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Inaugural Lecture Series 180

GEOHELMINTH INFECTIONS ARE NOT TRIVIAL

By

S. O. Asaolu
Professor of Parasitology

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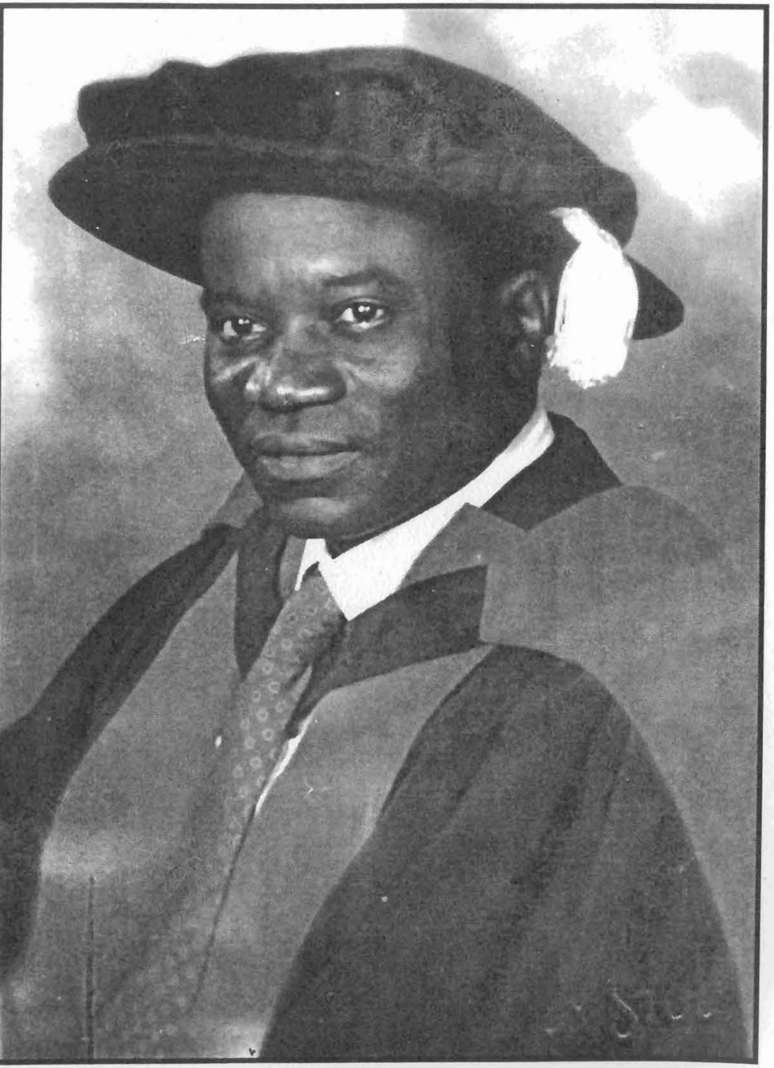

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INTRODUCTION

The Vice Chancellor, Fellow Scholars, Students of this great University, Distinguished Ladies and Gentlemen, it gives me great pleasure to give this Inaugural Lecture. The topic of my Lecture is "Geohelminth infections are not trivial".

During my first degree programme in Zoology in this University from 1970 to 1973, one of the subjects that I took and which interested me most was Parasitology. It was in this course that we were taught about the issues concerning a number of infectious diseases that are rampant in our communities and elsewhere in the world. This actually influenced my decision to carry out my undergraduate research project, and later in developing my academic career in the field of Parasitology.

Parasitology is a subject which deals with the problem of parasitism. Parasitism can be defined as a symbiotic relationship which involves an association between two animals of different species where one, called the parasite, lives in or on the body of the other, the host and while the host is indispensable to the parasite, the host can quite well do without the parasite. The parasite either harms the host, or in some sense lives at the expense of the host, while the host benefits in no way from the association. Parasites may damage the host in several ways, either by causing mechanical injury, such as boring a hole into the host tissue or digging into its skin or other tissues. It may stimulate a damaging inflammatory or immune response, or simply rob the host of its nutrition. Most parasites inflict a combination of these conditions on their hosts.

Much of the health problems in the developing countries in the tropics are actually traceable to parasitic infections. It is a common knowledge that to stay alive in this part of the world, we fight a running battle with parasitic diseases notable among which are malaria, amoebic dysentery, schistosomiasis, filariasis, intestinal worms and many others.

Among the myriad of parasitic diseases affecting human health in the tropics, some have been noted particularly to be of great public health importance. For example The Special Programme for Research and Training in Tropical Diseases (TDR) of the World Health Organization (WHO) has selected five parasitic diseases in particular, deserving special attention in the tropics. These are malaria, schistosomiasis, filarisis, trypanosomiasis and leishmaniasis. These diseases have been focused for a number of reasons. Firstly, they are widespread and, in some cases, infect every member of the community. Secondly, there are no satisfactory methods for control of the diseases in the prevailing situations in the endemic tropical countries. Thirdly they cause serious debility, morbidity and in some cases high mortality, thereby impeding socio-economic development.

However, the parasitic diseases mentioned above are only a few examples of the parasitic infections of public health concern in the tropics. There are a host of others which have not been particularly focused, not because they are not important but apparently because they produce less overt disease. Some of such parasites belong to the group called intestinal worms. According to Coombs and Crompton (1991), 342 different parasitic worms have been reported in the human host, 197 of which reside in the gastrointestinal tract (GIT). The helminths regarded as intestinal worms are those which attain their adult or reproductive stage in the intestine of their hosts. The majority of these GIT worms belong to two main Phyla, the Platyhelminthes (flatworms) and the Nematoda (roundworms). There are reports also of some members of the Acanthocephala (spiny headed worms). Examples of some of the common worms found in the human GIT are shown in Table 1.

GEOHELMINTHS OR SOIL-TRANSMITTED HELMINTHS

Among the intestinal nematodes infecting humans, four species are particularly predominant, being highly prevalent and very widespread among the people in the endemic areas. These worms are the large common roundworm, *Ascaris lumbricoides*, the whipworm, *Trichiuris trichiura* and two species of hookworms *Ancylostoma duodenale* and *Necator americanus*. These worms are collectively called geohelminths (GH) or soil-transmitted helminths (S-TH). They are so called because they have a direct life cycle (which involves no intermediate hosts or vectors) and produce eggs which are passed out with host faeces but which will not embryonate and become infective until after passing through a mandatory period of incubation in the soil. The mode of infection of a new host is therefore, through the soil contaminated with the infective stage of the worms.

It may seem unbelievable but the best estimates indicate that over half of the world's population is plagued by these four species of parasitic worms. A great proportion of the infections is borne by millions of poor people of the world who endure chronic and massive burden of illness which are accorded little priority by the authorities. Some people may harbour two or even three species of these worms simultaneously. Hence infections with these roundworms have been termed 'forgotten problems of forgotten people' and most of these people reside in the developing countries in tropical regions of the world (Crompton .1991).

Table 1. Common Helminths found in the Human Gastro Intestinal Tract

Parasite	Life history	Transmission	Infective stage	Distribution
Platyhelminthes (flatworms)				
Digenea (flukes)				
Fasciolopsis buski	Indirect	Oral	Metacercaria	Orient
Eucestoda (tapeworms)				
Taenia saginata	Indirect	Oral	Cysticercus	Widespread
Hymenolepis nana	Indirect	Oral Autoinfection	Egg (oncosphere)	Widespread
Nematoda (roundworms)				
Ascaris lumbricoides	Direct	Oral	Egg	Widespread Tropics
Enterobius vermicularis	Direct	Oral	Egg	Widespread
Necator americanus & *Ancylostoma duodenale*	Direct	Cutaneous	Larva	Tropics Subtropics
Strongyloides stercoralis	Direct	Cutaneous Autoinfection	Larva	Tropics, Europe. US
Trichuris trichiura	Direct	Oral	Egg	Widespread Tropics

Despite the considerable numbers of geohelminth infections, the public health perception has traditionally been that these intestinal parasites contribute comparatively little to overt disease. Some people have resigned to the belief that human infection with GHs is inevitable, tolerating them like flies, both being a nuisance and unavoidable companions. Their ubiquity has led to a tendency to view the infections as a fact of life or as a problem which is too large to be tackled by the services. Some people even erroneously believe that the presence of at least a few worms in the intestine is essential for food digestion and that it may be unsafe to deworm a child completely. These attitudes to the intestinal roundworm infections are understandable. Unlike some infectious diseases like malaria or HIV AIDS, which relatively cause serious debility and heavy mortality in infected people, infections with GHs are chronic and appear to cause not much serious problems. However, that perception has now changed based on new information and understanding of the epidemiology of the GHs from new scientific investigations (Crompton, Nesheim and Pawlowski, 1985).

BIOLOGY AND PUBLIC HEALTH IMPORTANCE OF GEOHELMINTHS

Infections with the geohelminths are referred to as soil-transmitted helminthiases. Infection with *Ascaris* is a condition called ascariasis, infection with *Trichuris trichuira* as trichuriasis and with hookworms as hookworm disease.

Ascariasis

The organism called *Ascaris lumbricoides* has been known to its human hosts for hundreds of years. It is one of the commonest, most prevalent and persistent parasites infecting humans in the world today. It is endemic in parts of tropical and temperate regions of the world, where there is sufficient moisture, particularly in areas characterized with poverty, ignorance, low standard of hygiene and poor sanitation. The most recent estimates show that up to 1471 million people (over a quarter of the world's population) are infected, most of whom reside in developing countries of Africa, Asia and South America (Holland and Kenedy, 2002).

Morphology and Characteristics

A. lumbricoides (Fig. 1) is the largest nematode inhabiting the human alimentary tract and it usually resides in the jejunum in the small intestine. Males are 15 to 31cm in length and 2 to 4mm in width with a curved posterior end. The females are larger, measuring 20 to 49cm by 3 to 6 mm. Life worms appear creamy to whitish. Female worms lay eggs which are passed out with host faeces and the eggs appear brownish in colour. Fertilized eggs are round to

oval, 45-75 by 35-50μm in size, containing a developing embryo and covered with a thick shell with an outer surface that appears rough or irregular.

