INAUGURAL LECTURE
PRESENTED BY PROF SR MAGANO
UNIVERSITY OF SOUTH AFRICA

DATE: 31 JULY

TOWARDS THE USE OF PLANTS FOR TICK CONTROL

PRELUDE

Pro-Vice Chancellor, **Professor Narend Baijnath**, the Executive Dean of the College of Agriculture and Environmental Sciences and member of the university council, **Professor Maggie Linington**, the Director of the School of Agriculture and Life Sciences **Prof Mxolisi David Modise**, Pastors and their spouses, Colleagues from the College of Agriculture and Environmental Sciences, Ladies and Gentlemen.

As a **prelude** to this lecture, I thought I must reflect briefly on my impressions about this occasion. This day, in particular this lecture marks the **pinnacle** of my academic career. Indeed this lecture does not only represent the consummation of my efforts in pursuit of knowledge, but it also induces in me a need to take a pause and reflect back on the journey traveled to this end. It is at this point when I fully realize that in spite of this journey having been turbulent at times, in the final analysis it was a journey worth travelling. Yes, it is in times such as this, when the magnitude of the grace lavished upon one's life by the Almighty God becomes more vivid. Like David in Psalm 124 (here I am referring to the **Biblical David** and not the **Director** of our School, Prof Modise) I am persuaded to say: "If the Lord had not been on my side when the storms of life **raged** against me, when poverty sought to define who I am and who I will become, I would have been swallowed alive. But praise be to the **Lord** who has **not allowed** lack to define my **destiny.** Yes, I have escaped like a bird out of the **fowler's snare**; the snare has been broken, and I have escaped". Ladies and gentlemen, just imagine with me a young fellow who spent much of his youthful years selling oranges, apples, peanuts, and fat cakes in the dusty streets of Ga-Rankuwa, Marabastad and Bloed Street in Pretoria, this evening presenting a professorial inaugural lecture to you. Surely, it can only be by grace. Pro-Vice Chancellor I could not have found words nor scripture, which better **encapsulates** my experiences than this account by David.

Also, **Pro-Vice Chancellor**, this event presents an opportunity to me to recognize and appreciate once more, people who contributed meaningfully during my journey to this end. In my **mother tongue** which is Setswana, there is a saying that goes: "**Montsamaisa bosigo ke mo leboga bo sele**". By implication this **Setswana** saying, seeks to indicate that the best moment for anyone to appreciate those who have been of help to him/her, is the moment of success. In keeping with the implications of this Setswana saying, I will therefore in the **epiloque** of this lecture, take a minute or two to express my appreciation to people who have been of assistance to me.

Pro-Vice Chancellor, it truly gives me **the greatest of pleasures** to share with you and the audience present here this evening, some of the knowledge I have **amassed** over the years in the field of **Acarology**. **Acarology** as a field of study, is a sub-discipline of **Zoology**, focusing on **ticks** and **mites**. The name **Acarology** derives from the order name **Acari**, a **taxonomic group** into which these two types of **arthropods** are included. Because of the **vastness** of this field of study, **accentuated** also by the **richness in species** diversity within the **taxon Acari**, there are **Acarologists** who specialize on **ticks** and those who specialize on **mites**. I happen to be among the former.

My lecture this evening is entitled: "**Towards the use of plants for tick control**".
This topic appeals to me, not only because it seeks to reflect on the current research trends in the field of **Acarology**, but because it also embodies the **milestones** I have attained as a lecturer and a researcher in this field.

I have decided to dedicate this lecture to the memory of my parents the late **Letsoma-Tshukudu** and the late **Makidiane Magano**. In spite of lack and poverty, which characterized most of their lives, they have been **excellent parents** by any standard.

1. Introduction

This topic appeals to me, not only because it seeks to reflect on the current research trends in the field of Acarology, but it also embodies the direction of the milestones I have attained as a teacher and researcher in this field.

More specifically, when preparing this lecture I had four considerations in mind:

i. Firstly, I wanted to give an overview on the biology of ticks and their effects on humans and other animals.
ii. Secondly, to review the effectiveness of synthetic acaricides and the challenges they present
iii. Thirdly to explore the use of plants or plant-based products as alternatives to synthetic acaricides
iv. Fourthly to reflect on my personal contribution to the field of Acarology.

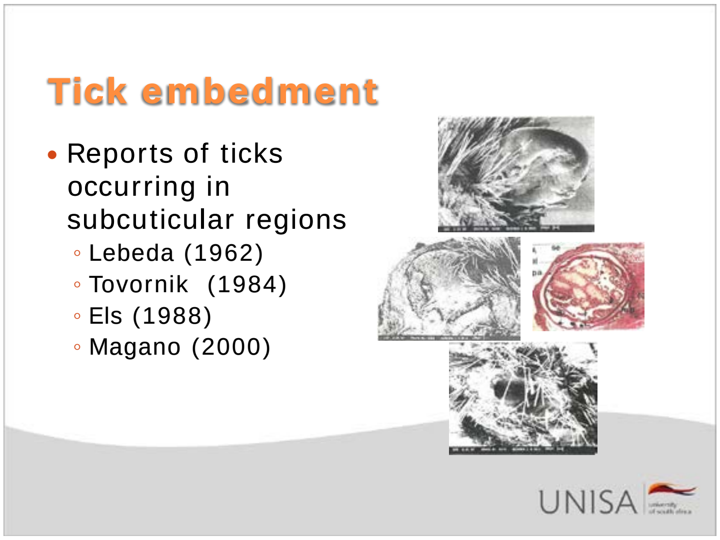
The key questions that I want to use as a base for this lecture are:

i. Why focus on ticks?
ii. What are ticks?
iii. What is their significance and the role they play in our lives?

