Tick, tick, boom! Trends in *Anaplasma sp.* seroprevalence in Mojave desert bighorn sheep

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Background

Desert bighorn sheep (*Ovis canadensis nelsoni*) are sub-species of bighorn found in mountainous regions of the Mojave desert, California (*Fig. 1*).

They are highly susceptible to diseases which transmit across wildlife-livestock interfaces.

Anaplasma sp. are tickborne bacterial haemo-parasites that can across wildlife-livestock interfaces[1].

Subclinical anaplasmosis in livestock results in suboptimal gains; acute anaplasmosis results in haemolytic disease[2, 3]. Clinical effects in desert bighorns are unknown.

Understanding the distribution, drivers, and health consequences of parasites in bighorns is important because they are vulnerable to climatic shifts having recently come off the endangered species list.

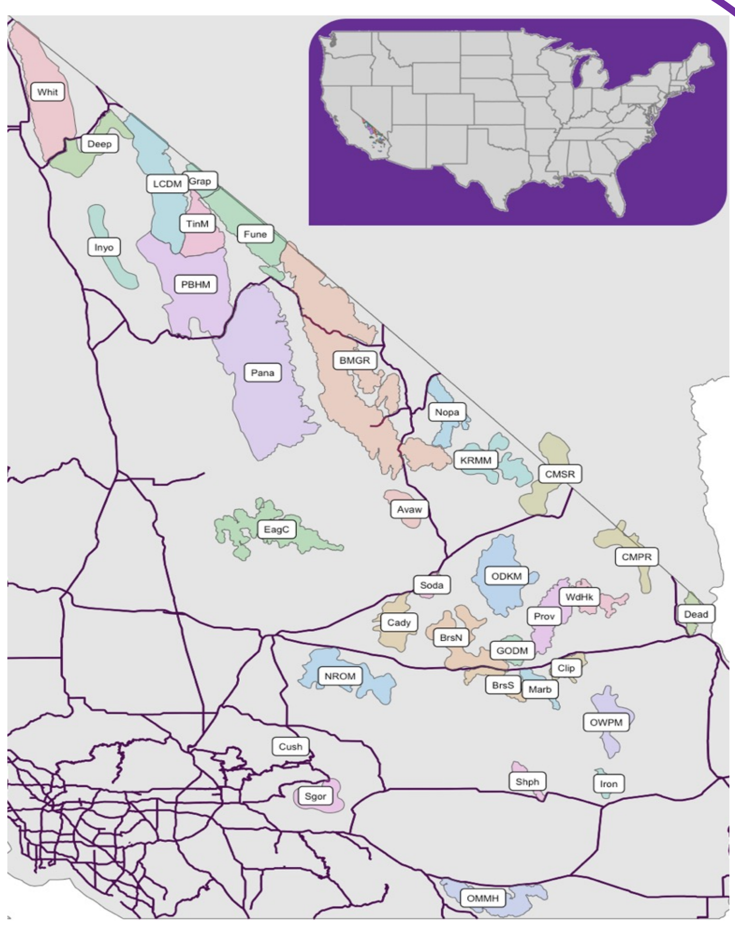

Fig. 1 Captured populations of desert bighorns

Hypotheses

1) Demography

Anaplasma seroprevalence increases with age and is higher in ewes

2) Health

Sheep in lower body condition have higher *Anaplasma* seroprevalence

3) Environmental

Conditions favourable to tick populations (green, wet, humid areas) will have higher *Anaplasma* seroprevalence

4) Alternative reservoirs

Bighorns in presence of alternative *Anaplasma* reservoirs have higher seroprevalence

5) Mixed mechanism: Combination of demography, health, environmental, and alternative reservoirs hypotheses

Methods

1. Desert bighorns captured using helicopter and netgun.
2. Blood serum samples collected and antibodies to *Anaplasma* detected with a cELISA.
3. Other data measurements were collected including age, sex, capture location, weight, etc.
4. Environmental data at capture site collected. Body condition approximated using residuals of weight regressed on log animal age[4].
5. Define hypothesised mechanisms and parameters that may drive *Anaplasma* infection risk, design models to represent each hypothesis, and carry out within and out-of sample validation of models.

