ECTOPARASITES OF DOMESTICATED ANIMALS AND MAN: A CONTRIBUTION TO KNOWLEDGE AND THEIR CONTROL

By

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DEDICATION

This inaugural lecture is dedicated to
my wife Hauwa Rosalind Agbede for her love and patience.

The Chairman of this occasion and
The Vice Chancellor
The Deputy Vice Chancellor Administration
The Deputy Vice Chancellor Academic
The Registrar
The University Librarian
The Dean of Postgraduate School
My Learned Colleagues
My Amiable Students
Distinguished Ladies and Gentlemen

It is my pleasure and priviledge to express my appreciation to the Vice Chancellor of this great University, through the ABU Organised lecture committee for extending to me an invitation to deliver this inaugural lecture, the 17th in the series, but the first this year and this millenium.

Although this lecture is coming up over a decade after my promotion to the rank of professor, I beleive and rightly too, that it is never late to give an inaugural lecture. I shall try within the alloted time of one hour to take you through my involment with ectoparasites these past 24 years.

ECTOPARASITES OF DOMESTICATED ANIMALS AND MAN: A CONTRIBUTION TO KNOWLEDGE AND THEIR CONTROL

1. INTRODUCTION

My research efforts have been directed at various ectoparasites of domesticated animals and man namely, lice, fleas, tsetse flies, mosquitoes ticks and mites. However for the purposes of this inaugural lecture, I will discuss my contribution to our understanding and control of only three ectoparasites:- Mosquitoes, tsetse flies and ticks.

For mosquitoes I will put forward a justification for the need to control them as a better strategy for malaria control. Traps as a valuable tool for ectoparasite control e.g. against Tsetse (Glossina) is not commonly used in Nigeria. I will discuss our attempts to transfer trap technology on Tsetse control to resource poor farmers - particularly the women in Kaura local government area of Kaduna state.

My contribution to our understanding of the dynamics of blood meal digestion in arthropod ectoparasites especially the ixodid (Hard) tick *Boophilus microplus* will follow. I will then explain the relevance and application of this knowledge in our attempts to break the transmission cycles of parasites for example *Babesia bovis* transmitted by *B. microplus* Finally, I will discuss the adaptation of the knowledge of the tick gut also in the control of the same tick, via vaccination using novel/concealed antigens.

2.i DEFINITION

A parasite may be defined as an organism which lives in or on another organism called the host from which the parasite derives benefits including feeding free of charge, but pays nothing in return and indeed inflicts injuries on the host (Fabiyi, 1996). This and many other definitions of parasites/parasitism emphasize the harmful effects of the parasite on its host, a point no doubt made bearing in mind the detrimental effects of parasites on man and his domestic stock. However, in their natural hosts, many parasites cause little or no harm and hence it is more satisfactory to use the factor of the metabolic link between the parasite and its partner in the association as a basis of the definition (Ogbe, 1998). A parasite may therefore be defined or regarded as a living organism having physiological relationship with a metabolic dependence on the tissues of another larger living organism (called its host) of a different species, such that it gains its nutritional requirements from the host.

A baby in the womb of its mother, feeding free of charge, sometimes the mother dying during child birth is not a parasite since they are of the same species.

2.ii SUBDIVISIONS OF PARASITISM

For convenience, parasites could be divided into those which live/ feed on the body surface of their host either temporarily or permanently (External or Ectoparasites) and those

which live inside their hosts (Internal or Endoparasites).

Our emphasis here is on ecto-parasites. Ectoparasites of domesticated animals and man are studied and taught in the Entomology section of the Department of Parasitology and Entomology; Faculty of Veterinary Medicine. Together with some colleagues (both here and abroad) and my post-graduate students, I have conducted research on many different ectoparasites and I will attempt in this lecture to highlight a few of such research. Arthropod ectoparasites that transmit disease causing pathogens to man or animal are called vectors. The two terms will be interchanged at will in this lecture.