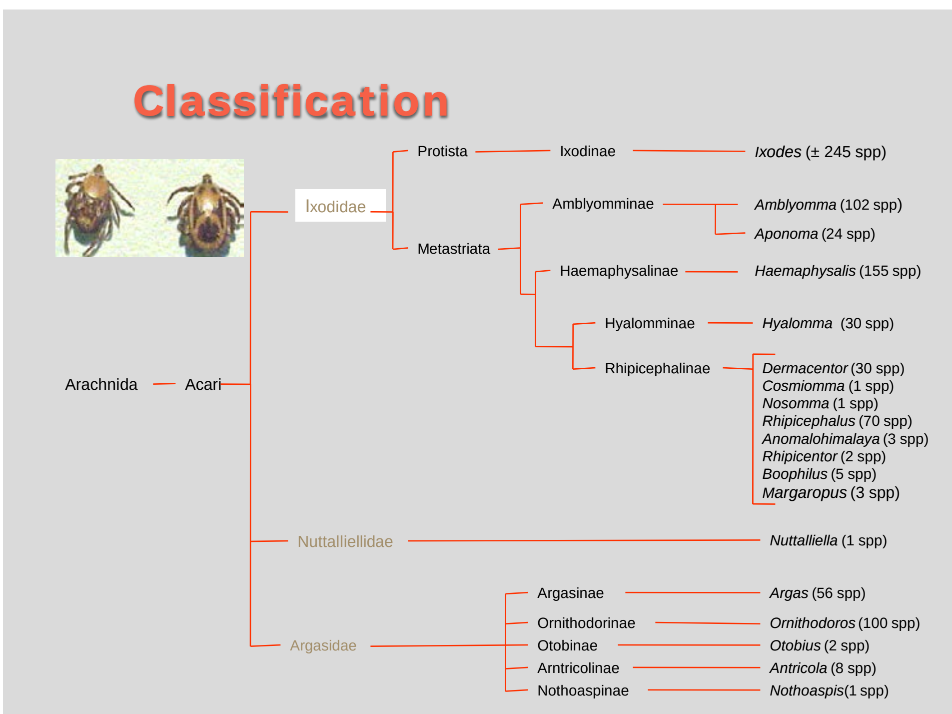
Ticks are haematophagous ectoparasites of veterinary and medical importance, parasitizing a variety of vertebrate hosts ranging from amphibians to mammals.

The term **Haematophagous** means blood feeding.
However, while we accept that blood is the main constituent of the tick's meal, reports of ticks ingesting non-blood fluids exists in literature.

The term **Ectoparasite** means: external parasite. This means that typically, these parasites acquire a blood meal from their host without the entire body penetrating the host. It is only the mouthparts that are inserted into the integument of the host. However, reports of ticks occurring in the sub-cuticular regions or deeper regions of the host skin exists. This phenomenon is rare and appears to be restricted to ticks feeding on their natural hosts.



In terms of classification, ticks belong to the Phylum Arthopoda, Class Arachnida and the Order Acari. There are three families namely Ixodidae (hard ticks), Argasidae (soft ticks) and Nuttalliellidae. The family Ixodidae includes about 683 species in 13 genera when Argasidae includes about 183 species in 5 genera (Sonenshine 1991). The family Nuttalliellidae is represented by the monospecific genus, *Nuttalliella namaqua*. This tick species is found in Namibia, South Africa and Tanzania.



2. Medical, Veterinary and Economic Importance of Ticks

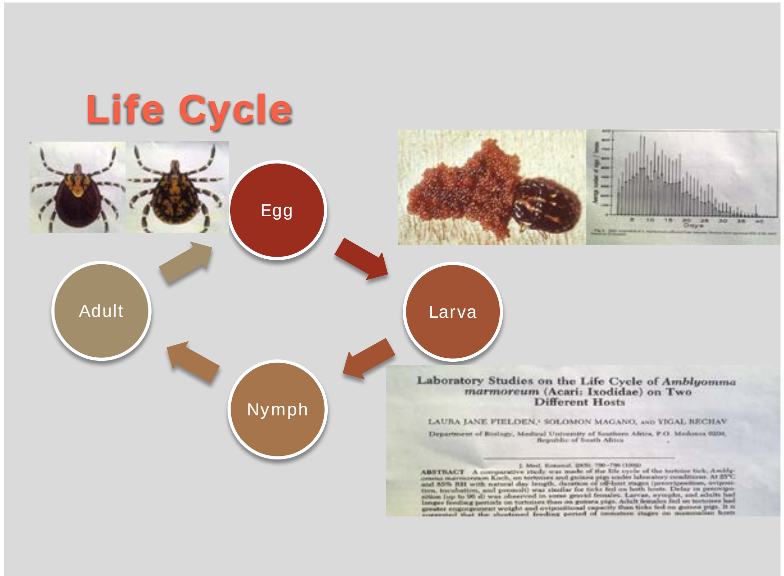
Ticks impact their hosts directly by inducing anaemia, toxicosis immunological disturbances (Wikel, 1999), stress due to tick loads and causing damage to hide which may lead to secondary infection by opportunistic pathogens. Indirectly, ticks affect their hosts by transmitting high-morbidity pathogenic agents (Labarthe, 1994). They also serve as vectors of zoonotic disease causing agents (Shepherd et al., 1989; Des Vignes et al., 2001).

