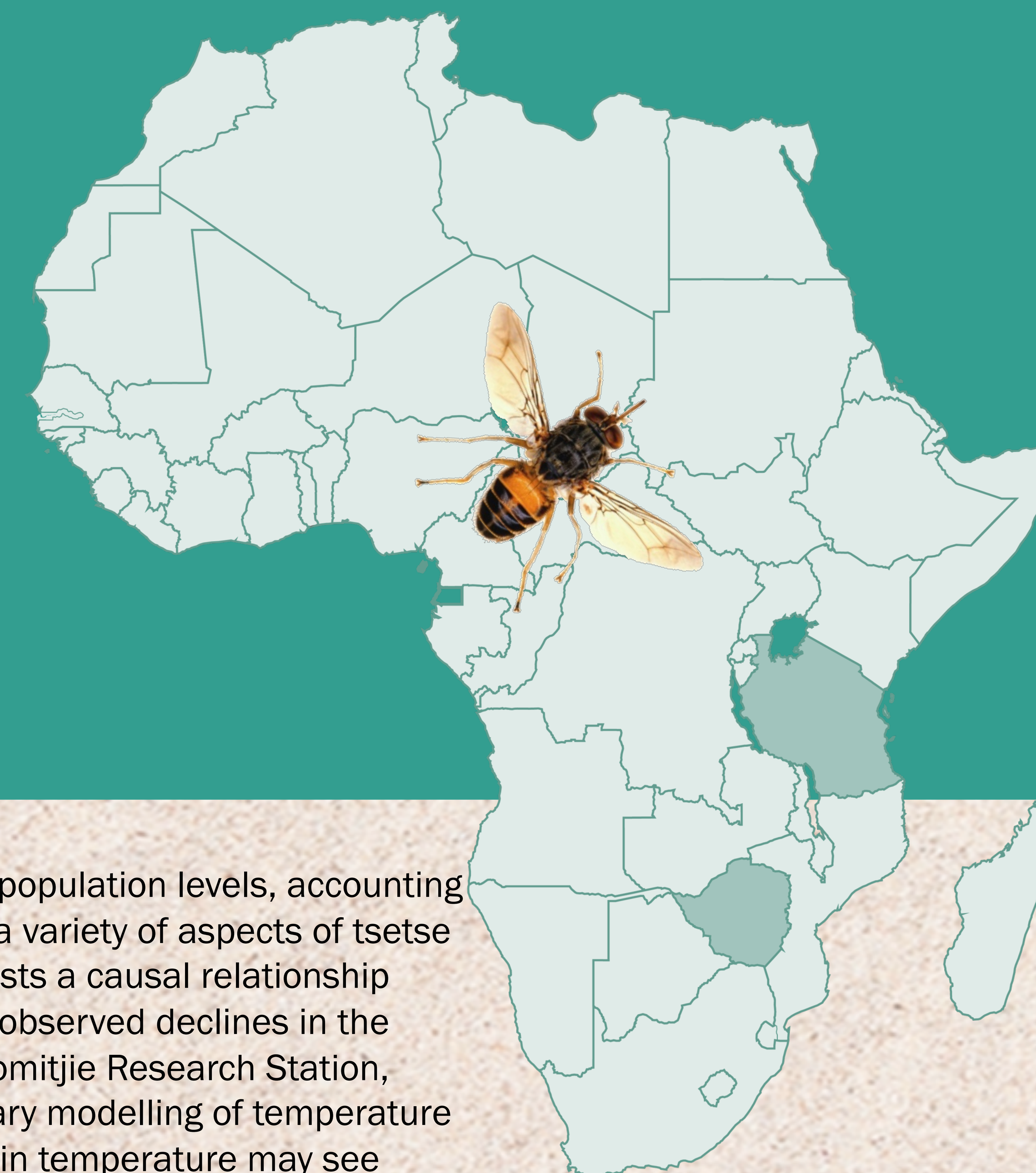
TRYPANOSOMIASIS: MODELLING THE EFFECTS OF INCREASING TEMPERATURES ON TSETSE POPULATION DYNAMICS AND DISTRIBUTION



AUTHORS LIST:

John Hargrove
Glyn Vale
Lisa van Aardenne

ABSTRACT

Tsetse flies (*Glossina sp.*) threaten health and livelihood by transmitting trypanosome parasites that cause the potentially fatal diseases of sleeping sickness (Human African Trypanosomiasis) in humans and nagana in livestock. Climate change may affect the abundance and distribution of tsetse flies, of great concern to people living adjacent to wildlife areas such as the Serengeti in Tanzania and the Mana Pools National Park in Zimbabwe. Monitoring of meteorological and entomological data in Zimbabwe show clear increases in temperature over the last 57 years, accompanied by a decline in overall densities of the tsetse species *G. m. morsitans* and *G. pallidipes*

We modelled past changes in tsetse population levels, accounting for known effects of temperature on a variety of aspects of tsetse population biology. The model suggests a causal relationship between temperature increases and observed declines in the tsetse numbers in the vicinity of Rekomitjie Research Station, Zambezi Valley, Zimbabwe. Preliminary modelling of temperature data suggests that further increases in temperature may see tsetse populations decline close to local extinction levels around Rekomitjie. Concomitant increases in temperature on the Zimbabwe highveld, however, will favour tsetse growth rates. Similar modelling for the Tanzania situation is ongoing

AIMS AND OBJECTIVES

To develop models for population dynamics of tsetse flies and trypanosomes with a view to: (i) Fit existing data on population levels of tsetse, their age structure and levels of trypanosome infection among them. (ii) Predict current and future distributions of both disease and vector under various scenarios of change in climate and land use and other sociological factors.

