UNIVERSITY OF ILORIN

THE ONE HUNDRED AND THIRTY-FOURTH (134TH) INAUGURAL LECTURE

'THAT WE MAY LAY SIEGE'

By

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My Fellow Scientists,
My Lords, Spiritual and Temporal,
Distinguished Guests,
Gentlemen of the Press,
Great Nigerian Students, in particular University of Ilorin Students,
Ladies and Gentlemen.

1.0 Preamble

The 134th inaugural lecture of today is the 2nd in the series in parasitology in the history of this university. The first was presented over two decades ago by one of our most respected icons in parasitology, Prof. L.D. Edungbola which was titled 'the crawling flier.., the flying crawler.., the warring worms... and the wormy world'. Mr. Vice Chancellor Sir, this inaugural lecture is coming barely two years after my appointment as a Professor, a statutory function I am expected to perform to this distinguished

audience. l give thanks to Almighty God, my creator and benefactor that made today a reality in my life because, to me, it is a rare privilege to speak as the 4th inaugural lecturer in this august academic ceremony in the history of Zoology Department of this University. I am obliged, therefore, to acknowledge late Prof. V.L. Yoloye, Prof. S.O. Oduleye and Prof. Gladys Nzeh that blazed the trail in Zoology as the 15th, 37th and 128th inaugural lecturers respectively of this great University, justifiably christened '*Better By Far'*.

1.1 Introduction

Zoology as rightly conceived by Aristotle (382-322 BC) and Charles Darwin (1809-1882), deals with forms and functions, behaviour, evolution and the relationship of animals' species to one another and to other living organisms in their environment. Unfortunately our understanding of this concept has been primarily centred on the conservation of animals and therefore holds the impression that zoology begins with simple microscopic animal, *Amoeba* and ends with large mammal, elephant. Such a misconception would indeed raise a depressing question, 'who wants to work in the zoo and behave like animals'? A number of other questions to wean the interest in zoology are tangentially related to a bleak future for the professional. It does not matter if the course contributes to the scientific understanding of the laws of nature. Really, if zoology is only about animals in the Zoo, surely you can do nothing with it in terms of job security. But our definition above suggests that the interests of the founding fathers of Zoology to understand the nature of animals that lived with

man since creation has fundamental implications on both animal and human health.

The definition of zoology as stated above indicates that no animal (indeed organism) exists in absolute isolation - they associate or live with other animals/organisms for metabolism, food, shelter and to sustain the environment. This is ecologically termed **symbiosis**. Animal associations are of two types; association between animals of the same kind/species (homospecific) and association between animals of different species (heterospecific). The former is out of the scope of my lecture, while the latter, heterospecific association vary widely, depending on the degree to which the participating species interact. For the purposes of this lecture, I will briefly explain the three heterospecific associations relevant to the context of this lecture:

a. Mutualism: when two different species of an organism associate for both partners to derive benefits.

b. Commensalism: Where one of the associating organisms benefits from the other participating species, while the other neither benefits nor loses.

c. Parasitism: where one of the associating organisms benefits and the other does not, rather it is harmed. My lecture will focus on this aspect of the relationships. Parasitism is clearly a one-sided partnership; the benefitting member in the association (the parasite) lives on or within the other member (the host). Literally, a parasite is likened to an individual who does not work and contributes nothing to human needs but lives on the efforts of another individual to whom it subsequently causes harm. In human society, such an individual will be viewed with disdain, disgust, or condemned. But parasites may not be as

disgusting. They are an integral component of the biosphere because they are God's creatures that have completely lost their ability to synthesize vital natural components for their independent existence and therefore have to live at the expense of their hosts. They are separated into three different functional categories:

- **Microparasite**: Mainly the viruses, bacteria, fungi and protozoa which are about few hundreds of micron in size;
- **Macroparasite**: This includes the tape worms, flatworms, roundworms and the parasitic arthropods and;
- **Parasitoids**: They are free living parasitic insects, but the insects' early stages parasitize other animal hosts which may die as a consequence of their infection before the insect attains maturity.

Historically, Zoology does not include some microparasites like the viruses, bacteria and fungi, but strictly animals, and of interest are those living at the expense of others. The latter falls within the discipline of **parasitology.** A *parasitologist* therefore is the scientist that studies parasites and the relationship between the parasites and their hosts.

Mr. Vice Chancellor sir, my story of academic stewardship for the past two decades will be centred on parasitology. It may partly address the frequently asked and puzzling questions on the fundamental concept of zoology and its relationship with medical science.

2.0. The Parasitic Animals

Animals with parasitic mode of life are far more in number than the nonparasitic animals, varying across a

wide range of body size in nearly all existing animal groups, from the simplest single-cell protozoa to the complex multicellular worms. They belong to five of the major groups into which the animal kingdom is divided. They are:

- **Protozoa**. Comprises mainly of microscopic animals, grouped into four basic forms:
  i. The flagellates, commonly *Giardia lamblia* in the digestive tract; *Trichomonas vaginalis* in the genital organs and *Trypanosoma* species in the blood where they cause dysentery, vaginitis and sleeping sickness in human host respectively.
  ii. The parasitic amoebae, *Entamoeba histolytica* occurs in the colon of man and primates and causes dysentery and diarrhoea. Others (*Naeglaria* and *Acanthoamoeba*) are tissue-invading amoebae.
  iii. The Apicomplexa, to which the coccidians, *Plasmodium* (the malarial parasites) and piroplasma (*Babesia* and *Theileria*) belong, cause severe pathologies in both man and animals.
  iv. The only ciliate of medical importance is *Balantidium coli,* living in the intestine of pigs and humans and causes dysentery in the latter.
- **Platyhelminths** (flatworms) are the flukes and tapeworms. Some flatworms of the genus *Schistosoma* and *Paragonimus* that inhabit the blood and lungs of their hosts' are extremely damaging in human host. A number of other flukes such as *Dicrocoelium* and *Fasciola,* the liver flukes are majorly of veterinary importance.

The most important tapeworms that cause obvious harm in man are *Taenia* species and the fish tapeworm, *Diphyllobothrium latum*.

