

Modeling the control of canine rabies

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<http://www.ici3d.org/daidd/>

Outline

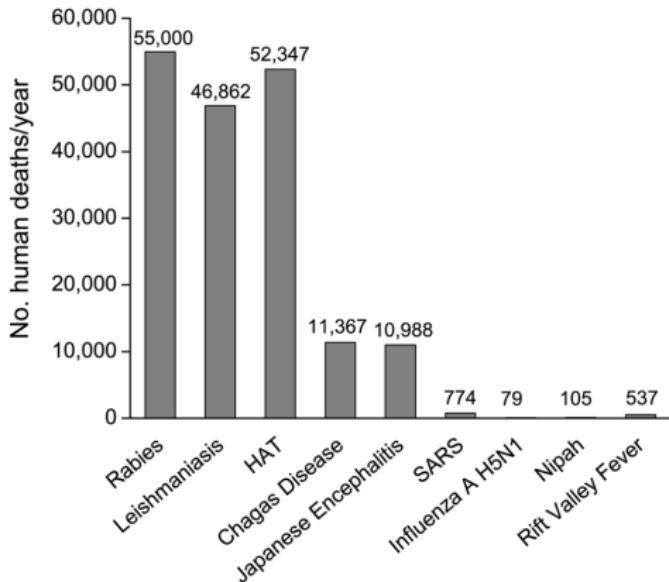
Introduction

Synchrony and periodicity

Reservoirs

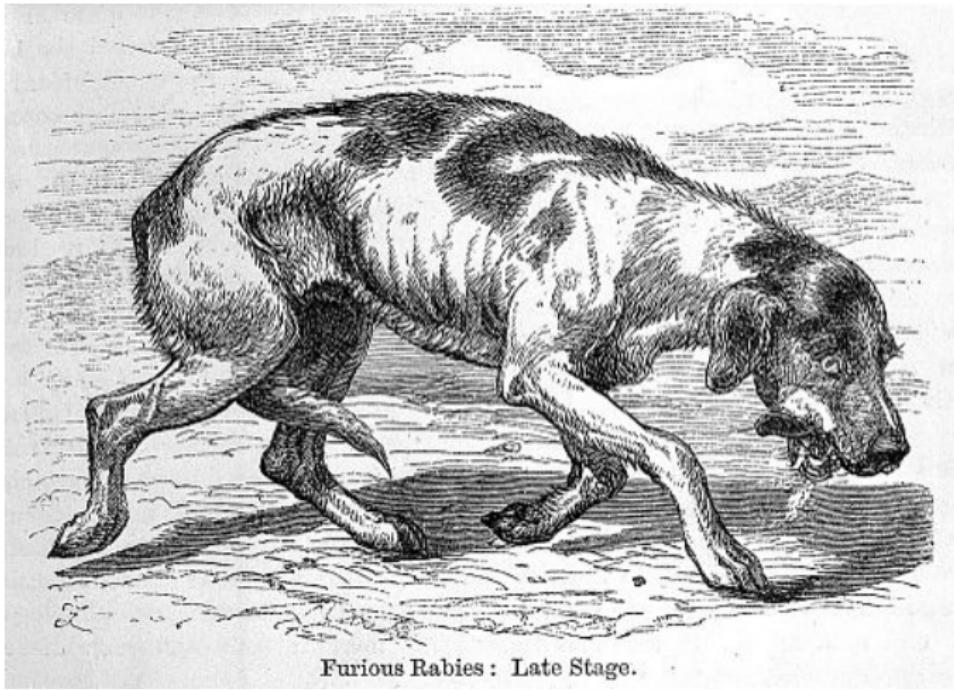
Transmission details

Rabies is an under-rated disease



Lembo et. al, PLoS NTDs

Rabies is scary



Furious Rabies : Late Stage.

