

Molecular Epidemiology of Anthrax in the Kruger National Park, South Africa

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Introduction - Overview

- General background
 - What is “ANTHRAX”?
 - History
 - Epidemiology
 - Where is it found?
- Study background
 - Previous investigations
 - Impetus for the Kruger studies



Introduction - Overview

- Diversity of *Bacillus anthracis* in the Kruger National Park (KNP)
- Ecological study of anthrax mortality rates
- Implications – local and global
- Continuing studies in Africa and North America

ANTHRAX

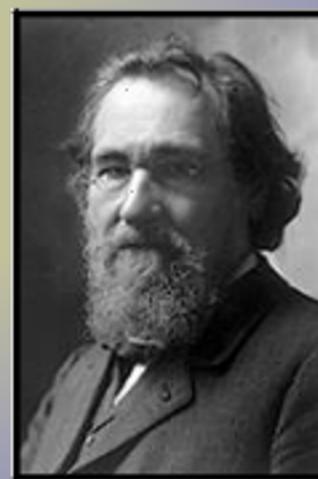


Bacillus anthracis



Gram positive
Rod shaped
Grows in chains
Forms spores
Aerobic
Circular chromosome
Two large plasmids

Historical Importance

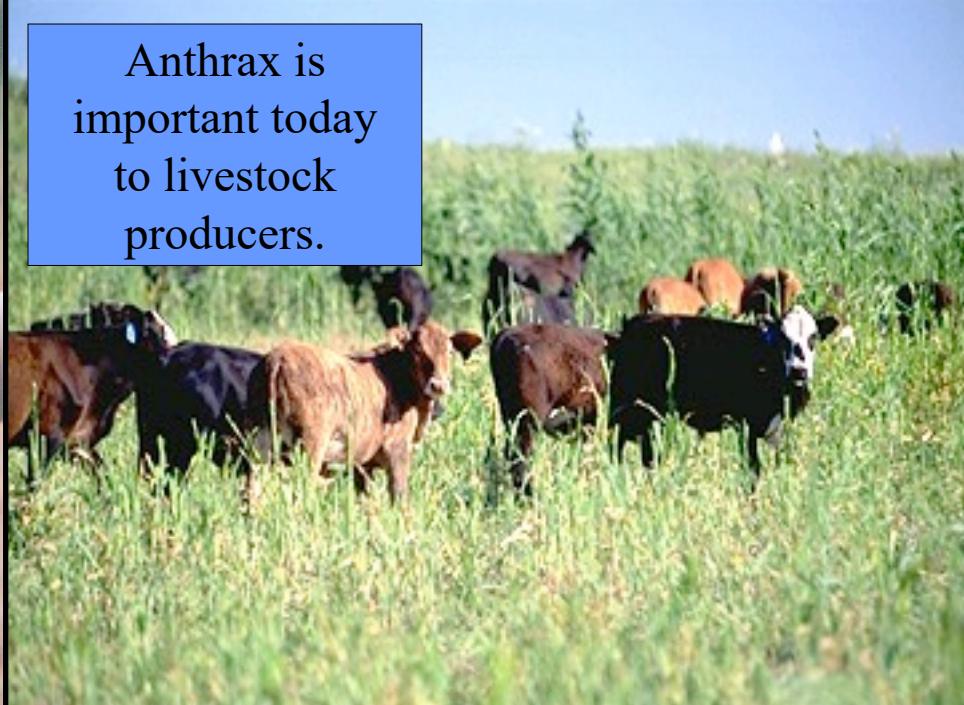


Robert Koch

Eli Metchnikoff



Anthrax is important today to livestock producers.



Anthrax is important today for public health.



Anthrax is important today to wildlife conservation.



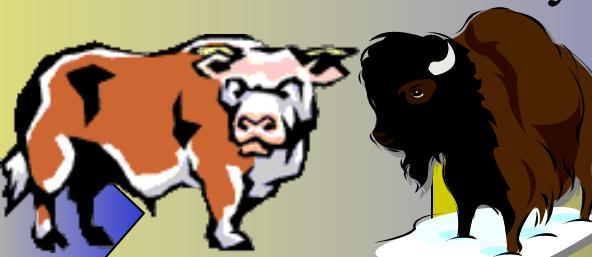
ANTHRAX
The Poor Man's
Atom Bomb

General Epidemiology of Anthrax

Spores acquired from meat (oral), hides and wool (cutaneous), or inhalation (bioterrorism).



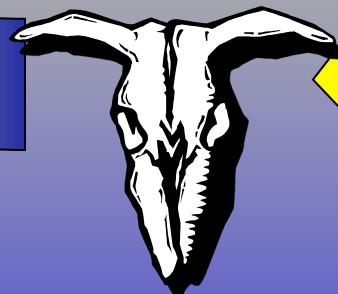
Herbivores Primarily



Spores
acquired
Orally

Spores
Re-seed
Environment

Disease
and
Death



Occasionally
Predators
and
Carnivores

The cause of death in cases of anthrax
is massive hypotension, edema, and shock.

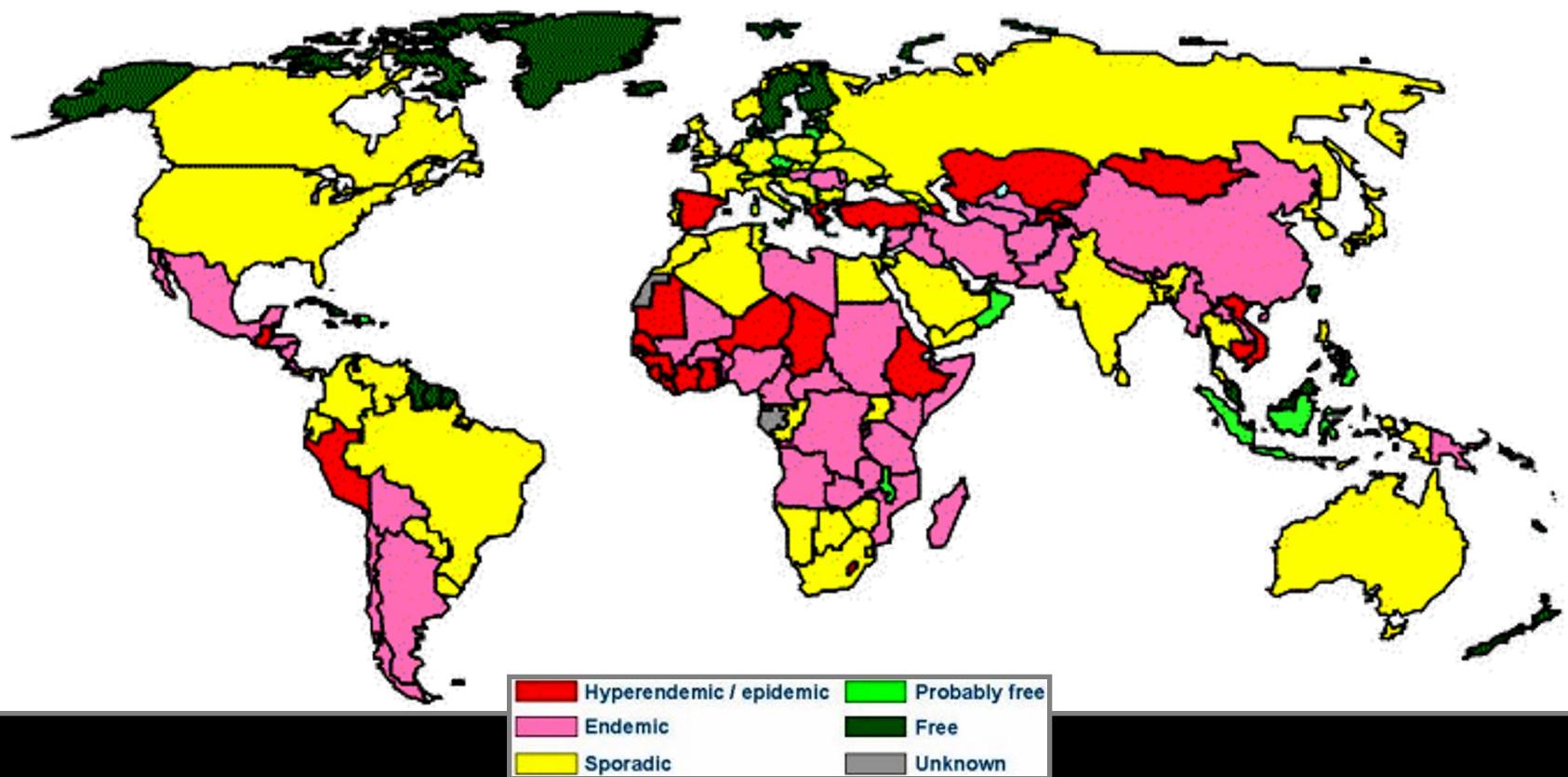
Plasmid pXO2:
Encodes a capsule
allowing evasion of
host macrophages