Results: Multiple mechanisms Generalised Additive Mixed Model explains most variation

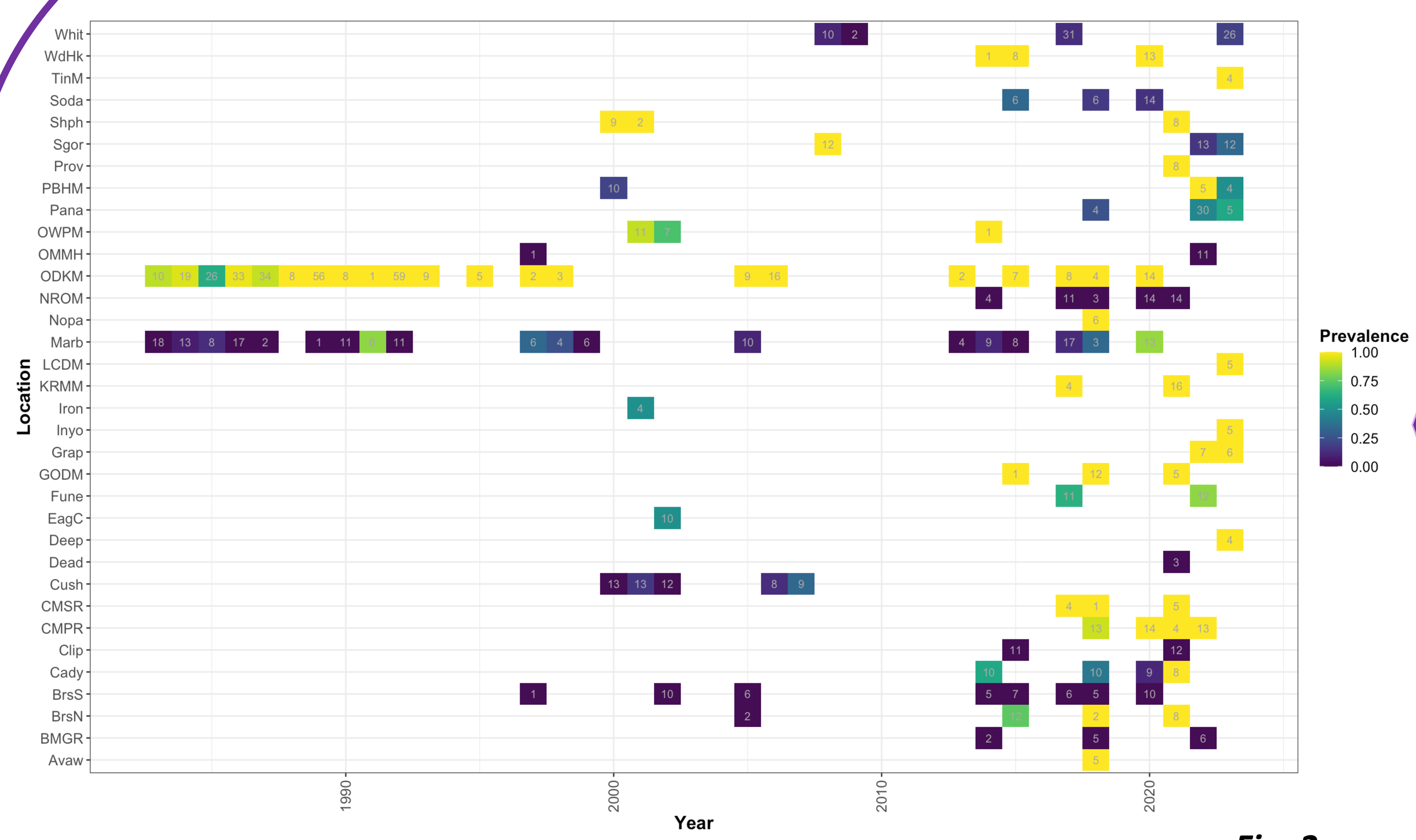

Fig. 2

Fig. 2 & 3

2) Heatmap shows some locations have endemicity for *Anaplasma* while others show serological absence.

3) Median rainfall is a significant predictor of *Anaplasma* seroprevalence (Rainfall: χ^2= 7.73, p-value= 0.048). Very low/very high rainfall associated with higher seroprevalence.