2.iii GENERAL EFFECTS OF ECTOPARASITES

Ectoparasites affecting domestic animals are widespread and varied. Some are parasites in their own right, since they feed and suck blood of animals and man (Mohammed 1976). When in large numbers (e.g. Lice and fleas) they suck a lot of blood and can produce anaemia, skin irritation and damage to hides and skins particularly in domestic animals. Such damaged areas e.g. tick bite wounds can be secondarily infested with myiasis causing flies (Mohammed and Agbede, 1980). Allergy could result from infestation with ectoparasites e.g. flea bite allergic dermatitis. Ectoparasites are also transmitters of diseases. In certain cases they may prevent the keeping of animals entirely or cause great restlessness among stock since they constitute a biting nuisance with resultant ill effects of skin damage, retarded growth and

production and general debility. Hence they are of great economic importance and must be controlled (Mohammed, 1976). The unique climatic conditions of the tropics i.e. warmth and humidity favour the development of arthropods thus making their control a gigantic task (Mohammed, 1974). Also the discovery of vast and often inaccessible animal reservoirs for most of the ectoparasite/vector borne infections and the realization that chemotherapeutic and chemoprophylactic measures seldom rid the general animal population of such infections, has resulted in increased attention being paid to the control of these diseases by measures directed against the vector ectoparasites (Okpalla, 1979). This change of attitude must not be taken as implying any weakening of faith in the necessity for continued research in chemotherapeutic methods. On the contrary new drugs and different formulations are churned out into the market so fast these days that many of us practitioners have a hard time keeping up with the new names. This apparent/recommended shift of emphasis to the control of vectors is predicated by the advances in methods for arthropod control which have progressed more rapidly and seem at the present time more likely to prove more successful. I am going to try in this lecture to convince you that it is cheaper, less time consuming, less painful and more rewarding to control ectoparasites/vectors of disease, than to attempt treatment as a means to control or eradicate the diseases.

2.iv IMPORTANCE OF PARASITES/PARASITOLOGY

The World Health Organization (WHO), targetted six tropical diseases of man for control and possible eradication. It is gratifying to note here that five of them are caused by parasites and four, (malaria, trypanosomosis, onchocercasisis and schistosomiasis) depend on ectoparasites/vectors/ intermediate hosts for their transmission.(Table,1)

3.i MOSQUITOES

For the purposes of illustration to justify the need to control arthropod ectoparasites as a better strategy for parasitic diseases control, I will discuss the control efforts directed against mosquitoes. Apart from their nuisance activities, I believe many of us here seated have suffered from at least an episode of malaria at one time or another. However malaria is transmitted by only one Genus: *Anopheles* of the many genera of mosquitoes known to man. Mosquitoes can make great areas of land uninhabitable and they retard the progress of agriculture in many areas by their worry and bites. A check list of the diseases transmitted to man and animals is shown in Tables 2a& 2b.. The need then to control mosquitoes is not debatable. Various methods are currently being employed in various countries to control mosquitoes. Each method relies exclusively on a good knowledge of their breeding sites and relative abundance. A summary of current methods in use in some countries is shown in Table 3. Control of all mosquitoes by the use of insecticides or pesticide is possible but eliminating just one

of the diseases e.g. malaria with drugs alone is not (WHO 1985). There is evidence from Brazil; Burkina Faso and India that mosquito control is possible (Service, 1980). There is the added need not only to eliminate malaria, but other devastating mosquito borne diseases shown earlier.

I have two ph.D. students working on mosquitoes. One is working on mosquito ecology and vector dynamics in Samaru. Through the work, we now know what genera and species of mosquitoes are present in Samaru , their breeding sites, and their possible seasonal dynamics. This is a challenge to our University Health System. I counsel we resuscitate the old system where A.B.U. had Health Inspectors in the Sick Bay. Staff / Experts from Veterinary Parasitology and Entomology will provide free consultancy to support them. Their duty in part will be to go round residential and academic areas applying prescribed / recommended insecticides to identified habitats to eliminate mosquitoes. This will be a model for Samaru and Kaduna State as a whole.

On the scorge of malaria in Nigeria, Fabiyi (1996) wrote and I quote "In Nigeria malaria infection is the most prevalent of all diseases. It accounts for 200,000 deaths mainly children under the age of 5 years annually. Estimates indicate that about 60 million Nigerians experience at least two episodes of malaria each year. One malaria attack temporarily incapacitates its victim for 3 - 5 days if correct treatment is administered. The cost of treatment on average using Chloroquine is around ₦50.00 / attack. Treatment cost for 60 million Nigerians twice a year amounts to about N6 billion per annum. Quite a number of people use more

expensive/fanciful drugs such as Fansidar' (about N100/treatment) or Halfan' (about N500/treatment). This may raise the cost of treatment to around N7 billion a year". Controlling mosquitoes by larviciding using DDT powder and pellets nationwide will cost the country only about one tenth of the above cost. We therefore cannot over-emphasize the need to control mosquitoes as a better strategy in eliminating malaria.