Fig. 1 *Ascaris* adult

Life cycle

Ascaris eggs (Fig. 2) are released with human faeces. They are not infective when released but in warm and moist soil, the eggs develop and become infective in 15 to 35 days, containing a larva coiled within the egg shell. Infection occurs when the infective eggs are ingested by humans with contaminated food or drink. The eggs hatch in the jejunum and the larvae migrate up the portal vessels and lymphatic system into the liver from where they are carried through the heart to the lungs. They spend about 10 days in the lungs, then move up the trachea and swallowed down the oesophagus. On returning to the intestine, the larvae develop to mature adult male or female worms. Copulation occurs between the two sexes and females start releasing eggs about 60 days after the infective eggs were ingested. A female *A. lumbricoides* lays between 200,000 to 250,000 eggs per day and adults survive for one to two years. The fertilized eggs of *A. lumbricoides* is the most resistant of all soil-transmitted helminth eggs and can remain viable in the soil for up to six years (Crompton, *et al.*, 1985).

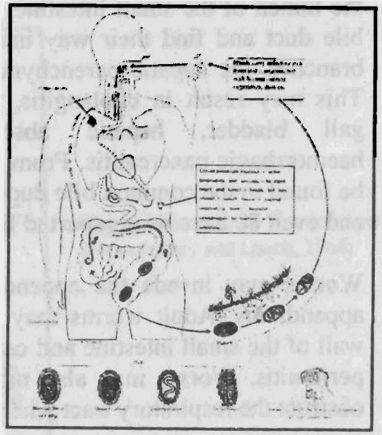


Fig. 2 Life cycle of *Ascaris lumbricoides*
(From Jeffrey and Leech, 1966)

Pathogenesis of ascariasis

Ascaris larvae migrating through the intestinal mucosa, liver and lungs provoke hypersensitivity reactions in the human host. Some of the larvae become immobilized and covered with eosinophils, resulting in the formation of granulomas. In the lungs, movement of the larvae from the blood vessels into the air spaces results in haemorrhage and oedema of the alveoli. This can give rise to dry cough, high fever and bronchial asthma. The effect is severe when the number of larvae is large or when transmission is seasonal.

Adult worms in the intestine induce disorder in the jejunal mucosa and intestinal muscle layers. Protein energy malnutrition, reduced food intake and impared cognitive function in children are associated with the problems of ascariasis.
Adult *Ascaris* can migrate from the jejunum to the upper gastrointestinal tract and become vomited. In heavy infections, several worms may ball up and obstruct the intestine.
About 12 million acute cases of ascariasis occur globally each year with about 10,000 deaths. *Ascaris*-induced intestinal obstruction is the commonest, accounting for 72% of all complications. This is most frequent in children who are under 10 years of age. Such intestinal obstructions in children usually result in emergency hospital cases requiring surgery, and is associated with a mean case fatality of up to 5% (Louw, 1974) (Fig.3).

Ascaris can be found in various ectopic locations with serious consequences. The worms may leave the lumen of the small intestine, enter the common bile duct and find their way into the hepatic duct branches, the hepatic parenchyma or the pancreas. This may result in cholangitis, perforation of the gall bladder, hepatic abscess and acute haemorrhagic pancreatitis. From 1 to 5 worms may be found in the common bile duct but as many as 60 and even 80 have been reported from this site.

Fig. 3 Cardiac *Ascaris*

Worms may invade the appendix and precipitate appendicitis. Adult worms may also perforate the wall of the small intestine and cause granulomatous peritonitis. Worms may also move anteriorly and obstruct the respiratory tract where they cause abscesses.

Allergic reactions like asthma, eosinophilia and urticaria have been reported in laboratory workers who are not infected but have had previous exposure to

materials from *Ascaris* worms.

Trichuriasis

Trichuris worms are called whipworms because the anterior two thirds of their body is thin and threadlike, while the posterior one third is abruptly thick which makes the worms appear like whip. *T. trichiura* is estimated to infect about 1049 million people globally and has a distribution similar to that of *A. lumbricoides*. The worm usually resides in the caecum of the mammalian host. Adult male *T. trichiura* measures from 30-45mm, while the female is 30-50mm in length. The diameter of the anterior portion is 100-150µm and the posterior portion 400-700µm. The eggs are ovoid in shape with characteristic plugs at each end and measure 50-54 by 22-24µm.

Life cycle

The eggs are released with host faeces (Fig.4). They are not infective when released but develop in warm moist soil and become embryonated in 3 weeks. Infection results from ingesting infective eggs from hands or from food or drink contaminated with soil. The eggs hatch in the small intestine releasing the larvae that enter the crypts of Lieberkuhn, develop for about a week and re-enter the intestinal lumen. They migrate to the caecum and mature to adult males and females. Copulation takes place and eggs start to appear in host faeces 70 to 90 days after initial ingestion of infective eggs. Adults live for several years and one female worm releases from 1000 to 6000 eggs per day. *Trichuris* eggs can remain viable in the soil for six years in suitable environment.

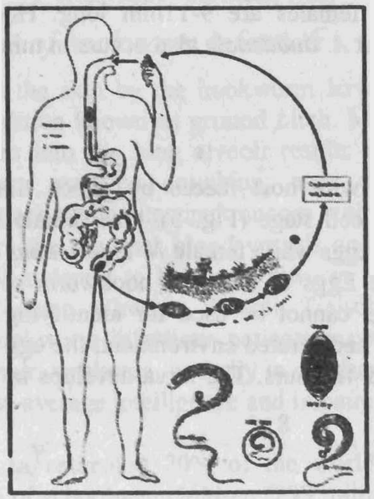


Fig. 4 Lifecycle of *T. trichiura*
(From Jeffrey and Leech, 1966)

Pathogenesis of trichuriasis

Trichuris attaches to the surface of the intestine by its anterior end, penetrating deep into the mucosa of the colon by its thin anterior portion. This causes mechanical damage to the epithelium and underlying submucosa, consequently resulting in chronic haemorrhage. Infection with *T. trichiura* may involve significant blood loss and may be associated with iron-deficiency anaemia (IDA). The damage to the mucosal epithelium results in secondary infection and invasion by bacteria and protozoan parasites. Majority of the worms usually locate in the caecum but in heavy infection, the posterior end of the ileum, the whole of the colon and the rectum are invaded. Infection of the appendix may also lead to appendicitis. Few number of worms (less than 100) may be asymptomatic but since adult worms live for several years, large numbers may gradually accumulate, leading to intensive trichuriasis, especially in children. Massive infantile trichuriasis (with more than 800 worms or 30,000 epg) is characterized by chronic diarrhoea with mucus and blood, abdominal pains, tenesmus and rectal prolapse. Symptoms also include severe anaemia, digital clubbing and growth retardation.

Hookworm disease

Hookworms are nematodes with a stout body. Their anterior end is curved dorsally, giving the worm a hook-like appearance. The two important species infecting humans are *Ancylostoma duodenale* and *Necator americanus*. The global estimate shows that up to 1,277 million people are infected. In *A. duodenale*, the mouth is armed with teeth and in *N. americanus* with cutting plates for piercing host blood vessels from where they suck blood. Males of *A duodenale* are 9-11mm and females 10-13mm, while the males of *N. americanus* are 7-9mm while females are 9-11mm long. Hookworms are primarily found in the tropics but *A. duodenale* also occurs in mines in the cold regions of the world.

Life cycle

Hookworm eggs are released with host faeces by which time they have developed to 2-, 4- or several cell stage (Fig. 5). One female *A. duodenale* releases from 10,000 to 30,000 eggs while female *N. americanus* releases from 5,000 to 10,000 eggs per day. Eggs of different hookworm species are not distinguishable, hence the eggs cannot be used for identifying the different species. In warm, shady, moist and aerated environment, the egg develops and then hatches to a larva in 24 to 48 hours. The larva develops in the soil to an

infective stage in about 8 days. The larva infects the next host whose skin contacts the soil containing the infective larva by penetrating into the skin. From the skin, the larvae are carried in the blood vessels or lymph via the heart to the lungs, and from there move up the trachea, get into the oesophagus and become swallowed. When they arrive in the small intestine, they attach to the mucosa with their mouth, grow and become sexually mature male and female adults. The worms mate and females start to lay eggs. It takes at least five weeks from the time of infection to the first appearance of eggs in host faeces.

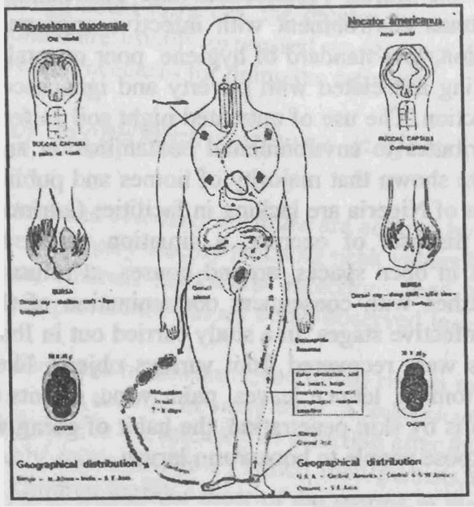


Fig. 5 lifecycle of hookworm
(From Jeffrey and Leech, 1966)

Pathogenesis of hookworm infection

Penetration of the skin by the hookworm larvae results in urticarial reaction causing a condition known as ground hitch. Migration of the larvae from the lung capillaries into the lung alveoli results in haemorrhage and secondary infection; there may be coughing, sore throat and pneumonia. Adult hookworms attach to the intestinal mucosa with their strong buccal capsule and teeth, puncture the mucosal blood vessels and from there continuously suck blood. Hence moderate to heavy hookworm infection will produce anaemia (Stoltzfus, Albonico, Chwaya, Savioli, Tielsch, Schulze and Yip, 1996). In very heavy hookworm infections patients experience protein deficiency, with dry skin and hair, weakness, potbelly in children, with stunted growth, delayed puberty, below-average intelligence and impaired educational performance.