While ticks are primarily parasites of wild animals, about 10 % of the tick species feed on domestic animals. However, it is interesting to note the extent to which these few tick species have prospered, causing considerable economic losses to farmers in developing and developed countries. Although ticks are regarded to be second only to mosquitoes as vectors of disease-causing agents to humans and to other animals Balashov (1972), they are not rivaled by any other arthropod with regard to the number of different types of pathogens they can transmit. The wide spectrum of pathogenic microorganisms transmitted by ticks includes protozoa, rickettsiae, spirochaetes and viruses. In Africa tick-borne protozoan diseases (e.g. theileriosis and babesiosis) and rickettsial diseases (e.g. anaplasmosis and heartwater) constitute the main health problem of domestic ruminants (Petney, 1997).

Globally, losses due to tick infestation and the diseases they transmit to livestock are estimated to be in the range of several billion US dollars annually. The situation appears to be grave in Africa when considering the diversity of tick species in the continent and the fact that livestock farming forms the main source of revenue for Africans (de Castro, 1997; Mukhebi et al*.* 1999).

3. Vector capacity of ticks

The capacity of ticks as parasites and vectors of disease causing-agents is evidenced among others in their life-cycle and life-patterns. The life-cycle consists of four stages (the egg, hexapod larva, octopod nymphs and adult male or female), and includes alternation of parasitic blood feeding and free living phases (Sonenshine, 1991).



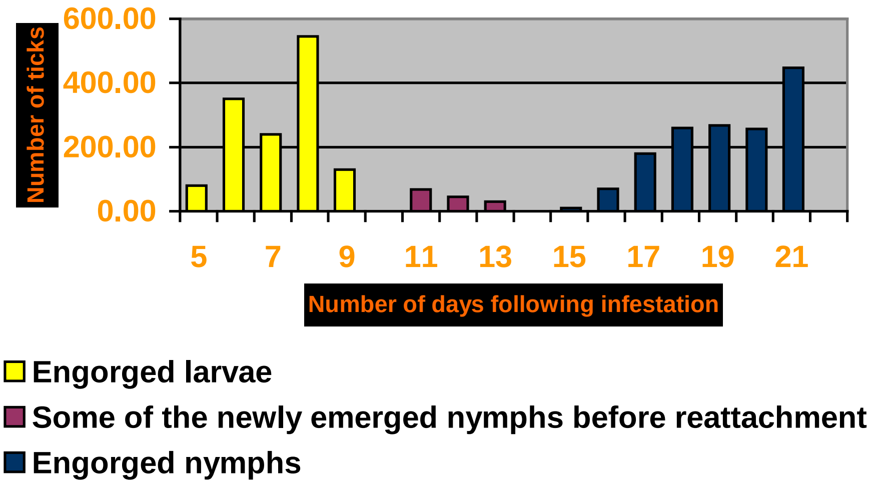
Life cycle of an ixodid tick. (Fielden *et al*. 1992)

Ixodid ticks have only one nymphal stage whereas argasids may have as many as five. Ixodid ticks are described as one-host, two-host or three-host ticks, depending on the number of hosts required for development from unfed larval form to an engorged adult form.

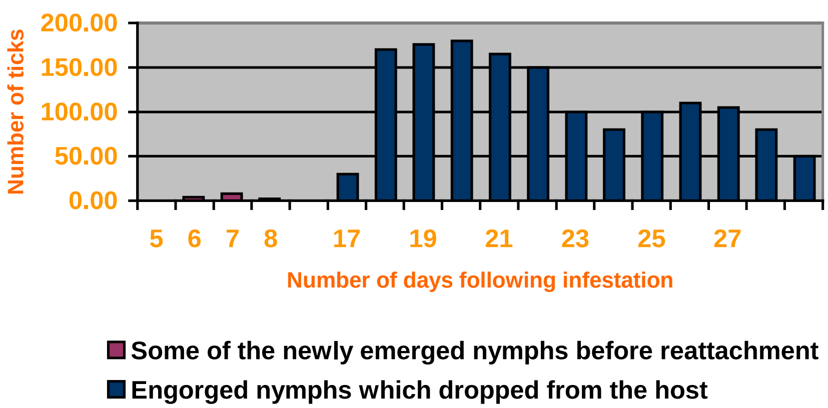
Ticks are referred to as **one-host**, **two-host** or **three-host** depending on the number of hosts required to complete a life-cycle. In **one-host ticks** all active stages from larvae to adults feed on a single host. Following feeding, the adult female drops to the ground to lay eggs. This life strategy is exemplified by *Rhipicephilus* (*Boophilus*) *microplus*.

In **two-host ticks** the larvae and subsequent nymphs feed on the same individual host. The engorged nymphs then drop-off the host to moult into adults under vegetation. The emerging adults search for the second host. This live strategy is exemplified by *Rhipicephilus evertsi evertsi* and *Hyalomma marginatum rufipes*.

In **three-host ticks** each of the active stages seeks a host to feed on. In other words three hosts are required to complete the life-cycle. Most tick species (e.g. *Amlyomma hebraeum*, *Rhipicephilus appendiculatus*) use this life strategy.



Mixed two-host, three host development on guinea-pigs (Magano *et al*. 2000)



Two-host development of *H. m. rufipes* on rabbits (Magano *et al*. 2000)

3.1 ***Structural and physiological adaptations to the parasitic mode of life***

Mouthparts

The mouthparts in ticks are adapted to a parasitic mode of life. They include a pair of palps, a pair of chelicerae and a hypostome. Once a tick has selected a suitable feeding site on the host, the skin is penetrated by the outward cutting movements of the chelicerae. Both the hypostome and chelicerae penetrate the host during feeding. The salivary glands secrete cement to secure the mouthparts.

