

**Does frequent exposure  
to *Mycobacterium bovis*  
affect lion existence?**

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# Data collection and processing

- Ailing emaciated & Repeat Offender lions necropsied on an *Ad Hoc* basis (n = 180)
- Bacterial culture for *M. bovis* (n = 180)
- Intradermal tuberculin testing (n = 198)
- Sero-analysis & blood chemistry of samples collected. Western Blot Tests & Electrophoresis (n = 550)
- Monitor 32 (16 south & 16 north) radio-collared lions associating with 6 distinct prides and 3 peripheral prides for a period of 5 years
- Statistical analysis: Medical Research Council.  
Program: STATA Version 10

# GIS Mapping

- Aerial & ground radio tracking analysis.
- ArcGIS - ArcView from ESRI Version 9.2. (ESRI, 380 New York Street, Redlands, CA 92373-8100, USA)
- Hawth's Analysis Tools for ESRI's ArcGis. Available from:  
<http://www.spataleecology.com/htools>

# Results *M. bovis*

- **Aerosol transmission most important. Other routes are oral and peripheral.**
- **Cervical Intradermal tuberculin testing (Specificity 89% Sensitivity 86%) of apparently healthy lions indicated a prevalence of 82% in the HPZ (*Marula*), 52% in the MPZ (*Nkayeni*) & 7% in the LPZ (*Nxanatseni*) (n = 198).**

# Results *Feline Immunodeficiency Virus (FIV<sub>Ple</sub>)*

- Infection occurs throughout KNP at equal prevalence *i.e.* 61.76% (n = 455). Pearson chi2 Pr = 0.228 - Only lions in optimum condition were considered.
- Two subtypes of FIV<sub>Ple</sub> isolated from KNP.
- FIV<sub>Ple</sub> causes a moderate to severe CD4 depletion and a reduction of the CD4+/CD8+ ratio in lions. This indicates an as yet undefined immunological cost.
- Males (n = 144) become infected at an earlier age than females (n = 137). Two sample Ttest p = 0.02
- Prevalence increases with age with eventually no difference between sexes.
- 53% of lions in optimum condition tested for both pathogens in HPZ (n = 92) are co-infected.
- Primary route of transmission is through biting.

# **FIV<sub>Ple</sub> & *M. bovis***

- **No immunological relationship could be determined. Pearson chi2 Pr = 0.228**
- **Co-infection is probably only due to the high prevalence of both pathogens in the southern half of the KNP.**
- **Higher prevalence of sero-positivity for FIP, Fe Panleucopenia, Calici Virus and Ca Distemper was found amongst FIV<sub>Ple</sub> positive lions (n = 275) in KNP.**

# Average ages for infection classes.

\*Only lions in optimum condition were considered & where BTB was included lions had to originate from infected areas.

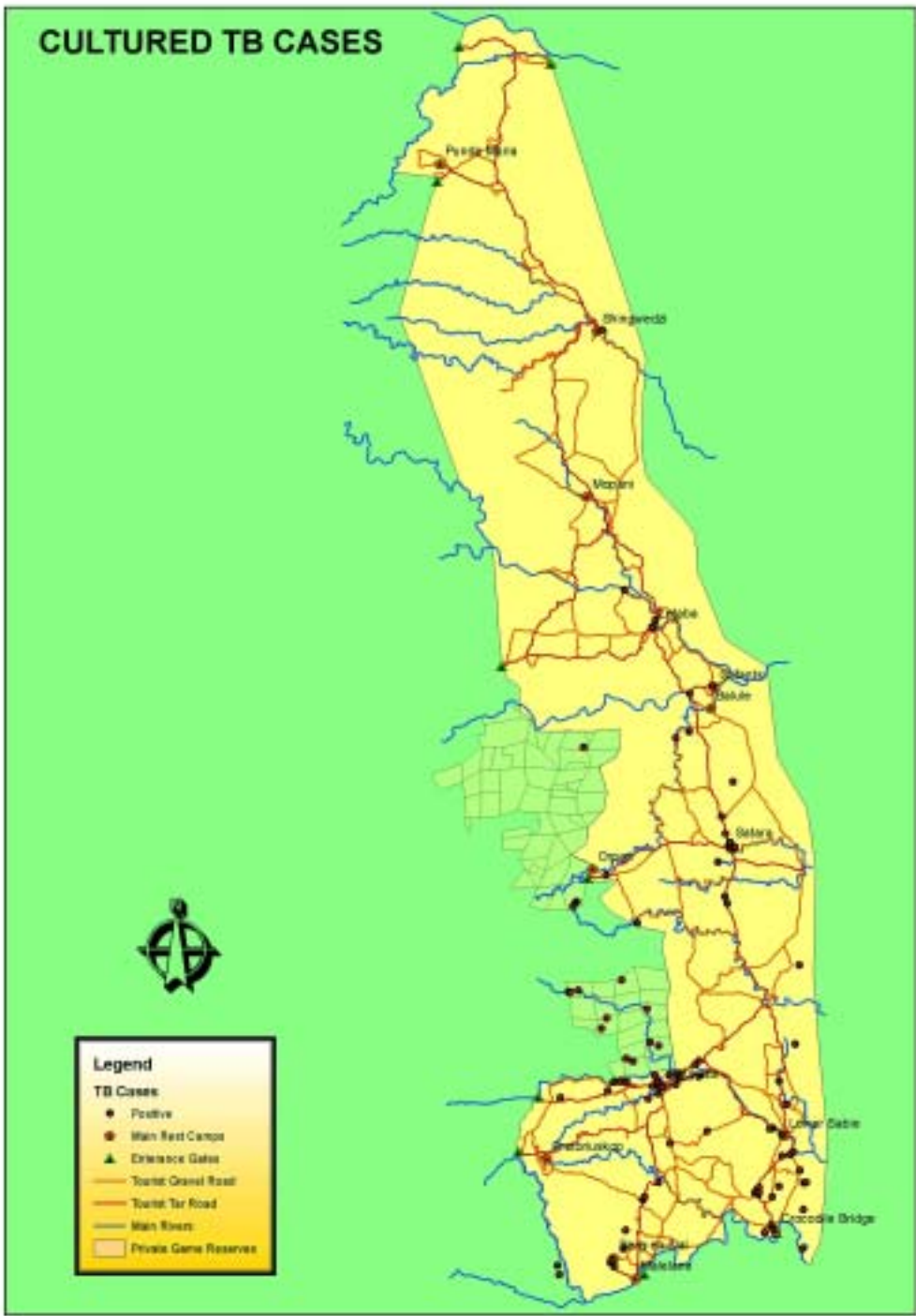
Calculations were done at 95% confidence intervals.