As at 1990, an estimated 70% of the world's preschool-age children (41 million), 26% of school-age children (239 million) and 39% of the developing world's pregnant women (124.3 million) haboured hookworm infections (WHO, 1996).

EPIDEMIOLOGY OF GEOHELMINTHS

Crompton (1999) stated that by 1990, geohelminths have been reported in at least 151 countries of the world. Contributive factors to endemic GHs include favourable environmental conditions, as the worms are more prevalent in warm and wet regions of the world. Promiscuous and indiscriminate defaecation loads immediate human environment with infective eggs and larvae of the worms. Poor sanitation, low standard of hygiene, poor or total lack of sewage disposal, overcrowding associated with poverty and ignorance expose people continuously to infection. The use of untreated night soil as fertilizer for crops in some areas contributes to environmental contamination and transmission. Various surveys have shown that majority of homes and public places in both urban and rural areas of Nigeria are lacking in facilities (latrines and functional toilets) for proper disposal of excreta, a situation which has encouraged deposition of feaces in open spaces, around houses, at refuse dumps, gutters and surrounding bushes with consequent contamination of the environment with geohelminths infective stages. In a study carried out in Ibadan by Ogunba (1990) *Ascaris* eggs were recovered from various objects like paper money, food items such as tomato, lettuce leaves, palm wine, carrots and gari. Since hookworm infection is by skin penetration, the habit of going with barefoot in tropical countries expose people to hookworm larvae.

Assessing the distribution of geohelminths in host population

The distribution of GHs among a host population is often discussed in terms of **prevalence** and **intensity** of infection (Crompton, 1991). **Prevalence** of infection is defined as the proportion (expressed as percentage) of the host population that is infected at the time of survey. Diagnosis of infection is usually made by the detection of the helminth eggs in stool samples of the hosts. Results of various investigations on prevalence show that GHs have a patchy distribution within countries and within districts in a country. Distribution varies from community to community depending on local situations. In Nigeria for example, prevalence values reported for *A. lumbricoides* vary from 6% in parts of the north to 92% in some areas of the southwest (Ogunba, 1990).

Intensity of infection with intestinal helminths is defined, depending on the objectives of the investigation, as either the number of worms per person or the number per infected person in the population examined. It is measured directly by counting the number of worms expelled in the host stools following anthelmintic chemotherapy or indirectly by counting the number of worm eggs

released in the host stool.

Treating people with anthelmintics and counting the number of worms they expelled is the more accurate procedure for determining intensity of infections and is invaluable for research studies. However, the procedure is laborious and is not a practicable means that can be employed for extensive investigations. Quantifying the density of eggs in faeces is a more convenient means of estimating the intensity of infection. This procedure assumes that egg intensity in faeces is directly proportional to the number of worms in the intestine, that is, the higher the egg count in faeces, the greater the number of worms in the intestine. Egg counts are usually expressed as eggs per gram (epg) of faeces and there are several procedures for doing the estimate.

Distribution of geohelminths among subjects of different age groups

Ascaris lumbricoides and *Trichuris trichiura* are aquired by young infants early in life. Prevalence rises very steeply reaching peak values by the time children are aged 10 years, whereas hookworm infections tend to be aquired more gradually with peak prevalence values being observed in later childhood (Fig. 6).

For *Ascaris, Trichuris* and hookworms, the initial rise in intensity of infection with age closely mirrors the rise in prevalence. *A. lumbricoides* and *T. trichiura* exhibit a marked decline in the intensity of infection after the peak in childhood to reach a relatively stable low level which then persists through adulthood. This implies that children harbour most of the worms in the community. With hookworms, intensity rises gradually with age and attains a peak in adulthood (Bundy, Hall, Medley and Savioli. 1992) (Fig. 7).

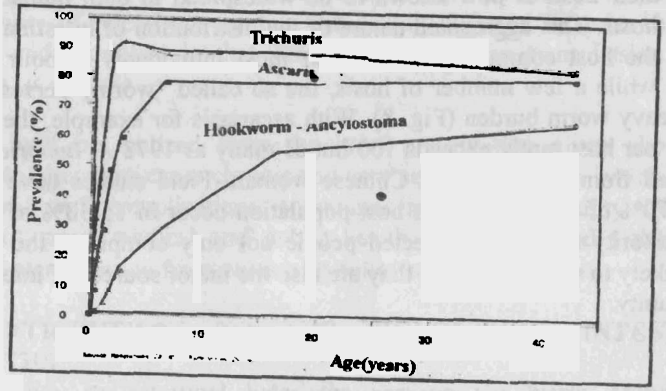


Fig. 6 Comparison of typical age/prevalence relationship (From Bundy *et al*., 1992)

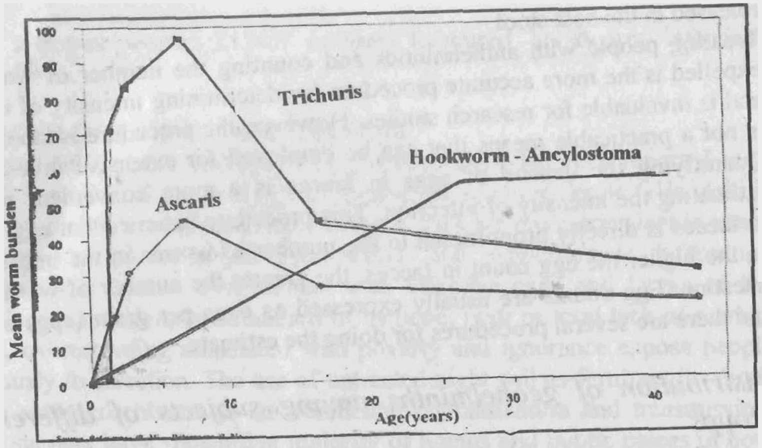


Fig. 7 Comparison of typical age/intensity relationship (From Bundy *et al.*, 1992)

Distribution of number of worms per host

Studies on the intensity of infection have shown that the numbers of worms per host are not distributed randomly in the host population. Crofton (1971) has shown that the frequency distribution of parasites in a host population is clumped or overdispersed and best described mathematically by the negative binomial distribution. This pattern of overdispersion among helminth parasites within their hosts is now known to be widespread in both human and other animal hosts. This aggregated nature of the distribution of intestinal helminths within the host community means that most individuals harbour few or no worms while a few number of hosts, the so called "wormy persons" harbour very heavy worm burden (Fig. 8). With ascariasis for example, the number of worms per host rarely exceeds 100 but as many as 1978 *A. lumbricoides* were retrieved from a 29-year-old Chinese woman. Field studies have found that about 70% of the worms in a host population occur in 15-30% of the people. The minority of heavily infected people not only comprises the individuals most likely to suffer diseases, they are also the major sources of infection in the community.

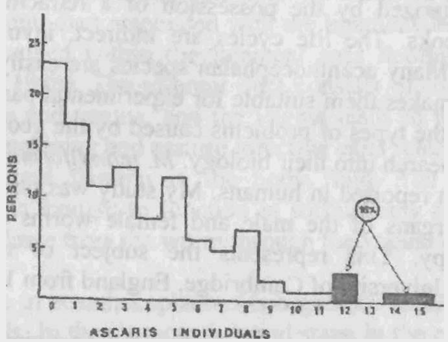


Fig. 8 Frequency Distribution of *A. lumbricoides*, Esfahan (From Croll *et al.*, 1981)

Predisposition of hosts to light or heavy infection status

From longitudinal studies carried out in endemic countries, it has been observed that some individuals in the communities are predisposed either to light or to heavy infection intensity with the geohelminths. Predisposition has been observed for *A. lumbricoides, T. trichiura* and hookworms (Elkins, Haswell-Elkins and Anderson, 1986). The practical implications of predisposition of hosts to certain worm intensity were significant and related to the possibility of selectively treating the heavily infected in order to reduce morbidity and mortality in that group and to reduce transmission in the community as a whole.

I hope it will be realized from the brief presentation given above that geohelminth infections cause chronic and very serious morbidity which may be accompanied with complications, sometimes resulting in fatality. They are therefore of grave medical and public health importance and I think they deserve greater attention from our health policy makers.

MY CONTRIBUTIONS TO THE BIOLOGY OF INTESTINAL HELMINTHS

My first study on intestinal helminths was on the worm *Moniliformis moniliformis* which belongs to the phylum Acanthocephala. Acanthocephalans represent an obscure group of worms. Members are endoparasites which attain sexual maturity in the alimentary tracts of vertebrates. Sexes are separate and they range in size from 0.1 to 100cm in length. They are white to creamy in colour and characterized by the possession of a retractile proboscis which generally bears hooks. The life cycles are indirect, involving an arthropod intermediate host. Many acanthocephalan species are easily maintained in the laboratory, which makes them suitable for experimental parasitological studies including some of the types of problems caused by the geohelminths. This has also invigorated research into their biology. *M. moniliformis* is a parasite of rats but it has also been reported in humans. My study was on the development of the reproductive organs of the male and female worms using the light and electron microscopy. This represents the subject of my Ph.D. research programme at the University of Cambridge, England from 1974 to1977.

The strain of *M. moniliformis* used for my work was maintained in laboratory-bred albino rats and the intermediate host, the cockroach *Periplaneta americana*. Infective eggs obtained from the gravid female worms are fed into cockroaches. The eggs hatch in the intestine and the released larvae migrate to the haemocoel of the cockroach. The larvae develop through the acanthor, acanthella and finally to the cystacanth larval stages in the cockroach. Rats are infected by feeding them with the cystacanths removed from the haemocoel of the cockroach. Adult worms become sexually matured in the rat at about 16 days and egg release by the female commences about 5-6 weeks post infection (Fig. 9). Six papers (Asaolu, 1980, 1981, 1986, 1989, 1990; Asaolu, Whitfield, Crompton and Maxwell, 1981) were published from my studies.