Rabies is expensive



Effective, economical control measures are available



Outline

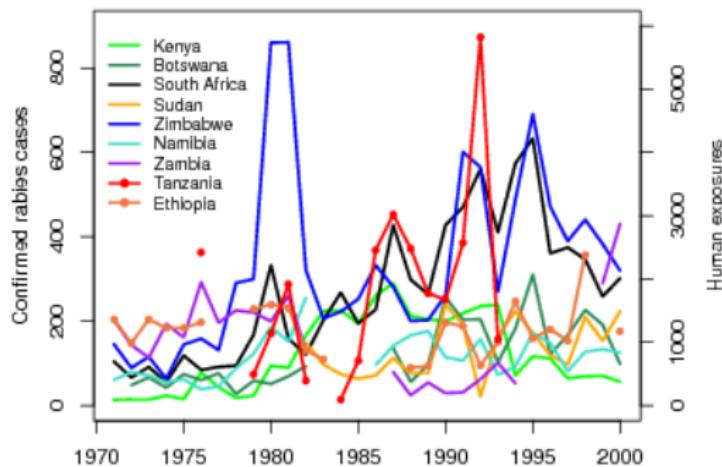
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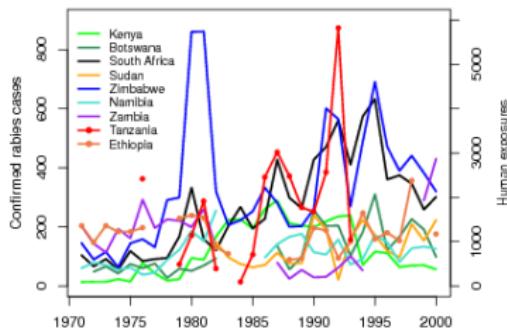
Transmission details

Spatiotemporal patterns of rabies in Africa



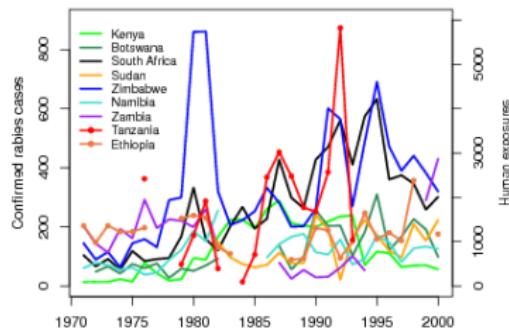
Hampson et al., PNAS, 2007

Synchrony



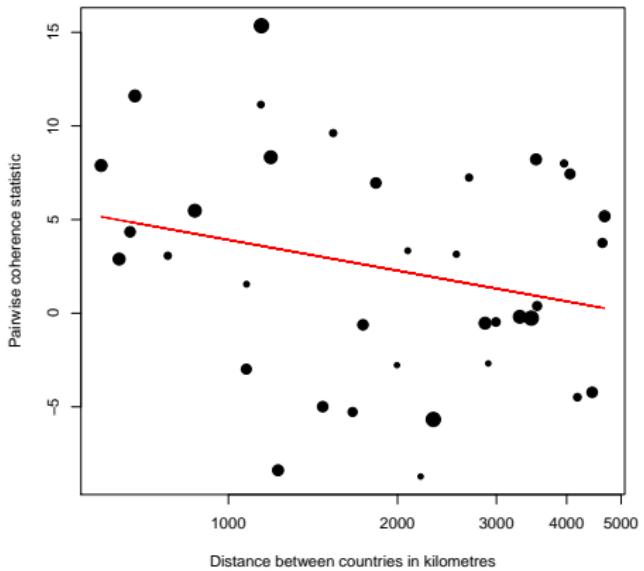
- ▶ What is a fair way to compare these to a null (unsynchronized) model?

