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Temperature Interaction with Density on the Growth and Survival of a Common Generalist Butterfly

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Warming temperatures have the potential to disturb species interactions, organism phenology, and alter the natural ranges of species. Organisms vary in their responses to climate change ranging from no response to range shifts and evolutionary adaptations. Ecototherms, like Lepidopterans (moths and butterflies) are particularly sensitive to changes in temperature.
Lepidopterans impact ecosystem productivity because they facilitate pollination, directly impact plant biomass through herbivory, and are prey for higher trophic levels. Many species have large ranges and develop with cohorts of variable densities on host plants. Thus, how different lepidopterans are affected by warming temperatures can have large consequences on ecosystem function.

We tested the hypothesis that high temperature and caterpillar densities would accelerate growth and decrease survival. Our hypotheses were first that higher temperature levels would increase growth rates and survival by speeding up metabolic processes, and that caterpillars raised in lower temperatures would have the opposite effect. Second, we hypothesized that higher density levels would increase growth rates through intraspecific competition but also increase mortality. We used painted ladies (*Vanessa cardui*) to test our predictions due to its widespread range and generalist diet. We setup four treatment groups to test how different densities of lepidopterans would respond to temperature: 1) low density + low temperature, 2) low density + high temperature, 3) high density + low temperature, and 4) high density + high temperature. Temperatures were determined using temperature predictions for the years 2040 – 2059 for Texas and Michigan based on high CO_2 emissions, which represent part of the southern and northern range of *V. cardui*) for the high and low treatments respectively. The density levels for the treatments were taken from lepidopteran density experiments that were based on field observations of cohort size. 2nd instar caterpillars (from Carolina Biology™) were reared until pupation or death. We measured mortality and growth rates over 3 weeks.

Temperature and caterpillar density impacted both the growth and survival of caterpillars. However, temperature had the largest impact on larval mortality, while density had the largest effect on growth rates. Specifically, increased temperatures correlated with higher larval mortality, and higher population densities corelated with increased growth rates. Contrary to predictions, high temperature had the highest mortality with only 10-20% survival after 1 week compared to 50% in low temperatures.

These results suggest that warming temperatures could cause increased mortality in Painted Ladies along their equatorial range. This could result in local extirpation in the southern portion of their current range and an increase in their northern range. Increased growth rates were observed in higher density treatments in the absence of any resource limitation and all other factors were controlled besides density, which suggests that increased population densities innately triggers increased growth rates. One possible explanation for this is that Painted Ladies have evolved plasticity for growth based on larval densities due to typical environmental selection pressures such as competition high larval density in natural habitats. This is also seen
in locusts, however more research is needed to determine the mechanism.