stool samples. The bulk of the worm burden per person (the intensity of infection) in the two villages was harboured by quite a small section of the population, namely children of 10-15 years of age (mean eggs per gram of faeces = 6854); about 29% of the study population contributing 75% of the helminth egg output. The overall hookworm burden was much lower in females aged between 15 and 30 years than in males, whereas the reverse seemed true for *A.lumbricoides* and *T.trichiura* infections. The study by Holland *et al.* (1989) found that the intensity of *A.lumbricoides* in primary school children (as measured by mean worm burden/child) was found to be greatly reduced after anthelmintic treatment (Ketrax [levamisole], I.C.I. Pharmaceuticals) in all age classes particularly the 13 to 16 year olds. Worm burden data, which is seen to be one of the more reliable measures of intensity and which involves counting all the worms passed by an individual for 48 h after anthelmintic treatment, is particularly scarce. The lack of such data reflects the difficulty in its collection and the high level of community co-operation needed.

By assessing the number of worms passed by a group of individuals, frequency distributions of the numbers of worms per host can be generated. This data is useful in identifying patterns of infection and the individuals which are most in need of treatment (see Holland *et al.*, 1989; Nwosu, 1981).

1.3 SOCIO-ECONOMIC, BEHAVIOURAL AND CULTURAL FACTORS WHICH INFLUENCE THE TRANSMISSION OF HELMINTHS

Human behaviour, human culture and human socio-economic status all play a large part in the transmission and control of parasitic infections (Holland, 1989 and Croll, 1983). Housing, economic status, occupation, health education and religion influence the spread of disease. In a long-term study in four villages in Anambra State, Nigeria, Nwosu (1983) emphasised the need to look at the relationship between human ecology and helminth infections, so as to design the most appropriate control programmes using the limited resources that are available to the health authorities in a developing country. In rural villages, sanitation as a whole is poor. It has been established that the decisive factors in the transmission of hookworms, *A.lumbricoides* and *T.trichiura*, which constitute the bulk of the helminth burdens of these villages, are poor latrine hygiene and indiscriminate defaecation. In addition, overcrowding and large population densities enhance the contamination problem of the rural villages. In Nwosu's study, four groups were identified in the communities based on literacy levels, nature and sanitary status of households, defaecation habits, excreta and refuse disposal practices, and attitudes to chemotherapy. It was found that helminth prevalence rates were lower among the literate population while the illiterate farmers were heavily infected. Amongst the literate wage earners and traders of the villagers, self-medication was common. School-children had consistently high worm burdens despite their socio-economic group, and it was concluded that there was inadequate latrine hygiene in the schools.

Defaecation behaviour also plays a major role in the transmission of intestinal parasites. This behaviour is an integral part of village culture which cannot be separated from community ethnography. Children defaecate promiscuously near the houses and it is this group which carry the highest worm loads in the community. Therefore improvement of the health status of rural populations should be directed at the younger age groups. It was found in Nwosu's study that there was a high incidence of non-use of pit latrines and which, through their design, were unsafe for children. Nwosu also recorded activity-based differences in helminth prevalence in his study. Men engaged in high energy tasks, such as cultivating yams, were more likely to be exposed to infective hookworm larvae than women and children who picked vegetables which become a problem where human faecal slurry is used as an agricultural fertilizer. Women and children were more exposed to infective eggs of *A.lumbricoides* and *T.trichiura*. Nwosu also found that rainfall affected the transmission of various helminths. During the rainy season infective stages of the helminths are abundant and farming is at peak activity. The villagers (usually bare-footed) make frequent contact with hookworm larvae in the top soil, in pools between yam mounds and on blades of grass onto which the larvae have been washed by the torrential rainfall.

Adekunle *et al.* (1986) also provided evidence of a relationship between socio-economic status and helminth infections. The prevalence of intestinal helminths among children of 512 families of three different social categories were studied in Ibadan, south-west Nigeria. Children from less than one - year- old to 15- years-old were selected randomly from three social groupings. These included families who inhabited the traditional areas (characterised by overcrowding, few sanitary facilities, extended family living together), the middle-class areas (planned area but the facilities are still inadequate) and an upper-class residential neighbourhood (well-spaced houses, separate bath and toilet facilities, monogamous family structure). It was found that the prevalence of intestinal helminths was strongly correlated with the father's social status and the position of the child in the family hierarchy. A third of the infected children had unemployed fathers, 26.6% were of petty traders while 18.7% were children of fathers in the intermediate class and 15.5% were children of clerical officers. A higher proportion of children who were 3rd or 4th in the family position had a higher prevalence of intestinal helminths than the other positions of children in the families. In addition, a higher proportion of children whose parents had either been divorced or separated, were found with a higher prevalence of helminths than those children whose parents remained married.

The health of school age children is influenced by a whole network of multiple factors involving the economy of the home, educational status of the parents, cultural practices in the home and the standard of environmental sanitation in the community.

Oduntan (1974) has published a series of reports on the health of Nigerian children. "Elite" children of ages 6-15 years in Ibadan (south-west Nigeria) were found to have the lowest intestinal helminth prevalence rate compared with other groups (urban primary school, secondary grammar school, rural school and non-school children). The rural school children lived in villages where the standard of environmental sanitation is very low and their parents are poor and not well educated. The "elite" children lived in government housing areas with adequate facilities for disposal of excreta. Their parents were well educated, earned high salaries and maintained a relatively high standard of personal hygiene which was reflected in 95% of the"elite" children having no detectable intestinal parasites. In a city like Ibadan, many of the homes are without adequate means of sewage and refuse disposal and there is a constant shortage of piped water and the inhabitants walk barefoot and prepare food in open spaces in dirty containers. The important role of schools in the promotion of the health of children is to be very much encouraged in Nigeria. School health services are necessary for the foundation of concepts on hygiene, health and disease in the young generation.

Food quality is another factor relevant to social status and it occupies a central and important position in every household. The standard diet is typical throughout all categories of people in Nigeria, although the elite households may have a higher protein content than the workers and their families. Dietary surveys of selected households which cut across socio-economic strata showed a considerable dependence on starchy staples such as cassava, yams, and cocoyams (Nwosu, 1983). Street-hawkers and food-handlers play a role in the transmission of intestinal helminths particularly in the urban areas (Nnochiri, 1968). Food-hawking, which is a well known feature of the life in towns and cities of Nigeria, is an effective means of spreading helminth infections. Food-handlers such as mothers, servants, cooks and palm-wine tappers are other sources of infection. Food can be contaminated by faeces, but also through polluted water, dirty hands, contaminated soil and flies. Adekunle *et al.* (1986) showed that drinking and cooking water did not correlate so strongly with helminth infections as such social categories as the father's occupation or the mother's level of education. In a more recent study on social aspects of helminthiases, a high prevalence of *A.lumbricoides* was found in Bauchi State, northern Nigeria, which agreed with results obtained half a century ago in similar areas (Akogun, 1989). Again, several factors may account for the high prevalence of soil-transmitted helminths. The use of water for cleaning after defaecation and indiscriminate defaecation on pastures and around houses seemed an acceptable social behaviour in this district. Communal feeding from a common bowl (which is regarded as a symbol of comradeship) and meals, which are often left exposed to the wind, insects and domestic animals are all possible routes for the contamination of food with helminth eggs and larvae. An indifference of people to faeces also exists, especially amongst children . The excrement of children is regarded as "pure". A general laxity in personal hygiene was observed among those older than 40 years (Akogun, 1989). Street-yards were used as a natural playground by children where the contaminated soil and garbage serve as toys. The fact that the findings of this survey do not differ appreciably from those obtained in 1934 by Ramsay in northern Nigeria is a reflection of the magnitude of the problem facing the health care and social welfare system.

Sanitation and health care has improved in some parts of Nigeria. A community in Oyo State learnt to appreciate the inter-relationships between poor sanitation and health as a result of health education intervention for a period of 12 months (Omishakin, 1988). The same community constructed refuse depots at strategic locations and simple technologies, such as mud and drum incinerators have been installed for the burning of refuse.

Faecal contamination is also high in the urban environment of Lagos. A survey of faecal samples collected from the streets of Lagos near markets, motor parks, residential and recreational areas revealed that 96.3% of the samples contained *A.lumbricoides* eggs (Fashuyi, 1983). Kofie and Dipeolu (1983) looked at the role of pigs in the epidemiology of human *Ascaris* infection. Pigs often live in close contact with human households and visit human refuse dumps for defaecation and scavenging. Although an attempt to infect *Ascaris*-free piglets experimentally with *A.lumbricoides* eggs cultured from human ascarids failed, the authors suggest that the role of pigs in the dissemination of *A.lumbricoides* infection is worthy of further attention (Kofie and Dipeolu, 1983).

1.4 HOST NUTRITION

There is strong evidence for an association between intestinal helminth infection and nutritional status of children in many countries (Stephenson, 1987; ACC/SCN, 1989) and there is no reason to suppose that Nigeria is an exception. With the increasing evidence for the impact of ascariasis on the nutritional status of both malnourished children and protein deficient pigs (Crompton, 1985), it is highly likely that nutritional morbidity is also important in developing countries. Heavy infections with intestinal helminths are often reported to be associated with stunting and general malnutrition, through reduced food intake, decreased digestion, malabsorption of nutrients and increased gastro-intestinal protein loss (Stephenson *et al.*, 1980b). Hussain (1980) found that a gradual reduction in weight and height in Nigerian children occurred with an increase in the degree and type of parasitic infection. The intake of energy, protein and riboflavin also gradually decreased; even a mild to moderate *Ascaris* infection reduced the energy intake (Hussain, 1980). Malnutrition in Nigeria is still a leading cause of morbidity and mortality among infants, particularly in the rural areas of Nigeria, where health facilities and health supervision are very limited. Cultural food practices and food habits are major contributory factors to malnutrition as Ojofeitimi (1987) pointed out from a study carried out in Ita-Elewa village. About 25% of the mothers condemned fish and meat to their children because they assumed they caused intestinal worms.

Practically all the mothers were ignorant as to what constituted a balanced diet for a growing child. Also the mothers, whose children were suffering from malnutrition, thought that intestinal helminths were the leading causes of protein-energy malnutrition (PEM). This finding is beneficial in a way, because health programmes in the community can be set up where health workers can capitalise on this concept and can promote environmental and food hygiene.

1.5 PROSPECTS FOR CONTROL

At present, there is no operational policy for a nationwide programme for the control of soil-transmitted helminths in Nigeria. This does not mean that projects in Nigeria have not been attempting to control soil-transmitted helminthiases. In many parts of Nigeria, projects aimed at improving sanitation, water supplies, and health education may help to control soil-transmitted helminths in the long-term. The fact that there are so few published articles on the control of helminths in African countries strongly implies that there probably are few large scale control efforts aimed primarily at intestinal helminths. Also health professionals find it hard to publish the results because they are too overburdened with patient care and daily responsibilities. Modern control actions can probably be introduced at a relatively low cost into established primary health care programmes (see Crompton *et al.*, 1989). For effective control, however, it is essential to generate epidemiological data on soil-transmitted helminths at the local level in order to formulate suitable control programmes (Nwosu, 1981).