METHODOLOGY

Methodology We use various modelling options: deterministic differential equations, agent-based models and cohort-based models. The last-named approach has so far produced the most extensive results. We account for the following aspects of tsetse biology that are temperature dependent: adult development rates and inter-larval periods; abortion rates; puparial duration, fat utilisation and mortality; neo-natal and mature adult mortality.

Moreover, we account for fly sex-specific mortality, and for age-dependent mortality among adult flies and consider the effects of density-dependent mortality, applied to pupae and/or adults.

RESULTS

Annual average temperatures at Rekomitjie have increased by 1.2⁰C since 1959 (Figure 1). Increases have been greater for average minimum (1.7 ⁰C) than for average maximum temperatures (0.9 ⁰C). Nonetheless, there have been increasing numbers of "extreme temperature events," with 20 days running mean maximum temperatures now often exceeding 39 ⁰C in the hot-dry season.

The most severe increases in both maximum and minimum temperatures, occurred in the hot dry season, October-November, the hottest time of the year. This is significant for tsetse population dynamics, because our analyses show not only that this is when tsetse mortality is already highest – but also that the mortality is particularly increased among immature stages and among adults that have just emerged. Increases in temperature, particularly over the past 20 years, have seen some major short-term collapses in tsetse numbers, and a steady decline.

Predicted future increases in temperature of around 2°C by the mid 21st Century would shift the temperatures above the optimal threshold for part of the year. In contrast, this warming is projected to increase the temperatures over the highveld of Zimbabwe to within the optimal range.

