COMMUNITY ECOLOGY OF VECTOR MOSQUITOES: LINKING LARVAL COMPETITION, CLIMATE CHANGE, AND VECTOR-BORNE DISEASE

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LARVAL COMPETITION ALTERS THE THERMAL NICHE OF VECTOR MOSQUITOES

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Mosquitoes have temperature-dependent vital rates

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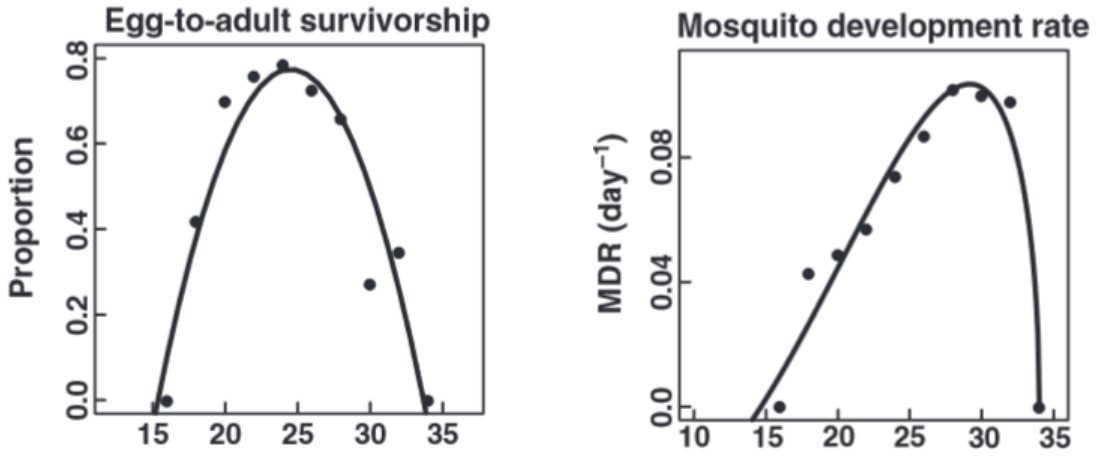
LARVAL STAGE
Survival
Development



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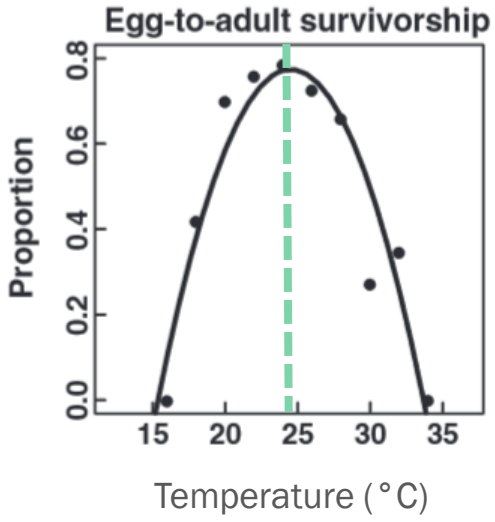
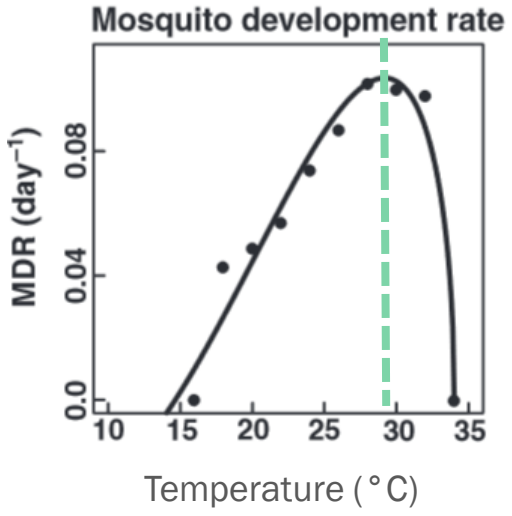
(from Mordecai et al. 2013)

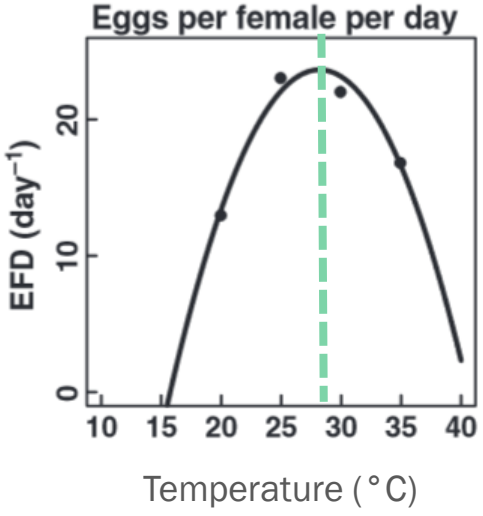
Mosquitoes have temperature-dependent vital rates