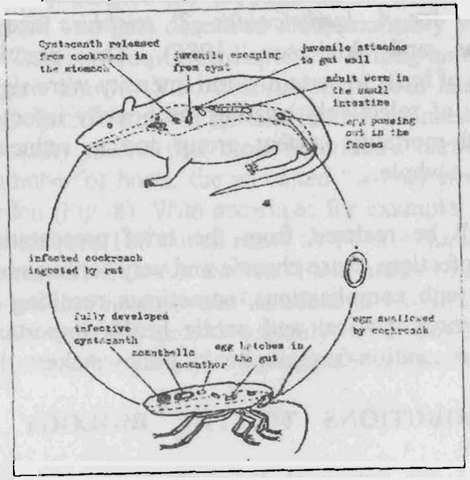


Fig.9 *Monoiliformis* lifecycle

Reproductive system of female M. moniliformis

The reproductive system of the female adult *M. moniliformis* was observed to consist of the efferent duct associated with the ligament sacs, and thousands of ovarian balls contained within the ligament sacs floating in the body fluid (Fig.10) (Asaolu, 1980). The efferent duct consists of the uterine bell which leads to the uterus and vagina, and the vagina leads to the outside. In patent female worms, developing and mature infective eggs released from the ovarian balls, are also found floating in the body fluid. The uterine bell of the acanthocephalans is thought to function in sorting only mature eggs from the body cavity for release from the worm through the vagina (Fig 11).

The ovarian tissue in acanthocephalans is organized as large numbers of units called ovarian balls. In the cystacanth larval stage in the cockroach, and up till the time the adult worm is one week old in the rat, the number of ovarian balls was eight and they maintain a spherical shape. After this stage, the balls adopt an irregular shape, and the number was found to increase to several thousands by the time the worm becomes sexually matured.

Electron micrographs show ovarian balls in the cystacanth and young female adults of *M. moniliformis*, to be cellular and bound on the surface by a fibrous coat up till the time the worms were 5 days old in the rat (Asaolu, Whitfield, Crompton and Maxwell , 1981). In 7-day-old adult females, the balls still show individual cells but also areas which are syncytial. The ovarian balls in the 9-day-old females have lost the fibrous surface coat, become irregular in shape and organized internally into two zones. Zone one consists of individual germ line cells, and zone two consists of a syncytium which embeds the germ cells and forms the boundary of the balls (Figs. 12a, 12b, 12c). This coincides with the time when the ovarian balls start to increase rapidly in number. In the 14-day-old female worms the ovarian balls show three zones; zone one is an inner region of oogonial syncytiuum, zone two consists of cells, mainly oogonia and oocytes and zone three is the supporting syncytium which forms the boundary of the balls, and embeds the oogonial syncytium and the cells. This is the structure of the balls in sexually matured females (Fig. 12d)

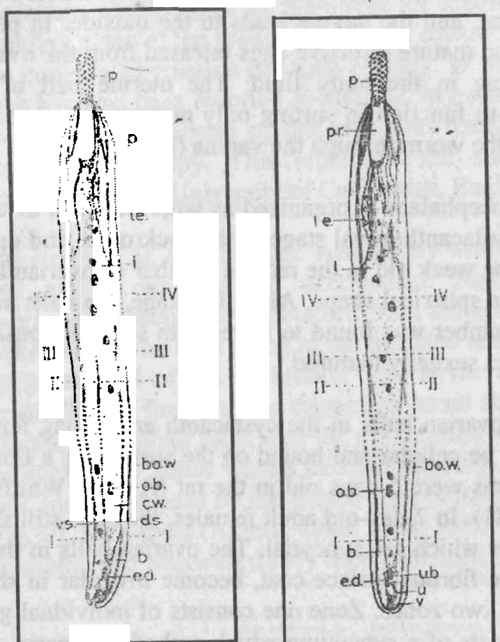


Fig. 10 Organisation of the efferent duct and ligament sacs of female *M. dubius*
(From Asaolu, 1980)

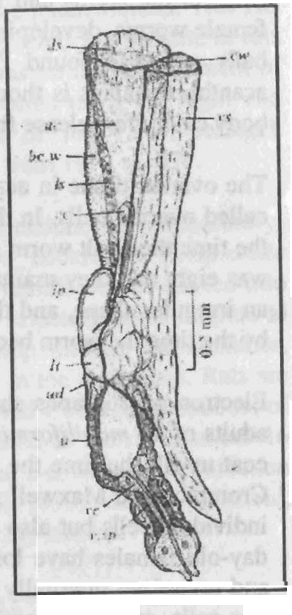


Fig. 11 Whole mount of the efferent duct system in a 3-week-old *M. dubius*
(From Asaolu, 1980)

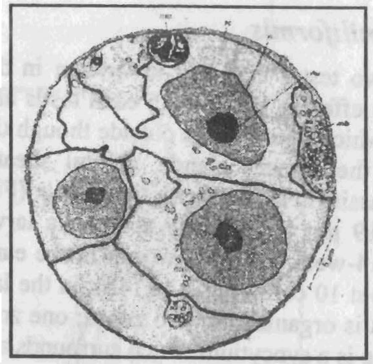


Fig. 12a Structure of an ovarian ball from a female *Moniliformis* after 1 day in the rat

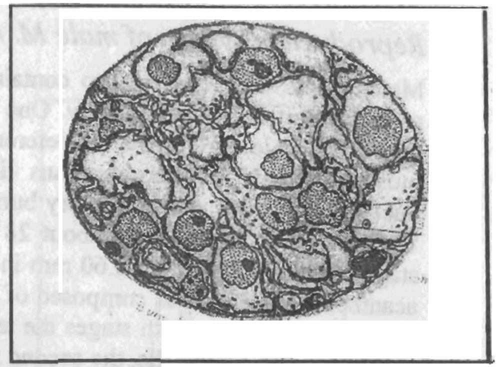


Fig. 12b Electron Micrograph Structure of an Ovarian Ball from a female *Moniliformis* after 7 days in the rat

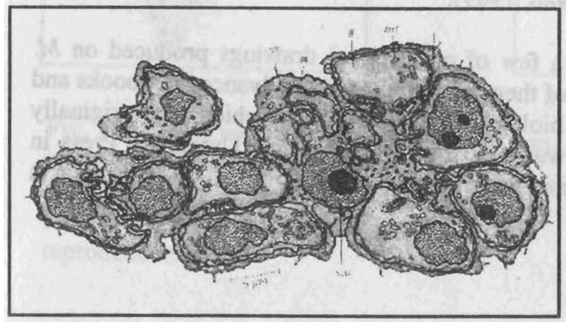


Fig. 12c Electron Micrograph Structure of an Ovarian Ball from a female *Moniliformis* after 9 days in the rat

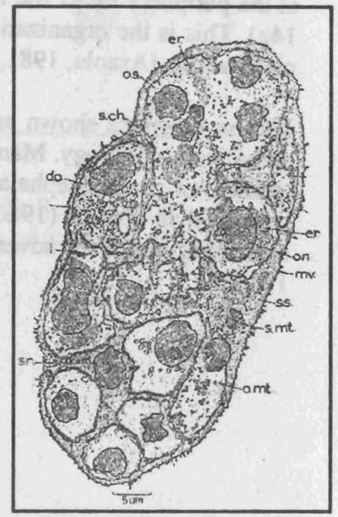


Fig.12d Electron Micrograph of a section of an ovarian ball from an adult female *M. dubius* aged 3 weeks

(From Asaolu *et al.*, 1981)

Reproductive system of male M. moniliformis

Male worms were observed to contain two testes arranged in tandem in the posterior part of the body cavity. One vas efferens arises from each testis and the two ducts join to form a vas deferens which opens to the outside though the muscular penis. Accessory organs like the cement glands, genital sheath, Saefftigen's pouch and copulatory bursa assist in mating with the female (Fig. 13a,b). The testis measures about 28 x 19 μm in the early acanthella larval stage increasing to 3.27 x 0.60 mm in a 14-week-old adult worm. In the early acanthella, each testis is composed of about 10 cells (Fig. 14a,14b); in the late acanthella and cystacanth stages the testis is organized in two zones; one zone consists of germ line cells, the second zone is a syncytium which surrounds and embeds the cells. This organization is maintained in the testis up to the time the adult worms are a few days old in the rat (Fig. 14c,d,e,f). In male worms that are 7 days old in the rat, the testes still contain individual germ line cells but the supporting syncytium has now broken down into a loose system, leaving lots of wide spaces in the testes in which the spermatozoa formed in the testes move to the sperm duct. A thin layer of the supporting syncytiun is maintained at the periphery under the fibrous surface coat to form the testis envelope(Fig. 14g). This is the organization of the testes morphology in the sexually mature male worms (Asaolu, 1981, 1986, 1989).

All the diagrams shown are a few of my original drawings produced on *M. moniliformis* biology. Many of them have appeared in advanced textbooks and treatise on acanthocephalan biology. In fact, Fig. 14e which was originally published in Asaolu (1986) was used by the Cambridge University Press in decorating one of the advertising leaflets for the British journal, *Parasitology* in 1986.

