TESTING ASSUMPTIONS OF THE METABOLIC THEORY OF ECOLOGY

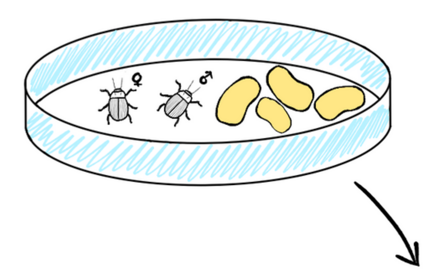
The rate of egg laying and emergence

INTRODUCTION

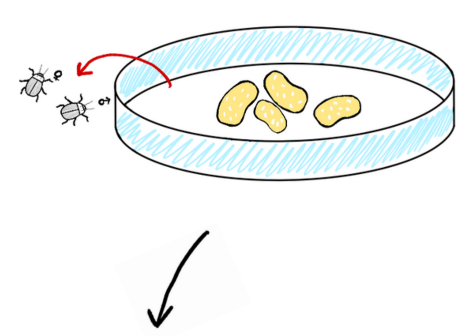
Metabolic theory of ecology (MTE) predicts how metabolic rate controls ecological processes at all levels of organization, from individuals to the biosphere. In this study we are comparing two equations of MTE; one from Brown et al. (2004) and one from Arroyo et al. (2022), to see if they do well at predicting ecological processes in *Callosobruchus maculatus*. We are looking at egg-laying rate and emergence rate.

Our hypothesis is that both ecological processes will follow the curve predicted from the Arroyo et al. model. We expect an optimum temperature, where lower and higher temperatures would have a negative impact on the metabolism, explaining the shape of the curve.

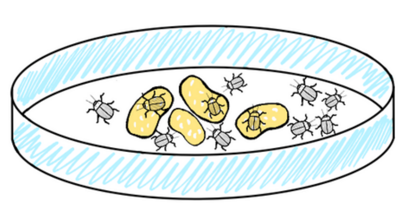
METHODS



1. 1 female and 1 male of *C. maculatus* are put in a petri dish with 135 beans.

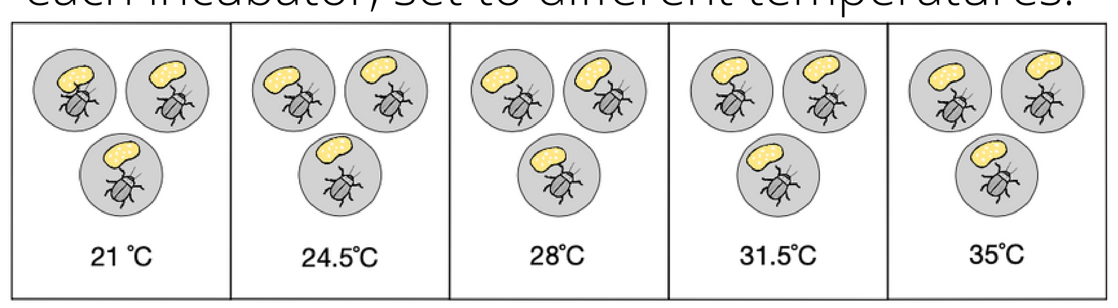


2. After egg laying is finished, the adults are removed and the eggs are counted.



3. After hatching, the emerged bean beetles are counted.

The setup consisted of 3 parallels of beetles and beans in each incubator, set to different temperatures.



ANALYSIS

The data of egg laying and emergence rate were compared to the MTE, Gilloly et al. and Arroyo et al. models using AIC model selection.

RESULTS

MTE model	AIC	p-value
Egg laying rate		
Brown et al.	23.202	0.5548
Arroyo et al.	16.163	0.1431
Emergence rate		
Brown et al.	9.0684	0.5930
Arroyo et al.	-0.9453	0.2035

Table 1. The AIC-value shows the predicted deviation from the models, For the Arroyo model this value is smaller, which means that this model has less deviation than the Brown's one. The p-values tells us the probability for the models to be correct according to our data.