	FIV-ve	FIV+ve	BTB-ve	BTB+ve	FIV/BT B-	FIV/BT B+	Necrop FIV/BT B+
<b>M</b>	41.15 ± 5.31 N = 78	60.22 ± 4.27 N = 144	44.36 ± 8.64 N = 30	56.95 ± 6.95 N = 64	37.83 ± 17.59 N = 6	68.34 ± 8.01 N = 43	85.28 ± 14.92 N = 25
<b>F</b>	54.82 ± 6.08 N = 96	68.16 ± 5.28 N = 137	44.91 ± 7.15 N = 48	63.83 ± 7.86 N = 60	38.58 ± 13.47 N = 17	67.00 ± 10.69 N = 21	96.5 ± 16.72 N = 18

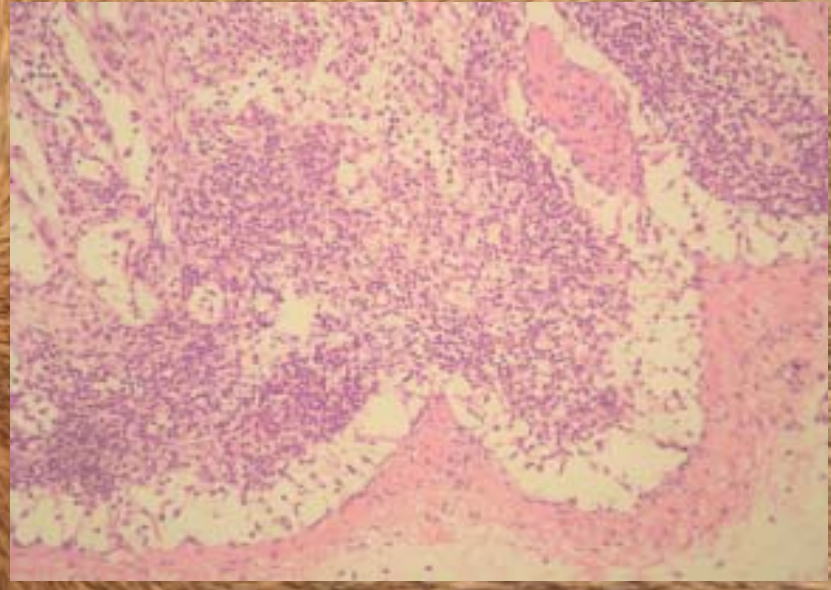
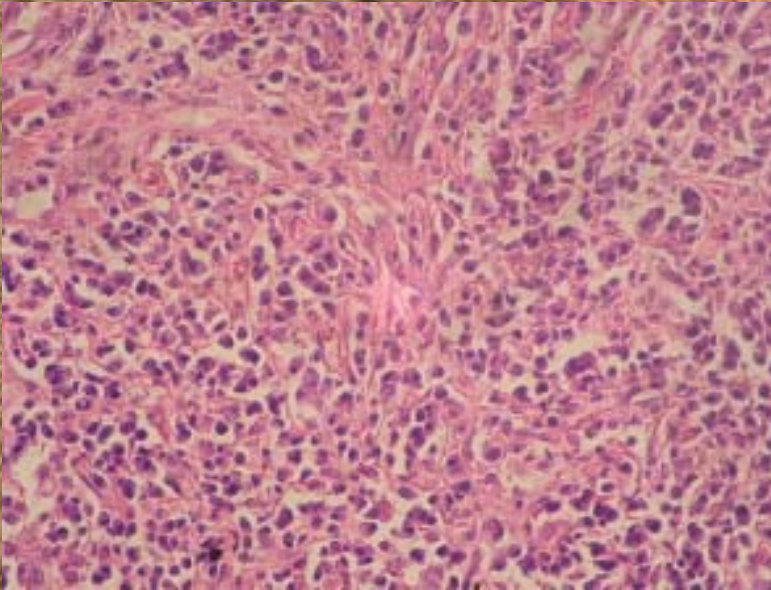
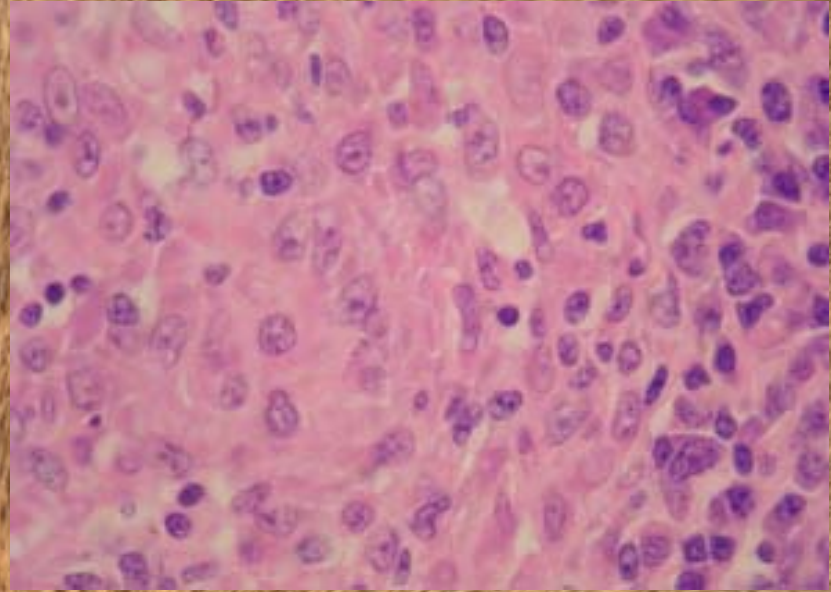
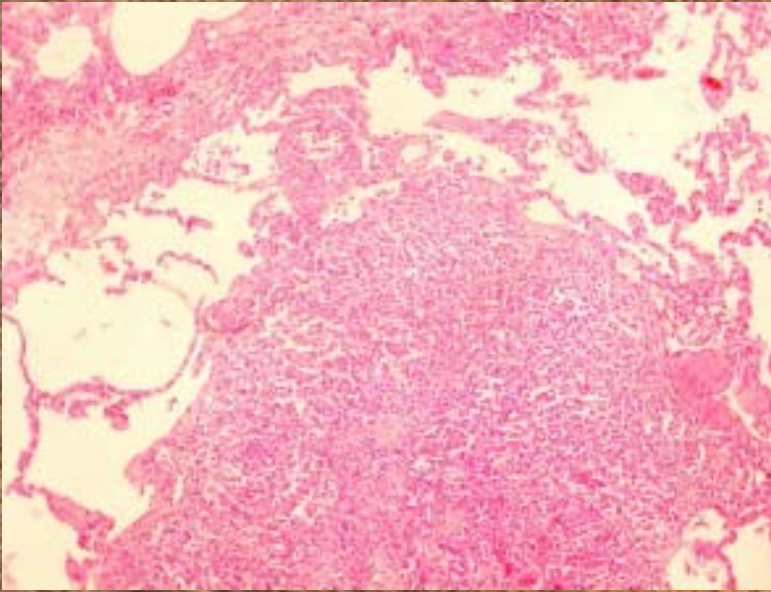
# Necropsy Results

