Geographic risk factors for anthrax in the Serengeti ecosystem

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Introduction

Anthrax (pathogen *Bacillus anthracis*) is a zoonotic and frequently fatal disease (Figure 1) widespread throughout Africa. In the Serengeti ecosystem (Tanzania: Figure 2) cases of anthrax occur as both endemic cases and as outbreaks (Figure 3). In different environments anthrax cases have been associated with sudden rainfall and soil nutrient availability (Hugh-Jones and deVos, 2002). The recent finding of high seroprevalences of anthrax antibodies in dogs provided the stimulus for using these data for analysis of risk factors. These data, together with data on the location of cases during a recent wildlife outbreak were used to investigate environmental risk factors for anthrax infection in the Serengeti, specifically:

1. To investigate soil-based risk factors for anthrax infection using seroprevalence patterns in dogs.
2. To investigate clustering of cases in buffalo around rivers.

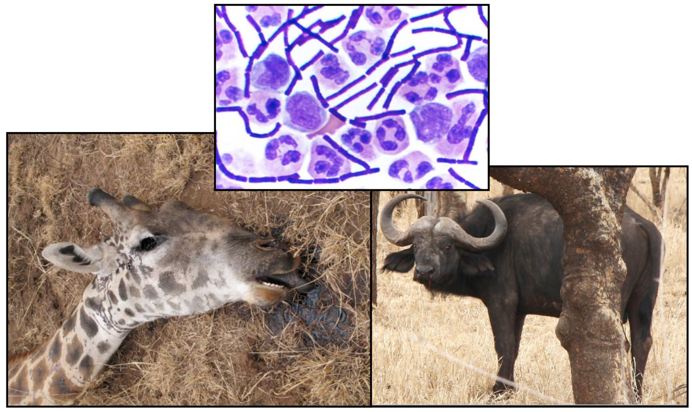

Figure 1. Clockwise from top: *Bacillus anthracis* among white blood cells, live buffalo with acute anthrax infection, giraffe fatality with characteristic bleeding from the mouth. Photos courtesy of the TAWIRI-Messerli Foundation Wildlife Veterinary Programme

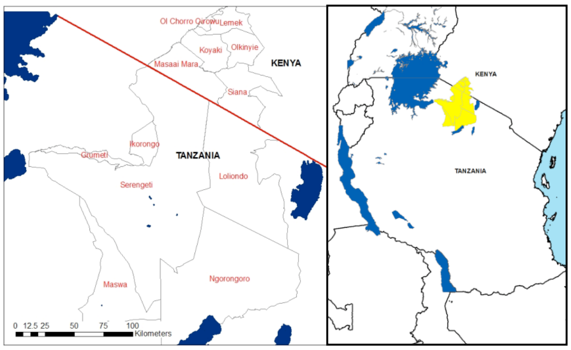

Figure 2. Map of the Serengeti ecosystem and its location within Tanzania (inset).

Methods

Serum samples from 314 dogs in 24 villages surrounding the Serengeti ecosystem (Figure 3) were tested for antibodies to *Bacillus anthracis.* These data were analysed with respect to soil related variables derived from the harmonised world soil database (FAO/IIASA/ISRIC/ISSCAS/JRC, 2009). Multivariate analysis followed univariate screening in a mixed logistic regression model in which the antibody status of the dog was the outcome and the village was the random effect. The estimated age of the animal and the district of the village were included in addition to the soil predictors as fixed effects.

81 confirmed anthrax cases in buffalo during an outbreak in the Maswa district in November 2009 were georeferenced (Figure 3). Using a 2-sided t-test the distances of the cases to rivers were compared to the expected distances if buffalo were distributed homogeneously.

