THE TAPESTRY OF PARASITISM

AN INAUGURAL LECTURE, 2006

BY

B.O. FAGBEMI

UNIVERSITY OF IBADAN

UNIVERSITY OF IBADAN LIBRARY

THE TAPESTRY OF PARASITISM

An Inaugural Lecture delivered at the University of Ibadan

on Thursday, 2 November, 2006

by

B. O. FAGBEMI
Professor of Parasitology
Faculty of Veterinary Medicine
University of Ibadan
Ibadan, Nigeria

UNIVERSITY OF IBADAN

UNIVERSITY OF IBADAN LIBRARY

Ibadan University Press
Publishing House
University of Ibadan
Ibadan, Nigeria

© University of Ibadan 2006
Ibadan, Nigeria

First Published 2006

All Rights Reserved

No part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means, electronic, photocopying, recording or otherwise, without permission in writing from the author.

ISBN: 978 – 121 – 414 - 7
978 – 978 – 121 – 414 - 1

Printed by: Ibadan University Printery

UNIVERSITY OF IBADAN LIBRARY

The Vice-Chancellor, Deputy Vice-Chancellor (Administration), Deputy Vice-Chancellor (Academic), Registrar, Librarian, Provost of the College of Medicine, Dean of the Faculty of Veterinary Medicine, Dean of the Postgraduate School, Deans of other Faculties and of Students, Distinguished Guests, Ladies and Gentlemen.

Preamble

It is with great pleasure that I stand before you this evening to present, on behalf of the Faculty of Veterinary Medicine the latest in the 2005/2006 series of Inaugural Lectures. This is the 27th inaugural lecture from the Faculty of Veterinary Medicine and this event marks a generational handing-over because all the 26 inaugural lecturers before me were my teachers at the undergraduate level. On the other hand, some of the people in this distinguished audience are academicians of professorial status whom I taught at the undergraduate level.

Veterinary medicine is my profession, teaching and research my career, and community service my hobby. I have been taking care of animals probably before I was old enough to take care of myself. Before I was twelve years old I had read all the twenty volumes of *Young Peoples' Science Encyclopedia* and conducted some amateur experiments together with my immediate younger brother, who, today, is also a university Professor. I am fortunate, therefore, to belong to the small group of very few people who are paid for doing what would simply have been a favourite pastime.

My choice of parasitology as a field of research is both divine and fortuitous. A week after I completed the National Youth Service, I was informed by my mentor, Professor Olusegun Dipeolu, that an international organization, ILCA (now ILRI, International Livestock Research Institute), with headquarters in Addis Ababa, Ethiopia was searching for a research fellow in parasitology. I applied for the position and appeared before the interview panel to find out that the Director, a retired British professor of veterinary medicine with whom I had performed in an opera in the University of Ibadan Arts

UNIVERSITY OF IBADAN LIBRARY

Theatre, as a secondary school student about ten years earlier, was the chairman of the interview panel. Of course, the result was not in doubt. The tapestry of music, performing arts, inter-human relations, and science became the tapestry of research and produced the tapestry of parasitism.

What is a tapestry? A tapestry is a pattern. In the ordinary sense, it is a large piece of cloth in which threads of different colours are woven to produce a picture. I was informed that an inaugural lecture is a simple talk to a diverse audience on what has made one to become a professor. However, with the euphoria attached to the position long gone after over a decade, the mind may be moving along the channel of a valedictory rather than an inaugural lecture.

What are Parasites?

Parasites are organisms which use other living organisms as their environment and source of food, at the same time relinquishing to their hosts, partly or completely, the task of regulating their relationships with the external environment (modified from Dogiel, 1978).

Parasites are so pervasive that parasitism is the most common lifestyle on earth. In all species of animals, including man—to the veterinary doctor, a human being is simply another species of animal for, after all, the difference between the gene of man and that of the chimpanzee is just 2%). Parasites are found in almost every organ. It is found in the brain (Fig 1, Hydatid); the eye (Fig 2, *Loa loa*); the respiratory system, the heart (Fig 3; *Dirofilaria*); the gastrointestinal tract (Fig 4; hookworm); the skin; the urinogenital tract (Fig 5; Bilharzia); the skeletal muscles, and in the limbs (Fig 6; elephantiasis).

Many parasites do not just make their hosts sick; they change the hosts' behaviour, or ultimately, kill them. Sometimes they castrate them. Theobald Smith (1969) realistically described all infectious processes as parasitism. In inter-relationships between organisms, individuals, families, communities and states, parasitism is a distinct feature in what we often consider free-living, mutualism, symbiosis, etc.

UNIVERSITY OF IBADAN LIBRARY

Economically and scientifically, Africa is on the periphery but in terms of parasitism, Africa occupies the centre stage. Africa is a paradise of parasites.

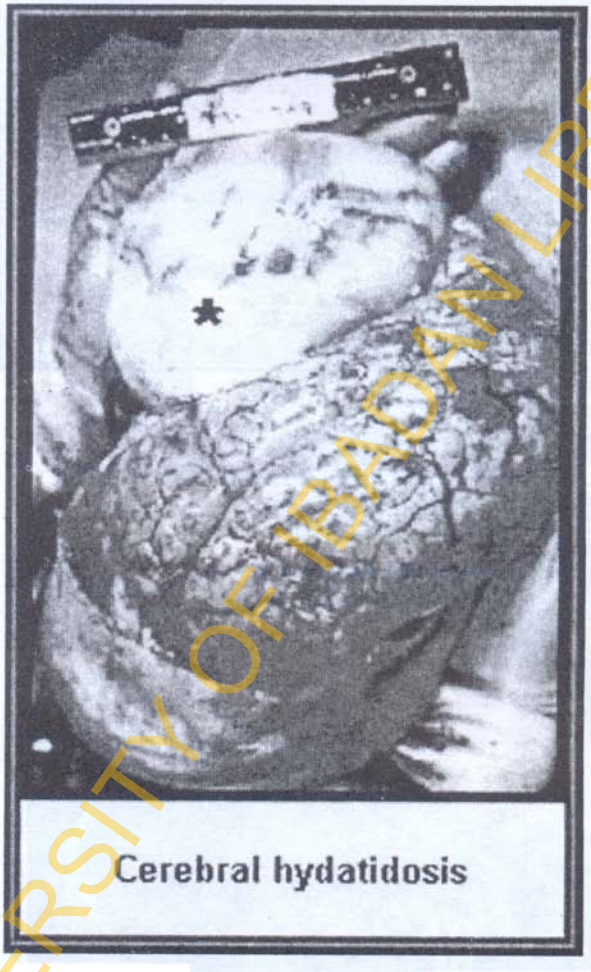


Fig 1: Parasite in Brain

UNIVERSITY OF IBADAN LIBRARY

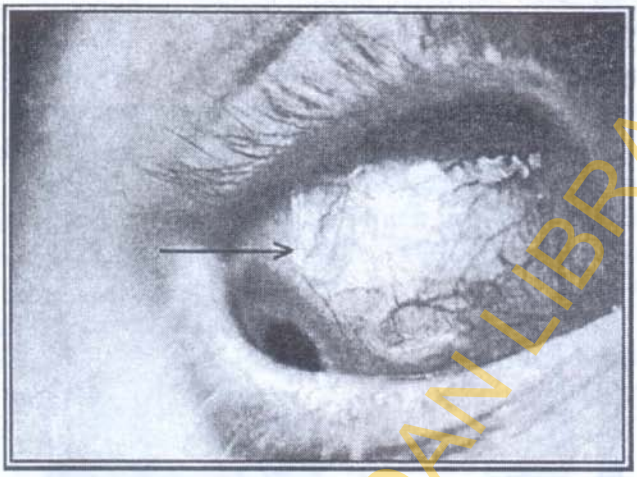


Fig 2: Parasite in the Eye (*Loa loa*)

Fig 3: Parasite in Heart (*Dirofilaria*)

UNIVERSITY OF IBADAN LIBRARY

Fig 4: Parasite in Gastrointestinal Tract (Hookworm)

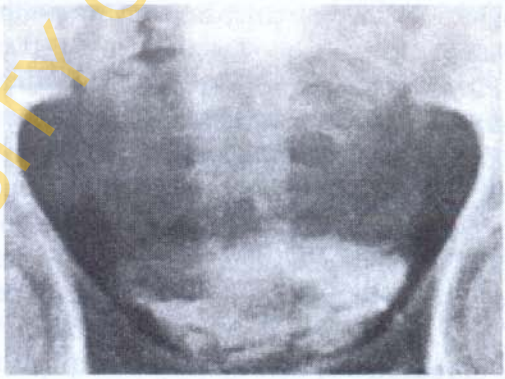


Fig 5: Parasite in Urinogenital Tract (Bilharzia)

UNIVERSITY OF IBADAN LIBRARY

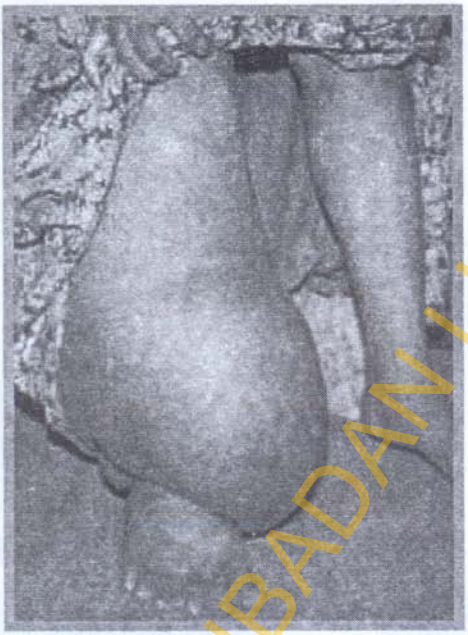


Fig 6: Parasite in the Limb (Elephantiasis)

The first Ph.D thesis of this University was written by a parasitologist, Professor Onabamiro. Since then, inaugural lectures have been given by eminent parasitologists like Dipeolu: *Parasites: Scourge of man and Livestock, Enemy of Man Livestock and Plants*; Ukoli: *Order Among Parasites*; Ogunba *Encounter with Parasites: An Uneasy Encounter*; Ogunrinade; *Parasites: Killing us softly*, and Akinboade: *Parasites: The Bottom Line*. I consider myself fortunate for the privilege of interacting academically and socially with these great minds, two of whom are of blessed memory. It will therefore be monotonous and unproductive to repeat the inevitable introductions, definitions and explanations which are of great value to the layman but which have been dealt with elaborately in those earlier lectures. Besides, I approached research into parasitism from a different perspective. In this

UNIVERSITY OF IBADAN LIBRARY

lecture, I will refer to only those works with which I was involved and I will try my best to avoid sermons, reviews and statements on works that I did not do. I will also hasten to add, as I have said earlier while alluding to lateness in giving inaugural lectures, that many of the recommendations that emanated from my works of fifteen to twenty five years ago have either been used in the industry (for example dog-flea collar based on anti-flea hormone, 1981) or incorporated into everyday teaching or research (for example, my discovery of a new species of *Amerianna* in 1983) or used as a baseline for subsequent research (for example, my work on gastro-intestinal helminthiasis in sheep and goats in the West African sub-region, 1980). Works of science generate a life and momentum on their own and need not be pushed by homilies.

The Concept of Parasitism

It is very tempting to conceptualize parasitism as a simple parasite-and-host relationship in which each parasite exists in a host and interacts with it by depending on it; but the reality is far more complex. The human mind would prefer to view the world of parasitism from the perspective of the binary logic: good or bad, black or white, parasite present or parasite absent. In reality, however, parasitism fits into the fuzzy logic in which there occur various degrees of parasite burdens in an individual or population. Furthermore, different species of parasites occur in the same individual. The consequences of parasitism depend on the various interactions between one parasite and another in the same individual, the interrelationships between these parasites and their hosts, and their interactions with the biotic and abiotic factors in the environment. One important aspect that is always overlooked is the interaction between one parasite and another within the same host. Parasites interact with each other, for limited resources, through non-specific immunological responses of the host to genetically unrelated parasites. Such responses may be provoked by the parasites' possession of common antigens and by the physical or pathological alteration of the environment within the host by a parasite, thus making it more or less suitable for another parasite. In this way, a parasite

UNIVERSITY OF IBADAN LIBRARY

may alter, reduce or increase the effect of another parasite in a concurrent infection and the consequences of parasitism may be modified. I have always been convinced that Crofton's (1971) mathematical model from which modern parasitology stems, and other models such as Anderson's (1982), suffer from the omission of a vital variable: the effect of one parasite on the other in an *in vivo* milieu. Surprisingly, I have found that some social scientific models explain parasitism more realistically. For instance, I have found an adaptation of Kwame Nkrumah's set theory (1964), based on principles analogous to the rules of predicate calculus, more fulfilling. Parasitism is an interactive pattern which evolved over millions of years. It is an intricate tapestry woven over immeasurable time.

Interactions Between Parasites

Fasciola sp (liver fluke) is a worm which inhabits the liver of cattle, sheep and goats (Fig 7). It causes severe liver disease. *Babesia* sp is a protozoan parasite that infects the red blood cells of the same animals (Fig 8). We found that a seven-week old infection with *Fasciola* modulates a subsequent or concurrent infection with *Babesia* (Fagbemi, Christensen and Nansen, 1985a). There was a marked suppression of *Babesia* parasitaemia in the dual infection. However, the reductions in haematological parameters were far less than the addition of the reductions induced by each parasite acting separately (Fig 9). We attributed this effect to the modulation of erythrocyte kinetics, age profile and immuno-modulation. In the chronic stage however, although the parasitaemia in the monoinfected animals was negligible between weeks 20 and 44, the parasitaemia in the animals with double infection was persistently higher than in the monoinfected ones (Fagbemi, Akinboade and Christensen, 1988) (Fig 10). The haematological values were not significantly lower in the animals with the dual infection than in those with monoinfection. Postmortem examination showed an increase in the severity of splenomegaly (enlargement of the spleen) in *Babesia* – infected animals than in *Fasciola*– infected animals but greatest in the *Fasciola* plus *Babesia*- infected animals (Fig 11). In addition, relative to the

UNIVERSITY OF IBADAN LIBRARY

controls there was an enlargement of the kidneys of the animal having the dual infection (Fig 12). The kidneys were pale and soft in consistency. Histopathological examination of the spleens revealed severe hyperplasia of the white and red pulps in the animals with *Fasciola* plus *Babesia* dual infection with extensive amyloid-like deposits (Fig 13a, b, c, d). The kidneys of the animals with the dual infection were characterized by chronic nephritis with severe dilatation of the tubules, fibrosis and amyloid-like deposition in the glomeruli and renal tubules (Fig 14a, b). In the livers, the histopathological changes included periportal hepatitis with neutrophilic and lymphocytic infiltration, fibrosis and amyloid-like deposition in the periportal areas (Fig 15). I have used this model graphically to show that multiple or dual parasitism is not a simple matter of 1 + 1 = 2.

