ENDEMIC STABILITY FOR TICK-BORNE DISEASES

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ENDEMIC STABILITY

- Endemic stability is defined as the state where the relationship between cattle, parasites, vectors and environment is such that clinical disease occurs rarely or inapparently, and without measurable economic losses.

ENDEMIC STABILITY IN ZIMBABWE

- Endemic stability was the normal situation in Zimbabwe until 1890. In 1891 the first outbreak of redwater was reported in trek oxen from South Africa.
- Importation of Asian redwater from Mozambique in 1900 followed by East Coast fever from Tanzania, and the dipping campaigns that followed, destroyed the possibility of a return to stability.

COMPONENTS OF ENDEMIC STABILITY

- Tick resistance
  - Immunity resulting from prior exposure
- Disease tolerance
  - Innate tolerance
    - Genetic
    - Age related
  - Acquired tolerance
    - Immunity resulting from prior exposure or immunisation

DEFINITIONS

- Resistance
  - “Disease resistance implies that the host has a negative impact on the fitness of the pathogen, causing its death. Thus, resistance describes the host’s ability to limit pathogen load.”

DEFINITIONS

- Tolerance
  - “Disease tolerance is related to the impact of a given level of infection on the animal’s performance, namely, the reduction in performance in the presence of a pathogen load. Disease tolerance is different from resistance because it promotes host health while having a neutral to positive effect on pathogen fitness.”

TOLERANCE

- Tick-borne Disease Tolerance
  - Pathogen establishes successfully, but the inflammatory response limits damage to ox tissues and systems without eliminating pathogen.
  - Immediate – innate immunity
  - Delayed – adaptive immunity

RESPONSES TO INFECTION

- Immunological – activation of antibodies and immune cells to neutralise and/or destroy pathogens or abnormal cells
- Inflammatory – changes in blood flow, tissue fluids and production and movement of white blood cells to facilitate the process and remove pathogens and damaged tissue

IMMUNE RESPONSE

- Innate –
  - Present at birth and for a variable time thereafter
  - Reacts to the presence of abnormal structures (e.g. bacteria) and damaged cells (e.g. cells containing viruses and other intracellular pathogens)
  - Non-specific
  - Limited number of triggers

IMMUNE RESPONSE

- Adaptive –
  - In cattle becomes active after one month of age
  - Requires two to four weeks to become effective
  - Highly specific
  - Develops against an almost infinite number of antigens

DISEASE TOLERANCE

- Mild or subclinical disease, self-limiting
- Controlled, appropriate inflammatory response.
- Pathogen persists in carrier status

DISEASE SUSCEPTIBILITY

- Severe or fatal illness
- Disorderly, inappropriate, excessive inflammatory response

GENETICS AND TOLERANCE

- Common knowledge that indigenous cattle in an environment in which tick-borne diseases are prevalent are rarely clinically affected.
- Indicine (Zebu) – more tolerant than
- Indicine crossbreds with African taurine (Sanga) and European taurine (synthetic breeds) – more tolerant than
- European taurine
- Significant within breed variation

GENETIC FACTORS BABESIOSIS

- Genetic tolerance to *Babesia bovis* has been demonstrated.
- No statistical evidence of tolerance to *B. bigemina*, but field experience confirms that it does exist.

GENETIC FACTORS ANAPLASMOSIS

- Genetic tolerance to *Anaplasma* not a factor.
- Endemic stability in field attributed to tick resistance, leading to low infection rates in ticks and low tick numbers.
- Transplacental transmission and colostral antibodies may help to establish tolerance.

GENETIC FACTORS HEARTWATER

- No statistical evidence
- Indicine generally more tolerant than taurine
- No consensus on the status of Sanga cattle

GENETIC FACTORS THEILERIOSIS

- Genetic tolerance to East Coast fever and tropical theileriosis demonstrated in indicine breeds.