TSETSE AND TRYPANOSOMOSIS

To highlight the severity of the problem of tsetse and trypanosomosis, I reproduce here famous quotes from literature. "About 10 million square kilometres of Africa is infested with Tsetse (Glossina); or 45 million people are at risk of sleeping sickness or Cattle production in African's grasslands will double once we eradicate tsetse" (Ormerod, 1976; Jordan 1978 and Ikede 1989). The point being emphasized here is that African trypanosomosis are amongst Africans most devastating diseases - the human disease (sleeping sickness) and the livestock disease (Nagana) both are transmitted by tsetse flies.

In Nigeria about 60% of the total land area is infested by 11 of the 22 species of tsetse flies that exist in Africa (Table 4) and at least four of these namely, *Glossina morsitans submorsitans, G. longipalpis, G. palpalis palpalis; G. tachinoides* act as vectors of the human disease.

My contribution to tsetse control started in 1977 with my M.V.Sc. thesis. Amongst other findings my work then showed that

a mite *Glyciphagus destructor* (Shrank, 1781) killed tsetse pupae in the laboratory (Agbede, 1977). This is biological control; however breeding/rearing large numbers of the mite in the laboratory for use in tsetse control proved difficult.

Through the European Economic Community (EEC) project on Tsetse and Trypanosomiasis control in Nigeria, we were able to respond to a call in the Concord daily Newspaper of November 26th, 1990. Apart from assigning a ph.D. student, to help us unravel the unique epizootiology of tsetse and trypanosomosis in Kaura L.G.A. - Southern Kaduna (Maikaje, 1998); we were able to introduce the use of traps (Biconical and Nitse) to the farmers.Tables 5&6 summarize Tsetse control methods.

Traps/Targets/Screens were integrated into tsetse control schemes in Nigeria in the late 1970's. This was followed by the establishment of Biological Control of Tsetse (BICOT) project in Vom. BICOT was funded by the International Atomic Energy Agency (IAEA) and an attempt was made to control tsetse in Nigeria using the sterile male release method (SMRM). The traps, targets and screens were used to create barrier zones in Lafia area thereby preventing re-invasion by tsetse to areas where sterile males had been released. The biconical traps were particularly successful against *G. palpalis palpalis* and gained wide acceptance in the country. However since Biconical traps caught mainly riverine species, Nigerian Institute for Trypanosomiasis Research (NITR) funded research aimed at developing a trap for savanna flies, hence the birth of - NiTse-trap (Omoogun, 1992).

Trap technology is cheap and very efficient in controlling biting flies

carried by the animal. Different studies in Australia have shown that infestation results in reduction of live weight gain ranging from 0.28kg to 0.8kg per tick, per year (Gee et. al. 1971).

The blood loss caused by engorging females ticks which are responsible for a major part of this reduction in live weight gain, may under certain circumstances cause severe anaemia and even death (Callow, 1978). Although such mortalities frequently result from infestation with *Boophilus decoloratus* and *Amblyomma variegatum* (Agbede 1984), they may also be caused by other species of ticks e.g. *Haemaphysalis longicornis* in Australia (Kemp D.H. personal communication).

The injection of tick derived toxins into cattle results in different clinical manifestations such as

(i) Paralysis caused by *Ixodes holocyclus; I, rubicundus* and *Dermacentor andersoni;*

(ii) Sweating sickness caused by *Hyalomma truncatum* and

(iii) Tick toxicosis caused by *Rhipicephalus* spp. These conditions may be fatal and the mortality high depending on the size of the tick burden.

The indirect effects of ticks on production are through diseases they transmit. Table 7 shows tick borne parasites only of domestic animals in Nigeria. Ticks also transmit numerous viruses to man and animals. In Nigeria alone within the last decade evidence has also been obtained that ticks may play some role in the transmission of four viral organisms viz. Dugbe virus; Thogoto virus; Congo virus and Bhanja virus (Obi, 1978; Durojaiye 1981).

Infact three emerging infectious diseases of man identified recently in the U.S.A. Human monocytic Ehrlichiosis (HME);

Human granulocytic Ehrlichiosis (HGE) and Lyme disease are all tick borne (Walker and Dumler 1996). Finally tick infestation, has been shown to lower the resistance of animals to other infections.

5. ii TICK CONTROL

The above list of piroplasms, viruses and rickettsiae are transmitted mainly by hard ticks of the order; Ixodidae. They occur abundantly in the vegetation and feed on both wild and domesticated animals (Mohammed 1974; Mohammed and Aliu 1973 and Agbede 1984). The major hard ticks found in Nigeria are listed in Table 8. Strategies used to control ticks over the years are summarized in Table 9. Only two will be discussed in this lecture viz. **Immunological control** (induced resistance) via vaccines and the use **of Pheromones and their analogues** in combination with acaricides.