- **Necropsied co-infected ailing lions (n = 43) showed more severe lesions and multi-systemic, extra-pulmonary tuberculous infections and specifically more musculo-skeletal pathology (n = 25) when compared to BTB-only, FIV-only or negative lions.**
- **These clinical findings are similar to that of HIV/Tuberculosis infection.**

# CULTURED TB CASES



# Histology



## Parameters evaluated histologically

FIV/BTB+ group was compared to Uninfected, FIV+, BTB+ groups  
(n = 87)

- Total lesion index: Bonferoni  $p = 0.007$
- Lymphoid atrophy: Fisher exact  $p = 0.028$
- Granulomatous lymphadenitis: Fisher exact  $p = 0.001$
- Plasmacytic infiltration: Fisher exact  $p = 0.114$
- Granulomatous pneumonia: Fisher exact  $p = 0.002$
- Chronic pleuritis: Fisher exact  $p = 0.5$
- Renal amyloidosis: Fisher exact  $p = 0.387$

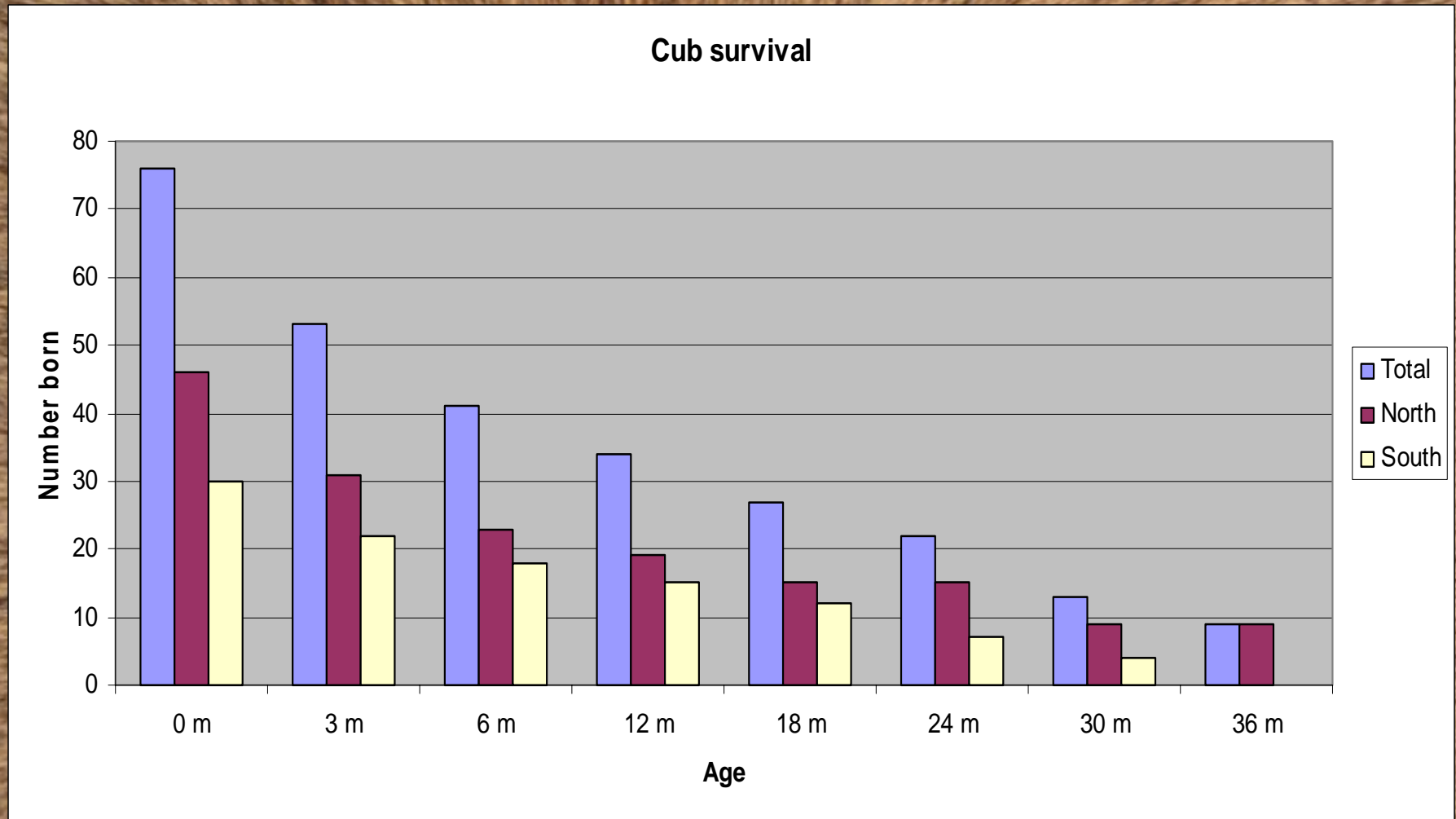
## **Terminal cases where both FIV<sub>Plc</sub> & BTB status was determined (n = 124)**