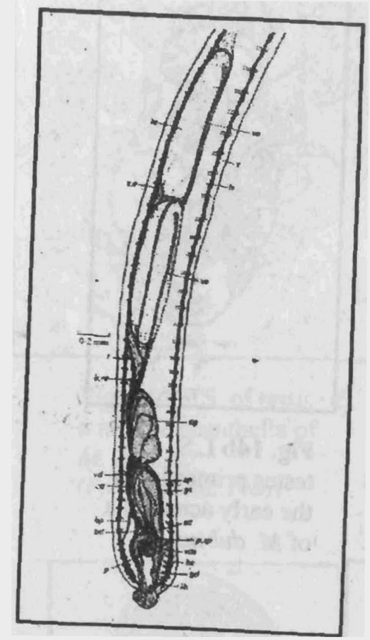


Fig. 13a Whole mount of the posterior end of a two week old male worm viewed laterally showing the reproductive organs

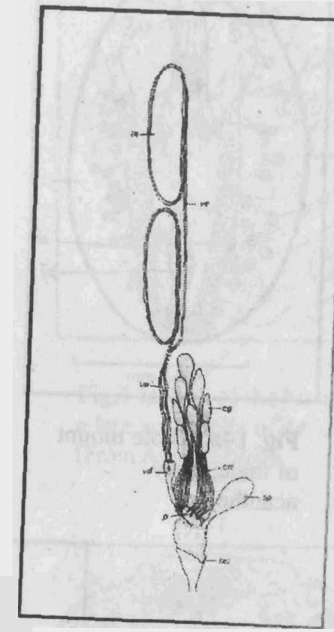


Fig. 13b Reproductive organs of the male *M. dubius*

(From Asaolu, 1981)

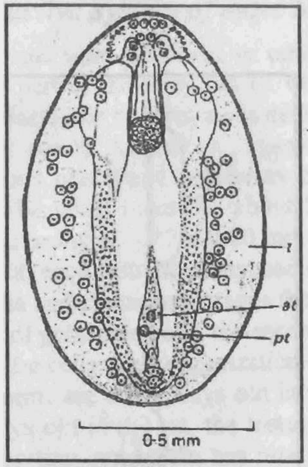


Fig. 14a Whole mount of male, early acanthella

Fig. 14b L.S. of testes primordia in the early acanthella of *M. dubius*

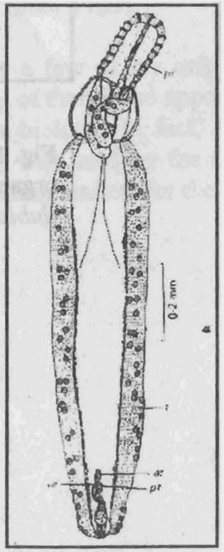


Fig. 14c Whole mount of male, middle acanthella, 22 days old in the cockroach

(From Asaolu, 1986)

Fig. 14d T.S. of testis of a middle acanthella of *M. dubius* (From Asaolu, 1986)

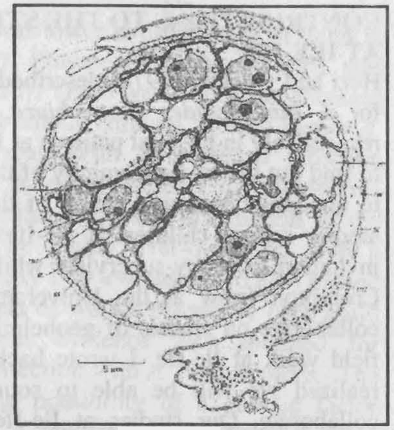


Fig.14e T.S. of the testis from a late acanthella of *M. dubius* (From Asaolu, 1986)

Fig. 14f A section of the testis of a male *M. dubius* aged 1 day in the rat (From Asaolu, 1989)

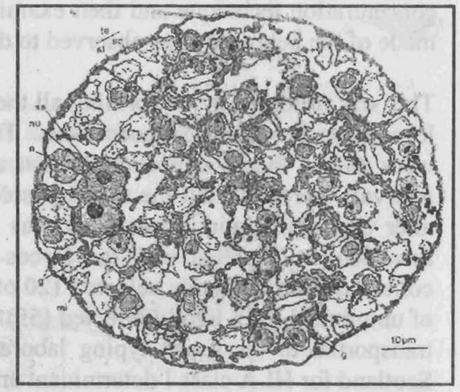


Fig. 14g T.S. of testis of a male *M. dubius* after 7 days in the rat (From Asaolu, 1989)

CONTRIBUTIONS TO THE STUDY OF GEOHELMINTHS AT ILE-IFE

Hori and Odiachi (1978) described prevalences of 97.4, 79.4, 69.5 and 10.9% for *A. lumbricoides, T. trichiura*, hookworms and *Strongyloides stercoralis* respectively in hospital patients at Ile-Ife and Midwest State hospitals. In order to find out the true endemicity of the geoheminths in the community, I decided to undertake an investigation of the prevalence and intensity of these worms among school children at Ile-Ife. As I was planning this study, I got an invitation from my supervisor while I studied in Cambridge, Professor D.W.T Crompton (now at the University of Glasgow), that he will want us to collaborate on studies of geohelminths epidemiology if we can carry out the field work at Ile-Ife. I wrote back that I agreed to his suggestion because I realized we will be able to source adequate funding for the work if we collaborate. Our studies at Ile-Ife, carried out between 1987 and 1996 in collaboration with Dr. C.V. Holland of Zoology Department, University of Dublin, produced very useful results most of which have been published.

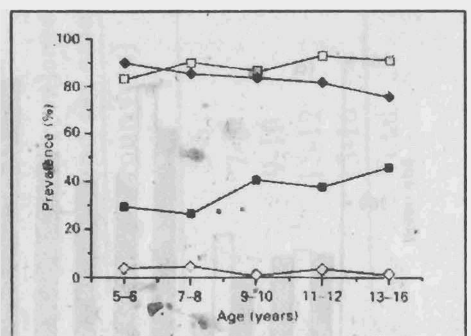
Our first study was carried out in 1987 among the children attending St. Peter's Primary School, Oke-Esho, Ile-Ife. Faecal samples were collected from 808 children aged 5 to 16 years. The samples were processed using formol-ether concentration technique and then examined with the microscope. Counts were made of the helminth eggs observed to determine infection intensity (epg).

This was followed by deworming all the children using recommended doses of levamisole (ketrax) on 3 occasions. The first treatment was given within a week of the faecal sample collection and the remaining two at six monthly intervals thereafter. All the stools passed by each child over the next 48 hours after each anthelmintic treatment was collected and all the specimens of *A. lumbricoides* expelled with the faeces extracted and counted. Venous blood collected from randomly selected 120 of the children belonging to three groups of uninfected (35), lightly infected (55) and heavily infected (30) children were transported to the tissue typing laboratory at the Glasgow Royal Infirmary, Scotland for HLA class I determinant analysis.

The results from our faecal examinations for eggs showed prevalences of 88.5, 84.5, 33.1 and 3% for *Ascaris lumbricoides, Trichuris trichiura*, hookworms and *Strongyloides stercoralis* respectively. The mean ± SD egg count per gram (epg) of faeces were 13315 ± 18140.0 for *A. lumbricoides*, 384 ± 1063.3 for *T. trichiura* and 96.4 ± 445.8 for hookworms. At the first deworming exercise, the 808 children passed a total of 8910 *A. lumbricoides*. The mean number of worms per child was 11.02 ± 13.74 with a range of 1-196 (Table 2). There was no significant association between age and prevalence of *A. lumbricoides* or

S.stercoralis but prevalence of *T. trichuria* was lower in older children (90% in 5-6 and 76% in those aged 13-16 years). Prevalence of hookworms was significantly higher in older children (Fig. 15). There was significant increase in intensity of *A. lumbricoides* with age and female children showed higher *A. lumbricoides* egg counts compared to males. With *T. trichiura* infection intensity was independent of age and sex whereas intensity of hookworms increased with age (Fig. 16). We observed the frequency distribution of the number of *A. lumbricoides* per child to be highly over-dispersed with a variance to mean ratio of 17.13 (Fig. 17). Fifty five individuals (6.8%) passed ≥ 30 worms each. By comparing the numbers of worms passed by each child after each of the 3 deworming exercises evidence was obtained for predisposition of children to heavy or light infection with *A. lumbricoides.* The results of the HLA study also suggest the possibility of a genetic factor predisposing children not to be infected with *A. lumbricoides*. At the end of our study, in order to promote hygiene in the school, the research team helped to repair the school latrine which had broken down and dig a well for water supply for use by the teachers and pupils. These results came out in three publications (Holland, Asaolu, Crompton, Stoddart, Macdonald and Torimiro, 1989; Holland and Asaolu, 1990; Holland, Crompton, Asaolu, Crichton and Torimiro, 1992).

Fig. 15 Prevalence of intestinal helminthiases by age for the total sample of children. (□) *Ascaris lumbricoides;* (◆) *Trichuris trichiura;* (■) Hookworm; (◇)*Strongyloides stercoalis*
(From Holland *et al.* 1989)