Plasmid pXO1:
Encodes a 3-part toxin
Protective Antigen
Lethal Factor
Edema Factor



In the case of inhalation anthrax,
massive pulmonary edema, also.

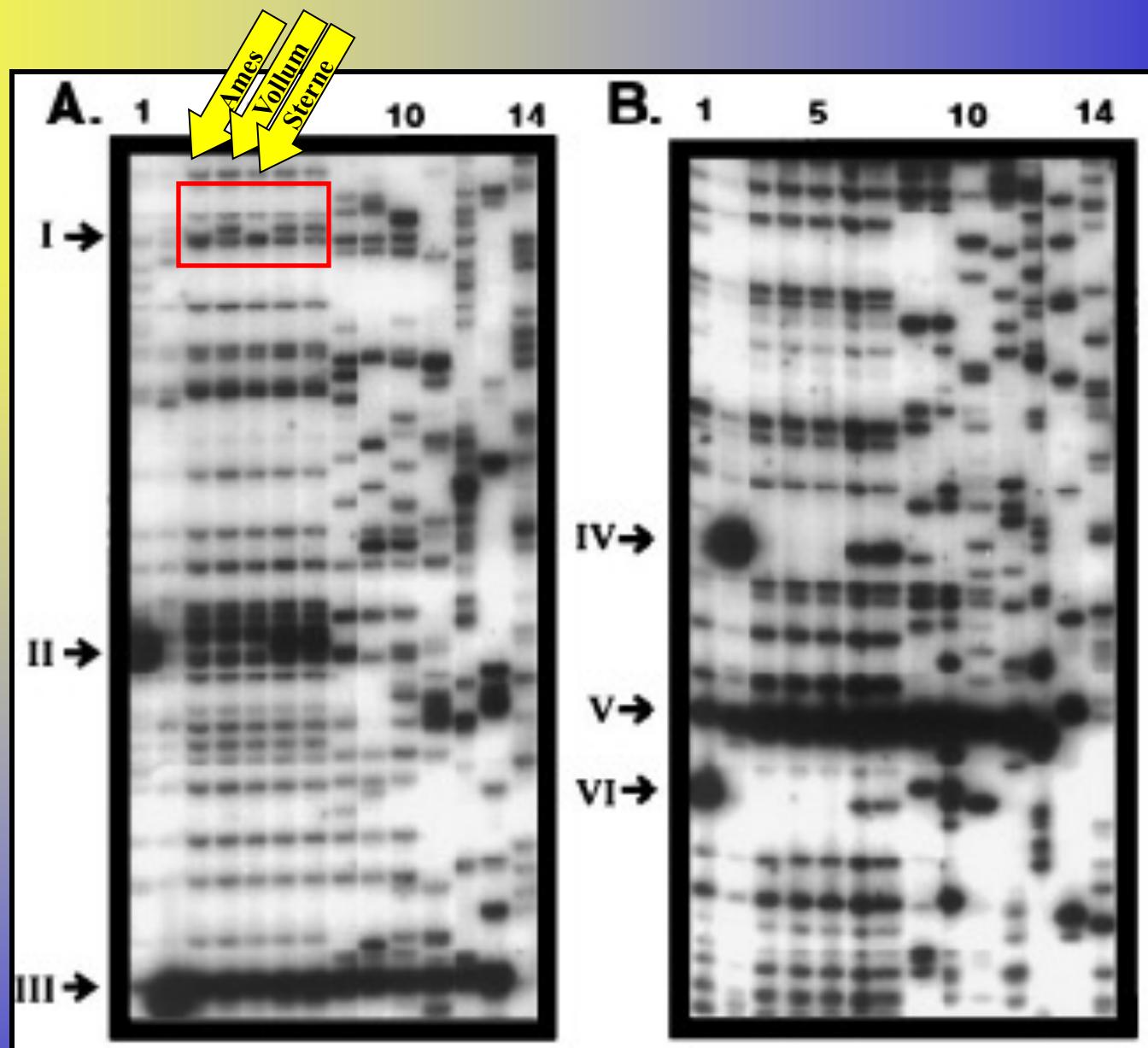
Global Anthrax Distribution

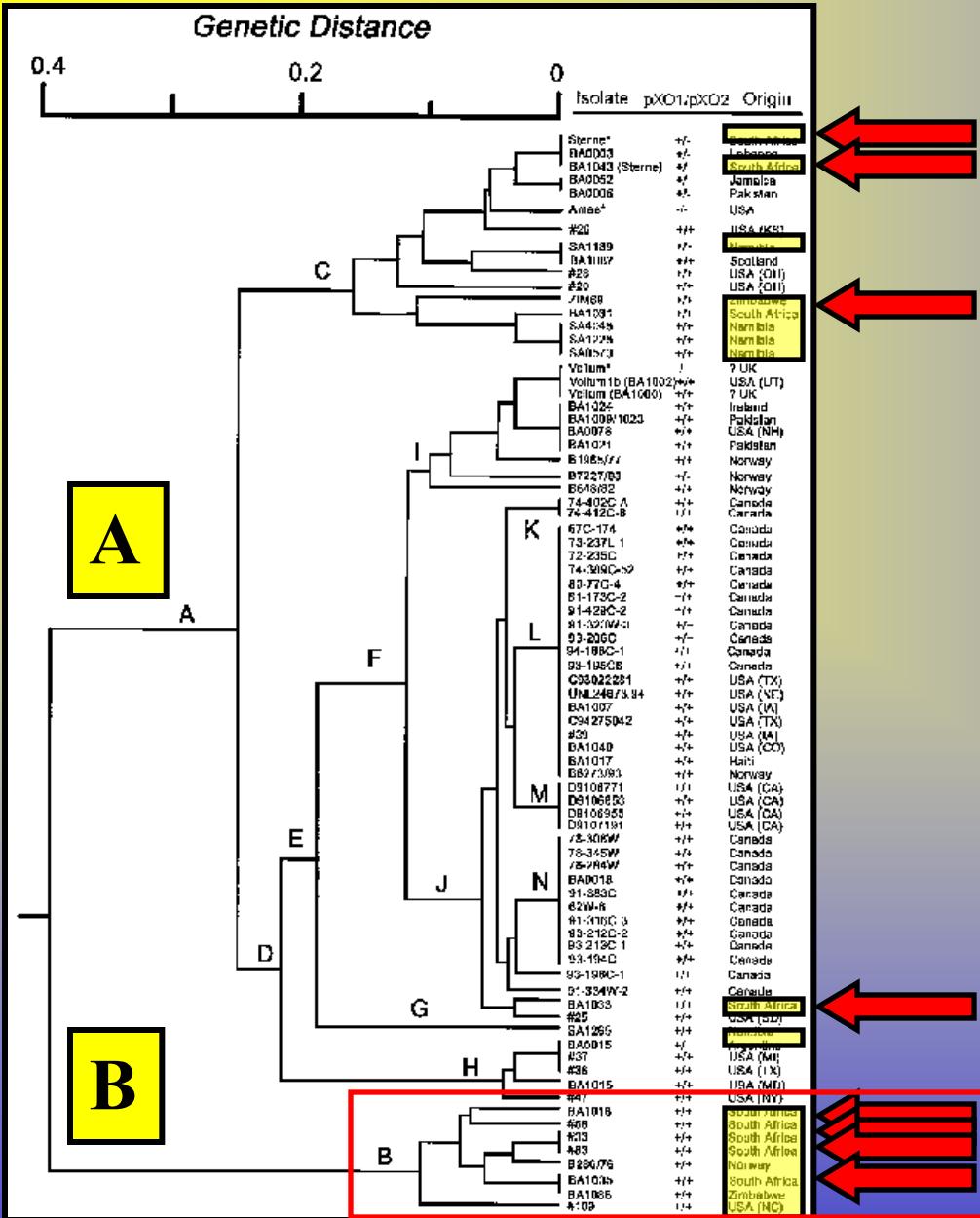


Previous Investigations

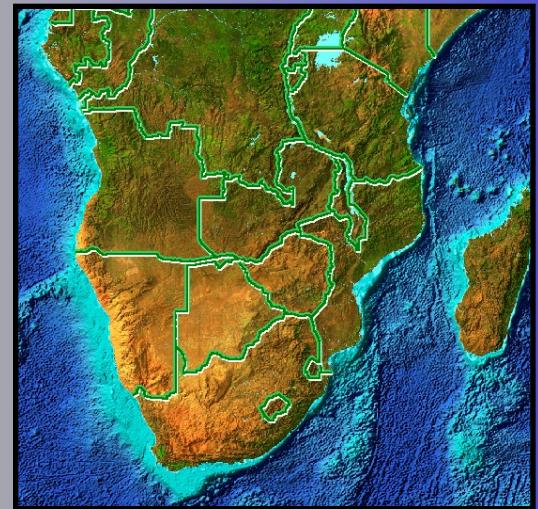
- Impetus for studies of anthrax in the KNP derive from the **first successful** molecular genetic investigations of *Bacillus anthracis*