- **Nematodes** (roundworms) are cylindrical worms with pointed ends. Some are parasites of plants, vertebrates and invertebrates while others are free-living. The medically relevant species are the intestinal worms- *Ascaris lumbricoides* (large worms), *Trichuris trichiura* (whipworm) and the hookworms (*Ancylostoma duodenale* and *Necator americanus*). Others are the blood-dwelling *Wuchereria bancrofti* and the tissue-dwelling *Onchocerca volvulus* that cause elephantiasis and river blindness respectively. Domestic animals such as poultry and sheep are also frequently infected with nematodes that colonize the intestine, lungs, muscles or eyes.
- **Acanthocephalans** (the spiny-headed worms) are like the nematodes, cylindrical with pointed ends but they lack digestive tract and possess a prominent retractable proboscis for attachment to hosts' intestinal wall. *Monoliformis* is the only species associated with human infection.
- **Arthropods** are animals with jointed limbs. It consists of the crustaceans (pentastomids and Cyclops), the ectoparasitic Arachnids (ticks, mites, lice) and fleas (*Tunga penetrans*), and the insects (Mosquitoes, Tsetse fly, blackfly). Pentastomids, the tongue worm is associated with swelling syndrome of the throat while *Tunga penetrans* (jigger) causes ulcerative lesions. Blood-sucking arachnids and insects are transmitters of other parasitic animals that cause severe pathologies on their hosts; Mosquitoes (*Anopheles, Culex* and *Aedes*)

transmit malaria parasite and lymphatic filarial worms while tsetse flies and black flies are the causative agents of sleeping sickness (trypanosomiasis) and river blindness (onchocercarasis) respectively. A number of other insects' larva invade or develop in digestive system, nose, pharynx, ear, eye and skin as myiasis.

The occurrence of parasites even in the smallest animals like insects indicates that all animals offer potentially favourable habitats for a would-be parasite. The location of parasite in a host is an evidence of adaptation to that particular site, whether inside or outside a host. Surprisingly, every available space in humans and other large mammals offers a wide variety of favourable conditions for parasites to colonize as illustrated in figure 1.

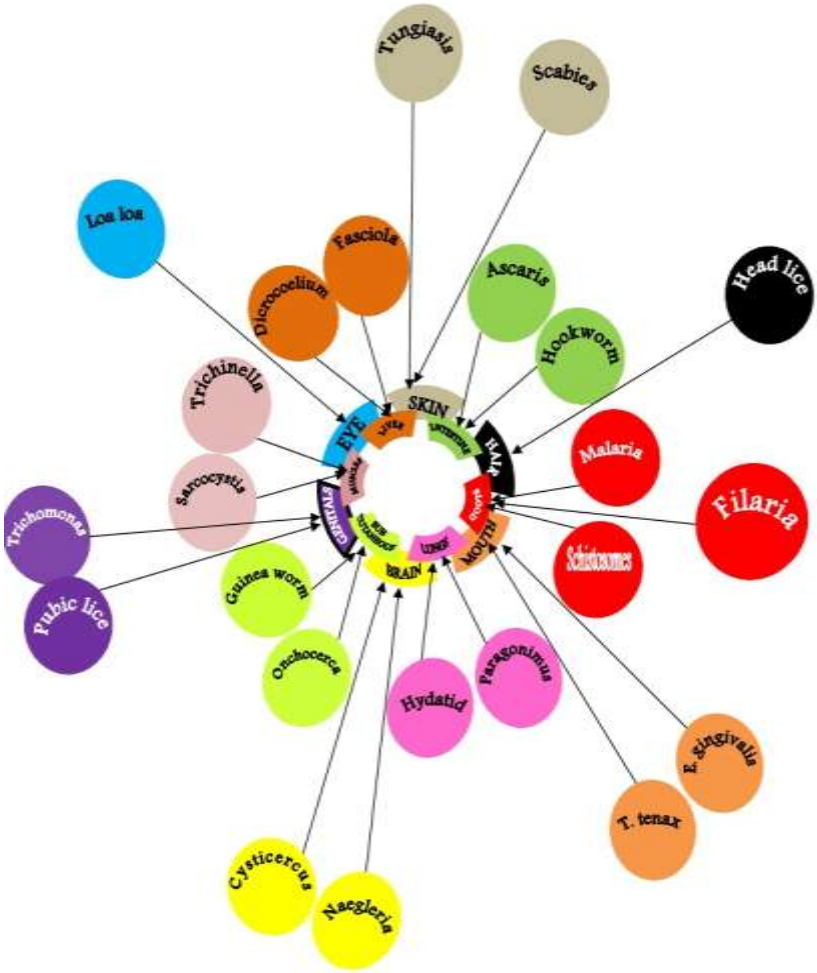


Fig. 1. Some parasites living in various regions in human hosts (Original)

The survival of a parasite depends primarily on its ability to access, establish and reproduce in the desired host. Every parasite reaches its desired hosts either by **indirect** process (if intermediate organism(s) are required to nurture the parasite to infective stage) or **direct** process (if no intermediate organism is required). These processes are facilitated through:

Foods: Commonly, foods and beverages prepared under poor hygienic conditions including those sold by vendors in streets and other public places for immediate consumption. Examples of such parasites are roundworms, amoebae, *Giardia, Cryptosporidium, Paragonimus, Taenia, Trichinella*

Soil: A well-aerated, non-adhesive sandy soil or moderately moist humus soil, with a pH of 6.5-7.0 serves as a conductive environment for the survival and development of eggs and larvae of parasites that contaminate foods/water or actively penetrate unbroken skin of host victim. This includes round worms (*Ascaris, Trichuria*, hookworms and *Strongyloides*) and the intestinal protozoans' amoebae, *Giardia*

Water: This is the most important medium for the transmission of many infective stages of parasites. Water-related parasitic infection occur

- by drinking contaminated water (i.e. water-borne) e.g. amoebiasis (including the free-living tissue invading species, *Naegleria, Acanthoamoeba), Giardia*, and *Cryptosporidium* species,
- through other water-inhabited organisms (i.e. water-based) e.g. guinea worm, schistosomes and,
- by lack of water supply (i.e. water-washed) e.g. scabies

Other Animals: Chiefly the lower ones that serve as reservoir and intermediate hosts. They actively carry the parasite from one host to another**.** These include mosquitoes (transmit malaria and elephantiasis); blackflies (river blindness), Tsetse fly (Sleeping sickness), Sand flies (leishmaniasis); Ticks (babesiosis), Cyclops (Guinea worm).

Sexual Contact: Contagious parasites like Amoebae, *Trichomonas*, *Giardia*, pubic lice and Scabies are transmitted through this process.

Dust or Air: The infective stages of pinworm and *Toxoplasma gondii* are carried in dust particles (air-borne)

Parasites' successful contact with a host does not always translate into infection. Infection only occurs in a natural condition when the host and the parasite make contact and mutual reaction between them favours the survival of the parasite. This is because parasites access several potential host species, some of which will be preferred (i.e. normal host), with which it will establish an infection while in others (abnormal/wrong hosts), the parasite is unable to survive and spread within the host population- host specificity.