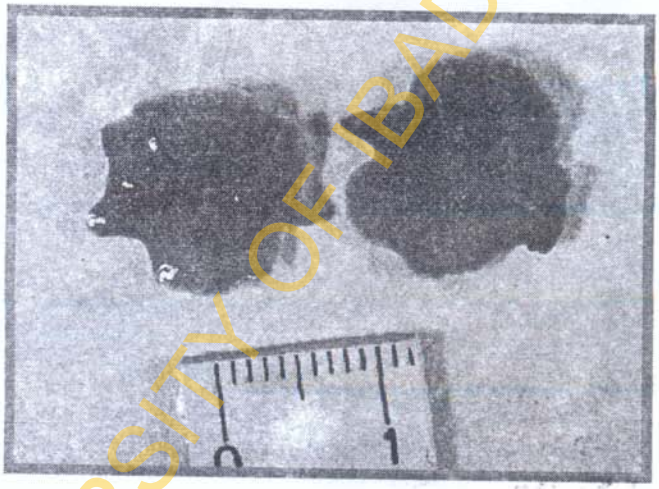


Fig 7: 52 Weeks-old *Fasciola* sp

UNIVERSITY OF IBADAN LIBRARY

Fig 8: Babesia bigemina

UNIVERSITY OF IBADAN LIBRARY

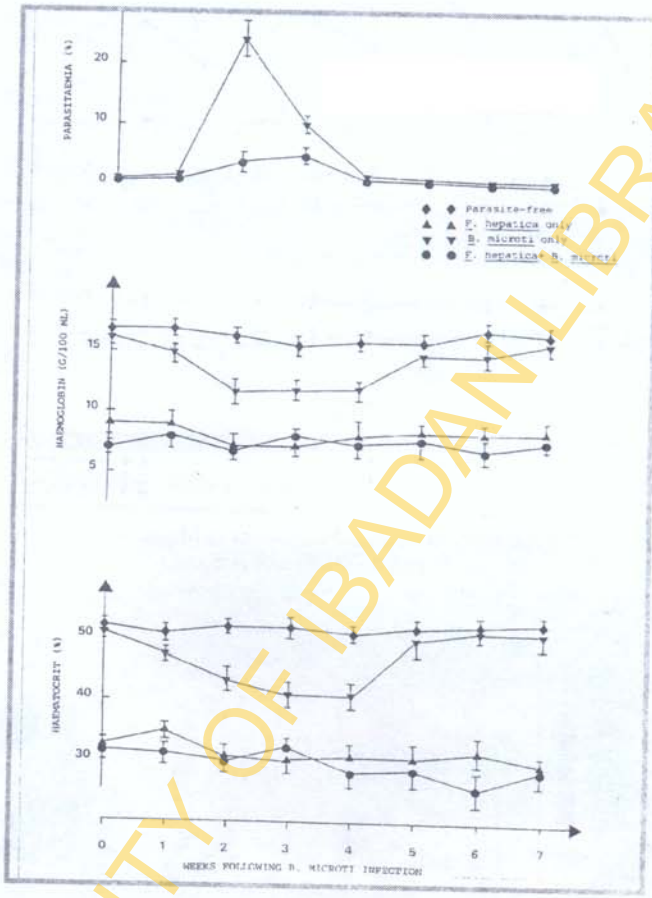


Fig 9: Parasitaemia and Haematological Parameters in Mice with Dual Infection of *Fasciola* + *Babesia*

UNIVERSITY OF IBADAN LIBRARY

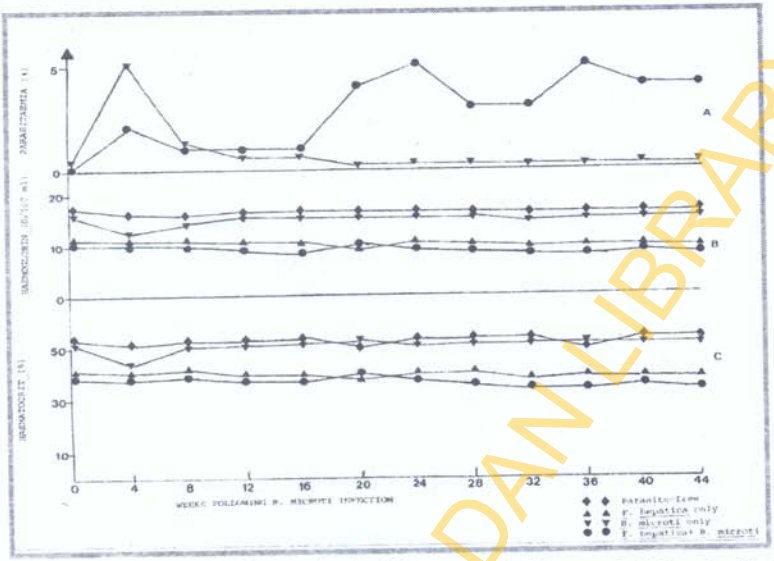


Fig 10: Parasitaemia and Haematological Parameters in Mouse with Chronic Dual Infection with *Fasciola* and *Babesia*

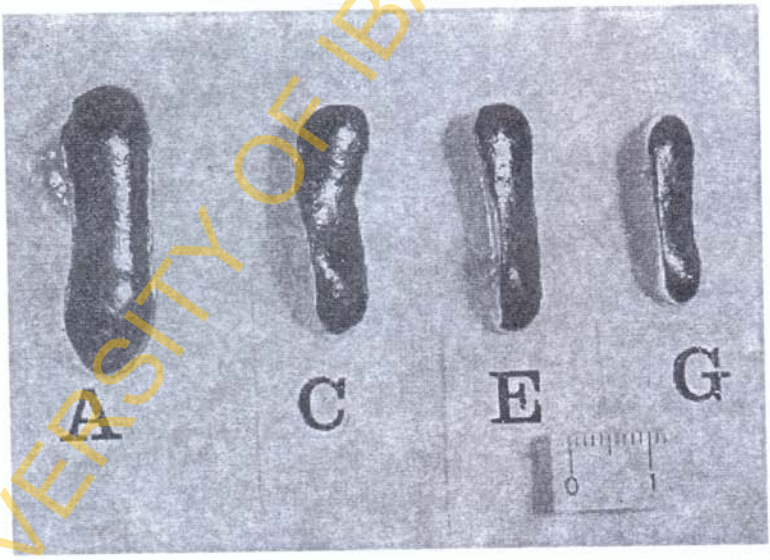


Fig 11: Gross Splenic Enlargement in Dual Infection with *Fasciola* + *Babesia*

UNIVERSITY OF IBADAN LIBRARY

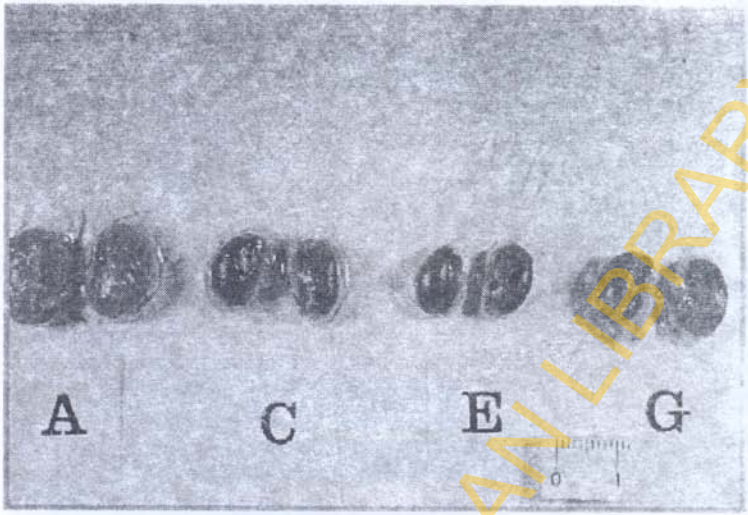


Fig 12: Gross Kidney Enlargement in Dual Infection with ***Fasciola + Babesia***

Fig 13a: Photomicrograph of Spleen from *Babesia*-infected Mouse showing Splenic Hyperplasia

UNIVERSITY OF IBADAN LIBRARY

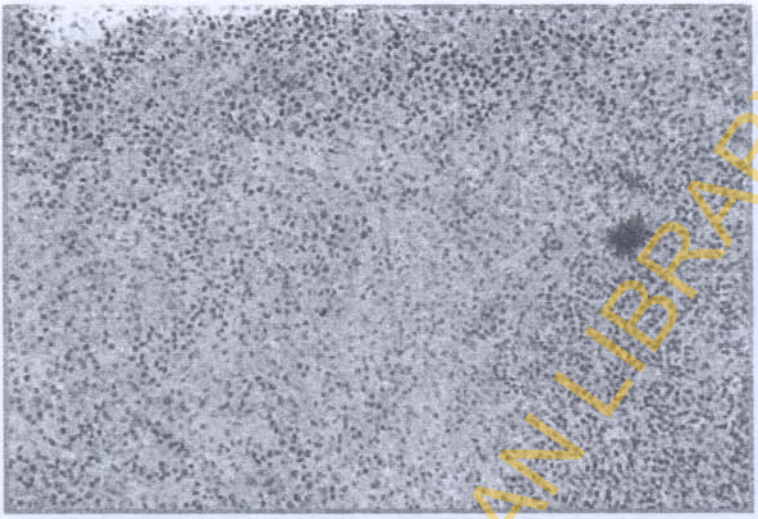


Fig 13b: Photomicrograph of Spleen from *Fasciola*-infected Mouse

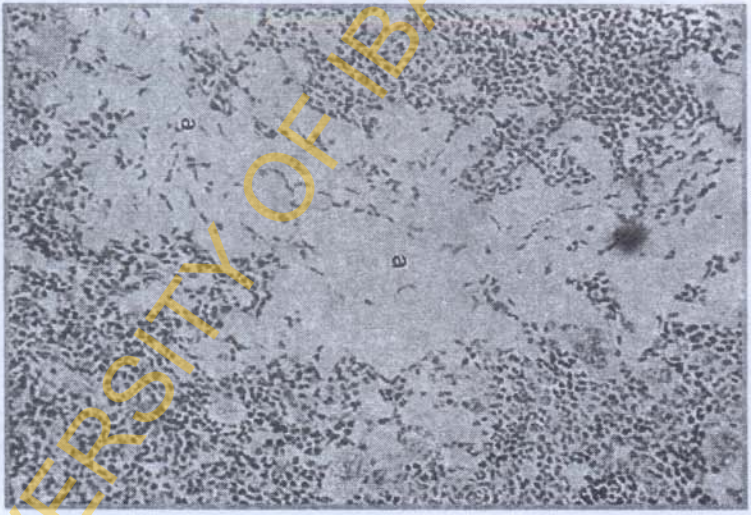


Fig 13c: Photomicrograph of Spleen of Mouse with Dual Infection of *Fasciola* + *Babesia* showing Hyperplasia and Amyloid-like Deposits

UNIVERSITY OF IBADAN LIBRARY

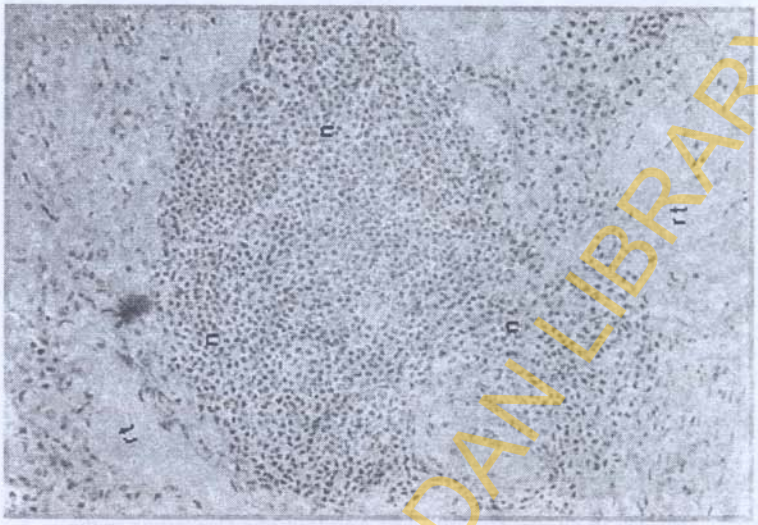


Fig 14a: Chronic Nephritis in the Kidney of Mouse with Dual Infection of *Fasciola + Babesia*

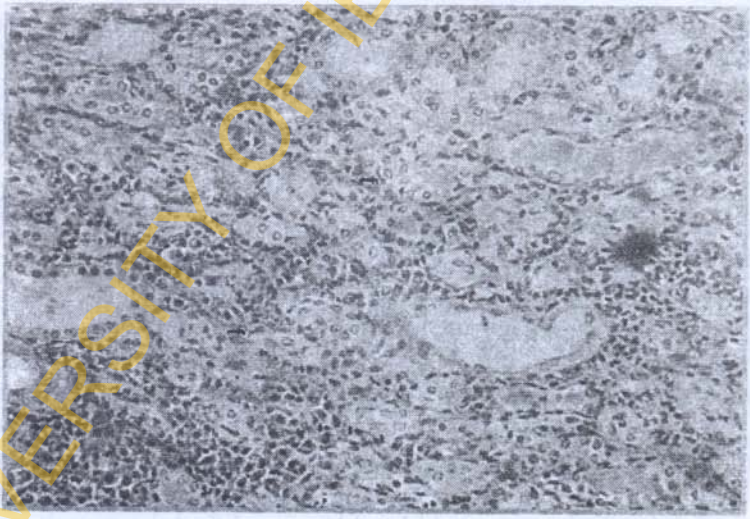


Fig 14b: Fibrosis in Kidney of Mouse with Dual Infection of *Fasciola + Babesia*

UNIVERSITY OF IBADAN LIBRARY

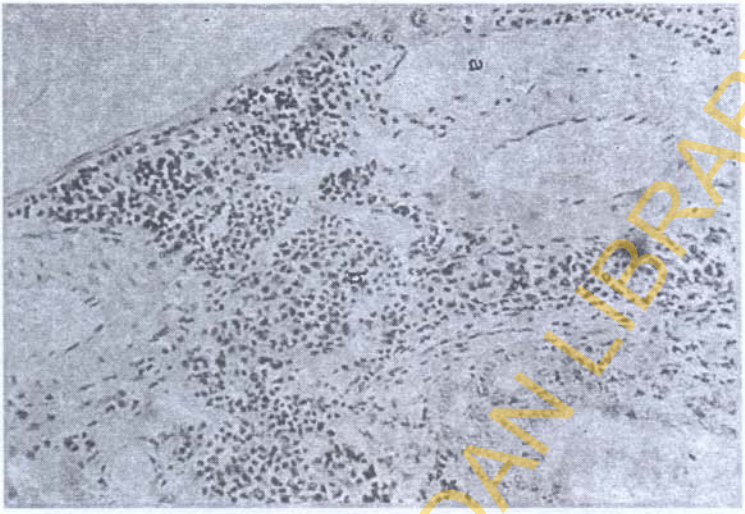


Fig 15: Periportal Hepatitis and Amyloid-like Deposition in the Liver of Mouse with Dual Infection of *Fasciola* + *Babesia*

In order to ascertain if these observations could be reproduced in another helminth-protozoan combination, these experiments were repeated using Schistosoma-*Babesia* combinations. Similar parasitaemic and haematological results were obtained (Fagbemi, Christensen and Nansen, 1985b).

Due to the fact that either fascioliasis or schistosomiasis (liver fluke infection and bilharziasis) alters erythrocyte kinetics because of haematophagia and intermittent haemorrhage, we decided to ascertain whether the observations made in the animals with multiple or dual parasite infections were due to the alteration of the erythrocyte age profiles of the hosts by the worms and the preference of intra-erythrocytic protozoan parasites for red blood cells of particular ages. At first, we used a method of artificial trickle intermittent haemorrhage that was not severe enough to cause anaemia but was able to alter the red blood cell kinetics in experimental animals. The result (Fig 16) showed that little, repeated blood loss modified the parasitaemia of *Babesia*. Although the mechanism was not understood, we suspected that the protozoan parasite exhibited a preference for

UNIVERSITY OF IBADAN LIBRARY

red blood cells of a particular age. To confirm or disprove this, I injected radio-isotopic iron 59 (^{59}Fe) into experimental animals

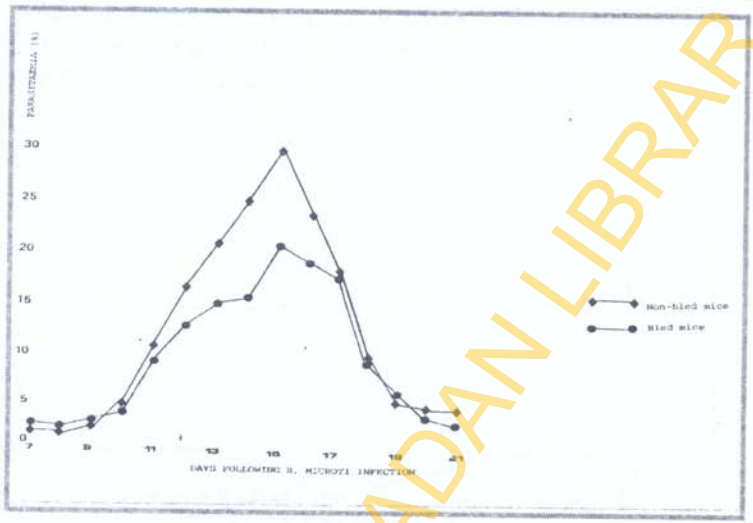


Fig 16: Effect of Trickle Haemorrhage on *Babesia* Parasitaemia

to pulse-label a cohort of red blood cells which was monitored daily by gamma scintillation counting (Fagbemi, 1987a). A new method which enabled the simultaneous determination of haematocrit values and radiation counts on the same minute amount of blood sample was evolved. The result (Fig 17 a, b) showed that *Babesia* has affinity for old (20-day old) as well as young (2-3-day old erythrocytes). This suggested that *Babesia* is erythrocyte-age independent, as was shown for *Plasmodium falciparum* (Devakul, 1966). The notion that *Babesia* and most intra-erythrocyte parasites prefer young erythrocytes to old erythrocytes is probably due to the fact that older infected red blood cells are destroyed by the parasites in them more quickly than the younger red blood cells. It is noteworthy that after this finding was published, studies on the erythrocyte age-preference of *Babesia* stopped abruptly worldwide. A coincidental finding in our study was that a parasitized red blood cell undergoes a change in its mass and this affects the behaviour of the cells in blood circulation. A parasitized red blood cell is moved more sluggishly and tends to be sequestered in capillaries. This was reported in our work "Hydrodynamics of Parasitized

UNIVERSITY OF IBADAN LIBRARY

Erythrocytes in Deep Capillary Beds" (Fagbemi and Christensen, 1984). This probably plays some roles in the manifestations of neurological signs of malaria in man and babesiosis in some species of animals. It also makes such cells amenable to isolation for research purposes by differential centrifugation.