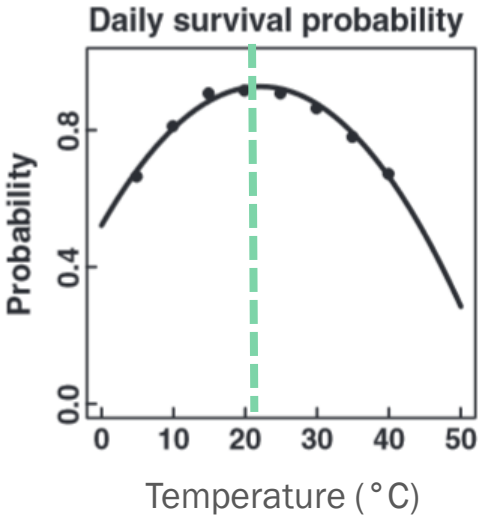
LARVAL STAGE
Survival
Development

ADULT STAGE
Fecundity
Longevity









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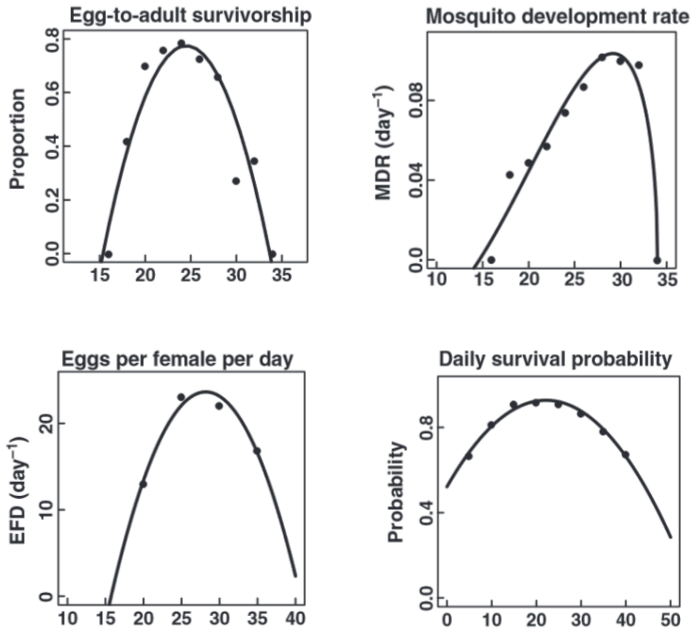
Vital rates determine a species' thermal niche

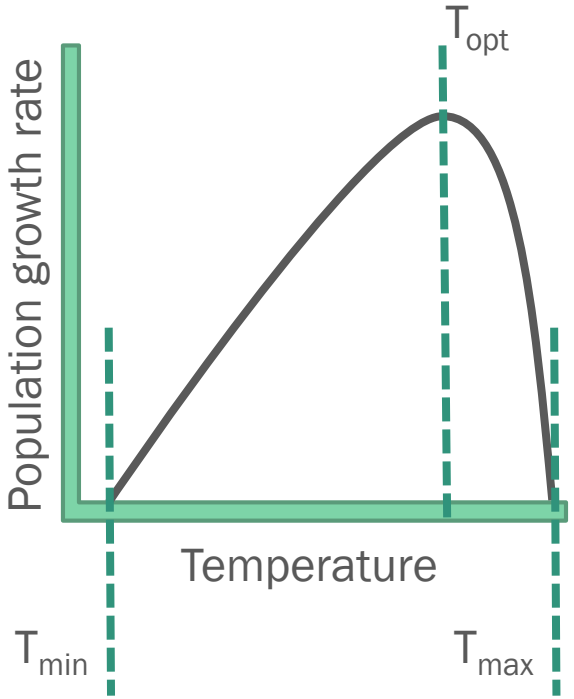
Temperature-dependent vital rates



Population growth rate

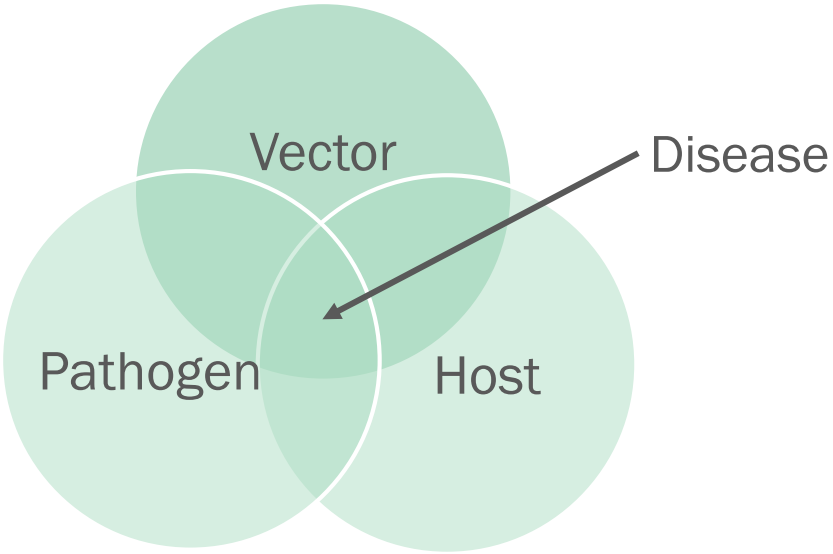
$$r' = \frac{ln\frac{1}{N_0}\sum A_x f(\overline{w}_x)}{D + \frac{\sum xA_x f(\overline{w}_x)}{\sum A_x f(\overline{w}_x)}}$$

