Too hot to handle? Metabolic upper limits in bean beetles

RQ: What are the upper the metabolic limits in bean beetles?

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Abstract

This study investigated the upper metabolic limit of *Callosobruchus maculatus*, observing an emergence rate increase with temperature up to 28°C, followed by a decline at 35°C. There is a trend through an optimum, and thereafter a drop, but the optimum is lower than we expected. More data points could improve the accuracy and contribute to the implementation of metabolic theory in different ecological systems.

What is the metabolic theory of ecology?

The metabolic theory of ecology (MTE) predicts ecological patterns and discloses that nearly all biological rates increase with temperature [1]

Bean beetle (*Callosobruchus maculatus*)

In this experiment we investigating the emergence rate in the bean beetle *(Callosobruchus maculatus)*. We wish to observe whether this rate follows the prediction of the MTE, or if is there is an observable upper metabolic limit. **We expect the highest rate of bean beetle emergence to be at the upper metabolic limit of 32˚C**, with an observable drop in emergence rate thereafter.

Experimental design

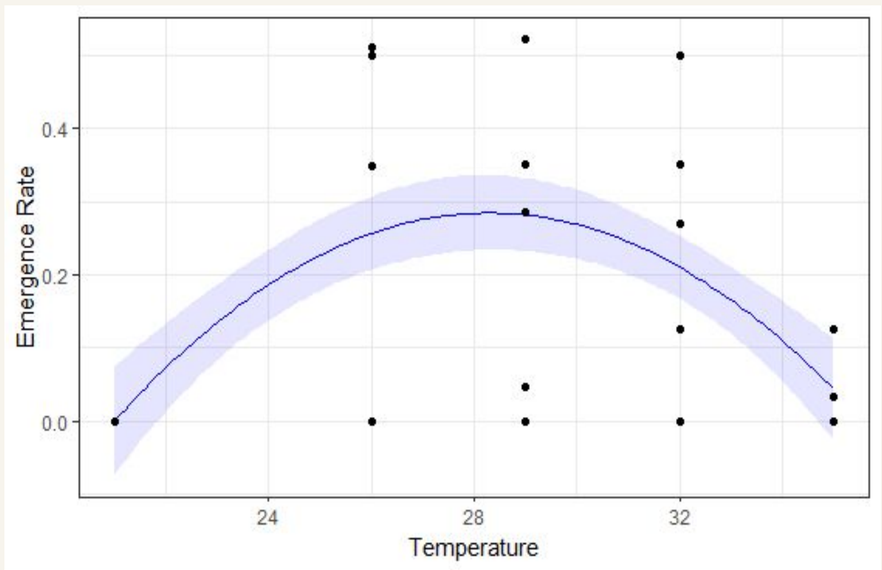

Fig. 1: Unimodal model for emergence rate of bean beetles across temperature in celsius (˚C). (Temperature intervals (˚C): 21, 26, 29, 32, 35)

P-value = 0.00298 < 0.05
AIC = -13.03509

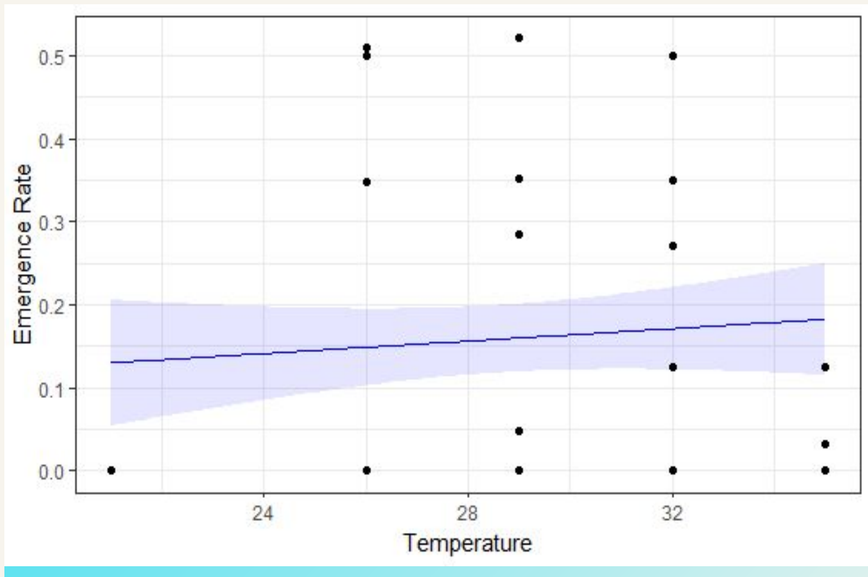

Fig. 2: Linear model for emergence rate with bean beetle mass correction, where mass equals mean bean beetle mass of 0.003g.

P-value = 0.659 > 0.05
AIC = -4.78922

What did we discover?

The results showed a higher emergence rate in bean beetles with rising temperatures, but decreased after the optimal temperature 28.3 ˚C. In *fig. 1*, the emergence rate increased between 21˚C and 28.3˚C (optimal temperature). The rate decreased at 35˚C (the highest temperature). This means that looking for the activation energy did not work in this case and the optimum temperature is the more interesting value. P-value and AIC indicate that unimodal model represent results with statistical significance and it is a good fit. For the linear model, P-value and AIC indicate that this is a poor choice for representing our results and does not present with statistical significance.

What does this mean?

- The results match our hypothesis in terms of there being a trend through an optimum and a drop in emergence rate after. However, following the unimodal model, there is not a clear trend of emergence rate going up to the optimum, and the optimum is lower than expected at 28.3 ℃ instead of 32 ℃.
- Our experimental model doesn't fit with the existing research on metabolic theory [1], mainly due to our use of unimodal model. Although we see the aforementioned anticipated drop in metabolic activity, there is a margin of error for each of the temperature intervals which lead to some degree of uncertainty in our results. Possible improvements could be made by adding data points.
- As the optimal temperature was found at 28.3 ℃, this indicates that to find the activation energy in future research, lower temperatures should be tested instead of higher temperatures.
- Further evidence that our model is ill suited for the metabolic theory, is the positive slope of the linear model *(fig. 2)*. Metabolic theory predicts empirical phenomena in ecology and suggests that energy and materials are inextricably linked [1]. Therefore, it can be beneficial to do more research into the metabolic theory to figure out how it can be implemented in different systems and help us better understand them.

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References

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[2] Allen L, O'Connell A, Kiermer V. How can we ensure visibility and diversity in research contributions? How the Contributor Role Taxonomy (CRediT) is helping the shift from authorship to contributorship. Learned Publishing. January 2019;32(1):71–4.

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