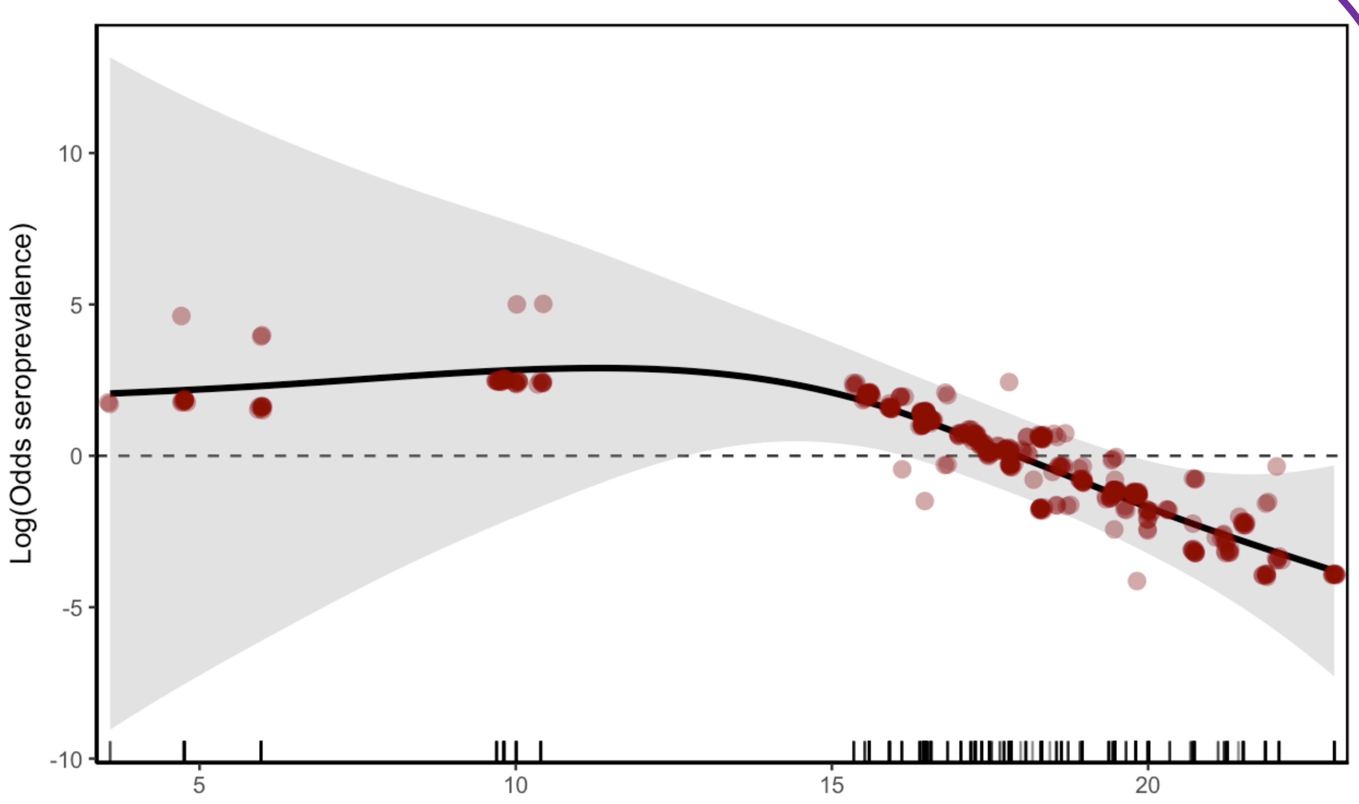

Fig. 4

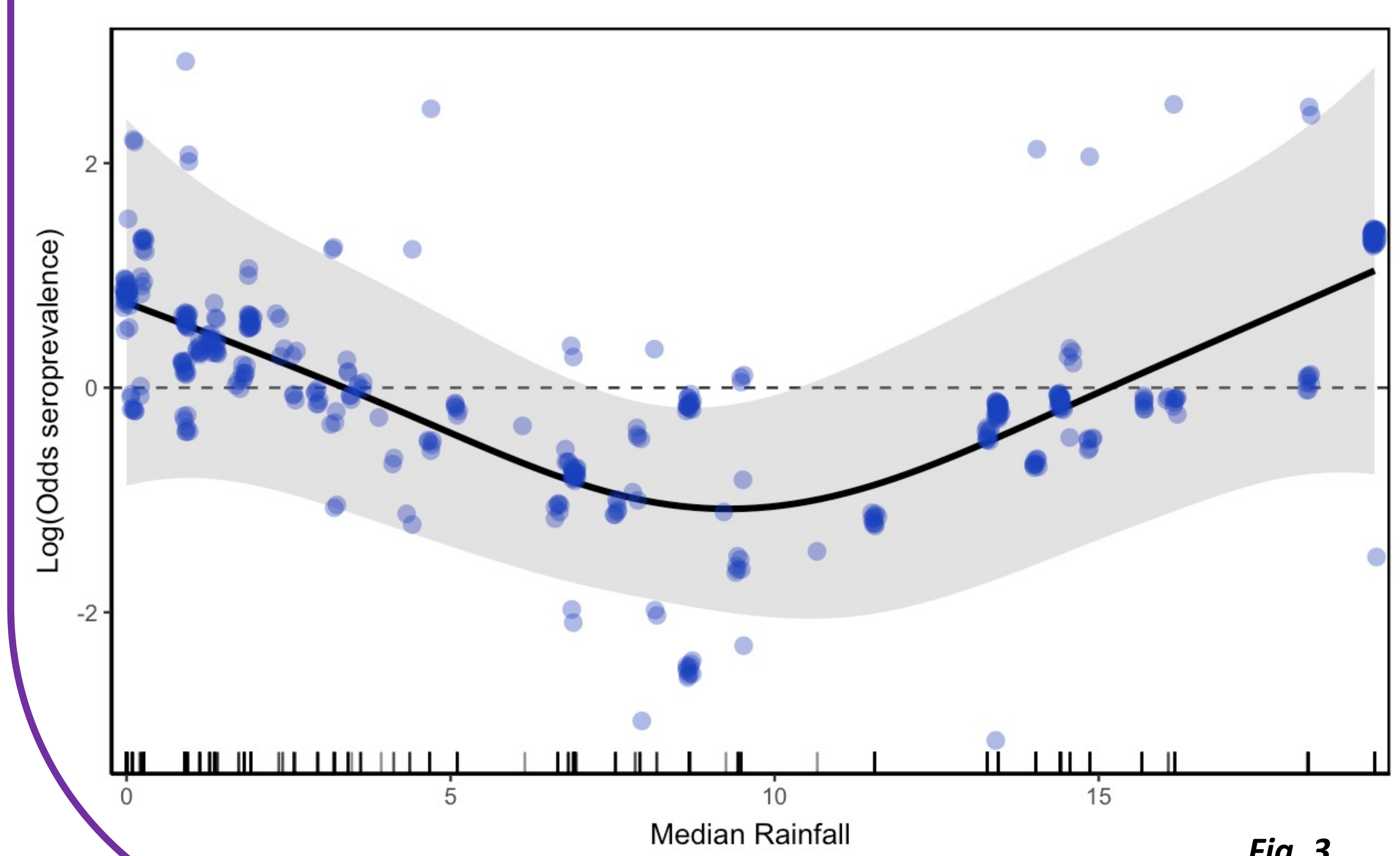

Fig. 3

Fig. 4 & 5

4) Median temp. is a significant predictors of *Anaplasma* seroprevalence (Med. temp.: $\chi 2$= 8.62, p-value= 0.028). Lower temp. associated with higher seroprevalence.

5) Year is a significant predictor for *Anaplasma* seroprevalence (Year: χ^2= 30.14, p-value= 2.55e-05). Higher seroprevalence in recent years.