Thermal niche



(from Mordecai et al. 2013)

Why is thermal niche important?



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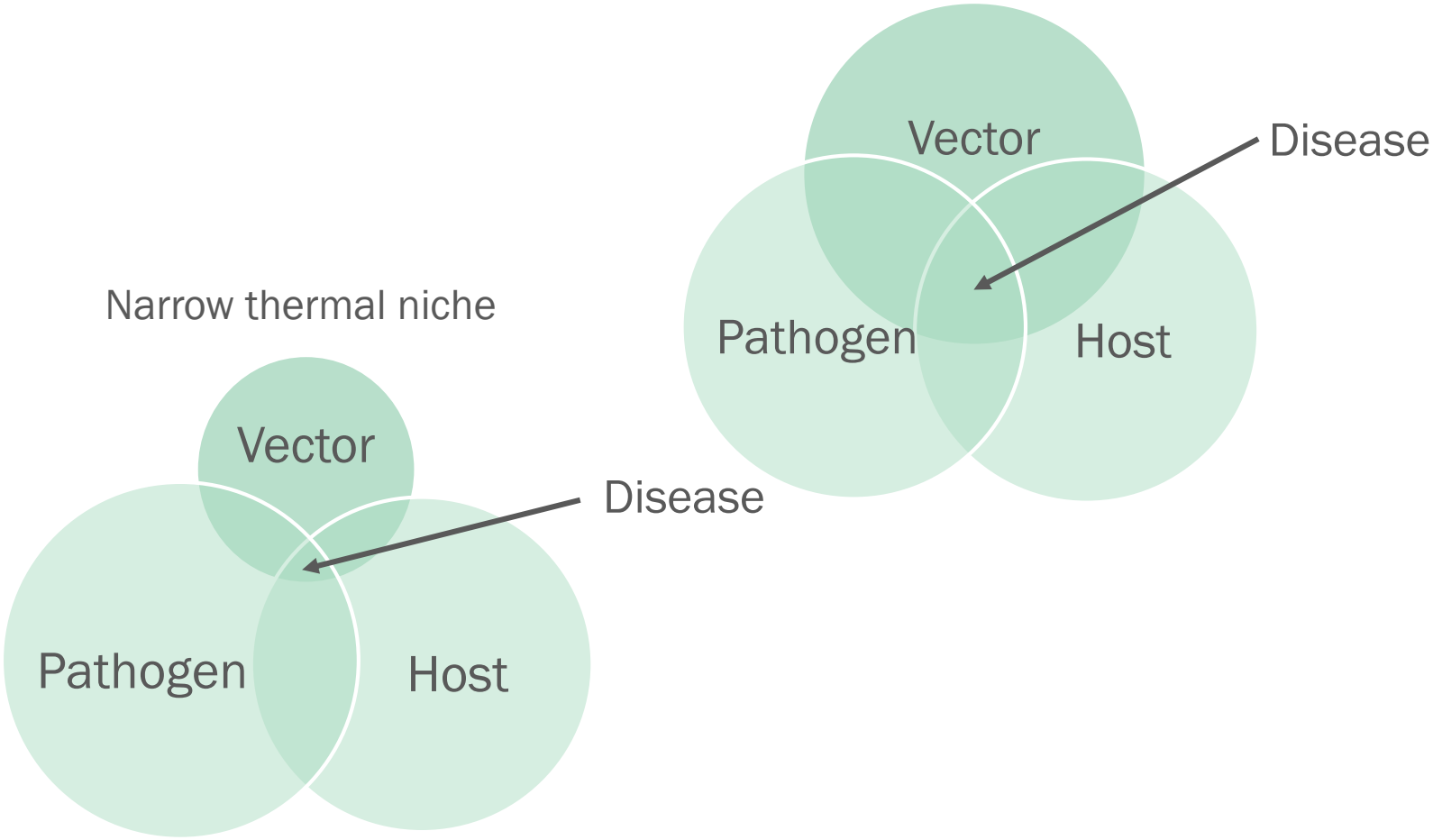