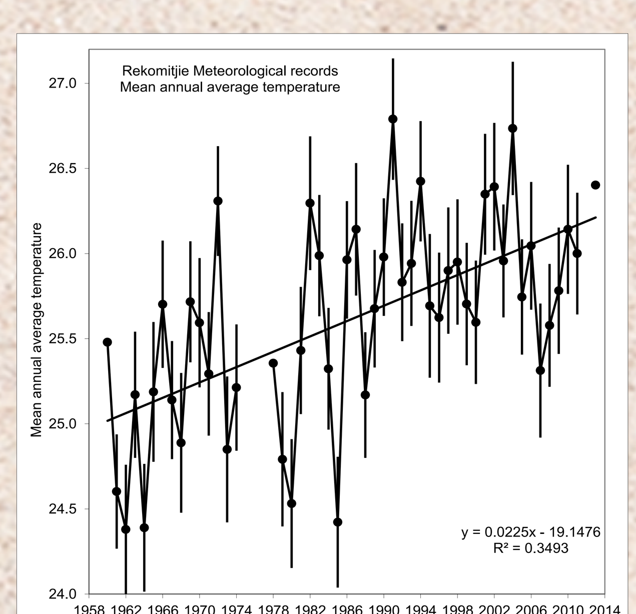


Figure 1: Rekomitjie Research Station 1960-2014

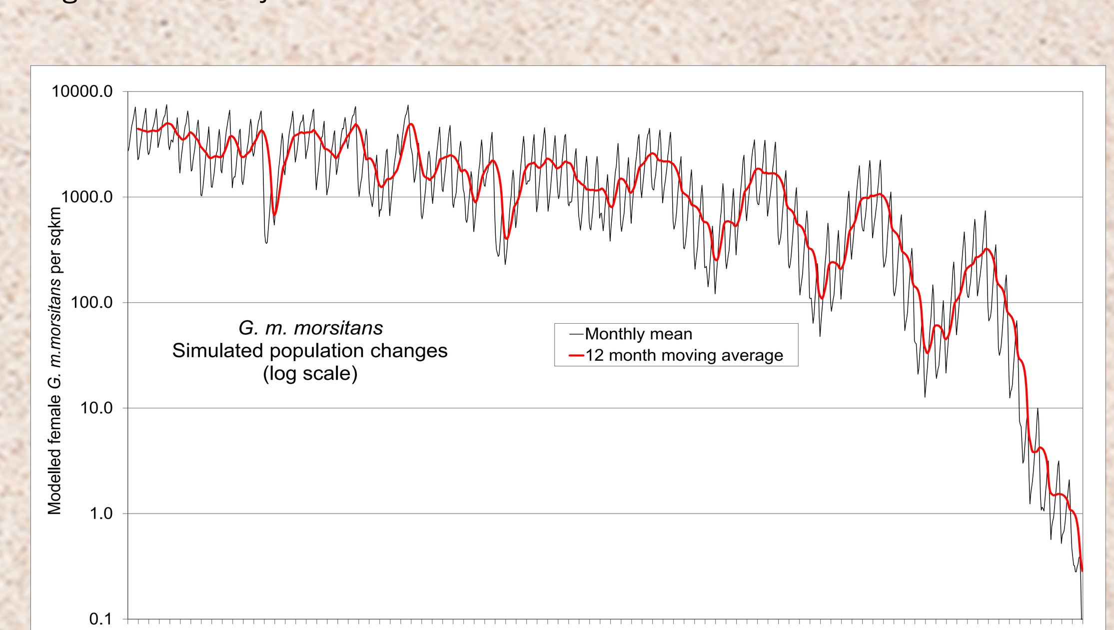


Figure 2: Rekomitjie Research station 1960-2050

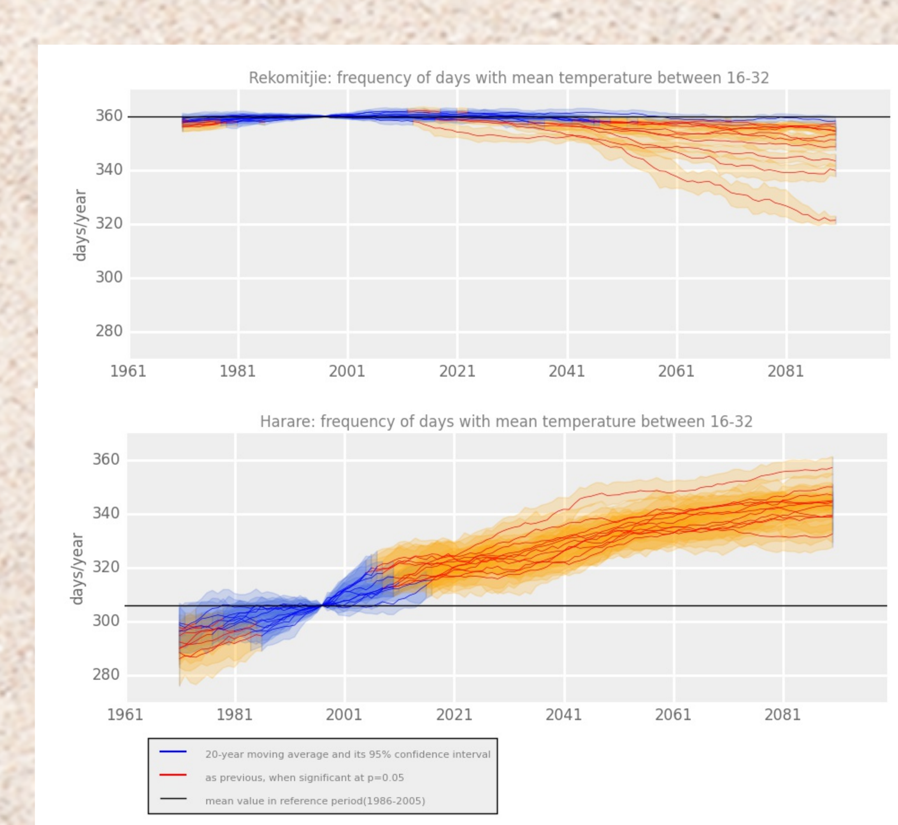


Figure 3: Projected increases in monthly means of daily temperatures for an ensemble of 11 statistically downscaled CMIP5 GCMs under the RCP4.5 emission scenario for the Rekomitjie Research Station (top) and Harare (bottom).

CONCLUSIONS

There have been severe increases in temperature in the Zambezi Valley of Zimbabwe over past decades and these are correlated with substantial declines in local tsetse populations. We conclude that there have already been direct effects of the temperature increases on tsetse growth rates, via increased mortality – particularly among the immature stages at the hottest times of the year. We do not exclude the possibly that there are also indirect effects: extreme heat, coupled with low rainfall in some years, could adversely affect numbers of local game animals, leading to the increased probability of tsetse dying of starvation. Increases of temperature on the middle and highveld of Zimbabwe, which has historically been too cool for optimal tsetse growth, might become more favourable for the flies and this could see a southward extension of the flies' range. We are currently working on applying the results from the Zimbabwe studies to the Tanzanian situation. In both countries the developing disease situation will be influenced by sociological as well as meteorological and entomological factors.

TEAM MEMBERS

J Hargrove
N Abdelatif, M Byamungu, A Chamisa, A Chihota,
S English, R Ferreira, T Jamah, K Kigoda,
V Kovacic, C Mangwiro, Z Mthombothi,
D Mwaseba, R Ouifki, R Pilossof, W Shereni, D Tsikere,
S Torr, G Vale, L van Ardenne

PROJECT PARTNERS

SACEMA (Stellenbosch University),
CSAG (University of Cape Town),
Tsetse Control Division, Government of Zimbabwe
Bindura University of Science Education,
Sokoine University of Science Education,
Tsetse & Trypanosomiasis Research Institute,
Liverpool School of Tropical Medicine

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