61st Inaugural Lecture

MAN AGAINST PARASITES:
AN ENDLESS BATTLE

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By

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“MAN AGAINST PARASITES: AN ENDLESS BATTLE’’

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LAGOS STATE UNIVERSITY

DEDICATION

This inaugural lecture is dedicated:

- To the Almighty God for His mercies, faithfulness and protection.
- To the entire human race, for their efforts in the prevention, control and eradication of major parasitic diseases.
- To my dear parents.

PROTOCOL

The Vice Chancellor,

Deputy Vice-Chancellor (Academics),

Deputy Vice-Chancellor (Administration),

Registrar,

University Librarian,

Other Principal Officers,

Provosts, Deans and Directors,

Distinguished Colleagues,

Staff and Students of Lagos State University

Gentlemen of the Press

Distinguished guests,

Ladies and Gentlemen

MAN AGAINST PARASITES: AN ENDLESS BATTLE

INTRODUCTION

It is with great pleasure, gratitude and thanksgiving to the Almighty God for His mercy upon my life that I stand before you this day to deliver my inaugural lecture. I thank the Vice-chancellor for giving me the opportunity to deliver this inaugural lecture to this great University. My research work spanning over three decades has contributed modestly to the existing body of knowledge, all geared towards emancipating man from the scourge of parasites. I have taught and supervised quite a large number of students and by divine providence elevated to the position of Professor of Parasitology in the Department of Zoology. In the light of this, I Comfort Adejoke Ibidapo present myself to the university community to give my inaugural lecture entitled "**MAN AGAINST PARASITES: AN ENDLESS BATTLE.**"

Mr. Vice-Chancellor Sir, It is interesting to note that humans have acquired an amazing number of parasites over the ages with over 4.5 billion worms in existence. The systematic study of parasites began with the rejection of the theory of spontaneous generation and the promulgation of the germ theory. Thereafter, the history of human Parasitology proceeded along two lines, the discovery of a parasite and its subsequent association with disease and the recognition of a disease and the discovery that it was caused by a parasite.

Parasites are some of the most successful and abundant creatures on the planet. Parasites are all around us; in the air we breathe, the food we eat and the water we drink, even in the soil we step on. Every single living organism can be infected by these "Super Beasts." The truth is that parasites are a universal part of daily life. Only those with the most vibrant immune systems can hold them at bay. They can be found in both unsanitary and sanitary conditions, around the globe. Parasites are supremely adaptable. There are far more parasitic organisms than non-parasitic organisms in the world. More than any other creatures, parasites have an enormous genetic plasticity, which allows them to alter their structure and metabolic profile to adapt to attacks by the immune system of their host, resistant parasitic drugs and chemicals, move from host to host and survive in hostile environment . The major reasons why parasites are dreaded are due to the intricate biochemical relationships which are always detrimental to their hosts, often leading to morbidity and mortality. The highest costs are paid in the tropics and subtropics where parasites present a continual and unacceptable threat to the wellbeing of millions of people and livestock. The cost of harboring parasites in terms of human misery and economic loss is incalculable. Indeed parasites are bad news for us. In their award winning documentary program, the 'Body Snatchers', National Geographic reported, "Parasites have killed more humans than all the wars in history" (Season 1, Episode 17). Of the 7.8 billion acres of potential arable land on earth, only 3.4 billion acres can be farmed. Most of the rest cannot be developed because of diseases such as malaria, trypanosomiasis, schistosomiasis and onchocerciasis. That is, less than half the farmable land of our planet is available to us, because of these ceatures, at a time when humans need food resources like never before.

DEFINITION OF ZOOLOGY

Zoology is the division of biology that deals with the study of animals and their interactions with the environment. Zoology is a huge field that covers the classification of every animal on earth as well as many broader fields of experimentation related to animal life. The field keeps expanding due to scientific advances that continue to open new areas of research. All living organisms belong to five kingdoms, virus, bacteria, fungi, plants and animals. Though several scientists have presented various theories of the origin of life, the account given in Genesis Chapter 1 of the Bible about the origin and evolution of living organisms, plants and animals has remained steadfast. This is Zoology in action! The orderliness exhibited by the Creator has become a guiding factor for all scientists. The eventful act of creation was followed by nomenclature, the procedure of naming organisms, Genesis 2:19 , 20 states: "out of the ground the Lord God formed every beast of the field and every bird of the air and brought them to Adam to see what he would call them. And whatever Adam called each living creature that was its name. So Adam gave names to all cattle, to the birds of the air and to every beast of the field." It is amazing to note that the first man on earth was a Zoologist!! The discipline of Zoology encompasses several specialized areas such as conservation of natural resources, genetics, evolution, animal ecology, parasitology, entomology, physiology, histology, aquatic biology and others. Human and veterinary medicine programmers require several foundational courses in Zoology. Enumerable, opportunities exist in Zoology especially with the accession of interest in new areas of environmental toxicology and animal breeding. These aspects are expected to take care of environmental pollution, climate change, reduced biodiversity of both plants and animals, also, the increased need for food production for the ever increasing human population. Also, the use of animal models in the study of human physiology cannot be overestimated.

WHAT IS PARASITOLOGY?

Parasitology is an aspect of symbiology which deals with the study of parasites and parasitism. It is also an aspect of biology concerned with the phenomena of dependence of one living organism on another.

What is a parasite?

A parasite is an exploitative dependent organism that is in intimate and continuous association with another organism (the host). Morphologic, physiologic, reproductive and behavioral adaptations are important features in parasitism. Parasites must be metabolically and physiologically dependent on the host which is its environment. Several definitions of a parasite exist but each of these must take into cognizance the following facts: must integrate and incorporate the degree of intimacy of the association, the degree of damage or injury within the relationship, the nature of physiologic or metabolic dependence, the ability to recognize the host and the specific ecological niche within the host. Some of these definitions are listed below;

i. Parasitism is an intimate and obligatory relationship between two heterospecific organisms during which the parasite, usually the smaller of the two partners, is metabolically dependent on the host (Cheng , 1986).

ii. It is a relationship between two species of populations. The essential features are that the parasite is physiologically dependent on the host, that it has a higher reproductive potential than the host, and that it is capable ultimately of killing heavily infected hosts, also that the infection process tends to produce an over-dispersed distribution of parasites within the host population (Kennedy, 1975).

iii. A parasite is an organism which has a detrimental effect on the intrinsic growth rate of its host population (Anderson and May, 1978).

iv. A parasite is an organism living in or on another living organism, obtaining from it part or all of its organic nutriment, commonly exhibiting some degree of adaptive, structural modification, and causing some degree of damage to its host (Price, 1980)

The model of the "ideal parasite" is shown in (Figure 1).

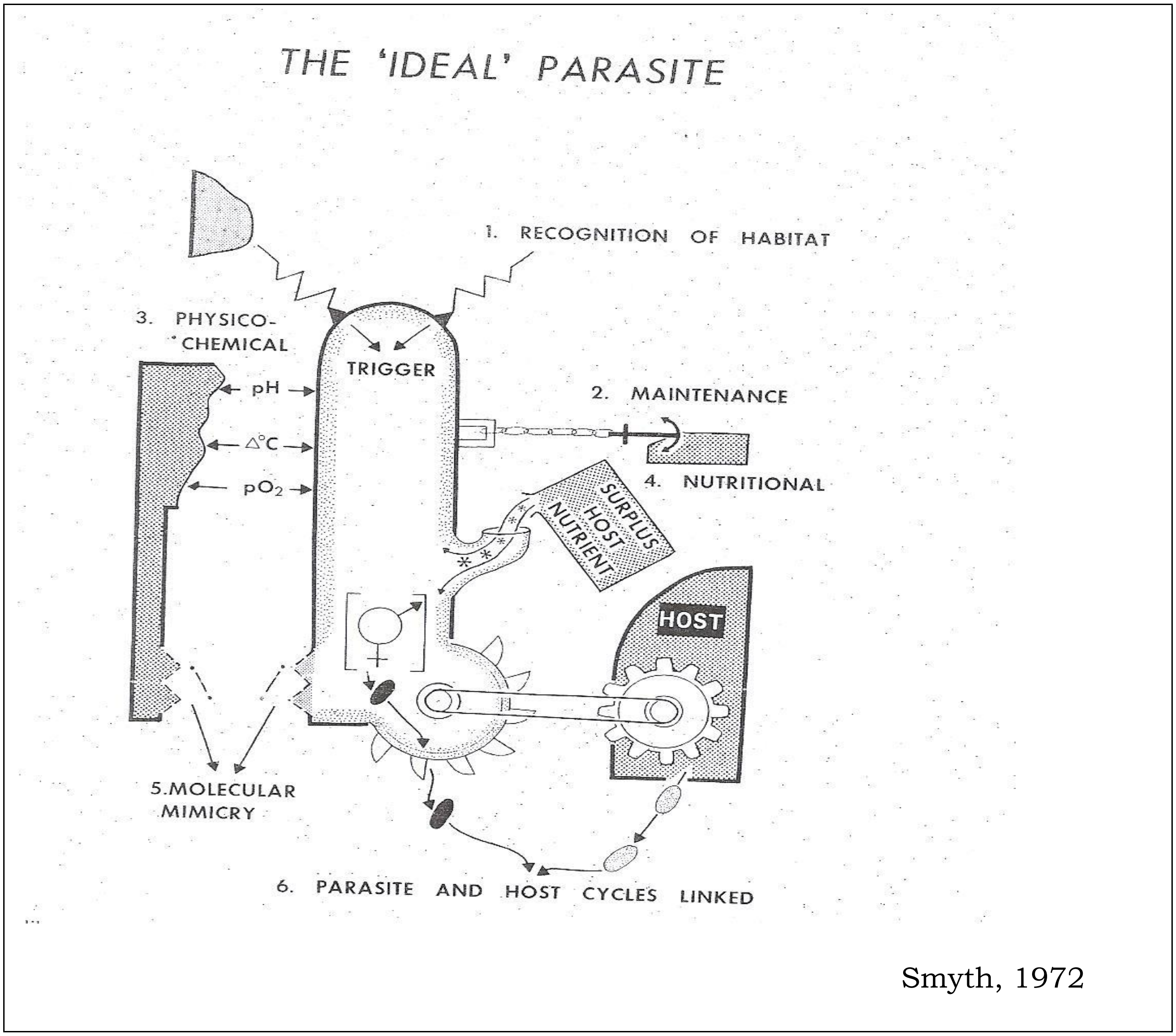


Fig. 1a. A cartoon-like representation of the 'IDEAL' parasite

1. Recognizes a host site suitable for establishment.
2. Maintains its position there.
3. It is adapted to the physico-chemical conditions of the host.
4. Utilizes host nutrient in a manner compatible with host survival.
5. Presents a surface with a molecular configuration such that the host immune response is absent or minimized.
6. Host life cycle synchronized with that of the host.

CHARACTERISTICS OF PARASITES

1. It must live in close intimate contact with its partner, the host.
2. It must be the dependent organism and must possess the ability to recognize the host as a suitable ecological niche.
3. It must be smaller than the host.
4. It must have a higher reproductive potential than the host.
5. It must exhibit some degree of metabolic dependence.
6. It must injure or cause a certain degree of damage or pathological changes to the host, resulting in disease.
7. It must be adapted to survive in the host.
8. The distribution of the parasite must be over dispersed within the host population.
9. Significantly, a parasite must live in harmonious equilibrium with its host, to ensure its survival.

ORIGIN OF PARASITES

Parasitism must have arisen very early in the history of life on earth, when primordial microorganisms learnt to survive inside other cells which they had invaded either passively (e.g. by phagocytosis) or actively (e.g. by penetration).

When multicellular organisms with alimentary tracts appeared, they would have inevitably (accidentally or intentionally) eaten free living microorganisms (and later free living helminthes). Ingested animals that managed to survive in this new environment would have appreciated the nutrient rich environment. The energy saved in looking for food could then be diverted to proliferating and resisting the host's efforts to dislodge them. With time, these parasites became so adapted to life in the host that they "forgot" how to survive outside. However, to succeed, they still needed to produce offsprings that could negotiate the outside world to find new hosts. Not surprisingly all parasitic animals have free living counterparts to which they are clearly related. The greatest diversity of parasites are found within the alimentary tracts of "higher" animals. As host species diverged with evolution, they carried with them their parasites (Cox, 1998).

PARASITE GROUPS

Man as host.

Man ranks as the most parasitized of all animals. A number of these parasites causes severe human diseases. A number of these parasites cause severe human diseases. Majority of these diseases are caused by emerging parasites whose aetiology has not been clearly established. Figure 1b illustrates the parasitic diseases that predominantly affect man globally.

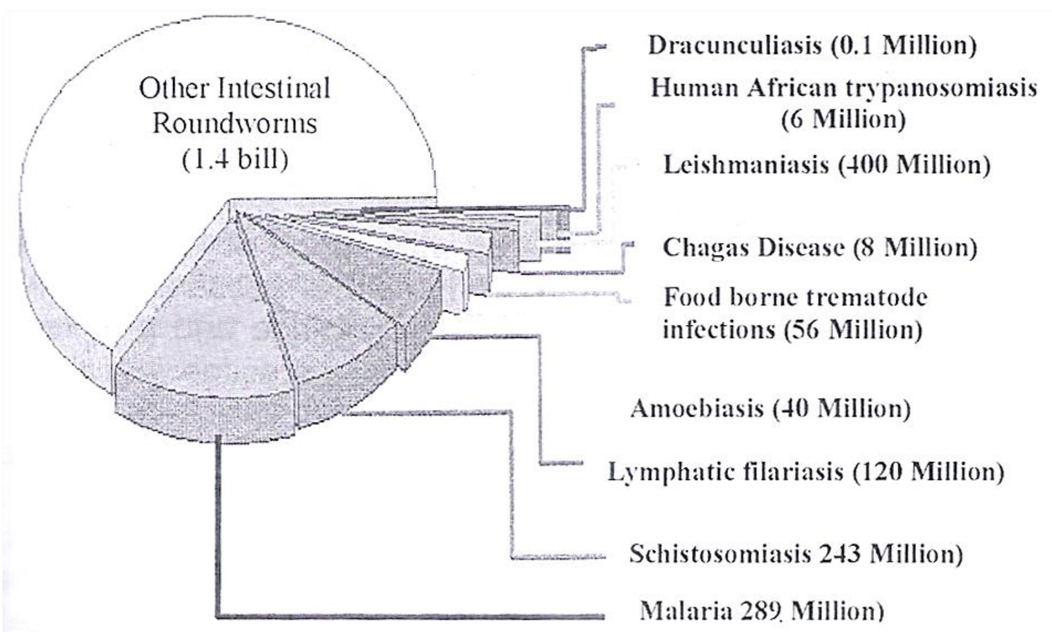


Fig1b: Global parasitic Burden in Man as at 2013 (Otubanjo, 2013)

For the purpose of this lecture emphasis will be on protozoan and helminthes of man and animals. Brief outline classification of protozoan and helminthes parasitic in vertebrates are shown in Tables 1a and 1b.

