Temperature dependent emergence of bean beetles, related to the Metabolic Theory of Ecology

How does temperature affect the emergence rate of *Callosobruchus maculatus*?

Introduction

The Metabolic Theory of Ecology (MTE) posits that metabolic rate is the foundation for most observable ecological patterns. We look at MTE by studying the emergence rate of the bean beetle *Callosobruchus maculatus* at different temperatures.

Hypothesis: We expect that higher temperature, until a certain point, will result in a higher emergence rate.

Materials & Method

- ✓ Incubated 3 petri dishes at different temperatures (21, 26, 29, 32, 35)°C.
- ✓ 120 beans, 5 female and 5 male bean beetles were placed into each petri dish.
- ✓ Counted number of bean beetles that emerged each day for 3 weeks.
- ✓ The Sharpe-Schoolfield model was used for plotting the rates
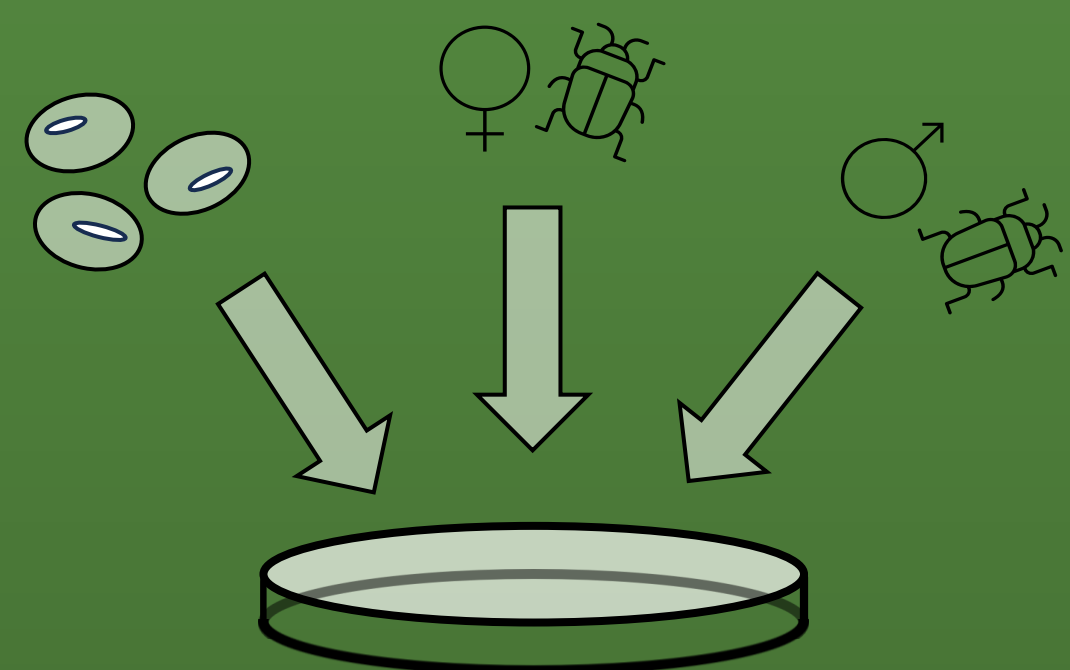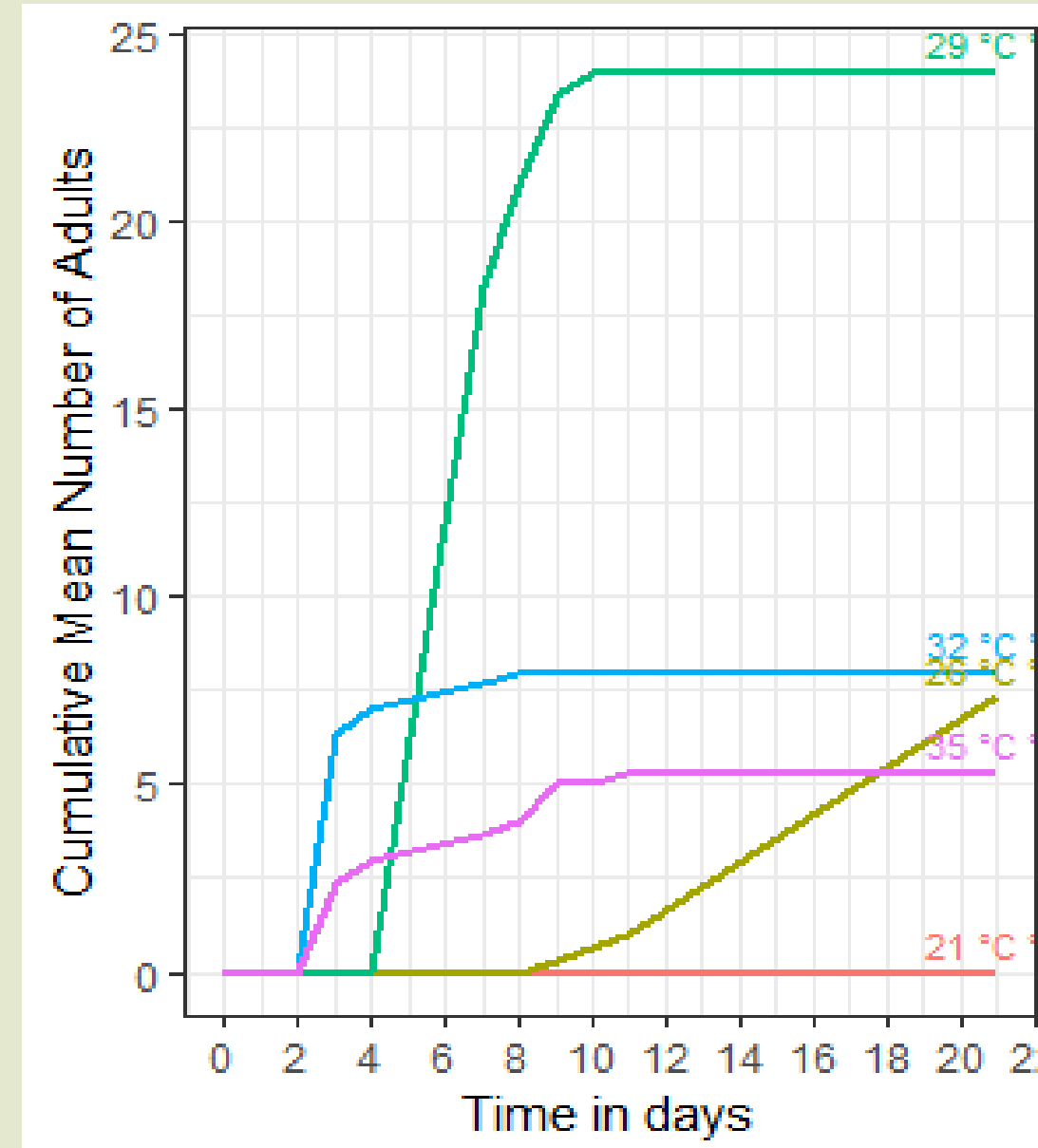
Results