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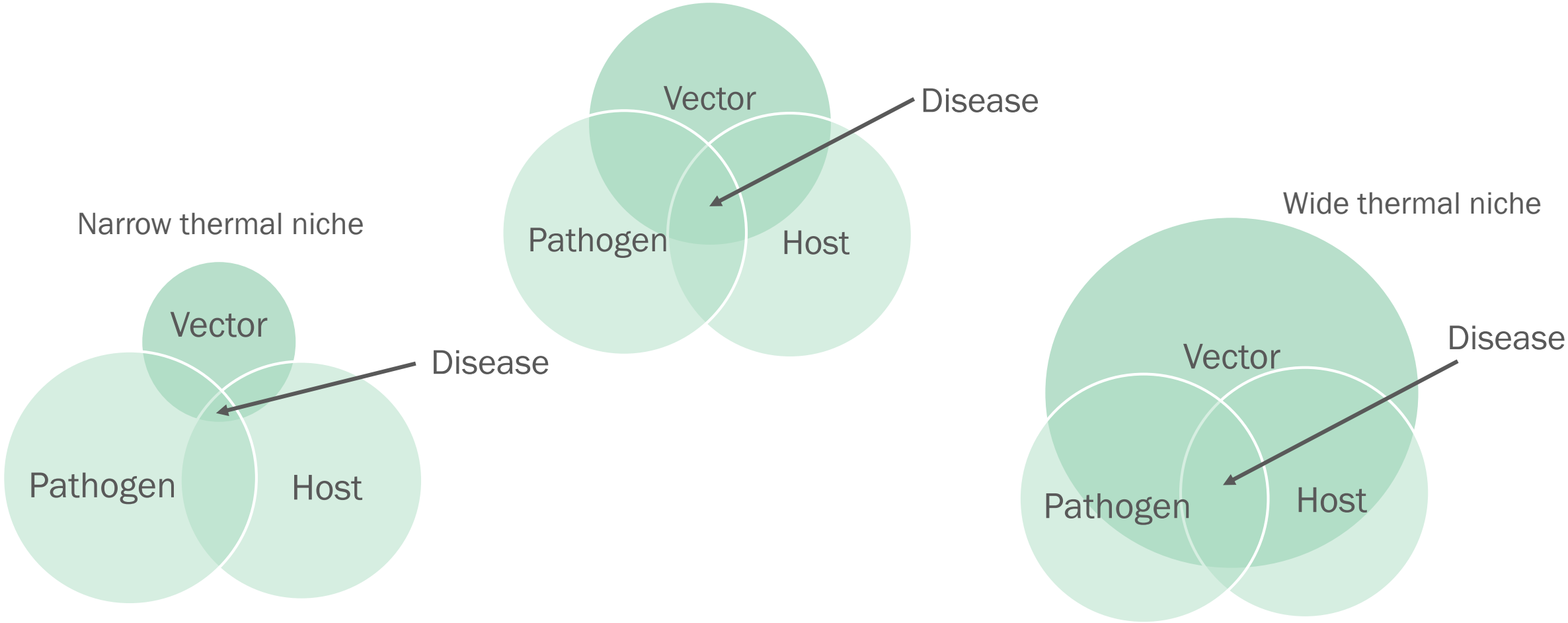
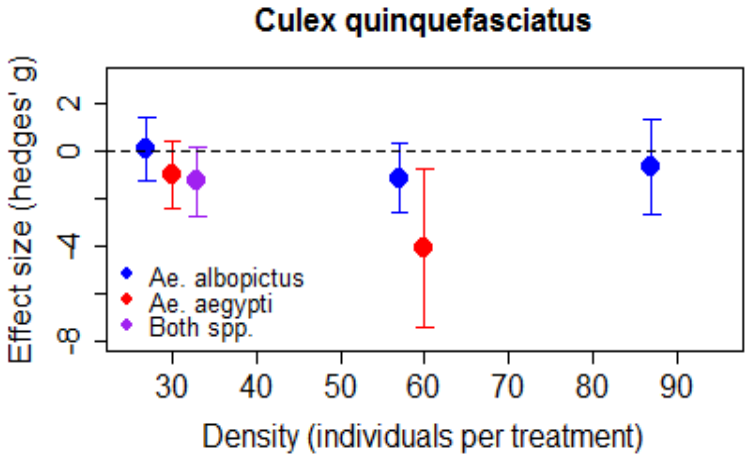
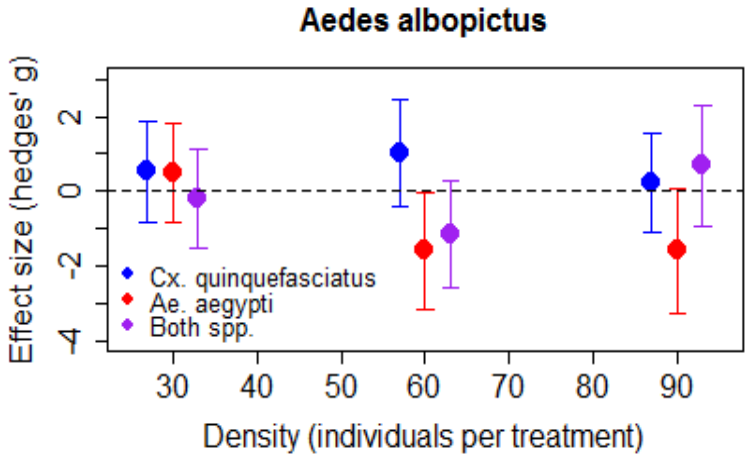
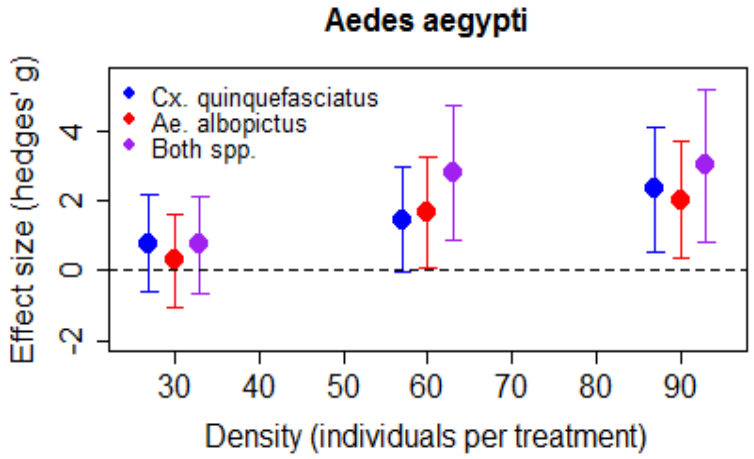