TABLE 1a: Brief Outline Classification of Protozoa Parasitic in Vertebrates

Phylum	**Sarcomastigophora**
Subphylum	Mastigophora
Class	Zoomastigophora
Order	Trichomonadida e.g *Trichomonas*
Order	Kinetoplastida e.g *Leishmania* , *Trypanosome*
Order	Diplomonadida e.g. *Giardia*
Subphylum	Sarcodina
Superclass	Rhizopoda e.g *Entamoeba*
Phylum	Apicomplexa
Class	Coccidia
Order	Eimeriida e.g *Cryptosporidum*
Class	Haemosporinea
Order	Haemospororida e.g *Plasmodium*

Table 1b:

Brief Outline Classification of Helminths Parasitic In Vertebrates

Phylum	Platyhelminthes (Flatworms)
Class 1 :	*Trematoda:* e.g *Schistosoma, Fasciola*
Class 2:	Monogenea : Fish parasites e.g *Gyrodactylus*
Class 3:	Cestoda: e.g *Taenia*
Phylum	Nematoda (Round worms)
Class 1:	*Phasmidia* e.g *Ascaris, Enterobius, Ancylostoma, Necator, Wuchereria, Dracunculus, Loa loa, Onchocerca*
Class 2:	*Aphasmida* e.g *Trichinella, Trichuris*

OCCURRENCE OF PARASITES IN AFRICA

Parasites of man and his domestic animals occur throughout the world but it is in the warm climates of the tropics that they constitute the greatest threat to the health and socio economic status of the people. The reason is not farfetched. Most of the important parasites complete their life cycles in invertebrate hosts. These find the warm and humid tropics most favorable for rapid breeding and development. In addition, the high temperatures reduce the duration of the developmental cycle of the parasites within their intermediate hosts. These two factors combine to ensure that more infective stages are produced for dissemination to a wider range of victims. The tropics are ecologically relatively less stable than the temperate zones. Hence the ecological balance between man and his environment is easily upset by parasites, pests etc, which makes their effects more pronounced. As control strategies are applied, the parasites develop immune response thus rendering man's effort an endless battle.

Parasitic diseases are not only prevalent in the tropics because of the combined effects of ecological and climatic factors on the parasite and their vectors; human behavior, cultural practices, customs, traditions and their socio-economic conditions are quite significant. Indeed parasitic diseases have played an important role in shaping the course of African history (Hartwig and Patterson, 1978). Life in tropical Africa is characterized by a trinity of poverty, ignorance and disease. This is a vicious cycle and all are interdependent. This vicious cycle must be broken if any progress is to be made. Parasitism contributes directly to malnutrition and malnutrition reduces resistance to infection. This is another vicious cycle to be broken. Therefore the control or eradication of parasitic infections will have a tremendous impact on the health of the people. Health is defined by the World Health Organization as a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity. The achievement of these factors is a dream for most tropical countries, especially the rural communities constituting 75% of the population.

Major diseases endemic to Africa are, protozoa and helminthic, including amoebiasis, giardiasis, trichomoniasis, leishmaniasis, trypanosomiasis, malaria, schistosomiasis, fasciolisasis, taeniasis, loiasis, onchocerciasis, ancylostomiasis, stronglyloidiasis, and dracunculiasis . Some of these are of particular importance because they are zoonotic diseases. A zoonotic disease is one that is transmissible between animals and man.

A zoonotic disease is one that is transmissible between animals and man. Some emerging zoonotic diseases are toxoplasmosis, cryptosporidiosis, fascioliasis and HIV/AIDS. The spectrum of parasitic diseases being dynamic and impacted by disease factors such as climate change, migration and others enhance the spread of zoonotic infections.

Neglected Tropical Diseases (Diseases of Poverty)

This terminology is used to collectively describe diseases, disabilities and health conditions that are more prevalent among the poor than among wealthy people. The main neglected tropical diseases as identified by World Health Organization are:

- Soil transmitted helminths
- Schistosomiasis (bilharziasis)
- Food borne trematode infections
- Dracunculiasis (Guinea worm disease)
- Cysticercosis
- Echinococcosis
- Lymphatic filariasis (Elephantiasis)
- Onchocerciasis (river blindness)
- Trypanosomiasis (Sleeping sickness)
- Leishmaniasis

The special programme for Research and Training in Tropical Diseases (TDR) of World Health Organization selected some of these parasitic diseases for special attention. In many cases, poverty is considered the leading risk factor or determinant for such diseases. In some cases the diseases themselves are identified as barriers to economic development that would end poverty. Diseases of poverty are often co-morbid and ubiquitous with malnutrition. For many environmental and social reasons, including crowded living and working conditions, also inadequate sanitation, the poor are more likely to be exposed to infectious diseases. Malnutrition, stress, over work and inadequate, inaccessible or nonexistent health care can hinder recovery and exacerbate the disease.

CONTAMINANATED WATER SUPPLY

One of the major contributing factors to the severity of diseases of poverty is contaminated water supply. Barry Mason's analyses indicates that in developing countries 80% of all diseases result from a combination of poor hygiene, contaminated water and poor sanitation. This is why inadequacies in water and sanitation hinder socio economic development particularly on a backdrop of unstructured urbanization and rapid population growth. Each year many children and adults die as a result of a lack of access to clean drinking water and poor sanitation. According to UNICEF, 3,000 children die every day, worldwide due to contaminated drinking water and poor sanitation. Although the Millennium Development Goal (MDG) of halving the number of people who did not have access to clean water by 2015 was reached five years ahead of schedule in 2010, there are still 783 million people who rely on unimproved water sources. In 2010, the United Nations declared access to clean water a fundamental human right, integral to the achievement of other rights. This made it enforceable and justifiable to permit governments to ensure their populations have access to clean water (Singh *et al*, 2012).

While access to water has improved for some, it continues to be difficult for women and children. Women and girls bear most of the burden for accessing water and supplying it to their households. This has a significant impact on girls' educational attainment. Clean water is necessary for cooking, cleaning and laundry, because of this many people come into contact with disease causing pathogens through their food, or while bathing or washing. The spread of diseases such as malaria, intestinal parasitic diseases, schistosomiasis and dracunculiasis are very much impacted by water.

DISEASE BURDEN

The public health significance of a disease is determined through an estimation of the burden of disease. The economic burden of diseases is the totality of direct and indirect costs associated with infections. These include morbidity, loss of productivity, absenteeism, and cost of health care in infected people as well as agricultural and non-agricultural enterprises. The Disability Adjusted Life Year (DALY) is a measure of overall disease burden, expressed as the number of years lost due to ill- health, disability or early death. It extends the concept of potential years of life lost due to premature death to include equivalent years of healthy life lost by virtue of being in states of poor health or disability. Years of life lost (YLL) and Years of life lived with disability (YLD) is represented by DALY = YLL+YLD**.** (Table 2).

Table 2: Burden of disease in DALYS by cause, sex and income group in WHO regions

Cause			WHO REGIONS					
			Africa	South East Asia	The Americas	Eastern Mediterranean	Europe	Western pacific
Population (millions)	**Both sexes (6,437)**		**Low and Middle Income**	**Low and Middle Income**	**Total**	**Total**	**Total**	**Total**
TOTAL DALYS	1,523,259	100	376,525	442,979	143,233	141,993	151,461	264,772
Infectious and parasitic diseases	302,144	19.8	159,817	82,900	9,650	23,691	6,041	19,763
Diarrhoeal diseases	72,777	4.8	32,203	22,987	2,576	8,349	1,393	5,225
Malaria	33,976	2.2	30,928	1,341	89	1,412	4	229
Tropical –cluster diseases	12, 133	0.8	6,077	4,789	529	574	7	169
Trapanosomiasis	1,673	0.1	1,609	0	0	62	0	128
Chagas disease	430	0.0	0	0	426	0	0	0
Schistosomiasis	1,707	0.1	1,502	0	46	145	0	0
Leishmaniasis	1,974	0.1	328	1,264	45	281	6	6
Lymphatic filariasis	5,941	0.4	2,263	3,525	10	75	1	1
Onchocerciasis	389	0.0	375	0	1	11	0	0
Intestinal nematode infections	4,013	0.3	1,528	1,076	180	269	0	955
Ascariasis	1,851	0.1	915	404	60	162	0	308
Trichuriasis	1,012	0.1	915	404	60	162	0	308
Hookworm disease	1,092	0.1	377	286	20	43	0	364

Source: WHO (The global burden of disease 2004 update www.WHO.int/health info/global_burden _ disease/GBDreport_2004update

The DALY is becoming increasingly common in the field of public health and Health Impact Assessment (HIA). One DALY is equal to one year of healthy life lost. A high burden of disease has disastrous consequences for the resilience of population. This is directly reflected in a deterioration of public health and economic development of a country. Combating diseases is therefore of great importance not only for general health, but also for economic development thus confirming adage heath is wealth.

EPIDEMIOLOGY OF DISEASES

Epidemiology is the study of the distribution and determination of health events and health characteristics in a well-defined population . This study is applied to the control of diseases and other health problems. It is the principal methodology of public health research. Epidemiological information is used to plan and evaluate strategies to prevent illness and as a guide to the management of patients in whom disease has already developed. A key feature of epidemiology is the measurement of disease outcome in relation to a "population at risk". The population at risk is the group of people, healthy or sick, who would be counted as cases if they had the disease being studied. Implicit in epidemiological investigation is the notion of a target population about which conclusions are to be drawn. More often, observations can only be made on a study sample which is selected in some way from the target population. Of prime importance is the fact that epidemiological studies provide information on disease causative factors, characteristics, mode of transmission, geographic mapping and determinants of natural cause of disease.

Prevalence

The frequency of a disease at a specific time is known as prevalence. It is the most widely used measurement in epidemiology. It is recorded in rates or percentages. Prevalence indicates the percentage or proportion of infection within the population. Varying degrees of prevalence of diseases occur within populations. The common types are:

Endemic prevalence

The maintenance of a relatively constant but moderate level of occurrence. The percentage of infected individuals in a community is an index of the endemicity of a parasite.

Hyper endemic prevalence

This denotes a highly persistent and continuous level of occurrence. Infections occur in all ages and groups.

Epidemic prevalence

This is an outbreak or sudden occurrence of disease with considerable intensity.

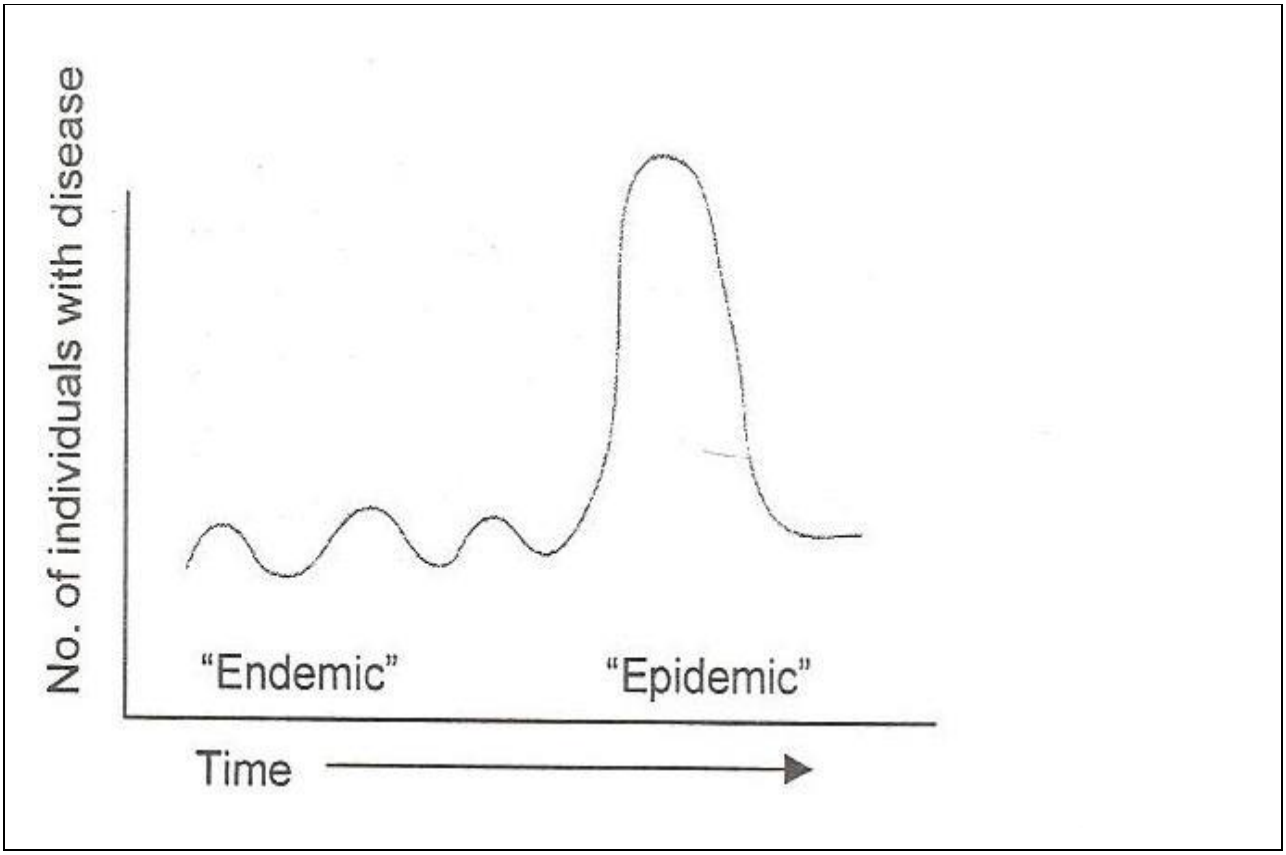


Figure 2: Endemic versus Epidemic (Otubanjo, 2013)

Sporadic prevalence

This is associated with occasional increase in infections in a small percentage of the population.

Pandemic prevalence

This is a global epidemic that has spread over several countries and continents worldwide. This is enhanced by increased human mobility, freedom of travel and migration of man and animals.

Holoendemic prevalence

There is a high prevalence amongst children in a population. Prevalence decreases as the age group increases.

Control

Control is to reduce through deliberate concerted efforts the occurrence of infection or endemicity of disease in the host community so that the disease is no longer of public health importance. Control necessitates reduction of the burden of infectious disease by reducing the disease incidence, prevalence, morbidity and mortality to very low levels. Control programmes require long term measures with continuous intervention. Campaign on any control programme is specialized and needs to be incorporated into the basic primary health care services for efficacy. Control efforts involve treatment, prevention and specific methods to reduce the disease.

Prevention

This is usually undertaken along with control. It involves measures to hinder the transmission of infection to susceptible hosts. This often involves changes in host habits attitudes in addition to environmental modifications.

Eradication

This involves the total removal of the occurrence of a disease within a selected population. This implies that there is permanent reduction to a zero level of infection caused by a specific agent as a result of deliberate efforts. Intervention methods are no longer necessary when eradication is achieved and it implies that the disease will no longer occur. This is a rare occurrence. For many endemic tropical human parasites, eradication is unrealistic and few diseases are candidate for eradication. Vaccination is a most effective way to eradicate a disease. Eradication programmes are quite expensive, consuming major human and financial resources. However, in the long term it has a high cost benefit, producing sustainable improvement in the health and economic development of the people.

Elimination

These are control programmes that reduce the incidence of disease to zero level in defined geographical areas. There is a deliberate effort to prevent re-establishment of transmission in the region.