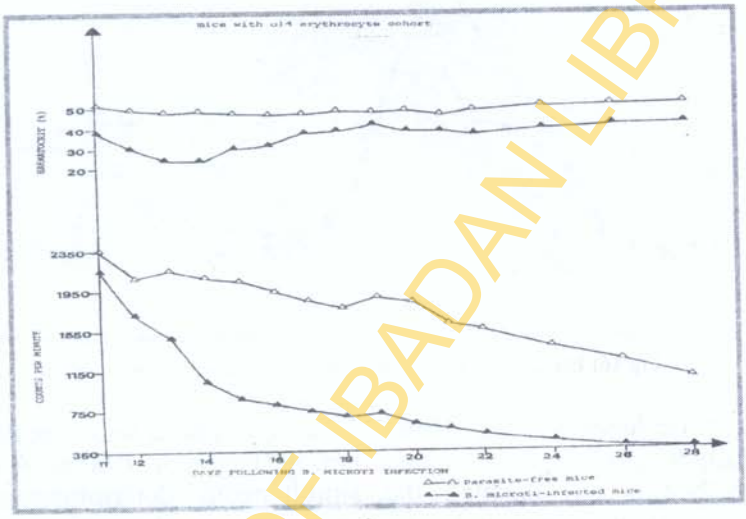


Fig 17a: Erythrocyte Radioactivity and Haematocrit in Babesia-infected Mice with Old Erythrocyte Cohort

UNIVERSITY OF IBADAN LIBRARY

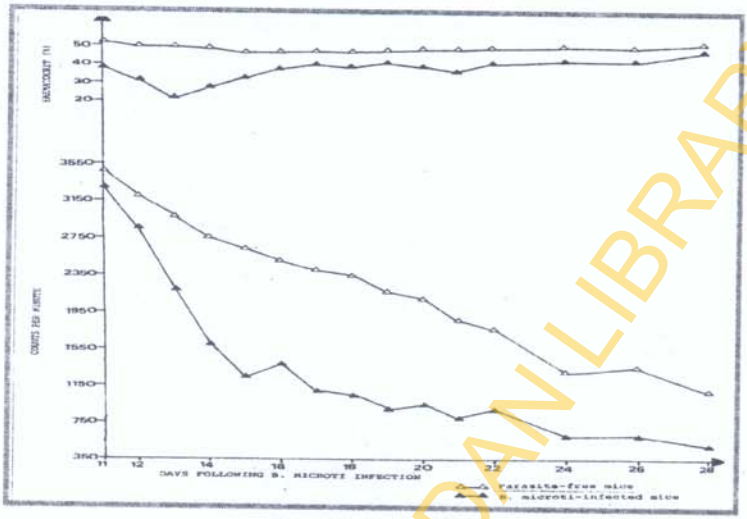


Fig 17b: Erythrocyte Radioactivity and Haematocrit in Babesia-infected Mice with Young Erythrocyte Cohort

The unanswered question remained: By what mechanism(s) does one parasite affect another in the same host and change the pattern of disease attributable to each one acting separately? Although the alteration of erythrocyte kinetic states by a worm and artificially induced haemorrhage may suppress the parasitaemia of an intraerythrocytic parasite, studies with radio-isotopic tracer techniques indicated that such factors might not constitute the underlying mechanisms. It was considered plausible that other mechanisms, possibly immunological, may be involved.

This challenged us to assess the action of homologous and heterologous macrophages and immune sera on the survival of *Babesia in vitro* (Fagbemi and Akinboade, 1987). Macrophages (Fig 18) are cells within the tissues that originate from specific white blood cells. They act in both specific and non specific defense after stimulation by pathogens. Macrophages were collected from mice that were experimentally infected with either *Schistosoma mansoni* or *Babesia microti* and from non-infected control mice.

UNIVERSITY OF IBADAN LIBRARY

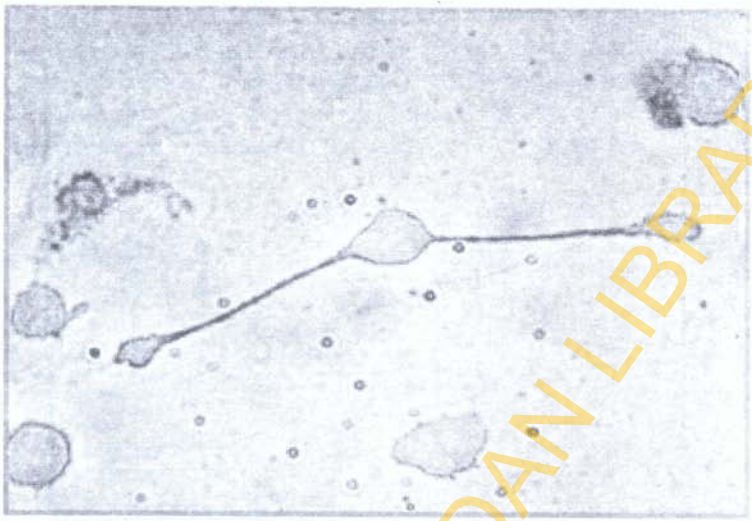


Fig 18: Macrophage Extending "Arms" To Engulf Pathogen

The macrophages were incubated with *Babesia microti* in the presence of anti-*Babesia* or anti-*Schistosoma* immune sera while macrophages and sera from non-infected animals served as controls. It was interesting to observe that macrophages from *Schistosoma*-infected mice produced a very significant inhibition on the growth of *Babesia microti* (Tables 1 a, b). It was possible for macrophages activated by *Schistosoma mansoni* to kill the unrelated *Babesia microti* because macrophages activated by independent mechanisms share common immunological pathways. This phenomenon is analogous to misdirected or transferred aggression in animals, man or communities. Although macrophages activated by either *Babesia* or *Schistosoma* were able to kill *Babesia* even in the absence of immune sera, optimal effects were obtained in the presence of *Babesia*-immune sera because of the possibility that antibodies enhance the recognition of the parasites by the receptors on the macrophages. In the layman's parlance, immune sera serve as appetizers or spices for the voracious macrophages.

UNIVERSITY OF IBADAN LIBRARY

Table 1a: *In Vitro* Survival of *B. Microti* in the presence of Serum and Macrophages: *B. Microti* Parasitaemia (%)

	Time (Hours)	Normal Macrophage (NM)	Babesia Macrophage (BM)	Schisto-soma Macroph-age (SM)
Normal Serum	24	5.6	2.0	2.0
	48	3.7	0.4	2.6
	72	5.0	1.3	1.1
Babesia Serum	24	4.9	3.2	0.8
	48	2.8	0.1	0.3
	72	2.4	0.0	0.3
Schistosoma Serum (SS)	24	4.5	3.2	3.5
	48	3.0	3.3	1.9
	72	3.3	1.8	1.8

*Initial Parasitaemia in all groups at 0 hour = 3%

Table 1b: *In Vitro* Survival of *B. Microti* in the presence of Macrophages with or without Serum: *B. Microti* Parasitaemia (%)

	Time (Hours)	Normal Macrophage (NM)	Babesia Macrophage (BM)	Schistosoma Macrophage (SM)
Normal Serum	24	2.1	1.8	1.7
	48	2.7	1.2	1.5
	72	3.4	1.5	1.5
Babesia Serum	24	1.5	1.7	1.4
	48	2.9	0.3	0.1
	72	2.1	0.0	0.0
No Serum	24	2.0	2.0	3.1
	48	3.1	1.3	2.7
	72	3.0	1.1	1.7

*Initial Parasitaemia in all groups at 0 hour = 2%

UNIVERSITY OF IBADAN LIBRARY

Our subsequent studies revealed that *Trypanosoma brucei*, a protozoan parasite, blocked the expulsion of a worm, *Echinostoma revolutum,* and the tapeworm *Hymenolepis diminuta* from animals (Christensen and Fagbemi, 1984; Fagbemi and Christensen, 1984). Within the same disease module, the disease in *Schistosoma*_infection is caused by the severe granulomatous reaction of the parasitized host around the worm eggs in tissues (Fig 19a). There was reduced migration of eggs and juvenile schistosomes in animals with a concurrent *Trypanosoma* infection (Fagbemi, 1987b). Besides, trypanosomiasis reduced the granulomatous reaction around schistosome eggs and thereby attenuated schistosomiasis (Fagbemi, Christensen and Dipeolu, 1987) (Fig 19 b, c, d). The interaction of two or three parasites inhabiting a host concurrently is like a Jekyll and Hyde situation. In some situations, there is a reduction of the cumulative disease while, in other situations, there is an exacerbation of the disease, with serious consequences for the host and the parasite. The interactions between one or two parasites in the host and with the host result in an intricately woven pattern of disease which is not easy to unravel.

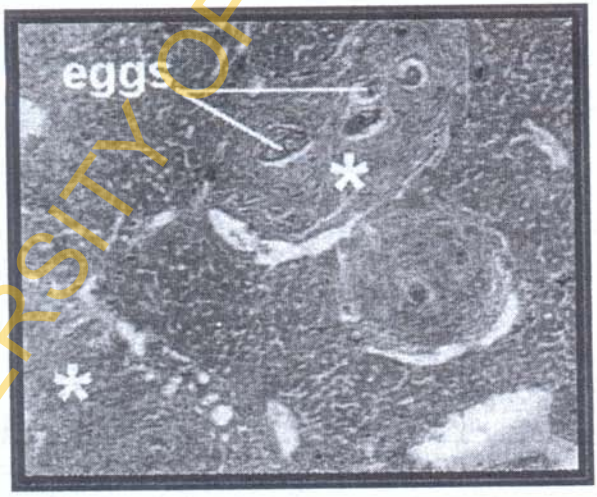


Fig 19a: *Schistosoma* Egg Granuloma

UNIVERSITY OF IBADAN LIBRARY

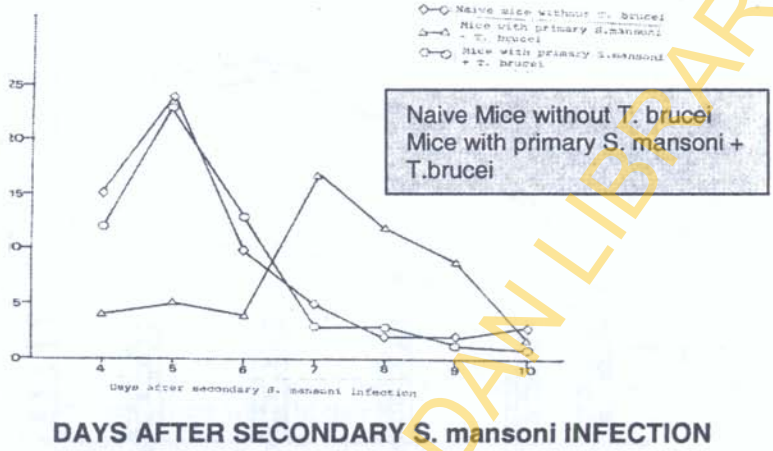


Fig 19b: Reduction in Number of Migrating Schistosomules in Lungs of Mice with Dual Infection of *T. brucei* and *S. mansoni*

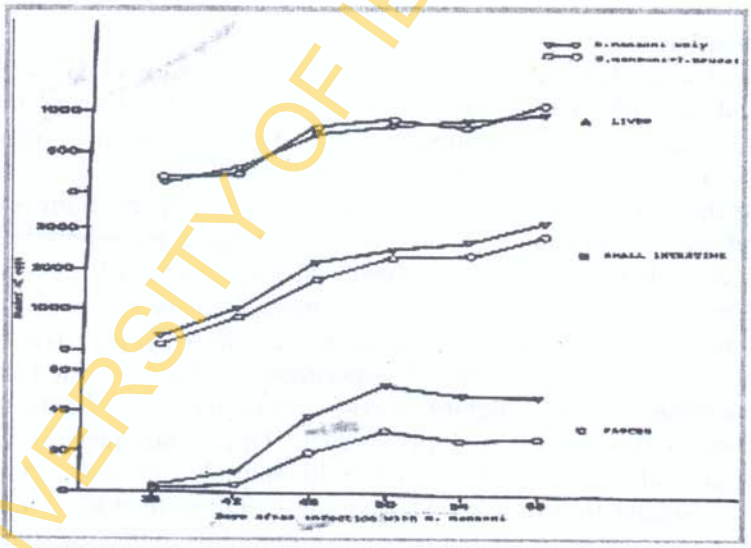


Fig 19c: Reduction in Number of Schistosoma Eggs in Dual Infection with T. brucei and S. Mansoni

UNIVERSITY OF IBADAN LIBRARY

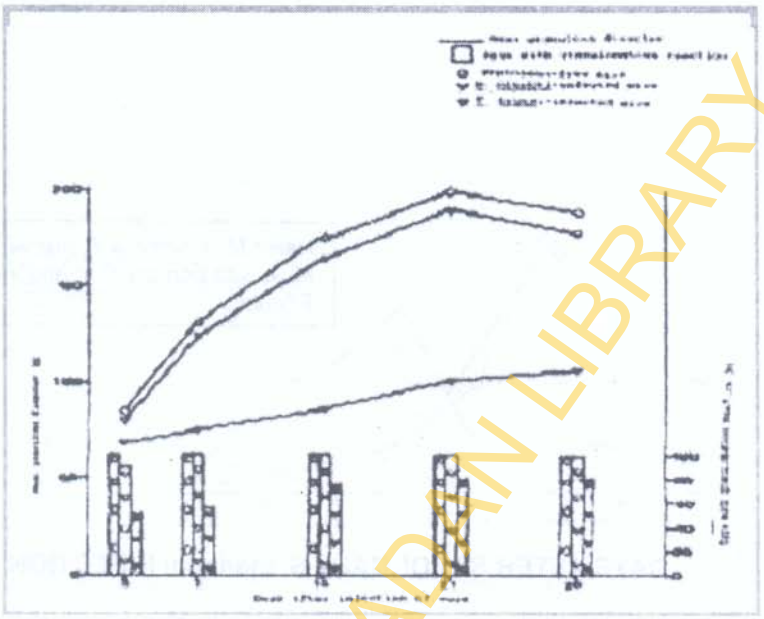


Fig 19d: Reduction in Granuloma Formation around Schistosoma Eggs in Tissues of Mice Infected with T. Brucei

Parasitism and Nutrition

The situation becomes more complicated when another fabric is introduced into the tapestry. Parasitism is an affliction of the lower class while malnutrition is a disease of the poor. Unfortunately, these coexist in Africa, a continent heavily laden with the yoke of parasites. We have shown that parasitism is a point in an intricate web and it is modulated by interacting factors within and outside the host. In the tropics, it is easy to imagine that parasitic diseases are aggravated by malnutrition during the dry season when feeds are in short supply (ILCA, 1980). In the first in a series of experiments, we investigated the relationship between dietary energy levels and the severity of trypanosomiasis using the pig model. Trypanosomiasis is an infection of most domestic and wild animals and man. It is called nagana in animals and sleeping sickness in man. Three groups of pigs were placed on diets containing high-, medium-

UNIVERSITY OF IBADAN LIBRARY

or low- energy planes, respectively. The protein levels in the three rations were isonitrogenous (similar). Parasitaemia was remarkably lower while live weight gains and haematological indices were significantly higher in the animals which were fed on high-level energy diets than in those on medium or lower level energy rations (Tables 2a, 2b). We concluded that adequate dietary energy levels ameliorate trypanosomiasis in growing pigs (Fagbemi, Otesile, Makinde and Akinboade 1990). We desired to know whether serum biochemistry might give an indication of damage to tissues and hence the severity of the disease in relation to nutrition. We therefore redesigned the study using matured male pigs as the model. Low dietary energy level aggravated the decrease in serum total protein and albumin levels in the animals. Besides, the infection was accompanied by a rise in serum aspartate aminotransferase and serum alanine transferase which were higher in the group on low- energy diet. An observation that was of particular interest was that serum testosterone concentration was remarkably lowered by a combination of trypanosomiasis and low- energy diet (Fig. 21), (Otesile, Fagbemi and Adeyemo 1991). The implication of this is that the reproductive efficiency of animals may be modulated by a combination of parasitism and low-energy diet. Further experiments (Otesile, Fagbemi, Makinde and Akinboade, 1992) revealed that lower-energy diet reduced the compensatory growth of *Trypanosoma*—infected pigs after chemotherapy (Table 3a, b). Even after recovery and good feeding, the retarded weight gain as a result of parasitism and low energy could not be reversed. These series of experiments were multidisciplinary, carefully designed and conducted for three years. What this implies is that in parasite-infested poor countries with malnourished populations, the affected individuals with a poor start may never catch up. No nation can rise from low estate and esteem as long as the overwhelming proportion of the population is malnourished, and her people are walking museums of parasites.

