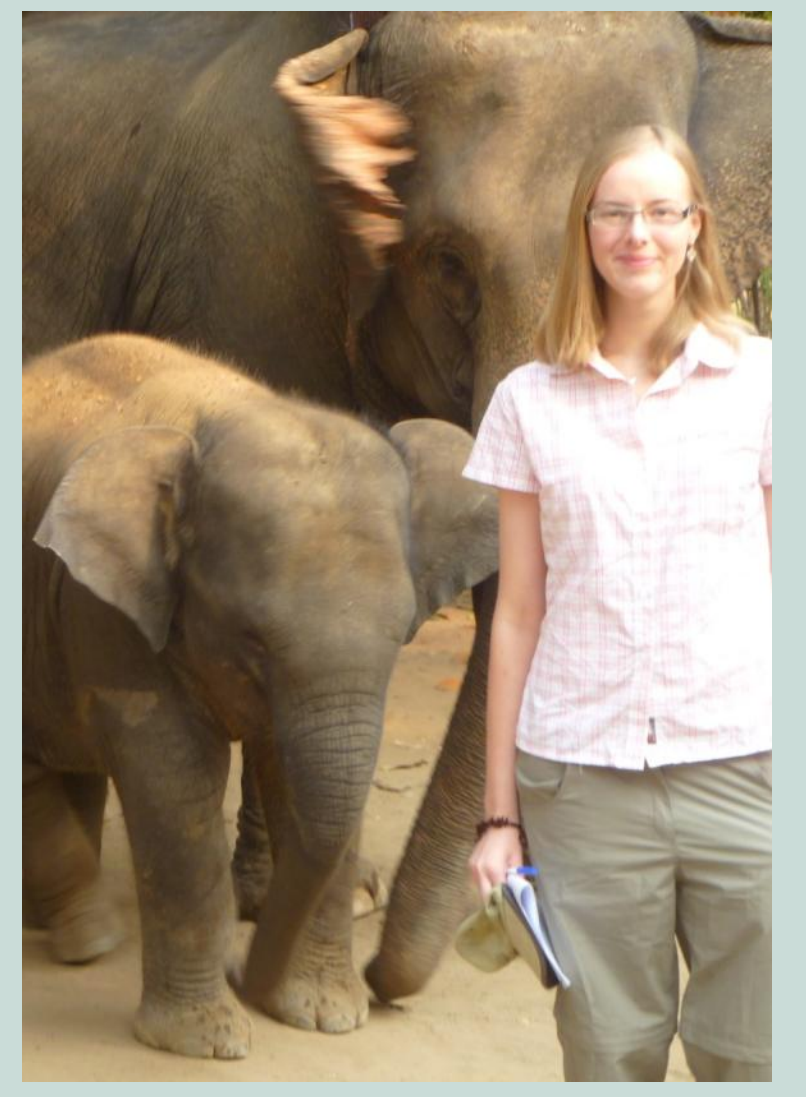h.mumby@sheffield.ac.uk

Effects of climate on survival of Asian elephants (*Elephas maximus*)