Species interactions can also impact vital rates







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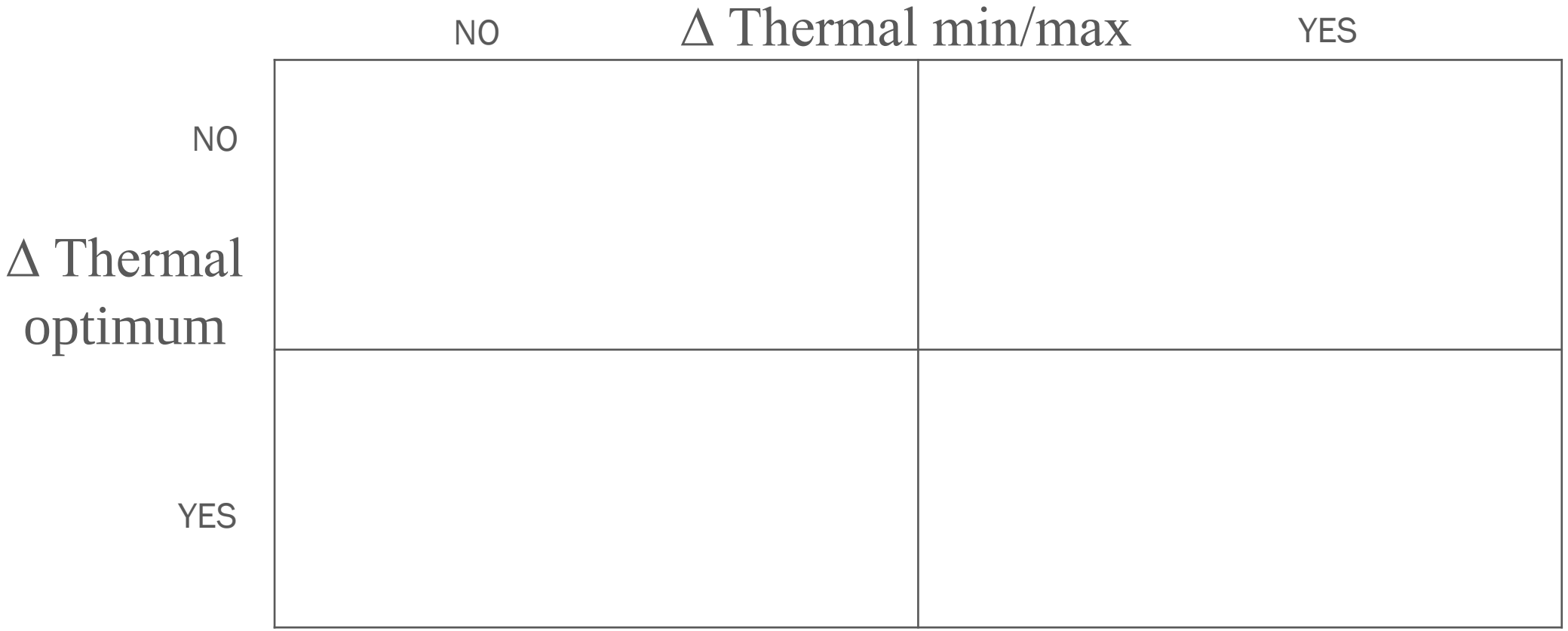
Bowden and Drake, in prep

How does temperature alter species interactions?