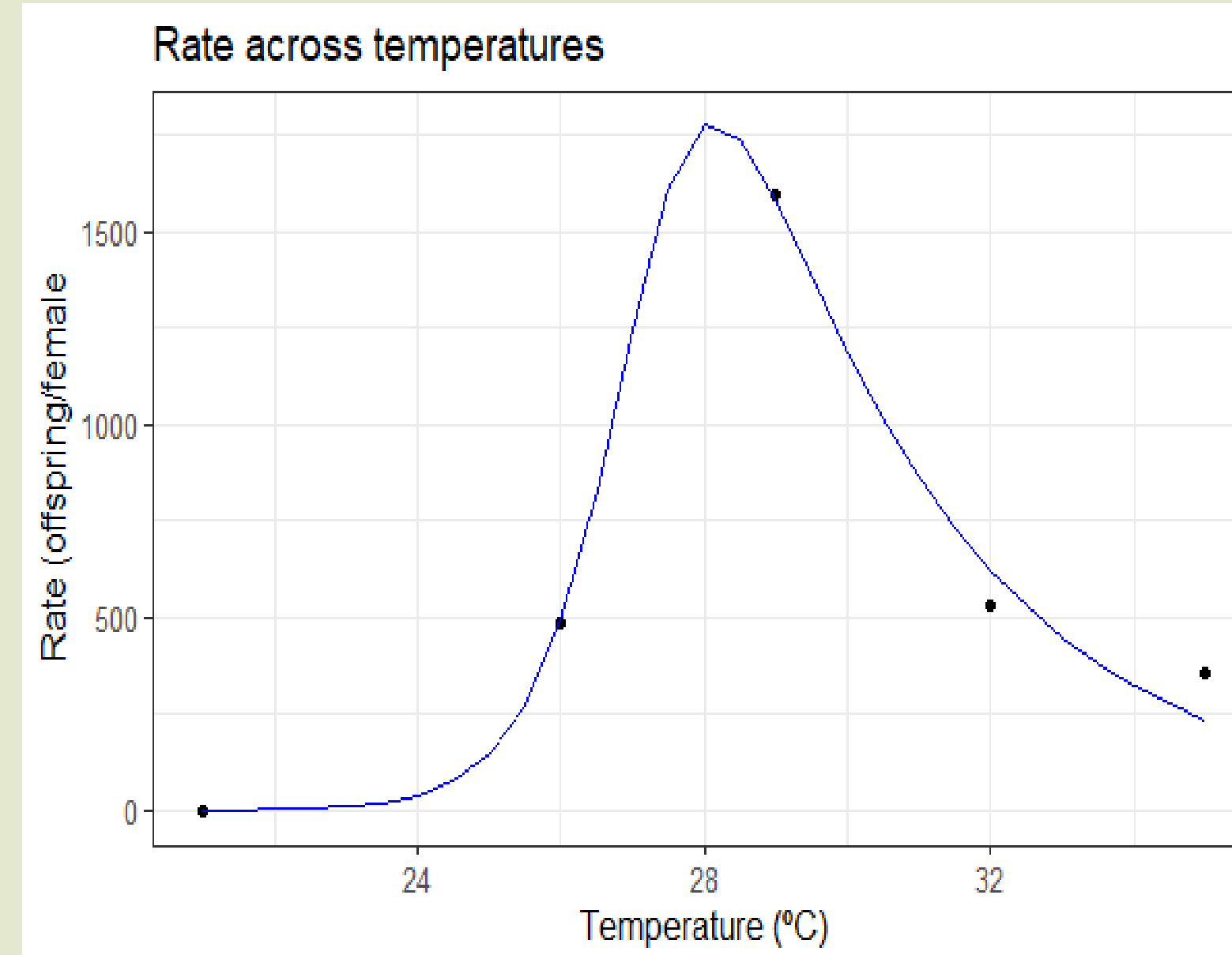Fig 1: Cumulative mean number of hatched beetles per day for each temperature