Feeding

Ixodid ticks feed once in an instar, a process which takes from several days to several weeks, and during which time large quantities of blood are ingested and the fully engorged tick can weigh over 100 times that of the unfed. The feeding and digesting processes in ticks occur in three phases namely:

i. The preparatory phase – The rate of feeding and digestion is very low and as such there is no visible change in weight
ii. The growth phase – Feeding and digestion are very intensive. The nutrients gained are used to build the cuticle in preparation for the enormous expansion of the body during the third phase.
iii. The expansion phase – It is short and lasts for a day. There is a decline in the digestion rate while the tick ingests huge amounts of blood (see Figure below).

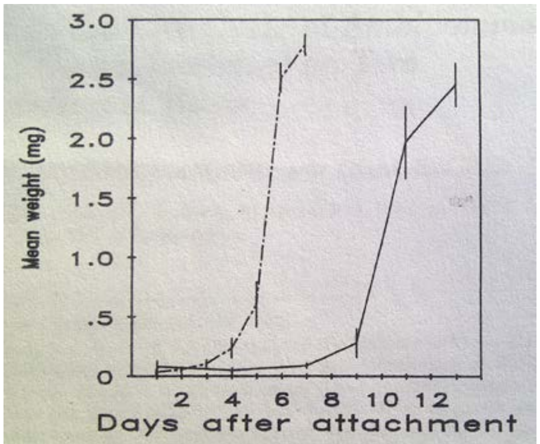


Fig. 4. Changes in weight (mean ± SD) of larvae of *A. marmoreum* during their feeding period (based on samples of 10 larvae each). —, tortoise; —, guinea pig. Fielden *et al*. (1992)

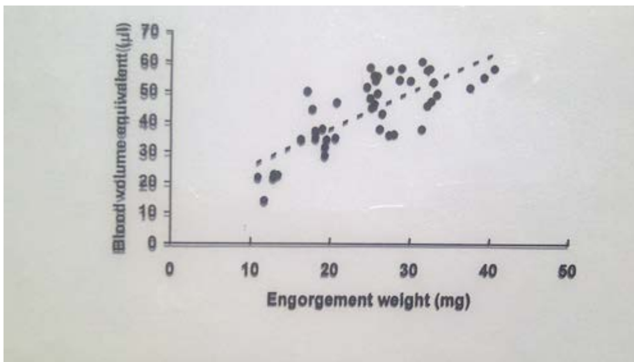


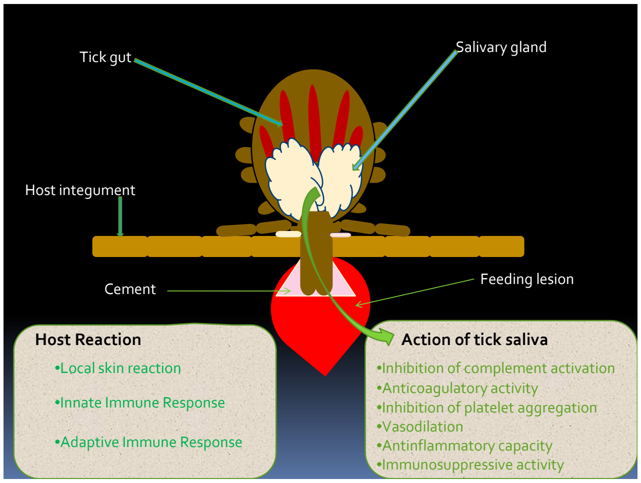
Fig. 3-8: Association between weight of engorgement (mg) and the volume of blood (μl) ingested by non-embedded ($Y = 1.241X + 13.104$, $R^2 = 0.583$, $F_{(1;42)} = 58.701$, $P < 0.0001$) nymphs of *H. truncatum* fed on the laboratory rat Magano *et al*. (2000)

During the process of feeding, ixodid ticks intermittently ejaculate salivary secretions into the host and by doing so concentrates the bloodmeal. This process also permits the introduction of disease causing agents into the host.

Pharmacology of tick saliva

In order to feed successfully on their hosts, ticks must have the capacity to overcome or neutralize the haemostatic responses induced in the host as a result of tick infestation. It is generally agreed that the salivary secretions of some ticks have a variety of factors including anticoagulants, vasodilators, platelet aggregation inhibitors and **immunosuppressants** (Ribeiro, 1995; Schoeler *et al*., 2001; Valenzuela, 2002) that allow such ticks to feed to repletion even on immunologically competent hosts. These factors do not only facilitate tick feeding but may also favour the establishment of pathogens in the host (Aljamali *et al.* 2002).

The salivary gland homogenate of several tick species has been shown to severely impair T-cell functions. See illustration below.



Sensory organ

The sensory organ of ticks, the **Haller's organ** is capable of detecting changes in odours, temperature and CO_2. Ticks rely on this organ to identify the host.

Respiration

One of the main adaptations in ticks for their parasitic mode of life is the separation of the respiratory system from the feeding system. This implies that feeding does not obstruct respiration, allowing ticks to be attached on their host for prolonged periods. A striking feature of gaseous exchange in ticks is the occurrence of discontinuous gas exchange cycles.

Furthermore, ticks like insect arthropods are capable of using discontinuous gas exchange. This enables them to conserve water and avoid desiccation particularly when off the host.