Chemotherapy in the community has been a more realistic option for helminth control. A solution, suggested by Nwosu (1983), showed how mass chemotherapy if directed at the most heavily infected individuals in a community and treating them over a period of 3-4 years during the dry season (when transmission conditions are least favourable) would reduce infection rates with minimal costs. The initial results (1978-1979) showed that such a strategic mass chemotherapy campaign initially achieved a tremendous success in reducing infection levels, but the data showed that in the long run this success would be limited. The reasons for this are environmental and underline the need to view mass chemotherapy as part of a health-promoting behaviour that must be combined with improved environmental sanitation campaigns.

In establishing chemotherapeutic action, various aspects of the available anthelmintic drugs should be considered including its spectrum of activity, efficacy, cost, lack of side-effects, stability and acceptability. Based on these factors treatment regimes using anthelmintics have produced over 80% worm egg reduction rates, and the campaign periods are usually the dry season months (November-March). Levamisole is currently the anthelmintic of choice because of its broad-spectrum efficacy and high worm egg reduction rates. The approach of using chemotherapy solely for high risk groups has been approved by a number of workers, however, the need to simultaneously improve sanitation and health education to achieve an effective reduction of transmission and intensity still remains. Nwosu also emphasised the need to target the younger age classes for health education and behaviour modification in order to reduce environmental contamination with parasitic infective stages.

An integrated approach for the control of intestinal helminth infections in Nigeria has become more significant now, taking into account the local conditions of the general problems of helminth infections in village communities: latrine hygiene, water supplies, farming activities, literacy level, health education and mass chemotherapy. With changes in farming practices and the introduction of agro-based industries sited in the villages (with the necessary educational and administrative support), the earning power and literacy level of farmers will increase, improved housing and latrine hygiene will follow, which will in turn result in the elimination of soil-transmitted helminths. Therefore the eradication of soil-transmitted helminths will be a consequence of economic growth. A major constraint to this approach is that it will have to take place over a very long period in view of the limited resources of developing countries as Ukoli (1984) points out. He presents a more realistic picture of the prospects for control of parasitic infections in

Nigeria, pointing out problems such as lack of funds and of trained, committed parasitologists, political difficulties and the need to appreciate the advantages of control. Before control programmes can be instigated both health and governmental personnel need to be more aware of the adverse effects of soil-transmitted helminths, and the potential of their control as an introductory tool to other health care programmes in rural Nigeria.

CHAPTER 2.

TREATMENT TACTICS PROJECT IN OYO STATE, NIGERIA.

2.1 INTRODUCTION

Studies by many workers have shown that *A.lumbricoides* and *T.trichiura* have a high prevalence in Nigeria (Holland and Asaolu, 1990). Much of this work has involved parasitological examinations of hospital patients (Cowper and Woodward, 1961) government workers (Okpala, 1961), school children (Abioye and Ogunba, 1972), or other specific groups within a community (Gilles, 1965). Not many surveys have run continuously over a reasonable length of time (Cowper and Woodward, 1961; Obiamiwe, 1977) and not many have involved entire village communities. A study, entitled "Treatment Tactics with Anthelmintics in Ascariasis Control Programmes 1989-1990", has recently been undertaken with time and community-involvement as two important factors in the tactics for the control of intestinal helminths. The study was carried out over a 13-month period (March 1989 to March 1990 inclusive) in 4 rural communities of Oyo State, Nigeria. The aim of the study was to evaluate the effect of 3 different tactical uses of an anthelmintic drug in lowering the intensity of soil-transmitted helminth infections in human communities in an endemic area of Nigeria. The anthelmintic drug used was levamisole (Ketrax, I.C.I. Pharmaceuticals, U.K.) and the treatment tactics are described in more detail below. Levamisole has activity against other species of helminth in addition to *A.lumbricoides* as described by Davis (1985), and so attention was also paid to the intensity of other helminth infections during the study.

My participation in this project took place in March and April 1990, when I visited Nigeria to assist with stool collections and treatment regimes under the supervision of Dr. S.O. Asaolu and Dr. C.V. Holland. The fieldwork allowed me to observe and understand the difficulties in obtaining adequate data and it also made easier the interpretation of the analysis of soil-transmitted helminths. The data which I present here extend from the results obtained from the initial stool collection in March 1989 before any treatment was given. I have analysed these data to give a basic understanding of the epidemiology of intestinal helminths (*A.lumbricoides, T.trichiura* and hookworm) in rural people of Oyo State, Nigeria.

2.2 MATERIALS AND METHODS

2.2.1. STUDY AREA

The study area was situated in a 20 km zone around Ile-Ife in Oyo State, in the southwest part of Nigeria approximately 250 km north-east of the capital, Lagos (see map). The area is characterised by tropical rain forests and wooded plains. The four rural villages are within a manageable distance from the main market town, Ile-Ife. Ile-Ife and the villages of Alakowe, Iyanfoworogi and Akeredolu are in Oranmiyan Local Government of Oyo State and Iloba is in the adjoining Alakumosa Local Government (see map). The four villages were selected, because intestinal nematodes are endemic to the area and the local communities are known to be co-operative. Each village is a rural community of about 400 people of the same tribe. They are predominantly subsistence farmers. The houses are built close to each other and near to the farms where yams, cassavas, rice and beans are harvested. Indiscriminate defaecation in the farms and houses is common, because there are no obvious pit latrines and sanitation and living conditions are poor by the standards of developed countries. Prior to the start of the study the local village headman gave his approval of the study and ethical clearances were ensured also a local physician was employed at the start to examine the health and condition of the village people.

2.2.2. STUDY DESIGN

The study design is displayed in the form of a chart. The first stool collection took place in March 1989 to measure the initial intensity of infection for each village. After this, 3-monthly treatments of the anthelmintic drug were administered to the three villages in three different ways for one year. In Akeredolu, treatment was given to the whole population (MASS); in Iyanfoworogi, treatment was targeted at one group of individuals, the primary school children (TARGET); in Alakowe, treatment was selectively given to individuals who were identified prior to the project as being heavily infected (SELECTIVE) and in Iloba, treatment was not

Map of Nigeria showing Oyo State and location. of Oranmiyan (A) and Ilesa (B) Local Government Areas

Map of Oranmiyan and Ilesa LGAs showing locations of villages studied

Study design: treatment tactics with anthelmintics in ascariasis control programmes.

VILLAGE	treatment	time 0	+ 3 months	+ 6 months	+ 9 months	+ 12 months
Akeredolu	MASS	1st treatment	2nd treatment	3rd treatment	4th treatment	5th treatment
Iyanfoworogi	TARGETED	""	""	""	""	""
Alakowe	SELECTIVE	""	""	""	""	""
Iloba	CONTROL	—	—	—	—	""

First stool collection

Final stool collection

given (CONTROL) until the end of the study. In March, 1990, the final stool collection took place, and the fifth treatment of anthelmintic was given to everybody in the villages. Age, sex and identification number were compiled for the people of each household before the start of the study.

2.3 PARASITOLOGICAL TECHNIQUES

Stool samples were collected in plastic Sterilin Universal bottles and each was thoroughly mixed with 10% aqueous formaldehyde solution and aliquots were examined in the laboratory using a modified Kato-Katz technique (WHO, 1985). Before examination, each stool sample was centrifuged for 5-10 min at 2000 rpm. The supernatant fluid was discarded and the pellet was passed through a stainless steel template providing approximately 50 mg of stool on a microscope slide. Two drops of 3% malachite green in 50% glycerol were added to the slide and mixed well before examination at a magnification of x100 some 30 min later. Eggs of intestinal helminths are easily observed and counting the number of eggs (e.p.g.) gives an indirect, reproducible measure of the worm intensity in the host (WHO, 1985). Levamisole was chosen for this study, because it is one of the essential drugs recommended by WHO, Geneva (1988). In Nigeria the Government is making strenuous efforts to ensure that only WHO-recommended drugs are used. Levamisole which is an efficacious drug that is taken orally and has minimal side-effects, was distributed to the people in the relevant villages at the described times in the study design (Table 1.). Children aged 1-4 years old received 5 ml of "Ketrax" syrup, those who were 5-15 years old received two tablets and those who were 16 years old and over received three tablets. Throughout the survey, all the people, in particular the caregivers, were fully informed of the purpose of the study.

2.4 STATISTICAL INVESTIGATION

Several statistical methods were employed to analyse the base-line epidemiological data for the "Treatment Tactics Project". The versatile Chi-square test was used in a number of ways. Chi-square is a method for assessing the significance of deviations of values observed amongst the enumeration data, in this case egg count values. It enables us to check on the probabilities of occurrence of different degrees of deviation from expectation, the Null hypothesis being that the deviations are caused by chance alone. Another application of this test is its use in contingency 2x2 tables, allowing the comparison of simple ratios of uninfected and infected individuals for the appropriate parasitic infections.

Analyses of variance (ANOVA) were applied to the intensity of infections to compare the means of egg counts with age (one way ANOVA) and with age and sex (two way ANOVA). Such analyses assume that the data are normally distributed and the variances are not significantly different. Egg count data was, as expected, found to be highly variable and so was subjected to logarithmic transformation before analysis took place. As a measure of overdispersion for each helminth infection, variance to mean ratios were used (Anderson and Gordon, 1982).

CHAPTER 3.

RESULTS

A total of 1412 faecal samples was collected in March 1989 from the 4 rural villages in Oyo State, Nigeria. On the basis of the results of the microscopic examination, *Ascaris lumbricoides, Trichuris trichiura* and hookworm species (hookworm in this part of Nigeria is identified as *Necator americanus*) were found to be the common intestinal helminths in the villages. *Schistosoma mansoni, Enterobius vermicularis* and *Strongyloides stercoralis* were also detected in some of the stools, but of considerably less abundance.

3.1 OVERALL PREVALENCES OF INTESTINAL HELMINTHS IN THE 4 VILLAGES

The overall percentage prevalences of *A.lumbricoides, T.trichiura* and hookworm were high in each village (Table 1). The values obtained at the 4 locations were all similar, although Akeredolu showed the highest prevalence figure for all three parasite species. For *A.lumbricoides,* the prevalence values varied from 61.7% to 74.4% , for *T.trichiura* from 64.7% to 73.7% and for hookworm from 51.9% to 62.5%.

3.1.1 AGE AND PREVALENCE

For each village, subjects were grouped into age classes and the prevalence of infection per group was determined (Table 2.1, 2.2 and Figs. 1a-d). To assess whether prevalence differed significantly between age classes or not, Chi-square tests were used, with contingency tables being constructed to see if the observed values differed from expected ones. Since prevalence data as such is unsuitable for this test, percentage values were converted back to the original counts of infected and uninfected individuals. Once the Chi-square value for a particular contingency table was significant, this meant a difference lay somewhere between the age groups. This difference was worked out by means of "partitioning" the

Table 1. Overall prevalences (%) of *Ascaris lumbricoides*, *Trichuris trichiura* and hookworm in the 4 villages.

	Iloba	Iyanfoworogi	Alakowe	Akeredolu
Ascaris lumbricoides	72.2	70.4	61.7	74.4
Trichuris trichiura	64.7	69.3	69.2	73.7
Hookworm	60.1	51.9	61.7	62.5

contingency tables into subtables and analysing each of them. These tables have one degree of freedom. The overall Chi-square values obtained for each village are shown in Tables 2.1 and 2.2.