Synchrony

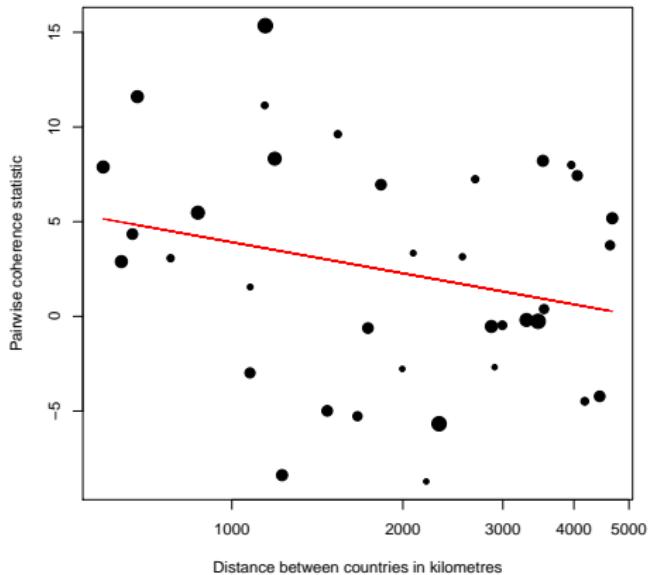


- ▶ Randomize starting points, not each point individually

Geographic correlations

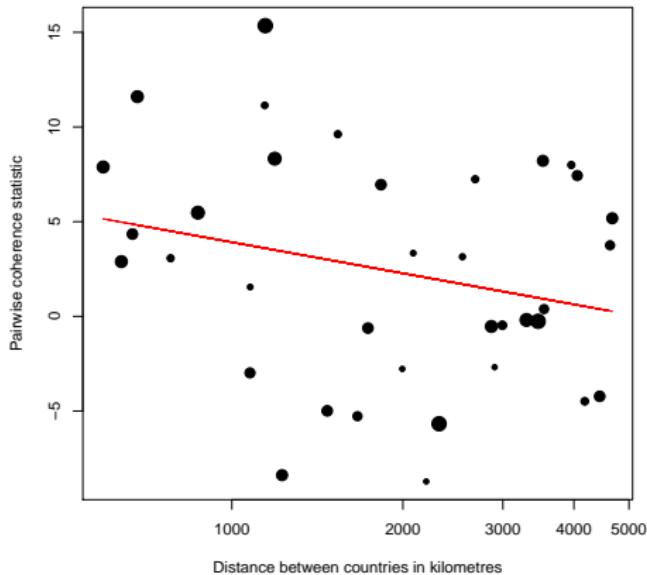


Geographic correlations



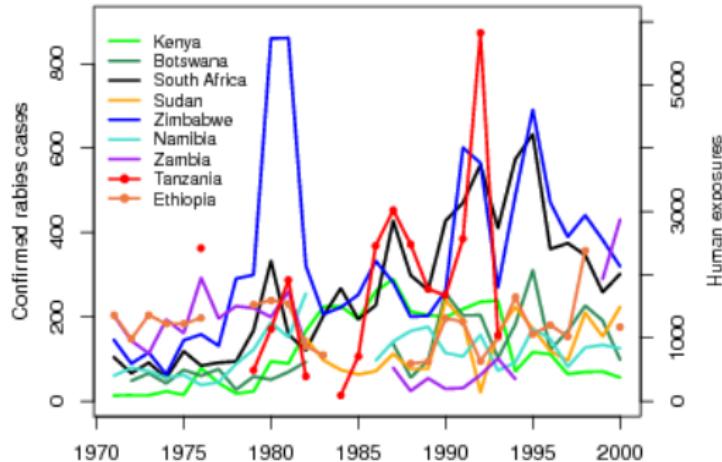
- ▶ What is a fair way to compare *these* to a null model

Geographic correlations



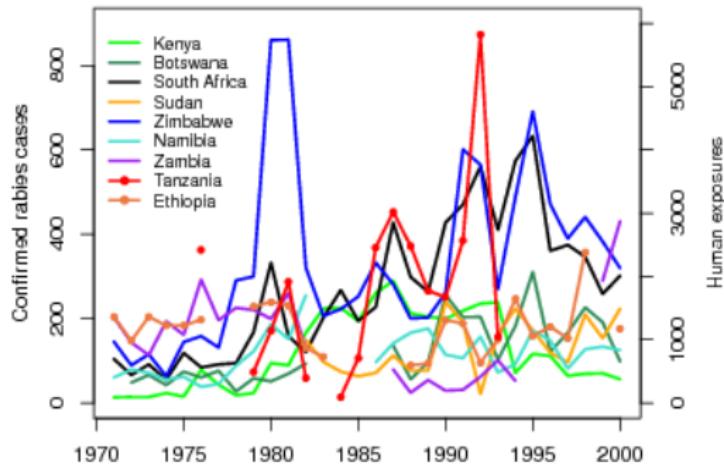
- ▶ Randomize one of the *country lists*, not the individual points

Periodicity



- ▶ What is a fair way to compare these to a null (non-periodic) model?