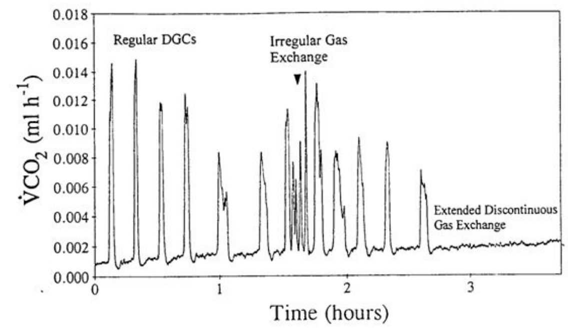


Fig. 4-4: Discontinuous CO_2 emission recording of non-engorged *Hyalomma truncatum* female showing regular DGCs, irregular CO_2 emission and extended discontinuous gas exchange

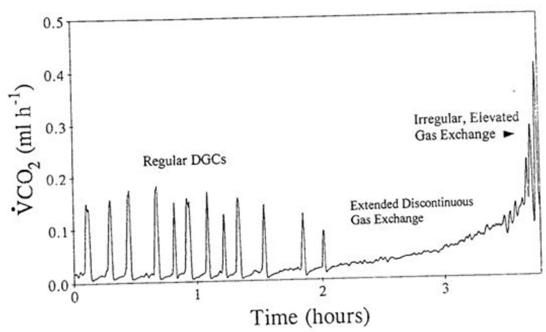


Fig. 4-5: Typical discontinuous CO_2 emission recording of engorged *Hyalomma truncatum* female showing regular DGCs, extended discontinuous gas exchange and irregular elevated gas exchange

Magano (2000)

Other factors that make ticks efficient vectors of pathogens are:

i. Rapid feeding by argasids and firm host-attachment by slow-feeding ixdids prevents dislodgement and removal by the host.
   - Slow feeding by ixodids gives them ample time to ingest large numbers of pathogens from an infected host and to transmit the infection to a new host
   - It also allows the dispersal of infected ticks to new areas while attached to the hosts.
   - Similar opportunities for acquiring and transmitting pathogens by argasids are provided by the multiple feeds by nymphs, and by both females and males.

ii. Blood-feeding at least once by each stage gives more opportunities to acquire and transmit a variety of pathogens, while a wide host range makes a blood-meal more certain.

iii. Many ixodid ticks have a very high reproductive potential and can live for long periods. The ability to starve in argasids even surpasses that of ixodids and they can go without a blood-meal for years. This is of great survival value and also ensures survival of pathogens in infected ticks for long periods.
Examples of the number of eggs produced:

iv. **Transtadial** and **transovarial** transmission of many pathogens by ticks makes ticks true reservoirs of infection and some tick-borne pathogens, such as spirochaetes in argasids, can be maintained in nature in the absence of vertebrate hosts by transtadial and transovarial passage through several generations.

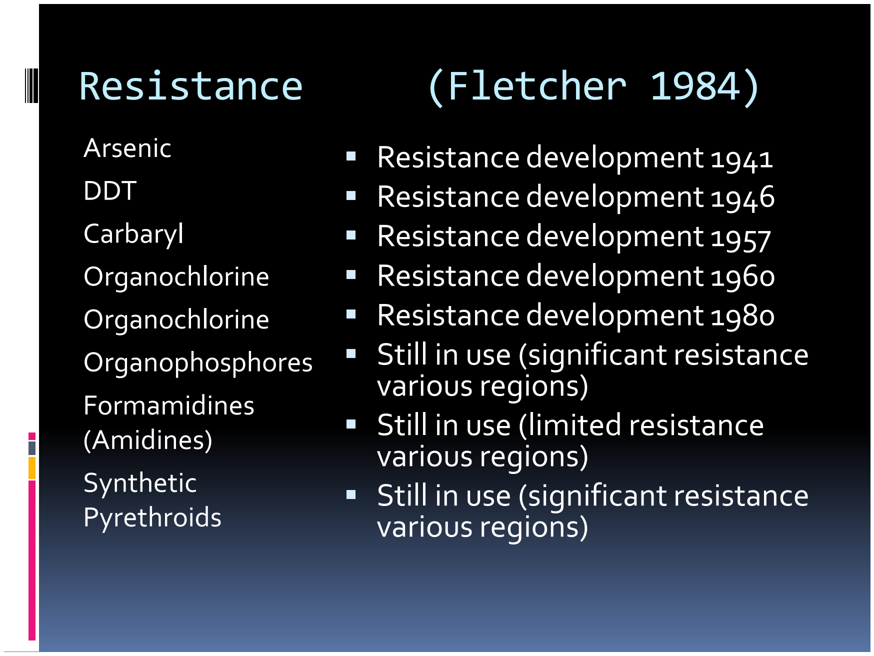
In view of the above aspects of ticks and their deleterious effects of ticks on livestock and humans, the need for effective tick control methods is heightened.

4. Current Tick Control Methods

The use of Synthetic Chemicals for tick control

Currently, tick control methods rely largely on the use of synthetic acaricides including carbamates, organophosphates, synthetic pyrethroids, amatraz, menthanediol and fipronil (Witchey-Lakshmanan, 1999). However, over reliance on these chemicals as a means of control has been shown to result in problems which include:

i. The accumulation of toxic substances in the environment
ii. The accumulation of chemical residues in products destined for human consumption
iii. Lack of specificity resulting in the demise of non-targeted species
iv. High purchase costs which are out of reach by poor resourced livestock keepers
v. The emergence of tick strains that are resistant to acaricides (Dipieolu, 1982; Kagaruki, 1997). See the Table below which shows resistance developed by ticks to different acaricides.