- Co-infected lions had more multi systemic, extra-pulmonary infections than other infected groups. Fisher exact p = 0.000**
- Co-infected lions had more musculo-skeletal pathology than other infected groups. Fisher exact p = 0.000**
- Co-infected males succumbed at an earlier age (X = 85.28mnts) than females (X = 96.5mnts) Two sample Ttest p =0.01**

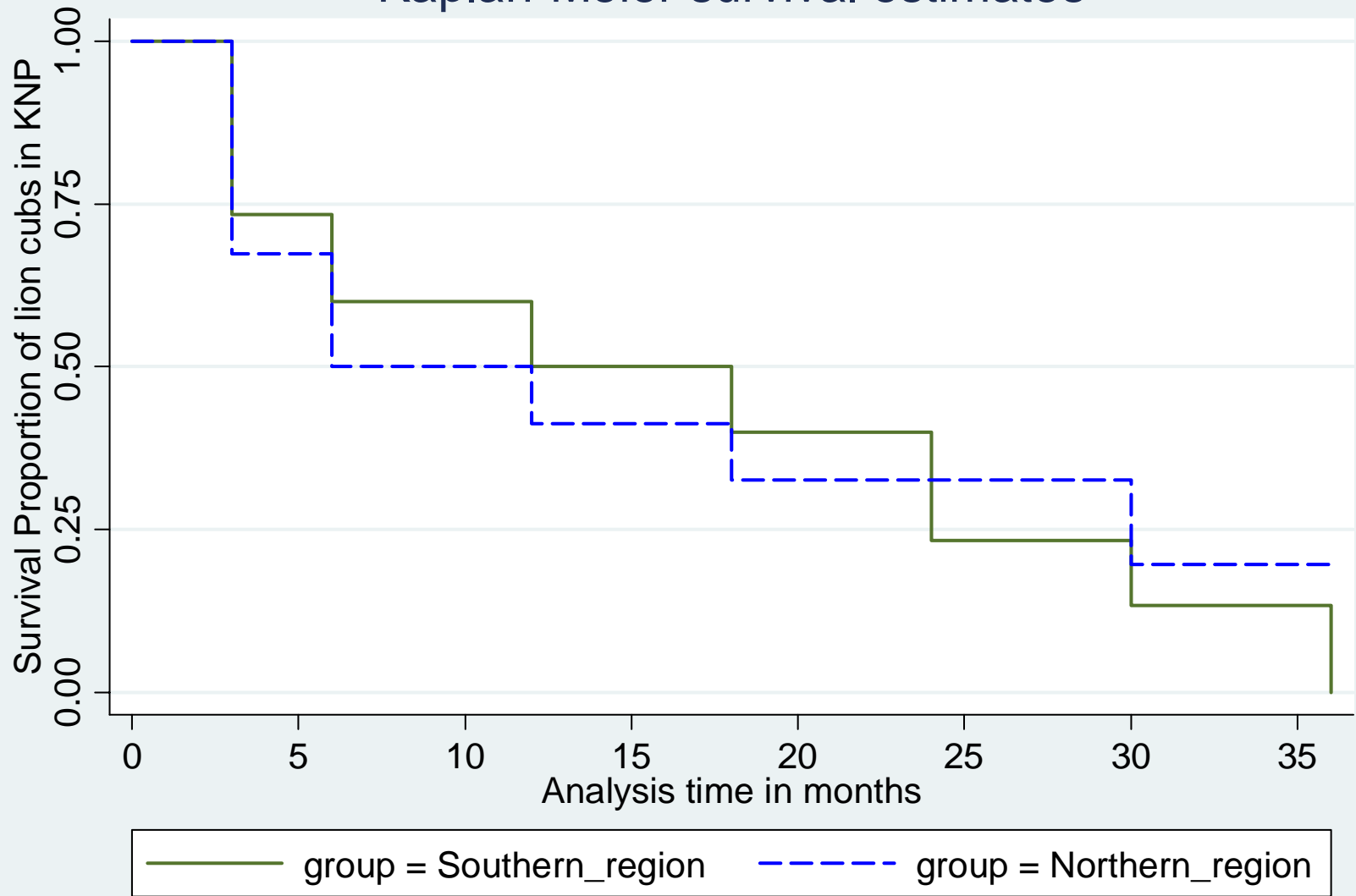
# Other clinical parameters investigated

- Albumin levels decrease: Bartlett's chi2 p = 0.000
- Albumin globulin ratio decreases: Bonferoni p = 0.003
- Beta globulin levels decrease: ANOVA p = 0.2
- Gamma globulin levels increase: Bartlett's chi2 p = 0.272
- Hemoglobin decreases: Ttest p = 0.0188, Mann-Whitney p = 0.0193
- Hematocrit decreases: Ttest p = 0.0491, Mann-Whitney p = 0.0897