Periodicity



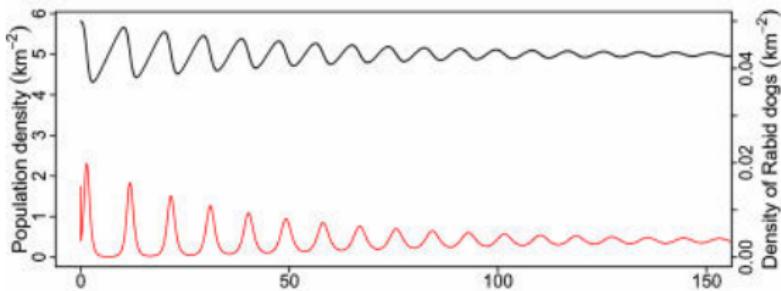
- ▶ Randomize *differences* rather than observations

Results

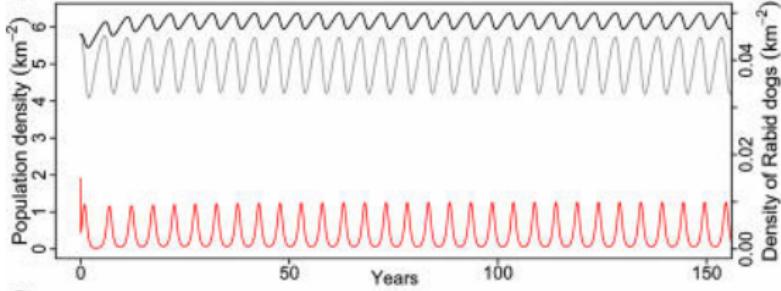
- ▶ Rabies in Africa is
 - ▶ Synchronized at a large spatial scale
 - ▶ Periodic
 - ▶ Fast (ie., cycles are faster than simple models can predict)

Explaining fast cycles

A



B



Conclusions

- ▶ Rabies in Africa is synchronous and periodic
- ▶ Synchrony may be due to weak coupling by cross-border transmission, or by cross-border response
 - ▶ We don't believe it's due to temporal changes in reporting
- ▶ Evidence for ebbs and flows in human response
- ▶ Calls for a consistent, co-ordinated effort at control

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Synchrony and periodicity

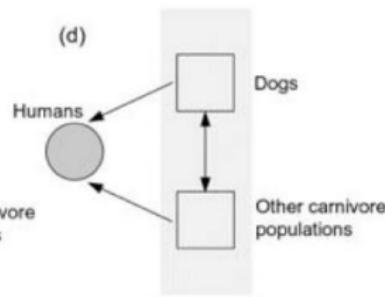
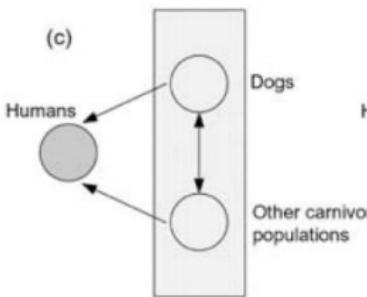
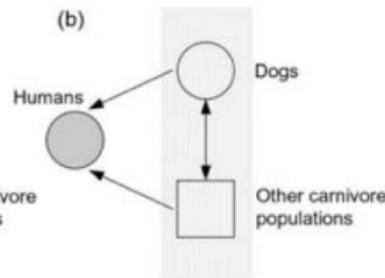
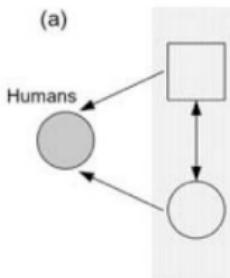
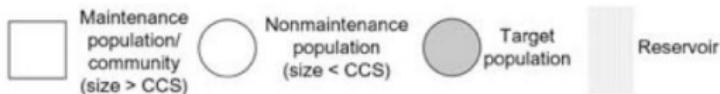
Reservoirs