Surveillance

This involves the continuous monitoring of the distribution pattern and spread of disease agent, also considering related factors in the environment. It helps to detect emerging problems, identify human and animal disease, track any recrudescence after control activities and provide evidence on which to base policy decisions. A good surveillance system is the cornerstone of an effective and sustainable disease control programme. It is dependent on comprehensive health information systems, supported by readily available and appropriate diagnostic tools. Effective surveillance relies on gathering information from a broad range of information sources including surveys, laboratories, and registries. Studies on the global burden of diseases act as essential building blocks for surveillance, providing baseline information and giving an insight into the prevalences, incidences, mortality ratios and DALYs of several infectious diseases. Surveillance data is needed for baseline mapping of infectious diseases and for measuring the effectiveness of disease control programmes and interventions.

APPROACHES TO THE CONTROL OF PARASITIC DISEASES

The study of life cycles of various parasites is very important in designing disease control programmes. Three basic approaches are relevant,

1. Elimination of source of infection e.g. reservoir hosts and treating infected hosts.
2. Interruption of the pathway of transmission.
3. Protection of the susceptible hosts.

The elimination of reservoir of infection in animal hosts can be achieved by destroying and exclusion of animals from human and their habitations. The control of infection in the reservoir animal host constitutes an integral part of any programme directed towards controlling infection in man. However, man can be protected by the use of vaccine. The interruption of transmission by various activities that eliminate the vectors or intermediate hosts involved in the parasite life cycles has proved to be very effective. Environmental management involves the elimination of pools, stagnant water bodies and surface gutters. Improved sanitation and modification of host habits are essential components of control. Safe water supplies must be provided within homes. Urinals and adequate toilet facilities are vital. Indiscriminate defecation in the environment must be discouraged and penalized. Susceptible hosts can be protected in several ways. Chemotherapy which is the utilization of drugs by infected persons is paramount to parasitic disease prevention and control. It is used in preventing, reducing or eliminating morbidity and disease prevalence thereby reducing transmission. Drugs administered to sick persons kill the adult parasites and thus bring an end to egg production which would otherwise have infected new individuals. Effective disease control requires that a campaign strategy be incorporated into the primary health care services. Radio jingles and illustrative posters in various local languages are very effective.

The relevance of advocacy in disease control

Advocacy is of prime importance in any control programme. Advocacy is defined as the process of generating sustained commitment of the community to the control of the diseases. It helps to explain the ideas and strategies involved in the control programme being proposed. Involvement of community leaders is necessary since they are in the best position to mobilize and instruct their subjects to comply with the necessary changes that enhance the success of control programmes. With the multiplicity of dynamic determinant factors, the battle against parasites despite the relentless deliberate and concerted efforts by man remains an 'endless battle'. However, the divine instruction to subdue every creature is an endless exercise.

Protozoa and Helminthes of Medical and Veterinary Relevance

It is pertinent to note that economic losses due to parasitic infections cause devastating effects both in man and his domestic animals. However, over the years, research efforts have been geared towards the study and control of human parasites to the detriment of those inhabiting their domestic animals. Bovine helminthes of epidemiological importance include *Fasciola gigantica* and *Dicrocoelium dendriticum* among others. The adult flukes are localized in the bile ducts of the liver or gall bladder of cattle, sheep, goats and other ruminants who are the definitive hosts of these two genera of which, *Fasciola gigantica* (Figs. 3), is more prominent.

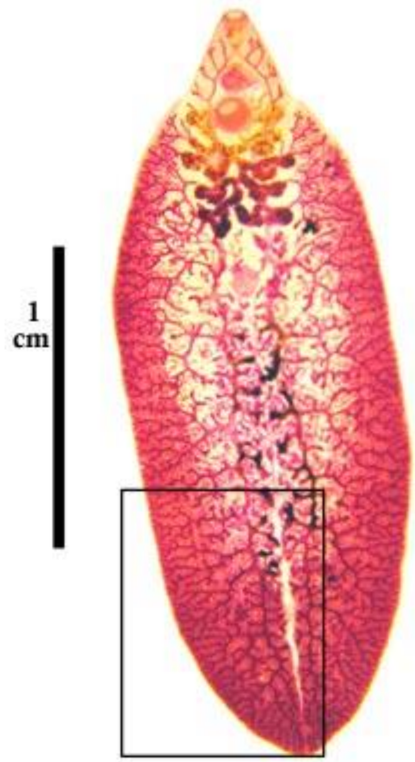


Figure 3: *Fasciola gigantica* (Adult)

This tropical helminth causes the disease fascioliasis, also known fasciollosis, distomatosis, liver rot and liver fluke of ruminants. This disease belongs to the plant borne zoonoses. Human infections occur as a result of the consumption of raw freshwater vegetables on which the infective metacercaria is attached (Mas-Corma *et al.,* 2005). In Europe and America the related genera *Fasciola hepatica* is a major concern, but distributions overlap in Africa and Asia where *F. gigantica* is prominent. The importance of fascioliasis in domestic animals seems to have been underestimated in earlier years. The attention of veterinary authorities was focused on the eradication of more contagious diseases such as rinderpest and trypanosomiasis. Fascioliasis predisposes the host to other infections, principally *Clostridium and Salmonella,* also possibly blood parasites (Ogunrinade, 1978).Losses in animal productivity due to fascioliasis worldwide were conservatively estimated at over US$3.0billion per annum, (Mas-Corma *et al.,* 2005).

In West Africa, Nigeria inclusive, important economic losses associated with fascioliasis are great. These include expenses on anthelmintics used for treatment, liver condemnation, production loss due to mortality, lower production of meat, milk and wool, reduced weight gain, metabolic diseases and impaired fertility.

Fascioliasis is now recognized as an emerging human disease. The World Health Organization has estimated that about 2.4million people are infected with *Fasciola* and a further 180 million people are at risk of infection. (Anonymous, 1995). In Nigeria, Magaji *et al* (2014) reported a prevalence of 27.7% with fascioliasis in Northern Nigeria. Distribution of fascioliasis worldwide is limited to biotopes suitable for the development of the aquatic gastropod *Lymnaea natalensis (*Fig. 4) *which* serves as the intermediate host in the life cycle of *Fasciola gigantica..*

Figure 4: *Lymnaea natalensis shells*

These indications of annual losses due to bovine fasciolisasis and more importantly the zoonotic impact of the disease on human health, emphasize the need for adequate control measures against *L. natalensis* .

This will inevitably break the transmission cycle. In order to achieve successful control measures, the ecology of this intermediate host is paramount.

My research contributions in Parasitology

My researches over the years has been directed towards the provision of information relevant to the prevention and control of some major endemic parasites of humans and domestic animals in Nigeria. A number of my efforts in these areas are hereby listed and presented.

1. Bioecology of *Lymnaea natalensis* intermediate host of *Fasciola gigantica*, the causative agent of bovine fascioliasis and emerging zoonotic human infections.
2. Epidemiology of liver fluke and other helminth parasites of cattle in Lagos area.
3. Diversity and epidemiology of intestinal parasites of man and dogs in Lagos metropolis.
4. Soil transmitted helminthes of man in rural communities.
5. Evaluation and utilization of diagnostic tools in the determination of human schistosomiasis.
6. Helminths of fishes in a cross section of Lagos lagoon.
7. Dracunculiasis in Lagos State: Epidemiology and Control.
8. Loiasis and Onchocerciasis in Ondo State: Epidermiology and Control.
9. Trichomoniasis: diagnosis and epidermiology in Lagos.
10. Malaria studies:
    - (a). Epidemiology and perception in urban and rural locations in Lagos State
    - (b). Vector studies: Ecology, abundance, diversity, and molecular identification of anopheline mosquitoes in the rain forest ecotype.
    - (c). Treatment strategies:
        - (i) Role of plant extracts in malaria control
        - (ii) Insecticidal evaluation of local plants.

1. Studies on the biology and ecology of *Lymnaea natalensis*

(a) Effect of physico-chemical factors on the distribution of *L.natalensis*

The dearth of information on the biology and ecology of *Lymnaea natalensis,* the snail intermediate host in the life cycle of *Fasciola gigantica* caught the attention of my supervisor, late Professor Frank Ukoli then in the University of Ibadan, who already had several PhD students working on schistosomiasis in various study locations in the country. This prompted his suggestion that I undertake this study of which I also personally found interesting. This is the beginning of my research sojourn in parasitology with the intent to battle the parasites.

The study sites were dams, ponds, slow flowing streams, drainage ditches and river margins within Ibadan and its environs in Oyo State, Nigeria. A comprehensive study of the physical and chemical parameters of the aquatic habitats was considered. These include temperature, salinity, hydrogen ion concentration (pH), conductivity, turbidity, dissolved oxygen, alkalinity, calcium, current speed and exposure of the habitat to sunlight over a period of 24 months.

Plate 1 shows some of the study sites. Results obtained are shown in Tables 3 and 4.

A Dam B Stream

C Drainage ditch

Plate 1.Some of the study locations

Table 3: Ranges of five physical factors in the intensive study sites and the correlation coefficient (r) of each factor with the abundance of *L. natalensis* in some of the habitats.

Habitat Ref. no.	No. of *L. natalensis* collected	Temperature (°C)	Exposure (%)	Turbidity (FTU)	Water current (m/sec.)	Ph
1+	112	27.0-30.5 r= - 0.2281 (N.S.)	30-100 r=+ 0.4767 *	5.2-30.1 r= -0.7336 ***	0.0-0.1 r=- 0.4776 *	6.7-8.0 r=-0.0076 (N.S)
2+	5	26.0-30.0 r=+0.1774 (N.S.)	20-60 r=+0.2032 (N.S.)	18.4-74.3 r=-0.0064 (N.S.)	0.1-0.5 r=+ 0.1637 (N.S.)	6.8-8.1 r= +0.1594 (N.S.)
3+	158	27.0-32.0 r=- 0.5125 *	100 -	10.6-55.3 r= + 0.5217 * **	0.0-0.1 r=+0.4855 *	6.1-9.8 r=-0.5442 * **
4+	3	27.0-30.0 r=+0.3261 (N.S.)	5-80 r= +0.4582 *	18.3-80.6 r=-0.1751 (N.S)	0.0-0.3 r=+0.1282 (N.S.)	6.7-9.0 r= - 0.1443 (N.S.)
5	-	25.0-30.0	10-40	6.8-95.4	0.0-0.25	6.8-8.2
6	-	26.0-30.0	30-60	8.7-55.3	0.0-0.3	6.1-8.2
7	-	26.0-32.0	30-80	11.6-100.1	0.0-0.3	6.1-8.0
8	-	27.0-30.0	20-70	25.8-114.5	0.0-0.3	6.3-8.1
9	-	24.0-30.0	10- 60	22.6-90.4	0.0-0.5	6.2-8.0
10	-	26.0-29.0	30-80	31.6-160.4	0.0-0.5	5.8-8.2
11+	269	26.0 - 30.0 r=+0.2542 (N.S.)	10-70 r= +0.0954 (N.S.)	31.0-114.2 r= - 0.4883 *	0.0-0.3 r= - 0.4865 *	5.9-7.8 r=-0.3945 (N.S.)
12+	12	26.5-30.0 r=+0.3385 (N.S.)	50-90 r=+0.4653 *	18.4-120.4 r=-0.3842 (N.S)	0.1-0.5 r=-0.0890 (N.S)	5.8-8.1 r= +0.2983 (NS)
13+	16	27.0 - 30.0 r=+0.1498 (N.S.)	40-100 r=+0.1169 (N.S)	6.1-59.3 r=+0.3292 (N.S)	0.0-0.08 r= - 0.2564 (N.S.)	5.6-7.9 r= + 0.920 (N.S.)
14	-	27.0-32.0	10-100	6.1-80.4	0.0-0.08	6.9-8.6
15+	373	26.0-31.0 r=+0.6266 (N.S.)	20-90 r=+0.5889 ***	13.5-93.4 r=-0.4109 *	0.0	6.0-8.9 r=+0.3762 (N.S.)
16	-	27.0-31.0	60-90	4.8-51.4	0.0-0.2	6.0-8.0
17	-	26.0-30.0	30-80	27.4-121.4	0.0-0.33	6.2-7.7
18	-	29.0-31.0	40-90	105.8- 270.1	0.16-2.0	7.8-10.3
19	-	26.0-30.0	20-80	25.8-130.4	0.0-0.6	5.9-8.2
20+	5	26.0-32.0 r=-0.2073 (N.S.)	30-80 r=+0.3586 (N.S.)	25.8-114.3 r= -0.2559 (N.S.)	0.0-0.2 r=-0.1563 (N.S)	5.3-8.6 r= -0.4079 *

(*) = significant at $p < 0.05$ (5%) (**) = significant at $p < 0.01$(1%) N.S. = not significant at any level. + = habitat which contained *L. natalensis*.

Table 4: Ranges of five chemical factors in the intensity study sites and the correlation coefficient (r) of each factor with the abundance of *L. natalensis* in some of the habitats.

Habitat Ref. no.	No. of *L. natalensis* collected	Alkalinity (meq./1)	Conductivity (microhms)	Dissolved oxygen (% sat.)	Calcium (p.p.m.)	Salinity (‰)
1+	112	1.03-2.45 r=+0.2480 (NS)	180-630 r=-0.3526 (NS)	38.9-103.6 r=+0.1712 (NS)	17.4-34.2 r=0.5788 ***	0.1-0.3 r=-0.4941 *
2+	5	1.24-2.64 r=+0.1423 (NS)	140-900 r=-0.2606 (NS)	27.5-102.6 r= - 0.1831 (NS)	18.2-35.5 r=-0.2745 (NS)	0.1-0.3 r=-0.0615 (NS)
3+	158	0.83-1.98 r=+0.1281 (NS)	200-650 r=+ 0.2117 (NS)	74.5-186.8 r=+0.0718 (NS)	15.2-25.8 r=+0.6082 * **	0.1-0.3 r=+0.5035 *
4+	3	0.84-2.25 r=+0.2055 (NS)	190-1020 r=-0.1630 (NS)	54.4-115.8 r=- 0.2129 (NS)	16.8 -70.8 r=-0.1928 (NS)	0.1-0.3 r=+0.2069 (NS)
5	-	1.42-4.4	320-1750	17.5-100	25.0-40.8	0.1-0.3
6	-	0.82-1.82	150-460	72.7-183.0	9.2-18.5	0.1-0.3
7	-	0.74-1.81	180-620	61.5-216.6	10.6-21.8	0.1-0.4
8	-	1.33-3.45	260-1610	57.9-137.6	20.2-33.4	0.2-0.7
9	-	1.42-4.18	210-1500	7.5-82.9	25.4-55.6	0.2-0.5
10	-	1.66-5.54	130-800	3.7-60.5	17.6-49.6	0.1-0.4
11+	269	0.71-2.45 r=- 0.4088 *	110-680 r=-0.2656 (NS)	7.5-88.2 r=+0.2130 (NS)	6.4-47.0 r= - 0.4261 *	0.1-0.3 r=-0.2804 (NS)
12+	12	0.94-1.97 r=+0.1695 (NS)	210-620 r=-0.2992 (NS)	51.0-177.9 r=- 0.0761 (NS)	15.8-25.6 r=-0.2304 NS	0.1-0.3 r=-0.2630 (NS)
13+	16	1.13-2.36 r=+0.2166 (NS)	230-720 r=-0.2707 (NS)	52.6-116.6 r=+0.3756 (NS)	18.8-28.2 r=-0.0999 (NS)	0.1-0.3 r=-0.1646 (NS)
14	-	1.01-3.82	320-1200	12.4-189.5	23.0-66.8	0.2-0.3
15+	373	1.6-5.45 r=+0.4599 *	310-850 r=-0.1382 (NS)	7.5-228.9 r=+0.3688 (NS)	18.8-60.8 r=+ 0.2963 (NS)	0.1-0.3 r=0.1177 (NS)
16	-	0.58-1.45	180-370	57.0-203.2	11.2-17.3	0.1-0.3
17	-	1.12-2.51	230-680	28.0-137.6	19.2-30.6	0.1-0.3
18	-	2.39-5.33	590-1450	0-19.0	21.9-49.6	0.1-0.7
19	-	0.54-1.96	180-350	12.7-137.6	8.1-12.8	0.1-0.3
20+	5	0.52-2.43 r=- 0.2190 (NS	160-700 r=-0.0442 (NS)	12.5-108.8 r=- 0.2115 (NS)	13.4-27.6 r=+0.1150 (NS)	0.1-0.2 r=0.0839 (NS)

(*) = significant at $p < 0.05$ (5%) (**) = significant at $p < 0.01$(1%) N.S. = not significant at any level. + = habitat which contained *L. natalensis*.