The choice of a host among parasite species is influenced by the phylogenetic and/or environmental factors. If the environmental and physiological factors in a host are adequate for the survival and development of a parasite, such host becomes <u>susceptible</u> to infection otherwise, infection fails and the host is said to be <u>unsusceptible</u> or resistant to the parasite. This accounts for why variability in the reaction to parasitic infection is determined partly by genetic constitution of the parasite itself and the host. But like every other organism that

struggles for existence, parasites evolve strategies to survive in related hosts other than the naturally desired host; literally saying that if the *'desirable is unavailable the available becomes desirable'*. It is therefore not surprising to observe a human parasite in other animals from which he may have acquired the parasite. Technically, this is termed **zoonosis,** i.e. a parasite is transmissible between man and animals. However, the success of a parasite in host-parasite relationship depends largely on the level of hosts' degree of tolerance. An attempt for the parasite or the host to 'over react' in the association makes both parties do the best of a bad job; as the hosts tend to reduce the inconveniences posed by the parasite, the parasite would have to strive to live as unobstructively as possible in a hostile environment in the host. Thus, the degree of injury caused by parasite on its host is often an evidence of unperfected relationship between the parasite and the host. As much as the effect of parasite on their host is a problem, it would be a suicide mission for it to kill the host.

2.1. What is Potentially at Stake?

Parasites infect both man and animals worldwide, with high prevalence and mortality in many regions. The amount of harm caused by infection varies considerably with individuals or population depending, among other factors, the type of parasite, intensity of infection, nutritional and immunological status of the affected host, and for humans, the socio-economic factors. Today, about 300 species of parasitic worms and over 70 species of parasitic protozoa infect man (Ashford & Crewe, 1998). A few of these have exclusively become adapted to humans and notoriously deforming and disabling the affected. This

level of impact is often associated with intense stigma. The greatest number of these parasitic infections occurs in equatorial regions of the world, tropical and subtropical regions of Asia, Latin America and sub-Sahara Africa with decreasing prevalence as latitude increases. The reason for their high occurrence in these regions is that warm and humid climate favours the breeding and development of the parasite infective stages and their intermediate hosts. The World Health Organisation (WHO) noted that several parasitic diseases contribute significantly to the overall burden of disease globally, particularly in the developing countries in Africa. Many of these debilitating diseases have now been classified as 'neglected tropical diseases' (Table 1).

Table 1: Neglected tropical Parasitic diseases and their prevalences

Parasite categories	Parasitic diseases	Approx. Global prevalence
Protozoan infections	• Amoebiasis • Giardiasis • Human African trypanosomiasis, Visceral & cutaneous • leishmaniasis, • Chagas disease (South America) • Malaria* • Cryptosporidiosis • Toxoplasmosis	- - <0.01 million 12 million 8–9 million 515 million - -
Helminth infections	• Soil-transmitted helminths (hookworm, *Ascaris*, *Enterobius*, *Stronyloides*, *Hymenolepis*, *Trichuris*) • Schistosomiasis (*Schistosoma mansoni*, *haematobium japonicum)* • Food-borne trematodiasis (*Clonorchis*, *Opisthorchis*, *Paragonimus)* • Trichinellosis • Lymphatic filariasis, • Onchocerciasis, • Dracunculiasis	576 million (hookworm) 807 million (ascariasis) 604 million (trichuriasis) 207 million 20–40 million ND 120 million 37 million <0.01 million ND

	• Taeniasis (bovine cysticercosis, echinococcosis)	
Ectoparasitic skin infestations	Tungiasis, Sarcoptic scabies, Pediculosis Myiasis	- - - -

(WHO, 2010)

Mr. Vice Chancellor sir, there is really no single consensus definition for this group of diseases, but they are referred to as *Neglected Diseases* because they affect the poorest of the poor (*the Neglected Populations*). They are largely ancient infectious diseases whose conditions and treatment have been described in the Holy books (Bible and Qur'an); their infections do not often lead to epidemiological emergencies and thus attract little or no attention from the media and the public sector.

Meanwhile, an estimated global death rate of 530,000 (1,452 deaths/day), with Disability Adjusted Life Years (DALYs) loss of 57 million occur annually as a consequence of these infections. About 85% of these disease burdens are attributable to helminths infections. The prevalence figure of some of these parasites in sub-Saharan Africa shows that Nigeria is indeed the 'giant theatre' of parasitic infection (Table 2).

Table 2: Geographical Distribution of some major helminth Neglected Tropical Diseases in sub-Saharan Africa

Disease (No. of cases in SSA)	Estimated SSA Disease burden in DALYs	Country with Highest prevalence	Country with 2nd Highest prevalence	Country with 3rd Highest prevalence
Hookworm (198 million)	0.5–7.5 million	Nigeria (38 million)	DR Congo (31million)	Angola & Ethiopia (11 million)
Schistosomiasis (192 million)	1.6–4.2 million	Nigeria (29 million)	Tanzania (19 million)	DR Congo & (15 million)
Ascariasis (173 million)	0.4–2.2 million	Nigeria (55 million)	Ethiopia (26 million)	DR Congo (23 million)
Trichuriasis (162 million)	0.5–1.7 million	Nigeria (34 million)	DR Congo (26 million)	South Africa (22 million)
Lymphatic filariasis* (382-394 million)	2.0 million	Nigeria (106 million)	DR Congo (49 million)	Tanzania (31 million)

Source: Hotez & Kamath (2009), *PLoS NTD **3**(8). e412*

Whilst the diseases may not result in immediate death, they are of public health importance. Many of them are debilitating with great adverse impact on children education, adult work output and general social lives. For instance children heavily infected with soil-transmitted helminths suffer from mental alertness and learning disability (WHO 2010). This situation obviously will set up a vicious cycle that leads to low intellectual capacity of affected children and illiteracy as school drop-out increases. In adults, disability due to hookworm, guinea worm, river blindness and elephantiasis impacts on the farmers' productivity. It thus impairs economic growth since income and agricultural earnings will be affected. This is the poverty trap that characterizes the burden of parasitic diseases in the poor endemic communities (Fig. 2).