UNIVERSITY OF IBADAN LIBRARY

Table 2a: Effect of Nutrition on *Trypanosoma brucei* parasitaemia

Days p.i.	Parasitaemia (log_{10} trypanosomes ml^{-1} blood)*		
	High plane	Medium plane	Low plane
4	1.7	1.9	2.2
7	3.2	3.6	3.9
10	1.8	1.5	1.8
13	1.4	1.2	1.8
16	2.7	3.0	2.9
19	5.4	6.0	6.2
22	6.5	6.8	7.2
25	6.2	6.3	6.8
28	7.8	8.1	8.3
31	5.9	6.2	6.3
34	7.2	7.0	8.7
37	6.3	6.1	6.5
40	7.6	7.9	8.0
43	6.0	7.1	6.9
46	7.8	8.3	8.5
49	5.8	6.5	7.3

- mean parasitaemia in pigs on diets with different energy levels

Table 2b: Effects of *Trypanosoma brucei* infection and Nutrition on Liveweight Gains in Pigs

Energy level of ration fed	Status of pigs	Number of pigs	Liveweight (kg)			
			Day 0	Day 56	Overall gain	Mean daily gain*
High	Infected	4	22.6±6.2	36.6±10.7	14.0	0.25
	Controls	2	21.6±9.1	48.6±14.8	27.0	0.48
Medium	Infected	4	20.0±2.9	23.8±3.4	3.8	0.07
	Controls	2	18.6±3.4	36.8±7.1	18.2	0.33
Low	Infected	4	15.2±2.9	18.2±6.0	3.0	0.05
	Controls	2	13.9±1.3	21.2±5.4	7.3	0.13

* Liveweight gains of pigs following infection with *T. brucei*.

UNIVERSITY OF IBADAN LIBRARY

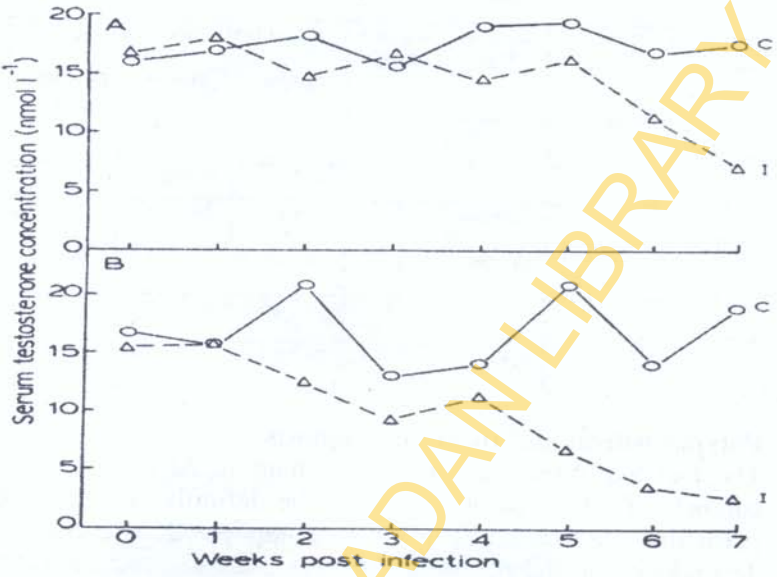


Fig 21: Reduction in Testosterone Levels in Male Pigs infected with *T. brucei* Under Low level of Dietary Energy

Table 3a: Disappearance of *T. brucei* from Blood of Pigs on Different Dietary Energy Levels After Treatment with Isometamidium

Pig group	Parameter	Hours after treatment 0	24	48	72
High (A)	*Mean parasitaemia	$10^{5.88}$	$10^{4.9}$	$10^{1.4}$	0
	+Ratio positive	4/4	¾	¼	0/4
Medium (B)	Mean parasitaemia	$10^{6.5}$	$10^{3.4}$	$10^{1.5}$	0
	Ratio positive	4/	2/4	¼	0/4
Low (C)	Mean parasitaemia	$10^{7.3}$	$10^{5.4}$	0	0
	Ratio positive	4/4	3/4	0/4	0/4

*Mean parasitaemia for the four treated pigs in a group

+Ratio positive: $\frac{\text{No. of parasitaemic pigs}}{\text{No. of pigs treated}}$

UNIVERSITY OF IBADAN LIBRARY

Table 3b: Live Weight of Pigs after treatment of *T. brucei* infection with Isometamidium Chloride (Series 2).

Pre-treatment Energy Level of Ration	Status of Pigs	Number of Pigs	Mean (±SD) Live weight (kg)			Daily Gain
			Day 0	Day 56	Overall gain	
High (A)	Infected	20	34.8± 5.1	63.5± 5.3	28.7	0.51
	Controls	15	46.7 ± 7.3	80.6 ± 6.1	34.9	0.62
Medium (B)	Infected	20	25.4 ± 5.4	50.1± 6.3	24.7	0.44
	Controls	15	40.6 ± 6.3	77.2 ± 7.5	36.6	0.65
Low (C)	Infected	20	23.7 ± 4.6	38.4 ± 6.1	14.7	0.26
	Controls	15	26.3 ± 4.3	60.8 ± 7.4	34.5	0.61

Polyparasitism and Immunodiagnosis

The fact that most animals and humans in Africa are walking cabinets of mixed parasites makes the definitive diagnosis of a particular parasite infection a complicated exercise. The dependence on the detection of adult stages of the parasites is disadvantageous because severe disease would have been caused at that stage. On the other hand, reliance on immunodiagnosis which detects early stages of infection is hampered by the concurrent occurrence of many parasites which almost always have common antigens. For example, three parasites, *Fasciola gigantica* (Fig 22) *Schistosoma bovis* (Fig 23) and *Dicrocoelium hospes* (Fig 24) co-exist in cattle, sheep and goats in Africa and they possess common or shared antigens. Fagbemi and Obarisiagbon (1990, 1991) fractionated the crude antigens of these three trematode worms using sephacryl S – 300 column chromatography (Fig 25 a, b, c,). Common antigens were however found in both the crude extracts and the semi-purified fractions using the double immunodiffusion test and the enzyme-linked immunosorbert assay (ELISA). I then imagined that since different parasites feed on different components of the same host, the enzymes which they use to digest their food could serve as antigenic fingerprints for specific and accurate immunodiagnosis. That imagination and actions that followed about sixteen years ago lured me into an adventure that was challenging and productive, resulting in the awards of fellowships and prizes.

UNIVERSITY OF IBADAN LIBRARY

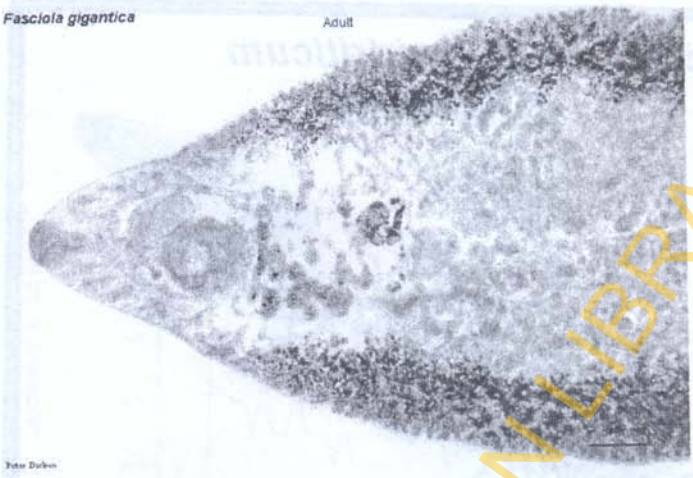


Fig 22: *Fasciola gigantica* (Anterior End)

Fig 23: *Schistosoma bovis*

UNIVERSITY OF IBADAN LIBRARY

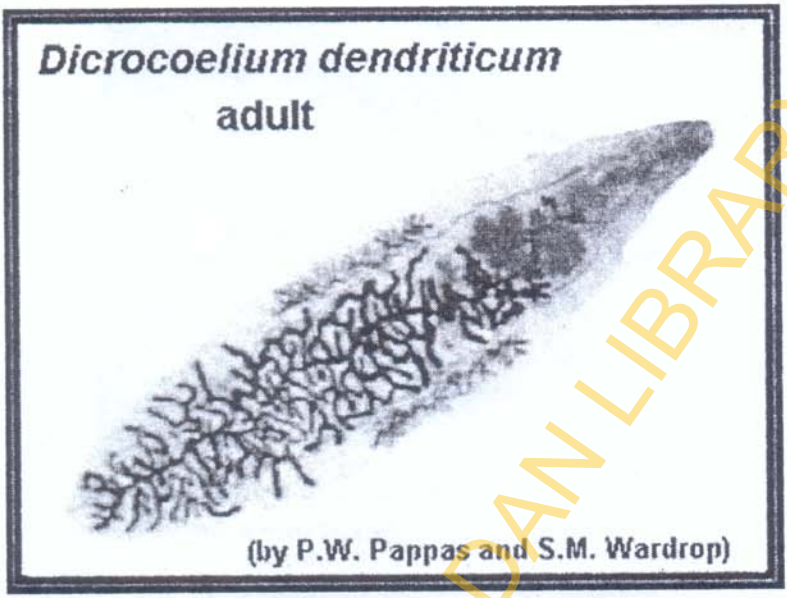


Fig 24: *Dicrocoelium*

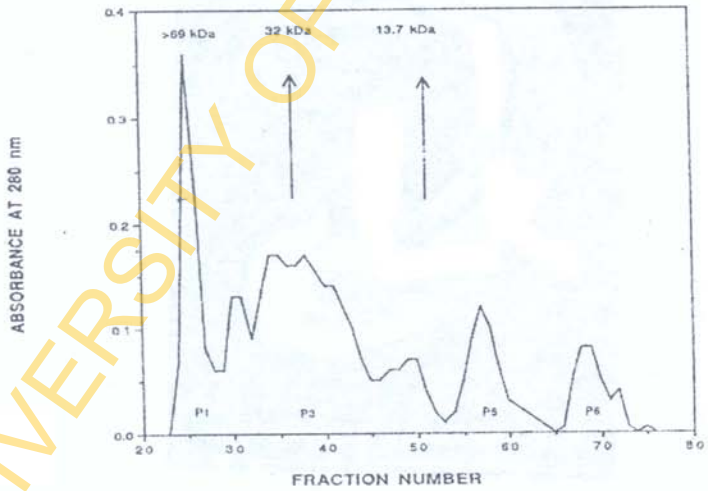


Fig 25a: Elution Profile of *Fasciola gigantica* whole worm antigen after Column Chromatography

UNIVERSITY OF IBADAN LIBRARY

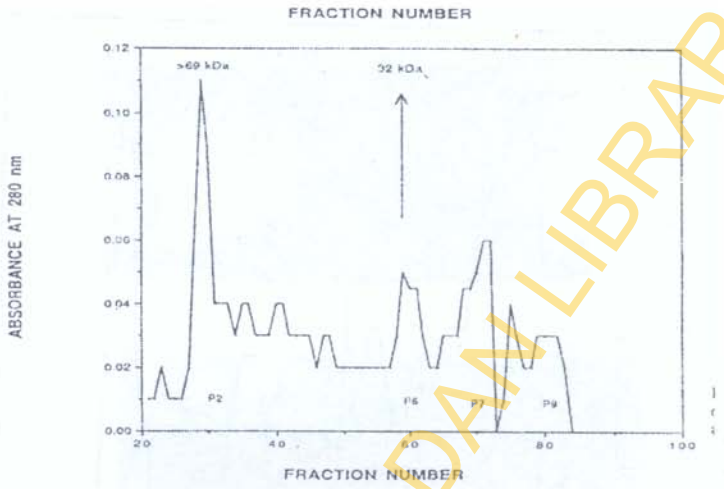


Fig 25b: Elution Profile of *Schistosoma bovis* whole worm antigen after Column Chromatography

UNIVERSITY OF IBADAN LIBRARY

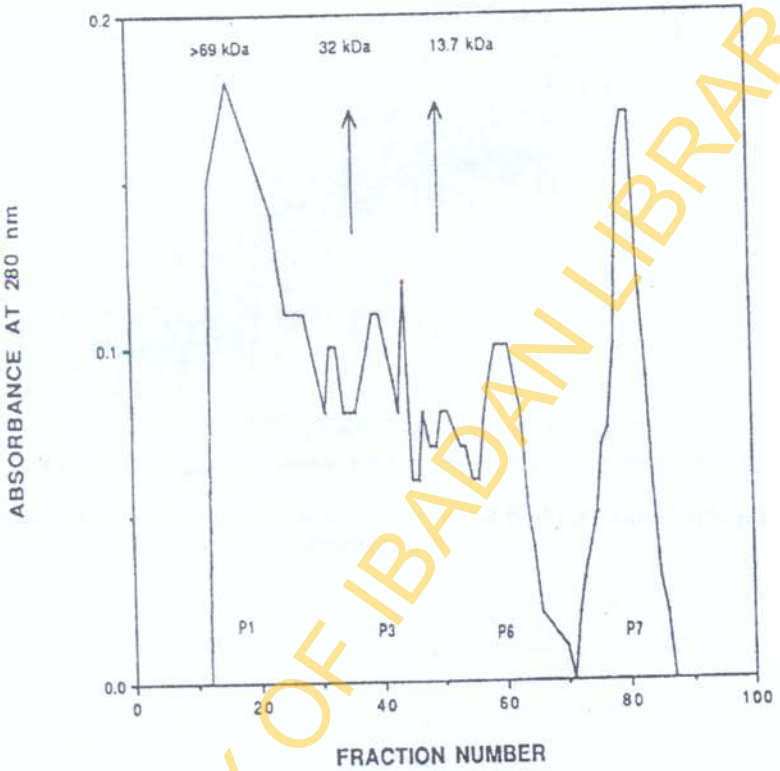


Fig 25c: Elution Profile of Whole-worm Antigen of Dicrocoelium in Sephacryl S-300 Column

First of all, the entire proteolytic enzyme repertoire of *Fasciola gigantica* was identified and analysed by preparative isoelectric focusing and by gelatin-substrate gel electrophoresis at acidic and neutral pH. Fifteen proteases with molecular weights ranging from 26 to 193 kilodalton and isoelectric points 4.92 to 7.64 were observed. The proteases with molecular weight range of 26 to 96 kilodalton digested bovine haemoglobin *in vitro* (Fagbemi and Hillyer,. 1991) (Fig 26 a, b). This work was the first identification of the proteolytic enzymes of the liver fluke and it attracted a lot of attention when I presented it at international conferences.

UNIVERSITY OF IBADAN LIBRARY

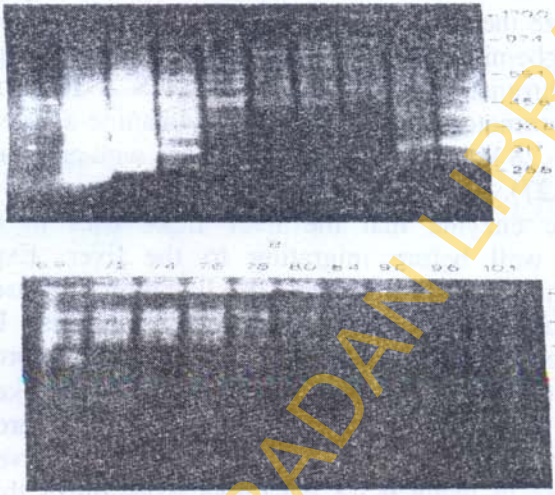


Fig 26a: Gelatin-Substrate SDS-PAGE of IEF Fractions of Proteolytic Enzymes of *F. gigantica*

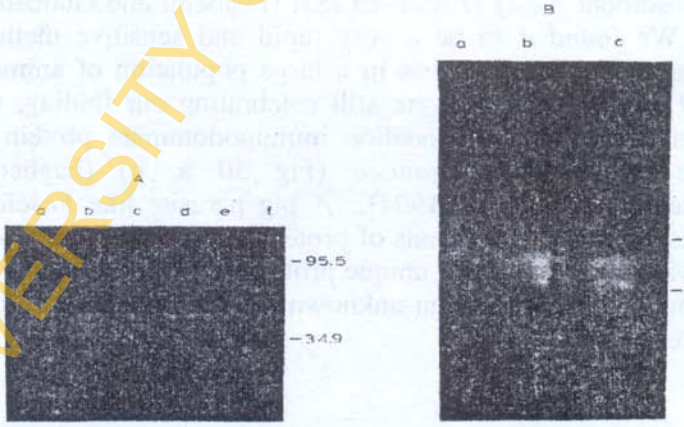


Fig 26b: Substrate-gel Analysis of Protease-rich Fractions of *F. gigantica* obtained by Column Chromatography

UNIVERSITY OF IBADAN LIBRARY

I received many letters of commendation from the scientific community and from the editor-in-chief of the journal in which it was published. This stimulated us to successfully purify and characterize the most important proteolytic enzyme of the liver fluke (Fagbemi and Hillyer, 1992) by a two-stage process of column chromatography in a sephacryl S – 200 column and affinity chromatography in an L-phenylalanine-agarose column. It is a 26 – 28 kilodalton cysteine protease with an optimal pH of 4.5 (Fig 27). This was also a pioneering work. It is the proteolytic enzyme that the liver fluke uses to digest the intestinal wall before migrating to the liver. Experimental animals in which mucosal anti–28 kilodalton protease antibody was produced were not susceptible to fascioliasis. In view of the uniqueness and usefulness of the 28 kilodalton protease as a potential tool in the diagnosis and control of liver fluke infection in cattle, sheep and goats, I moved swiftly to produce and characterize a monoclonal antibody that was reactive to it, for the purpose of using it for the direct isolation of this enzyme from *Fasciola gigantica* (Fagbemi, 1994) (Fig 28). Isotype analysis revealed that this monoclonal antibody was an IgG3 (Immunoglobulin G3). We were able to use the 28 kilodalton protease for the immunodiagnosis of fascioliasis in cattle, sheep and goats by the Falcon Assay Screening Test enzyme-linked Immunosorbent Assay (FAST–ELISA (Fagbemi and Guobadia, 1994). We found it to be a very rapid and sensitive method which is useful for diagnosis in a large population of animals (Fig 29 a, b). While we were still celebrating our finding, we discovered that an 88 kilodalton immunodominant protein is specific to *Fasciola gigantica* (Fig 30 a, b) (Fagbemi, Obarisiagbon and Mbuh, 1994). A big parasite like *Fasciola* contains millions and millions of protein molecules. Therefore, identifying and purifying a unique protein molecule is similar to searching for and finding an unknown nameless person without an address, in a continent.

