Embryonic Temperature Shifts Increase Adult Size in *Drosophila melanogaster*

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Background

Thermal stress can lead to shifts in the genetic and/or phenotypic correlations between life history traits (Norry et al., 2002). In Drosophila melanogaster, temperature affects body size primarily by affecting critical size, the point in development when larvae initiate the hormonal cascade that stops growth and starts metamorphosis (McDonald et al., 2018). This study analyzed the effect of shifting early incubation temperature by switching among high and low temperatures after 24 hours of embryonic development. Overall size was estimated by measuring 5 morphological traits.

Hypothesis

It was hypothesized that temperature during the first 24 hours of development would be a significant source of variation on fly development.

Methods

Treatments consisted of four groups: 1) flies incubated at a constant high temperature (28° C); 2) flies incubated at a constant low temperature (18° C); 3) flies switch from 28° C to 18° C after 24 hours of development; 4) and flies switched from 18° C to 28° C. Two days following eclosure, flies were etherized and frozen. 5 morphological traits were measured: body length, wing length, eye area, tibia length, thorax length, and abdomen length. The dimensionality of the data was reduced by performing a principle component analysis. An ANOVA was then performed on the first principle component (PC1).

Abstract

The developmental history of organisms is critical in determining phenotypic outcomes. Shifts in environmental factors can constrain or redirect ontogeny in ways that traditional models of plasticity have failed to predict. In this study we examined the impact of shifting between high and low thermal regimes during the embryonic stage in Drosophila melanogaster. We found that extreme temperatures (both high and low) resulted in larger flies at enclosure than the temperature during subsequent development would have predicted. Thus, embryonic temperature poses a critical window that can have lasting effect son morphology and fitness.

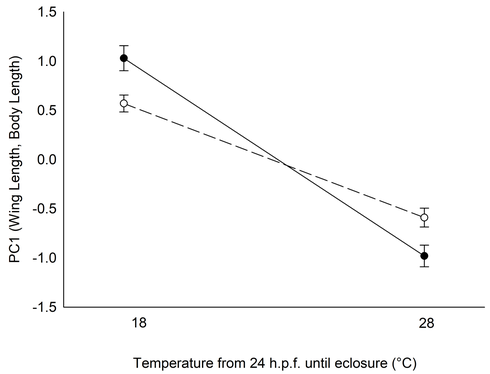


Figure 1. Fly size (PC1) as a function of incubation temperatures. Solid symbols represent flies incubated in 28°C for the first 24 hours of development. Open symbols represent flies incubated in 18°C for the first 24 hours of development.

Source	df	MS	F	P
T_{0-24}	1	0.073	0.221	0.064
T_{24-E}	1	69.58	210.217	<.001
T_{0-24} x T_{24-E}	1	6.220	18.793	<.001
Error	111	0.331		

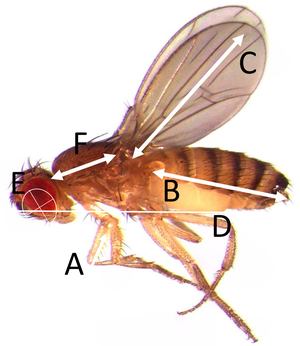
Table 1. ANOVA results for PC1. Sources of variation included the incubation temperature for the first 24 hours of development (T_{0-24}), the incubation temperature from the 24th hour of development until eclosure (T_{24-E}), and the interaction between incubation temperatures (T_{0-24} x T_{24-E}).

Results

Temperature was a significant source of variation in fly size at eclosure. Flies raised at low temperature grew larger than flies raised in high temperature (Table 1, T_{24-E} $p<.0001$). However, the temperature during the first 24 hours of development increased developmental size if it mismatched the subsequent developmental temperature (Table 1, T_{0-24} x T_{24-E} $p<.0001$).

Discussion

Thermal environment has been demonstrated to influence overall size in ectotherms (McDonald et al., 2018). This study demonstrates that temperature during the first day of development can affect overall size of adult flies. These findings suggest that the first few hours of development in ectotherms may pose critical windows that have lasting effects on growth and fitness (Burggren and Mueller 2015). In humans, the first trimester is known to be a critical window of development (Triche and Hossain 2007). These findings indicate that drosophila may pose valuable model in exploring the effects on environmental insult during early critical windows of development.



Tibia – A
Abdomen – B
Wing – C
Body length – D
Eye – E
Thorax – F

References

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