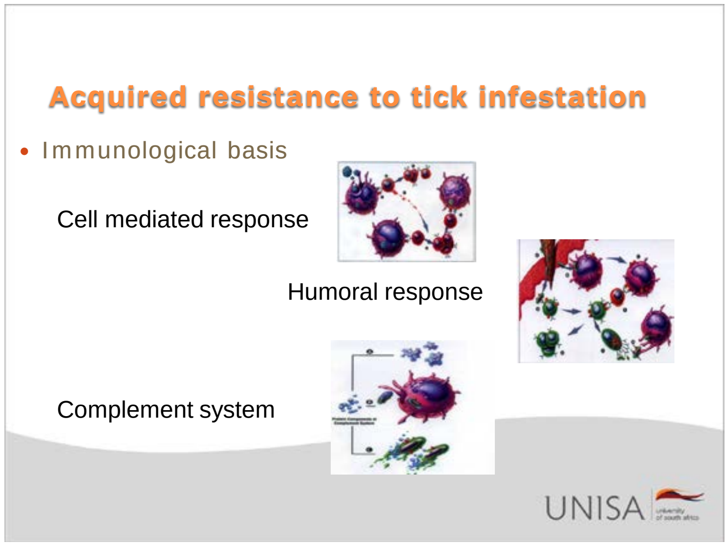
5. Alternative Tick Control Methods

The problems that plague the use of synthetic chemicals for tick control necessitates the search for alternative tick control methods.

Acquired Resistance

Many laboratory studies have shown that hosts acquire resistance following repeated tick infestations. The acquired resistance to tick infestation is known to have an immunological basis including:

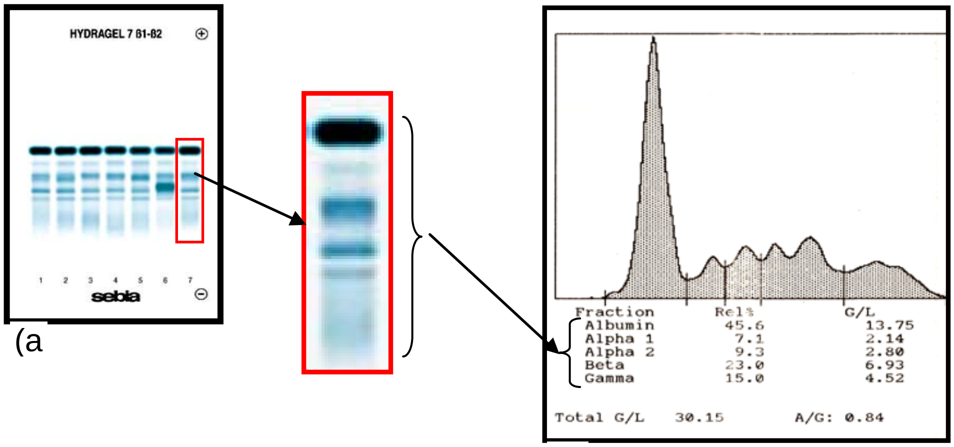
i. Cell-mediated (Nithuithai and Allen, 1984; Brossard and Wikel, 1997)
ii. Humoral (Willadsen, 1980; Wikel, 1996) and
iii. Complement components (Berenberg *et al*., 1972; Wikel, 1999).



It is generally accepted that the resistance to ticks by hosts is characterized by the following:

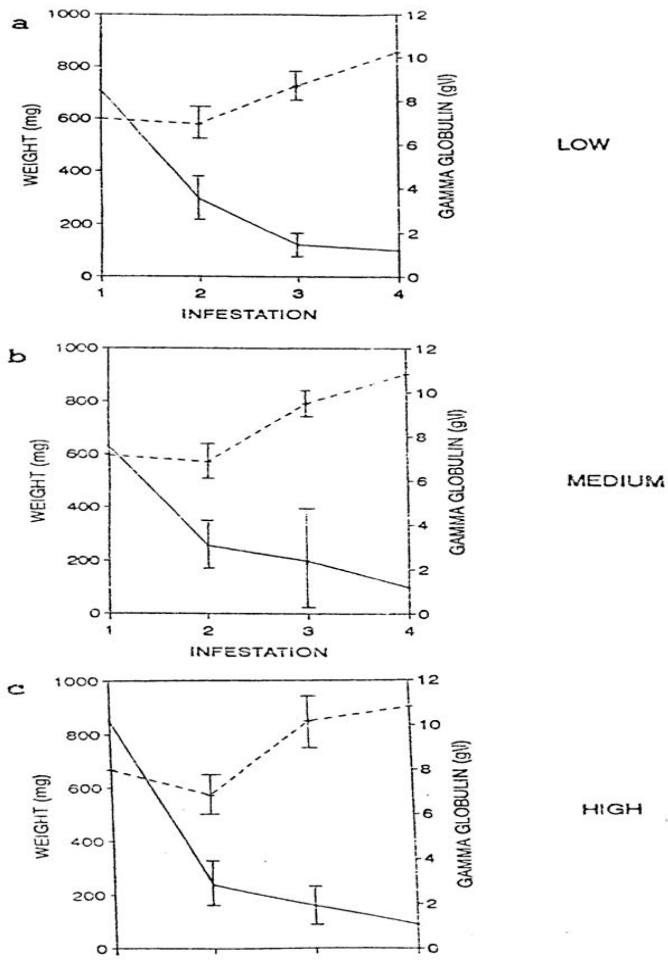
i. Failure by many ticks to complete a blood meal
ii. Ticks spending prolonged periods on the host to complete the feeding process
iii. Reduced blood intake, resulting in a reduction in weight of engorged ticks
iv. Reduction in the number of eggs laid

In our study which involved repeated infestation of guinea-pigs with adults of *Rhipicephalus evertsi evertsi* we were able to demonstrate that the levels of beta-globulins increased with the number of infestations when the engorgement weight declined with an increase in the number of infestations. Beta globulins and gamma globulins are known to have the same electrophoretic mobility with antibodies. Therefore their increase following repeated host infestations with ticks is attributed to the increase in antibodies.