- “...*Bacillus anthracis* may be one of the most genetically monomorphic bacterium known to man...”

Amplified Fragment Length Polymorphism

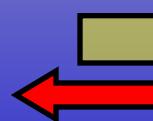




Is Southern Africa the
Geographic origin
of *Bacillus anthracis*?

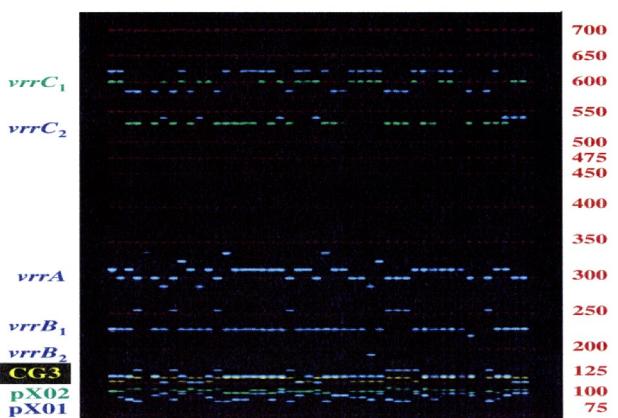


What has restricted the
B-branch in distribution
and diversity?

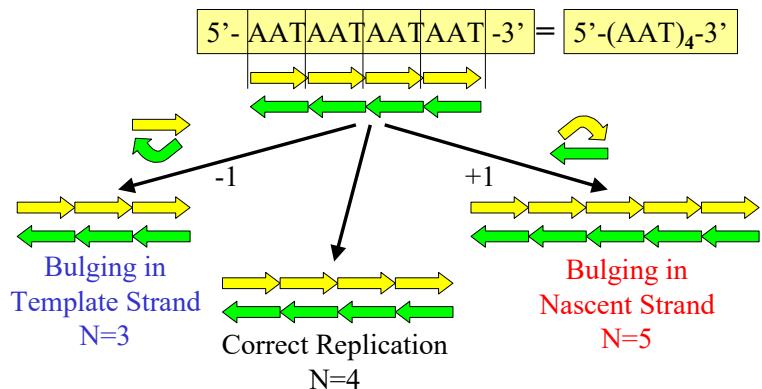


Southern Africa
South Africa

Multi-Locus VNTR Analysis (MLVA)