Currently the main stay for tick control is the use of chemicals (acaricides). Problems of chemical residues, cost of acaricides and development of resistance by ticks have long been recognized and have helped to stimulate interest in tick control by immunological means. One approach has been to seek ways to enhance the natural immunity often acquired by animals in response to tick infestation. The alternative is to vaccinate with "novel" or "concealed" antigens not normally encountered by the host and so stimulate a different immune effector mechanism (Kemp and Agbede 1986); Willadson and Kemp 1988).

5.iii VACCINATION AGAINST TICKS

The *Boophilus microplus* sub-unit vaccine (Tick guard,[R] Hoechst) Tellam et.al. 1997) is the most successful attempt to date of a vaccine based on immunization with a parasite molecule which is not normally antigenic in animals infested with the parasite (Lightowers 1994). The hope of using antigens for the purposes of controlling haematophagous arthropods was raised many years ago. For example an increase in death rate of *Anopheles stephensi* fed on rabbits immunized with mosquito antigen was observed by Alger and Cabrera (1972); Lesions were found in Stable flies after feeding on rabbits immunized with the fly's tissues (Schlein and Lewis 1976); and there was reduction in the number of *Dermacentor andersoni* ticks engorging on guinea pigs and cattle immunized using partially fed female *D. andersoni* ticks (Allen and Humphreys 1979). This was the state of knowledge at the time I found myself in Brisbane, Queensland, Australia struggling to find something original to research on for a ph.D. degree.

My supervisor insisted I differ from the other scientists by first attempting to improve our understanding of the fate of the blood meal taken in by ticks. This led to the study of the gut cells in *B. microplus*

The high points of this research were:

We were able to establish the progression in the development of the gut cells involved in blood meal digestion (Agbede and Kemp, 1985)

We discovered and identified two **Secretory cells** named

Secretory cells A and B in the gut of *B. microplus* (Agbede and Kemp 1987).

Hitherto ticks were thought to have only one secretory cell which secreted the haemolysin that lysed red blood cells in the gut of ticks. We also identified the materials secreted by the cells and postulated on the role each cell played in blood meal digestion. Armed with the above knowledge we tried to establish the possible cycles of cellular development during blood meal digestion in ticks. The cellular nomenclature we postulated has also now been universally accepted (Agbede, 1986).

(iii) We also were able then to explain the fate of *Babesia bovis* parasites taken in with the blood meal. We found that after fertilization of the gametes of *Babesia*, the ookinete invaded the digest cells with haemoglobin food vacuoles (dhv cells), from where the vermicules invaded the vitellogenin secreting cell ("d" cells) before being liberated into the haemolymph leading to invation of the ovaries. As a result, the eggs become infected and the resulting larvae hatching from such eggs are infected too (Transovarian transmission) (Agbede, Kemp and Hoyte 1986; and Agbede and Kemp 1986).

iv Using electron microscopy, we were able to explain water and ions transport in *B. microplus* ticks (Agbede and Kemp 1987);

v We were also able to study the feeding and survival of *B. microplus* ticks on vaccinated cattle (Kemp,

Agbede et al 1986);

Boophilus microplus ticks feeding on vaccinated cattle were studied and compared with ticks feeding on control animals to be able to establish and confirm the damage to the gut cells histologically using glycol methacrylate (GMA) Plastic embedding techniques (Agbede and Kemp 1986);

The success of the vaccination studies were presented as POSTER at the International Congress of Parasitology (ICOPA 1986) Kemp and Agbede (1986.)

It was at the above congress that Biotech Australia developed interest in the findings. The work had already been patented by the Commonwealth Scientific Industrial and Research Organization (CSIRO) Project on immunization against ticks **Patent application Number PG6461/84-antigen extracts derived from *Boophilus microplus*.**

5. iv NEWER CONTROL TECHNIQUES - DECOY TECHNOLOGY

In 1996 I was a Fulbright Senior African Research Scholar in the United States of America. My duty post was at the International Program on Ticks and Tick borne diseases - a unit of the Department of Pathobiology, University of Florida. My colleagues there co-joint with Prof. Sonenshine at Old Dominion University, Virginia had pioneered the research on *Amblyomma* spp tick pheromones in particular, the genital sex pheromones. They isolated using High Pressure Liquid Chromatograph (HPLC);