# Comparative study – cub survival



## Kaplan-Meier survival estimates



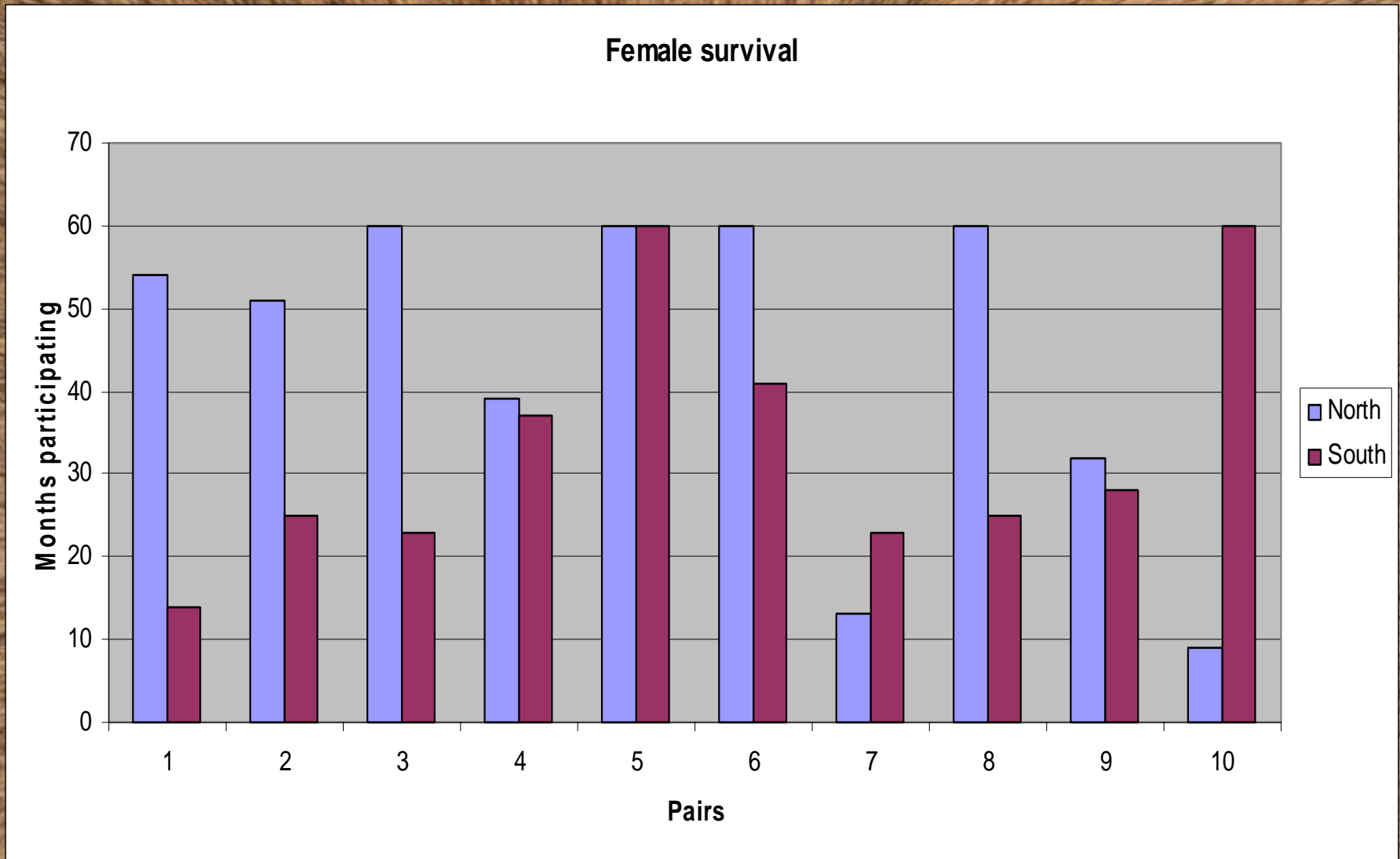
# Cub survival

- **No significant difference could be found between infected and non-infected groups. Wald chi2 = 0.7167 This in spite of survival of 9 sub-adults in north.**
- **Factors – eviction of two entire infected prides *i.e.* no more participation.**
- **Extended tenure in infected Ngomondwane pride – only one cohort of cubs born. Followed by staggered unsynchronized births and not in viable cohorts.**