Significant differences were detected between various age groups for the three species of helminth. High prevalence was observed in children of ages 5 to 14; this was true for each helminth infection in all 4 villages (Tables 2.1 and 2.2). In Iloba, it was found that the 50+ age group had a significantly lower prevalence ($P<0.01$) of *A. lumbricoides* than the rest of the population. The 5-9 and 10-14 age groups were found to have significantly higher prevalences ($P<0.001$) of *T.trichiura* than the other age groups and, in the case of hookworm infection the 5-9, 10-14 and 50+ age groups had significantly higher prevalences ($P<0.001$, $P<0.01$ and $P<0.005$ for the respective groups) than the other age groups (see Fig.1a). In Iyanfoworogi, the 5-9 age group had a significantly higher prevalence ($P<0.05$) of *A.lumbricoides* than the 0-4 age group. The 5-9, 10-14 and 35-49 age groups had significantly higher prevalences ($P<0.001$, $P<0.01$ and $P<0.05$ respectively) of *T.trichiura* than the other age groups. The 5-9 age group had a significantly higher prevalence ($P<0.01$) of hookworm infection than the 0-4 age group. The 10-14 and 15-24 age groups had significantly higher prevalences ($P<0.001$, $P<0.05$ respectively) than the other age groups (see Fig.1b).

In Alakowe, the 5-9 age group had a significantly higher prevalence ($P<0.05$) of *A.lumbricoides* than the rest of the population and the 15-24 age group had a significantly lower prevalence ($P<0.01$) of *A.lumbricoides* than the other age groups. The 5-9 and 10-14 age groups had a significantly higher prevalence ($P<0.001$ in both cases) of *T.trichiura* than the other age groups. Age groups 5-9, 10-14, 15-24 and 35-49 had significantly higher prevalences ($P<0.001$, $P<0.001$, $P<0.05$ and $P<0.05$ respectively) of hookworm infection than the remaining age groups (see Fig.1c). In Akeredolu, age groups 5-9 and 10-14 had significantly higher prevalences ($P<0.001$ and $P<0.01$ respectively) of *A.lumbricoides* than the other age groups. This was also the case for *T.trichiura* prevalence. The 5-9, 10-14, 15-24 and 25-34 age groups had

Table 2.1 Prevalence of intestinal helminth infections by host age for the villages of Iloba and Iyanfoworogi

Iloba.

Age	Number examined	% Infected with Ascaris	% Infected with Trichuris	% Infected with Hookworm
0-4	41	66.0	29.3	22.9
5-9	71	82.0	71.8	63.4
10-14	69	85.5	84.1	66.7
15-24	49	67.3	73.5	69.4
25-34	33	75.8	54.5	54.5
35-49	44	77.3	70.5	59.1
50+	86	58.1	55.8	68.6
	Chi-square	20.1***	42.1***	31.3***

Iyanfoworogi.

Age	Number examined	% Infected with Ascaris	% Infected with Trichuris	% Infected with Hookworm
0-4	37	51.4	27.0	10.8
5-9	67	74.6	76.1	40.3
10-14	49	79.6	83.7	73.5
15-24	55	76.4	72.7	61.8
25-34	28	64.3	64.3	53.6
35-49	51	74.5	82.4	56.9
50+	47	63.8	61.7	59.6
	Chi-square	11.88*	43.1***	41.6***

Table 2.2 Prevalence of intestinal helminth infections by host age for the villages of Alakowe and Akeredolu

Alakowe.

Age	Number examined	% Infected with *Ascaris*	*Trichuris*	Hookworm
0-4	43	53.4	39.5	14.0
5-9	63	77.7	76.2	68.3
10-14	45	68.9	91.1	75.6
15-24	28	35.7	75.0	78.6
25-34	24	54.2	54.2	45.8
35-49	42	66.7	66.7	76.2
50+	37	54.1	73.0	70.3
	Chi-square	19.03**	32.7***	57.1***

Akeredolu.

Age	Number examined	% Infected with *Ascaris*	*Trichuris*	Hookworm
0-4	67	44.8	31.3	17.9
5-9	101	84.2	83.2	61.4
10-14	49	87.8	85.7	83.7
15-24	38	81.6	81.6	84.2
25-34	37	75.7	75.7	75.7
35-49	69	69.6	79.7	71.0
50+	42	83.3	85.7	66.7
	Chi-square	44.2***	6.09 n.s	79.1***

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

significantly higher prevalences ($P<0.001$, $P<0.001$ $P<0.001$ and $P<0.05$ respectively) of hookworm infection than the 0-4 age group (see Fig.1d).

3.1.2 SEX AND PREVALENCE

Statistically significant host sex-related differences were observed in some of the villages for the prevalences of some of the parasites (Table 3). In Iloba and Alakowe, females had a significantly lower prevalence than males for hookworm infection (Chi-square = 4.585, $P<0.05$ for Iloba; Chi-square = 3.645, $P<0.05$ for Alakowe) and in Iyanfoworogi, males had a higher prevalence as compared with females for *A.lumbricoides* infection (Chi-square = 3.645, P $P<0.05$).

3.1.3 ASSOCIATIONS BETWEEN HELMINTH PREVALENCES

To investigate whether the presence of one helminth was in any way related to the presence or absence of another, 2x2 contingency tables were constructed and tested for significance using Chi-square tests on all combinations of the three species of helminth; *Ascaris/Trichuris*, *Ascaris*/hookworm and *Trichuris*/hookworm (Table 4). The helminth associations showed statistically significant results. A strong positive association was seen between *Trichuris* and hookworm infection for all four villages in that the Chi-square value was highest. It is interesting to note that a significant association between *Ascaris* and hookworm was not detected in Iloba and Alakowe, but was detected in Iyanfoworogi and Akeredolu.

3.1.4 PREVALENCE OF MIXED INFECTIONS (POLYPARASITISM)

It is the rule rather than the exception that mixed parasitic infections occur in communities living in the tropics. The data presented in Table 5 demonstrate that triple infections (*A.lumbricoides/T.trichiura*/hookworm) were more prevalent than single infections in the four villages. The prevalence of triple infections varied from 35.8% to 42.7%, whereas the prevalence of a single infection varied from 15.1% to 24.5%.

Table 3. A comparison of the prevalences (%) of *Ascaris lumbricoides*, *Trichuris trichiura* and hookworm infections relative to host sex for each village.

Village	Number examined	*Ascaris*	*Trichuris*	Hookworm
Iloba.				
males	211	70.6	62.1	64.9
females	184	75.0	66.8	54.3*
Iyanfoworogi.				
males	168	75.0*	67.9	55.9
females	167	65.8	70.6	47.6
Alakowe.				
males	134	60.4	68.7	67.9
females	146	62.3	70.5	56.9*
Akeredolu.				
males	201	75.6	75.1	64.2
females	194	74.7	74.7	61.3

*$P < 0.05$,

Table 4. Associations between the prevalences of *Ascaris lumbricoides*, *Trichuris trichiura*, and hookworm infection in the people of the 4 villages.

	Villages			
Helminth association	Iloba	Iyanfoworogi	Alakowe	Akeredolu
Ascaris/Trichuris	12.6*	18.4	19.6	21.6
Ascaris/hookworm	2.4	17.4	3.7	11.6
Trichuris/hookworm	22.9	21.4	36.2	34.9

*Chi-square values; those above 3.84 are statistically significant at the 5% level.

Table 5. Prevalence of single, double and triple infections in each village

Village	No. examined	Infections					
		Single		Double		Triple	
		No.	%	No.	%	No.	%
Iloba	421	103	24.5	129	30.6	154	36.6
Iyanfoworogi	335	82	24.5	100	29.9	120	35.8
Alakowe	282	56	19.9	92	32.6	101	35.8
Akeredolu	403	61	15.1	136	33.8	172	42.7

3.2 OVERALL INTENSITY OF INTESTINAL HELMINTHS IN THE 4 VILLAGES

Intensity of infection was measured indirectly using egg counts (epg). It is usually assumed that a high epg reflects a high worm burden, and a low epg reflects a low burden, although at high worm densities, density-dependent forces may act to reduce individual worm fecundity (Keymer, 1982).

There was large variation in the egg counts for all three infections. For example, *A. lumbricoides* egg counts ranged from 20 to 147520 epg. Similar patterns were observed for *T.trichiura* and hookworm. The overall mean intensity value for *A.lumbricoides* was 8448.0 whilst that of *T.trichiura* was 182.8 and hookworm was 209.0. These mean values reflect a range of values obtained at each village (Table 6). Akeredolu and Iyanfoworogi, which were neighbouring communities, appeared to have a higher intensity of *A.lumbricoides* infection than the other two villages.

3.2.1 AGE AND INTENSITY

The intensity of each infection was investigated with regard to the age of the population using the same age groups as before (see section 3.1.1). The mean intensity values for *A.lumbricoides*, *T.trichiura* and hookworm infection in each village are summarised in Tables 7.1 to 7.4. These results were transformed to logarithms making the data more amenable to statistical analysis and graphic display (see Figs.2a-d).

To test the results for significant effects, one way analysis of variance was applied to each infection, so that the means of intensity for each age group could be compared (assuming that the sample is random). Significant differences were detected between age groups in all of the villages. In Iloba, the 5-9 age group was found to have a significantly higher ($P<0.001$) mean intensity value of *A.lumbricoides* than the other age groups. The 0-4 age group was found to have a significantly lower ($P<0.001$) intensity of *T.trichiura* than the other age groups and this was also true for hookworm intensity ($P<0.001$) (Table 7.1 and Fig.2a). In Iyanfoworogi, the youngest age group (0-4 years) was found to have a significantly

Table 6. Mean intensities (epg) ± S.D. of *Ascaris lumbricoides, Trichuris trichiura* and hookworm in each village population.