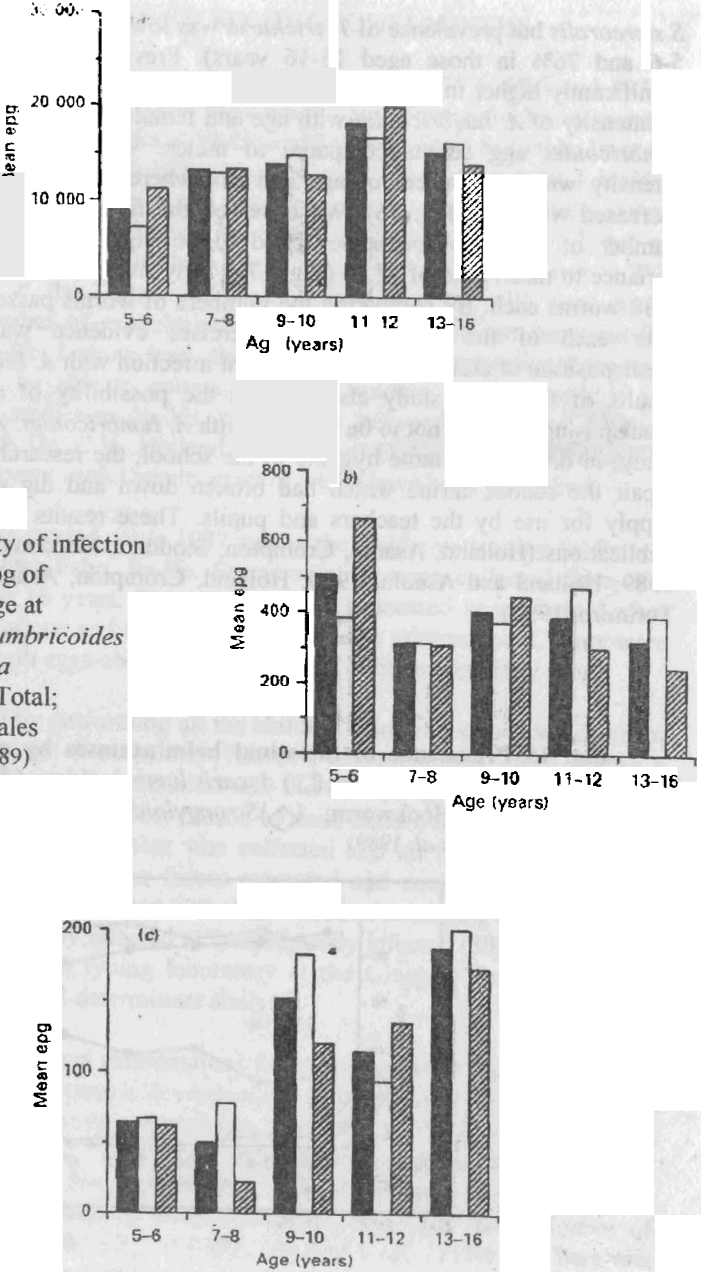


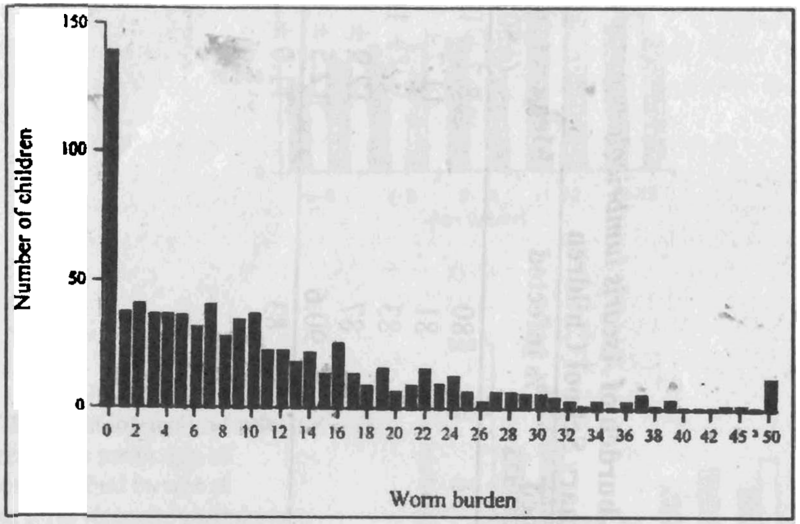
Fig. 16 Mean intensity of infection expressed as mean epg of faeces stratified by age at phase I. (a) *Ascaris lumbricoides* (b) *Trichuris trichiura* (c) hookworm. (■) Total; (□) males; (▨) females (From Holland *et al.* 1989)

Table 2. Prevalence and mean worm burden of *Ascaris lumbricoides* per person by age and sex among St. Peters Primary School Children

Age group (yrs)	Number examined	% infected	Mean worm count (±50)
5-6	172	80	8.7 ± 13.7
7-8	299	81	11.7 ± 16.5
9-10	147	83	9.9 ± 10.9
11-12	105	87	12.9 ± 12.0
13-16	85	90.6	12.5 ± 14.9
Total	806	83	11.0 ± 13.7

(From Holland *et al.* 1989)

Fig. 17 Frequency distribution of numbers of *Ascaris lumbricoides* per child in Ile-Ife, Nigeria (n=808)



(From Holland *et al.* 1989)

Studies on the endemicity of geohelminths in rural communities

After this first study, we carried out in 1989 surveys of geohelminth infections in four villages, Iloba, Alakowe, Akeredolu and Iyanfoworogi (all within 20km outside Ile-Ife), by examination of stool samples from all willing inhabitants of the villages, using Kato-Katz concentration technique. The results came out in Asaolu, Holland, Jegede, Frazer, Stoddart and Crompton, (1992). Prevalences of *A .lumbricoides* ranged from 61.5 to 72.2%, *T. trichiura* from 65 to 74% and hookworms from 52.4 to 63% in the four villages (Table 3). Intensity determined by egg count per gram of faeces (epg) varied from 6815 to 10823 for *A. lumbricoides,* 127 to 246 for *T. trichiura* and 122 to 267 for hookworms. Age related prevalences for *Asacaris, Trichuris* and hookworms rose steeply and peaked at over 80% among the children aged 11 to 14 years before dropping slightly among the older age groups. Intensity followed similar pattern for *Ascaris and Trichuris* (Fig.18,19). Intensity was found to increase as the number of inhabitants of a household increases (Fig. 20) indicating the effect of over crowding on transmission.

Table 3 Overall prevalence and intensity values of *Ascaris lumbricoides, Trichuris trichiura* and hookworm in the study villages

Village	N	*Ascaris*	*Trichuris*	Hookworm
Iloba	418	72.2%*	64.7%	60.1%
		6815.1 ± 10 872.3†	126.9 ± 239.2	251.4 ± 1253.3‡
Iyanfoworogi	334	69.8%	67.8%	52.4%
		8821.1 ± 16 732.3	143.5 ± 250.8	121.7 ± 343.8
Akeredolu	403	74.3%	73.8%	62.8%
		10 822.8 ± 17 586.7	246.0 ± 528.2	203.5 ± 537.4
Alakowe	279	61.5%	70.2%	62.5
		6900.2 ± 1358.9	239.9 ± 570.3	267.1 ± 881.2

*Prevalence %.
†Mean eggs per gram of faeces (epg) ± S.D.
(From Asaolu *et al.*, 1992)

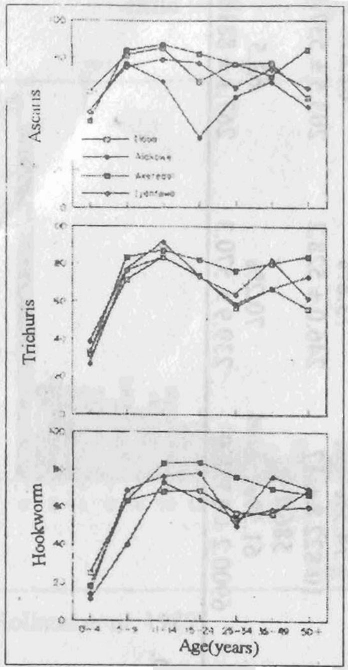


Fig. 18 Prevalence of intestinal helminths stratified by age for four villages.
(A) *Ascaris lumbricoides*
(B) *Trichuris trichiura*
(C) Hookworm

(From Asaolu, *et al,* 1992)

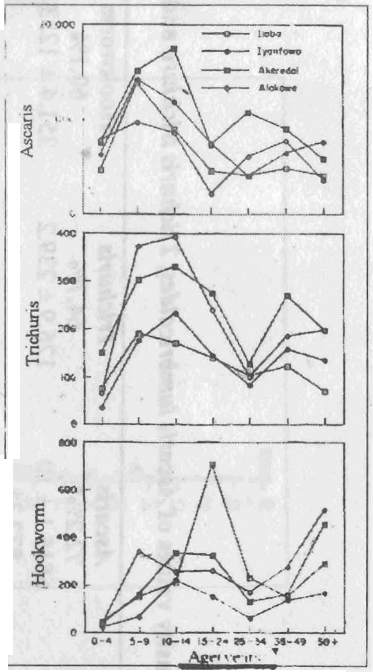


Fig 19 Intensity of Infection expressed as mean eggs g-1 of faeces (epg) stratified by age in four villages. (A) *Ascaris lumbricoides*
(B) *Trichuris trichiura*
(C) Hookworm

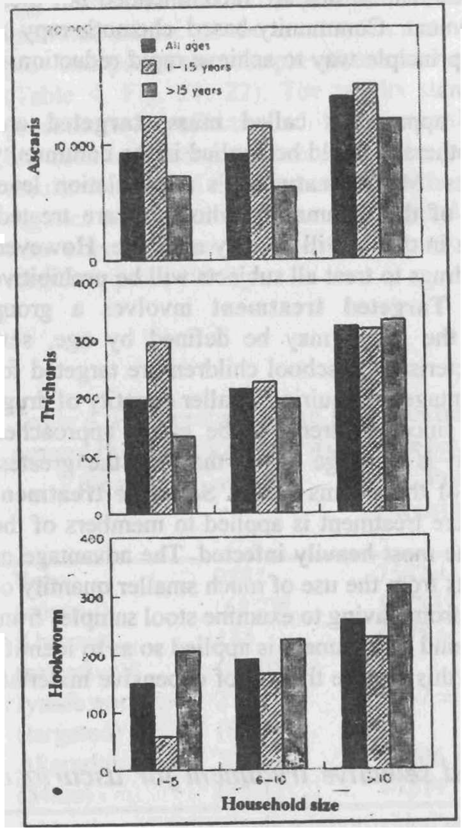


Fig. 20 Intensity of Infection (mean epg) and Household size in Akeredolu village.
(A) *Ascaris lumbricoides*
(B) *Trichuris trichiura*
(C) Hookworm

From Asaolu, *et al,* 1992

Studies on control tactics for the geohelminths

The WHO (1987) has advised endemic countries to undertake programmes that will reduce intensity and hence morbidity of the geohelminths, especially among the children. Improvement in sanitation and standard of hygiene, safe water supply and safe disposal of human wastes are recommended but these measures take very long to implement. Community-based chemotherapy at regular intervals is regarded as the principle way to achieve rapid reduction in prevalence and intensity of the worms.