UNIVERSITY OF IBADAN LIBRARY

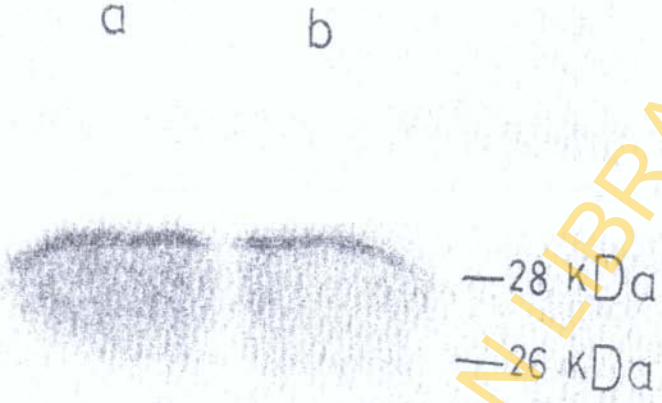


Fig 27: SDS-PAGE of Purified Most Important Proteolytic Enzyme of *F. gigantica* under (a) Reducing and (b) Non-Reducing Conditions

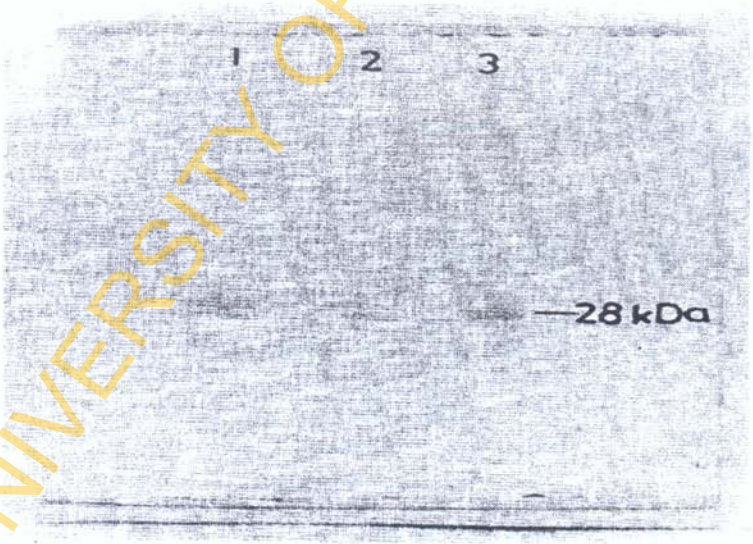


Fig 28: Immunoblot of Purified 28 kDa Proteolytic Enzyme of *Fasciola gigantica* with Monoclonal Antibody

UNIVERSITY OF IBADAN LIBRARY

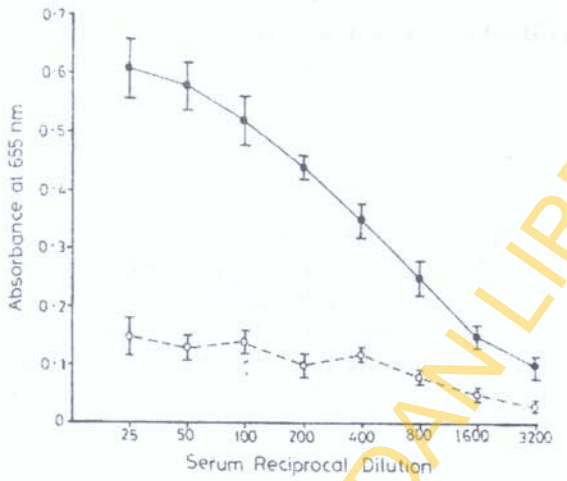


Fig 29a: Results of FAST-ELISA of pooled sera of *Fasciola*-infected cattle (solid line) and *Fasciola*-free cattle (broken line) using 28 kDa Protease

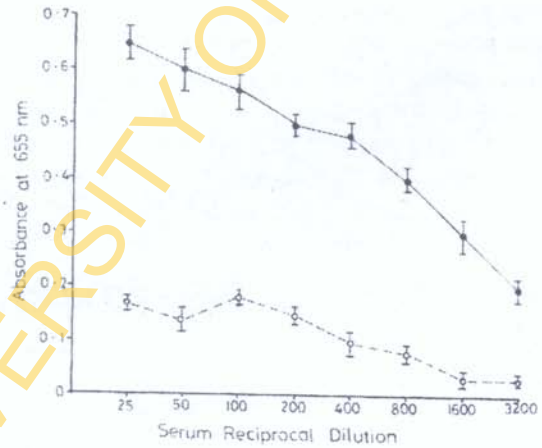


Fig 29b: Results of FAST-ELISA of pooled sera of *Fasciola*-infected goats (solid line) and *Fasciola*-free goats (broken line) using 28 kDa Protease

UNIVERSITY OF IBADAN LIBRARY

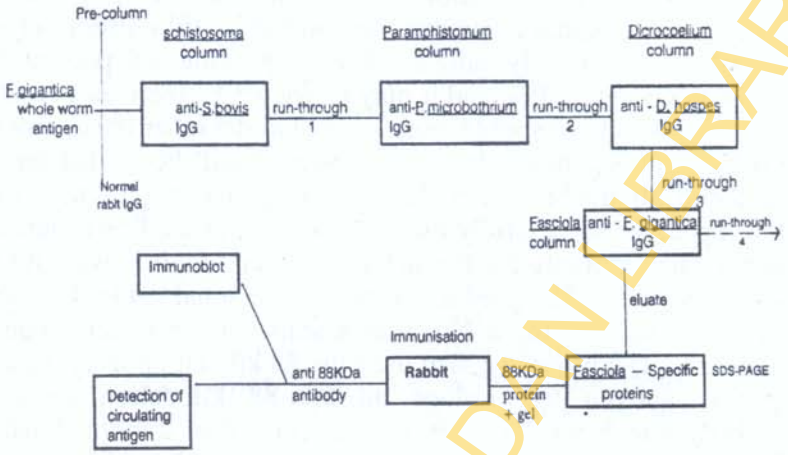


Fig 30a: Scheme for Immunoaffinity Purification of *F. gigantica* 88 kDa Antigen and Production of anti-88 kDa Antibody

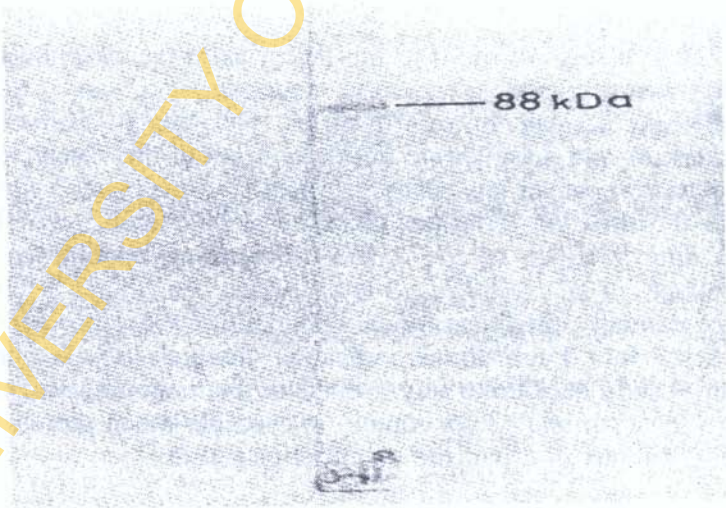


Fig 30b: Immunoblot of *Fasciola gigantica* whole-worm antigen with anti-88 kDa protein antiserum

UNIVERSITY OF IBADAN LIBRARY

One disappointing reality in immunodiagnosis of a parasite infection is that the detection of antibodies (antisera) against a parasite does not guarantee that the parasite is still present in the animal or man. It only indicates that the parasite was present in a host at a point in time and it may no longer be there as a result of chemotherapy or spontaneous cure. On the other hand, when a parasite is in a host, circulating antigens will be in that host. To avoid all doubts about the use of the techniques that we developed, we successfully used our anti -28 kilodalton protease monoclonal antibody for the detection of circulating liver fluke antigen in cattle. The production of a monoclonal antibody is an expensive venture for a Nigerian scientist in an under-funded university. Therefore, we also used the 88 kilodalton liver fluke-specific antigen to produce an anti-88 kilodalton protein antibody which we jocularly called "poor man's monoclonal" (Fagbemi, Obarisiagbon and Mbuh 1994) and we used it for the detection of circulating antigen in the sera of liver-fluke infected cattle and sheep. Nevertheless, for researchers who do not want to go through the rigours of detecting circulating antigens, we evolved a time-course analysis of antibody response by EITB and ELISA in sheep and antibody profiles in goats before and after chemotherapy (Guobadia and Fagbemi 1994; Mbuh and Fagbemi, 1994).

At that stage of my research, I received several applications from young scientists from other countries who wanted to join our team because only two of us, Dr. George Hillyer, an American, and myself were in the forefront of this research. At that time, however, my salary as a Reader (Associate Professor) was a paltry six thousand naira per month and I was busy deciding whether to get a more rewarding appointment or contract in the U.S.A, South Africa or the Caribbean. Providentially, the International Foundation for Science gave me a prize for "Publications indicating research of exceptional merit" and I decided to stay in Ibadan. International recognition as a 'host' in one's own country is certainly much preferred to being famous as a 'parasite' in a foreign country.

UNIVERSITY OF IBADAN LIBRARY

A Chapter in the Guinea Worm Story

Ladies and Gentlemen, the interacting effects of infectious agents are not limited to that between metazoan and protozoan parasites, it also occurs between parasites and bacteria.

Guinea worm disease which is known scientifically as dracunculiasis is a human disease which, contrary to claims, is still a common disease in the poor countries, especially Nigeria. I did some research on this disease in some parts of Oyo and Osun States with my former Ph.D. Student, Professor Seyi Adeyeba. It is a severely painful, crippling and debilitating disease. One feature of this disease is that after infection, the parasite develops unnoticed in the body for about ten months (Fig. 31). Finally, the adult worm emerges through the skin, and once it does, there is no cure until it completes its natural life span. The worm emerges from any part of the body such as the limbs, abdomen, chest, face and even the tongue (Figs 32, 33). The excruciating pain and incapacitation caused by the parasite is due to the digestion and peroxidation of tissues and the skin as the worm emerges through the skin and the simultaneous infection of the wound by pathogenic bacteria. Adeyeba, Fagbemi, Adegoke and Codard (1990) found that *Staphylococcus aureus* was the predominant bacterium in guinea worm ulcers. The isolated bacteria were sensitive to oxacillin and erythromycin but resistant to penicillins and tetracycline.

UNIVERSITY OF IBADAN LIBRARY

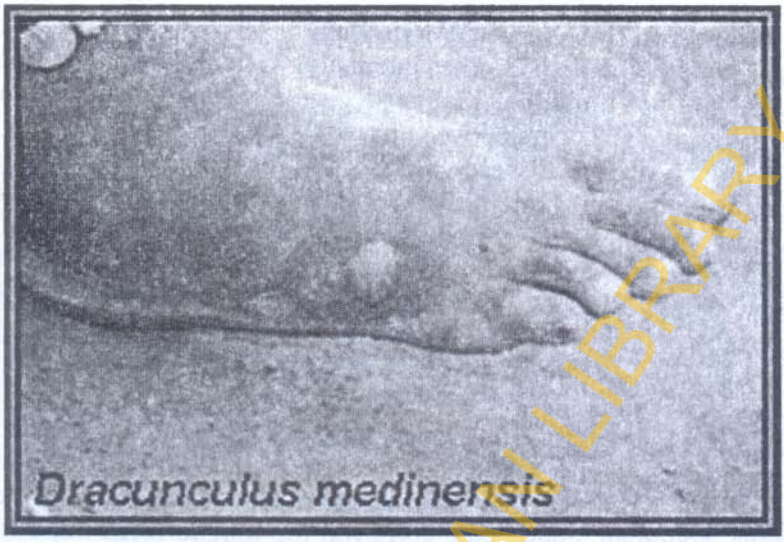


Fig 31: Guinea worm Blisters on Foot Before Emergence

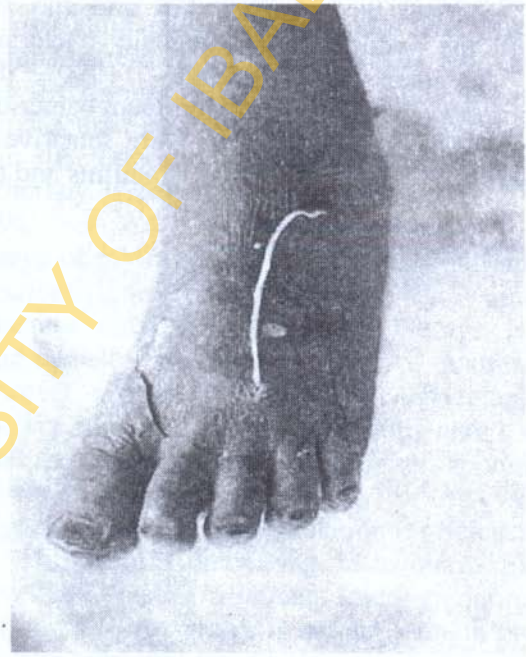


Fig 32: Guinea worm Emerging From Foot

UNIVERSITY OF IBADAN LIBRARY

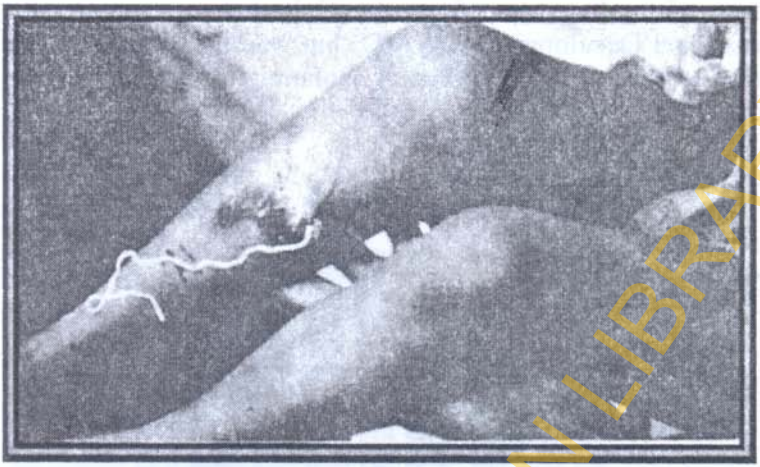


Fig 33: Guinea worm Emerging from Leg

We reasoned that if guinea worm could be detected during the ten months before the worm emerges through the skin and the worm is killed by treatment, the pain and incapacitation caused by the disease would be avoided (Fagbemi and Hillyer, 1990). Using the enzyme-linked immunotransfer blot (EITB) and FAST-ELISA techniques, we found that three polypeptides of the guinea worm with molecular weights 16 kilodalton and 17 kilodalton were recognized by sera of humans three months before emergence (Figs 34a,b). This was also another pioneering work. We also observed, to our disappointment, that sera from subjects whose guinea worm had been expelled three months earlier recognized these specific polypeptides. I reasoned that this happened because the antigens used in the study were obtained from adult guinea worm. I decided to use antigen from the larvae of guinea worm obtained from the Cyclops intermediate host. To my surprise, I ran into deep opposition from local reviewers who said such thing as "You want to kill a mosquito with a rifle"; "You don't need all these hi-tech methods to get rid of guinea worm, just provide clean water for the people" etc. Now, sixteen years later, guinea worm is still with us and the armchair critics have not provided the clean water. The only encouragement for the research in terms of

UNIVERSITY OF IBADAN LIBRARY

promise of funding came from the United States Agency for International Development (USAID) but we could not conclude arrangements before the political isolation of Nigeria in the 1990s.