From the data collected during the study, certain records of some environmental factors of the habitats were found to be inimical to the occurrence and distribution of *L. natalensis.*

Excessive fouling of the water, water temperature above 31°C, complete shading of the habitat, high turbidities , fast water current , high pH values (>9.8), low alkalinity (<0.7 m. eq./l $Cac0_3$), low dissolved oxygen content of water and saline conditions were significant in the distribution and survival of *L. natalensis*. It is probable that a combination of some or all of these factors may exert greater influence on the distribution and abundance of *L. natalensis* than the individual factors. Knowledge of the chemical composition of water in aquatic habitats is vital to the success of any mollusiciciding programme (Ibidapo, 2000).

The chemical and physical analysis of bottom sediments in *L. natalensis habitats* was examined. A linear Correlation matrix indicating relationships between the abundance of *L. natalensis* and various chemical components of the soil did not reveal any significant correlations between each of the chemical components of the bottom with the presence of *L. natalensis*.

The chemical components examined include hydrogen –ion concentration (pH), organic carbon, exchangeable cations (Ca, mg, K, Na) and available phosphorus. However, the nature of the bottom sediments did influence the distribution of *L. natalensis* since the specie was absent from purely sandy or clayey soil. Sandy–loam or loamy-sand bottom sediments were noted to support large snail populations in this study, due to the abundance of organic matter.

Table 5: Monthly collection of *L. natalensis* in some of the intensive study habitats (1978-1980)

	MONTHS OF THE YEAR																								
Habitat	1978		1979												1980										Total of *L.*
REF. NO	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	*natalensis*
1	10	8	4	3	4	0	0	0	0	0	3	8	11	17	9	11	6	0	0	0	0	0	7	11	112
2	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	5
3	0	0	2	0	0	0	15	26	10	0	10	0	4	0	0	0	0	0	30	28	15	10	8	0	158
4	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
11	15	10	25	29	1	13	20	O	0	0	34	6	8	25	15	10	3	9	8	0	0	0	27	11	269
12	0	0	0	0	0	0	0	0	0	0	0	0	0	5	3	4	0	0	0	0	0	0	0	0	12
13	0	0	5	3	0	0	0	0	0	0	0	0	0	6	2	0	0	0	0	0	0	0	0	0	16
15	5	4	10	50	68	49	15	0	0	0	10	8	16	9	6	14	50	35	0	0	0	0	12	4	373
20	0	0	0	1	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	5

Table 5 reflects the monthly collection of *L. natalensis* over the 2-year study period. Though *L.natalensis* was collected during the dry and rainy seasons, this study showed that its distribution at the peak of the rainy season was limited to a pond which was unaffected by floods. Flooding of the habitats with a consequent rise in water level, constitute an important factor limiting distribution of the species. *Lymnaea* was never collected alone in any habitat but was often associated with other species of snails. Statistically significant values for association were recorded between *L. natalensis* and the occurrence of each of the following species of snails: *Bulinus globosus (39.3), Physa waterloti (33.9)* and *Melanoides tuberculata* (25.1). This study has also shown that the presence of *B. globosus, P. waterloti* and *M. tuberculata* in an aquatic habitat is an indication of the presence of *L. natalensis* in that environment. (Ibidapo, 2002).

(b) Studies on the feeding habit of *L. natalensis*

Several workers have commented on the feeding habits of the lymnaeidae and other fresh water snails but none of these studies was on the diet of *L. natalensis*

Analysis of stomach contents of *L. natalensis* conducted in this study as described by Ndifon (1980), confirmed that food types of plant and animal origin are included in the diet. Frequency of occurrence of these food types are shown in Table 6.

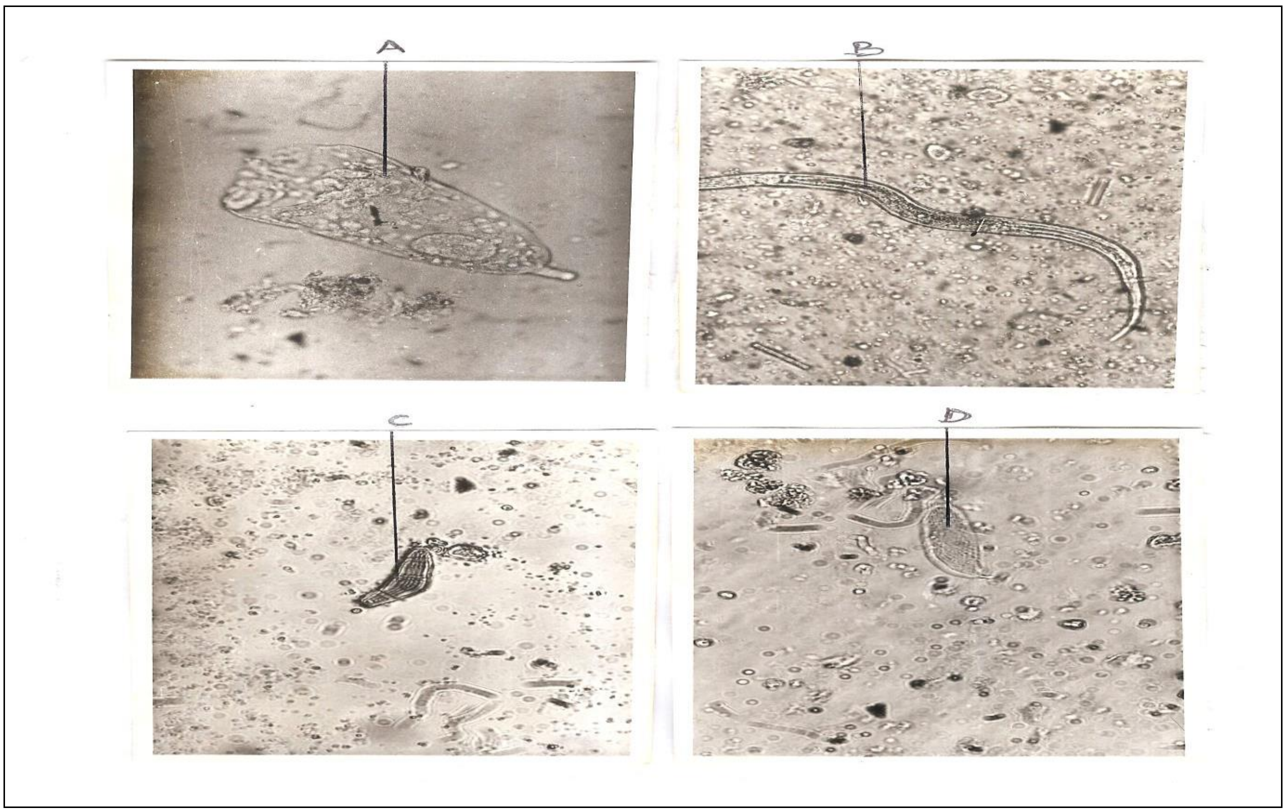
Table 6: Frequency of occurrence (percent values) of various types of stomach content in six groups of *L. natalensis*, collected from the study area.

A- Filamentous algae	E- Rotifer	I- Nematode	M- sand particles	R- Water mite
B-Other algae	F- Macrophyte tissue	J- Insectlarva	O- Ciliate	S- Cladoceran
C-Desmids	G- Crustaceans	K- Sarcodina	P- Flagellate	
D-Diatoms	H- Spores	L- Gastrotrich	Q- Bryozan	

Snail group*	Mean length of snails (mm)	Percentage of various types of stomach contents in six groups of L. natalensis																		
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
Adults from Jemata pond	11.9	96	92	80	80	82	46	40	42	18	30	8	12	100	100	16	10	20	10	10
Adults from the drainage ditch	11.9	100	100	30	74	26	64	22	52	12	6	4	6	100	100	10	10	0	0	4
Adults from Sango Stream	11.8	82	84	64	82	70	14	80	72	38	12	6	12	100	100	6	4	10	0	0
Juveniles from Jemata pond	6.9	94	100	86	90	66	0	100	72	0	0	4	6	100	100	0	0	0	0	0
Juveniles from the drainage ditch	7.0	92	94	80	94	76	0	96	70	0	0	6	4	100	100	0	0	0	0	0
Juveniles from Sango stream	6.8	92	100	72	98	100	0	0	42	0	0	4	4	100	100	0	0	0	0	0

*Each group consists of fifty *L. natalensis*

Previous reports indicated that the lymnaeidae are microphagous herbivores but this study confirmed that microscopic animals are also eaten. This is the first of such report for *Lymnaea natalensis*. Food types of plant origin in the stomach content include filamentous algae (*Spirogyra* sp, *Chaetophora* sp. and *Oedogonium* sp*).* Other types of algae are *Protococcus* sp.,*Scenedesmus* sp. *Chlorella* sp. and *Chlorococum* sp.Desmids (*Cosmarium* sp.,) diatoms, (*Navicula sp* and *Pinnularia* sp, spores and macrophyte tissue. Food items of animal origin include rotifers, crustaceans, nematodes, gastrotrich, sarcodine, ciliates and others (Plate 2), (Ibidapo, 2000).Clearing of vegetation in an aquatic habitat would mean the removal of shelter and a major food source, which would impact negatively on snail population and thereby encourage snail control.



A. Vorticella **C.** Rotifer

B. Nematode **D.** Gastrotrich

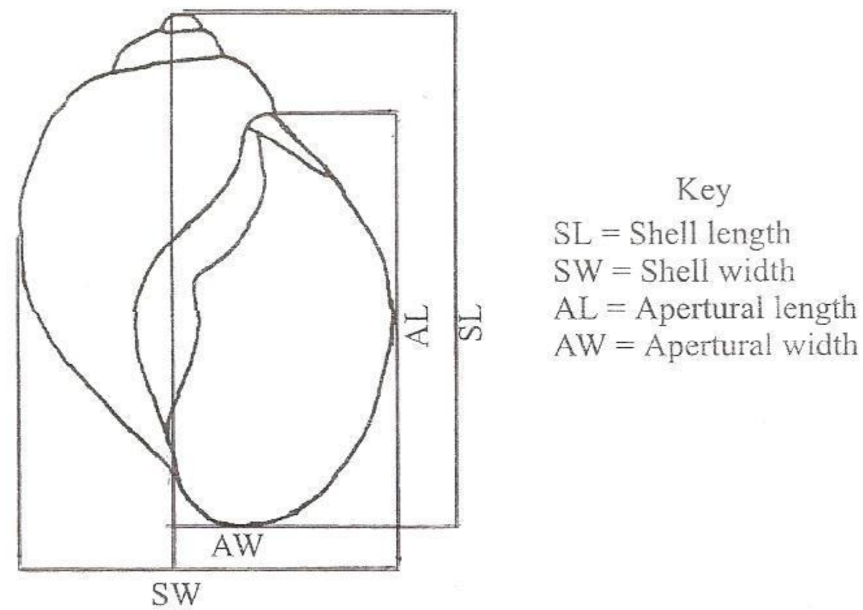
Plate 2: Food items of animal origin

(C) Shell morphology and morphometrics of *L. natalensis* populations

Researches on variation in shell morphologies and morphometrics are indices for identification, taxonomic importance and growth studies.

In this study I examined the shell morphology of *Lymnaea natalensis* .The relevant dimensions include shell length (L) , shell width (W) , apertural width (AW) and apertural length (AL) as described by Anon (1973), (Fig.5).

The shell of *L. natalensis* is dextral and the colour varies from almost black to light brown. Microscopic growth lines are visible when shells are examined under the dissecting microscope.The shell whorls varied in number from 3 to 4. The outer whorls of all specimens were thin and sharp with pointed spire. *Lymnaea natalensis* collected from the nine habitats showed significant variations in shell ratios, ($P<0.05$) L/W (indicating slenderness or globosity) , L/AL (form of the spire) and AL/AW (shape of the apertural opening) in all the size groups of snails within the same habitat and those from different habitats. The mean values of all the ratios were significantly different ($P<0.05$) in all the habitats.



(Anon, 1973)

Fig.5: Shell morphology

Table 7: Mean Ratios of Shell Measurements for selected habitats

Habitat Name and Ref. No	Total No. of Snails collected per habitat	Mean Length of Snails Per Habitat	XL/W	XL/AL	X AL/AW
Oba dam (1)	82	12.96 ±4.31	1.86±0.15a	1.38±0.9b	1.64±15c
Eleiyele dam (13)	96	10.62 ±4.33	1.76±0.11a	1.37±0.12b	1.48 ±0.21b
Jemata pond(3)	168	11.39±5.64	1.81±0.15a	1.37±0.12b	1.72±0.15c
Ijokodo pond (20)	65	12.58±4.53	1.92±0.11a	1.40+0.12b	1.78±0.08c
Earth Pit reservoir (15)	223	15.77±7.59	1.85±0.14a	1.42±0.13b	1.70±0.12c
Iya-Ganku Stream (2)	5	6.04±1.98	1.68±0.10a	1.31±0.07b	1.61±0.09c
Jericho stream (4)	2	9.87±6.67	1.93±0.05a	1.36±0.12b	1.77 ±0.9c
Ona River (12)	8	10.31±4.70	1.84 ±0.10a	1.34±0.04b	1.71±0.08c
Sango stream (11)	52	9.54±5.34	1.81±0.17a	1.36±0.11b	1.70+0.17c

Shell length andwidth (L/W) indicating slenderness were positively and significantly correlated ($P<0.05$) in the snails collected from all the habitats. The variations observed in the morphology of the snails collected in the study area were attributable to ecological differences. Ponds, dams and earth pit reservoir with slow current and abundant algal growth supported the growth of large snail populations in contrast to the fast flowing water bodies with scanty plant growth.Fast water current dislodged the snails and washed them away before any appreciable size was reached.

The fact that variations in shell shape could create confusion in the identification of snails was remarked by Ndifon and Ukoli (1989). This study was able to highlight intra and inter sample variations thus reducing to the minimum, errors in the identification of this intermediate host in any aquatic habitat.