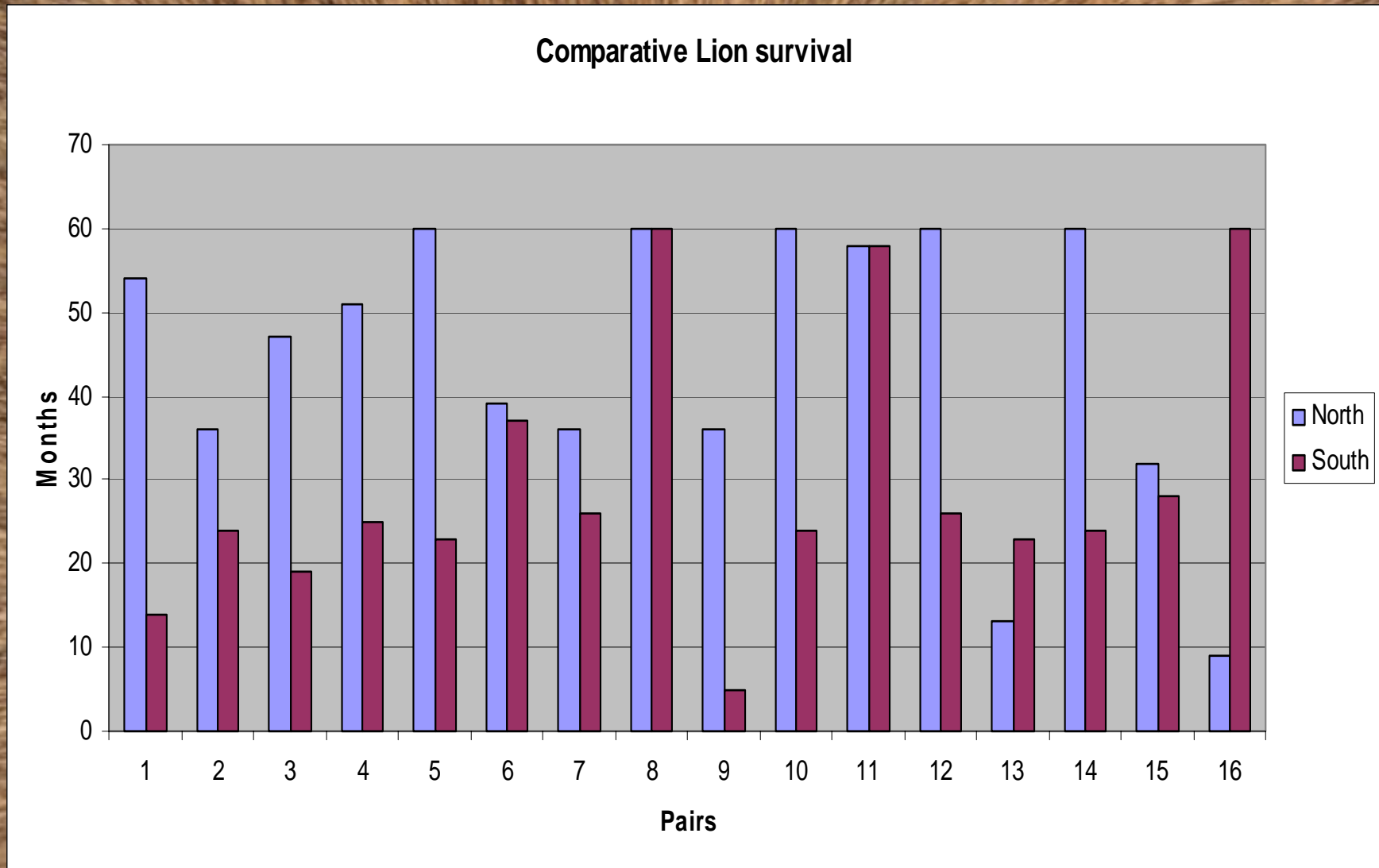
# Male survival – Ttest $p = 0.019$



# Female survival - Ttest $p = 0.13$



# Comparative survival – Ttest $p = 0.009$ Mann-Whitney $p = 0.0053$



# Co-infection development in long-term study lions

- South (16 BTB positive lions)

Necropsies on 8 lions.

At the start of the study 5/8 were sero-negative for FIV.

At the time of necropsy 8/8 were co-infected.

- North (16 BTB negative lions)

Necropsies on 4 lions.

At the start of the study 4/4 were sero-positive for FIV.

Necropsy – 3/4 were sero-positive for FIV<sub>Plc</sub>.

- One geriatric lioness became negative during terminal phase.

# Lion density in two study regions

- Determined through All Night calling stations during optimum conditions in 1999, 2002 & 2004.
- North Study area size: 1 456.07 km<sup>2</sup>
- $X = 42.66667$  lions  $\pm 3.103889$
- Minimum of 2.72 & max 3.14 lions per 100 km<sup>2</sup>
- South Study Area size: 558.96 km<sup>2</sup>
- $X = 42.25 \pm 2.93026$
- Minimum of 7.03 & max 8.08 lions per 100 km<sup>2</sup>
- Lion density determined by minimum available prey biomass. Available prey biomass in the north (865.5 kg/km<sup>2</sup>) much lower than in the central (1 866.3 kg/km<sup>2</sup>) and south (1 173.7 kg/km<sup>2</sup>)(1994 Data).