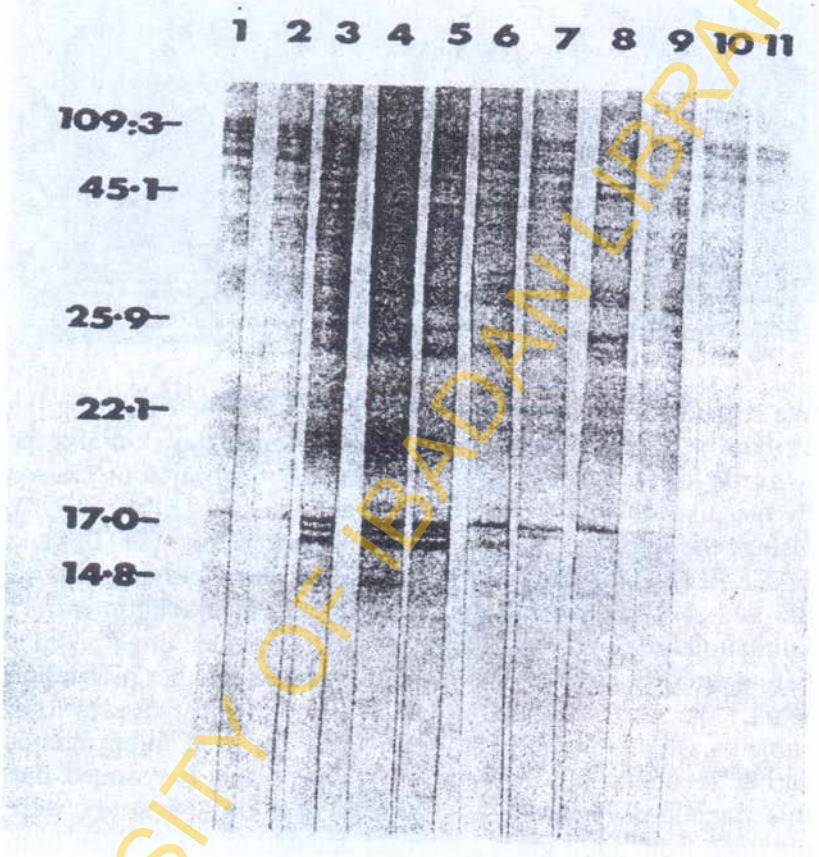


Fig 34a: Immunoblot of Guinea worm Antigen Reacted with Sera of Humans with Various Parasite Infections

UNIVERSITY OF IBADAN LIBRARY

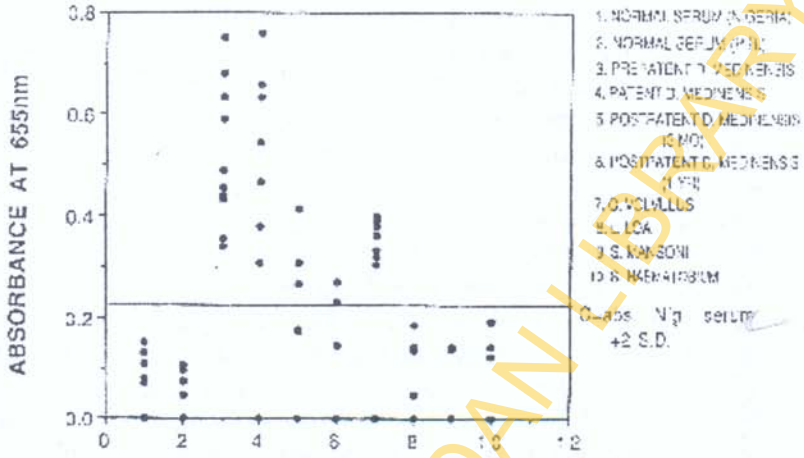


Fig 34b: FAST-ELISA with Guinea worm Antigen Reacted with Sera of Humans with Various Parasite Infections

Mr. Vice-Chancellor, all my research work to date has been supported by funding and fellowships from the Danish Foreign Affairs Ministry, the United States Department of Health and Human Services, the International Foundation for Science, Sweden, the United States Feed Grains Council, the United States Department of State e.t.c. I am grateful to Nigeria for giving me a university job and for paying my salary, even when it was six thousand naira per month. In this century, no nation can claim to be sovereign as long as it pays lip service to science and technology, and university funding is a 'no-go' area in negotiation with government. Scientists in all developed countries, and even in developing countries in Africa and the Caribbean, get research grants and conference grants from within their own countries. I have not heard of the United States of America giving money to a Spanish or Italian scientist for research. It is with deep sorrow and regret that I say that Nigeria is not a sovereign country—if science and technology are used as the yardsticks.

UNIVERSITY OF IBADAN LIBRARY

Wear these flowers till they fade
Wear these petals till they wither
Whither are the flowers
Where are the petals
The Petals die in the buds
Yet the buds shall blossom still.
Kunle Fagbemi, I.S.I. (1971)

Sleeping Sickness

In the early 1990s, Imevbore and Fagbemi studied human sleeping sickness in Benue and Edo States of Nigeria. Human sleeping sickness in West Africa is caused by a blood protozoan parasite called *Trypanosoma brucei gambiense* (Fig 35). It is transmitted by the bite of a tsetse fly. On rare occasions, it can be transmitted by blood transfusion or it may move from a pregnant woman to a baby in the womb. It stays in the blood for several months but it eventually crosses the blood/brain barrier into the cerebrospinal fluid where it causes neurological signs and sleepfulness. It is fatal if not treated. By using the techniques of EITB, detection of circulating antigens and antibody ELISA, we found that sleeping sickness was more prevalent in Edo State in the South than in Benue State in the Middle Belt, contrary to the common belief that it is a disease of the Middle Belt states in Nigeria (Awobode, Ohore and Fagbemi, 2002). However, the observation that was shocking to us was the high mortality rate. I asked my colleague, Dr. Imevbore (now Awobode) to revisit the infected people and collect samples for follow-up studies because we obtained information that an agency had moved in to do mass treatment of the infected people. She went and came back empty-handed. All the infected people had died. For the poor African, life is tough and short.

UNIVERSITY OF IBADAN LIBRARY

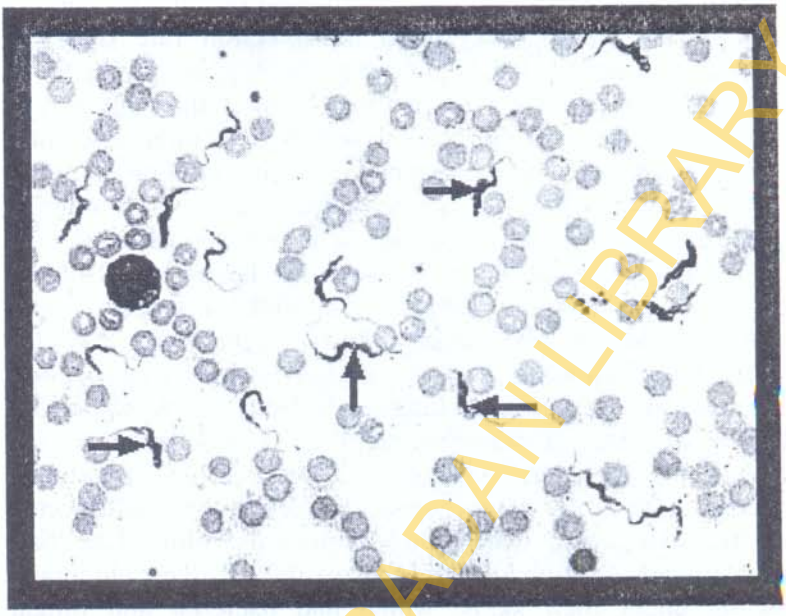


Fig 35: *Trypanosoma brucei gambiense* in Human Blood; Pathogen of Sleeping Sickness In West Africa

River Blindness: A Dark Fabric In The Tapestry

Ladies and gentlemen, not all parasitisms end abruptly and fatally. We (Opara and Fagbemi) worked on river blindness, otherwise called onchocerciasis, in the southern part of the Nigerian/Cameroon border and the Lower Cross River Basin. It is transmitted by the bite of *Simulium damnosum* (Black fly) (Fig 36). It is a chronic disease caused by the filarial worm called *Onchocerca volvulus* and it is the most devastating of all filariasis affecting mankind. Unfortunately, Nigeria has the largest number of cases and the widest geographical spread of the disease in the world. It is present in all the states of Nigeria, including the Federal Capital Territory, except Lagos, Rivers and Akwa Ibom States. It is characterized by partial or total blindness (Fig 37a), nodules on the body, in which the adult worms live (Fig 37b), discoloration and depigmentation of the skin, called leopard skin (Fig 37c). The developing stages of the worm are found in the blood and just under the skin (Fig 37d).

UNIVERSITY OF IBADAN LIBRARY

Sometimes, there is lymphatic complication of the female genitalia (Fig 37 e). We found an infection rate of 45%. Besides, we reported significant eye pathology and blindness in the forest zone, contrary to previous reports that linked eye damage to *Onchocerciasis* in the savannah vegetation zone only. We also found a new pattern, namely, that the ABO blood group is very important in the susceptibility to river blindness. Furthermore, we found that the skin lesions or leopard skin may be a result of the interaction between the larval stages of the worms and the concurrent bacterial infection with *Staphylococcus aureus, Staphylococcus epidermis, Bacillus subtilis, Pseudomonas aeruginosa* and *Streptococcus pyogenes*. As if these were not enough, fungal infections; *Trichophyton sp, Candida albicans, Aspergillus niger* and *Epidermophyton* sp were in the deformed skin of the patients as opportunist invaders. We were therefore confronted by a multifaceted parasitic infection in which the victims were blind, had their bodies covered with nodules, had microfilaria in their blood and crawling under their skins, which had bacterial and fungal infections. Some of the victims preferred to die. This is the dark side of the tapestry of parasitism. Somebody designed a bronze monument for this 'Mother of Parasitic Infections' (Fig 37 f).

Fig 36: *Simulium damnosum* (Black fly)

UNIVERSITY OF IBADAN LIBRARY

Fig 37a: Total Blindness caused by River 'Blindness'

Fig 37b: Onchocerca Nodule On the Body; adult worms live in the nodules

UNIVERSITY OF IBADAN LIBRARY

Fig 37c: 'Leopard Skin' Caused by River Blindness

Fig 37d: Onchocerca microfilaria (larvae) Emerging fro Skin Snip

UNIVERSITY OF IBADAN LIBRARY

Fig 37e: Lymphatic complication of River Blindness in a Female

Fig 37f: Bronze Monument to 'River Blindness'

UNIVERSITY OF IBADAN LIBRARY

Phytomedicine Development: Tapestry in Bright Light

Mr. Vice-Chancellor, when all appears to be gloomy and dark, there is always a ray of light in the horizon. Perseverance, persistence, fortitude and even stubbornness are attributes in science. The tapestry of parasitism is vast, intricate and complicated and the realms are so pervasive, resulting in a twilight zone of health and sickness. To make matters worse, these parasites develop resistance to drugs almost as quickly as drugs are developed against them. Traditional belief systems do not provide remedies. We, on our part, are at the forefront in developing local remedies against parasites. As a primary school pupil, I had fun showing to my friends that the oily substance from orange peelings could kill flies and cockroaches. In the early 1980s, Dipeolu, Fagbemi and Ayoade used ethanol and aqueous extracts of various local plants to kill ticks and insects that transmit protozoan parasites to animals and man. More recently, Ademola, Fagbemi and Idowu (classified) did elaborate research on four plants; *Nauclea latifolia* (egbesi in Yoruba, igiya in Hausa, Fig 38a), *Spondias mombin* (iyeye in Yoruba, Fig 38b), *Spigelia anthelmia* (ewe aran in Yoruba, Fig 38c), *Khaya senegalensis* (oganwo in Yoruba, ono in Igbo and madachi in Hausa, Fig 38d), with the aim of using them against gastrointestinal worm parasites. We observed that both the aqueous and the ethanol extracts had the ability to kill gastrointestinal worms and that *Khaya senegalensis* gave the most efficacious anthelmintic activity. We proceeded to do bioactivity-guided fractionation of *Khaya senegalensis* using the techniques of vacuum liquid chromatography. The most active fraction was recovered and for now we have given it the code KH913 for proprietary reasons. KH913 was purified by preparative thin layer chromatography and flash chromatography to produce KH913A (Fig39). This purified extract was subjected to a series of screening and analyses such as the ferric chloride test, the vanillin/HCl test and spectroscopic analysis, and its ability to kill gastrointestinal worms in sheep was assessed in a larval development assay. Mr. Vice-Chancellor, KH913A, which is derived from the Nigerian plant *Khaya senegalensis,* is an antihelminthic to which resistance has

UNIVERSITY OF IBADAN LIBRARY

not developed. It is highly efficacious and non-toxic. It can be developed further by the private sector (either Nigerian or foreign, after they have paid the price which will be determined by us (Ademola, Fagbemi and Idowu)). For now, it is the physical and intellectual property of our research team and it is appropriately protected.

Fig 38a: *Nauclea Latifolia* (Yoruba = Egbesi)

UNIVERSITY OF IBADAN LIBRARY

Fig 38b: *Spondias mombin* (Yoruba = Iyeye)

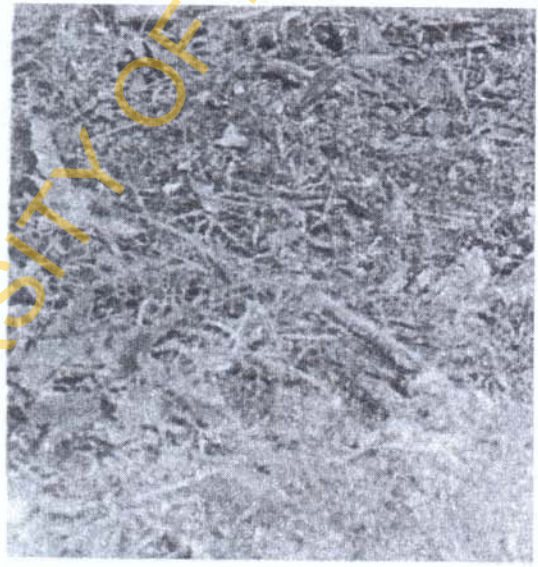
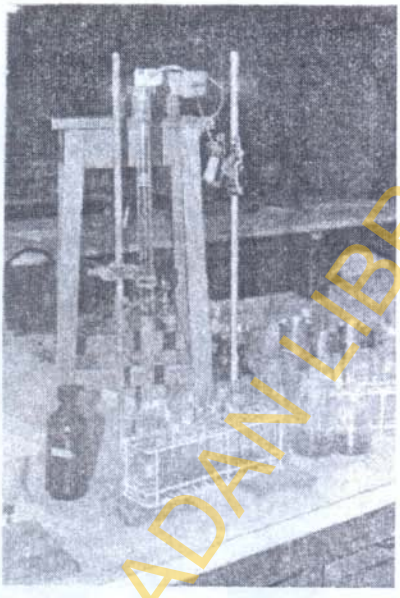


Fig 38c: *Spigelia anthelmia* (Yoruba = Ewe Aran)

UNIVERSITY OF IBADAN LIBRARY

Fig 38d: *Khaya senegalensis* (Yoruba = Oganwo)

UNIVERSITY OF IBADAN LIBRARY



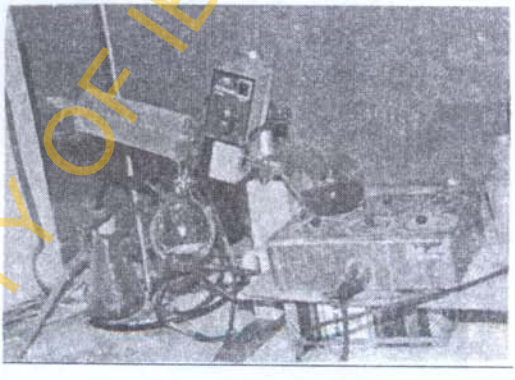


Fig 39: Purification of KH913A by Thin Layer Chromatography and Flash Chromatography

UNIVERSITY OF IBADAN LIBRARY

Drug-Resistant Malaria

At this juncture, it is relevant to tell this distinguished audience what we are doing against malaria. We all know what malaria does to us, but you may not be aware of what some people do to malaria. Malaria remains a major public health problem in most developing countries. There are 300 - 500 million clinical cases each year in over 90 countries worldwide and 90% of the estimated 1.5 to 2 million annual mortalities occur in African children. In humans *Plasmodium falciparum* (Fig 40a) is the deadliest of the four species that cause malaria. Unfortunately, the malaria parasite has become resistant to most of the usual drugs used for malaria treatment, especially chloroquine. However, some compounds have been observed to reverse chloroquine resistance. We therefore investigated amodiaquine (camoquine) combined with promethazine on chloroquine resistant strains of *Plasmodium falciparum in vitro* (Olalubi, Fagbemi and Oduola). A schizont inhibition assay was used and it was based on the ability of promethazine to potentiate the intrinsic antimalarial activity of camoquine. We observed that promethazine (phenergan) potentiates the intrinsic antimalarial activity of amodiaquine (camoquine) against resistant strains of plasmodium falciparum (Figs. 40b and 40c).