Intraspecific larval competition vs. interspecific larval competition



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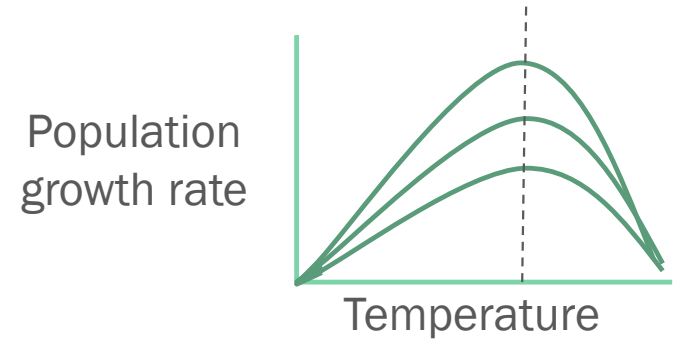
NO		
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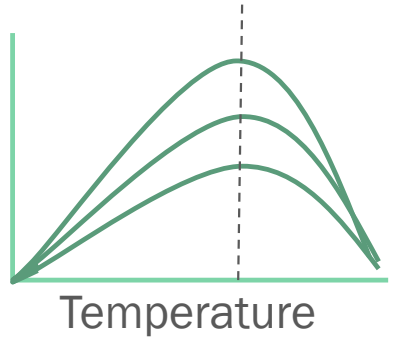
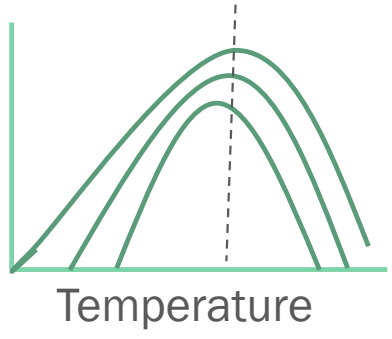
NO		
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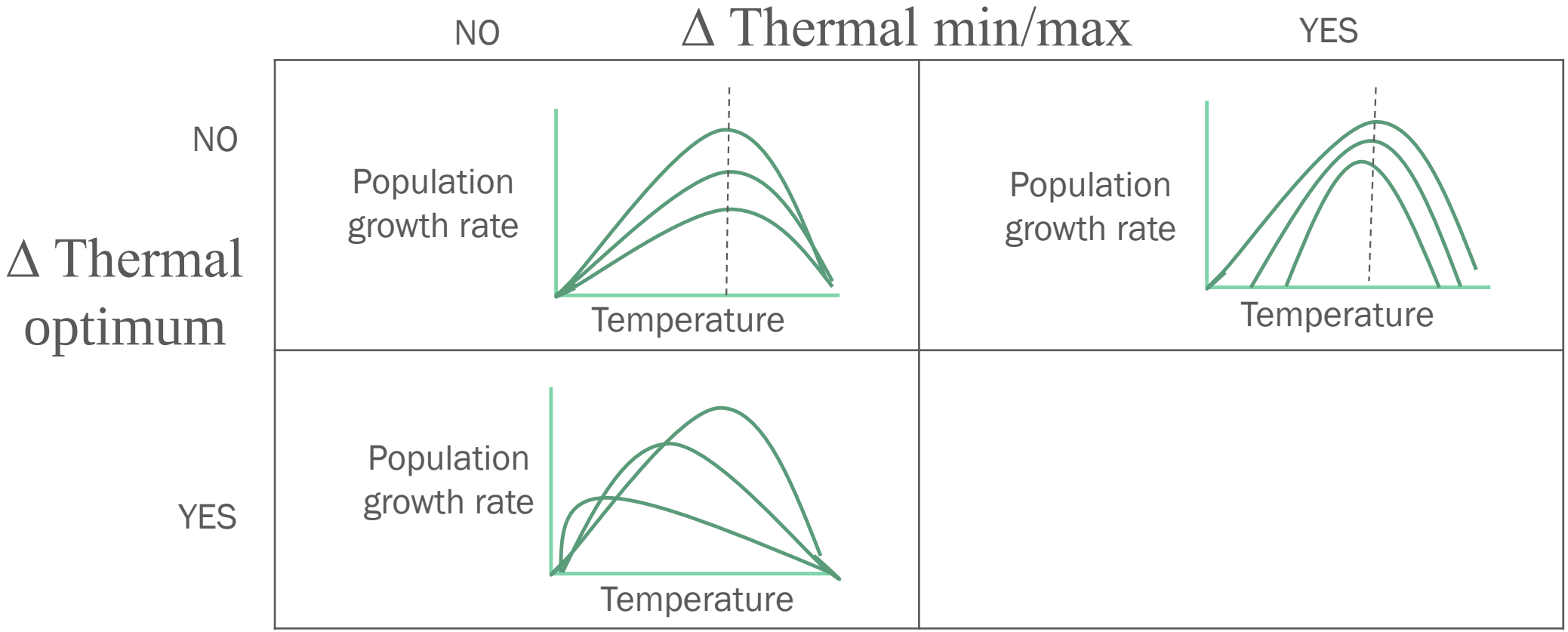