VNTR Polymorphism



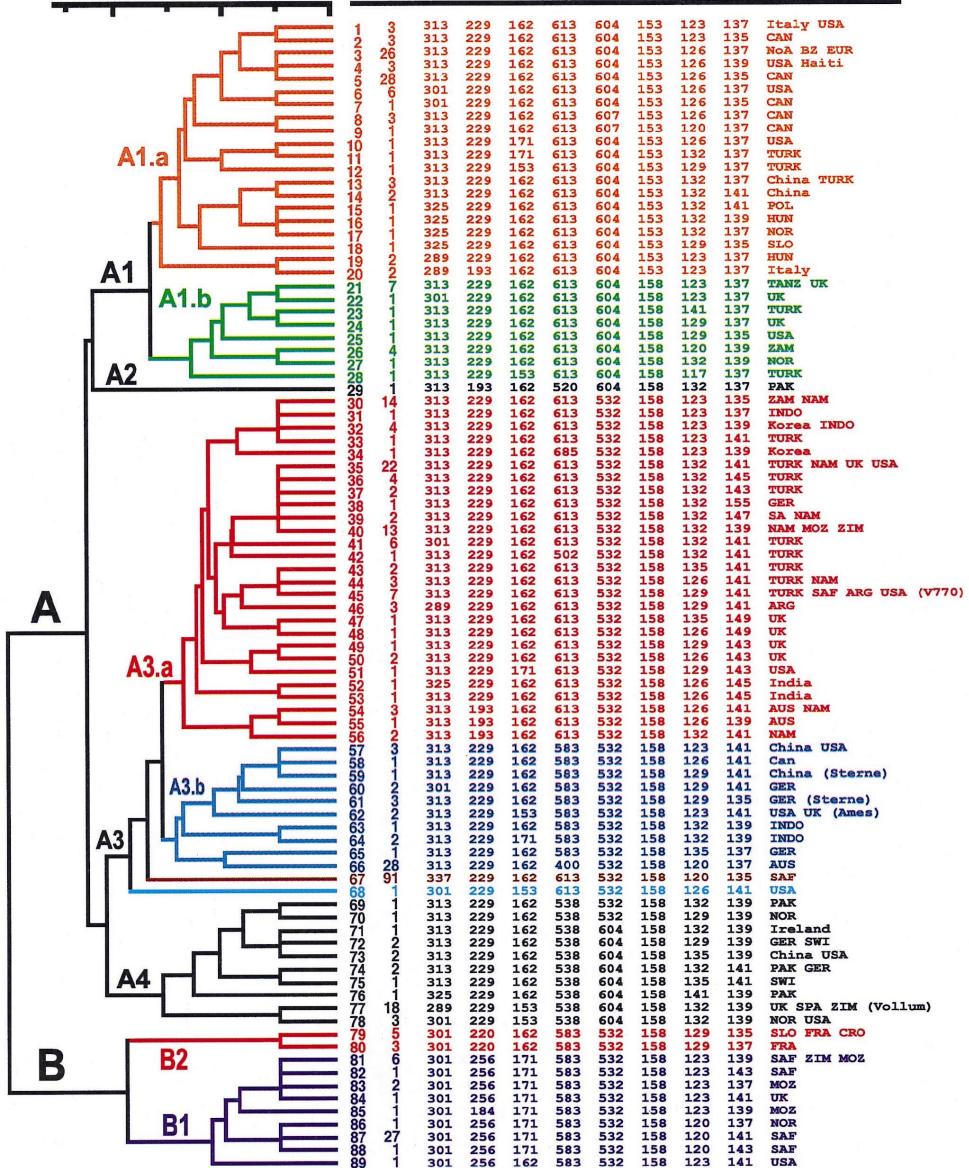
Marker Differences

4 2 0

G N

vrrA *vrrB₁* *vrrB₂* *vrrC₁* *vrrC₂* CG3 pXO1 pXO2

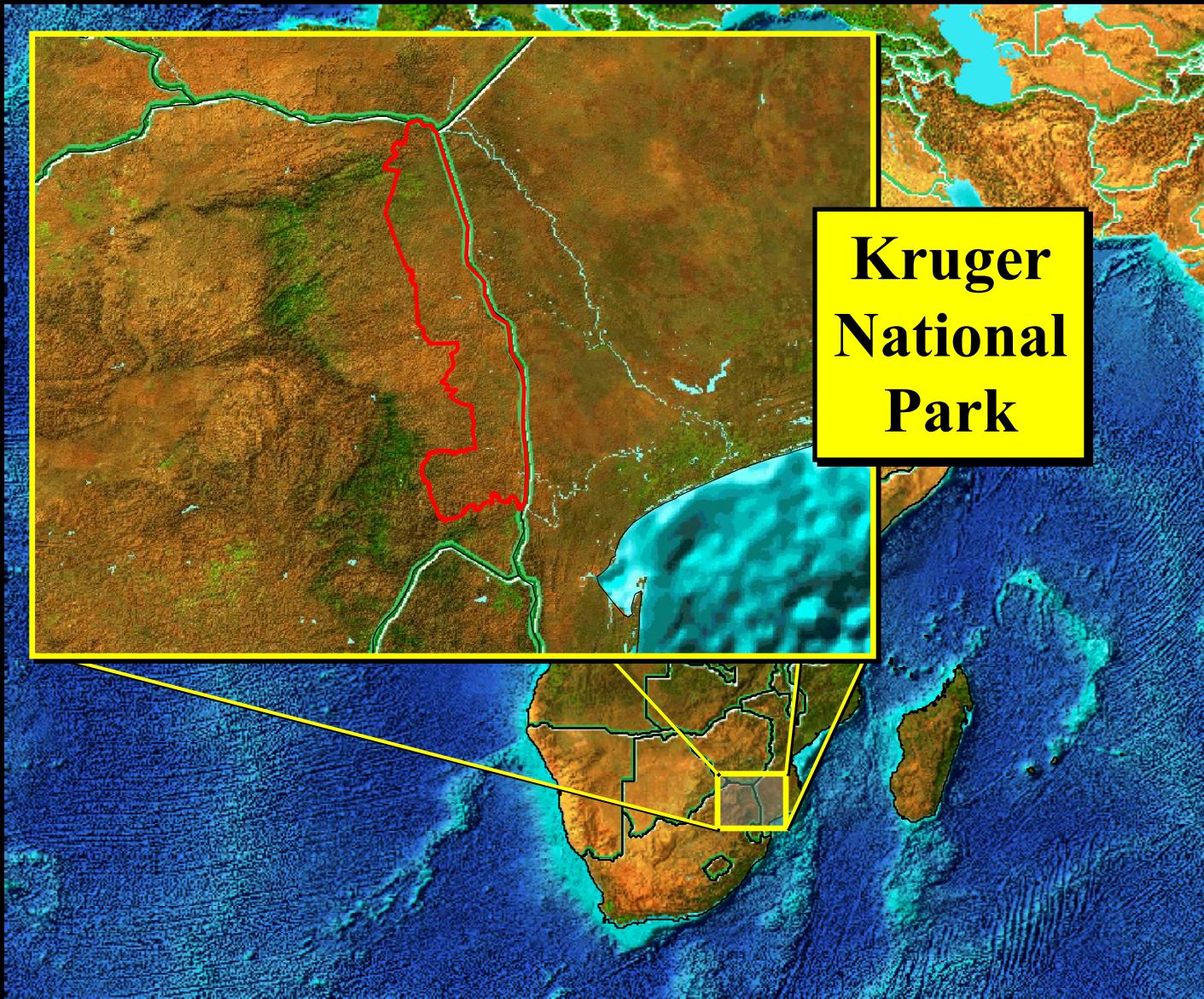
Geo. Region



Investigations in the KNP

Genetic diversity of *B. anthracis* in the KNP