GENETIC FACTORS ANAPLASMOSIS & BABESIOSIS 1997 – PEN TRIAL

Breed	Number	B. bovis	B. bigemina	Anaplasma
		Treated		
Bos indicus	10	0	0	5
Bos indicus 50%	20	5	0	15
Bos taurus	10	8	0	10

GENETIC FACTORS BABESIOSIS 1999

Breed	Number	Anaemia	Severe Illness
	Babesia bovis – Field trial		
Bos indicus	56	20	1
Bos indicus 50%	52	39	10 (1 died)
Sanga cattle as susceptible as *Bos taurus*			
	Babesia bigemina – Pen trial		
Bos indicus 100% and 50%	12		0
Bos taurus	7		6

GENETIC FACTORS EAST COAST FEVER 2005 – PEN TRIAL

Breed	Number	Clinical Disease	Death
Trial 1			
Shorthorn Zebu	5	2	0
Boran	9	5	2
Friesian	8	8	3
Trial 2			
Shorthorn Zebu	10	6	0
Boran	20	18	7
Friesian	10	9	4

WITHIN BREED VARIATION BORAN - CORRIDOR DISEASE FIELD TRIALS - 2013-2018

- International Livestock Research Institute
- Kapiti Research Station, Kenya
- Vaccination trials - 2013
- 4/6 survivors were offspring of one bull
- Exposed offspring to Corridor disease on Ol Pejeta Ranch for four years
  - First generation – 2014-15
  - Offspring from males from first generation – 2017-18

WITHIN BREED VARIATION BORAN - CORRIDOR DISEASE FIELD TRIALS - 2013-2018

Sire	Number	Survived without treatment
First Generation		
3167	28	19 (67.9%)
Other	29	1
Second Generation		
3167	47	24 (51.1%)
Other	13	3

WITHIN BREED VARIATION SHORTHORN ZEBU

- East African Shorthorn Zebu from endemic and non-endemic areas compared after challenge with East Coast fever.
- Endemic areas – 100% survival
- Non-endemic areas – 60-70% survival

WITHIN BREED VARIATION SHORTHORN ZEBU NATURAL EXPOSURE – 2007-2009

FAF1B	Death	Illness
32 Deaths in 548 calves		
T/T	0	
C/T	16	
C/C	16	
Clinical Illness in 98 Survivors		
T/T		2
C/T		8
C/C		21

INVERSE AGE TOLERANCE

- Young calves are generally less likely to develop clinical tick-borne disease than adults
- Suggested reasons
  - Physiological differences developing with age
  - Innate non-specific immunity
  - Maternal specific immunity
  - Congenital infection

CALFHOOD TOLERANCE BABESIOSIS

- Calves under 6 months old tend to be tolerant, irrespective of the immune status of their dams.
- Maternal immunity may enhance tolerance
- Tolerance attributed to an earlier, better coordinated inflammatory response than adults.

CALFHOOD TOLERANCE ANAPLASMOSIS

- Calves under 6 months old tend to be tolerant, irrespective of the immune status of their dams.
- Maternal immunity may enhance tolerance
- Transplacental infection can occur in 10-15% of calves and may play a role

CALFHOOD TOLERANCE HEARTWATER

- Calves under 4 weeks old tend to be tolerant, irrespective of the immune status of their dams
- Tolerance may extend to 6-8 months
- Congenital infection can occur and may play a role

CALFHOOD TOLERANCE THEILERIOSIS

- No evidence of calfhood tolerance, except to January disease. In January disease calves under 4 weeks old tend to be tolerant, irrespective of the immune status of their dams. In the field, mortality is rare under 7 months, but the reasons are unknown.