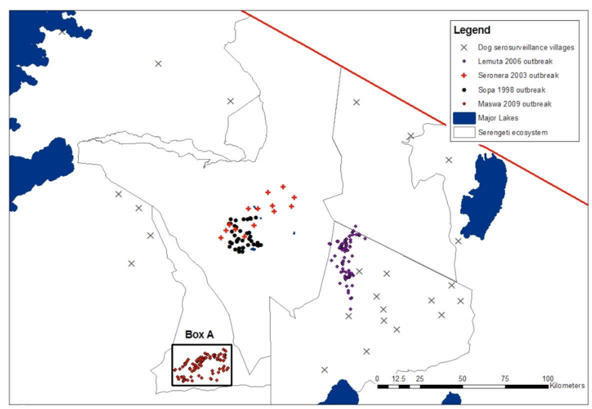

Figure 3. Map of outbreaks of anthrax in wildlife in the Serengeti ecosystem and the locations of villages in which dog serum was sampled. Box A corresponds to the area of Figure 5.

Results

The cation exchange capacity (CEC) of the clay components of the soil was positively associated with seroconversion to antibodies to anthrax (OR = 1.044 (95% CIs = 1.003, 1.086), Table 1, Figure 4).

The Maswa buffalo outbreak was found to be 202m (95% CIs = 78, 326m, t = -3.25, p = 0.002) closer to river than expectation (Figure 5).

Predictor	Unit	Estimate	SE	z-score	p-value	OR (95% CI)
Intercept		-7.917	1.596	-4.960	<0.001	NA
Age	Months	0.042	0.011	3.999	<0.001	1.043 (1.022, 1.065)
Area	West	-	-	-	-	1
	Loliondo	3.013	1.474	2.044	0.041	20.36 (1.133, 366.0)
	NCA	3.807	1.202	3.167	0.002	45.03 (4.269, 475.1)
CEC		0.043	0.020	2.113	0.035	1.044 (1.003, 1.086)

Table 1. Results of multivariate mixed logistic regression analysis

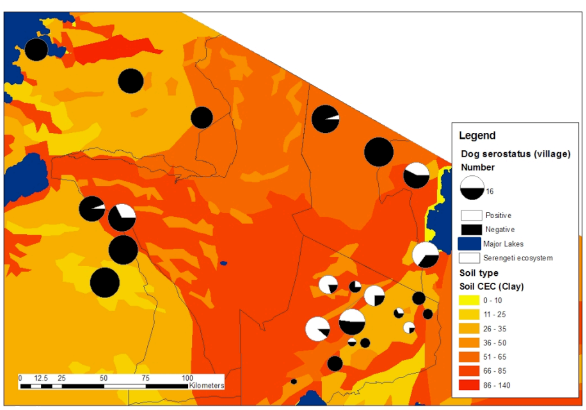

Figure 4. Map of village level seroprevalence in relation to soil CEC (clay component)

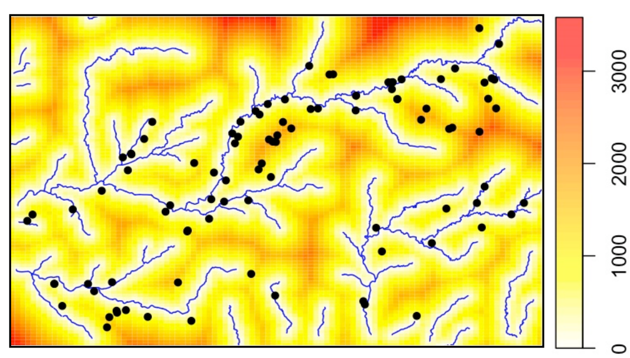

Figure 5. Map of confirmed anthrax cases in buffalo (black points) in relation to rivers (blue lines) in the Maswa district - an outbreak that followed a prolonged dry period. Colour bar represents distance to rivers in meters. The map area corresponds to Figure 3; Box A.

Discussion

This paper has demonstrated that anthrax risk is related to properties of the soil that determine nutrient availability. This supports the suggestion by Hugh-Jones and de Vos (2002) that properties of the soil support anthrax spores. It also demonstrates the value of non-case (seroconversion data) in a sentinel species (Halliday et al. 2007). Furthermore, these analysis provide evidence for an association with outbreaks and proximity to rivers. Several possible explanations exist for this association including lack of rainfall and the distribution of buffalo in the area.

References

Hugh-Jones and de Vos (2002). Rev Sci Tech. Aug;21(2):359-83.

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Acknowledgements

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