	Village			
Helminth	Iloba	Iyanfoworogi	Alakowe	Akeredolu
Ascaris lumbricoides	6815.1 ± 10872.2	9013.0 ± 16928.0	6988.0 ± 13663.0	10976.0 ± 17725.0
Trichuris trichiura	126.9 ± 239.2	142.5 ± 250.7	240.3 ± 574.4	221.6 ± 400.2
Hookworm	251.4 ± 1253.3	112.5 ± 312.7	268.3 ± 887.3	203.8 ± 540.0

Table 7.1 Mean intensity (epg) of *Ascaris lumbricoides*, *Trichuris trichiura* and hookworm infection with regard to the age of the population in Iloba

Ascaris

Age class	Sample size	No.infected	mean intensity ± S.D.
0-4	41	27	5107.0 ± 7661.0
5-9	71	57	13722.0 ± 16645.0
10-14	69	59	9008.0 ± 13648.0
15-24	48	32	4727.0 ± 6858.0
25-34	33	24	4191.0 ± 6122.0
35-49	44	34	4929.0 ± 5122.0
50+	86	51	4016.0 ± 6480.0

Trichuris

Age class	Sample size	No.infected	mean intensity ± S.D.
0-4	41	11	32.2 ± 85.7
5-9	71	49	187.0 ± 319.6
10-14	69	58	176.5 ± 222.3
15-24	48	35	137.1 ± 263.7
25-34	33	18	91.5 ± 262.0
35-49	44	31	134.5 ± 317.3
50+	86	49	65.7 ± 104.8

Hookworm

Age class	Sample size	No.infected	mean intensity ± S.D.
0-4	41	8	23.0 ± 67.0
5-9	71	43	147.0 ± 295.0
10-14	69	46	217.0 ± 687.0
15-24	48	33	645.0 ± 3329.0
25-34	33	18	136.0 ± 281.0
35-49	44	26	161.0 ± 521.0
50+	86	60	271.0 ± 708.0

Table 7.2. Mean intensity (epg) of *Ascaris lumbricoides, Trichuris trichiura* and hookworm infection with regard to the age of the population in Iyanfoworogi

Ascaris

Age class	Sample size	No.infected	mean intensity ± S.D.
0-4	37	19	8235.0 ± 23975.0
5-9	67	50	14174.0 ± 21545.0
10-14	49	39	11620.0 ± 19960.0
15-24	55	42	7390.0 ± 11197.0
25-34	28	18	3995.0 ± 6851.0
35-49	51	38	6389.0 ± 8952.0
50+	47	30	7476.0 ± 14502.0

Trichuris

Age class	Sample size	No.infected	mean intensity ± S.D.
0-4	37	10	34.1 ± 73.9
5-9	67	51	167.2 ± 231.8
10-14	49	41	230.6 ± 383.6
15-24	55	40	145.8 ± 264.6
25-34	28	18	82.1 ± 122.7
35-49	51	42	143.9 ± 158.9
50+	47	29	133.2 ± 286.3

Hookworm

Age class	Sample size	No.infected	mean intensity ± S.D.
0-4	37	4	19.5 ± 77.7
5-9	67	27	57.9 ± 112.9
10-14	49	36	215.5 ± 637.4
15-24	55	34	153.5 ± 281.5
25-34	28	15	58.6 ± 95.5
35-49	51	29	82.7 ± 138.3
50+	47	28	169.4 ± 335.5

Table 7.3 Mean intensity (epg) of*Ascaris lumbricoides, Trichuris trichiura* and hookworm infection with regard to the age of the population in Alakowe

Ascaris

Age class	Sample size	No.infected	mean intensity ± S.D.
0-4	43	23	8713.0 ± 23616.0
5-9	63	49	9028.0 ± 12077.0
10-14	45	31	8636.0 ± 12616.0
15-24	28	10	2094.0 ± 4810.0
25-34	24	13	5521.0 ± 10170.0
35-49	42	28	7586.0 ± 12477.0
50+	37	20	3477.0 ± 7252.0

Trichuris

Age class	Sample size	No.infected	mean intensity ± S.D.
0-4	43	17	65.6 ± 147.6
5-9	63	48	366.7 ± 704.7
10-14	45	41	401.8 ± 886.5
15-24	28	21	232.1 ± 737.2
25-34	24	13	90.8 ± 171.4
35-49	42	28	185.7 ± 321.3
50+	37	27	196.8 ± 269.0

Hookworm

Age class	Sample size	No.infected	mean intensity ± S.D.
0-4	43	6	34.0 ± 127.7
5-9	63	43	335.6 ± 823.3
10-14	45	34	259.6 ± 587.0
15-24	28	22	255.0 ± 783.6
25-34	24	11	155.0 ± 460.4
35-49	42	32	274.8 ± 794.6
50+	37	26	513.0 ± 1754.8

Table 7.4 Mean intensity (epg) of *Ascaris lumbricoides, Trichuris trichiura* and hookworm infection with regard to the age of the population in Akeredolu

Ascaris

Age class	Sample size	No.infected	mean intensity ± S.D.
0-4	67	30	7340.0 ± 19233.0
5-9	101	85	15057.0 ± 17808.0
10-14	49	43	17934.0 ± 23199.0
15-24	38	31	7216.0 ± 14124.0
25-34	37	28	10668.0 ± 18524.0
35-49	69	48	8937.0 ± 14911.0
50+	42	35	5866.0 ± 7995.0

Trichuris

Age class	Sample size	No.infected	mean intensity ± S.D.
0-4	67	21	151.3 ± 613.7
5-9	101	84	299.2 ± 454.9
10-14	49	42	324.9 ± 337.2
15-24	38	31	197.9 ± 224.4
25-34	37	28	128.6 ± 151.1
35-49	69	55	177.1 ± 292.7
50+	42	36	202.9 ± 266.2

Hookworm

Age class	Sample size	No.infected	mean intensity ± S.D.
0-4	67	12	33.7 ± 128.9
5-9	101	62	153.5 ± 548.9
10-14	49	41	327.8 ± 658.2
15-24	38	32	327.4 ± 637.6
25-34	37	28	129.7 ± 226.6
35-49	69	49	167.2 ± 277.9
50+	42	28	464.8 ± 941.8

lower ($P<0.033$, $P<0.001$ and $P<0.001$ respectively) intensity of *A.lumbricoides, T.trichiura* and hookworm infection than all the other age groups (Table 7.2 and Fig.2b).

In Alakowe, the 5-9 age group was found to have a significantly higher ($P<0.001$) intensity of *A.lumbricoides* than the other age groups. The 0-4 age group was found to have a significantly lower ($P<0.001$) intensity of *T.trichiura* than the other age groups, and this was also the case for hookworm intensity ($P<0.001$) (Table 7.3 and Fig.2c).

In Akeredolu, the 0-4 age group was found to have a significantly lower ($P<0.001$) intensity of *A.lumbricoides* than the other age groups. This was also true for *T.trichiura* and hookworm intensity values, where the youngest age group was significantly less ($P<0.001$) than the other age groups (Table 7.4 and Fig.2d).

3.2.2 SEX AND INTENSITY

Significant differences were observed when the overall intensity of infection was related to host sex in three of the villages. In Iloba, Iyanfoworogi and Alakowe, the overall mean intensity of hookworm infection was observed to be significantly lower in females than in males ($P=0.074$ for Iloba, $P=0.034$ for Iyanfoworogi and $P=0.0045$ for Alakowe, using Student's t-test on log $(x+1)$ transformed egg counts).

3.2.3 AGE AND SEX AND INTENSITY

Mean intensities of *A.lumbricoides, T.trichiura* and hookworm infection, expressed as epg of faeces, were studied with regard to the ages and sex of the participants in each village (Table 8.1, 8.2 and Figs.3,4,5,6). Two way analysis of variance was applied to the log transformed egg counts for each village. Such a test of significance enables the investigator to see the effects of 2 variables (age and sex) on the intensity of infection and the interaction between the two.

In Iloba, age was considered to be an important factor in *A.lumbricoides, T.trichiura* and hookworm intensities ($P<0.0004$; $P<0.001$ and $P<0.001$ respectively). Sex was found to be a significant factor for only hookworm intensity in that

Table 8.1. Mean intensities (epg) of *Ascaris lumbricoides, Trichuris trichiura* and hookworm infections stratified by host age and host sex in the villages of Iloba and Iyanfoworogi

Iloba

	No. examined		Mean Intensity					
			A.lumbricoides		*T.trichiura*		Hookworm	
Age class	male	female	male	female	male	female	male	female
0-4	24	17	4745.8	5688.2	55.8	56.4	55.0	32.9
5-9	38	33	14347.9	13006.1	170.5	225.4	194.7	106.0
10-14	41	28	7448.7	11290.0	156.5	205.7	309.2	82.8
15-24	27	22	5205.9	4021.8	152.6	115.4	1249.6	63.18
25-34	19	14	2302.1	6585.7	32.6	171.4	205.2	42.8
35-49	11	33	6394.5	4440.0	76.3	153.9	61.09	191.5
50+	51	35	2800.8	5897.7	75.3	52.6	352.1	206.2

Iyanfoworogi

	No. examined		*A.lumbricoides*		*T.trichiura*		Hookworm	
Age class	male	female	male	female	male	female	male	female
0-4	19	18	9383.0	7023.0	51.6	15.56	25.3	13.3
5-9	34	33	11812.0	16608.0	111.8	224.2	50.6	65.5
10-14	25	24	10716.0	12562.0	244.8	215.8	196.8	235.0
15-24	32	23	6134.0	9138.0	145.6	146.1	213.1	70.4
25-34	10	18	1462.0	5402.0	44.0	103.3	108.0	31.1
35-49	24	27	4792.0	7808.0	125.0	160.7	90.8	75.6
50+	24	23	5340.0	9704.0	180.0	84.3	234.2	101.7

Table 8.2. Mean intensities (epg) of *Ascaris lumbricoides, Trichuris trichiura* and hookworm infections stratified by host age and host sex in the villages of Alakowe and Akeredolu

Alakowe

	No. examined		Mean Intensity					
			A.lumbricoides		*T.trichiura*		Hookworm	
Age class	male	female	male	female	male	female	male	female
0-4	17	26	5222.0	10996.0	61.2	68.5	72.9	8.46
5-9	36	25	6566.0	12995.0	221.1	606.0	418.0	243.0
10-14	20	25	6258.0	10539.0	647.0	205.6	462.0	97.6
15-24	13	15	1497.0	2612.0	132.3	319.0	341.0	155.4
25-34	14	10	2847.0	9264.0	84.3	100.0	241.0	34.0
35-49	16	26	6066.0	8523.0	122.5	224.6	342.0	233.0
50+	18	19	3374.0	3575.0	240.0	155.8	960.0	89.5

Akeredolu

	No. examined		*A.lumbricoides*		*T.trichiura*		Hookworm	
Age class	male	female	male	female	male	female	male	female
0-4	32	30	6093.0	9893.0	221.0	98.0	63.1	7.33
5-9	55	46	14243.0	16029.0	298.5	300.0	226.2	66.5
10-14	27	20	17483.0	17957.0	303.7	386.0	396.0	252.0
15-24	13	25	4934.0	8403.0	310.8	139.2	414.0	282.0
25-34	20	17	3347.0	19281.0	82.0	183.5	75.0	194.1
35-49	23	45	3577.0	11876.0	73.9	233.8	99.1	184.0
50+	31	11	6725.0	3447.0	203.2	201.8	440.0	535.0

females have a lower intensity of infection than males ($P<0.0094$) (see Fig.3); there was no significant interaction between age and sex for all three infections (Table 8.1).

In Iyanfoworogi, age has a significant effect on the intensity of *A.lumbricoides, T.trichiura* and hookworm intensities ($P<0.0312$; $P<0.001$ and $P<0.001$ respectively). Sex has no significant effect on the intensity of infection for all 3 parasites; there was no significant interaction between age and sex on all 3 infections (Table 8.1 and Fig.4).

In Alakowe, age has a significant effect on the intensity of *A.lumbricoides, T.trichiura* and hookworm infection ($P<0.0010$; $P<0.001$; and $P<0.001$ respectively). Sex has a significant effect on hookworm intensity ($P<0.0051$) in that females have a lower intensity of infection than males (see Fig.5); there was no significant interaction between the 2 variables for all 3 infections (Table 8.2).

In Akeredolu, age has a significant effect on *A.lumbricoides*, *T.trichiura* and hookworm intensities ($P<0.001$; $P<0.001$; and $P<0.001$ respectively). Sex and the interaction between age and sex have no significant effects on the intensities of all 3 parasites (Table 8.2 and Fig.6).