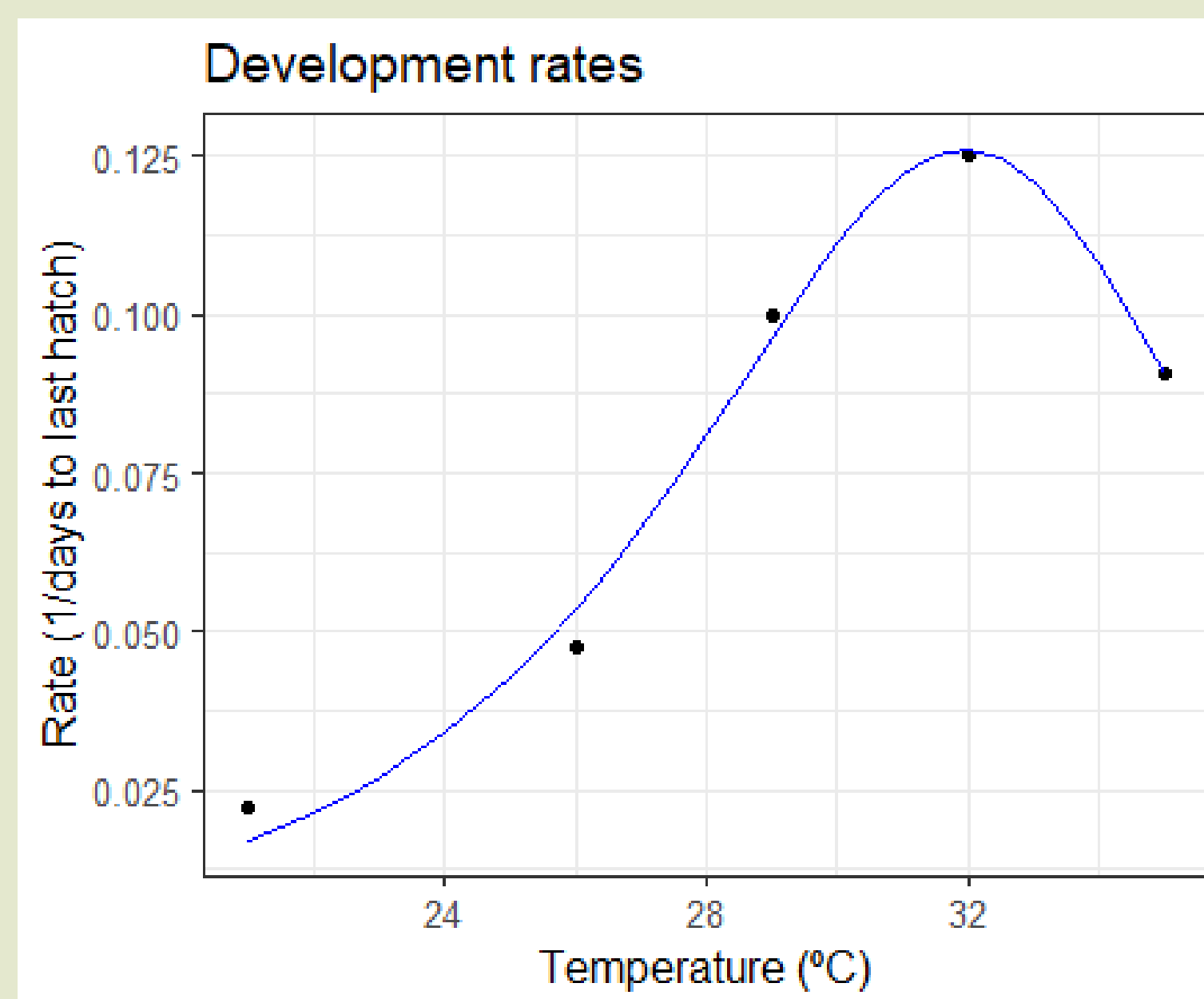Fig 2: Rate of produced offspring per female across temperatures