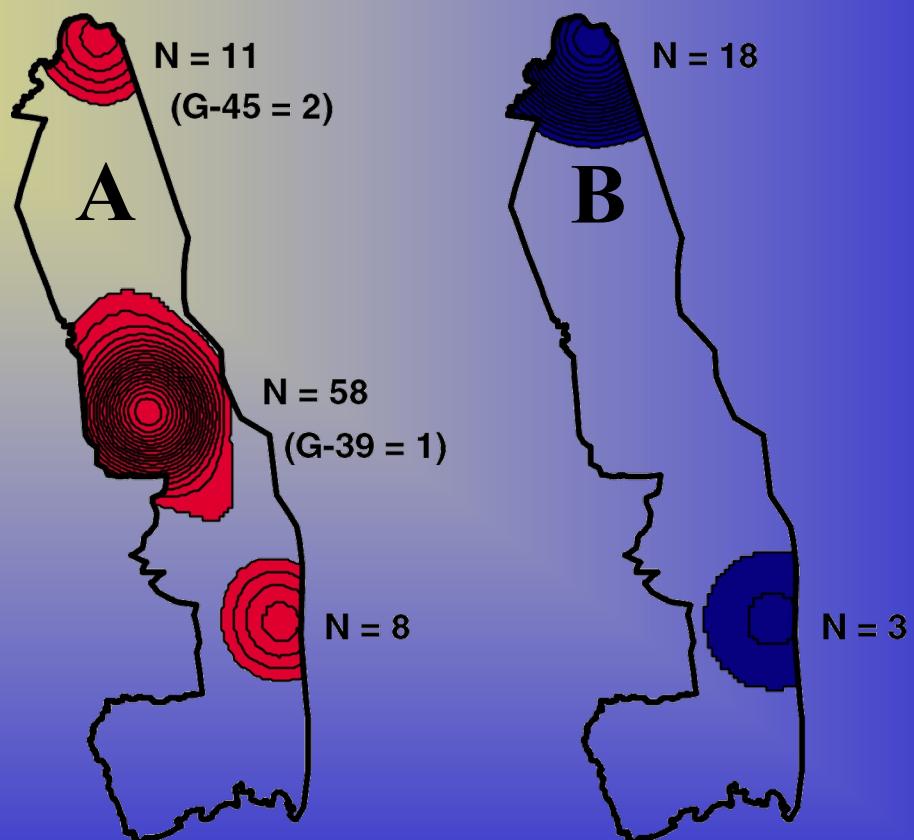
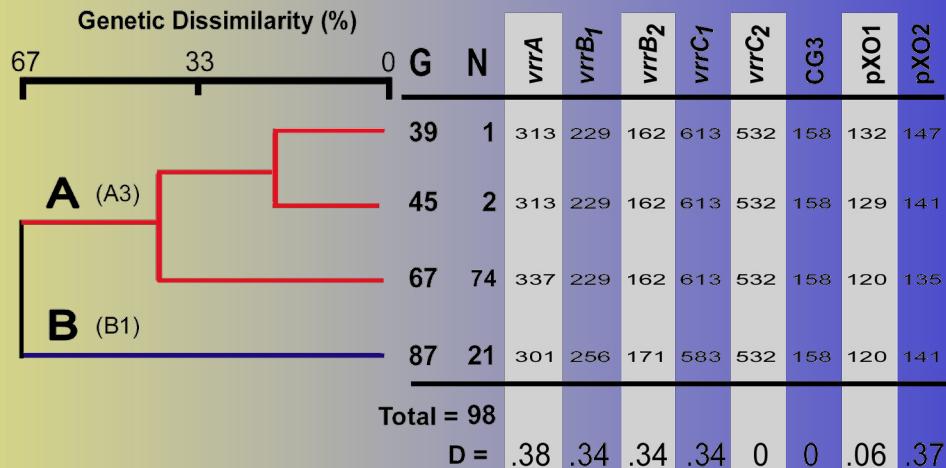


Approach to Questions

- Characterize the genetic diversity of *Bacillus anthracis* in the KNP
- Collect additional cultures, field samples and associated information
- Assess availability of environmental data