3.3 FREQUENCY DISTRIBUTION OF EGG COUNTS PER HOST

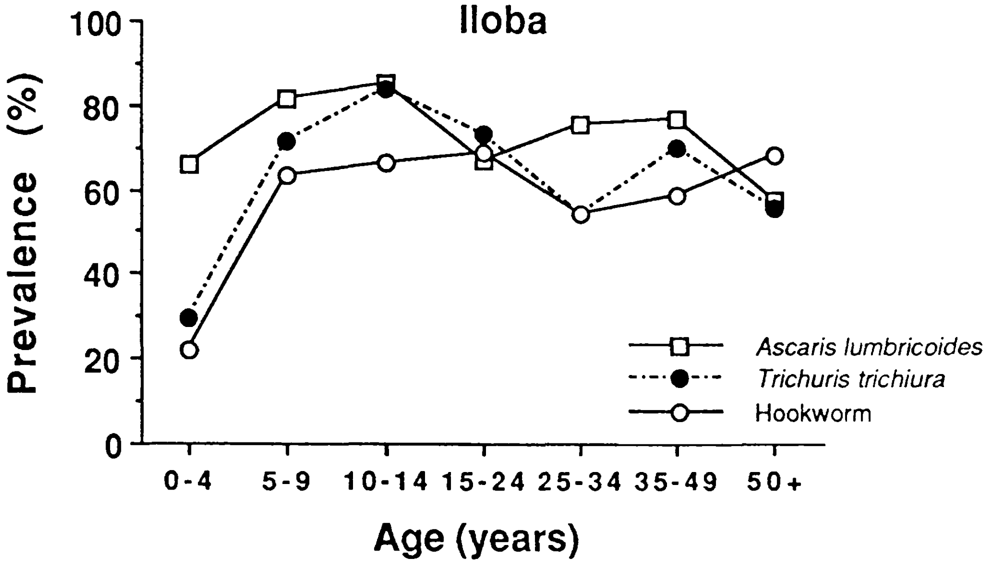
Dispersion or distribution patterns of helminths within the host population can be broadly divided into three categories: underdispersion, random and overdispersion. For each helminth, the variance (S^2) to mean ($\overline{x}$) ratio ($S^2 / \overline{x}$) was calculated as an indicator of the degree of aggregation or overdispersion of the worms with regard to the population in each village. The variance is measured by squaring the standard deviations of the mean intensities of egg counts per age group. If this ratio is greater than one, then the egg counts amongst the hosts are overdispersed (Anderson & Gordon, 1982). It was found that in all four villages, the frequency distribution of *A.lumbricoides* and *T.trichiura* showed some degree of overdispersion and hookworm infection was overdispersed in two of the villages, Alakowe and

Akeredolu (Table 9). This indicates that for a given sample of hosts, a few individuals will harbour most of the infection in a community and the majority will harbour a small proportion of the infection. It is interesting to note that in Iloba and Iyanfoworogi, the variance to mean ratio for hookworm infection was less than one, which suggests that hookworm egg counts are not overdispersed to such a great extent.

Table 9. Variance to mean ratios ($S^2/\bar{x}$) of the egg count classes for each parasite (used as a measure of overdispersion) in the 4 villages

Village	Variance/mean ratio		
	Ascaris lumbricoides	*Trichuris trichiura*	Hookworm
Iloba	1.25	no value	0.588
Iyanfoworogi	2.438	1.644	0.558
Alakowe	1.918	1.540	1.313
Akeredolu	2.208	12.39	1.607

a



b

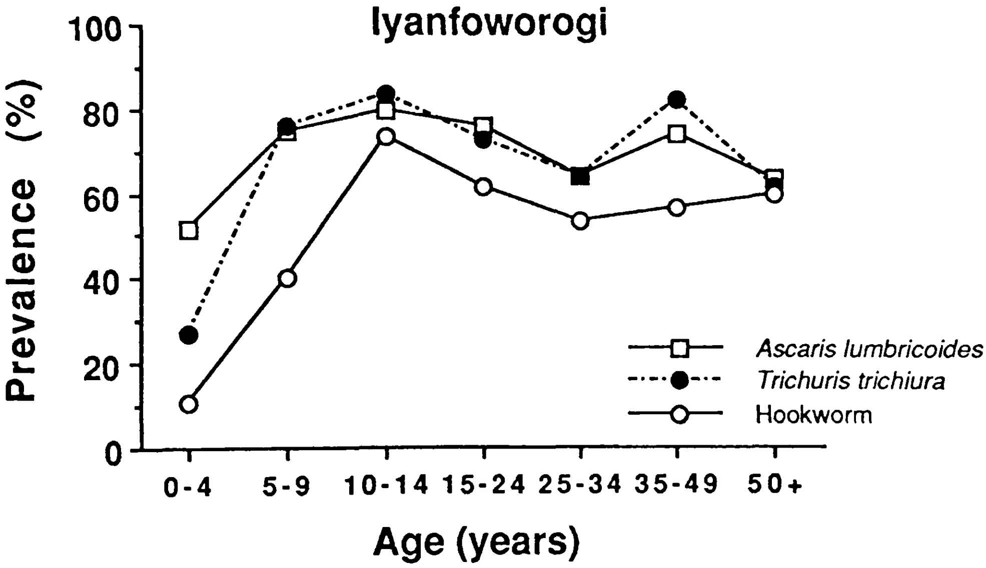


Fig. 1 a-b Prevalence of intestinal helminths by host age for the two villages of Iloba and Iyanfoworogi.

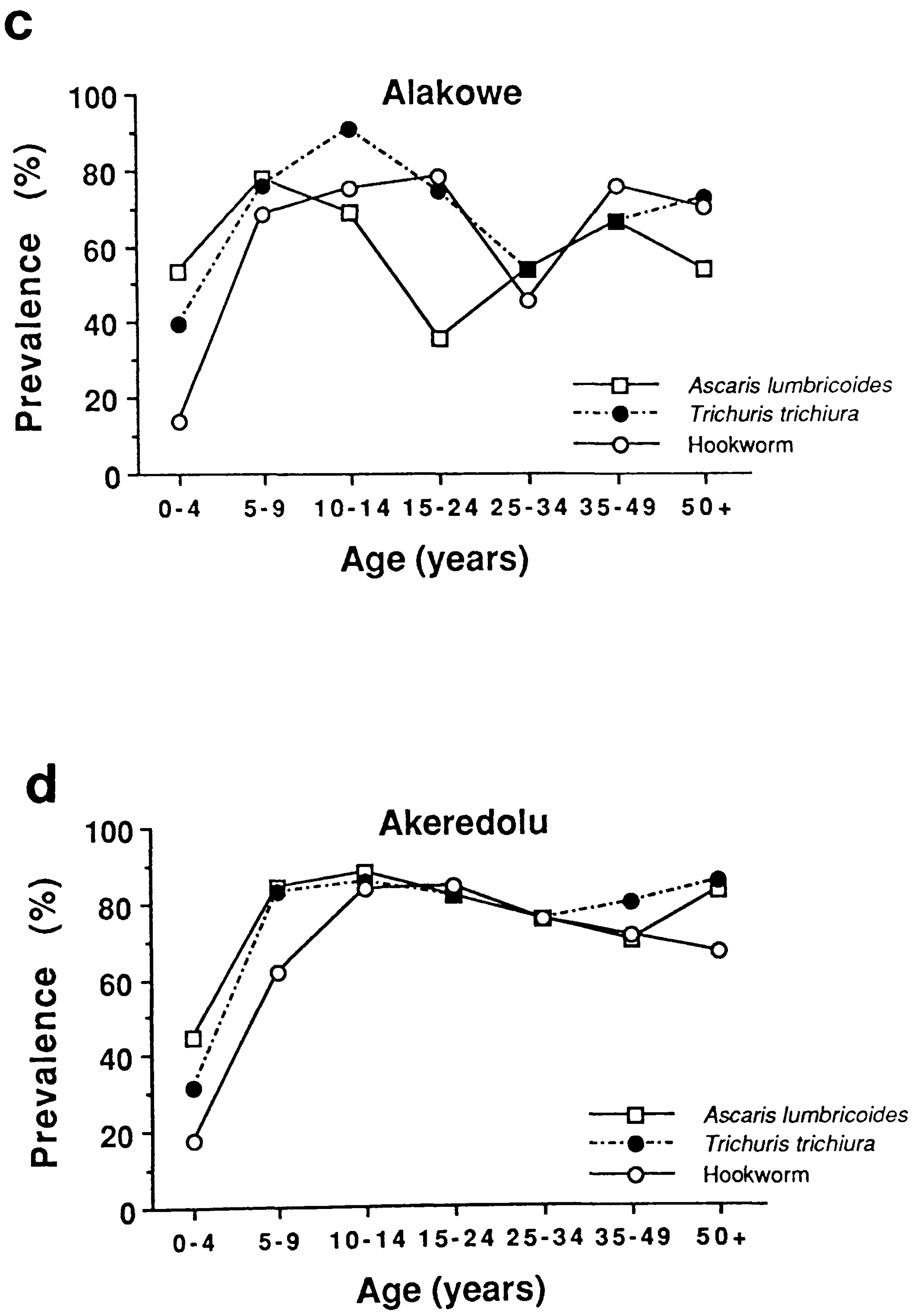


Fig. 1 c-d Prevalence of intestinal helminths by host age for the two villages of Alakowe and Akeredolu.