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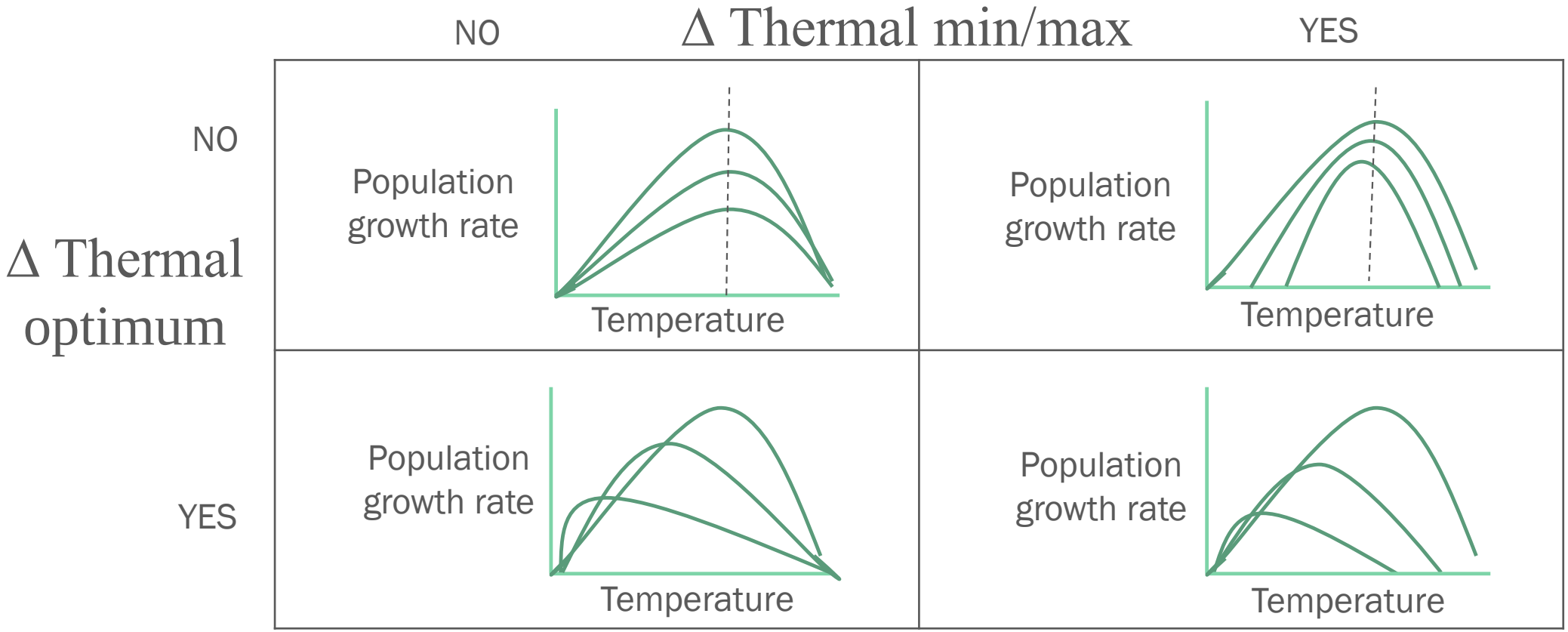