(d) Natural infection of *Lymnaea natalensis* with larval trematodes

This study became necessary in order to establish any source of infection of cattle with fascioliasis. The infective status of *L. natalensis* in the area had to be clarified. *Lymnaea natalensis* collected from the habitats were shed for cercariae in the laboratory. Three types of cercariae were shed by *L. natalensis* during the study.

These were echinostome, brevifurcate and "*F. gigantica*"cercariae (Fig 6).

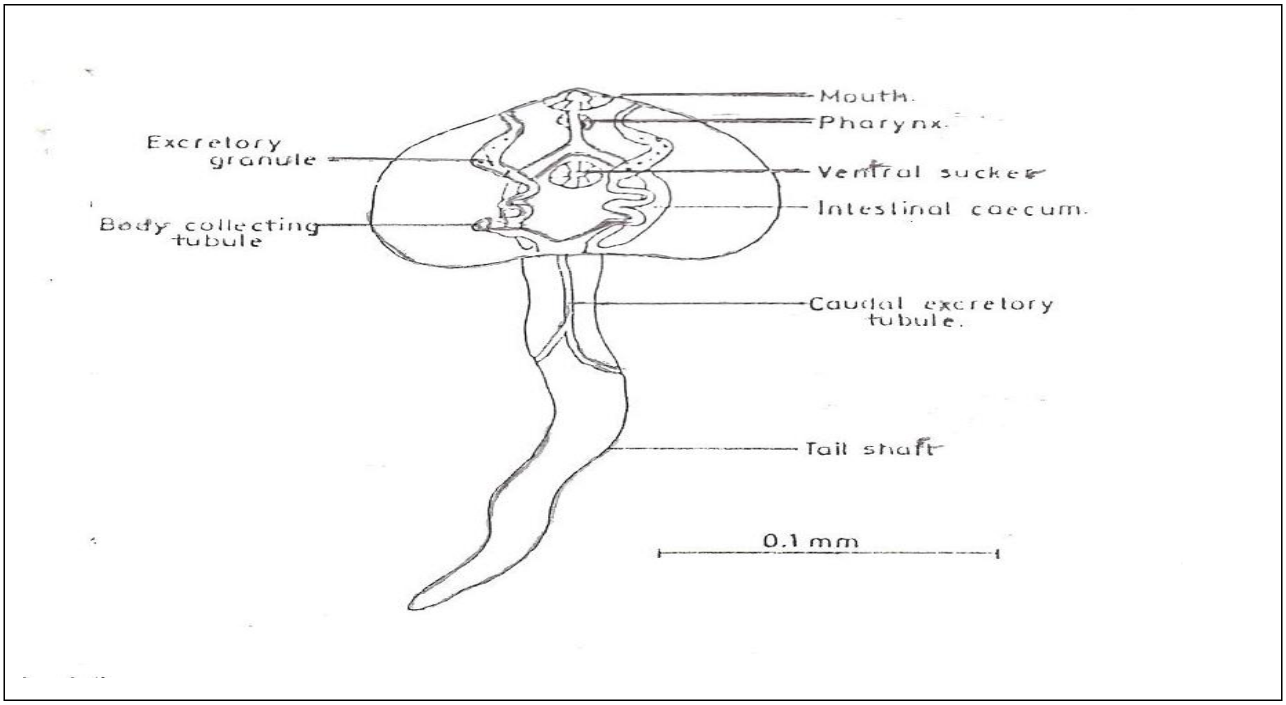


Figure 6: *"F. gigantica"* cercaria

The shedding of *"F. gigantica"* cercaria by L. *natalensis* collected from a pond was the first report of this infection in the study area. The identification was based on the behavioral and morphological characteristics described by Ogambo–Ongoma (1969). In the light of this knowledge i suggested to the authorities at that time that the grazing of cattle in the vicinity of that pond should be discouraged (Ibidapo, 1989). These studies constitute the first and detailed analysis of the ecology of *L. natalensis* in Nigeria.

2. Prevalence Of Liverfluke And Other Helminth Parasites Of Cattle

The widespread occurrence of L. *natalensis* roused my interest in examining the prevalence of fascioliasis in locally slaughtered cattle using five abattoirs in Lagos metropolis. The results obtained showed that a total of 4, 194 cattle livers were examined in five abattoirs and 40.4% were condemned due to helminth infections. The major and important parasites recovered were *Fasciola gigantica* (22.9%) and *Dicrocoelium dendriticum* (12.9%). Other parasites include *Oesophagostomum* sp (1.1%), *Cysticercus bovis* (1.8%) and *Echinococcus granulosus* (1.6%). The worm burden per cattle was high, it ranged between

32.063±07.0 and 51.67 ± 10.41 for fascioliasis. The trade cattle imported into the country through neighboring countries must have experienced series of re-infection along their routes while grazing on metacercariae infested vegetation. This is the most plausible reason for the high prevalence and heavy worm burden due to fascioliasis in all abattoirs studied. Ibidapo (1989) reported that flood plains and ponds should be avoided when grazing cattle during the rainy reason (May-June), since L. *natalensis* shedding cercariae were noted to be abundant at that time. I also recommended that cattle should be given doses of antihelminthics just before the annual migrations (Ibidapo, 2004). This will reduce transmission of the disease which adversely impact the quality of livestock and wellbeing.

3. Human Intestinal Parasites

It is estimated that 3.5 billion people are infected with intestinal parasites of which 450 million are ill (WHO, 1998). It is also projected that by the year *2025* about 57% of the population in developing countries will be urbanized. As a consequence, a large number of people will be living in shanty towns where parasites like *Ascaris lumbricoides* and *Trichuris trichiura* will find favorable conditions for transmission. The individual parasite provides the basic unit of study and it is therefore desirable to measure the burden of parasites within the host by direct methods (e.g. worm expulsion by chemotherapeutic agents) or indirect method (e.g. egg or cyst output in the faeces of the host). There is an ever increasing need to obtain current data on the incidence and prevalence of parasitic infections. These are useful tools for surveillance and control programmes.

3a. Prevalence of intestinal parasites in a cross–section of Lagos population

The results of examination of randomly collected stool specimens from a cross-section of the population are presented in Table 8.

Table 8: Prevalence (%) of intestinal parasites in a cross section of Lagos population.

Age group (years)	Ne	Al	Tt	Na	Ss	Ev	Dd	Hn	Sm	Ec	Eh	Th	Gi	Ib	En	Cm
½-under 1	50	22.0	4.0	2.0	0.0	0.0	0.0	0.0	0-0	6.0	0.0	0.0	4.0	2.0	0.0	0.0
1-5	125	78.4	60.0	24.0	4.0	12.8	0.0	1.6	0.8	24.0	5.6	4.0	22.4	10.4	2.4	0.0
6-15	392	74.0	70.2	47.7	4.1	5.1	0.5	2.0	1.5	24.2	18.4	13.5	18.6	8.7	8.2	2.6
16-25	240	70.8	40.0	27.5	20.8	4.2	4.2	1.3	1.7	30.8	24.6	20.4	17.1	10.8	10.0	2.1
26-35	150	72.0	39.3	26.0	40.0	1.3	3.3	2.7	0.7	16.7	10.7	24.0	4.7	10.0	6.7	2.0
36-45	58	82.8	44.8	34.5	22.4	3.4	10.3	0.0	3.4	22.4	29.3	25.9	5.2	5.2	8.6	1.7
46-55	20	75.0	55.0	20.0	15.0	0.0	15.0	0.0	0.0	25.0	20.0	15.0	5.0	10.0	10.0	0.0
Above 55	15	66.7	46.7	20.0	13.3	0.0	13.3	0.0	6.7	33.3	13.3	6.7	0.0	6.7	13.3	0.0
Total	1050	71.4	52.5	3.33	14.2	4.8	2.7	1.6	1.4	23.8	16.9	15.4	14.8	9.0	7.4	1.8

Key:

Ne =Number examined
Al = Ascaris *lumbricoides*
Tt= *Trichuris trichiura*
Na = *Necator americanus*
Ss = *Strongyloioles stercoralis*
Ev = *Enterobius vermicularis*
Dd= Dicrocoelium dendriticum
Hm = *Hymenolepis nana*
Sm = *Schistosoma mansoni,*
Ec = *Entamoeba coli*
Eh =*Entamoeba histolytica*
Th = *Trichomonas hominis*
Gi = *Giardia intestinalis*
Ib = *Iodamoeba butschilii*
En = *Endolimax nana*

Helminths accounted for a prevalence of 67.1% while 32.9% were infected with protozoa. The commonest helminthes were *Ascaris lumbricioides and Trichuris trichiura*,while protozoa were *Entamoeba coli, Entamoeba histolytica* and *Giardia intestinalis.* Polyparasitism was common across all age groups, occupation and educational status. Predisposing factors for infection include poor toilet facilities, dirty eating habits and walking barefooted in the case of hook worm infection. Indiscriminate purchase of food from hawkers was also commonly reported. (Ibidapo, 1997). Health educations, deworming with antihelminthics and provision of basic social amenities e.g. water and good toilet facilities were indicated to be vital to the reduction of infection within the studied communities.

3b. Helminth Fauna of Dogs

The transmission of parasites of zoonotic importance to man from domestic and recreational animals and the challenges of opportunistic infections necessitated this study on dog helminth fauna.

The helminth fauna of dogs in Lagos metropolis was studied with the aid of personnel of several veterinary clinics in the city and private dog owners. In this study, stool samples of domestic and free roaming or strayed dogs were examined for helminth ova. In the strayed –dogs category, of the 86 males, 61 (70.9%), and of the 49 females, 44 (89.7%) tested positive for helminth ova (Tables 9 and 10). The four helminth ova recovered from the strayed dogs were *Toxocara canis* (49.5%)*, Ancylostoma caninum* (47.6%)*, Dipylidium caninum* (41.9%) and *Trichuris vulpis* (20.9%). In the group of domesticated dogs, out of the 78 males, 9 (11.5%) and of the 97 females, 12(12.4%) tested positive for helminth ova. Overall prevalence of strayed dogs with helminth ova was 77.8% and that of domesticated dogs 12%, the difference being statistically significant (P<0.01). Prevalence of helminth parasites among domesticated dogs was very low due to regular treatment at the veterinary clinics. However, it was noted that puppies within the two groups were heavily infected.

The public health implication of this cannot be overemphasized, particularly in connection with the transmission of zoonotic diseases.

Table 9: The Prevalence of Helminth Ova* in Different Age Groups and Sex of Strayed Dogs, Lagos, Nigeria

Age group	**Males**		**Females**		**Total**	
	Number examined	Number Infected	Number Examined	Number Infected	Number Examined	Number Infected
Puppies (<6months)	34	31(91.2)	17	16 (94.1)	51	47(92.2
Young (>6 months - 2years)	28	19(67.9)	19	17(89.5)	47	36(76.6)
Adult (>2years)	24	11 (45.8)	13	11(84.6)	37	22 (59.5)
Total	86	61 (70.9)	49	44(89.7)	135	105 (77.8)

*Values within parenthesis are percentages of the total number of dogs examined in the respective age-group category.

Table 10: The Prevalence of Helminth Ova* in Different Age Groups and Sexof domesticateddogs inLagos, Nigeria.

Age group	**Males**		**Females**		**Total**	
	Number examined	Number Infected	Number Examined	Number Infected	Number Examined	Number Infected
Puppies (<6months)	30	6(90.0)	35	8(22.9) (94.1)	65	14 (21.5)
Young (>6 months - 2years)	25	2 (8.0)	45	3 (6.7)	70	5 (7.1)
Adult (>2years)	23	1 (4.3)	17	1(5.9)	40	2 (5.0)
Total	78	61 (11.5)	97	12(12.4)	175	21 (12.0)

*Values within parenthesis are percentages of the total number of dogs examined in the respective age-group category.

In toxocariasis, vertical transmissions from mother to puppies occur via the transplacenta and transmammary secretions.Children are more susceptible to infections because of their intimacy with puppies. The parasites can be transmitted by the ingestion of infective eggs. Response to questions by dog owners revealed that only 40% were aware of diseases transmissible between dogs and man, (Ibidapo, 2005). There is an urgent need for enlightenment on the zoonotic nature of diseases acquired from dogs such as cutaneous larva migrans, *Echinococcus* sp and myasis to mention a few. Regular deworming of dogs with antihelminthics is advocated while it is advised that dog faeces and vomitus should be cleared immediately and the environment disinfected.

4. **Soil transmitted helminthes**

Infections with soil transmitted helminthes have been increasingly recognized as an important public health concern, particularly in developing countries. Rural communities receive low medical and financial attention from government; hence prevalence records have to be presented regularly. Different models were studied to provide a comprehensive understanding of the disease epidemiology in diverse communities and population settings. The study examined the pattern of infection in a rural community and the school system.

(a). Studies in a Rural Community

A rural community, Era Awori off the Lagos Badagry Expressway recorded a prevalence of 83.3% for soil transmitted helminthes. Four soil transmitted helminths, namely *Ascaris lumbricoides,* hookworm*, Trichuris trichiura* and *Strongyloides stercoralis* were reported *(*Table 11). The egg load per gram of faeces was high in both sexes (Table 12). Pattern of infection was age dependent. Infection with *T. trichiura* and hookworm were most common among children, while *Ascaris lumbricoides* recorded the highest positive rates in all the groups. Educational background did not impact positively on the infection rate as both literate and illiterates were heavily infected. Factors such as fecal contamination of the environment, occupation and socio-economic status influenced the overall health situation. Lack of potable water, absence of adequate toilet facilities and walking barefooted enhanced transmission. (Ibidapo and Okwa 2008).

Table 11: Age Stratified prevalence of infection with soil transmitted helminths at Era-Awori Village, Lagos.

Years	No examined	No infected (%)	*A. lumbricoides* (%)	*T. trichiura* (%)	Hookworm (%)	*S. stercoralis* (%)
1-10	105	92 (87.6)*	82 (78.1)	40 (38.1)	54 (51.4)	10 (9.5)
11-20	50	45 (90.0)	41 (82.0)	15 (30.0)	24 (48.0)	10 (20.0)
21-30	50	38 (76.0)	32 (64.0)	13 (26.0)	18 (36.0)	08 (16.0)
31-40	34	26 (76.5)	17 (50.0)	06 (17.6)	15 (44.1)	07 (20.6)
41-50	19	15 (78.9)	12 (63.2)	07 (36.8)	06 (31.6)	02 (10.5)
51-60	25	21 (88.0)	09 (36.0)	08 (32.0)	11 (44.0)	13 (52.0)
61-80	17	13 (76.5)	10 (58.8)	05 (29.4)	07 (41.2)	04 (23.5)
Total	300	250 (83.3)	203 (67.7)	94 (31.3)	135 (45.0)	54 (18.0)

*Figures in parenthesis represent percentages.

Table 12: Mean Egg Load (EPG) and Levels of Infections with Helminths at Era-Awori Village, Lagos.