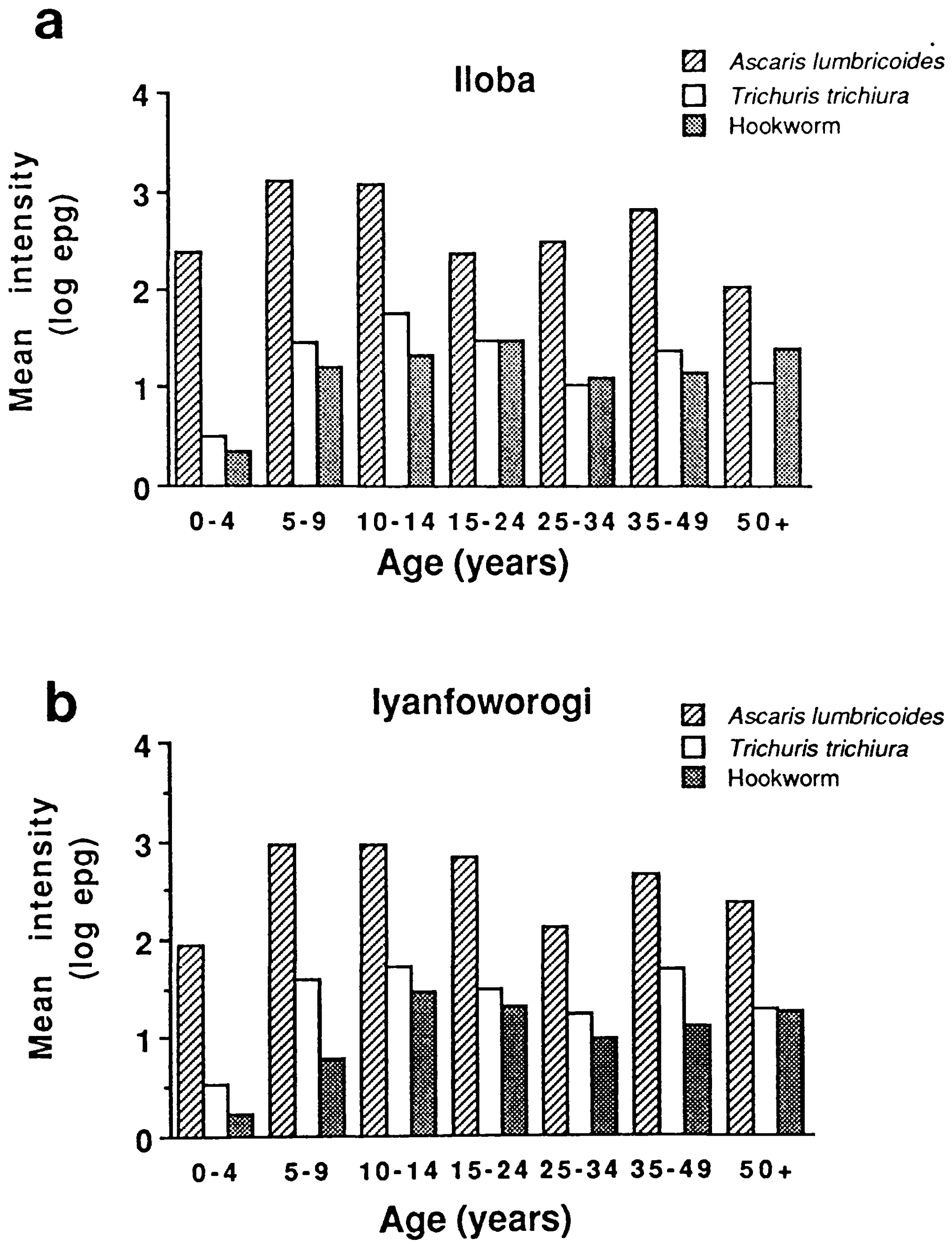


Fig. 2 a-b Mean intensity of each infection expressed as mean log transformed e.p.g. of faeces stratified by host age for the two villages of Iloba and Iyanfoworogi.

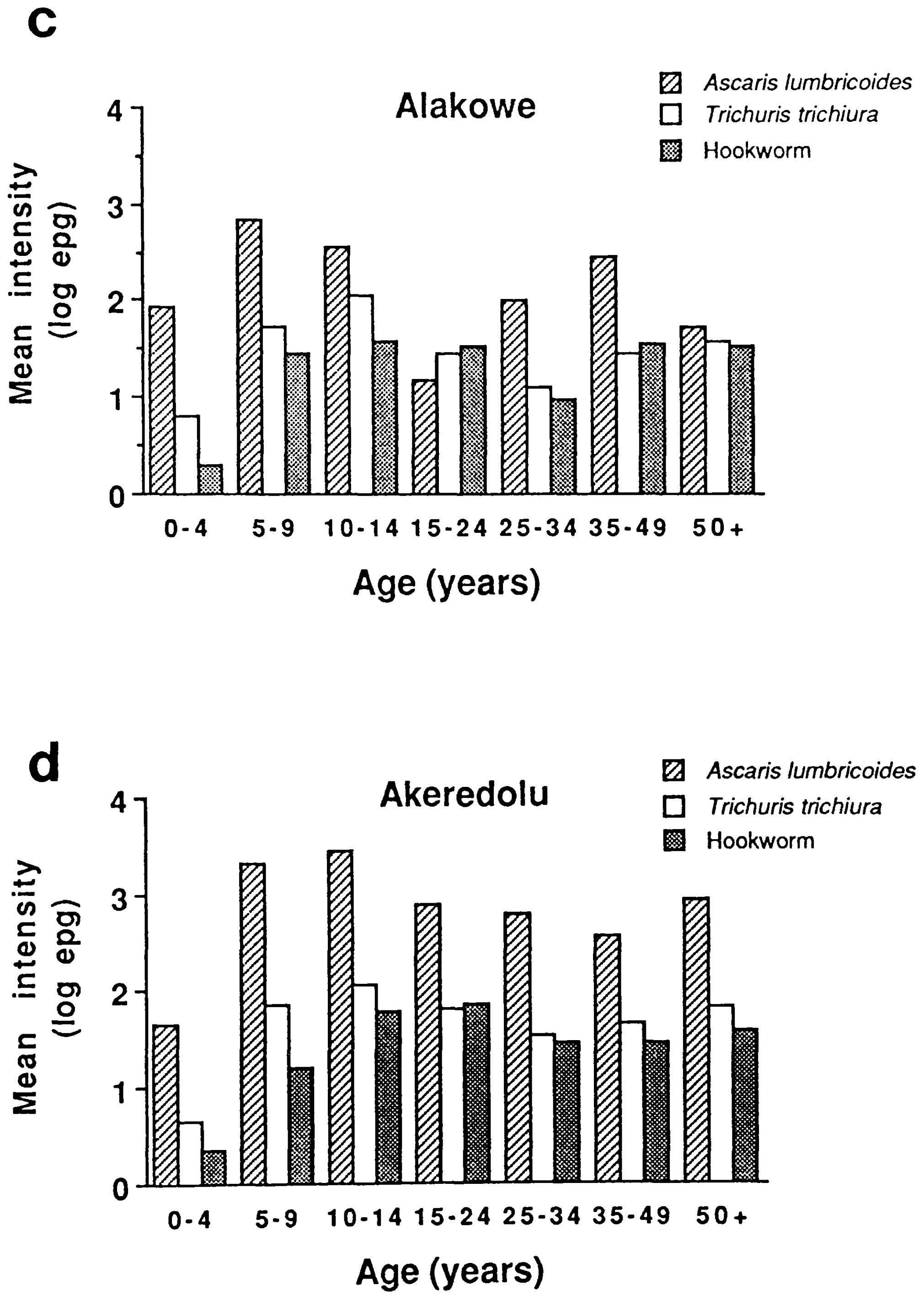
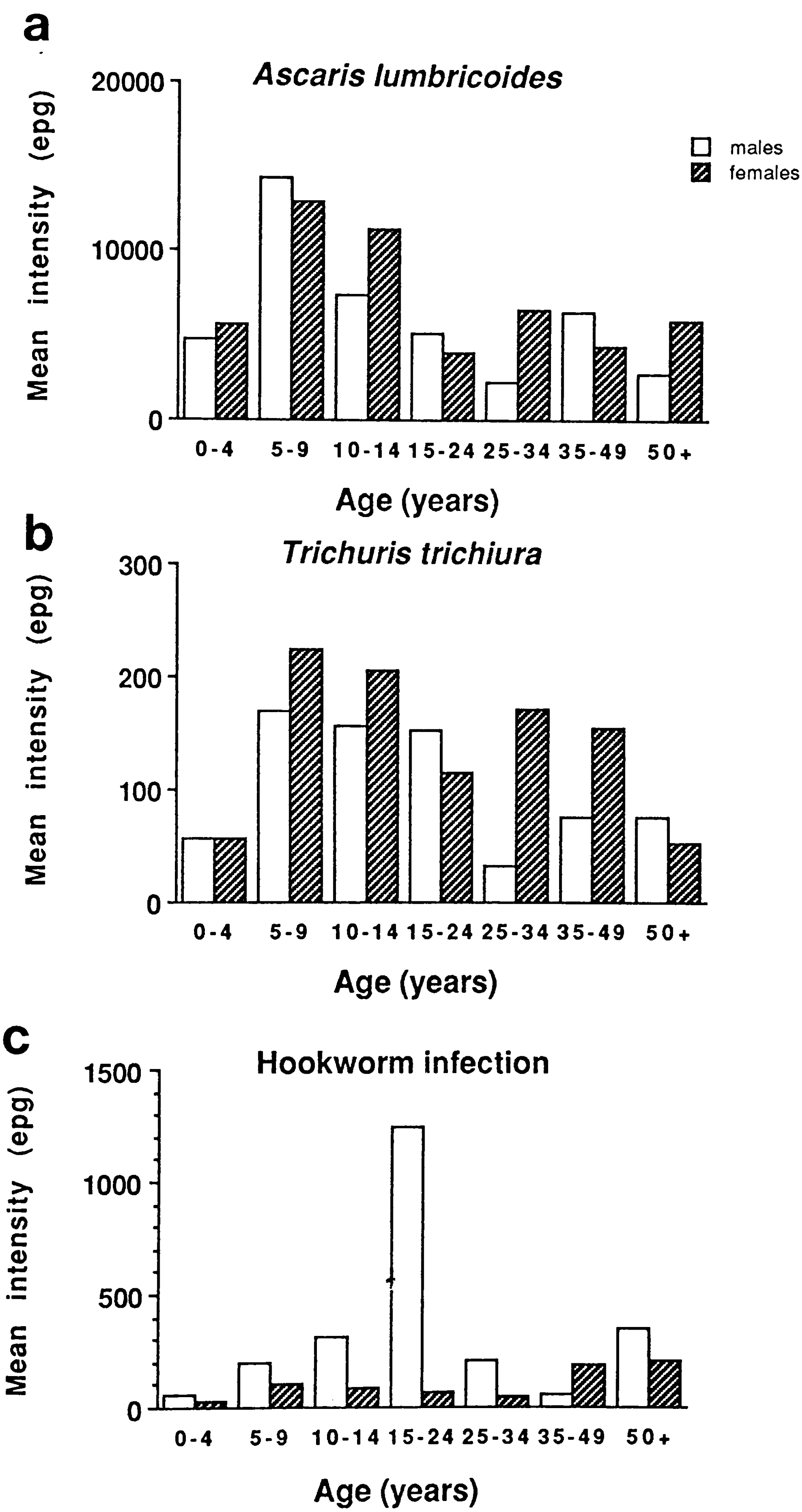


Fig. 2 c-d Mean intensity of each infection expressed as mean log transformed e.p.g. of faeces stratified by host age for the two villages of Alakowe and Akeredolu

Fig. 3 a-c Mean intensity of *Ascaris lumbricoides*, *Trichuris trichiura* and hookworm expressed as mean e.p.g. of faeces stratified by host age and host sex for Iloba.



a
Ascaris lumbricoides
Mean intensity (epg)
20000
10000
0
males
females
0-4
5-9
10-14
15-24
25-34
35-49
50+
Age (years)
b
Trichuris trichiura
Mean intensity (epg)
300
200
100
0
0-4
5-9
10-14
15-24
25-34
35-49
50+
Age (years)
c
Hookworm infection
Mean intensity (epg)
1500
1000
500
0
0-4
5-9
10-14
15-24
25-34
35-49
50+
Age (years)

Fig. 4 a-c Mean intensity of *Ascaris lumbricoides, Trichuris trichiura* and hookworm expressed as mean e.p.g. of faeces stratified by host age and host sex for Iyanfoworogi.