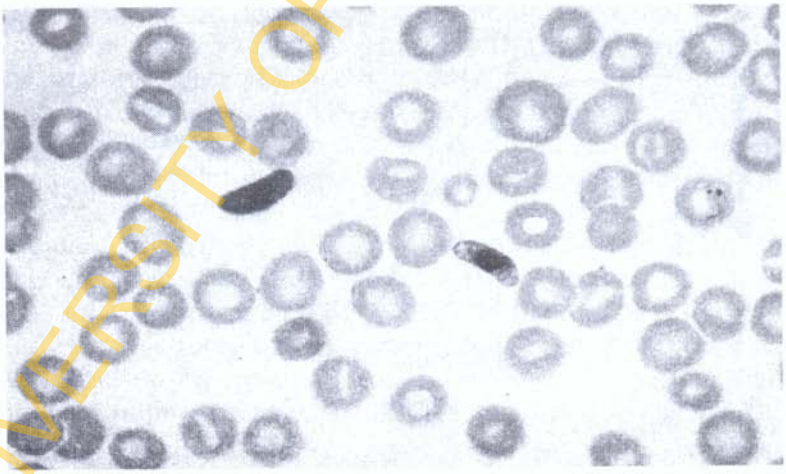


Fig 40(a): *Plasmodium falciparum*

UNIVERSITY OF IBADAN LIBRARY

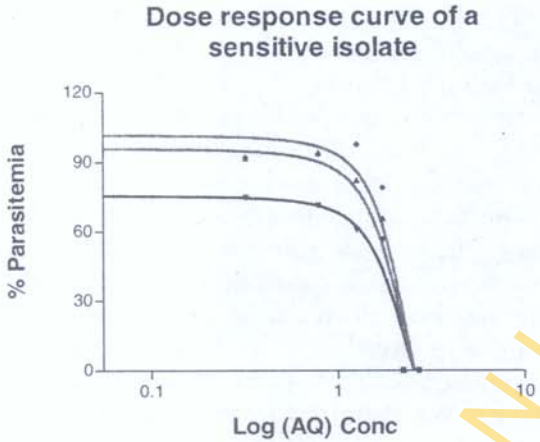


Fig 40b

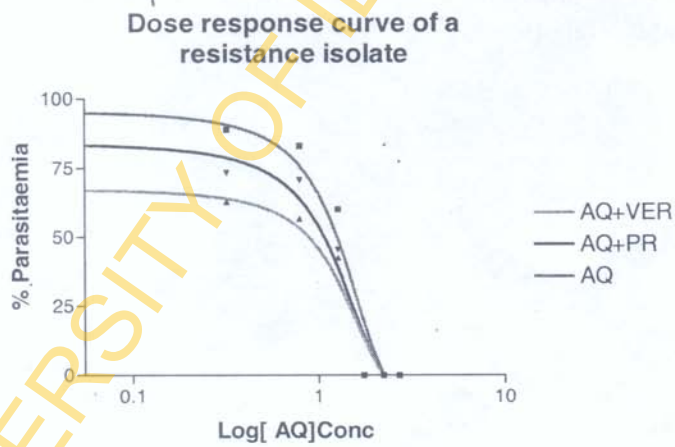


Fig 40c

UNIVERSITY OF IBADAN LIBRARY

Application of G.I.S. and Development of Computer Models

Finally, "No matter how civilized and organized human society may become, parasites, microbes, infected fleas, lice and insects, always lurk in the shadows, waiting to strike when we lower our defences. The only solution is to fight them with all the means at our disposal''. As a young Lecturer II, I read the publication of a veterinary parasitologist. I guessed that out of a combination of determination and frustration, he gave the paper the title "Tactical and Strategic Treatment: Application of Military methods to the Control of Parasite Diseases of Livestock". For several years, I have been involved in research aimed at the use of novel techniques to understand and control parasites. We have applied the robust and easily interpretable capability of the Geographical Information System (G.I.S.) in the study of the distribution of *Lymnaea natalensis* (the intermediate host of *Fasciola gigantica*) and the epidemiology of fascioliasis (Adedokun, Fagbemi et al, classified). We were able to accurately determine high-risk areas for fascioliasis in cattle. For example, by using GIS to generate maps based on parameters such as exchangeable cations, organic pollution, heavy metals, alkalinity and water hardness, high-risk areas for fascioliasis in cattle in Ibadan area were identified as Akinyele, Iddo, Ibadan North, Ibadan North East and Ibadan South West during the dry season (Figs 41a,b,c). During the rainy season, the high-risk areas include Egbeda, Oluyole, Iddo, Akinyele, Ibadan North and Ibadan North East Local Government Areas (Figs 41d, e, f)). We have also developed the first and only computer models in the world to simulate and control animal trypanosomiasis and coccidiosis in poultry (Fagbemi and Kupoluyi, classified) and fascioliasis in cattle (Adedokun and Fagbemi, classified, Figs 42a,b,c,d,e). The computer models took into consideration the processes of interaction between the biological systems of the parasite–host, parasite–intermediate host, parasite–environment, host-environment and intermediate–host environment. They simulated the tapestry of parasitism.

UNIVERSITY OF IBADAN LIBRARY

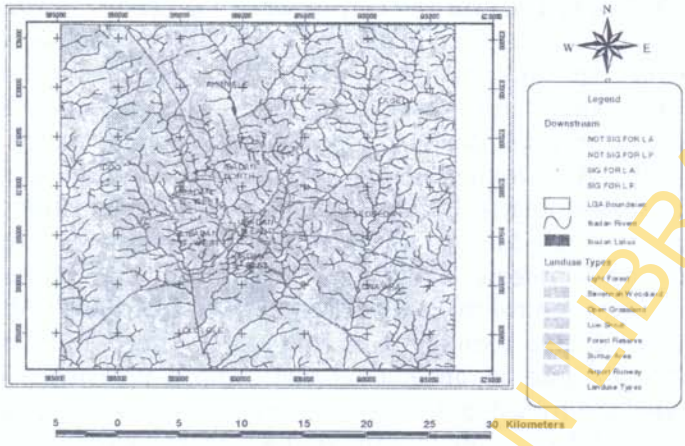


Fig. 41a: Map of the Downstream Sample Locations In Ibadan showing the influence of Exchangeable Cations on the occurrence of *Lymnaea Natalensis* During The Dry Season

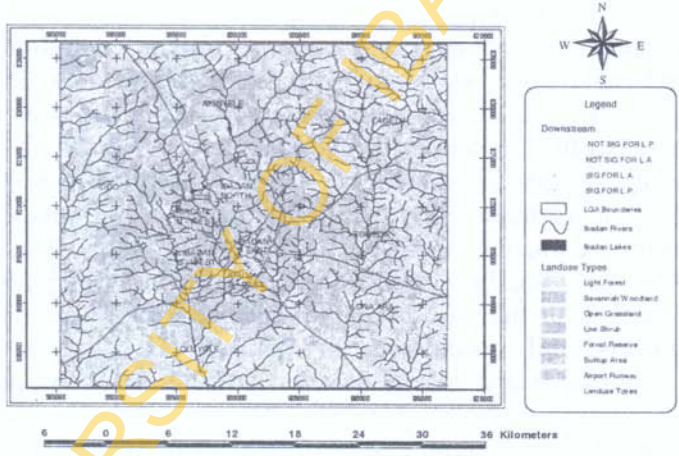


Fig. 41b: Map of the Downstream Sample Locations in Ibadan showing the influence of heavy metals on the occurrence of Lymnaea Natalensis during the dry season

UNIVERSITY OF IBADAN LIBRARY

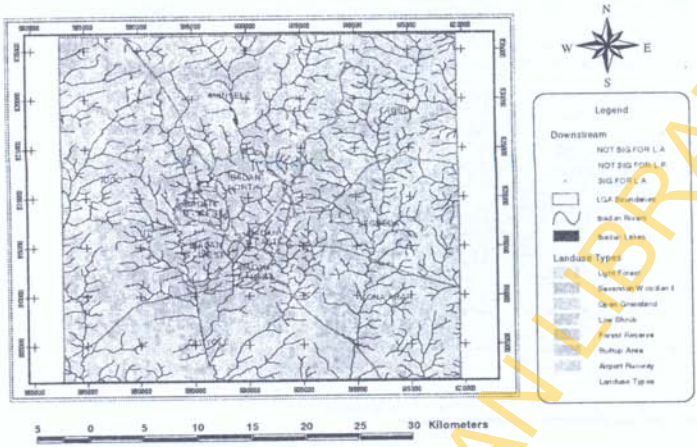


Fig. 41c: Map of the Downstream Sample Locations in Ibadan showing the influence of pollution on the occurrence of Lymnaea Natalensis during the dry season

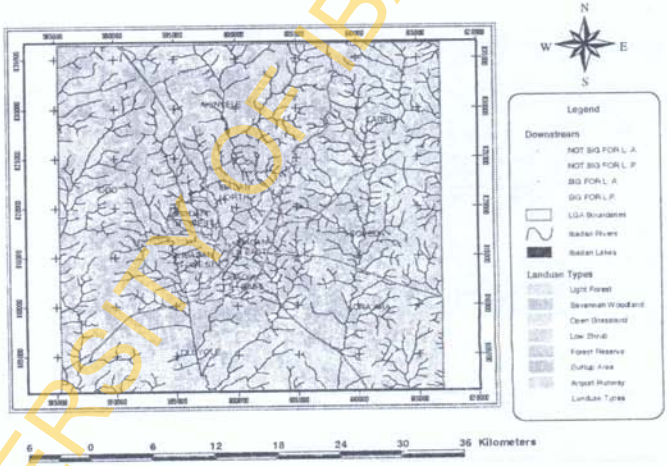


Fig 41d: Map of the Downstream Sample Locations in Ibadan showing the Influence of Exchangeable Cations on the occurrence of *Lymnaea Natalensis* during the rainy season

UNIVERSITY OF IBADAN LIBRARY

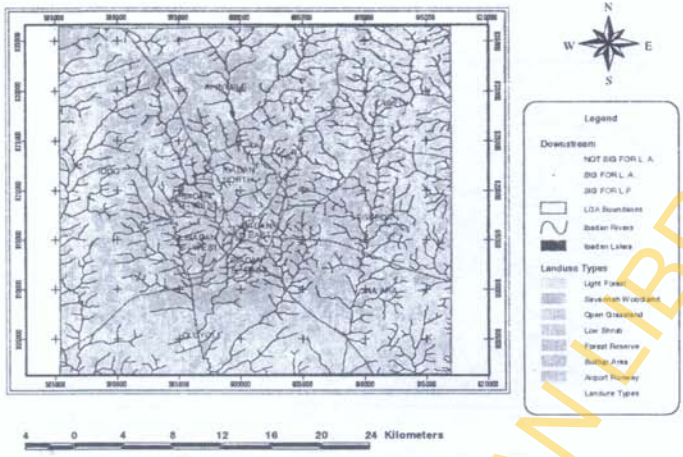


Fig 41e: Map Of The Downstream Sample Locations In Ibadan Showing The Influence Of Heavy Metals On The Occurrence Of *Lymnaea Natalensis* During The Rainy Season

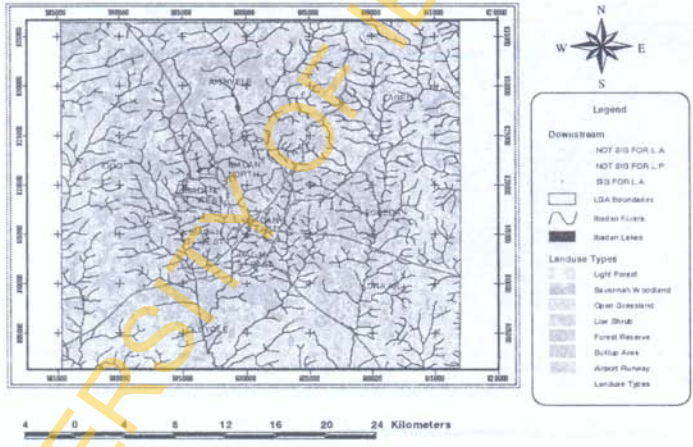


Fig 41f: Map Of The Downstream Sample Locations In Ibadan Showing The Influence Of Pollution On The Occurrence Of *Lymnaea Natalensis* During The Rainy Season

UNIVERSITY OF IBADAN LIBRARY

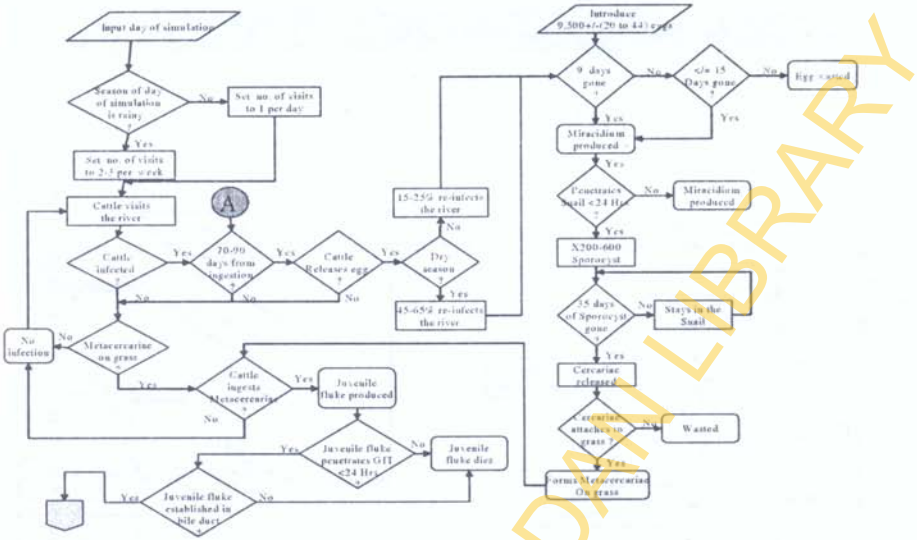


Fig 42a: Flowchart for the Model of Epidemiology of Fascioliasis

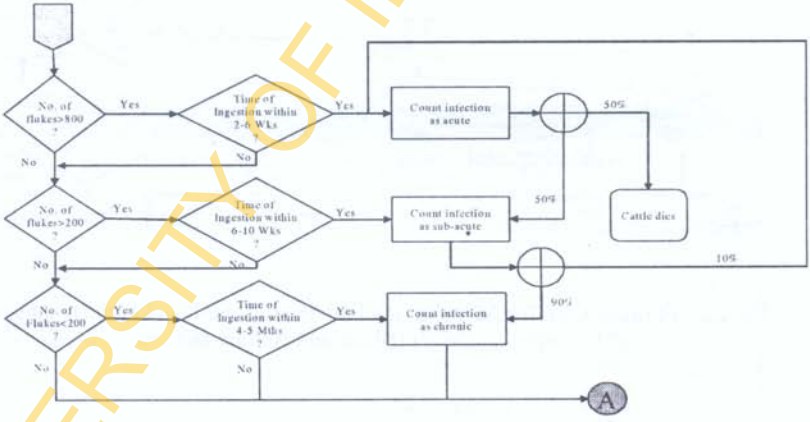


Fig. 42a(contd.) - Flowchart for the Model of Infection In Cattle

UNIVERSITY OF IBADAN LIBRARY

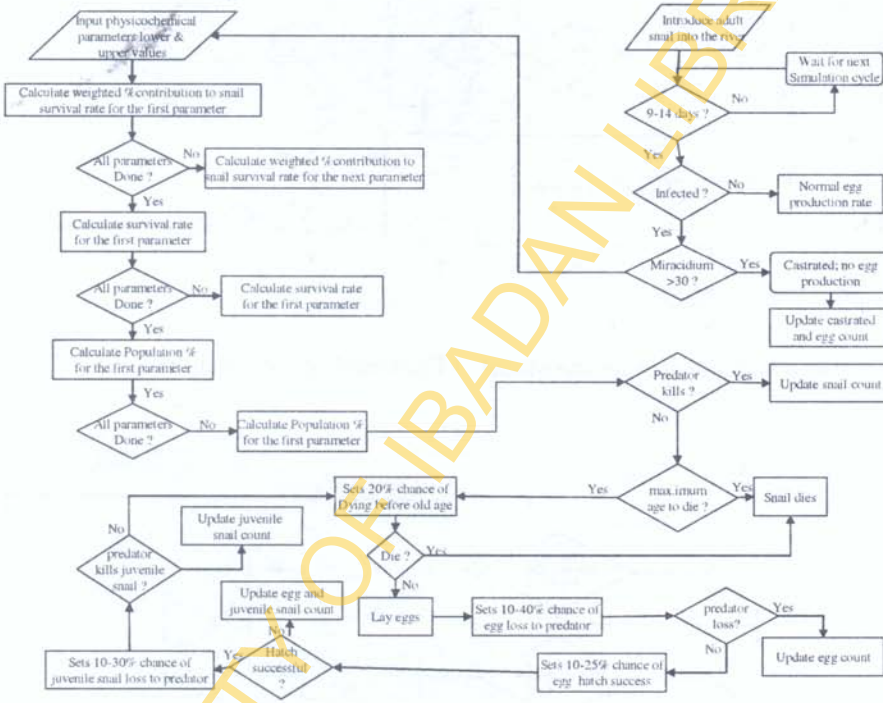


Fig 42b: Flowchart for The Model of the Distribution and Population Dynamics of *Lymnaea natalensis* (Biotic and Abiotic factors).