Age groups (years)								
	sex	1-10	11-20	21-30	31-40	41-50	51-60	61-80
	Male	55	22	13	07	12	08	07
Mean egg count (Epg)		1641.22 ± 2205.48	2369.7± 2962.3	748.8± 905.3	616.0 ± 745.4	845.3 ± 1112.2	202.0 ± 260.95	692.0 ± 857.67
Mean egg count (Epg)	Female	37	23	25	19	03	13	06
		2235.1 ± 2878.9	3184.8±3651.2	916.6±1170.6	844.8 ±1108.8	325.0 ± 403.11	419.5 ± 608.2	942.8 ± 1122.5
	Total no	92	45	38	26	15	21	13
	Cumulative mean Epg	1893.1± 2514.13	2841.1± 336.4	860.6 ±1089.6	764.1 ±1025.2	803.3 ±1053.9	392.6 ±561.2	797.9 ± 997.1
Multiple Infections (%)	170 (56.7)	66 (62.9)	33 (66.0)	27 (54.0)	17 (50.0)	10 (52.6)	09 (36.0)	08 (47.1)
Single Infections (%)	08 (27.0)	26 (24.8)	12(24.0)	11(22.0)	09(26.5)	05(26.3)	13(52.0)	05(29.4)
No infection at all (%)	49(16.3)	13(12.4)	05(10.0)	12(24.0)	08(23.5)	04(21.1)	03(12.0)	04(23.5)

(b) Studies in the School System

A cross sectional study of the prevalence of soil transmitted helminthiases in a primary school in Ukwani localGovernment areaof Delta State revealed that 92.7% of the respondents were infected. Helminths reported were *Ascaris lumbricoides*, hookworm and *Trichuris trichiura* . Risk factors noted were licking of fingers, drinking from wells or surface tanks, geophagy, and walking barefooted (Omah, *et al.*, 2014).

In Nigeria, helminthiases are an important epidemiological problem which cuts across communities, age groups and occupation. Regular deworming exercises by the administration of antihelminthtic drugs such as Mebendazole, Albendazole, Pyrantel and others recommended by WHO (2002) are effective control strategies. The provision of basic social amenities such as potable water, adequate toilet facilities and health education are initial aspects of an integrated control programme.

5. Schistosomiasis in the Community

Schistosomiasis is one of the major parasitic diseases of man in terms of its socio-economic and public health importance in tropical and subtropical areas. In Nigeria, it occurs mostly among children,affecting their growth and cognitive abilities and if untreated can result in severe urinogential disorders. This study examined the prevalence of infection due to urinary schistosomiasis among school children and residents of Badagry Local Government area using three different diagnostic tools. The urine samples were examined by the visual method for haematuria, diagnostic chemical reagent strip and the filtration technique. Macrohaematuria was detected in 12.5% of the urine samples (Table 13), while diagnostic chemical reagent strip detected 6.5% positive cases (Table 14). Filtration did not reveal the presence of eggs in any of the urine samples observed. Responses obtained from the administration of questionnaires indicated that 96% did not have any idea about the disease. The local belief was that blood in urine marked a sign of puberty (Ibidapo *et. al.,* 2005).

Domestic washing and swimming in rivers were the identified risk factors. Health education is of paramount importance to enlighten the people. Health centres in the community were encouraged to provide necessary drugs to assist in treating reported cases.

Table 13: Prevalence of Haematuria among Residents of Badagry area by Sex and Age.

Age (years)	Number examined		Number positive		Prevalence (%)	
	Male	Female	Male	Female	Male	Female
5- 9	8	4	0	0	0.0	0.0
10- 14	11	18	2	1	18.2	5.6
15- 19	32	30	4	4	12.5	13.3
20- 24	24	44	4	6	16.7	13.6
25- 29	9	19	2	2	22.2	10.5
>30	1	0	0	0	0.0	0.0
Total	85	115	12	13	14.1	11.3
Cumulative Total	200		25		12.5%	

Table 14: Prevalence of Urinary Schistosomiasis By Sex and Age Using Diagnostic Strip Among Residents Of Badagry Area.

Age (years)	Number examined		Number positive		Prevalence (%)	
	Male	Female	Male	Female	Male	Female
5- 9	8	4	0	0	0.0	0.0
10- 14	11	18	1	1	9.1	5.6
15- 19	32	30	3	1	9.4	3.3
20- 24	24	44	2	3	8.3	6.8
25- 29	9	19	1	1	11.1	5.3
>30	1	0	0	0	0.0	0.0
Total	85	115	12	6	8.2	5.2
Cumulative total	200		13		6.5%	

6. Fish Helminths in Lagos Lagoon

The emanating need to culture fishes for protein consumption by the teeming rapidly growing populations in developing countries have made it necessary to intensify studies on the parasite fauna of African freshwater fishes. Our team examined the helminth bioload of *Chrysichthys nigrodigitatus* from Lekki lagoon, Lagos. The prevalence of helminth infections was 12.7%. Statistical analysis did not indicate any relationship between sex, size and level of infection. Helminth parasites recovered include a cestode *Proteocephalus sp.,* and *nematodes*, namely *Aspidogastrea africanus* and Paracamallanus *cyathopharynx.*

Worm burden and intensity were low and independent of sex and age of fish. There was no seasonal variation in parasite intensity. This study is the first record of *Paracamallanus cyathopharynx* in *Chrisichthys nigrodigitatus*, but this parasite had been reported in other fish species. Aqua culturists need to ensure high quality of fish by reducing parasitic infections. (Akinsanya *et al.,* 2007).

7. Dracunculiasis in Lagos: Prevalence and Control

Dracunculiasis (Guinea worm, disease) caused by *Dracunculus medinensis* was believed to affect 5-15million people annually with a population at risk of 120 million in Africa (WHO, 1987). It is a very painful debilitating disease causing wound and immobility of the individual. There is no acquired immunity, so each year the disease can recur. Blisters are common in the lower limb as shown in (Plate 3).

Plate 3: Guinea Worm on human leg showing swelling and inflammation

With the inception of global eradication of guinea worm, Nigeria intensified prevalence, control and advocacy of the disease.

Our team carried out three case searches for active guinea worm disease in Lagos State between 1987 and 1990. Objectives were to determine disease prevalence, obtain information on drinking water sources, initiate health education and give advice on the treatment of guinea worm ulcers. In the 1987/88 guinea worm season, 42 active cases were reported in 7 out of 8 local government areas.

Table 15: Result of the 1987/88 Active Guinea Worm Search in Lagos State

S/N	Local Government Area	Population (Approx.)	Total No of Villages or Wards	No of Villages Searched	Name of Village or Urban Centre with Guinea Worm Case	No of Cases	Origin of Infection
1	Agege	613,000	53	-	-	-	-
2	Badagry	178,000	120	60	Tarfi Awori	10	indigenous
					Tarfi Awusa	5	indigenous
					Aradagun	3	Indigenous
3	Epe	233,000	115	102	Abijo	1	Oyo State
					Ahoyaya	1	Oyo State
4	Eti-Osa	424,206	48	-	-	-	-
5	Ibeju-Lekki	48,400	96	-	-	-	-
6	Ikeja	417,500	110	102	Iju- Ogundimu	2	OgunState (Igbo Ora)
7	Ikorodu	246,800	130	100	Majidun Awori	1	Anambra State
					Ikorodu Town	2	Anambra State
					Owode	1	Anambra State
					Maya 1	1	Indigenous
					Laiyeode- Lafose	1	Indigenous
					Ibeshe- Belogun	8	indigenous
8	Lagos Island	284,900	10 wards	10	Ado Nla	2	Anambra State
9	Lagos Mainland	1,224,00	14 wards	14	Ijora Oloye	2	Anambra State
10	Mushin	1,097,900	25	23	Mafoluku	1	Oyo State
11	Ojo	984,700	98	-	-	-	-
12	Somolu	743,500	76	21	None	None	

Table 16: Result of the 1988/89 Active Guinea Worm Search in Lagos State

SN	Local Government Area	Population (approx.)	Total no of Villages or Wards	No of Villages Searched	Name of village or urban centre with guinea worm case	No of case	Origin of infection
1	Agege	613,000	53	49	Orile Agege	1	Ogun State (Olodo)
2	Badagry	178,000	120	110	None	None	None
3	Epe	233,000	115	108	Iji	2	Oyo State
4	Eti-Osa	424,206	48	45	Victoria Island	1	Anambra State
5	Ibeju-Lekki	48,400	96	89	None	None	None
6	Ikeja	417,500	110	103	Idimu	1	Oyo State
7	Ikorodu	246,800	130	124	Odo-Nla Mowo-Nla	3 5	Indigenous Indigenous
8	Lagos Island	284,900	10 wards	10	None	None	None
9	Lagos Mainland	1,224,00	14 wards	12	Ijora-Oloye Surulere Isolo	1 1 1	Anambra State Anambra State Anambra State
10	Mushin	1,097,900	25	21	Idi-Araba Isolo	2 3	Anambra State Ogun State
11	Ojo	984,700	98	94	Tarfi Awusa Tarfi Awori Okun Tarfi Agaja	9 15 1 1	Indigenous Indigenous Indigenous Indigenous
12	Somolu	743,500	76	74	Alapere	1	Oyo State (Osogbo)

In the 1988/89 guinea worm season a total of 48 infected persons were reported in 9 out of 12 local government areas.

Only 20 cases of the infection were reported from 6 local government areas in the 1989/90 guinea worm season.t

Table 17: Result of the 1989/90 Active Guinea Worm Search in Lagos State

S/N	Local Government Area	Population (Approx.)	Total No of Villages or Wards	No of Villages Searched	Name of Village or Urban Centre with Guinea Worm Case	No of Cases	Origin of Infection
1	Agege	613,000	53	49	Ijaiye (Medium Housing Estate)	2	Ogun State (Igbogila)
2	Badagry	178,000	120	100	Badagry Town	1	Oyo State (Eruwa)
3	Epe	233,000	115	83	None	None	None
4	Eti-Osa	424,206	48	39	None	None	None
5	Ibeju-Lekki	48,400	96	89	None	None	None
6	Ikeja	417,500	110	103	Siwooku Ojodu Ikeja G.R.A	3 1 2	Ogun State Oyo State Anambra State
7	Ikorodu	246,800	130	124	Mowo-Nla Bagidan Ikorodu Town Majidun Odogunyan	4 1 2 1 1	Benue State Anambra State Anambra State Anambra state Anambra State
8	Lagos Island	284,900	10 Wards	10 Wards	None	None	None
9	Lagos Mainland	1,224,00	14 Wards	14 Wards	None	None	None
10	Mushin	1,097,900	25	25	Papa Ajao	1	Oyo State
11	Ojo	984,700	98	93	None	None	None
12	Somolu	743,500	76	64	Somolu	1	Benue state

Guineaworm season is the period between 1st July of one year and30th. June of the following year. Indigenous transmission was reported in four riverine villages of Ojo local government and some villages in Ikorodu local government. A total of 45 imported cases of guinea worm disease were reported in the state during the three–year survey period. These infected persons contracted the disease outside Lagos State but later came to reside in the state. Cyclops species, the crustacean intermediate host of the parasite was identified in the water samples collected from ponds in the affected villages (Ibidapo, 1998).

The strategy for the control involved the concept of Village Health Committee which formed the cornerstone of other interventions. Illustrative posters and hand bills were very effective media of communication with the rural populace. Boiling or filtration of unprotected water using the distributed monofilament nylon materials tied to the rim of the bucket had remarkable impact. Construction of fence round infected water bodies with a view to discourage residents from visiting them added value to the control programme. Individuals with guinea worm ulcers were prevented from coming into functional water sources.

The basic elixir against guinea worm is clean water. To this end, the Nigerian Guinea worm Eradication Programme (NIGEP) needed to provide about 90,000 villages with potable water (WHO, 1989). In Lagos State, as well as other states in Nigeria the, UNICEF sponsored Rural Water and Sanitation Programme (RUWATSAN), Jimmy Carter's global 2000 and the Bank of Credit and Commerce International (BCCI) played vital roles in the funding of programmes that brought an end to the scourge of guinea worm disease. Personnell were trained for field work of which I was a beneficiary and the chemical Abate (Temephos) were distributed for the treatment of infected ponds. The good news is that Lagos State and indeed Nigeria has now been declared free of guinea worm infections. Carter center announced only 148 cases of guinea worm disease worldwide in 2013. This is an instance of battle won. However, the battle is unending as vigilance and surveillance are vital

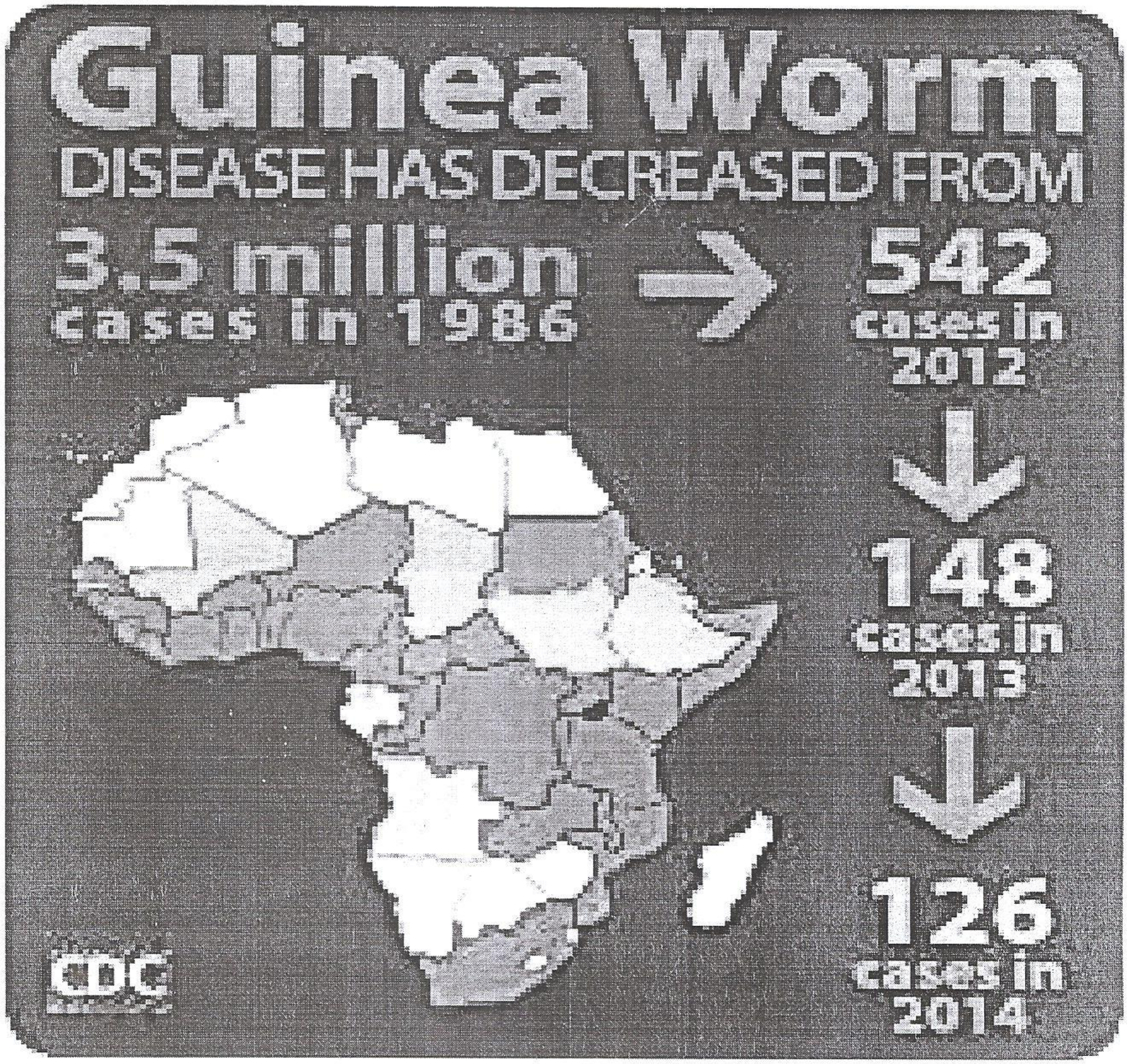


Figure 7: Guinea Worm Decline in Africa

Figure 7 provides a pictorial view of the decline of guinea worm cases in Africa. This control can only be maintained by active surveillance which can quickly prevent any resurgence of new cases.