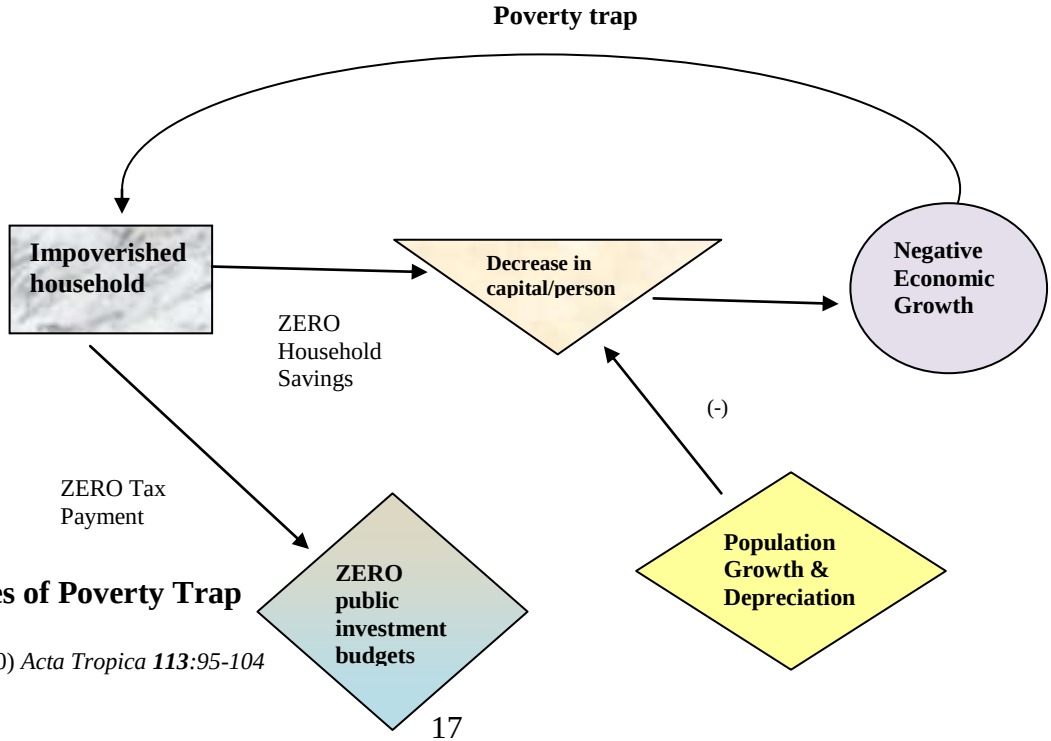


Fig.2. Features of Poverty Trap

Source: King (2010) *Acta Tropica* ***113****:95-104*

The economic costs of parasitic diseases are already significant, and their increasingly heavy toll on productivity and foreign investment could reduce GDP by as much as 20 percent or more by the next decade in some sub-Saharan African countries. According to recent studies, the annual cost of malaria to Nigeria GDP is estimated at 1 to 6%. This economic loss can best be imagined if the daily figures of all malarial cases reported in our hospitals are treated conservatively on an average cost of about ₦800. It is therefore not surprising when WHO (2008) and Hotez and Kamath (2009) reported that a small farmer in Nigeria spends 13% of his total household income on malaria treatment that could otherwise go to other forms of consumption of more benefit to the economy per year. Persistent infection is likely to aggravate and, in some cases, may not only provoke economic decay but also social fragmentation and political destabilization as already being experienced in Nigeria.

In sub-Saharan Africa, hundreds of millions of people are afflicted with these parasites, and more than a quarter of the affected population has one or more infections occurring simultaneously (Fig.3)

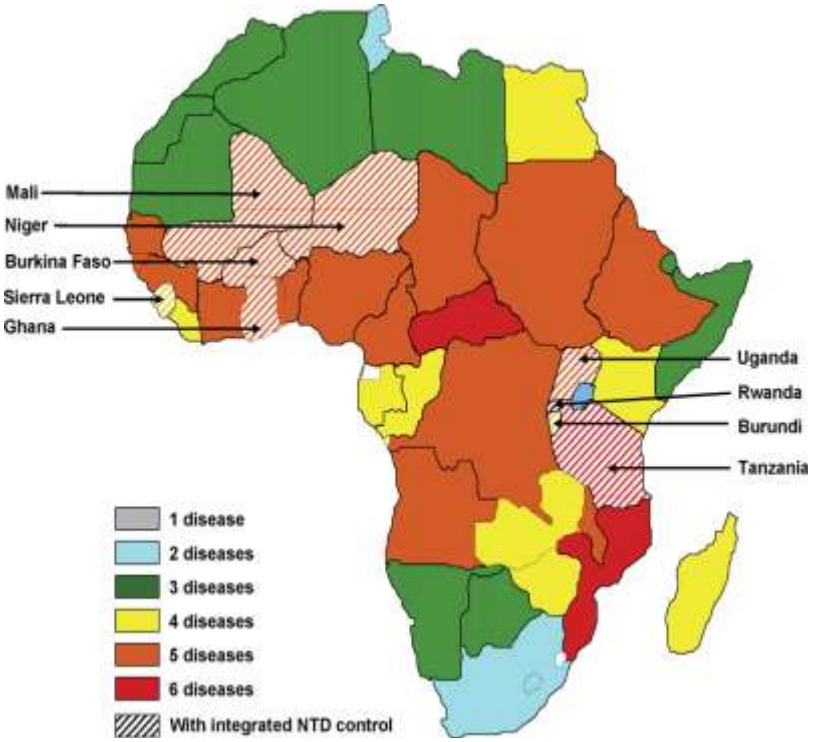


Fig. 3. Distribution map of polyparasitism in Africa
SOURCE: Fenwich et al. (2009).

Schistosomiasis and soil-transmitted helminths (STH) have become the most prevalent public health problems in sub-Saharan Africa while STH is endemic in many countries of the region. It is of common knowledge that malaria parasite is the leading cause of death in Africa, with 1 out of every 4 infantile death attributable only to malaria (Mokuolu, 2012). This is not the case in high-income (developed) countries where the causes of death are

majorly non-communicable diseases such as heart disease, stroke, lung cancer and asthma. In contrast, parasitic diseases remain the leading cause of death in Africa, and will continue to be with the prevailing indices of unhealthy lifestyles, land use patterns, increased trade and travels. The situation will be exacerbated by the inescapable climatic shifts that are likely to enable some diseases and associated vectors, particularly vector-borne diseases like malaria, elephantiasis and schistosomiasis to spread to new areas. The effects of increasing warmer temperatures and increased rainfall in higher latitudes have already expanded the geographic range of malaria to some areas in sub-Saharan Africa and Latin America hitherto unaffected. This scenario is estimated to add several million more cases of malaria in the disease burden of developing countries over the next two decades. The occurrence of waterborne diseases associated with temperature-sensitive environments is likely to increase.