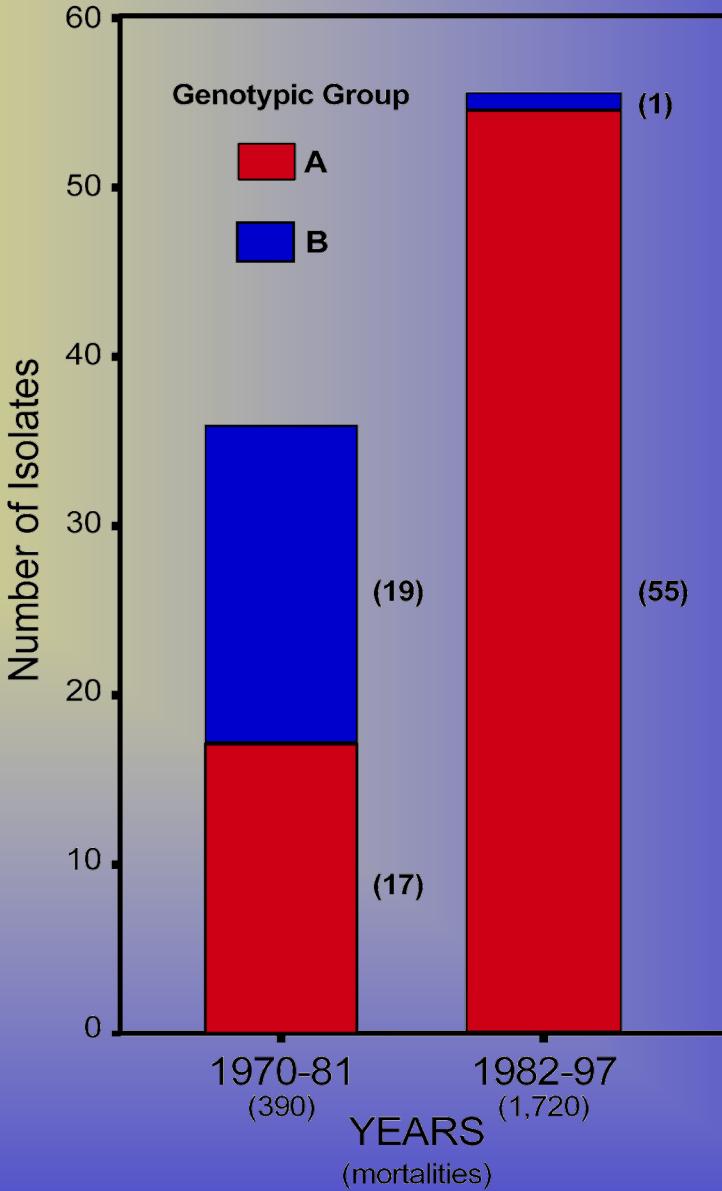
Genotypic Groups in the KNP

- Geographic distributions are overlapping but distinct



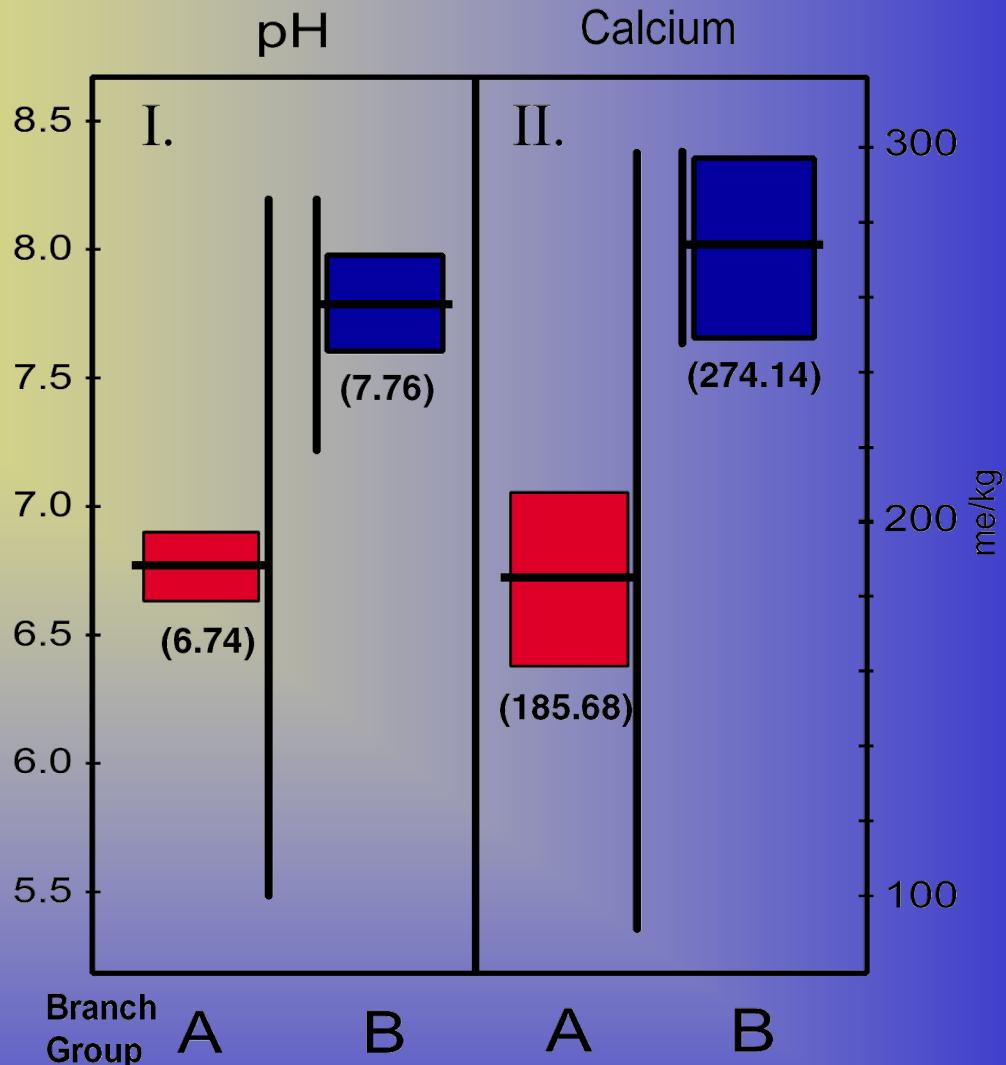
Genotypic Group Temporal Distribution

- Kruger A and Kruger B were found to co-occur during epidemics
- Overlapping yet distinct space-time distributions indicates multiple foci for epidemics, rather than point-source



Genotypic Group Environmental Associations

- Ca and pH ranges are overlapping but distinct
- Kruger A is found in a much broader range

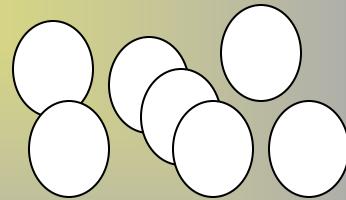


Investigations in the KNP

Modeling anthrax mortality in the KNP



Anthrax Spore Ecology



or

The acquisition of an infectious dose



“Concentrator Area”

Soils with:

- High calcium
- Greater than neutral pH

Geographic areas with:

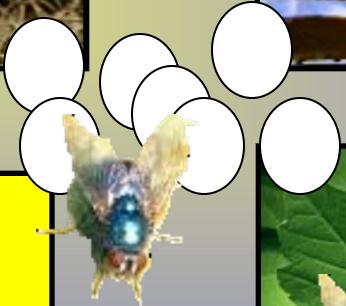
- Dish or pan topology
- Rainfall followed by drought





“Browsing Effect”

Flies feeding on carcasses deposit vomit and feces rich with spores on surrounding vegetation.