Transmission details

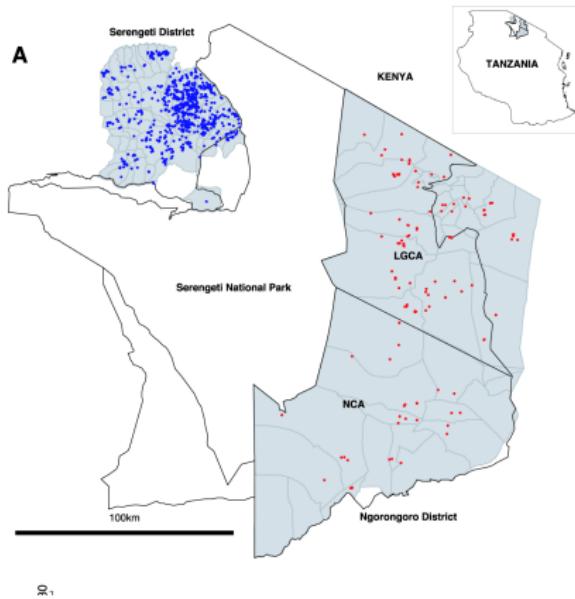
Multiple populations



Maintenance populations



NW Tanzania study



Hampson et al. PLoS Biology

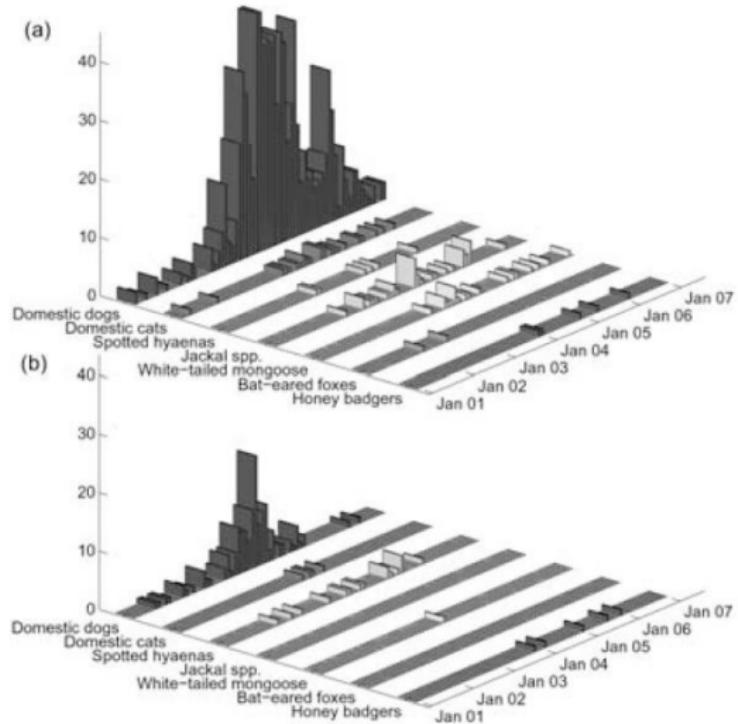
Ngorongoro district



Serengeti district

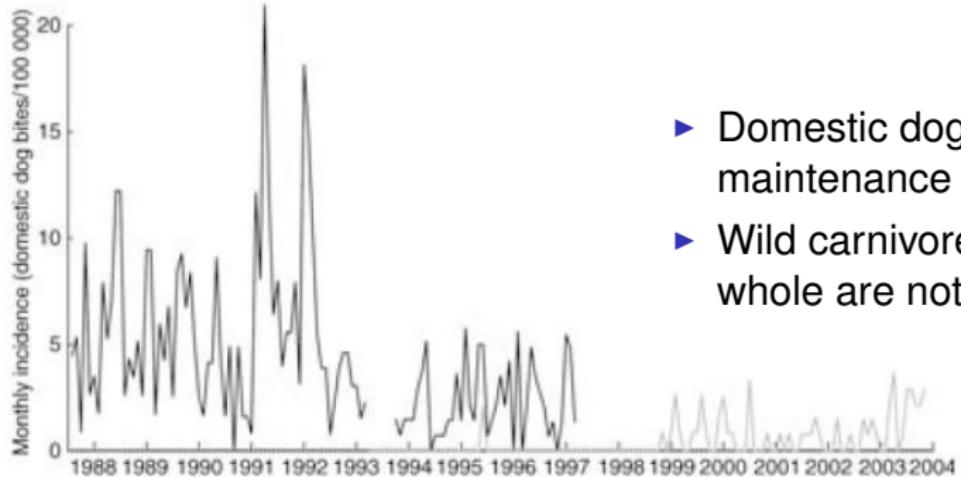


Rabies cases identified



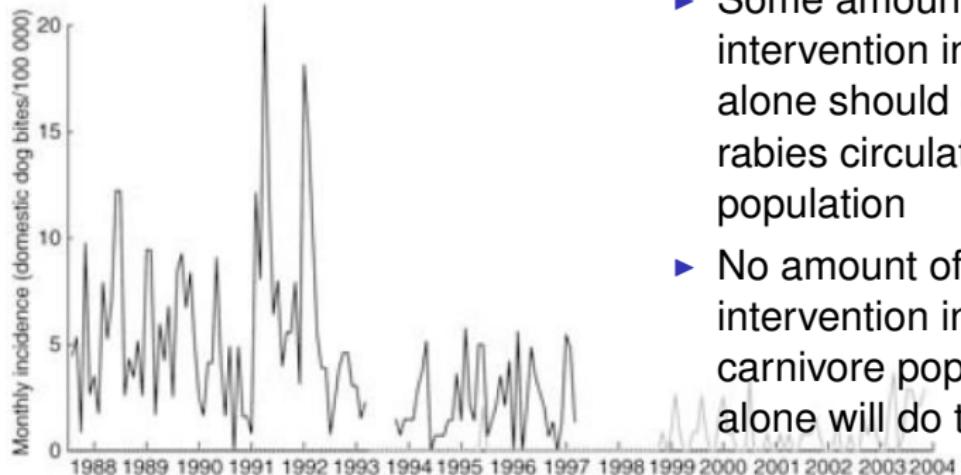