# Pride Territory sizes determined over 5 years

- South

Crocodile Bridge 41.12 km<sup>2</sup>

Nhlanganzwane 70.14 km<sup>2</sup>

Ngomondwane 89.09 km<sup>2</sup>

- North

Hlamalala 297.42 km<sup>2</sup>

Boyela 601.12 km<sup>2</sup>

Nkulumbeni 288.80 km<sup>2</sup>

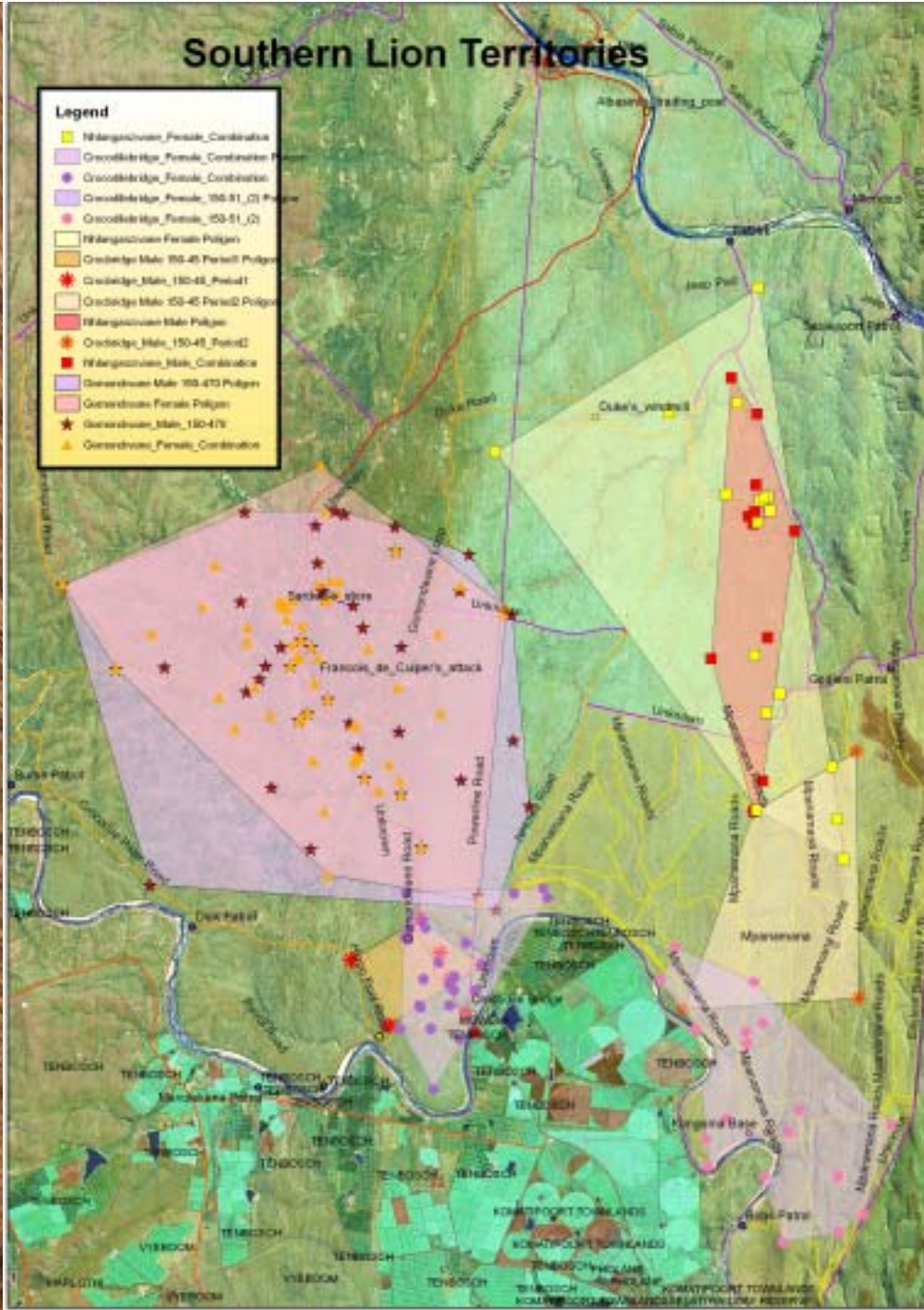


# Coalition Tenure: South

- **Crocodile Bridge, 2 males: 13 months**  
**Area: 5.39 km<sup>2</sup>**
- **Nhlanganzwane, 2 males: 24 months**  
**Area: 16.04 km<sup>2</sup>**
- **Ngomondwane, 2 males: 63 months**  
**Area: 113.28 km<sup>2</sup>**

# Southern Lion Territories

- Legend**
- Ntlangeniwe Female Coordinate
  - Grootkloof Female Coordinate
  - Grootkloof Female Coordinate
  - Grootkloof Male 150-81 (2) Polgen
  - Grootkloof Male 150-81 (2)
  - Ntlangeniwe Female Polgen
  - Grootkloof Male 150-45 Period1 Polgen
  - Grootkloof Male 150-45 Period2 Polgen
  - Ntlangeniwe Male Polgen
  - Grootkloof Male 150-45 Period2
  - Ntlangeniwe Male Coordinate
  - Grootkloof Male 150-47 Polgen
  - Grootkloof Female Polgen
  - ★ Grootkloof Male 150-47
  - ▲ Grootkloof Female Coordinate



# Coalition Tenure: North

- **Boyela period 1: 4 males, 25 months**  
**Area 222.76 km<sup>2</sup>**
- **Boyela period 2: 3 males, 33 months**  
**Area 467.38 km<sup>2</sup>**
- **Langtoon period 1: 3 males, 23 months**  
**Area 417.13 km<sup>2</sup>**
- **Langtoon period 2: 2 males, 25 months**

# Coalition Tenure Nkulumbeni

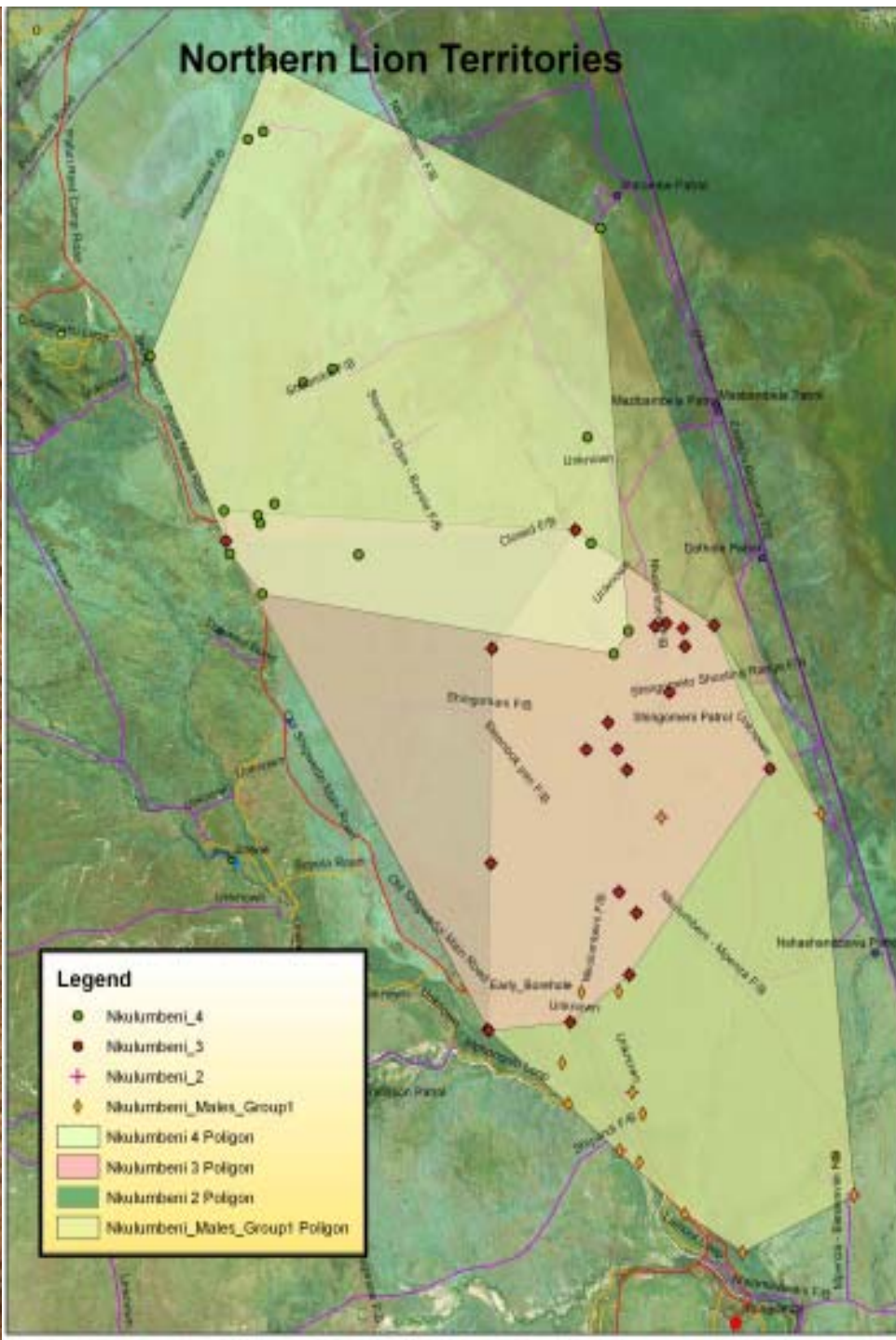
- Nkulumbeni period 1: 5 males, 30 months  
Area 302.98 km<sup>2</sup>
- Nkulumbeni period 2: 4 males, 27 months  
Area 417.59 km<sup>2</sup>
- Nkulumbeni period 3: 3 males, 29 months  
Area 278.56 km<sup>2</sup>
- Nkulumbeni period 4: 3 males, 23 months  
Area 323.85 km<sup>2</sup>