8. Loiasis in Ondo State: Prevalence and Control

In endemic areas of co-infection of loiasis with onchocerciasis or lymphatic filariasis, patients treated with ivermectin have reported adverse reactions such as encephalopathy. Ivermectin is a microfilaricide which is supplied free by Merck Dolme and Co. Inc. throughout the onchocerciasis endemic areas of Africa. Loiasis (eye worm) (Fig. 8), onchocerciasis (river blindness) and lymphatic filariasis (causes elephantiasis) are responsible for serious health problems in the rain forest zones in Africa.

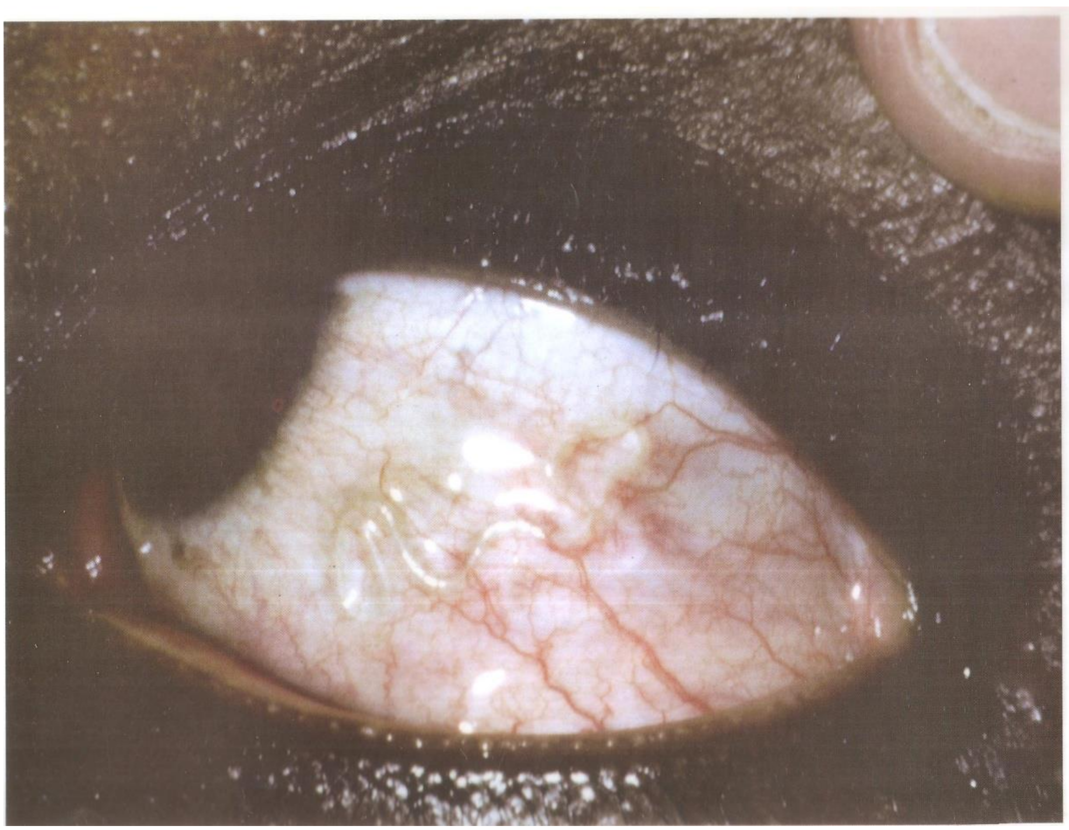
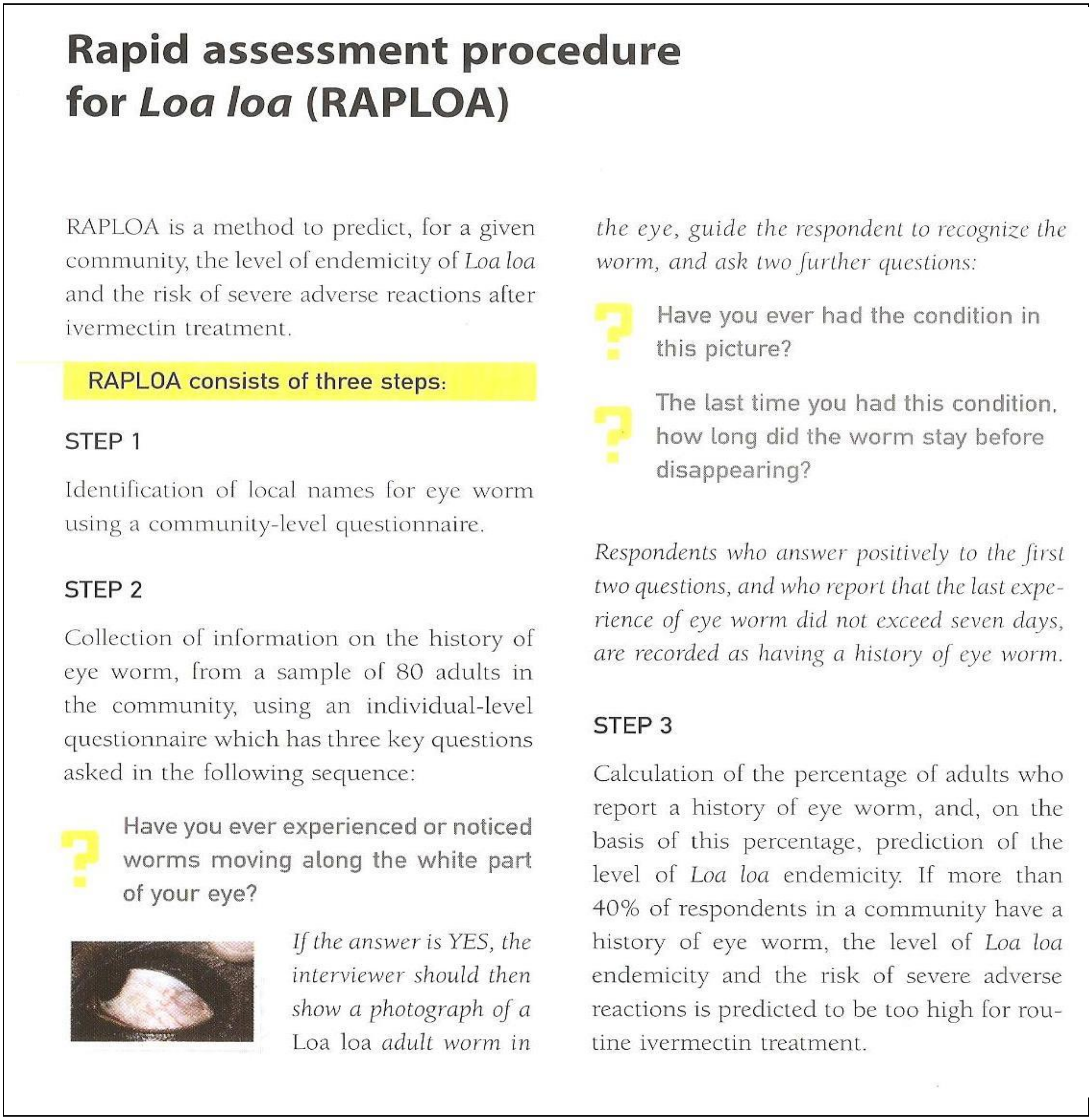


Figure 8: Loa *loa* (African Eye Worm) (WHO, 2002)

Information on the endemicity of loiasis in the communities must precede the administration of ivermectin in order to ensure success of the programme. To bridge this gap, our team carried out prevalence studies of loiasis among 4,800 subjects in 60 villages in Ondo State using the tool "Rapid Assessment for the

Prevalence of Loiasis" (RAPLOA) recommended by World Health Organisation (WHO, 2002). (Fig: 9).



Rapid assessment procedure for *Loa loa* (RAPLOA)

RAPLOA is a method to predict, for a given community, the level of endemicity of *Loa loa* and the risk of severe adverse reactions after ivermectin treatment.

RAPLOA consists of three steps:

STEP 1

Identification of local names for eye worm using a community-level questionnaire.

STEP 2

Collection of information on the history of eye worm, from a sample of 80 adults in the community, using an individual-level questionnaire which has three key questions asked in the following sequence:

? Have you ever experienced or noticed worms moving along the white part of your eye?

If the answer is YES, the interviewer should then show a photograph of a Loa loa *adult worm in the eye, guide the respondent to recognize the worm, and ask two further questions:*

? Have you ever had the condition in this picture?

? The last time you had this condition, how long did the worm stay before disappearing?

Respondents who answer positively to the first two questions, and who report that the last experience of eye worm did not exceed seven days, are recorded as having a history of eye worm.

STEP 3

Calculation of the percentage of adults who report a history of eye worm, and, on the basis of this percentage, prediction of the level of *Loa loa* endemicity. If more than 40% of respondents in a community have a history of eye worm, the level of *Loa loa* endemicity and the risk of severe adverse reactions is predicted to be too high for routine ivermectin treatment.

Figure 9: RAPLOA Questionnaire (WHO, 2002)

Our findings showed that 30.4% of adult respondents reported a history of eyeworm (Adeoye *et al.* 2008). Adverse reactions from ivemectin administration were recorded in 38 % of the subjects. Diverse adverse reactions experienced included itching, oedema of the face and limbs, rashes, and body weakness.

Expulsion of intestinal worms occurred in a few of the respondents. Neither fatal nor severe adverse reactions were reported by respondents. (Otubanjo *et al.*2008). The Rapid Assessment Procedure for *Loa loa* (RAPLOA) was adapted for market surveys in the study area. Market surveys in rural communities were considered to be cost effective and rapid in the determination of prevalence of any disease. Market days are highly esteemed in rural communities, thus ensuring large turnout, especially from areas that are inaccessible by road. Results of market surveys showed that 16.7% of respondents reported having had a history of eye worm, while 2.3% had a recent occurrence of the disease (Ibidapo *et al,* 2008). Our main findings showed that ivermectin administration had helped to reduce the prevalence and intensity of Loa*loa* microfilaraemia.Since less than 40% of the respondents in the study area reported having had a history of eye worm, and adverse reactions from the retrospective ivermectin administration was 0.83%, the entire area was classified as “low risk” as regards ivermectin administration.

9. Trichomoniasis in Lagos, Nigeria

Trichomoniasis is caused by an anaerobic, parasitic, flagellated protozoa and it is the most prevalent non-viral sexually transmitted infection worldwide (Chira *et al.,* 2006), with an estimated 180 millioninfections acquired annually (WHO, 2004). The disease is associated with vaginitis, cervicitis, urethritis, ectopic pregnancy and pelvic inflammation.

Our team examined the reliance on microscopy in *Trichomonas vaginalis* diagnosis and its prevalence in females presenting with vaginal discharge.

The participants were patients attending a gynaecology clinic in Lagos. A high vaginal swab was obtained after administering a short questionnaire. The overall prevalence of *Trichomonas vaginalis, Candida albicans and Gardnerella vaginalis were* 29.8%, 11.2% and 34.9% respectively. The three-day culturing of the parasite yielded more positive results, (29.8%) when compared to wet mount microscopy, (27.7%) and Giemsa staining (21.7%) techniques. There was no statistically significant difference in all the results. The study confirms the reliability of wet mount microscopy in the diagnosis of *T. vaginalis* when compared with culture. The implication of our finding is that microscopic examination of vaginal discharge will complement the syndromic diagnosis of sexually transmitted diseases involving *Trichomonas vaginals* and thus permit quicker intervention. (Ojuromi *et al.,* 2007).

10. Malaria in Nigeria

Malaria is undoubtedly the most debilitating mosquito-borne disease especially in sub-Saharan Africa where it is one of the main causes of morbidity and a large contributor to mortality. This occurs mostly among pregnant women and children under 5years old. (WHO, 2013). The complexity of the vectorial capacity and the highly efficient malaria vectors including members of the *Anopheles gambiae (Giles) and Anopheles funestus* (Giles) species complexes which are widespread, further aggravate the situation.

The burden of the disease has been a major source of concern to government and development partners. The expression of this challenge has been translated through many instruments. These include the Roll Back Malaria (RBM), a partnership that was launched in 1998 by the World Health Organization, the United Nation Children's Fund (UNICEF), the United Nations Development Programme (UNDP) and the World Bank.

Others are Abuja Declaration in year 2000 and Millenium Development Goals, (MDGs) to reduce disease burden by 2015.

Malaria is an infectious disease caused by the parasite *Plasmodium* of which there are four genera. These are *P. falciparum, P. vivax, P. ovale and P. malariae.*

In Nigeria, 98% of all cases of malaria is due to *P. falciparum, which* is responsible for the severe form of the disease that leads to death. The female Anopheles mosquitoes are the vectors responsible for transmitting the *Plasmodium parasites.* The implementation strategies and activities agreed upon at the Roll Back Malaria summit of year 2000 by African leaders aimed at halving malaria mortality by the year 2010 has not yet produced the desired results. Peoples' behaviors coupled with environmental factors encourage the breeding of mosquitoes and thus increase human vector contacts which promote the continuous transmission of infection. Among other control strategies, vector control remains the most generally effective measure to prevent malaria transmission. World Health Organization Expert Committee on Malaria defined Integrated Vector Management (IVM) as the targeted use of different control methods alone or in combination in order to prevent or reduce human vector contact. It is most cost effective while addressing the issues of sustainability. Our studies on malaria were based on the perception of the disease, ecology and molecular identification of vectors, transmission patterns in the rain forest ecotype, larvicidal and repellent activities of plant extracts on adult mosquitoes as well insecticide resistance burden of vectors in Nigeria.

(a) Perception of Malaria in Rural and Urban Communities of Lagos

Mr. Vice-Chancellor Sir, it is pertinent to note that a mother's ability to suspect malaria in the presence of fever has important consequences for a child's survival in malaria endemic areas. We examined the Knowledge, Attitude and Practices (KAP) of malaria in a rural community at Ijegemo, Ogun State. There was a randomized sampling of households with children of 0-5 years. Structured questionnaire was used to elicit information from care givers of the children. The results showed that 40% of the respondents did not know the exact cause of malaria, while 20% attributed the cause to sunlight. Of the respondents, 85.5% identified stagnant water as the breeding site of mosquitoes but could not correlate it with the occurrence of malaria fever. The use of herbal concoction was the first line treatment action of over 50% of the respondents while only 28% preferred to seek treatment from the Health Centre. This study highlights a critical need for targeting health messages towards poorly educated women in order to empower them with knowledge and resources to recognize and manage their children's health problems (Ibidapo, 2005).