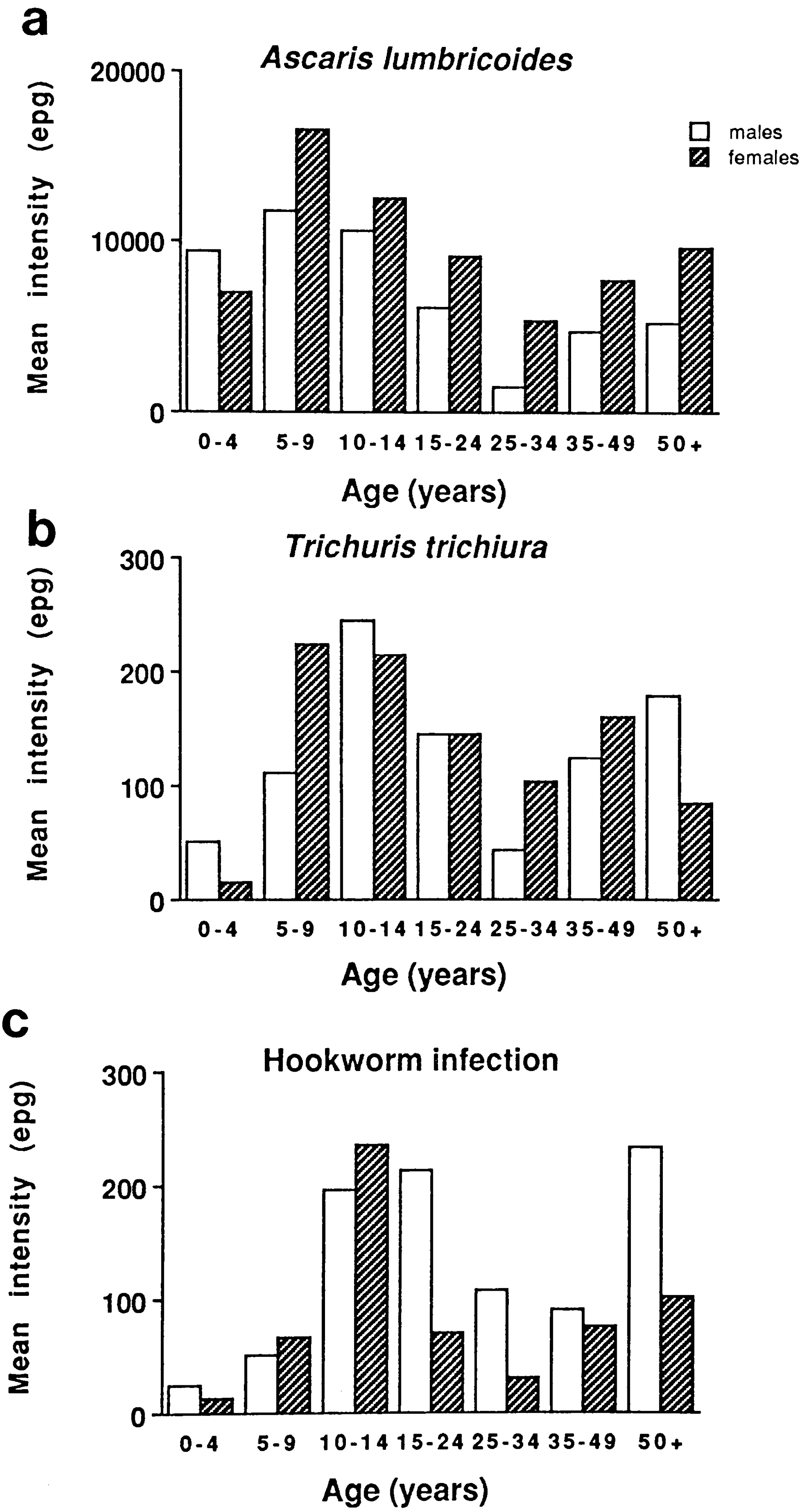
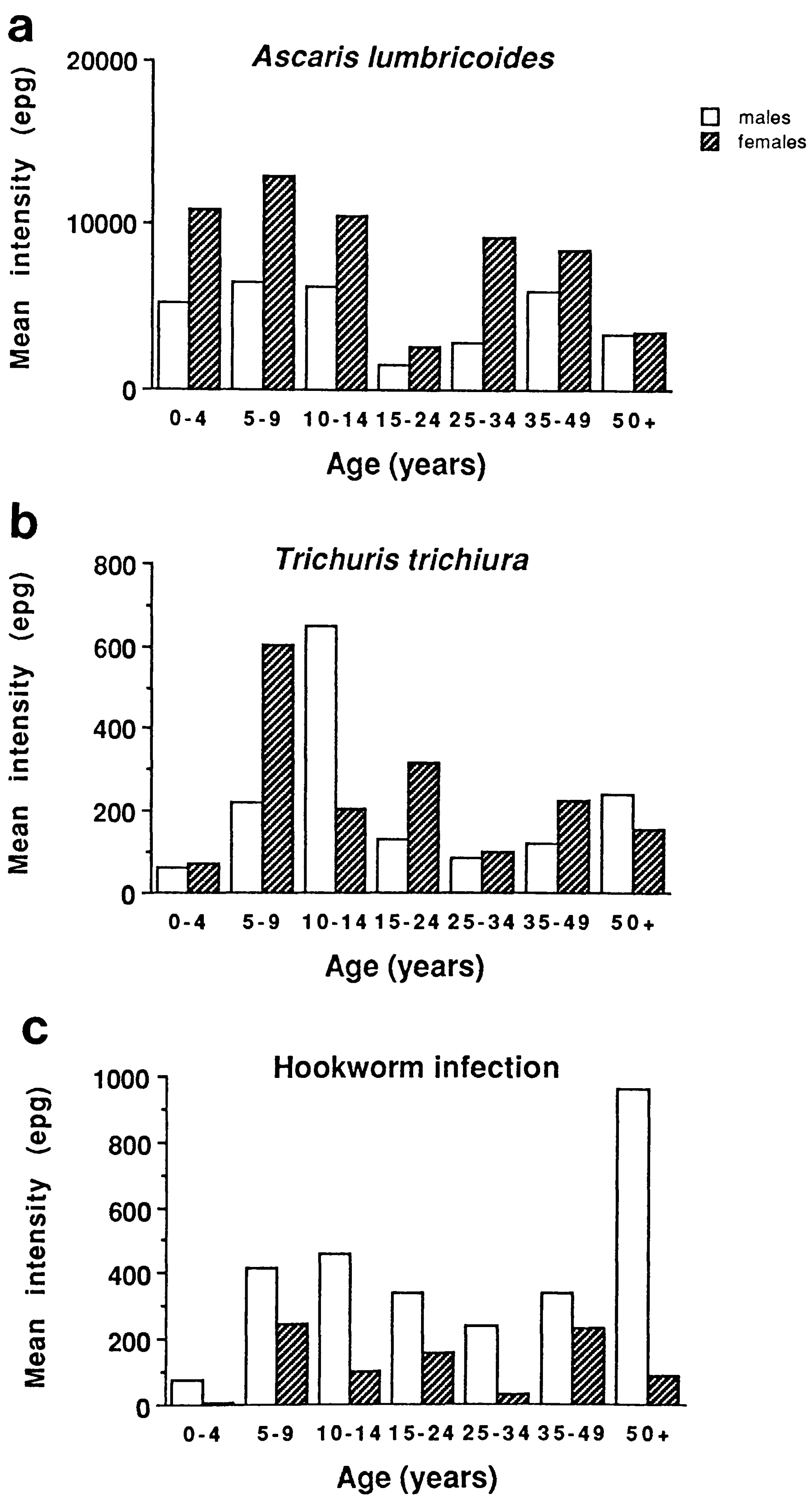
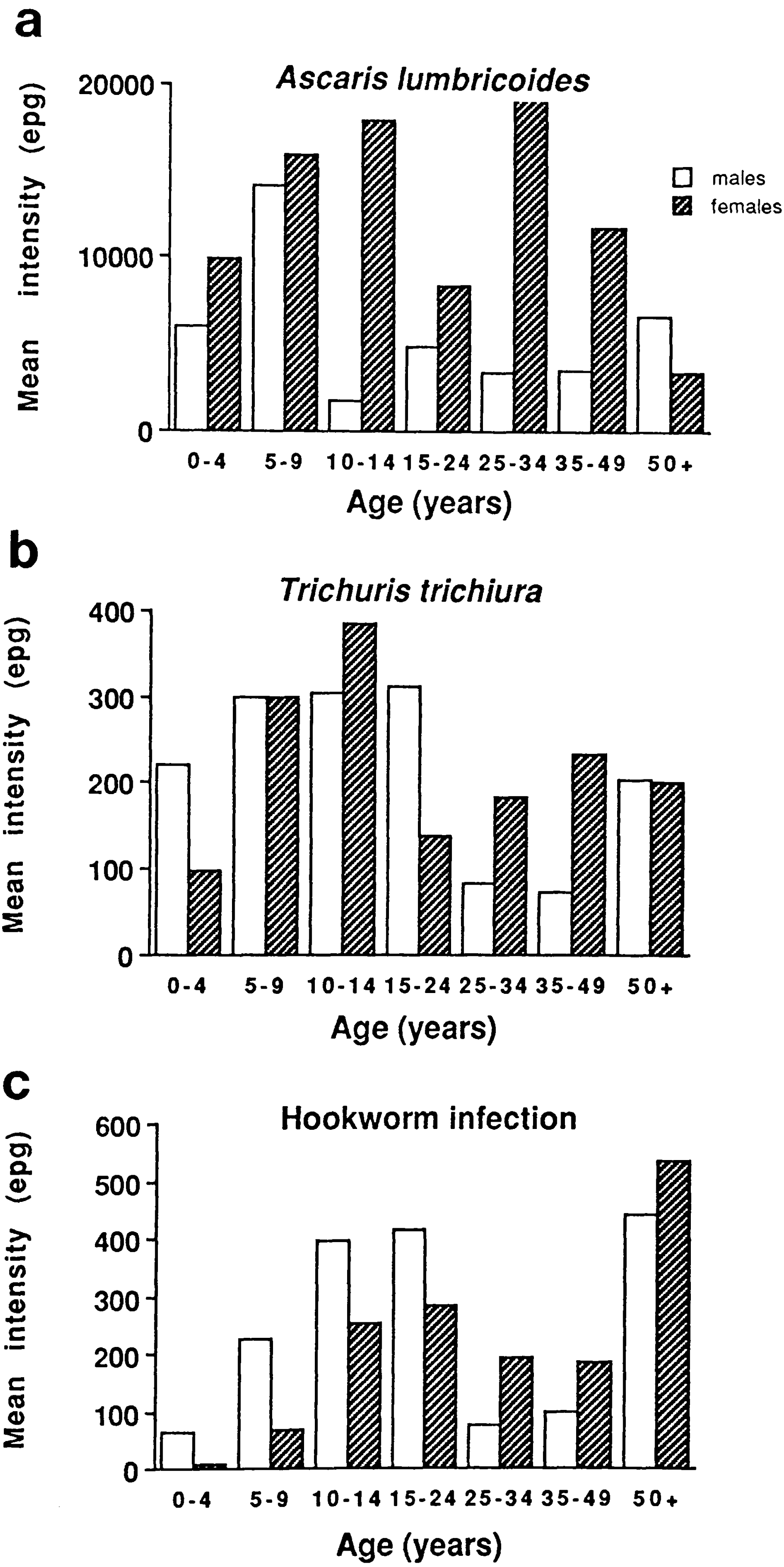

a
Ascaris lumbricoides
20000
10000
0
Mean intensity (epg)
males
females
0-4
5-9
10-14
15-24
25-34
35-49
50+
Age (years)
b
Trichuris trichiura
300
200
100
0
Mean intensity (epg)
0-4
5-9
10-14
15-24
25-34
35-49
50+
Age (years)
c
Hookworm infection
300
200
100
0
Mean intensity (epg)
0-4
5-9
10-14
15-24
25-34
35-49
50+
Age (years)