Lembo et al. 2008 J. App. Ecol.

Model fitting



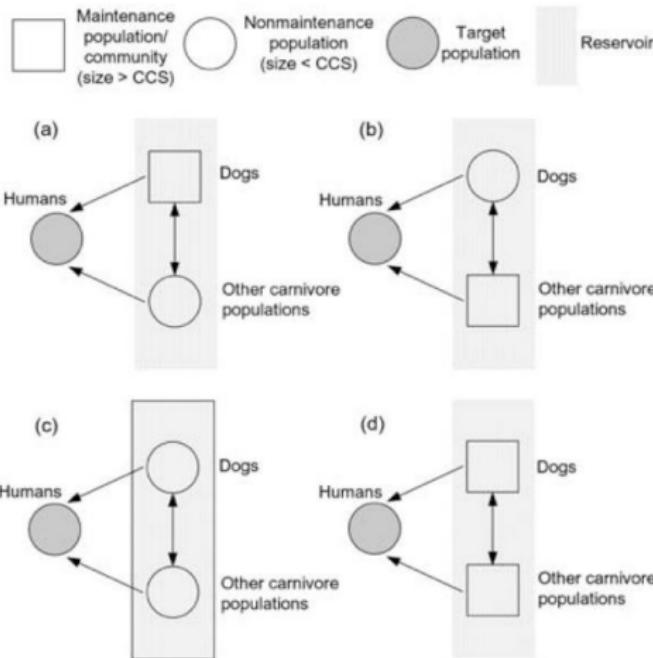
- ▶ Domestic dogs are a maintenance population
- ▶ Wild carnivores as a whole are not

Model fitting



- ▶ Some amount of intervention in dogs alone should eliminate rabies circulation in this population
- ▶ No amount of intervention in the carnivore population alone will do this