3.0 **My research contribution**:

Mr Vice Chancellor Sir, I have over the years beamed my research light on the interaction between factors that determine the course of infectious animals and their transmission in communities of hosts. The ultimate aim is **to lay siege to infectious animals by formulating appropriate control strategies that will end the pains of our people.** In appraising my humble research efforts in parasitology, I would like to provide background information on the parasitologist, the inaugural lecturer, and the parasitic disease status in our environment.

My voyage in the academic world started in a state University, Bendel State University (now Ambrose Alli

University), Ekpoma where I had my first degree as a pioneer graduate. As the best graduating student of my set (1984/85 session) I was offered automatic appointment as a Graduate Assistant barely a year after my National Youth Service Corps (NYSC) programme. I was reluctant in accepting this offer because of the stigma of becoming a 'pure village breed', having had my primary, secondary and tertiary education in villages. My desire then was to participate in academic activities in University of Benin, Benin-City where I was running my Postgraduate Programme.

Before now, my focus in parasitology bordered on the inadequate information on parasites of animals, particularly the peri-domestic and domestic ones that are constantly in close contact with man. The aim was not just to identify and categorize the parasites of these animals but also to evaluate the relative economic and medical importance of many of the unknown species of parasitic organisms and apply the information in the development of risk management strategies. With all the prospects, relevance and enthusiasm to break new grounds in this area, I was compelled to shift focus and specialize in epidemiology by the forces of economic recession and poor funding of Universities that left many research laboratories devoid of equipment.

Epidemiology deals with the ways parasites spread from host to host, studies the risk factors responsible for such spread and the effects of the parasites on the hosts; and thus suggest ways to prevent disease spread. As a Zoology-based parasitologist, 'laying siege' to infectious animals of public health importance is a moral duty to those I believe paid for my education, training and salary from

their taxes. My contributions through the application of my professional skills are therefore considered legitimate. Such driving force, challenges and satisfactory outcome were expressed in the mission statement of Professor Edungbola in his inaugural lecture of 1995, where he said:

> *"Whereas the Nigerian orthodox parasitology has its own relevance in training, it has translated into practice and application in order to meet the aspirations and need of the Nigerian society"*

How these societal needs were met by my research findings, even in the face of economic recession, was my greatest satisfaction in the academic world.

3.1. My Research in Food and Soil-Transmitted Parasites

The round worms most commonly associated with human diseases are the large worms (*Ascaris lumbricoides*), hookworms (*Ancylostoma duodenale*, *Necator americanus*) and whipworms (*Trichuris trichiura*). These worms live in different parts of human intestine, feed in different ways and successfully evade the force of hosts' immune system to maintain a long duration of infection in the host. But their infective stages enter their host victim through the mouth as a contaminant of food and water or fingers except for the larvae of hookworms which can also enter the host body by skin penetration. The severity of infection is related to the number of adult worms in the host (worm burden) as seen in plate 1.

Plate1: Patients with heavy worm load of large worm (*Ascaris lumbricoides*)

Individuals with low worm burden are usually asymptomatic, suggesting that they do not provoke diseases that will require serious medical attention. This is not the case because individuals with heavy worm load can be associated with severe and fatal syndromes leading to significant physical growth retardation, malnutrition, cognitive and educational impairments in children. Mr. Vice Chancellor sir, it is sad to know that our country, Nigeria has the highest number of infected cases of ascariasis (55 million), hookworm (38 million) and trichuriasis (34million) in sub-Sahara Africa (Hotez & Kamath 2009).

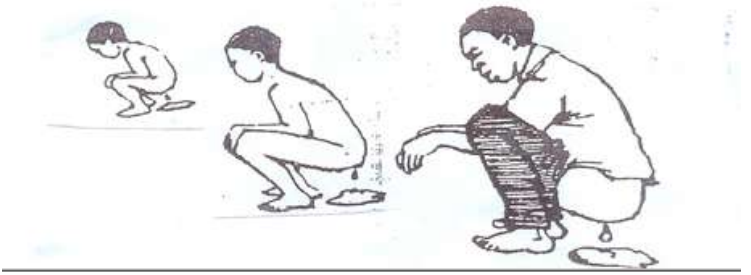
Permit me to acknowledge the notable contribution of many of our researchers in this area, particularly Prof S.O Asaolu of Obafemi Awolowo University, Ife on ascariasis, late Profs A.B.C Nwosu and J. Udonsi of

University of Nigeria Nsukka on the ecology of hookworm. Our current disease status on these worms shows that much is left to be done. The challenge of laying siege on these infectious animals spurred my earliest study on how and why infections remain unabated among our people. In our first study in a rural community in Osun state, we observed that four of every five persons in the community had one or more of these parasite species and overall prevalence of some of the parasites was three to four times higher than the National average (Ugbomoiko & Ofoezie, 2007). Children not attending schools were more at risk of infection than their counterparts attending schools. Bad enough, infections due to intestinal helminths were not independent of one another; they frequently co-occur with other parasite species. In many cases it is not uncommon to find two or three of these worms in children thus, complicating their disease condition. The impact of such (multiple) infection might be multiplicative or antagonistic.

Ugbomoiko et al. (2012) observed that individuals with *Ascaris* infection harbour more worms and were twice more likely to have *Trichuris* infections as compared to individual without *Ascaris*. Similarly individuals co-infected with hookworm and *S. mansoni* had higher number of adult hookworms and were four times more likely to have *S. mansoni* as individuals without. Further investigation showed that socio-environmental factors play major roles in the disease transmission in this community (Ugbomoiko et al. 2009a). Ugbomoiko et al. (2006b) confirmed earlier reports that the trios of *A. lumbricoides, T. trichiura* and hookworm are the commonest intestinal parasites, mostly in children; the infections were acquired through individual unhygienic practices - walking

barefooted, eating with unwashed hands after a hard-day farm work/playing or eating unwashed fruits and vegetables as illustrated in the figure 4 below.

The habit of hand feeding among the poor, ignorant villagers in our communities play significant role in faecal-oral transmission *of Entamoeba histolytica* and related parasites



In Nigeria, the habit of indiscriminate defaecation, especially among the rural poor communities aid and abate the spread of *E. histolytica* and other faecal-oral transmitted parasites

Fig. 4. Some processes of transmission of parasitic diseases
Source: Nwoke (2012)

3.2. My Research in Water-Borne Parasites

Schistosomiasis is a water-borne parasitic disease, ranked as the second most predominant Neglected Tropical Diseases in the world. The disease is endemic in all

countries of Africa except in Lesotho, but control programmes are currently going on in Burkina-Faso, Cameroon, Mali, Niger, Tanzania, Uganda and Zambia (Mone et al. 2010). The earliest report of this disease in Nigeria dates back to 1929 with less than 30% cases of infection (Robertson, 1929). It has increased steadily overtime to a large-scale epidemic status in Nigeria; with current estimate of 29 million out of the infected 192 million cases in sub-Saharan Africa (Hotez and Kamath, 2009). This shows that Nigeria harbours 93% of all schistosomiasis-infected cases in Africa.