Fig. 5 a-c Mean intensity of *Ascaris lumbricoides*, *Trichuris trichiura* and hookworm expressed as mean e.p.g. of faeces stratified by host age and host sex for Alakowe.



a
Ascaris lumbricoides
males
females
Mean intensity (epg)
20000
10000
0
0-4
5-9
10-14
15-24
25-34
35-49
50+
Age (years)
b
Trichuris trichiura
Mean intensity (epg)
800
600
400
200
0
0-4
5-9
10-14
15-24
25-34
35-49
50+
Age (years)
c
Hookworm infection
Mean intensity (epg)
1000
800
600
400
200
0
0-4
5-9
10-14
15-24
25-34
35-49
50+
Age (years)

Fig. 6 a-c Mean intensity of *Ascaris lumbricoides*, *Trichuris trichiura* and hookworm expressed as mean e.p.g. of faeces stratified by host age and host sex for Akeredolu.


a
Ascaris lumbricoides
Mean intensity (epg)
20000
10000
0
males
females
0-4
5-9
10-14
15-24
25-34
35-49
50+
Age (years)
b
Trichuris trichiura
Mean intensity (epg)
400
300
200
100
0
0-4
5-9
10-14
15-24
25-34
35-49
50+
Age (years)
c
Hookworm infection
Mean intensity (epg)
600
500
400
300
200
100
0
0-4
5-9
10-14
15-24
25-34
35-49
50+
Age (years)

CHAPTER 4

DISCUSSION

Ascaris lumbricoides, Trichuris trichiura and hookworm (*Necator americanus*) have been reported to be the most common intestinal parasites in the whole of southern Nigeria (Hinz, 1966). This relates to the results presented here such that the triad of intestinal helminths are extremely common throughout rural parts of Oyo State, Nigeria.

The analysis of this data reveals that a large helminth burden is carried by the villagers in Oyo State and this emphasises the importance of helminth infections in rural communities. The prevalence rates that have been determined for the villages studied are high, paralleling those found in other locations of similar biogeographical zones (Holland *et al.*, 1989; Hori and Odiachi, 1978). It is generally believed that prevalence rates of soil-transmitted helminths are higher in the rural than urban areas. In the four rural villages studied, poor sanitation and hygiene levels and contaminated water supplies are the main causative agents in the transmission of helminths. The lack of latrines and indiscriminate defaecation establish high levels of soil-transmitted helminth infections. Sanitary control, therefore, must be seen as a crucial role in the control of helminthiases and other important enteric diseases.

4.1 PREVALENCE OF INTESTINAL HELMINTHS

A general pattern emerges from these results which is repeated in all four villages for all the parasites concerned. The influence of age on the prevalence of *A. lumbricoides*, *T. trichiura* and hookworm show a significant association in all four villages. Prevalence values are high in all age groups of the population except for the 0-4 age group. For example, in Akeredolu, the prevalence of *A. lumbricoides*, which is relatively low in the 0-4 year-old age class (44.8%), rises steeply in the 5-14 year-old age class and then attains a plateau in the older age classes (see Fig. 1d). Children of preschool age (0-4) may be less exposed to parasitic infections as their mothers nurture and feed them at home. However, when the children become older (5-14) they are more exposed to the external environment and hence parasitic transmission. There is a further small increase in the 50+ age class (see Fig. 1d). There appear to be more fluctuations in the prevalence pattern of *A. lumbricoides* than the other two helminths which could be due to the shorter life span (one year) of *A. lumbricoides* compared with hookworm, which can live up to seven years and *T.trichiura* which can live up to four years.

The pattern for *T. trichiura* is very similar to that for hookworm except that there is no small increase in the 50+ age class. In the other three villages, the prevalences tend to peak in the 10-14 year-old age class and show a slight decline in the 15-34 year olds (see Fig. 1a, 1b, 1c). This is particularly pronounced in Alakowe. Secondary school children are in close contact with the contaminated environment. The middle section of the population (15-34 year olds) are the working force of the communities. They perhaps are more aware of sanitation problems and the consequences that these parasites bear. In communities like this, the high risk group (school children) can be targeted with chemotherapy to reduce the infection levels. However, in the long run, the success in reducing the levels of parasitic infection may be limited, because of the poor environmental sanitation. Therefore, it is essential to combine the anthelmintic treatment with environmental sanitation.

The prevalence of hookworm infection in Iloba and Alakowe was found to be associated with host sex (see Table 3). Females have lower prevalences of hookworm than males. The high prevalence of hookworm infection in males is expected in a rural population where the principal male occupation is farming. This agrees with other reports in southern Nigeria (Gilles *et al.*, 1965; Pugh *et al.*, 1981). Working in the fields, exposes the men to a larger area of contaminated soil than the women who are more occupied with household duties.

4.2 ASSOCIATIONS BETWEEN THE PARASITES

It is important to discover whether the prevalence data point to associations or not between any of the infections, in other words, do some infections occur together or avoid each other or are such relationships generated through random events? The most pronounced association was detected between *T. trichiura* and hookworm in all the villages (Table 4). This finding corresponds with data collected from Ghana and Panama (Annan *et al.*, 1986; Robertson *et al.*, 1989).The considerable prevalence of combined helminth infections indicates that faecal-oral transmission is one of the commonest modes of parasitic transmission.

4.3 MULTIPLE INFECTIONS

Many people were found to harbour more than 1 infection at once (Table 5). Multiple infections were common in the villages. This phenomenon, in which, an individual is infected with several parasites at one time, has been called polyparasitism by Buck *et al.* (1978) and appears to be a feature of helminth infections in rural populations in the tropics. Triple infections (*A. lumbricoides, T. trichiura*, and hookworm) are the most common, found in 35.8% to 42.7% of the total population. Single infections are least common. Clearly one helminth infection raises the chances of another infection. This emphasises an urgent need for serious health programmes (especially in schools) to be carried out in the rural villages.

4.4 INTENSITY OF INTESTINAL HELMINTHS

There are small differences in the intensity of infection between the four villages with regard to *A. lumbricoides, T.trichiura* and hookworm (Table 6). When age is introduced as a factor, significant differences are detected amongst the age groups. The general pattern that emerges from the results of intensity data for *A. lumbricoides*, is that the intensity rises to a peak in the 5-9 year olds in all the villages with the exception of Akeredolu where the peak is reached in the 10-14 year-old age class (see Fig. 2d). Intensity then tends to be lower in the older age classes, possibly as a result of the development of some degree of immunity or a change in behavioural habits as the individual becomes older, thus reducing the degree of exposure to infective stages of the parasite. A slight rise in the 35-49 year olds may occur, as in Iyanfoworogi and Iloba (see Fig. 2a-2b). Again, behavioural habits (such as working in the fields) may allow this age group to be more exposed to infection. In contrast to age, host sex was not found to be an important factor in the intensity observed in the four villages.

With regard to *T. trichiura* the pattern is similar to that of *A. lumbricoides* (Figs. 2a-2d). Age is a significant factor, with intensity increasing from the 0-4 year olds to a peak in the 5-14 year olds for all four villages. Intensity then declines in the older age classes, except for some small increases in the 35-49 year olds (Iyanfoworogi) and in the 50+ age group (Alakowe). The reasons for this have already been explained. As in the case of *A .lumbricoides*, host sex is not a significant factor in the intensity of *T. trichiura* within the four villages. The sex of an individual appears to only have an effect on hookworm infection and not on the other two helminths.

Finally for hookworm intensity, as is the case of the other two intestinal helminths, there is a rise in intensity from very low levels in the 0-4 year olds to a peak in the 10-14 or 15-24 year olds depending on the village concerned. In all four villages values tend to be slightly lower in the 25-34 year olds and start to rise again among the 35-49 year olds, culminating in the 50+ age group. In the case of Iloba (see Fig.3c) the pattern is slightly distorted by the very high values shown for the 15-24 year old males. Host sex is an important factor in the intensity of hookworm infection in contrast to *A. lumbricoides* and *T. trichiura*. The intensity is significantly lower among females than males for reasons which I have already explained in the prevalence section.

4.5 FREQUENCY DISTRIBUTION OF EGG COUNTS

Helminths are almost invariably overdispersed, or aggregated, within their host populations, where many hosts harbour a few parasites and a few hosts harbour large numbers of parasites (Anderson, 1985). There are several important reasons for increasing research into understanding the factors that influence the intensity of helminth infections. Firstly, morbidity is expected to be related to the intensity of the infection. Secondly, theoretical considerations show that the regulation of the parasite's populations hinge on intensity and thirdly, efficient control measures could be devised if heavily infected people could be identified and given particular attention (Anderson, 1985).

Here, the degree of overdispersion in egg counts for each helminth infection are generally similar for all four villages (see Table 9). Overdispersion appears to be higher for *A. lumbricoides* than *T. trichiura* and hookworm, perhaps this is a reflection of the higher prevalence values corresponding to *A. lumbricoides.* Overdispersion for hookworm infection is lower, but still indicates some degree of aggregation. The transmission of hookworms requires the infective larvae to penetrate the skin or oral mucosa of humans, hence the chances of infection may be slightly less than those of *A.lumbricoides* and *T.trichiura* infections.

4.6 CONCLUSIONS

The prevalence of soil-transmitted helminths in rural communities of Oyo State is high. Age is a significant factor that influences the prevalence of helminths. Notably, the 5-14 year olds have the highest prevalence rates. The intensity values (measured as eggs per gram of faeces/individual) appear to reflect the pattern of prevalence; the intensity of infection is high in the 5-14 year olds for all four villages (except for some minor distortions, where the intensity is highest in another age group, for example the 15-24 year olds in Iloba).

These villages are similar in terms of population size, socio-economic characteristics and medical and social facilities. The baseline epidemiological data of intestinal helminths presented here correlate well with the above conditions, although slight distortions are evident and can be put down to differences in local culture and genetic variabilities of the villagers . The data represents a good foundation for treatment control (the treatment tactics project has already been described in chapter 2). It is clear from this study of soil-transmitted helminths that the basic strategy of control is to target treatment towards those who are heavily infected, in this case the schoolchildren of ages 5-14 years. This should drastically reduce the parasitic infections, in other words lower the intensity, and in turn result in a pronounced reduction in morbidity (the symptoms have already been described in section 1, chapter 1 [1.2]). This should result in an improvement in the nutritional status of the people, especially the children. Probably the best strategy is to incorporate chemotherapy with sanitation control into the local communities. Improvements in sanitary control take a long time, but the combined end result would be very encouraging in terms of the health status of the people and in the elimination of soil-transmitted helminths.

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