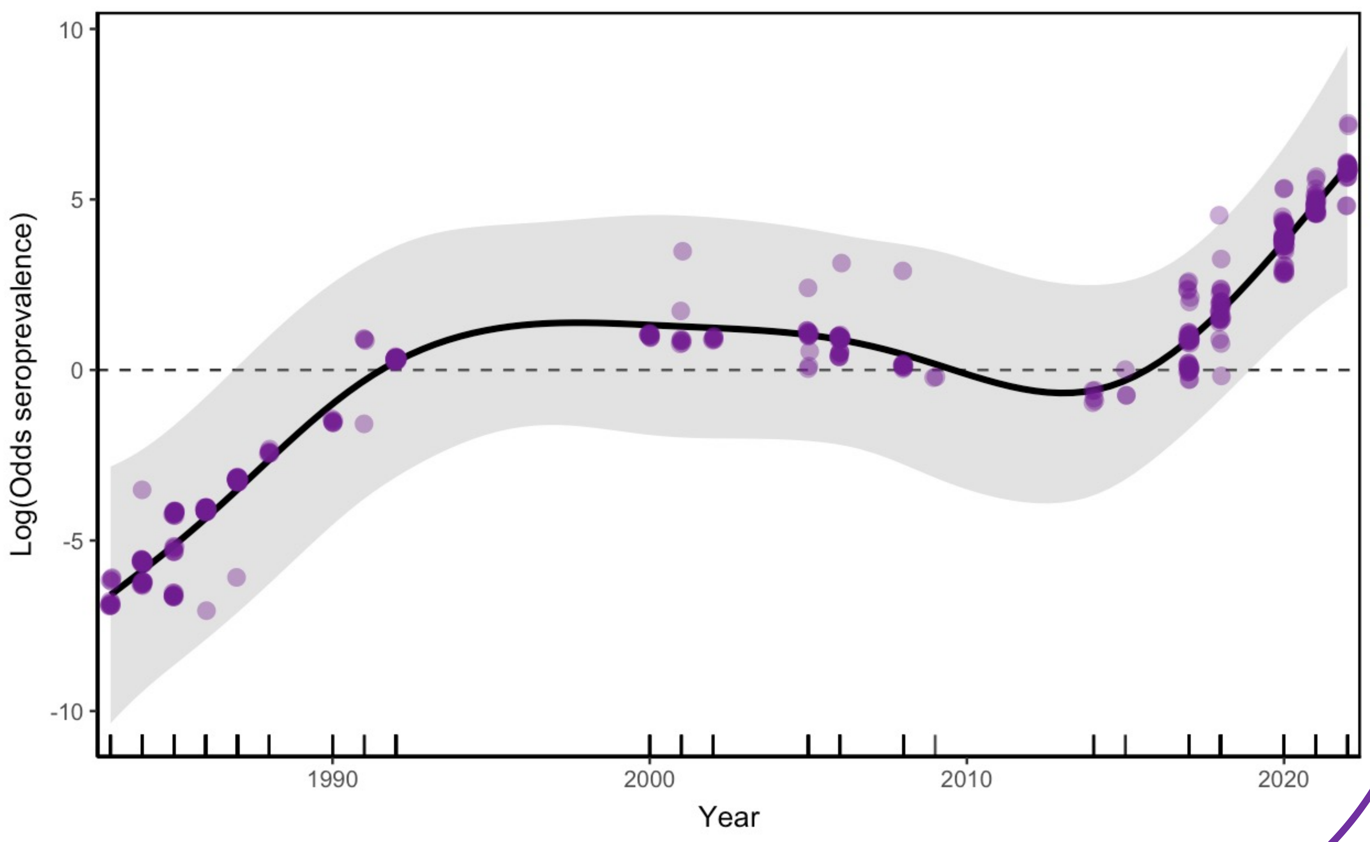

Fig. 5

Conclusions

- Models representing environmental conditions favourable to tick populations strongly supported. Within- and out-of-sample validation of final model (within AUC=0.98, out-of-sample AUC=0.70) indicate model is good prediction.
- Year shows recent increasing seroprevalence, which aligns with other studies[5, 6] where increased global spread and susceptibility to *Anaplasma* is seen/predicted.
- Low rainfall may cause bighorns to congregate at water sources, increasing chances of tick transferal between bighorns. High rainfall may represent greater vegetation and more questing opportunities for ticks.
- Low temp. could reflect more active and host seeking ticks than at higher temperatures, which cause tick dormancy.
- Given the link demonstrated between tickborne disease, year, and environmental conditions favourable to ticks, it is assumed that with climate change the distribution of *Anaplasma* in bighorns could shift. Continued monitoring is highly recommended.

Acknowledgments

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References

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