Anderson (1989) proposed three approaches called **mass, targeted** and **selective** treatment by which chemotherapy could be applied in the community for the control of the geohelminths. **Mass treatment** is a population level application in which all members of the community who wish are treated. Some authors support this approach in that it will be very effective. However, the disadvantage is that the cost of drugs to treat all subjects will be prohibitive for the poor endemic countries. **Targeted treatment** involves a group application when membership of the group may be defined by age, sex, religion, occupation or other characteristic. If school children are targeted for example, this approach has the advantage of requiring smaller quantity of drugs and administration will be easier since children can be easily approached through school attendance. Also, it is this age group that has the greatest prevalence and in which the bulk of the worms reside. **Selective treatment** concerns individual application where treatment is applied to members of the community who are identified as the most heavily infected. The advantage of this approach is that it will safe costs from the use of much smaller quantity of drugs. However, it will attract costs from having to examine stool samples from the whole population before each round of treatment is applied so as to identify any new heavily infected ones, and this require the use of expensive materials and trained personnel.

Efficacy of mass, targeted and selective treatment for ascariasis control

Our next study at Alakowe, Iyanfoworogi and Akeredolu was designed to compare the impact of mass, targeted and selective chemotherapy using levamisole, as an action for the control of *Ascaris limbricoides*. Selective treatment was applied at Alakowe by treating the most heavily infected 20% (excreting up to 20000 epg or above) of the inhabitants, targeted treatment in Iyanfoworogi involved children aged 2-15 years, while mass treatment was offered to all inhabitants excluding pregnant women and infants under one year at Akeredolu. Recommended doses of levamisole were given in the villages as described, at 3 monthly intervals during a period of one year. Prevalence and intensity (epg) of *A. lumbricoides* were determined immediately before and 3

months after the period of intervention, using a modified Kato-Katz technique. The study shows that in the selective village, no significant difference was found between the pre- and post-treatment prevalence and egg counts of *A. lumbricoides* in the total population. In the targeted treatment village, significant differences were recorded in pre- and post-treatment prevalence and egg counts for the total population, among the children alone and among the untreated adults. In the mass treatment village, significant differences in the pre- and post-treatment prevalence and egg count values were also recorded (Table 4, Fig. 21, 22). The results show that mass and targeted treatment procedures are effective while the selective treatment approach is ineffective for ascariasis control (Asaolu, Holland, and Crompton, 1991). From these results we carried out an analysis of the cost effectiveness of the 3 treatment regimes and found the mass and targeted approaches to be considerably more cost effective than the selective approach (Holland, O'Shea, Asaolu, Turley and Crompton, 1996).

Table 4. Pre-treatment and post-treatment intensty of *Ascaris lumbricoides* among the inhabitants of study villages

Village	n(%)	Pre-treatment	Post-treatment	Paired t-value (P value)
Iloba (control)	288* (68.2)†	7542 ± 11783‡	4735 ± 8137	0.62 ($P \leq 0.5383$)
Alakowe (selective)§	185 (63.0)	6775 ± 10790	4259 ± 10909	1.63 ($P \leq 0.1045$)
Iyanfoworogi (targeted)	211 (61.1)	9057 ± 15797	2579 ± 6529	9.01 ($P \leq 0.0001$)
Akeredolu (Mass)	224 (55.1)	11906 ± 17219	1489 ± 5165	12.97 ($P \leq 0.0001$)

* Number of individuals who provided pre-treatment and post-treatment faecal samples.

† Sample size presented as percentage of individuals who provided pre-treatment faecal samples.

§ Comparison of the 36 selected individuals who received treatment revealed a pre-treatment mean value of 30839 ± 7710 (n = 24) and a post-treatment value of 801 ± 2024 ($t = 11.24$; $P \leq 0.0001$).

Fig. 21 Percentage prevalence of *Ascaris lumbricoides* pre- and post-treatment in the four villages.

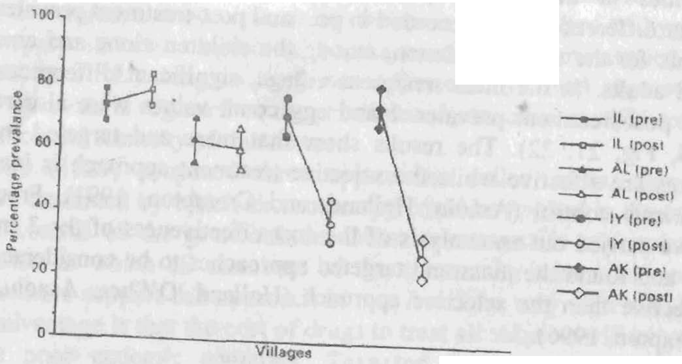
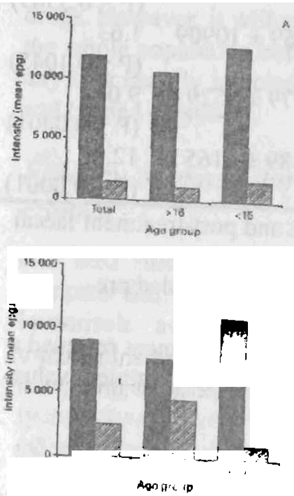
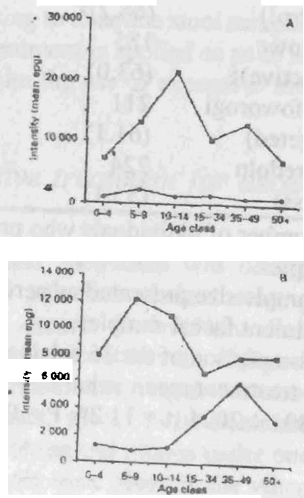


Fig. 22 Mean intensity of *Ascaris lumbricoides* (epg) pre- (■) and post-treatment (▨) for all age classes in (A)Akeredolu and (B) Iyanfoworogi



Mean intensity of *Ascaris lumbricoides* (epg) pre- (◆) and post-treatment (■) for all age classes in (A) Akeredolu and (B) Iyanfoworogi



(From Asaolu *et al.*, 1991)

Studies on frequency of application of chemotherapy

In another study carried out between 1991 and 1992, we investigated the frequency at which chemotherapy should be applied to have effective impact on the intensity of *A. lumbricoides* in children. The study was carried out using targeted treatment of primary school children aged 5-15 years at Alakowe, Iyanfoworogi and Akeredolu. A fourth community, Ladin served as the control village.The children at Iyanfoworogi, were offered treatment only once at the beginning of the exercise in July 1991, those at Akeredolu were treated twice at two 6-monthly intervals in July 1991 and January 1992 while those at Alakowe were treated thrice at 4-monthly intervals in July 1991, November 1991 and March 1992. We then compared the results of the pre-treatment faecal egg counts in June/July 1991 with those of post treatment counts in July 1992. At Iyanfoworogi where treatment was applied once and at Akeredolu with treatment at two 6-monthly intervals, a reduction in post-treatment intensity of *A. lumbricoides* was observed in the total population but this failed to attain statistical significance. In contrast, in Alakowe which received 4-monthly targeted chemotherapy, a significant reduction in post-treatment intensity of *A. lumbricoides* was observed in the total population and the targeted children (Table 5; Fig. 23). Our results appear in Holland, Asaolu, Crompton, Whitehead and Coombs (1996). After this study, about 25000 extra tablets of levamisole left at the end of our field work was donated to the university Health Centre.

A

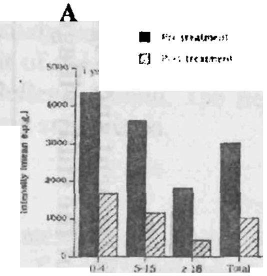
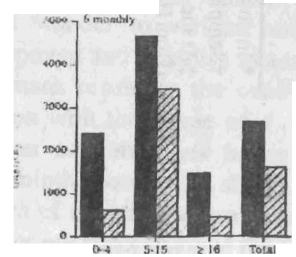


Fig. 23 Mean intensity of *Ascaris lumbricoides* expressed as eggs per gram of faeces (e.p.g.) pre- and post-treatment in (A) Iyanfoworogi (1 targeted treatment in 1 year), (B) Akeredolu (6-monthly targeted chemotherapy) and (C) Alakowe (4-monthly targeted chemotherapy). (From Holland *et al.* 1996)

B



C

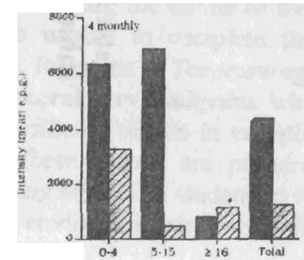


Table 5. Pre-treatment and post-treatment intensity of *Ascaris lumricoides* among inhabitants of the study villages

Village	Pre-treatment	Post-treatment	Z value	n
Ladin (control)	600 ± 4770*	80 ± 150	- 2.715	65†
Iyanfoworogi (1 year)	420 ± 3620	20 ± 1140	- 3.149	87
Akeredolu (6 months)	80 ± 1830	20 ± 800	- 1.404	125
Alakowe (4 months)	200 ± 2800	0 ± 100	- 4.465‡ ≤ 0.0001	87

* Intensity expressed as median e.p.g. (± interquartile ran.)
†Sample size for individuals who provided samples on both occasions.
‡At the 99.7% confidence level, pre-treatment and post-treatment intensity differed significantly
(From Holland *et al.*, 1996)

Impact of hygiene and health education on geohelminth infections

In 2002, a study was published on the relationship between ***Ascaris lumbricoides*** infection among pre-school-age children and the home hygiene situation in Ajebandele and Ifewara, 2 peri-urban communities near Ile-Ife, Osun State. Our results show that the prevalence of *A. lumbricoides* in the children at Ajebandele where there were more facilities for safe water supply (pipe-borne and shallow wells) and sanitation (flush toilets and pit latrines) was significantly lower than at Ifewara where more people throw excreta into the surrounding bush and depend on streams and ponds for water supply (Asaolu, Ofoezie, Odumuyiwa, Sowemimo and Ogunniyi, 2002; Asaolu, Ofoezie, Sowemimo, Odumuyiwa, Hassan and Onipede, 2004). I also contributed two chapters, one on *A. lumbricoides* and the other on *T. trichiura* in a book entitled *Antimicrobial Theapy and Vaccines* (Asaolu, Ofoezie and Onyeji, 2002; Asaolu, Onyeji and Ofoezie, 2002) and was commissioned by the WHO to write a review on "the role of health education and sanitation in the control of helminth infections" which was published in a special edition of *Acta Tropica* (Asaolu and Ofoezie, 2003).