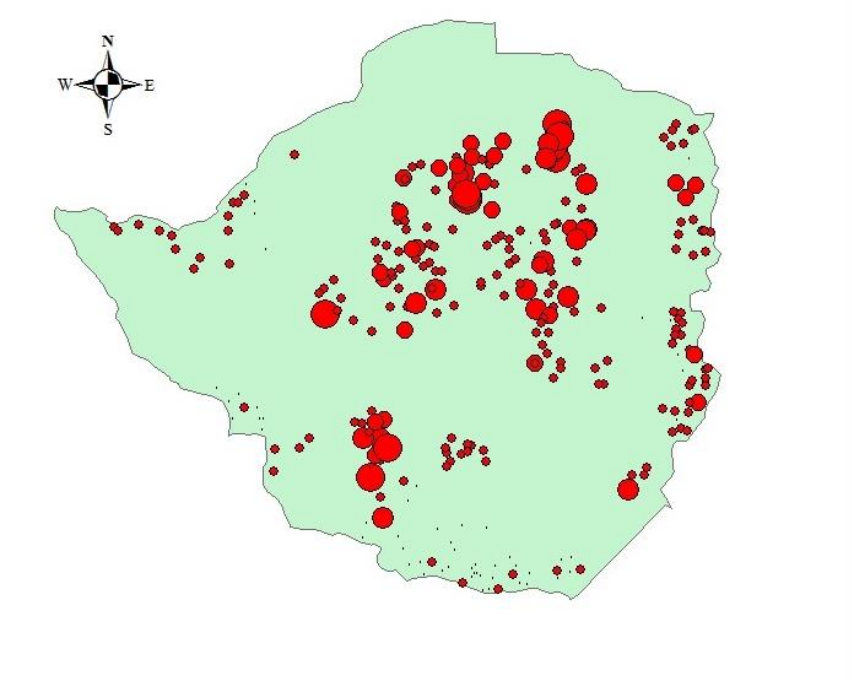
ACQUIRED TOLERANCE

- Adequate exposure to infected ticks – “strategic dipping”
- Treatment of cattle with acaricides to limit damage by ticks while maintaining their immunity against tick-borne disease.
- How many ticks is enough to ensure adequate transmission?
- How many ticks is so many that they cause significant weight loss and skin damage?

ACQUIRED TOLERANCE

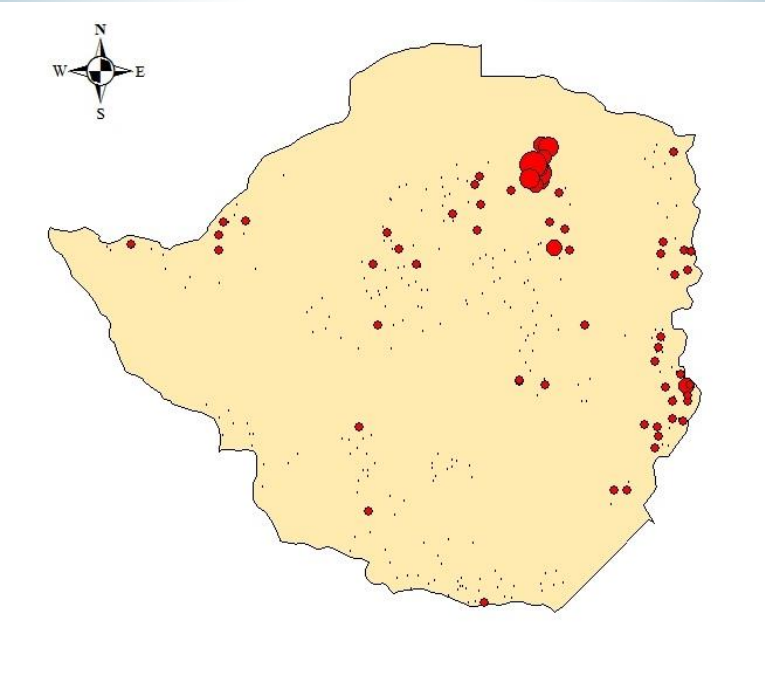
- How many ticks is enough to ensure adequate transmission?
- Enough to infect 100% of calves by weaning.
  - Babesiosis and anaplasmosis - >75% seropositive at weaning
  - Serology not satisfactory for heartwater and theileriosis. Can use molecular techniques to detect circulating parasites
  - Can estimate from infection rates in ticks and tick loads