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Introduction

- **Climate change** has intensified interest in understanding how climatic variability affects **survival.**
- **Long-lived mammals** could be at particular risk -> How does climate variation affect their **pattern and cause of death**?
- **We studied climatic effect on age- and sex-specific survival and cause of death in endangered Asian elephants that inhabit regions with high seasonality of temperature and rainfall.**
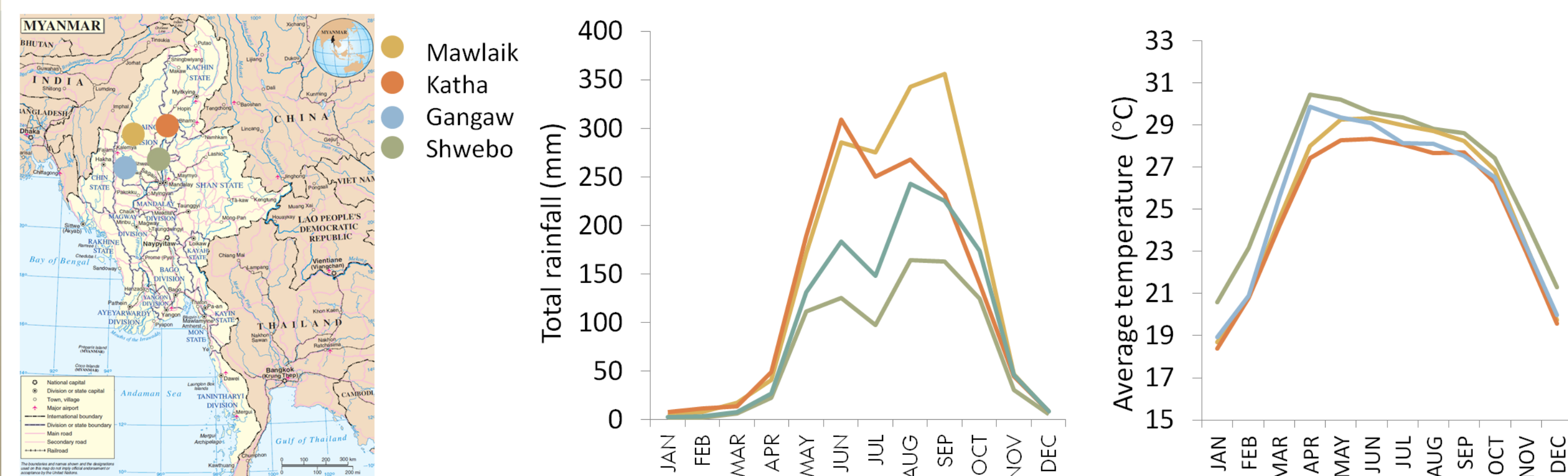