UNIVERSITY OF IBADAN LIBRARY

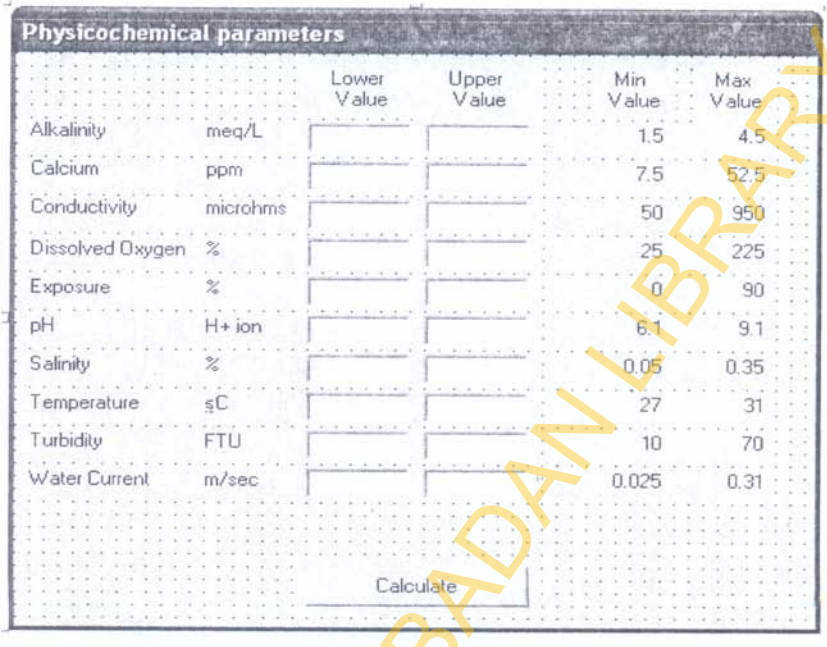


Fig 42c: Graphical User Interface for Inputing Physicochemical Parameters

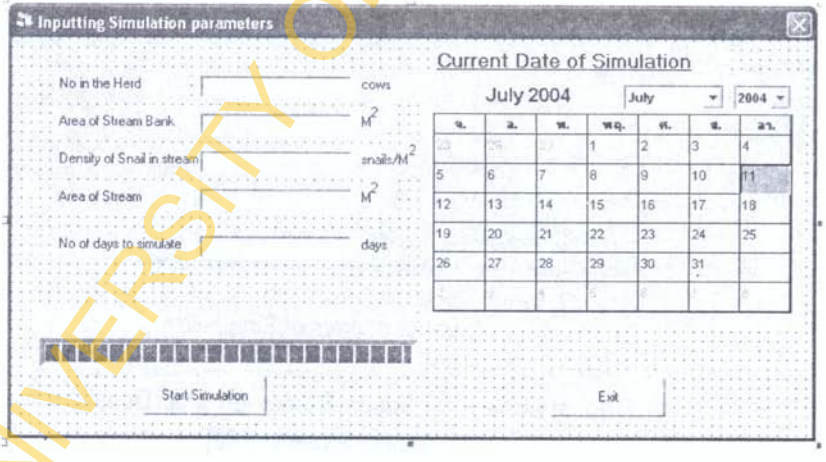


Fig 42d: Graphical User Interface for Simulation

UNIVERSITY OF IBADAN LIBRARY

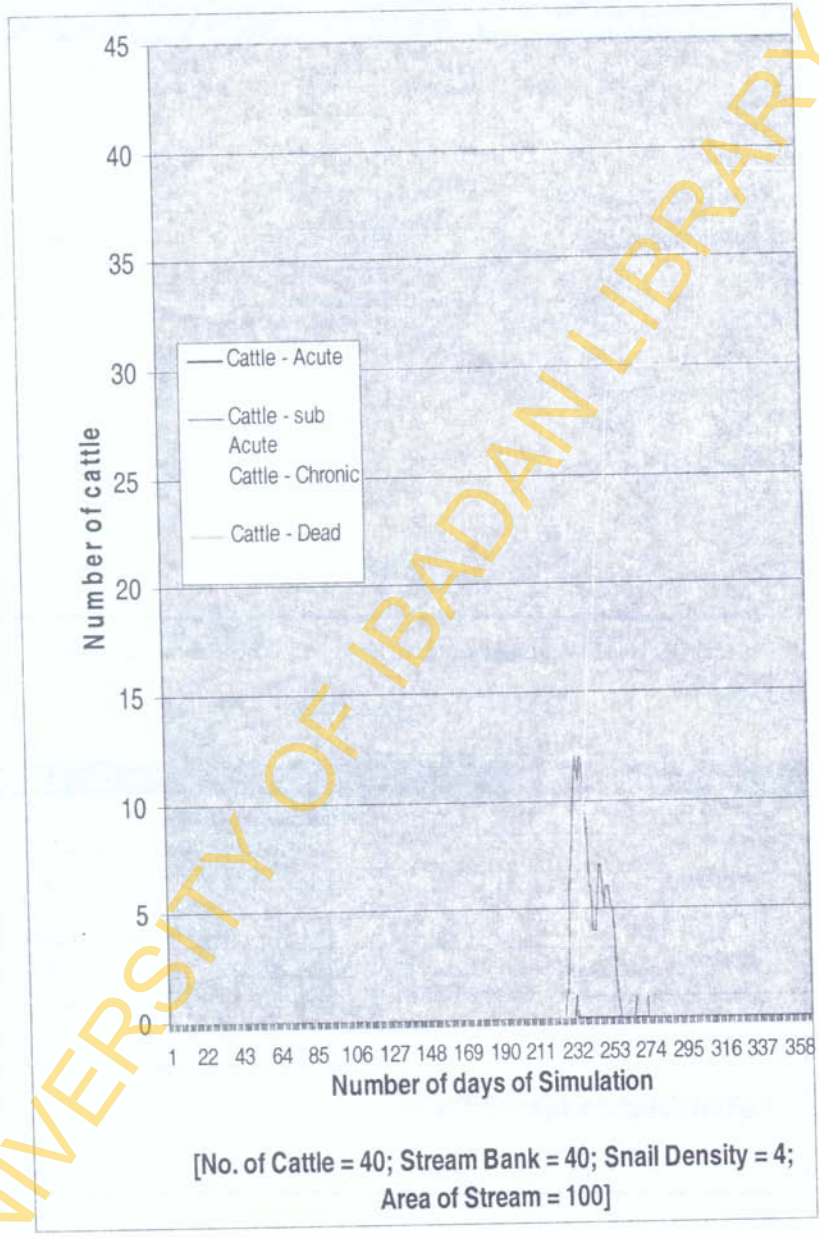


Fig 42e

UNIVERSITY OF IBADAN LIBRARY

Vice-Chancellor, a Nobel Prize Winner listed the prerequisites for success in science: a vigorous work ethic, passion for glory, patriotism and a little bit of eccentricity. That is a tall order. I have, however, on my own part tried to summarize the requirements for being a professor: scholarship, leadership in research and contribution to progress of the university as a whole. I hope that my endeavours have met these marks. Nevertheless, to all these I'll simply say:

I gave hope to many; I kept none to myself;
I gave succour to several; I expect none in return,
I'll be appreciated after I've gone;
Like a shooting star.

ACKNOWLEDGEMENT

I give all thanks, honour and praises to Almighty God, the creator all life and fountain of wisdom and knowledge. At this stage of my life, I am happy, peaceful and feel accomplished.

I wish to recognize Professor Olusegun Dipeolu, my teacher, supervisor and mentor who recognized my talents from undergraduate days and helped to bring out the best in me. I hope that I will have another opportunity to thank all teaching and non-teaching staff in my Department, the Faculty of Veterinary Medicine and the University of Ibadan as a whole. However, I have to mention Emeritus Professor M. Ola Ojo, Professor Wole Akinboade, Professor Tunde Otesile and Professor A. I. Adetosoye who are not only senior academic colleagues but brothers and friends. I gained a lot from their combined wealth of experience. I also deeply appreciate all past and current Heads of the Department of Veterinary Microbiology and Parasitology.

I remember all students, both undergraduate and postgraduate who I taught or guided at various times. Students are the most important component of the University. I cherish you all. We inherited the University from the founding fathers but we also borrowed it from generations of students unborn.

UNIVERSITY OF IBADAN LIBRARY

Finally, it is with joy that I announce to you that God has blessed me with a happy, wonderful, loving and supportive family. Some are here today but most are living in various countries of the world. I thank you for your love and tolerance of my academic idiosyncrasies. The only names I will mention on this occasion are those of my late parents – Chief James Olaniyan Fagbemi and Chief (Mrs.) Fanny Wuraola Fagbemi – Father, mother, teachers, educators, equal-rights activists, mentors, hero and heroine and consummate administrators. Thank you very much indeed.

UNIVERSITY OF IBADAN LIBRARY

REFERENCES

Awobode, O.A., Ohore, O.G. and Fagbemi, B.O. (2002). Evaluation of antigen ELISA in the diagnosis of Trypanosoma gambiense sleeping sickness. *The Zoologist*. 1, 82 – 90

Adedokun, O.A and Fagbemi, B.O. (Classified). Application of GIS and Computer Simulation in the distribution of *Lymnaea natalensis* and the prevalence of *fascioliasis* in cattle.

Ademola, I.O., Fagbemi, B.O. and Idowu, S.O. (Classified). Evaluation of the anthelmintic activities of four medicinal plants against gastrointestinal nematodes.

Adeyeba, O.A., Fagbemi, B.O., Adegoke, G.O. and Codard, C. (1991). Antibiogram and phagetypes of some *Staphylococcus aureus* isolated from bacterial-infected guinea worm ulcers in Nigeria. *Journal of Medical Sciences* 2: 65-69.

Anderson, R.M. (1982). In: *Modern Parasitology*. Editor; Cox F.E.G. Blackwell Scientific Publications. Pages 2040-251.

Christensen, N.O. and Fagbemi (1984). Trypanosoma brucei – induced blockage of expulsion Echinostoma revolution and of homologous E. revolution resistance in mice. *Journal of Parasitology* 70: 558-561.

Crofton, H.D. (1971). A quantitative approach to parasitism. *Parasitology* 62: 169-193.

Devakul (1966). Erythrocyte destruction in *Plasmodium falciparum* malaria: Effects of erythrocyte glucose-b-phosphate dehydrogenase deficiency. *Annals of Tropical medicine and Parasitology* 60: 432-437.

Dogiel, M. (1978). In: Thirty years of Parasitology research in Nigeria: A working bibliography 1950-1980. University of Ibadan.

Fagbemi, B.O. (1987a). The pathogenesis of anaemia in babesiosis: The lack of preference of *Babesia microti* for erythrocytes of specific age groups. *Vet. Archiv*. 57: 7-14.

Fagbemi, B.O. (1987b). Interference with homologous immunity and faecal egg excretion in Schistosoma infection mice concurrently infected with *Trypanosoma brucei* and *Schistosoma mansoni*. *Folia Parasitologica* 34: 317-323.

UNIVERSITY OF IBADAN LIBRARY

Fagbemi, B.O. (1994). Development and characterization of a monoclonal antibody reactive with a 28-kilodalton protease of *Fasciola gigantica* adult worms. *Veterinary Parasitology* 57, 351-356.

Fagbemi, B.O. and Akinboade, O.A. (1987). Mechanisms of parasite interactions in in vitro killing of *Babesia microti* with macrophages activated by *Schistosoma bovis* 57: 203-210.

Fagbemi, B.O. and Christensen, N.O. (1984). Delayed expulsion of Hymenolepis diminuta in Trypanosoma infected mice. *Zeitschrift für Parasitenkunde* 70: 663-665.

Fagbemi, B.O. and Hillyer, G.V. (1990). Immunodiagnosis of dracunculiasis by Falcon Assay Screening Tests Enzyme – linked Immunosorbent Assay (FAST-ELISA) and by Enzyme-linked Immuno-electro transfer Blot (EITA) techniques. *American Journal of Tropical Medicine and Hygiene* 43: 665-668.

Fagbemi, B.O. and Hillyer, G.V. (1991). Partial purification and characterization of the proteolytic enzymes of *Fasciola gigantica* adult worms. Veterinary Parasitology 40: 207-216.

Fagbemi, B.O. and Hillyer, G.V. (1992). The purification and characterization of the proteolytic enzymes of *Fasciola gigantica* adult worms. *Veterinary Parasitology* 43: 223-232.

Fagbemi, B.O. and Guobadia E.E. (1994). Immunodiagnosis of fascioliasis in ruminants using a 28kDa cysteine protease of *Fasciola gigantica* adult worms. *Veterinary Parasitology* 57: 309-318

Fagbemi, B.O. and Kupoluyi, V.O. (classified) Computer modelling and simulation of coccidiosis and trypanosomiasis in veterinary science.

Fagbemi, B.O., Akinboade, O.A. and Christensen, N.O. (1988). The modulation of disease in mice concurrently infected with *Fasciola hepatica* and *Babesia microti. Animal Technology* 39: 61-67

Fagbemi, B.O., Christensen, N.O. and Dipeolu, O.O. (1987). Effects of *Trypanosoma brucei* and *Babesia microti* infections on the primary granulomatous reactions to Schistosoma eggs. *Laboratory Animals* 21: 121-124

Fagbemi, B.O, Christensen, N.O and Nansen, P. (1985). Suppression of *Babesia microti* in mice concurrently infected with *Schistosoma mansoni. Acta Veterinaria Scandinavica* 26: 191-204

UNIVERSITY OF IBADAN LIBRARY

Fagbemi, B.O, Christensen, N.O and Nansen, P. (1985). Suppression of *Babesia microti* in mice concurrently infected *Fasciola hepatica*. *Veterinary Parasitology* 17: 101-110

Fagbemi, B.O and Obarisiagbon, I.O. (1990). Comparative evaluation of the Enzyme-linked Immunosorbent Assay (ELISA) in the diagnosis of natural Fasciola gigantica infection in cattle. *Veterinary Quarterly* 12: 35-38

Fagbemi, B.O and Obarisiagbon, I.O. (1991). Common antigens of *Fasciola gigantica*, Dicrocoelium hospes and *Schistosoma bovis* and their relevance to serology. *Veterinary Quarterly* 13: 81-87

Fagbemi, B.O and Obarisiagbon, I.O and Mbuh, J.V. (1994). Detection of circulating antigen in sera of Fasciola gigantica –infected cattle with antibodies reactive with a Fasciola-specific 88kDa antigen. *Veterinary Parasitology* 58: 235-246

Fagbemi, B.O and Otesile, E.B., Makinde, M.O. and Akinboade O.A. (1990). The relationship between dietary energy levels and the severity of Trypanosoma brucei infection in growing pigs. *Veterinary Parasitology* 35: 29-42

Guobadia, E.E. and Fagbemi, B.O. (1994). Detection of circulating *Fasciola gigantica* antigen in experimental and natural infections of sheep with fascioliasis. *Veterinary Parasitology*. 65: 29-39

Guobadia, E.E. and Fagbemi, B.O. (1994). Time-course analysis of antibody response by EITB and ELISA before and after chemotherapy in sheep infected with *Fasciola gigantica* 58: 24-253

Mbuh, J.V. and Fagbemi, B.O. (1995) Antibody and circulating antigen profiles before and after hemotherapy in goats infected with *Fasciola gigantica*. *Veterinary Parasitology* 66: 171-179

Nkrumah, K. (1964). In: *Consciencism*. London: Heinemann. 122 pages

Olalubi, O.A., Fagbemi, B.O. and Oduola, A.M.J. Evaluation of Amodiaquine combined with Promethazine on Chloroquine-resistant strains of Plasmodium berghei and Plasmodium falciparum in Ibadan, Nigeria. (Unpublished work).

Opara, K.N. and Fagbemi, B.O. Epidemiology of Onchocerciasis in the Lower Cross River Basin of Nigeria. (Unpublished work).

UNIVERSITY OF IBADAN LIBRARY

Otesile, E.B., Fagbemi, B.O. and Adeyemo, O. (1991) The effect of *Trypanosoma brucei* infection on serum biochemical parameters in boars on different planes of dietary energy *Veterinary Parasitology* 40: 207-216.

Otesile, E.B., Fagbemi, B.O., Makinde, M.O. and Akinboade, O.A. (1992). The response of pigs experimentally infected with Trypanosoma brucei to Isometamidium Chloride therapy and the relation to nutrition. *Veterinary Quarterly* 14: 88-91

Smith, T. (1969). In: Schwabe, C.W. *Veterinary and Human Health*. The Williams and Wilkins Company, U.S.A. 713pages

UNIVERSITY OF IBADAN LIBRARY

UNIVERSITY OF IBADAN LIBRARY