Artemisinin Combination Therapy (ACT) of drug administration is the current Nigerian malaria policy in malaria treatment as stipulated by the World Health Organization. Artemisinin itself is a derivative of the plant *Artemisia annua,* which is common in Chinese traditional medicine as a treatment for fever. Our study of the management strategy of malaria in a Nigerian urban center showed that self-medication was high, accounting for 66.8% of responses, as against hospital treatment which was 23.3% (Oyewole and Ibidapo, 2007).

Self-medication often involves incomplete curative dosage, ultimately paving the way for drug resistance which had been documented previously for Chloroquine in Nigeria. Late diagnoses, wrong medications, lack of knowledge about malaria episode are some of the factors militating against prevention and proper management of the illness. Studies on the perception of the cause of malaria conducted among some university undergraduates indicated that 41.7% of these students still have erroneous view about the cause of malaria (Okwa and Ibidapo, 2010).

(b) Ecology and Molecular Characterization of Malaria Vectors

Epidemiology of malaria requires adequate information of the vector species involved in disease transmission. Ecology, identification and characterization of vector species provides the pre – requisite for planning control measures. In Sub-Sahara Africa, the main malaria vectors that play major roles in disease transmission belong to *Anopheles gambiae* (Giles) and *Anopheles funestus (*Giles) groups. Other secondary vectors such as *An. moucheti,* and *An. nilli* have been reported in some parts of Africa. The An*. gambiae complex* comprises of seven morphologically indistinguishable species while An. *funestus* group consists of about nine morphologically identical species especially at the adult stage (Hunt *et al.,* 1998).

We examined the species composition and role of *Anopheles* mosquitoes in malaria transmission in the coastal ecosystem of Lagos lagoon in Badagry. Three species of *Anopheles* were identified. These were *An. gambiae, An. melas and An.* nili. ELISA-based analyses indicated that *An. gambiae ss and An. melas were the* main vectors of malaria in this area with an overall *P. falciparium* sporozoite infection rate of 4.8% and 6.5% respectively. Both species also maintained relatively high Entomological Inoculation Rate (EIR) indicating their prominent roles in malaria transmission in the study area. All the An. *nilli* tested negative for *P. falciparum* sporozoite infection.

Our team undertook a study aimed at using molecular assays to identify the major anopheline species attracted to man in order to provide information on the mosquito population dynamics and malaria transmission in a forest ecotype. The study area consisted of three communities in Ogun State which are within the rain forest ecotype. Identified female anopheline mosquitoes consisted of Anopheles *gambiae s.l* (77.7%) and *Anopheles funestus* (22.3%). The remaining mosquitoes caught were culicine. The cryptic species identified within the *Anopheles gambiae* group were *An. gambiae ss and An. arabiensis*. Cryptic species identified within the *An. funestus group were An. funestus* ss. and *An. leesoni. (Table 18).*

ELISAfor blood meal sources showed that *An. gambiae ss* and*An. funestus ss.* were highlyanthropophagic (fed on human blood.)*Anopheles arabiensis (patton) and An. leesoni* were both zoophagic since they fed actively on cattle blood outside the house. The density of the four species identified in the sampled communities varied according to the season of the years (Table 19).

Table 18: Sibling species composition of the two major *Anopheles* vector groups identified in the Ikenne and Remo North LGA.

Group	Sibling species	Numbers identified	Percentage	Total
An. funestus	*An. funestus s.s*	307	76.6	401
	An. leesoni	94	23.4	
An. gambiae s.l	*An. gambiae s.s*	636	45.5	1399
	An. arabiensis	763	54.5	
Total *Anopheles* collected				1800

Table 19: Seasonal variation in the relative abundance of the *Anopheline* species collected in three communities.

	Wet Season Collection			Dry Season Collection		
Species	Akaka Remo No (%)	Ilara-Remo No (%)	Ijesa-Isu No (%)	Akaka-Remo No (%)	Ilara-Remo No (%)	Ijesa-Isu No (%)
An. funestus s.s	224 (93)	10 (4.1)	7(2.9)	56 (84.8)	6 (9.1)	4 (6.1)
An. Leesoni	68 (86)	7 (8.9)	4 (5.1)	12 (80)	3 (20)	_
An. gambiae s.s	156 (32.2)	172(35.4)	157(32.4)	24(15.9)	67(44.4)	60(39.7)
An. Arabiensis	54(16.3)	214(64.4)	6(19.3)	76(17.6)	266(61.7)	89(20.7)
Total	506(28.1)	403(22.3)	232(12.9)	168(9.3)	342(19.1)	95(5.3)

The overall number of *Anopheles mosquitoes* collected in the wet season was significantly higher than that of the dry season. (Oyewole,*et al.* 2005). This study provides information on mosquito ecology, genetic and molecular techniques for identification of specie complexes which are important strategies for planning control programs.

A longitudinal study was carried out to investigate the population dynamics, resting and feeding behaviour of major anopheline species found in a rain forest zone of Nigeria. Polymerase Chain Reaction (PCR) tests showed that both indoor and outdoor collections consisted of three groups of *Anopheles mosquitoes, An. gambiae sl (68.6%), An. funestus (30.7%)* and *An. moucheti* (0.7%).There was no significant difference in the biting activities (indoors and outdoors) of these species in four villages. However, An*. arabiensis* and*An. moucheti were* more exophagic with over 60% of their biting occurring outdoors while *An. gambiae* and *An. funestus* were more endophagic with a larger part of their biting occurring indoors. The human–vector contact with *An. gambiae* and*An. funestus* (indoors) was about 73.3% and 66.7% respectively as against 27.7% in *An. arabiensis and* 2.5.3% in *An. moucheti.* The wet season collections showed that*An. gambiae* caught were more than 67% of the total catch while *An. arabiensis* was predominant in the dry season. (Oyewole *et al.,*2007).

This study highlights some aspects of the behaviour of anopheline mosquitoes in Southern Nigeria, which is an important component of the epidemiology of malaria.

There was an examination of the physico-chemical characteristics of *Anopheles* breeding sites and the impact on fecundity and progeny development. Here, six replicates of water samples, from the Atlantic Ocean, river, well, rain; borehole and distilled water (control) were used to culture anopheline eggs collected from pure bred Kisimu species. Statistical analysis indicated that there was no significant difference in the hatchability of the eggs, but the rates of larval development to pupal stage and subsequent adult emergence showed a level of significant difference. Wing length used for determining adult size also showed no significant difference. This study provides information on mosquito ecology in relation to breeding habitat which may have bearing on vector population and distribution as well as malaria transmission (Oyewole *et al.,* 2009).These studies provide baseline information for planning vector control programmes relevant to reduction of malaria transmission in the coastal areas of Nigeria.

(c) Role of Plant Extracts in Malaria Control

i. *Phyllanthus amarus*

Insecticide resistance is the greatest current threat to the future of malaria control, thus it becomes necessary to explore new materials. Essential oils from plants have been used extensively to control insect vectors due to their broad spectrum activity, low mammalian toxicity and ability to degrade rapidly in the environment. There is scanty report on the general medicinal applications of the volatile components of *Phyllanthus amarus,* a small tropical shrub common in Nigeria.

Fresh shrubs of *P. amarus* were separately hydrodistilled in an all glass Clavenger- type apparatus. Analyses and identification of components were carried out using gas chromatography. Larvicidal bioassay was carried out under laboratory conditions, using larvae of *An. gambiae, An. aegypti and An. fatigans* . Results obtained indicated that the oil showed high potential as larvicide against all the tested mosquito species. The probit analysis and regression parameters at LC_{50} and LC_{95} for the observed mortality of the larvae are shown in Table 20.

All the mosquito species displayed high level of sensitivity at a low concentration and there was no statistical difference in the mortality recorded for the larvae of the three mosquito species at the various concentrations.

The plant has the potential to act as active agent for chemical synthesis of commercial larvicides. Presently, further researches on assessing the oil products from other locally available plants for development of suitable formulation to combat disease vectors are ongoing.

Table 20: Larvicidal effect of the oil extract from *Phyllanthus amarus* on mosquito vectors

Mosquito species	LC_{50}	LC_{95}	X^2	Regression Equation
An. gambiae	25.0	30.0	96.96	Y=9.3470*X=-0.7797
Cx. fatigans	35.0	35.0	146.60	Y=8.3929*X=-0.6720
Ae. aegypti	25.0	35.0	118.84	Y=8.0716*X=-0.6596

An. gambiae F1 12 =96.93, $P<0.05$; *Cx.fatigans* F2.12=146.60, $P<0.05$ *Ae. aegypti* $F2_{12}$=118.84 $P<0.5$

ii. *Tithonia diversifolia*

Extracts from the leaf of *Tithonia diversifolia* which had been used extensively as medicine for treatment of various ailments were tested for antimalaria and mosquito repellency properties in experimental animals and human volunteers, under laboratory conditions. Comparison of the effectiveness of chloroquine with the aqueous and methanolic extracts from the plant *T. diversifolia* showed that chloroquine was 100% effective in clearing the parasites while the aqueous and methalonic extracts were 50 and 74% effective in clearing the parasites respectively. It was noted that both aqueous and methanolic extracts were more effective when administered before the onset of the infection, probably indicating the time-dependency of the antimalaria effects. Earlier application of the extracts at the onset of the malaria symptoms was more effective in reducing the parasitemia within a few days. The administration of the plant extracts during the malaria episode was also effective with longer period of administration. The $LC_{50}$of the aqueous extract in mice was 1.2ml/100g body weight while the maximum tolerated dose (MTD) was found to be 1.0ml/g. The repellent activity of volatile oil at different concentrations was measured by the protection period against the bites of *Anopheles gambiae, Aedes aegypti* and*Culex quinquefasciatus*(Table 21). The volatide oil extract showed higher repellent effect on *A. gambiae* at higher concentrations.However, its repellent and protective effects at various concentrations on all other species of mosquito tested cannot be underestimated. (Oyewole *et al*. 2008)

Table 21: Repellent activity of *T. diversifolia* oil extract in three concentrations (10, 50 and 100%) against three species of mosquitoes under laboratory conditions.

Species of mosquitoes	10%								50%								100%							
	Number of landing mosquitoes				Protection time				Number of landing mosquitoes				Protection time				Number of Mosquitoes				Protection time			
	1	2	3	mean	1	2	3	mean	1	2	3	Mean	1	2	3	mean	1	2	3	mean	1	2	3	mean
Culex quinquefasciatus	6	5	6	6±0.3	90	60	90	80±10.3	4	4	4	4±0.0	120	120	150	130±10.0	6	3	6	5±1.0	150	150	150	150±0.0
Aedes aegypti	6	12	12	6±2.0	120	90	90	100±10.0	4	4	4	4±0.0	180	150	180	170±10.0	3	4	4	5±0.3	180	180	180	180±0.0
Anopheles gambiae	6	6	12	8±2.0	120	150	90	120+17.3	4	4	4	4±0.0	150	150	180	160±10.0	4	4	4	4±0.0	180	180	210	200±10.0

Recommendations

From the observations made during my research I propose the following:

1. **Funds Management**

Since parasitic infections have been the bane of development in the tropical world, Nigeria inclusive, adequate funding for research to control various diseases is imperative. Meaningful research programmes require adequate funding of which the government is the principal source. The budget of the health sector must be increased considerably in order to accommodate research on disease control and related matters. Managers of these funds must be made to account for such in order to prevent misuse and corruption. Funds, from international donor agencies for disease control and prevention must be utilized for the appropriate purpose and not diverted

2. **Integration of Research Findings**

A national data directory is required for effective coverage in the control of diseases. Data on distribution of diseases will guide drug management and identify areas of overlap. National and international conferences must be organized to provide forum for exchange of ideas and research information through media, journals and bulletins.

3. **The Human Aspect**

There is need to increase awareness to promote healthy lifestyles on individual basis as well as the community at large. Health information should be incorporated into the curricula of the school system to prevent and control parasitic disease. Frequent washing of hands and fruits before consumption are vital.

4. Basic Amenities

The provision of potable water in the form of pipe borne water or boreholes will go a long way in controlling water borne diseases such as schistosomiasis, ascariasis, and dracunculiasis. Improvement of infrastructure which involves construction of decent housing, safe human waste disposal and recreational facilities for children are crucial in overcoming resurgence of parasitic infections.

5. Health Policies

Government health policies should be targeted at improving the health profile of low income earners and the rural populace while the urban centres should not be neglected. Greater priority should be given to Primary Health Care since this is the key to disease control. Most of the parasitic diseases are those that affect the poor people in rural areas where their only hope for medical care are the Primary Health Centres. Non Governmental Organization (NGOs) should be more active in the rural areas where their influence would be greatly appreciated, especially in relation to disease control.

6. Malaria Interventions

Insecticide resistance is a growing global challenge that poses major threat to the eradication of malaria and other vector borne diseases. There is urgent need to find new approaches and innovation. The year 2015 represents the deadline set for the Millennium Development Goals, to be followed by the Sustainable Development Goals. Successes in malaria control during the period since the years 2000 have been achieved mainly through the innovations on indoor residual spraying (IRS) and long lasting insecticidal Nets (LN). For the post 2015, the malaria control community has defined new goals to cover the period 2016-2030.

This is laid down in two essential reports. The Roll Back Malaria Partnership (RBM)'s guide for collective "Action and Investment to defeat Malaria (2016 – 2030, AIM) – for a malaria free world.

This is expected to complement the World Health Organization's "Global Technical Strategy for malaria 2016 -2030 (GTS). Two key ideas shared by these bodies include:

1. To strengthen the enabling environment (policies, data and health system).
2. Foster innovation and responsive political environment , to fund research and development that would bring new innovations to the market as soon as possible (Public Health Journal, 26:2015).

While it is imperative for the Nigerian government to key into these goals, the war against mosquitoes should be concentrated on the larval breeding grounds which include the numerous open stagnant gutters, drainage pools, swampy land and others. Larviciding is paramount in this regard. The days of public Health inspectors spraying open stagnant gutters with larvicides and sanctioning occupants with dirty environment should be revisited. Once the larval stages are destroyed, then adults cannot emerge. This would inevitably reduce human vector contact, hence bring about disease control.

Conclusion

Since economic development helps in improving the overall health status of the populace, it becomes necessary therefore to integrate health financing interventions into all other programmes. We must dedicate ourselves to cost effective healthcare that focuses on clear goals and produces measurable results. Government health policies should exhibit continuity for sustainable performance.

A National programme of neglected tropical disease control and elimination, coupled with increased access to clean water and sanitation, would simultaneously serve to strengthen health systems in many parts of Nigerian states. In parallel with expanded disease control and elimination efforts, Nigeria's best universities and research institutes must expand their research and training capacity for NTDs.

The use of mass drug administration for the control of neglected tropical diseases or preventive chemotherapy would result in the control or total elimination of these diseases. The administration of albendazole and mebendazole would impact positively on school performance and the disease burden of soil transmitted helminthes.

A Nigeria free from its high prevalence of NTDs can be expected to accelerate that nation's economic development through improvements in child growth, intellect and cognition, pregnancy outcome and worker productivity. Through expansions in integrated NTD control and disease elimination, Nigeria would become an important model for all of Africa.

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