Figure 1. Location, rainfall and temperature of 4 study sites in Myanmar

Methods

Study population: Demographic data for all ages and both sexes on 834 longitudinally monitored timber elephants from four Myanmar sites between 1965-2000 (Fig. 1).
- **Climatic variation and age and sex specific survival:** GLMM of elephant survival by monthly mean temperature and total rainfall, using logistic regression as a discrete-time model by region (including 176,100 elephant-months).
- **Climatic variation and cause of death**: Climate and the distribution of 277 deaths with a known cause.
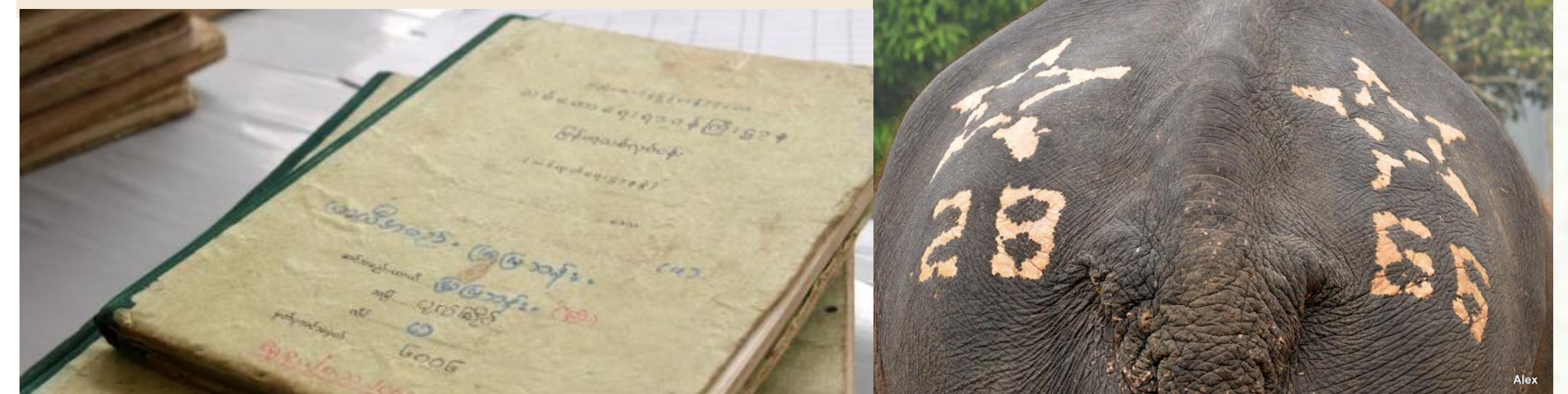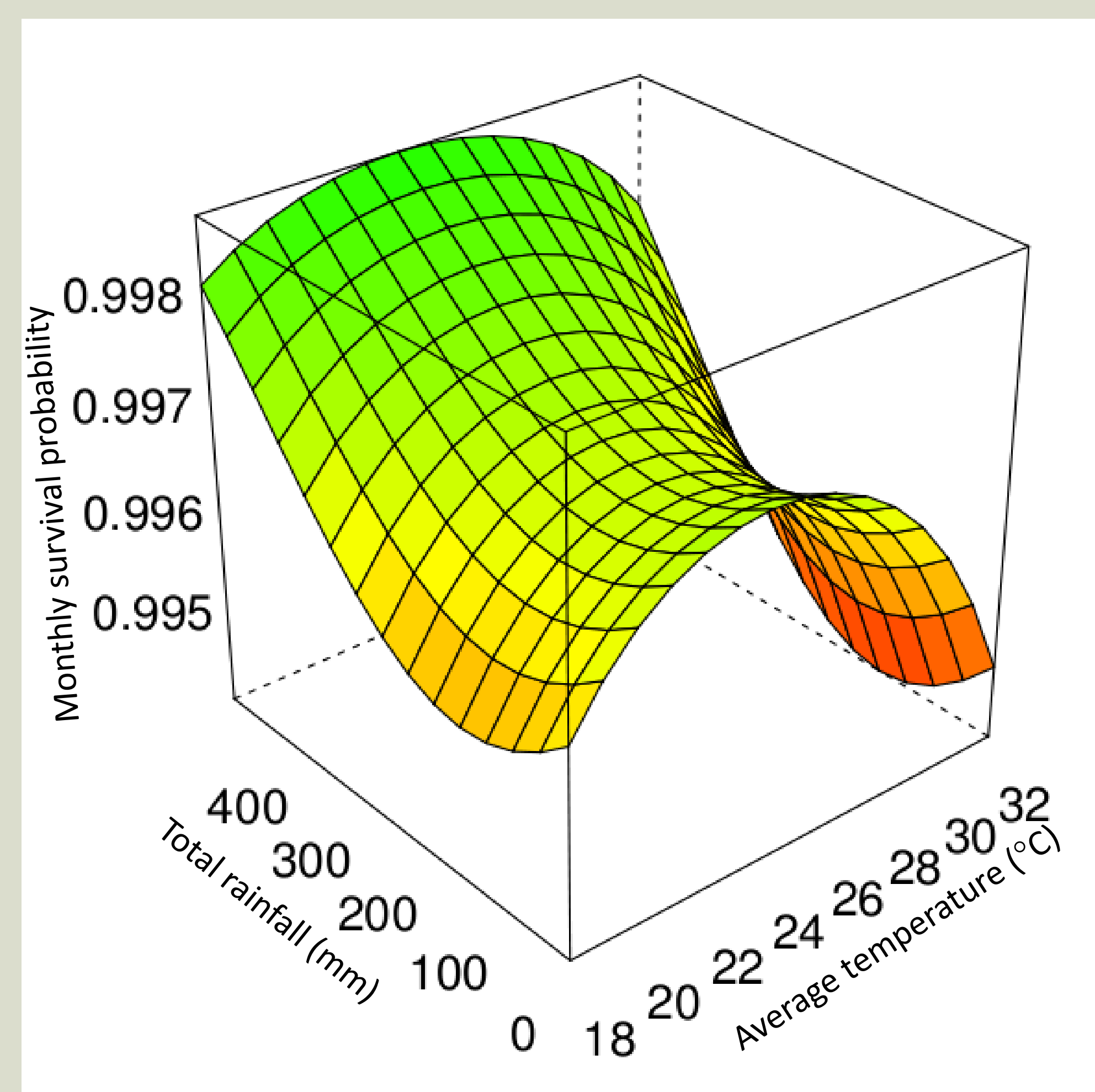

Results

Climatic effects on survival

Figure 2. Monthly elephant survival by temperature and rainfall in Myanmar (Reference: male newborn in Gangaw)

Elephant survival is highest at **intermediate temperature** (24.0°C; p=0.007) and at **highest rainfall** (*p*=0.037); Fig 2.

Although survival differed by **age** (lowest in newborns and infants) and **sex** (lower in males), the effects of climate on survival did not depend on age or sex.

Most deaths occur in the hottest months because elephants spend twice longer in "too hot" than in "too cold" conditions; Fig3.

Climatic effects on cause of death

Temperature affects causes of death (*p= 0.006*, Fisher's exact test).
- Of the 12 heat stroke deaths, 7 occurred in hottest quartile.
- Deaths from infection are highest in hottest months (29.2%).
- Non-infectious diseases (32.8%) were the leading cause of death in the coolest quartile (compared to <15.8% in other quartiles).