The sudden increase in the occurrence of the disease is attributable to the drastic increase in water development projects required for food production and generation of hydroelectric power (Cowper 1973; Ofoezie 2002.). Here in Nigeria, the disease is caused by two major parasite species, *Schistosoma mansoni* and *S. haematobium*. The latter is more widespread in our country, Nigeria. They develop in aquatic snails (species of *Bulinus* and *Biomphalaria*), abundant in many natural freshwater bodies (rivers, streams, ponds, lakes, swamps and irrigation channels) in all the states of Nigeria (Betterton 1984; Ndifon & Ukoli 1989; Ugbomoiko 1998; Ofoezie 1999; Ugbomoiko, 2006a). It is therefore expected that cases of infection will occur in several remote and rural communities in our country if the infective agents are present. The pattern of prevalence and intensity of infection from the four cardinal zones of Nigeria (Betterton et al. 1988; Ozumba et al. 1989; Bello and Edungbola 1992; Ogbeide et al 1994; Ofoezie et al. 1997; Okoli and Odaibo 1999 Oladejo and Ofoezie 2006) and, indeed all endemic areas in sub-Saharan Africa (Wilkins et al. 1984,

Chandiwana et al 1988, Raso et al. 2005), indicated that the index of transmission is highest in children of school age, 11 to 15 years. This was validated by Ugbomoiko (2004) as seen in figure 5.

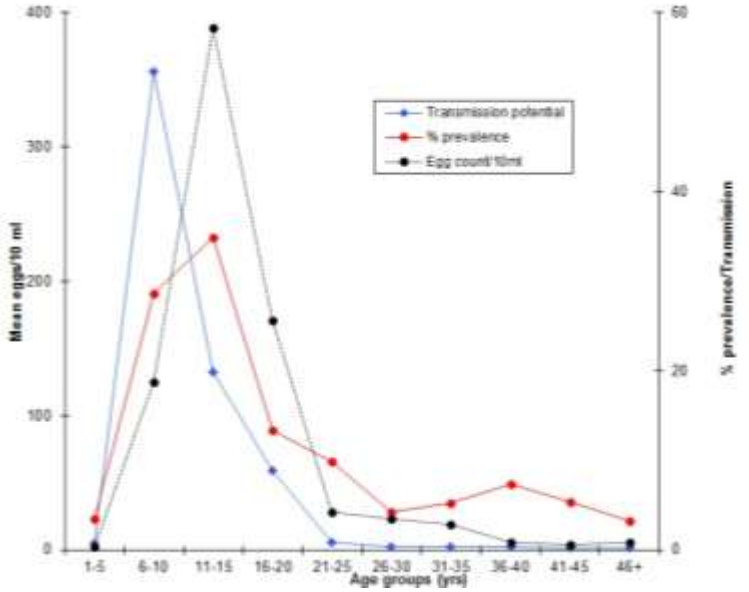


Fig. 5. Age –specific curves of prevalence, intensity and relative index of transmission.
Source: Ugbomoiko (2004a) Nig. J. Pure & appl. Sci. 19, 1560-1569

These reports of cross-sectional studies may clearly not represent the actual number of infected cases in the study areas, but show that the forces of infection vary, correlating the ecological and socio-cultural peculiarities of the community concerned. Our recent study conducted in

Osun state (Ugbomoiko et al. 2010a) revealed 62% infection rate with egg load of 114eggs excreted in 10 ml of urine. This was higher than the result of our studies in Edo state (Ugbomoiko 2000) and the earlier report of Oladejo and Ofoezie (2006), indicating that infection has remained unabated. My pre-occupation was how best I can assist the affected communities to lay siege and provide a relatively parasite-free (conducive) environment. This requires reasonable preventive measures which must consider **who, where, how, when and why** people engage in behaviour which puts them at risk of contracting schistosomiasis. Ugbomoiko (2000) reported that infection is periodic, occurring more during the dry months of the year (December to March). This coincides with the peak periods of daily water activities of man (i.e. afternoon) when nature usually calls for a cold bath (Ugbomoiko 2004).

Table 3: Incidence rate of urinary schistosomiasis with age group according to seasons

Age (in years)	15 Dec-31 May (165 days)		1 June – 13 Sept. (105 days)		1 Oct. – 31 Dec. (93 days)	
	No. Exam.	No. inf.	No. Exam.	No. inf.	No. Exam.	No. inf.
3-4	14	10	14	0	14	0
5	20	1	18	0	18	0
3-5	**7.6%**		**0.0%**		**0.0%**	
6-7	22	1	19	0	19	0
8-9	20	1	18	0	18	0
10	21	1	18	0	18	1
6-10	**12.6%**		**0.0%**		**7.0%**	
11	11	1	17	0	17	0
12	17	1	16	0	16	0
13-14	20	2	16	1	15	1
15	20	1	18	0	17	1
11-15	**16.8%**		**5.0%**		**11.5%**	

Source: Ugbomoiko (2000) *Australian & New Zealand J. of Pub. Hlth.**24** (6):* 642-643

This study became a pre-requisite for a clearer understanding of how the disease spreads within localities in southwestern Nigeria. As a basis for planning sustainable intervention, Ugbomoiko et al. (2010a) investigated and showed how behavioural, socio-economic and cultural factors such as urinating in water while bathing or swimming, rural-urban drift and poor knowledge of the causative organism play important roles in the spread of this disease.

Although urinary schistosomiasis is rarely fatal, it is most often associated with blood in urine (haematuria), especially in children. This symptom is widely understood in endemic communities and often used for diagnosis of the disease even though it is not always as reliable as detecting the parasite eggs in urine. Ugbomoiko et al. (2009b) confirmed the accuracy of this dipstick for the rapid diagnosis of haematuria and also proteinuria in urinary schistosomiasis, and suggested that their performance can further be enhanced by a combination of urine reagents tests (Ugbomoiko et al. 2009c). These studies were not without challenges; the most daunting were the inherent perception that demonstrates the level of unawareness of the disease. Many villagers regarded treated pipe-borne water as tasteless and that schistosome infection was natural- a sign of maturity in males. Regrettably, these are obvious indications of a failed public health education system in our country, Nigeria.