Rhipicephalus decoloratus



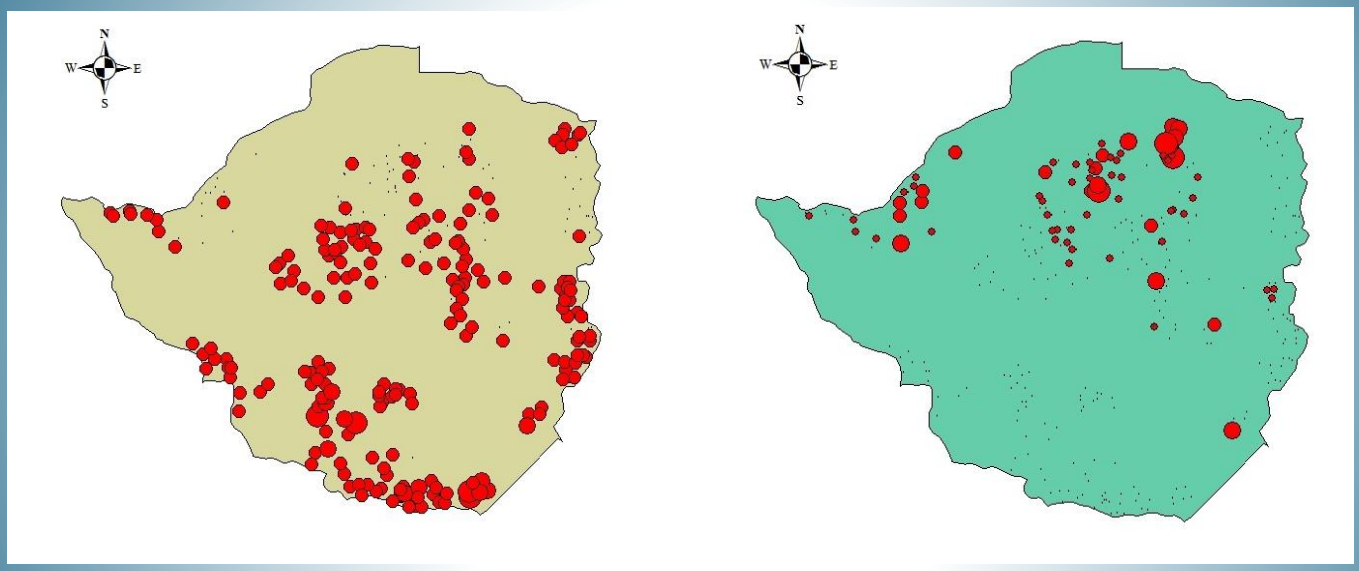
Transmits *Babesia bigemina* and anaplasmosis
Covers most of the country except hot, arid areas

Rhipicephalus microplus



Transmits *Babesia bigemina, B. bovis* and anaplasmosis
Prefers warm, humid conditions - “ecological niches”