Rainfall also affects causes of death (*p=0.05*, Fisher's exact test).
- Deaths by non-infectious disease are highest in the driest quartile 26.9%) compared to wettest quartile (7.2%).
- Perinatal deaths were highest in the wettest quartile (29.0%) in comparison to <17.9% in the other three quartiles.
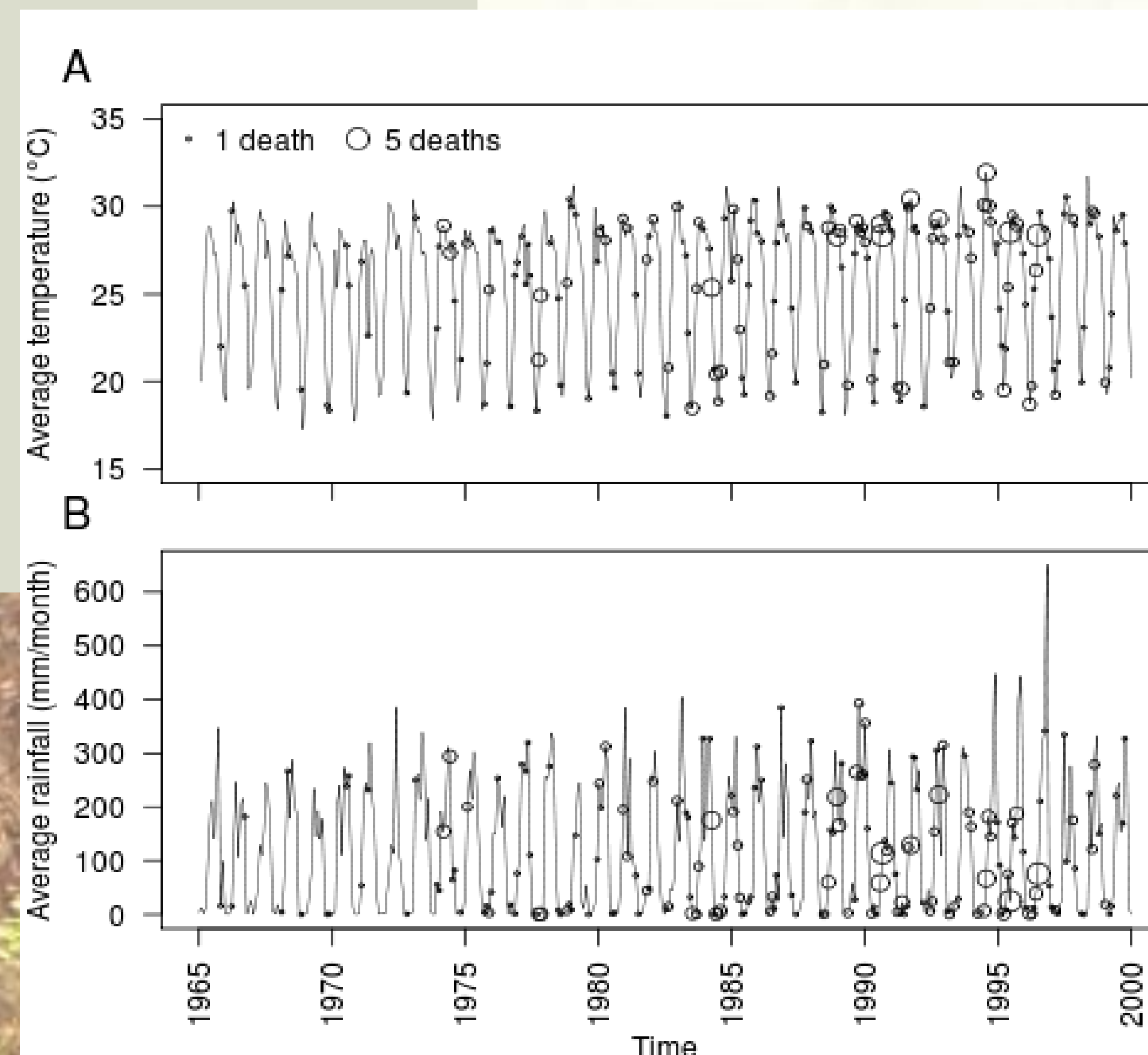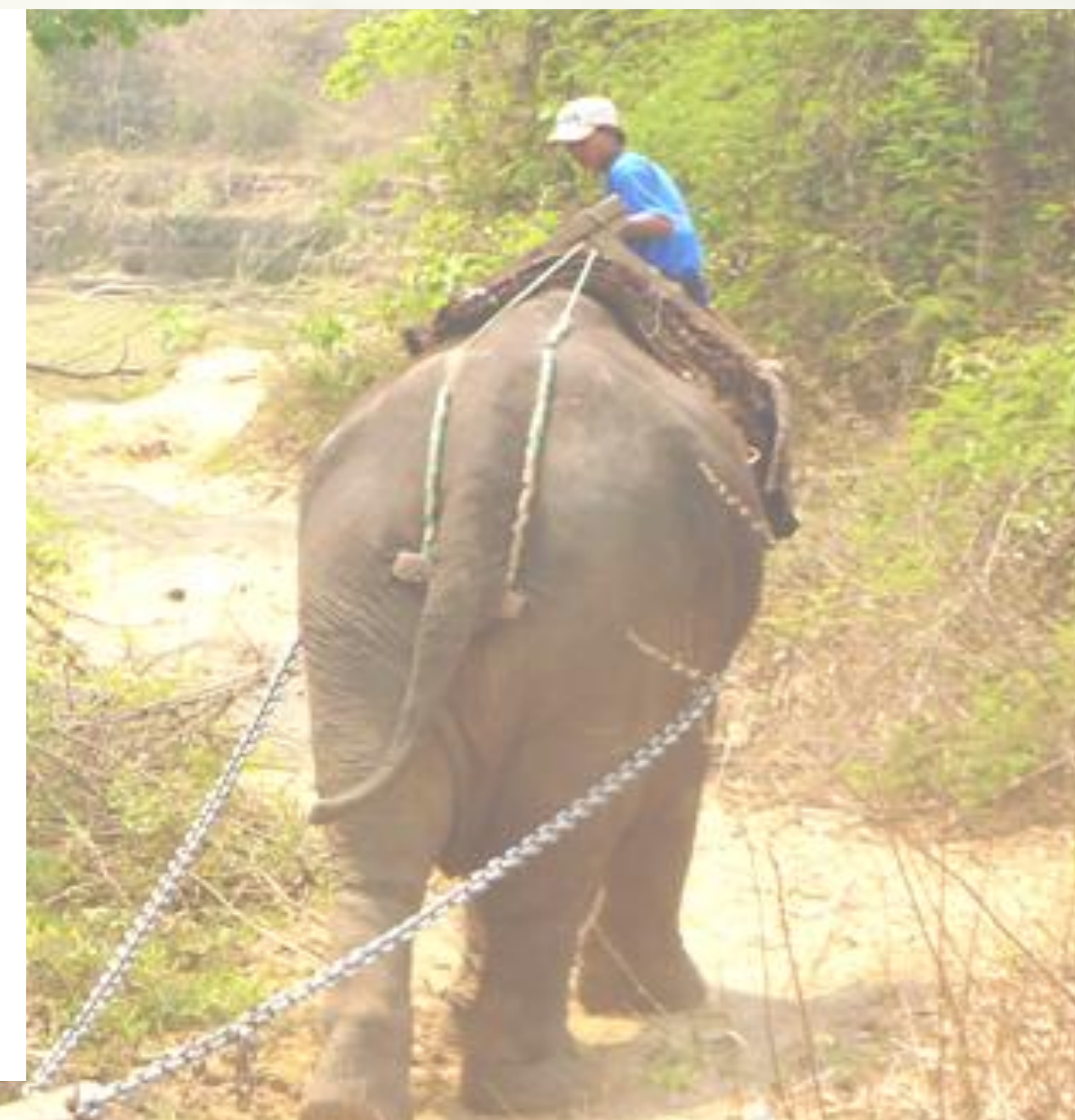

Figure 3. Elephant deaths in Myanmar over the study period by average temperature (A) and rainfall (B)

Conclusions

- **Normal-range monsoon** variation in climate can exert large impact on elephant **survival,** particularly amongst **youngest, male** elephants.
- Effects of climate on cause of death operate **directly** (e.g. heatstroke) and **indirectly** (e.g. infectious disease prevalence).
- A long-term trend towards **higher global temperatures** combined with the possibility of higher **variation** in temperature and longer periods without rainfall may pose a growing challenge to the **survival** of species such as the **endangered** Asian elephants.