Similar rigorous and intensive investigation is currently being conducted by my PhD student, Mr. Y. Danladi on a zoonotic water-borne protozoan parasite, *Cryptosporidium* species commonly associated with severe diarrhoea in many HIV-infected patients.

3.4. My Research in Zoonotic parasites

Zoonosis is a (parasitic) disease that is transmissible between animals and humans. Parasites which were hitherto known to infect wild and domesticated animals have been accidentally detected in humans. It is not uncommon to observe ectoparasites such as ticks and fleas of our pet animals (dogs and cats) on human skin. After all they do not cause obvious physical damage to the skin nor suck too much blood that will result in anaemic condition. For the reason that the risk of infection is low and income is readily generated, many rural and urban dwellers maintain unhealthy 'harmonious relationship' with pet animals. Such 'cohabitation' often results in disease transmission that may ultimately become a scourge. This was the case in tungiasis (jigger), a debilitating, disenabling and stigmatizing ectoparasitic disease infesting both man and animals in many parts of West- and Eastern Nigeria. It is caused by a blood-sucking flea, *Tunga penetrans*.

Mr. Vice Chancellor sir, I was reluctantly introduced into tungiasis research by Prof. Jorg Heukelbach, a German epidemiologist in Brazil after reading one of my published papers on ectoparasites of rodents. His invitation, coincidentally, came shortly after our Prof Edungbola, as a Deputy Vice Chancellor, had told me to look beyond the studies in schistosomiasis and Soil-transmitted helminths for a successful breakthrough in my career. I quietly left his office and rebuked his sincere wishes for me with Holy Ghost fire; but little did I know it was a prophetic message. Today, I have co-authored many scholarly research and reviewed articles in top scientific international journals in the world that earned me an international reputation, having been recognised as the only

expert in the West Africa Sub-region in the International Expert Meeting on Tungiasis. Historical reports indicate that the parasite was introduced into West African sub-region in the 18th and 19th century during the slave trade (Heukelbach & Ugbomoiko 2007). The disease became prevalent in most communities in Nigeria and many African countries in 1970s and early 1980s, and has now re-emerged as 'evil' plague in some localized resource-poor villages in Nigeria (Ade-Serrano & Ejezie 1981; Arene 1984; Nte & Eke 1991; Ugbomoiko et al. 2007a). The blood sucking female initiates infestation when it penetrates the skin of the host to start egg production. We observed that embedded parasites are inappropriately removed by other family members with unsterilized instruments such as pins, needles or thorns, thus causing disfigurement and mutilation of the feet as seen in Plate 2 below.

Plate 2: Jigger flea (*Tunga penetrans)* and the local process of extraction

Ulcer, gangrene and septicaemia were common; tetanus infection became a common risk factor for non-vaccinated individuals and death occurred in severe and untreated cases in many affected populations in many fishing communities in Badagry Lagos (Ugbomoiko et al 2008a).

Our assessment of infestation in these communities showed that point prevalence ranged between 45% and 55% with high intensity of lesions in all age and sex groups (Ugbomoiko et al. 2007a, Ariza et al. 2010). The worst case scenario was encountered in Angorin Beach where 18 year old man, an orphan had over 1,140 embedded sand fleas in all parts of his body. The entire feet were ulcerated, toes

were deformed and inflamed, he could neither grip nor walk. See plate 3.

Plate 3: Topographical distribution of Jigger infestation

The young man was despised and abandoned in a small hut without sanitation, when he actually deserves pity. The situation was not better in many other communities where men, women and children in some households suffered severe infestation. Children were so lame they could hardly walk to school as a consequence of severe infestation. A study on the risk factors indicated that irregular use of foot-wears, co-habitation with pigs and poor housing condition play a pivotal role in the transmission of jigger in the community. Other modifiable risk factors included the resting places of dogs on the compound (Ugbomoiko et al. 2007b, 2008b).

Table 4. Animals examined for tungiasis, the number infested and parasitic load

	Prevalence		No of Lesion		
	No Positive	% (95% CI)	No of lesion	%	Median per animal (interquartile range)
Pigs	17/31	54.8 (36.0-72.7)	184	83.3	9 (6-14)
Dogs	8/11	45.5 (16.8-76.6)	21	9.5	4 (3-5)
Rattus rattus	5/17	29.4 (10.3-56.0)	13	5.9	2 (2-4)
Mus minutoides	2/13	15.4 (1.9-45.5)	3	1.4	1.5 (1-2)
Goats	0/28	-	-	-	-
Sheep	0/15	-	-	-	-
Cats	0/9	-	-	-	-
Cows	0/9	-	-	-	-
TOTAL	29/133	21.8 (14.7-28.9)	221	100.0	6 (3-9)

Source: Ugbomoiko et al. (2008b). *Tropical Doctor* **28**:226-227

I was helpless not because I am not a physician but that there are no drugs in the market with satisfactory clinical efficacy for jigger. In the depth of my frustration, my principal collaborator, Prof. Heukelbach secured a grant from the Brazilian Government and commenced implementation of control measures based on the outcome of our study.

Plate 4: A classroom and residential houses in jigger endemic areas

Selected private schools and dilapidated residential houses in the endemic communities were revamped in 2007/2008. The good news is that by the time of the follow-up investigation in 2009, the prevalence and severity of infestation had dropped considerably to less than 18%. A Brazilian scholar, Miss Liana Ariza, who worked with me in Badagry, has since earned her PhD degree in her home country and she's currently working in Germany.

Like the pigs, dogs are potential reservoir host of a bewildering number of human diseases. This pet enjoys unrestrained association with their owners, many of whom

have limited knowledge regarding zoonotic diseases transmittable by the animal. In a baseline study conducted to assess dog parasites, the knowledge and perception of dog owners regarding zoonotic diseases transmittable by dogs, Ugbomoiko et al. (2008d) observed ten different ectoparasites and intestinal worms of dogs that infect man. Plate 5 shows the close relationship between dogs on one hand, and between dogs and their owners on the other hand.

Plate 5: Dog association with dogs, and with man

The intimate contact between people and dogs, often under unsatisfactory sanitary condition, is very difficult to break, and in many cases this love is often misunderstood. Zoonosis may have the potential to develop into a major human communicable disease; the only way to have any level of protection against them is to be constantly vigilant.