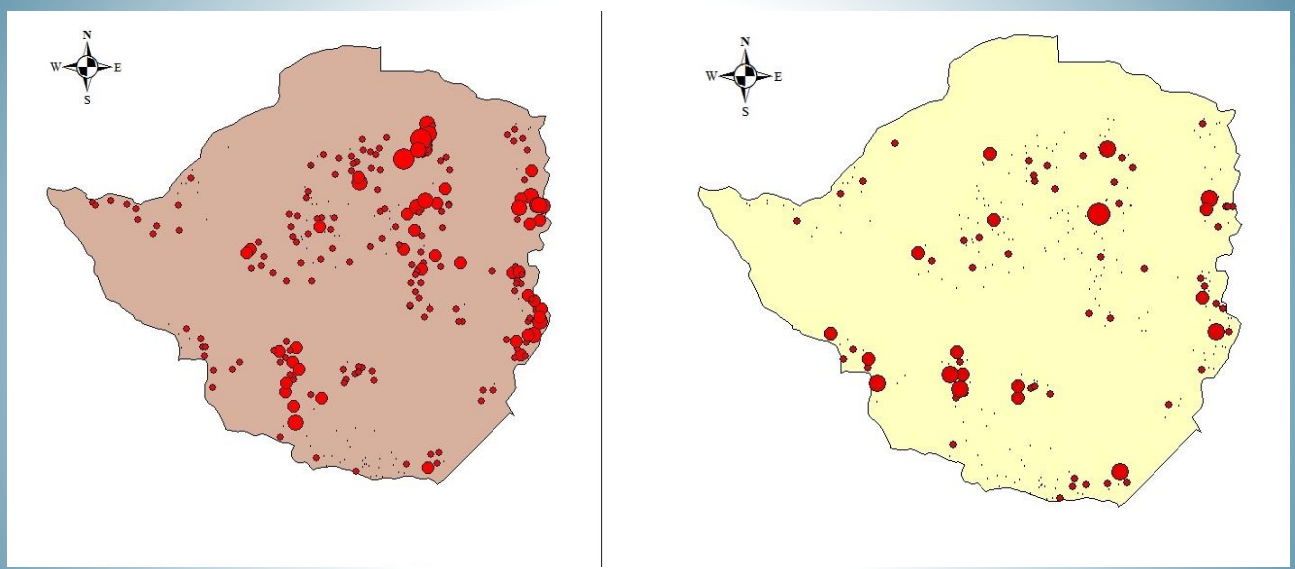
Amblyomma Species



A. hebraeum *A. variegatum*

Transmit heartwater. Between them they cover most of the country

Rhipicephalus Species



R. appendiculatus *R. zambeziensis*

Transmit *Theileria parva*.
Prefer wooded areas. Between them they cover most of the country

ACQUIRED TOLERANCE

- Immunisation
- Methods available for all tick-borne diseases in Zimbabwe involve infection with live organisms and treatment where necessary
  - Expensive to produce
  - Require ultra-low cold chains to maintain
  - Immunogenicity against different strains varies in heartwater and theileriosis
  - Availability variable

ENDEMIC STABILITY IN PRACTICE

- Is it necessary?
- Is it achievable?
- Is it desirable?

ENDEMIC STABILITY NECESSITY

- Alternatives
  - Keep cattle tick free by intensive dipping or zero grazing
  - Maintain endemic stability and practise strategic dipping

ENDEMIC STABILITY POSSIBILITY

- Can you keep your cattle tick free?
  - Do you have suitable dipping/spraying facilities?
  - Do you have reliable access to effective acaricides?
  - Do you have a closed herd?
  - Do you have secure boundaries?
- If not
  - Do you have cattle with zebu ancestry?
  - Do you have sufficient exposure to infected ticks?
  - If not, can you immunise your cattle against all tick-borne diseases?

NATURAL ENDEMIC STABILITY POSSIBILITY

- *Babesia bigemina* – easy in practice
- Anaplasmosis – easy in practice
- *Babesia bovis* – unlikely in Zimbabwe
- Heartwater – easy in practice, but a problem with variability of cross-immunity between strains
- Theileriosis –
  - Epidemic theileriosis – impossible without genetically tolerant cattle. Even then, calf deaths may occur
  - Corridor disease – does occur
  - January disease – probably achievable

ENDEMIC STABILITY DESIRABILITY

- Advantages
  - Reduced cost of acaricides
  - Reduced stress on cattle
  - Reduced disruption of farming activities
  - Reduced requirement for supervision
- Disadvantages
  - Occasional deaths from tick-borne disease
  - Production losses from high tick burdens
  - Cattle are carriers of infection
    - *B. bovis*, heartwater strains, theileriosis?

THE ALTERNATIVE SOLUTION

- A hybrid strategy
- Do not dip calves until weaning, unless they have problems before that, e.g. theileriosis, heartwater
- Dip adults as frequently as necessary to control disease
- Do not breed from animals that require treatment for tick-borne disease
- Naturally acquired immunity and genetically controlled tolerance will build up in the herd, while losses in non-immune cattle will be minimised