Thin Layer Chromatography (TLC) and Flame Ionization detection (FID) techniques what they called Attraction/Aggregation/ Attachment Pheromone (AAAP) of *A. hebraeum* and *A. variegatum* (Norval et al. 1993; Price et. al 1994). They impregnated special plastic with these pheromones together with a concentrated acaricide. A tag-like device. Once the device is placed round the neck of the animal using a special belt *Amblyomma sp* ticks attaching to the animal may not attach at their predilection sites rather, they seek out the tag then attach and die after contact with a lethal dose of acaricide. Since it mimics the sexes of the ticks by releasing pheromones, it is aptly named the "Tick decoy" technology. Trials are presently in the Carribean Islands and Zimbabwe.

A group of proteins from the tick gut B lectins-were found to bind carbohydrates and agglutinate cells and parasites. It was suggested that lectins could play a role in immunity as well as self and non-self recognition (Kaaya et al, 1986). How lectins could be exploited in tick and tick-borne disease control was unknown. However, one of my ph.D. students worked on Lectins in *Rhipicephalus appendiculatus* (Sebitosi, 1998). The research revealed that lectins should be looked at as possible immunogens in the blocking of transmission of *Theileria parva* as well as anti-tick interventions in the future of theileriosis control.

different methods for tick control must be complimentary, economically viable and sustainable. The concept of tick eradication is unachievable in Africa as yet (Young et al 1988) and only control is feasible. The use of acaricides alone would not only be expensive but also environmentally unacceptable with the added problem of resistance to acaricides.

The tick subunit vaccine and the decoy technology currently may appear revolutionary, but in reality, may not be able to control the vast number of ticks in the field. There will be the necessity to integrate two or more control methods in order to achieve the desired result (Agbede 1994).

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TABLE 1:

SIX TROPICAL DISEASES OF MAN TARGETTED FOR CONTROL/ERADICATION BY THE WORLD HEALTH ORGANIZATION (WHO)

1.	Malaria	-	*Anopheles* mosquitoes
2.	Trypanosomosis	-	*Glossina* (Tsetse flies) and other biting flies
3.	Onchocercaisis	-	*Simulium* sp (Black fly)
4.	Schistosomiasis	-	*Bulinus* sp lymnea sp, Biomphalaria etc.
5.	Lymphatic filariasis	-	*Anopheles, Mansonia, Aedes*
6.	Tuberculosis/leprosy	-	Aerosols, Fomites

TABLE 2-a

SOME MOSQUITO-BORNE DISEASES

MALARIA	- Simian - Human Anopheles sp - Bird about 55 different species
FILARIASIS	- Wuchereria bancrofti 3 genera - Brugia malayi Anopheles sp - Brugia timori Mansonia sp: Aedes sp
ARBOVIRUSES*	- 4 genera - Aedes sp - Anopheles sp - Culex sp - Psorophora sp - DENGUE, (1-4) (Group B) B? Aedes sp - YELLOW FEVER (Group B) B? Aedes sp

Complete list of viruses see Table 2b*

Table 2b

Mosquito - borne viruses known to Infect man

Group A.	Chikungunya		Zika
	Easter equine		Wesselsbron
	Mayaro		West Nile
	Middleburg		Yellow fever
	Onyongnyong		
	Semliki forest		
		Group C	Caraparu
			Murutucu
	Sindbis		
	Venezuelan equine	Oriboca	
	Western equine	Restan	
		Bunyammwera	
		Bunyawere group	Germiston
			Guaroa
			Wyeomyia
Group B.	Dengue 1	Bwamba group	Bwamba
	Dengue 2		Pongola
	Dengue 3		
		California group	California
	Dengue 4		
	Ilheus	Guama group	Catu
			Guama
	Japanese B		
	Kokobera	Simbu group	Oropouche
			Simbu
	Kunfin		

Murray valley		
SAH 336	Ungrouped	Mapputta
St Louis		Rift valley
		Spondweni
		Tahyna
Uganda 5		Witwatersrand

TABLE 3

CURRENT METHODS TO CONTROL MOSQUITOES

BIOLOGICAL	(naturalist) Control method e.g. use of pathogens, predators
GENETIC Methods e.g.	Sterile insect release method
PHYSICAL	(mechanical or environmental) control methods. e.g. Habital change; Impoundments and breeding source reduction.
CHEMICAL	control methods. e.g. use of larvicidal oils and residual insecticides. Bed nets etc.

Service, 1980.