Model fitting



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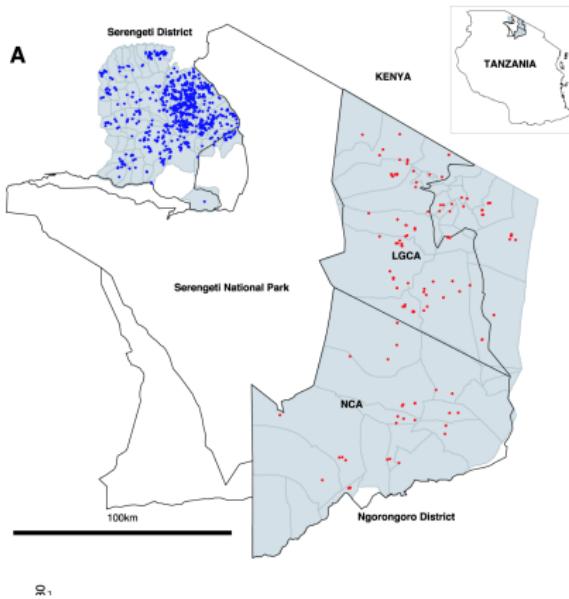
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Serengeti and Ngorongoro districts



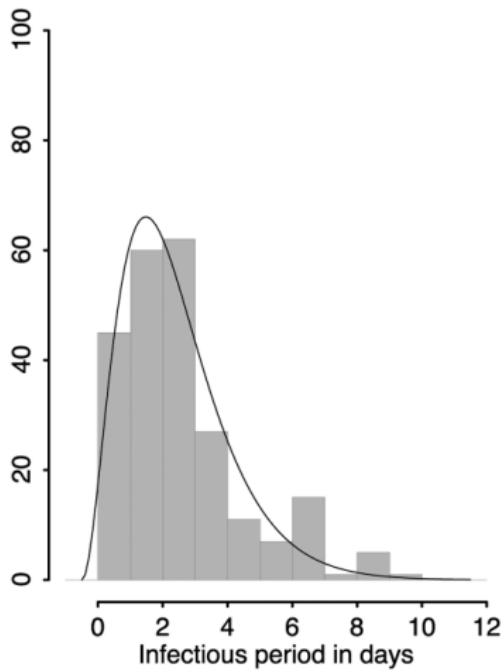
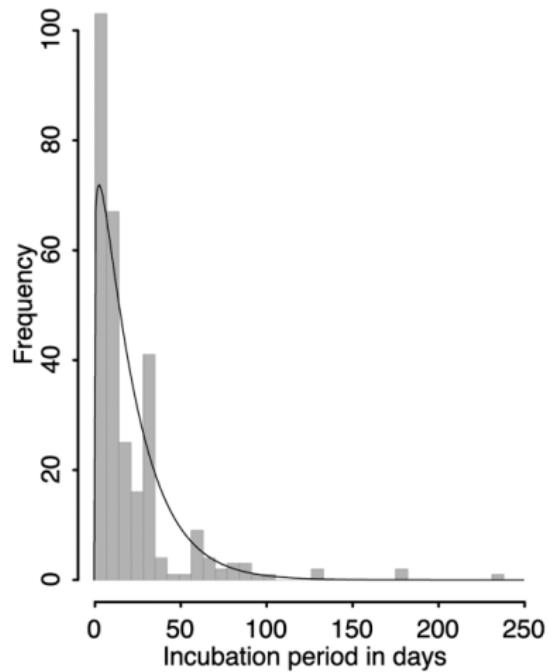
Hampson et al. PLoS Biology