# Northern Lion Territories

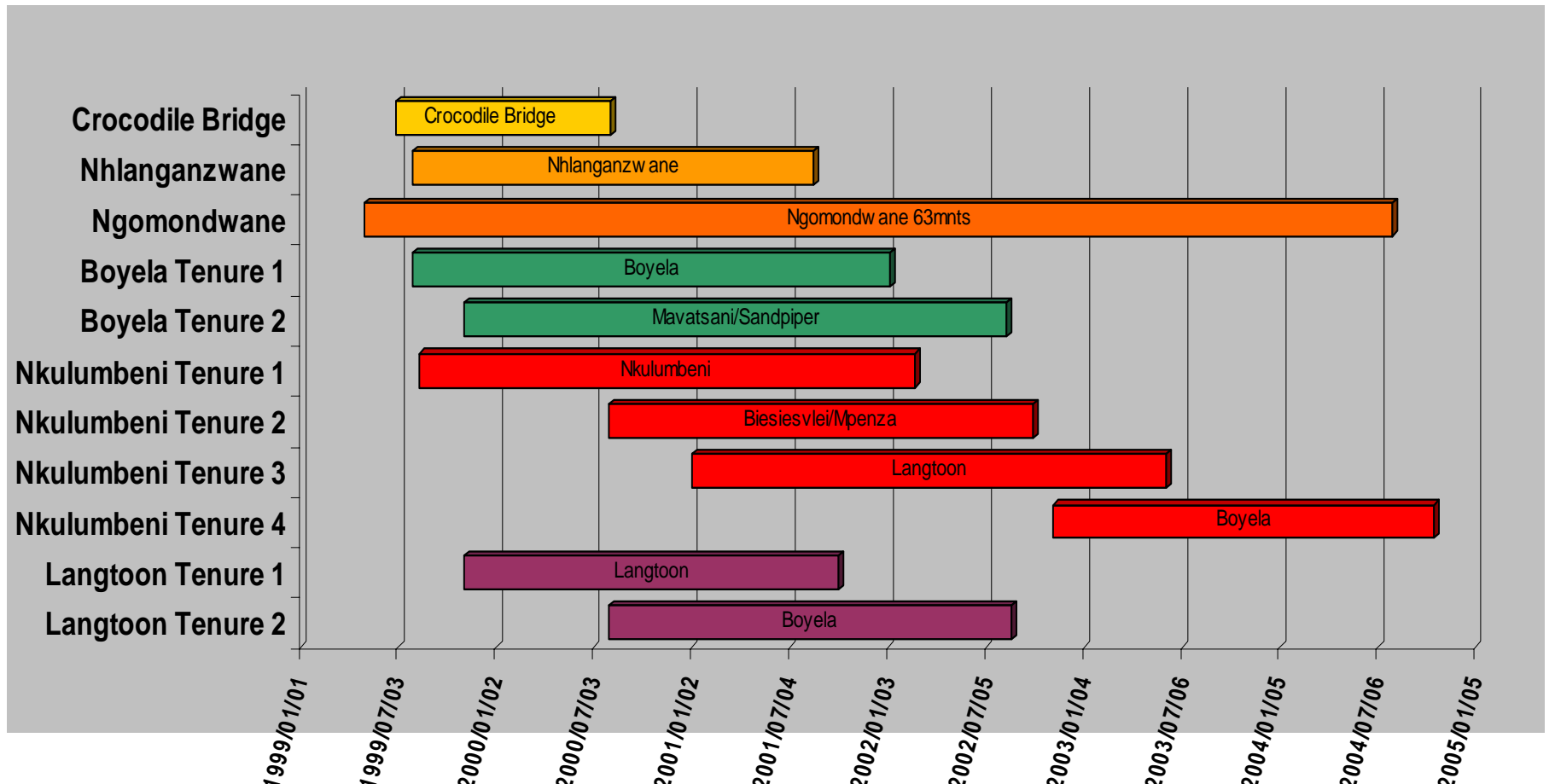
**Legend**

- Nukulumbeni\_4
- Nukulumbeni\_3
- Nukulumbeni\_2
- Nukulumbeni\_Males\_Group1
- Nukulumbeni 4 Polygon
- Nukulumbeni 3 Polygon
- Nukulumbeni 2 Polygon
- Nukulumbeni\_Males\_Group1 Polygon



# Coalition Tenure

## Coalition Tenure



# Summary

- **Co-infected lions are more compromised.**
- **Proportion of co-infected lions in the southern half is high.**
- **Male lions become co-infected earlier in life probably due to specific behaviour patterns.**
- **No difference in reproduction or recruitment could be found.**
- **Northern lions lived longer than southern lions.**
- **No difference could be found between female sub populations. However 2 southern prides were evicted.**
- **Larger male coalitions typically associate with more prides and often simultaneously.**
- **Northern pride territories are overwhelmingly larger than in the south.**

# Acknowledgements

- **South African Veterinary Foundation for financial and logistical support.**
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