Fig 3: Development rates at different temperatures

$$rate = \frac{r_{tref} \cdot exp^{\frac{-e}{k}\left(\frac{1}{temp+273.15} - \frac{1}{t_{ref}+273.15}\right)}}{1 + exp^{\frac{e_h}{k}\left(\frac{1}{t_h} - \frac{1}{temp+273.15}\right)}}$$

temp: temperature in degrees centigrade

r_tref : rate at the standardized temperature, tref

e: activation energy (eV)

eh: high temperature de-activation energy (eV)

th: temperature (°C) at which enzyme is 1/2 active and 1/2 suppressed due to high temperatures

tref: standardisation temperature in degrees centigrade. Temperature at which rates are not inactivated by high temperatures

Discussion

The development rate peaked at 32°C, indicating a preference for warmth. Higher temperatures slowed the rate, suggesting conditions were too hot. At 21°C, activity remained low, indicating it was too cold. At 26°C, beetles emerged for a longer period.

Our results showcase an optimal temperature range. Deviation from this range, negatively impacts the metabolic activity.

Conclusion

The result support MTE, revealing a temperature-dependent emergence pattern for *C. maculatus*. Although developmental rates were highest at 32°C, the total number of bean beetles that emerged was highest at 29°C.

References

Sharpe-Schoolfield model (high temperature inactivation only) for fitting thermal performance curves — sharpeschoolhigh_1981. (n.d.). https://padpadpadpad.github.io/rTPC/reference/sharpeschoolhigh_1981.html

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