Contact tracing



Distributions

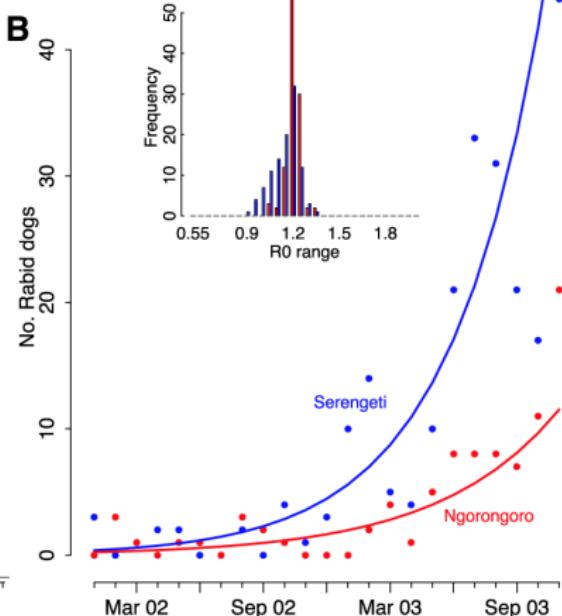
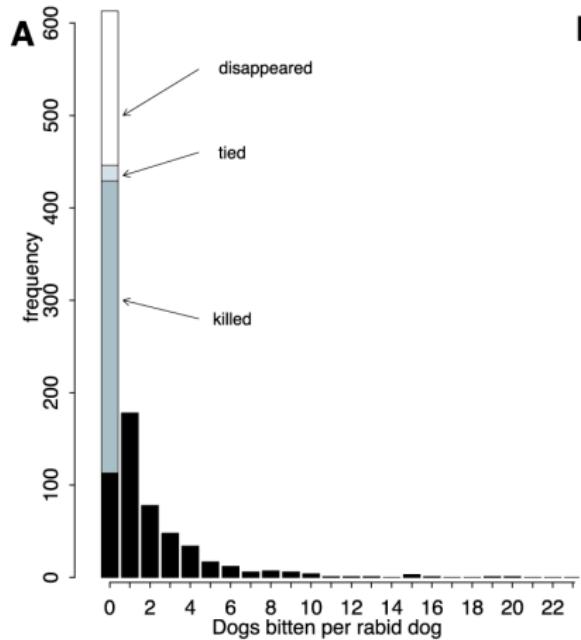
Time distributions



Estimating R_0

- ▶ We estimated R_0 in three ways:
 - ▶ Rate of spread compared to time distributions
 - ▶ Number of bites expected without control measures, \times probability of infection
 - ▶ Epidemic tree reconstruction (similar to reservoir paper)
- ▶ In the latter two cases we had a more than one estimate, depending on different assumptions about unobserved events

Estimating R_0

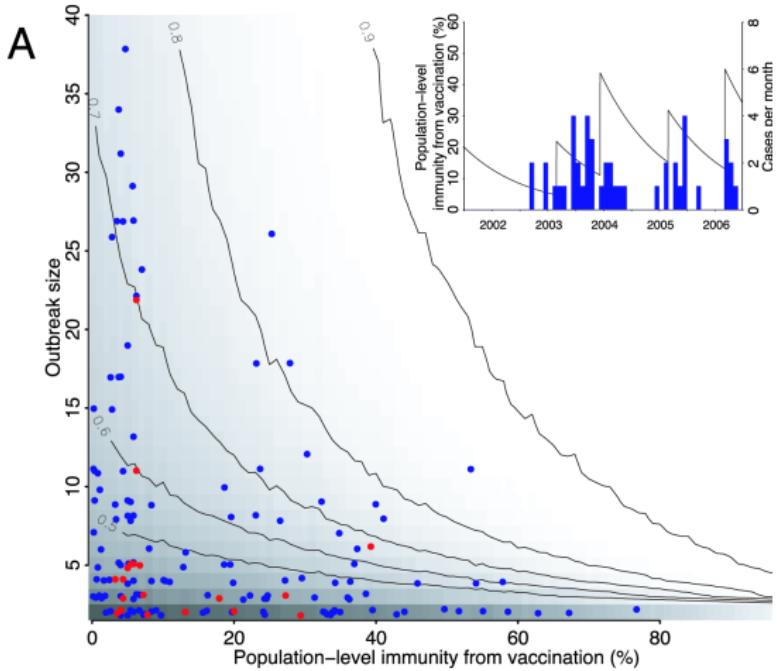


Vaccination campaigns

This can be achieved at ~\$1 per dog



Vaccination and outbreaks



Demography



Conclusions

- ▶ Low R_0 means that elimination of canine rabies and thus the public health threat of rabies is possible in this area
 - ▶ This implies that it should be possible in most or all areas of the world – it would be nice to know which
- ▶ Fast dog demography means elimination is not as easy as might be expected; co-ordinated, consistent effort is required

Open questions

- ▶ Why is R_0 for domestic dog transmission of rabies so consistently low?
- ▶ Why is there little effect of dog density?

Thanks



**Mass vaccination of domestic dogs
should lead to elimination of rabies from
all species**

Katie Hampson, Tiziana Lembo, many others