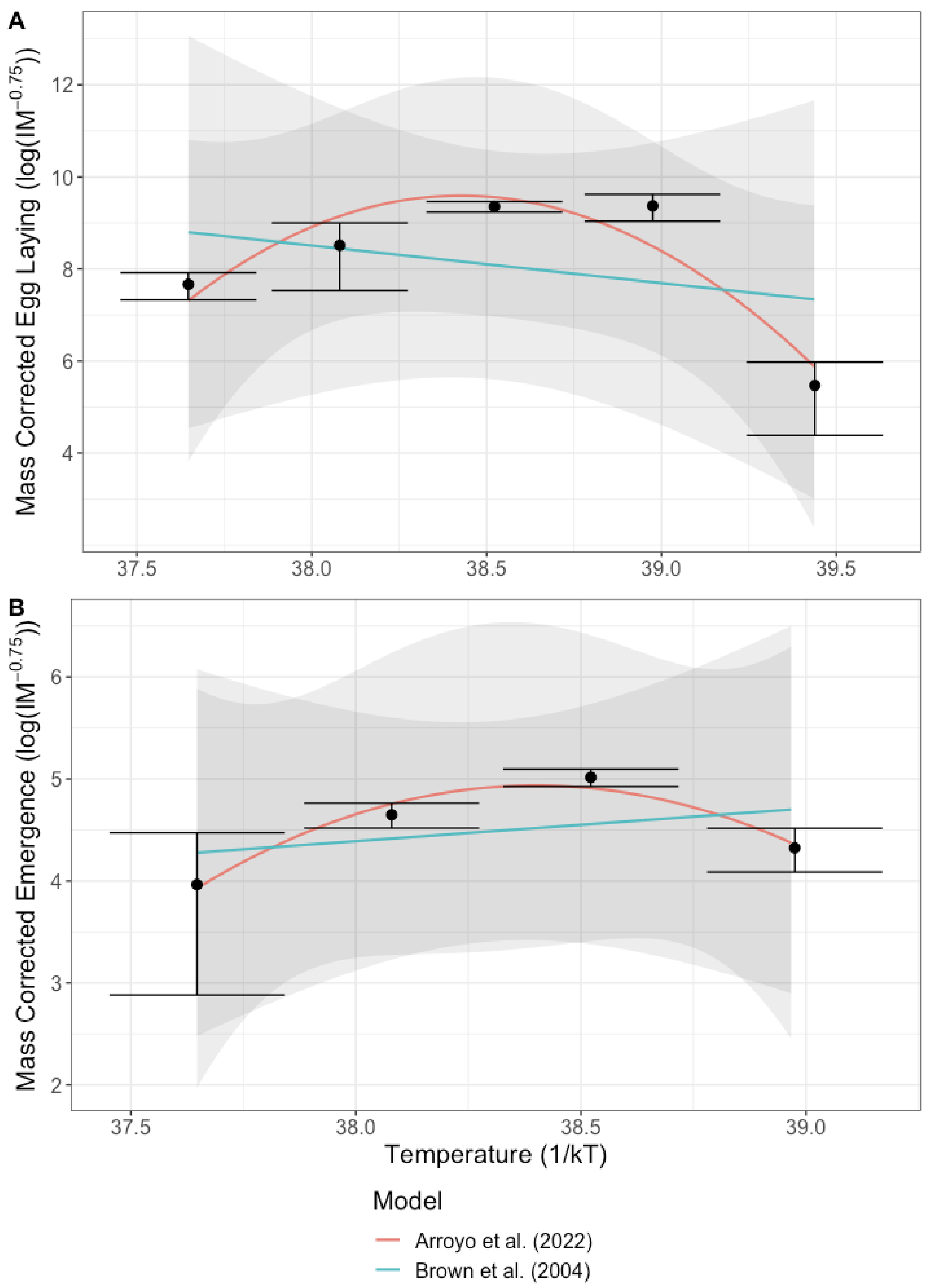


Figure 1. Graph A and B show the mass corrected egg laying rate and the mass corrected emergence rate respectively, in 5 different temperatures.

DISCUSSION

We can see from Figure 1 that the Arroyo et. al. model is a better prediction of both egg laying and emergence rate. **Thus, our hypothesis is confirmed.**

Our results show that the rates of the different ecological processes increase to an optimal temperature and then decrease. This could be explained by optimal temperatures for enzymes: that temperatures over the optimal can cause enzyme breakdown. One of the differences between the models is that the Arroyo et al. model assumes that a change in entropy is temperature dependent. This assumption creates the curve that we also see in our results. This could be the reason why the Arroyo et. al. model does a better job at predicting our results.

This fit isn't perfect. This could be due to some inaccuracy in the counting process and the small sample size we used. The Arroyo et. al. model matches better with emergence rate than egg laying rate (AIC value in table 1). This might be because of counting inaccuracy; the adult beetles were easier to count than the small eggs.

Our results indicate that the Arroyo model is a better prediction of ecological processes. For further studies we would expand the sample size for each temperature to eliminate some uncertainties. If the Arroyo et. al. model is better at predicting ecological processes it could help quantify ecological relationships and strengthen the MTE.

CREDITS

Regine Asbjørnsen: Writing, Conceptualization, Investigation, Visualization. **Thomas A. Bondevik**: Conceptualization, Formal analysis, Visualization, Investigation. **Anouk L. Hiland**: Conceptualization, Investigation, Visualization. **Alicia G. D. Marcuzzi**: Conceptualization, Investigation, Writing. **Helene R. Treeck**: Investigation, Writing.

REFERENCES

Arroyo et al. (2022) A general theory for temperature dependence in biology Proceedings of the National Academy of Sciences 119:30, e2119872119 [https://www.pnas.org/doi/abs/10.1073/pnas.2119872119]

Brown et al (2004) Toward a metabolic theory of ecology. Ecology, 85: 1771-1789. https://doi.org/10.1890/03-9000.