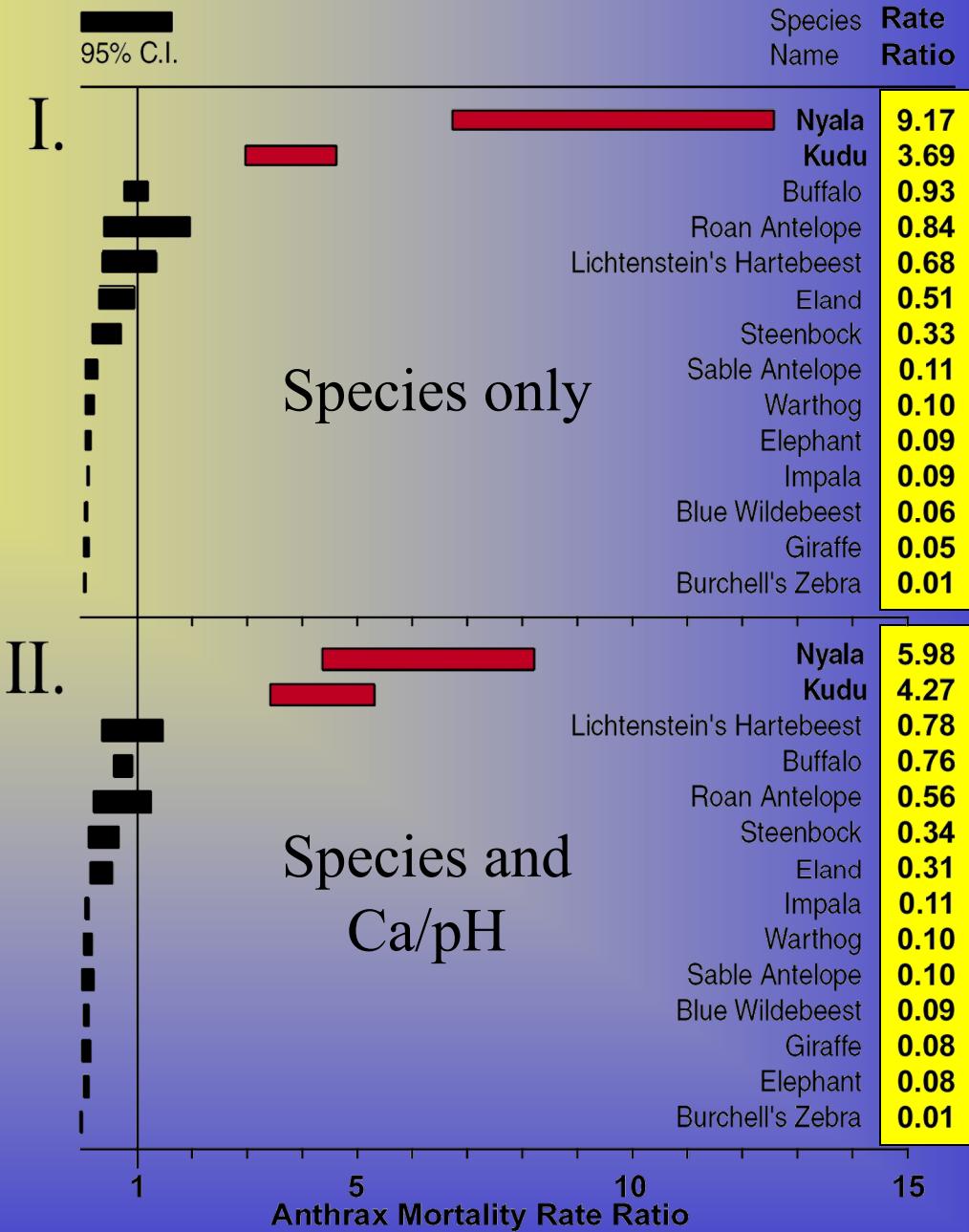


Approach and Questions

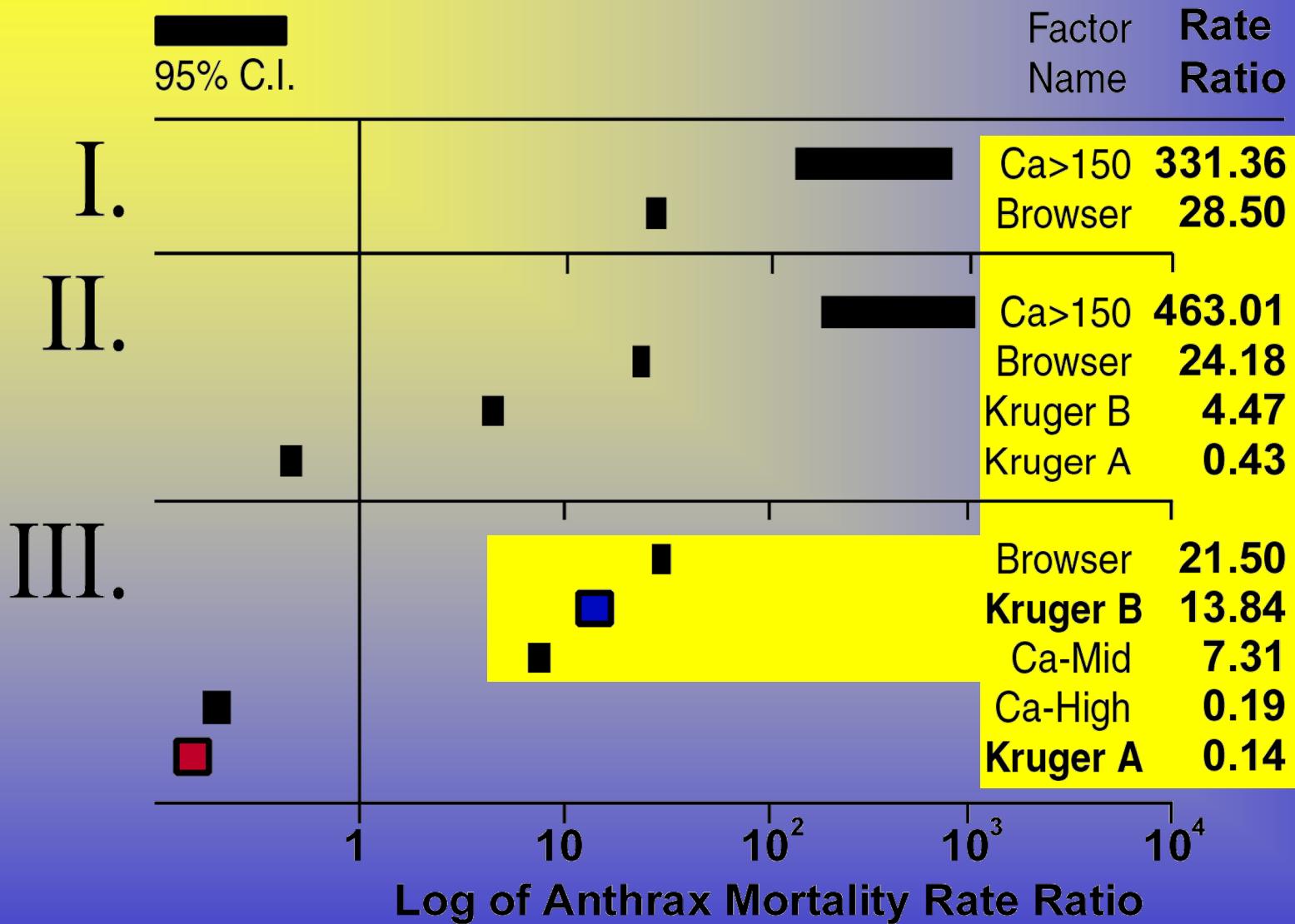
- Acquire additional population and mortality data to conduct an ecological study and Poisson regression of anthrax mortality rates
- Is there a measurable association between anthrax mortality rates and:
 - Topology?
 - Soil calcium and pH?
 - Browser effects?
 - Anthrax genotypic effects?

Anthrax Mortality in the KNP

- Kudu and Nyala have a higher mortality because of their browsing behavior.



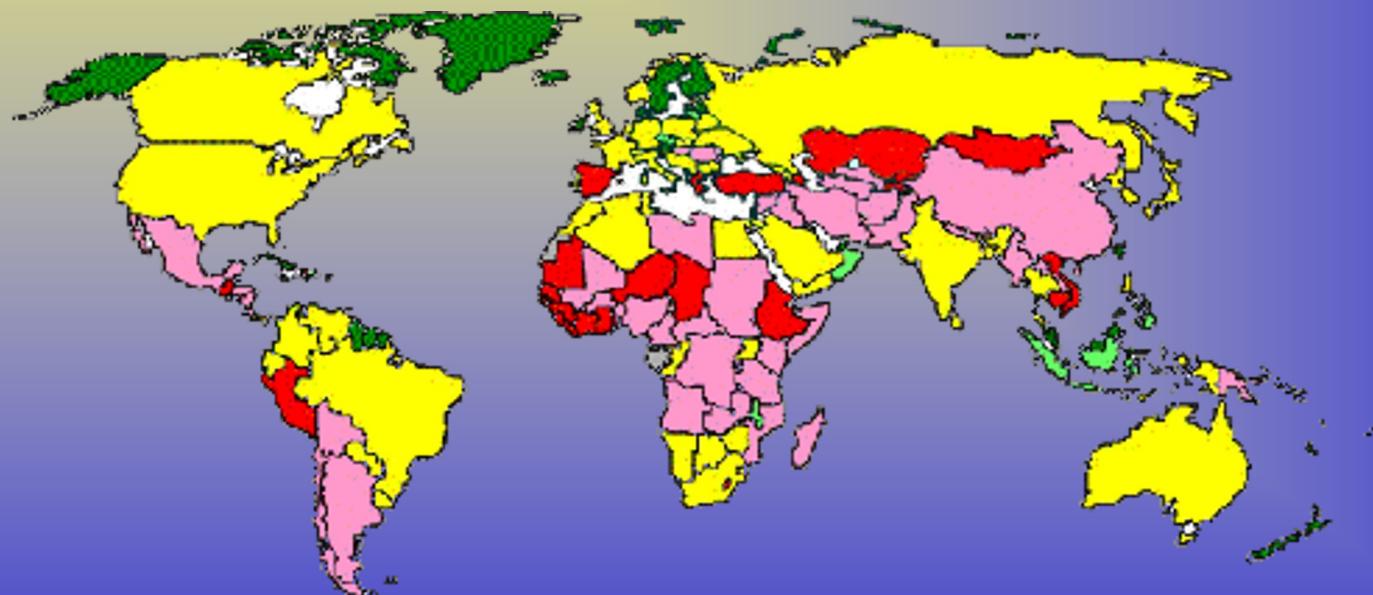
Exploration of Causal Effects of Mortalites