(b)

(a) Serum protein migration on Sebia Hydragel membrane and (b) the electrophoretic profile of rabbit sera showing the albumin, alpha 1, alpha 2, beta and gamma fractions



Association between mean weight (mg) (___) of engorged *Rhipicephalus evertsi evertsi* females and concentration of beta globulins (gL^{-1}) recorded in guinea-pigs at (a) one week (short interval) and (b) ten week (long) intervals between infestations. (Rechav *et al,* 1994).

Resent research in ticks has been largely devoted to the exploitation of resistance acquired by hosts to tick infestations as an alternative to the use of chemicals for tick control (Wikel, 1999).

Based on this understanding, work is currently underway to develop vaccines that can be commercialized. However, the main challenge is that such a vaccine must be produced in large quantities and according to Labarthe (1994) it is not feasible to obtain the antigen from a process that uses ticks. Therefore the issue here is not only to identify the antigen but also to develop the technology that can produce it in large quantities.

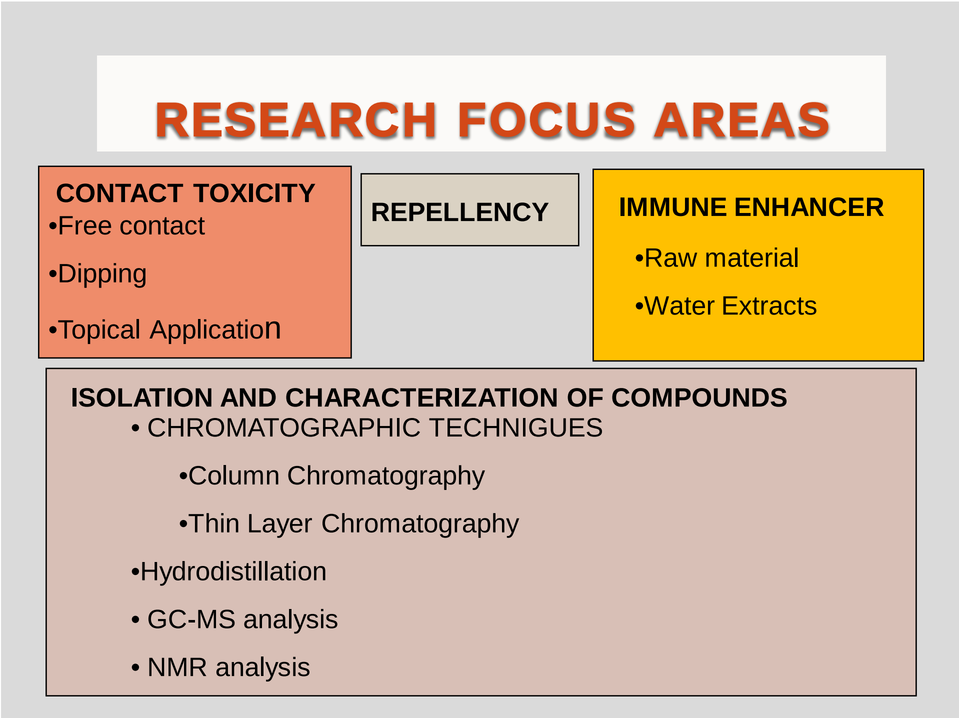
The use of plants for tick control

Plants having secondary metabolites

When I started lecturing at MEDUNSA, I was assigned to teach Botany in addition to Vertebrate Zoology. One of the modules that I taught to medical and BSc students was Medically Important plants. This put me in a vantage position to explore plants, and shifted the focus of my research to investigating the anti-tick properties of plants. In 2003 I received a grant from the NRF which enabled me to start a laboratory focused on screening plants for anti-tick properties. My research work since then has been focused on screening plants for anti-tick properties and providing scientific evidence to validate untested reports on the anti-tick properties of some plants.

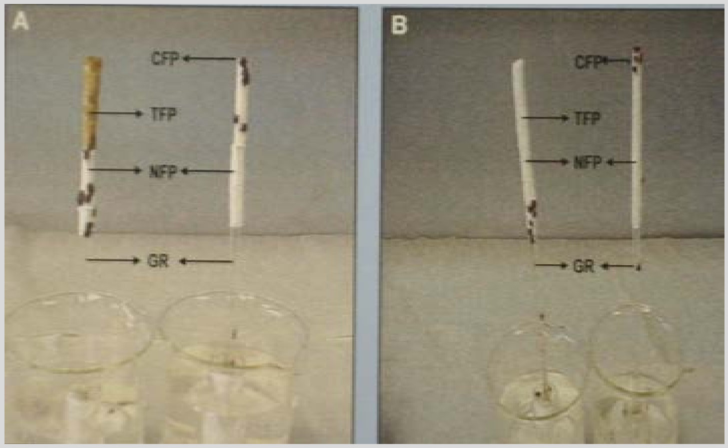
Plants are increasingly being recognized as possible sources of anti-tick agents. The use of plants or plant-based products for the control of arthropod ectoparasites on livestock is widespread among small scale livestock keepers in Africa (Lwande *et al*., 1999; Kaaya 2003, Matlebyane *et al*., 2010). This practice is typically community-based and as a result, the plant species used for such purposes may vary from one community to another. Furthermore, knowledge on such practices is orally transferred from one generation to another and often lacks scientific validation. A number of studies have so far been conducted to validate the use of plants for tick control. For example, most recently, Zorloni *et al*. (2010) demonstrated that extracts of *Calpurnia aurea* leaves used by the Borana people of northern Kenya and southern Ethopia to treat louse infestations in humans and calves also have anti-tick properties. Similarly, Magano *et al*. (2008) and Thembo *et al*. (2010) demonstrated that *Senna italia* subsp. *arachoides*, used by the Batswana people of southern Africa to improve the health of the livestock, has anti-tick properties. Such studies form a necessary precursor that may lead towards the development of community based tick control programmes. Furthermore, scientific identification of plants with anti-arthropod properties is necessary to avoid indiscriminate harvesting of plants that might not be having anti-arthropod properties.