A study on the application of anthelmintics for geohelminth control among infants aged 0-2 years has just been initiated jointly with Dr. C.V. Holland of Trinity College, Dublin and Dr. Titi Abiona of the Departments of Community Health, O.A. U. Ile-Ife. The planning of this study has enjoyed input from colleagues at the Parasitic Diseases Control Unit of the WHO and it involves the training of a Ph. D. student from Trinity College, Dublin. The field and laboratory work are taking place at Ile-Ife under my supervision.

Geohelminths of non-human origin

A full list of geohelminths should include some intestinal nematodes of dogs and cats, the ascarids, *Toxocara canis* and *T. cati* and hookworms, *Ancylostoma caninum* and *A. braziliense*. Infection of dogs and cats with the larvae of these worms will result in the establishment of the adults in the host intestine. However, in human, which is an abnormal host, the larvae of these worms wander to various body organs but are unable to complete their development and establish as adults in the intestine. Ingestion of *Toxocara* eggs by humans results in the condition known as **visceral larva migrans** while infection with the larvae of *A.caninum* and *A. braziliense* results in **creeping eruption or cutaneous larva migrans**. Hence these worms are primarily geohelminth zoonoses. A study, involving the training of a Ph.D. student on the problem of intestinal worms of dogs in Ile-Ife and environs, is currently going on under my supervision at the Department of Zoology.

WORKSHOPS ORGANIZED AND OTHER DUTIES ON GEOHELMINTHS

Two international workshops were organized by me in collaboration with Professor D.W.T. Crompton on the geoheminths. The first was on the theme of "Strategies for the Control of Soil-transmitted Helminthiases in Nigeria" held at the Conference Centre, OAU, Ile-Ife from 7 – 9 May, 1990. The second was held at Sheraton Hotels and Towers, Lagos on November 20 1992 on the theme *Parasite Control within Nigerian Primary Health Care.* Scientific papers were presented at these two meetings on the endemicity, morbidity, transmission, socio-economic issues and control strategies of the GHs. Participants came from academic institutions and the Pharmaceutical industry in Nigeria and Europe. The proceedings of the 1990 meeting were published in a monograph titled *Soil-transmitted helminthiases in Nigeria* (Asaolu, Crompton and Kale, 1990).

In August 1991, at the invitation of the WHO, I participated as a team leader, in a two-week training workshop organized for health workers in Kwale District, Kenya where an integrated control programme for intestinal helminthiases and schistosomiasis was being organized.

In November 2002, I was invited by the WHO to serve for a period of 4 years as a member of the WHO Expert Advisory Panel on Parastitc Diseases and later as a resource person for the global monitoring of resistance by the parasitic helminths to anthelmintic drugs.

CONTROL OF GEOHELMINTHS IN NIGERIA

The prevailing rates of geohelminths infections in Nigeria, as shown in the literature, are unacceptably high and if adequately examined, they will be found to pose serious medical and socioeconomic burden on the generality of the people in this country. Therefore there should be no further delay in establishing a credible programme to bring these geohelminths under control in the country. This is particularly important because of the children from economically deprived background who carry the greatest burden of these worms in the community, and in view of the fact that these infections could compromise their cognitive and physical development. To quote Gabriela Mistral, Nobel Prize winner poet from Chile,

'We are guilty of many errors and many faults, but our worst crime is abandoning the children, neglecting the fountain of life. Many of the things we need can wait. The child cannot. Right now is the time his bones are being formed, his blood is being made ad his senses are being developed. To him we cannot answer 'Tomorrow'. His name is 'Today''

Many of the industrialized countries where geohelminths are no longer common today have also been endemic for these worms in the past but the worms have been eradicated through public awareness and improvement in personal and municipal hygiene. In Japan the national annual average prevalence of *A. lumbricoides* was 62.9% in 1949 but following implementation of a parasite control programme, this fell gradually over the years to 0.05% in 1982 (Yokogawa, 1985). If it could happen in Japan, it can happen in Nigeria too if we are determined. The steps to take are what could be easily integrated to existing PHC programmes in the country.

1. There should be a national survey, using uniform diagnostic laboratory procedure to determine the prevalence and intensity of these worms at the local governmental level.

2. A regular deworming programme for school-age children in the country should be established to reduce the worm load in the communities

3. There should be adequate supply of safe portable water to every citizen of this country in order to improve personal hygiene and environmental sanitation.

4. It should be made mandatory for facility for safe disposal of human excreta to be provided at every home and in public places. Indiscriminate defaecation should be discouraged.

5.Food for consumption must be protected from houseflies and cockroaches because these insects visit latrines and refuse dumps and carry infective helminth ova and protozoan cysts on their bodies.

6.The general public should be enlightened about dangers associated with geohelminths and how to avoid infection.

7. Nigeria needs to pay more attention to the problem of mounting refuse in our major cities because refuse dumps frequently serve as sites for indiscriminate defaecation and for breeding of flies.

I belief that an effective control of the geohelminths will be a profitable investment for the country in that all the measures recommended above will in addition to tackling the problem of geohelminths also lead to the control or eradication of many other diseases transmitted through the faeco-oral route.

OTHER STUDIES ON PARASITIC HELMINTHS

In addition to the studies described above, I also participated in a number of collaborative research work on onchocerciasis (river blindness) surveys in the Federal Capital Territory, Abuja, in three Local Government Areas in the former Bendel State and in the Kainji Lake Basin Area of Kwara and Niger States from which seven publications were produced (Asaolu, 1983, Edungbola and Asaolu, 1984, Abayomi *et al.*, 1986, Edungbola *et al.*, 1986, 1987, 1990, 1991). From other collaborative studies, six papers were published on the problem of schistosomiasis in Nigeria (Asaolu and Ofoezie, 1990, Adewunmi *et al.*, 1982, Edungbola *et al.*, 1988, Ofoezie *et al.*, 1991, 1997, Ofoezie and Asaolu, 1997).

BENEFITS TO LOCAL COMMUNITY FROM RESEARCH ACTIVITY

St. Andrew's Clinics for Children (STACC), is a charitable company registered in Glasgow, Scotland UK, with the objective of "supporting and developing health care for children in Africa". Professor D.W.T Crompton, a research colleague, is a member of the Board of Directors. In 1998, I applied to STACC to support the running of a mobile clinic at Ife and this was accepted. This I saw as an opportunity to help children from the less privileged sector of our society. With approval from the university authority and the assistance of the Health and Medical Services Unit, a medical team was set up to run the clinics. Since September 1998, STACC has opened clinic centers at Ifetedo (Ife South LGA), Ile-Ife (Ife Central LGA), Ifewara (Atakumosa West LGA) and Ikire (Irewole LGA) where, to date, 825, 3181, 2032 and 2174 children have been registered respectively. The medical team visits each community fortnightly, when sick children brought to the clinic venue provided by the people are examined by the doctor and treatments prescribed are administered by qualified Midwife. Between December 2002 and January 2005, STACC gave out up to 1600 insecticide treated bed nets to children and their mothers to reduce episodes of malaria at Ifewara, Ile-Ife, Ikire, Abata Egba and Yekemi. All services provided by STACC in these communities are free.

In 1999, the ICI Pharmaceuticals Plc UK provided some drugs for use in our STACC clinics. The excess of the drugs supplied was donated to the University Health Centre to assist the university community. The drugs donated to the university included 360000 250 mg tablets of Avloclor, 92344 100 mg tablets of Paludrine, 80 litres of Hibiscrub antiseptic and 88 litres of Hibicet antiseptic (see OAU News Bulletin Issue No.1, Vol. 1 of Friday, August 6, 1999).

In 2001, the STACC Board provided for us two FUKUDA DENSHI FFsonic UF-4500 General Purpose Ultrasound scanners with probes. Dr. P.A. Odumuyiwa was sponsored by STACC to train to use one of the scanners for patients attending STACC clinics. The second machine was donated to the Obafemi Awolowo University Teaching Hospitals Complex (OAUTHC) to assist the hospital. The machine was delivered to the hospital on December 13, 2001, as reported in the OAUTHC News Bulletin Vol. 18, No. 1 Jan-July 2002.

Recently, I was asked to nominate a member of STACC medical team for a 3-month WHO sponsored workshop on the diagnosis and management of tropical infectious diseases being held in Italy and Tanzania from May to July 2005. Dr. A.O. Hassan of the University Health Centre who was nominated is currently on the course.

A number of equipment and materials I obtained through collaborative research with staff of Zoology Departments University of Dublin, Ireland and University of Glasgow, Scotland are available for students and staff in our Zoology Department.

I will take this opportunity to thank my research colleagues and technical assistants who have made the investigations presented possible.

The Vice Chancellor sir, kindly permit me to acknowledge the support of members of my family, my wife, Olabisi Asaolu, and children, Wole, Bunmi, Yemi and Ebun. I think I should mention that the funds with which I purchased 600 of the bednets distributed to the children at STACC clinics was sourced by Bunmi Asaolu, representing a prize he won through his participation in a competitive programme organized by the Goldman Sachs Foundation when he was a student at Imperial College, London. Part of the facility was used to provide materials for some of my students research projects on malaria endemicity among children at Ifewara and Ikire. The results from one of these projects have since been published (Alo, *et al.*, 2005).

Finally sir, I give God the glory and honour for the little contribution that I have been able to make to the academic life of this great university. I count it a great privilege to be an alumnus of this university, Great Ife. Thank you all for your time and God bless.

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