Summary

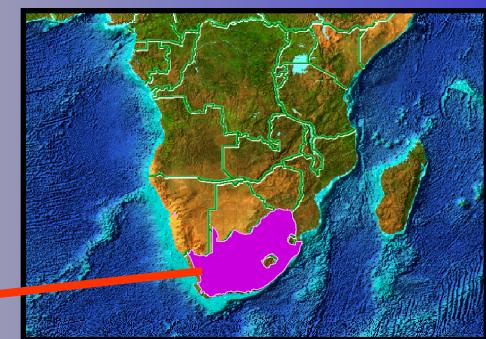
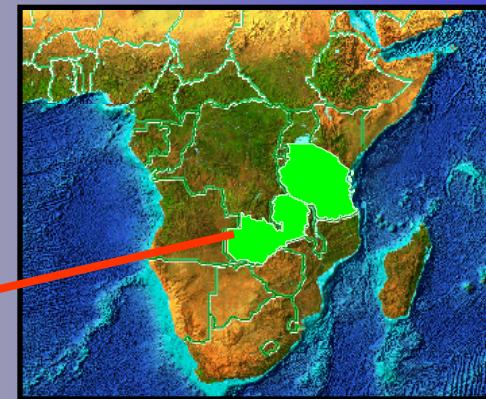
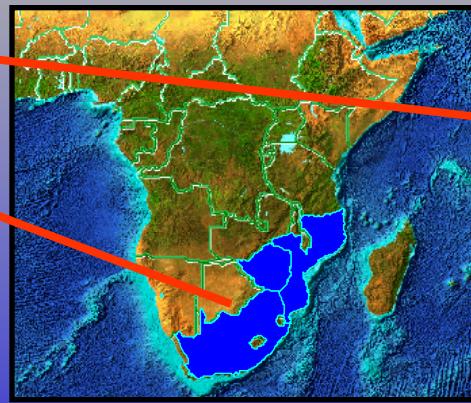
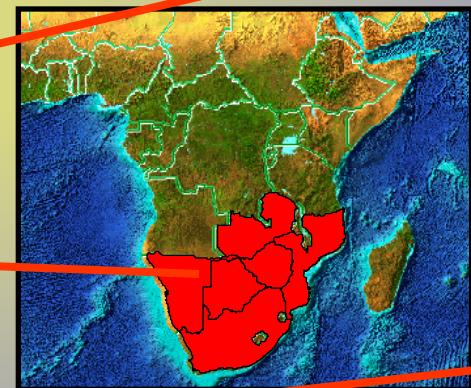
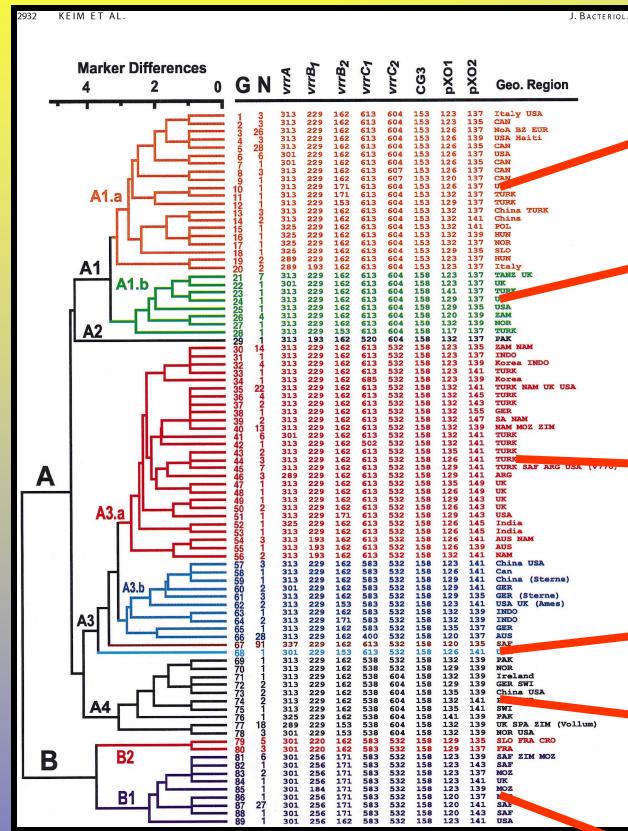
- Long co-existence
- Evidence of multiple foci
- Different environmental associations
- Browser effects on mortality
- Soil effects on mortality
- Genotypic group effects on mortality
- Bottleneck to distribution and diversity

Has the narrow environmental niche and higher mortality rate associated with branch B limited its distribution and diversity?

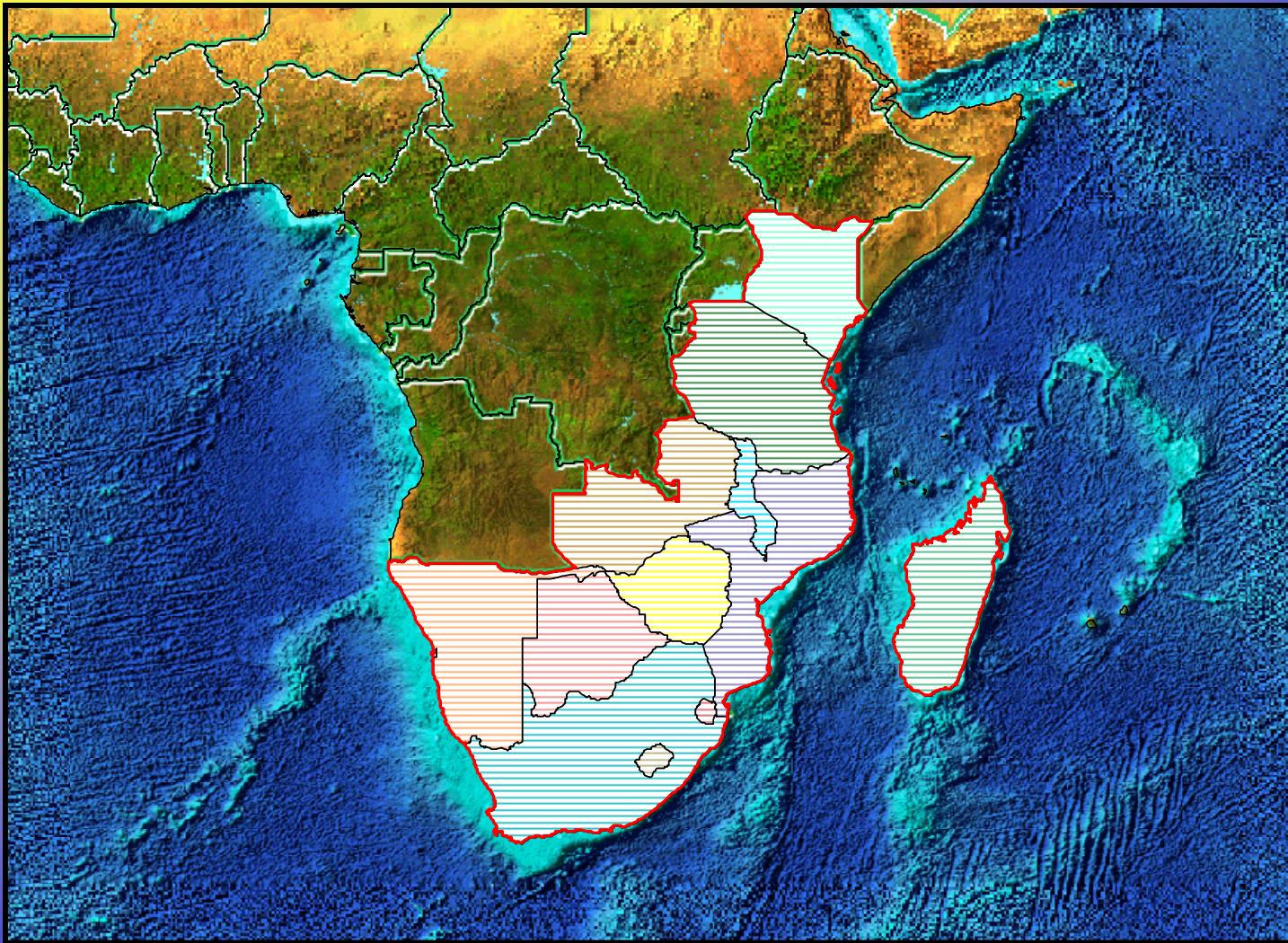


Ongoing Investigations

- National Institutes of Health funded study to investigate the evolution and epidemiology of *Bacillus anthracis*
 - North America
 - Central and South America
 - Southern Africa



Ongoing Studies: Africa



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ANTHRAX