Table - 4

KNOWN SPECIES OF TSETSE IN NIGERIA

SAVANNA GROUP - MORSITANS - GAME TSETSE-WOODLAND

Glossina submorsitans Newstead, 1910
Glossina longipalpis Wioedemann, 1830

PALPALIS GROUP - RIVERINE/LINEAR TSETSE

Glossina palpalis palpalis Robineau - Desvoidy, 1830

Glossina tachinioides- Westwood, 1850

FUSCA GROUP - FOREST TSETSE

Glossina fusca fusca - Walker 1849
Glossina medicorum - Austen, 1911
Glossina longipennis - Corti 1895
Glossina brevpalpis - Newstead, 1910
Glossina tabaniformis Westwood, '850
Glossina nashi Potts, 1955

TABLE 5

ESTABLISHED METHODS OF TSETSE CONTROL

1. GAME DESTRUCTION	destroys valuable resources
2. BUSH CLEARING	Soil erosion
(a)' CHEMICAL CONTROL	- Insecticides (ground and aerial spray) DDT, DIELDRIN, ENDOSULFAN
(b) AERIAL SPRAYING	of ultra low volume insecticides Resmethrin, Bioresmethrin other synthetic pyrethriods

TABLE 6

RECENT DEVELOPMENTS IN TSETSE CONTROL TECHNOLOGY

Traps and Targets:	- with or without insecticides - Enhanced by odour baits
Cattle dipping/pour on	- Animals are live targets
Genetic control	- Tanzania Burkina Faso BICOT,Vom, Nigeria
Juvenile Hormone analogues	- With traps or targets to sterilize flies Not kill them Odour baited natural objects, impregnated with insecticides.

TABLE 7

TICK-BORNE PARASITES OF DOMESTIC ANIMALS IN NORTHERN NIGERIA

Cattle

Anaplasma marginale
Babesia bigemina
Babesia bovis
Borrelia theileri
Cowdria ruminatium
Ehrlichia bovis
Eperythrozoon wenyoni
Eperythrozoon teganodes
Theileria veliferus
Haemobartonella bovis
Theileria mutans

SMALL RUMINANTS

Anaplasma ovis
Babesia motasi
Borrelia theileri

Cowdria ruminantium
Ehrlichia ovina
Eperythrozoon ovis
Theileria ovis

Equines

Babesia equi
Babesia cabali

DOGS

Babesia canis
Ehrlichia canis
Haemobartonella canis
Hepatozoon canis

CATS

Hepatozoon felis

POULTRY

Aegytianella pullorum
Borrelia anserina

Leeflang and Ilemobade (1977)

TABLE 8

IXODID (HARD TICKS) ATTACKING CATTLE IN NIGERIA

Amblyomma	gemma
Amblyomma	lepidum
Amblyomma	pomposum
Amblyomma	splendidum
** Amblyomma	variegatum
*Boophilus	annulatus
**Boophilus	decoloratus
**Boophilus	geigyi
Haemaphysalis	leachi leachi
Haemaphysalis	hoodi hoodi
yalomma	dromedarii
Hyalomma	impeltatum
*Hyalomma	mipressum
Hyalomma	nutidum
*Hyalomma	rufipes
*Hyalomma	truncatum
Rhipicephalus	cliffordi
Rhipicephalus	guilhoni
Rhipicephalus	evertsi
Rhipicephalus	longus
Rhipicephalus	lunulatus
*Rhipicephalus	muhsamae
Rhipicephalus	parmata
Rhipicephalus	pravus
Rhipicephalus	sanguineus
Rhipicephalus	senegalensis
Rhipicephalus	sulcatus
Rhipicephalus	ziermanni

*Generally found in moderate numbers

Generally found in large numbers. **After Fabiyi, 1984.

TABLE 9

TICK CONTROL METHODS

1. **ECOLOGICAL CONTROL**

   direct action on the environment removing vegetation periodically by burning, eforestation,
   Pasture spelling/rotation
   Withdrawal of domestic hosts.

2. **BIOLOGICAL CONTROL** - role of hyperparasites e.g. halcidlies, Hunterellus
   - role of predators e.g. ants, Birds (Buphagus sp) ; Oxpeckers;
   - Crotophagus sp ; various Magpies and
   - Local (village) fowl.

3. **GENETIC CONTROL** - Sterilization of males.

4. **CHEMICAL CONTROL** - Various acaricides; pheromones and analogues

5. **IMMUNOLOGICAL CONTROL** - Acquired resistance.
   - Tick resistant cattle
   - Induced resistance via Vaccines