In Kwara State, 99.5% of dog owners agreed that their children play with dogs, 53% held that the diseases transmitted by dogs do not cause serious threats to man, as 72% agreed that no veterinary expert has examined and

treated their dogs within the last 12 months (Ugbomoiko et al. 2008d). During my survey I had a remarkable encounter with a middle age woman who, in my presence, called a puppy for a freshly passed 'faecal diet' of her baby. When I asked why she feeds her dogs with baby's faeces, she turned to me and scornfully replied ***what will a dog eat if not baby's faeces?*** I replied, ***I guess the next assignment for your puppy is to lick the tears and saliva on your baby's face and mouth when she cries.*** She furiously shouted, ***God forbids.*** Ladies and gentlemen, God will not forbid this because of the potency of the traditional risk: what goes around comes around.

Other community-based research works include ectoparasitosis caused by head lice, *Pediculus humanus capitis* (Ugbomoiko et al. 2008c, 2010b & c) and scabies, *Sarcoptic scabiei* (Alassad et al. 2011, Heukelbach et al. 2013).

3.4. My research on Parasites of small mammals (rodents)

I had earlier revealed that my mission in parasites of small rodents was to create a predictive tool to measure the threat of zoonosis and formulate potential risk reduction strategies to mitigate disease impact. Rats, like some other domestic and wild animals, are natural reservoirs of more than 60 deadly parasitic and viral diseases of man. Our studies in rural communities in Edo State identified 8 species of protozoa, 17 helminths and 10 ectoparasites from 8 different species of rodents but the occurrence of parasites and their hosts were positively influenced by seasonal rainfall (Ugbomoiko and Obiamiwe 1991a, b; Ugbomoiko, 1997). As far as I know, the report of

Ugbomoiko et al. (2000) is the only research work that has documented thirteen species of *Hymenolepis* that were hitherto unknown in Nigeria. Of the parasites encountered in all our studies, four helminths; *Hymenolepis diminuta, Taenia taeniaeformis,* Acanthocephalan (*Monoliformis* sp.), *Capillaria hepatica* and 3 ectoparasites; *Xenopsylla cheopis*, *Cordylobia anthropophaga,* and *Ixodes* species were likely to be of public health importance in Nigeria having been reported in many human populations in Nigeria (Obiamiwe 1977, Ogbalu et al. 2013) and other parts of Africa (Cochrane et al. 1975). The situation is likely to worsen with the eminent global warming, which will increase parasite potential to change hosts.

Of particular interest is the 'most unwanted' peri-domestic multi-mammilated *Mastomys natalensis* known to be the reservoir host of Lassa fever that claimed so many lives in Ekpoma town, Edo State and its environs. My knowledge of this rodent has compelled me to raise the fundamental question on whether *Mastomys natalensis* is the only reservoir hosts of Lassa virus. This is not to undermine the current research data on the role of *M. natalensis* in the transmission of Lassa virus. This question may be begging for immediate answer because, as I said earlier, the occurrence of this peri-domestic rodent is seasonal; frequent in human habitations during the dry season, possibly due to bush burning or in search of the harvested/preserved grains at homes, but return to the bush during the rainy season. The fact that the number of Lassa virus infected-rodents are fewer in the dry season than in the rainy season (when this rodent had returned to the natural habitat), suggests that factors other than *Mastomys natalensis* could enhance the transmission of the disease. It

is not unlikely that local transmission cycle between this rodent and others could occur during the rainy season; therefore, we should reassess the role of other peri-domestic rodents like the *Lophorumys sikapusi*, *Mus minutoides* and *Crocidura* species that live frequently in many homes in urban and rural settings.

4.0. **Recommendations and Conclusion**

The most proffered solutions to health problems in Africa, perhaps Nigeria in particular is adequate health delivery. This should be a legitimate right of every citizen of any nation that prides the health of her people, but the important determinants of parasitic diseases in Nigeria and many other Africa countries lie outside the purview of the health sector. Therefore, comprehensive and sustainable solutions to parasitic diseases will not be the sole responsibility of health professionals. Reducing infections needs to go hand in hand with improved socio-economic and environmental indices like poverty, illiteracy, general social deprivation, poor sanitary condition, unsafe drinking water, human perception and behaviour that encourage parasite transmission. Strictly speaking, the prevalence data of parasitic infections in Nigeria are probably a better description of what is going on in our communities than the income figures, economical cut-off and outdated, inadequate public health surveillance system.

Mr. Vice Chancellor Sir, Ladies and gentlemen, there is no doubt that technology and chemotherapic strategies in disease control will ameliorate the growing threats of infectious animals, but are unlikely to provide what is needed to control parasitic diseases in Africa, particularly so when chemotherapy alone cannot prevent

new infections and re-infections of parasitic diseases. More critically, how much of these drugs do we manufacture in Nigeria? How cheap are these drugs to an average Nigerian with a minimum wage of ₦18, 000/month? But thanks to the National Health Insurance Scheme. How readily available are these drugs to the poorest of the poor in rural areas where people see three square meals as luxury. Improving the health of the poor is therefore not through technology alone, but by ensuring that the basic needs of all are met through intervention that is emancipatory in action. Therefore, the option of behavioural change that will cost nothing to the Government and the concerned individual will successfully complement disease control efforts. A change in behavioural activities where people relish undercooked meat and meat products, deliberately eat with dirty hands, eat unwashed fruits and vegetables with a strong assumption that 'germs don't kill Africa man'; the practice of keeping puppies (dogs) as 'baby nurse' to eat faecal wastes and wipe the anuses and tears of babies- an exercise a good mother will proudly perform; the culture of dumping wastes indiscriminately, urinate and defaecate at every available quiet place when nature calls and, the practice of allowing animals (pigs and dogs) to roam freely in homes, will continue to influence and sustain parasite transmission rather than breaking the cycle. As unhealthy as these may be, it has become part of our daily lives.

Ladies and gentlemen, the advocated Health for all by 2020 in the face of government complacency and lack of funding, in an environment where the gap between the rich and poor widens daily is likely to be a mirage without concerted efforts to change behavioural activities that cause the bulk of human parasitic diseases. Let us change the bath

water but keep the baby. In the words of Michael Wood, I quote: *"The most important advances in health lie in influencing the behaviour of the people, and this is a slow battle which will only be won yard by yard"*

In conclusion, I make bold to say it is high time the Nigerian Government saw the occurrence of ancient parasitic diseases like tungiasis, scabies, pediculosis, schistosomiasis and other helminthiasis in the present century as a social defect and formulate appropriate political will to address them. To achieve a qualitative and holistic control of these parasites, we must evolve a broad-based strategy that will combine good planning, policy consistency, with a progressive refinement guideline supported by strong framework for its implementation.
To you my listeners, I say thank for your patience.

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