In my laboratory we test plants for contact toxicity, repellency or immune enhancing. Extracts which show anti-tick activity are isolated and characterized (see slide below).



See the repellency bioassay that we use over leaf.

Tick repellency bioassay Mkolo & Magano (2007)



Mean % repellency of *N. tabacum*, *E. globoidea* and DEET against adults of *H. m. rufipes*

w/v %	10 min	20 min	30 min	40 min	50 min	60 min	90 min	120 min
20 *N. tabacum*	89	69	47	53	45	31	-	-
E. globoidea	87	72	78	61	55	40	65	60
DEET	100	97	83	85	64	59	49	31
30 *N. tabacum*	73	50	53	59	54	65	-	-
E. globoidea	86	93	91	92	90	79	79	63
DEET	100	100	100	86	87	86	86	69
40 *N. tabacum*	96	93	75	58	51	33	-	-
E. globoidea	94	93	100	96	91	90	94	69
DEET	100	100	100	100	97	94	86	71

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Epilogue

Pro-vice Chancellor, the evidence accumulated in my personal research so far, and that accumulated elsewhere by my peers, provides a strong case for plants as sources of **anti-tick agents**. However, let me hasten to indicate that this does not insinuate in any way that plants will be or are a panacea for the control of ticks. My view is that they may serve as suitable alternatives to the use of synthetic acaricides. Their effectiveness can be sustained if their use is coupled with other non-acaricide methods in an integrated manner. Of importance is that such methods must be friendly to the environment and also accessible to all livestock keepers, including those who are poorly resourced. Chief among the advantages that can be gained in the use of plants for tick control is that, much of the knowledge already exists in the form of indigenous knowledge. What is necessary is that such knowledge be subjected to scientific scrutiny and validation, leading to improved use.

Pro-Vice Chancellor, it is important that tick populations be brought under control particularly in view of the deleterious effects they cause to animals and man. It is clear that the current tick control methods are partially effective and will soon give-in.
In view of the fact that most livestock keepers in Africa are subsistence farmers and cannot afford the highly priced synthetic acaricides, the need for alternative non-acaricidal tick control methods cannot be over-emphasized.

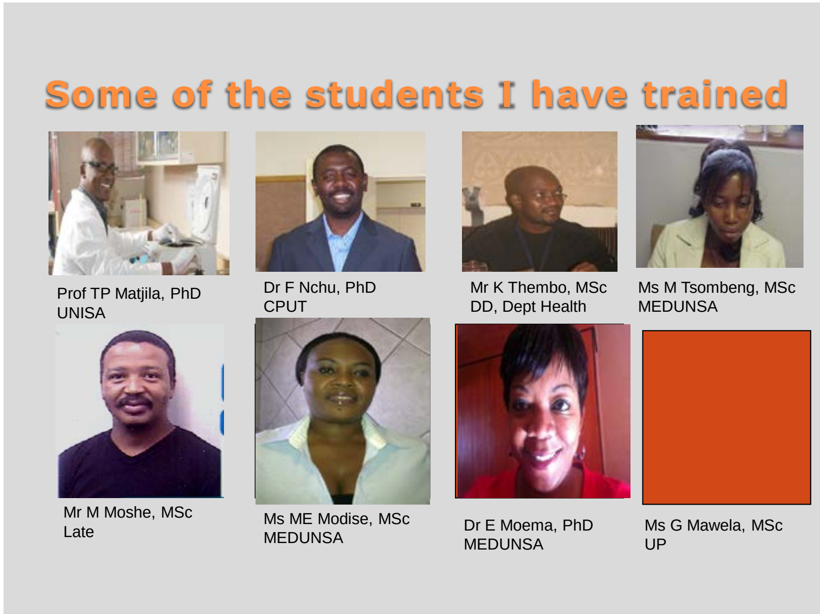
What is disappointing though, is that, it is only few centers or institutions in the country which are involved in tick research. Currently, the only institutions which do research in tick biology are the **University of Pretoria**, **University of Limpopo (Medunsa Campus), Veterinary Institute at Onderstepoort**, the **University of the Free State** and now **Unisa**. This is in spite of the enormity of the problems caused by tick infestations. It is important that research in this area be increased so as to inform the design of new non-acaricidal methods. Coupled to this should be a concerted effort to increase training of new scientists. Finally, it is important that research in this area lead to the development of products or methods that can be accessed by all livestock keepers.

Acknowledgements

Let me in conclusion appreciate the Magano family. Many thanks for the love and support over the years. But I want to single out my elder brother among my siblings, **Paul Magano**, for the role he played in my life, in particular for supporting me financially during the infancy stages of my tertiary education. I truly cannot piece together words that can accurately express my appreciation for what you did in my life.

Let me also appreciate my wife, **Dr Moyagabo Magano**. She is truly second to none. However, except for my mother, I have never seen a beautiful woman like her. To my sons many thanks for your support too and the willingness to take instruction and guidance from us as your parents. You are truly appreciated.

The following people are also appreciated:



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