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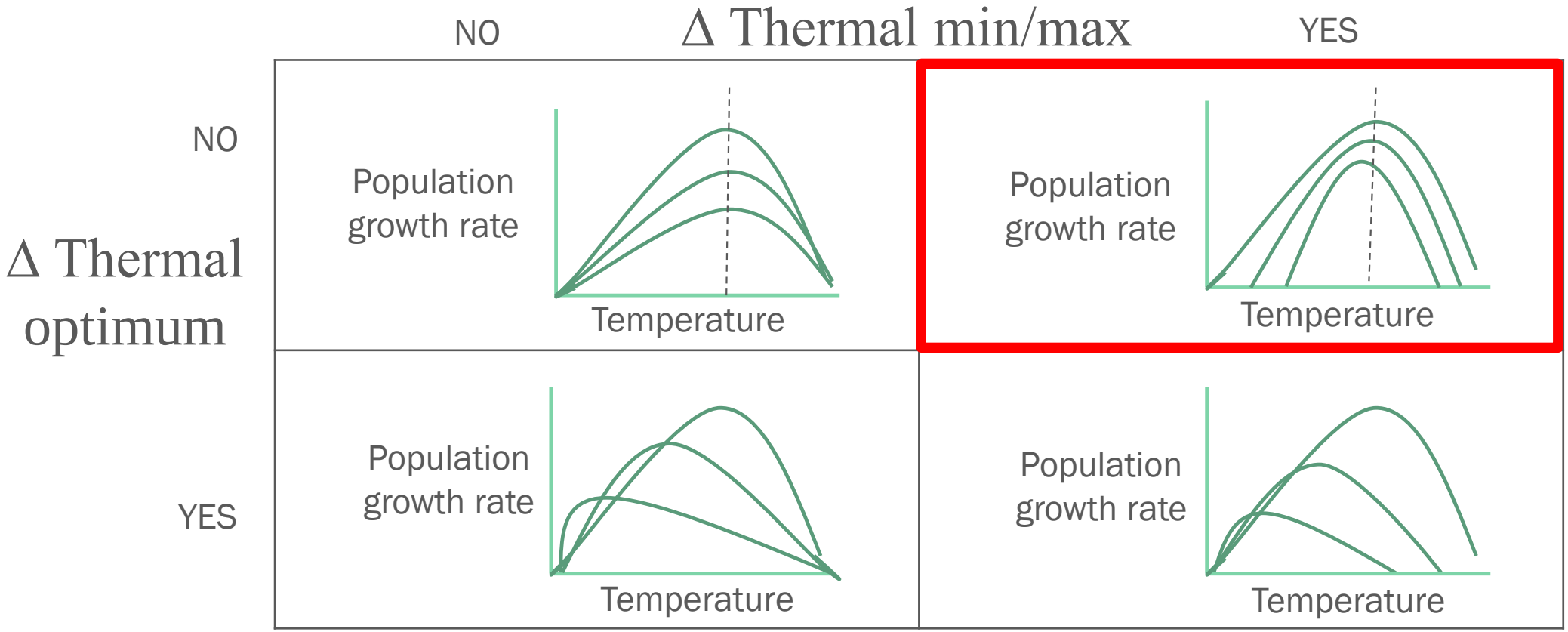

Selection of vector community

Selected 3 species with overlapping geographic ranges and similar preferences for larval habitat

Culex quinquefasciatus

Primary WNV vector in the southeast U.S.

Aedes albopictus

Invasive species and vector of Yellow fever, dengue, and chickungunya viruses

Aedes aegypti

Primary vector of dengue, chickungunya, and Zika viruses

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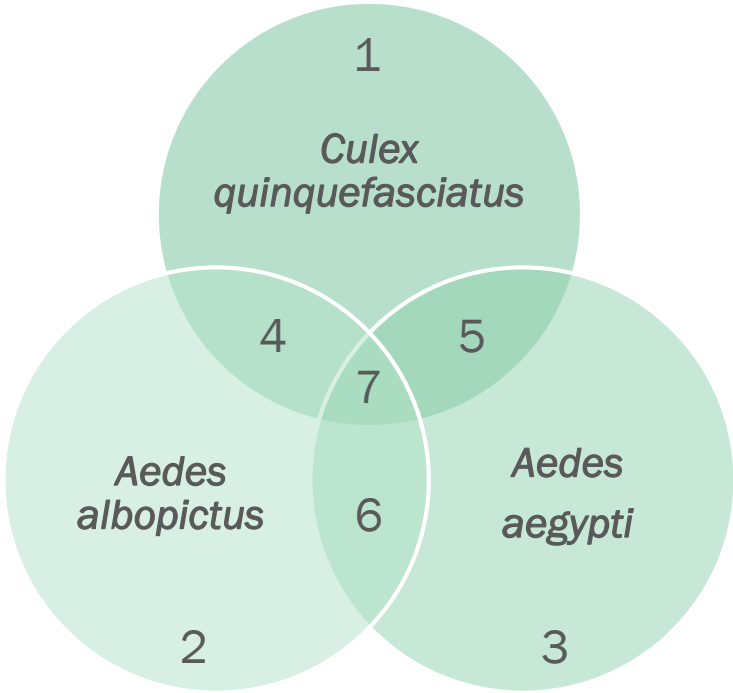
Competition experiments in laboratory microcosms

- Substitutive design at low density (30 individuals)
- 7 species combinations x 5 temperature treatments x 5 replicates
- Temperature gradient from 21-33°C with treatments every 3°C
- Incubated at constant temperature for 21 days and collected newly emerged adults every 24 hours

Experimental design



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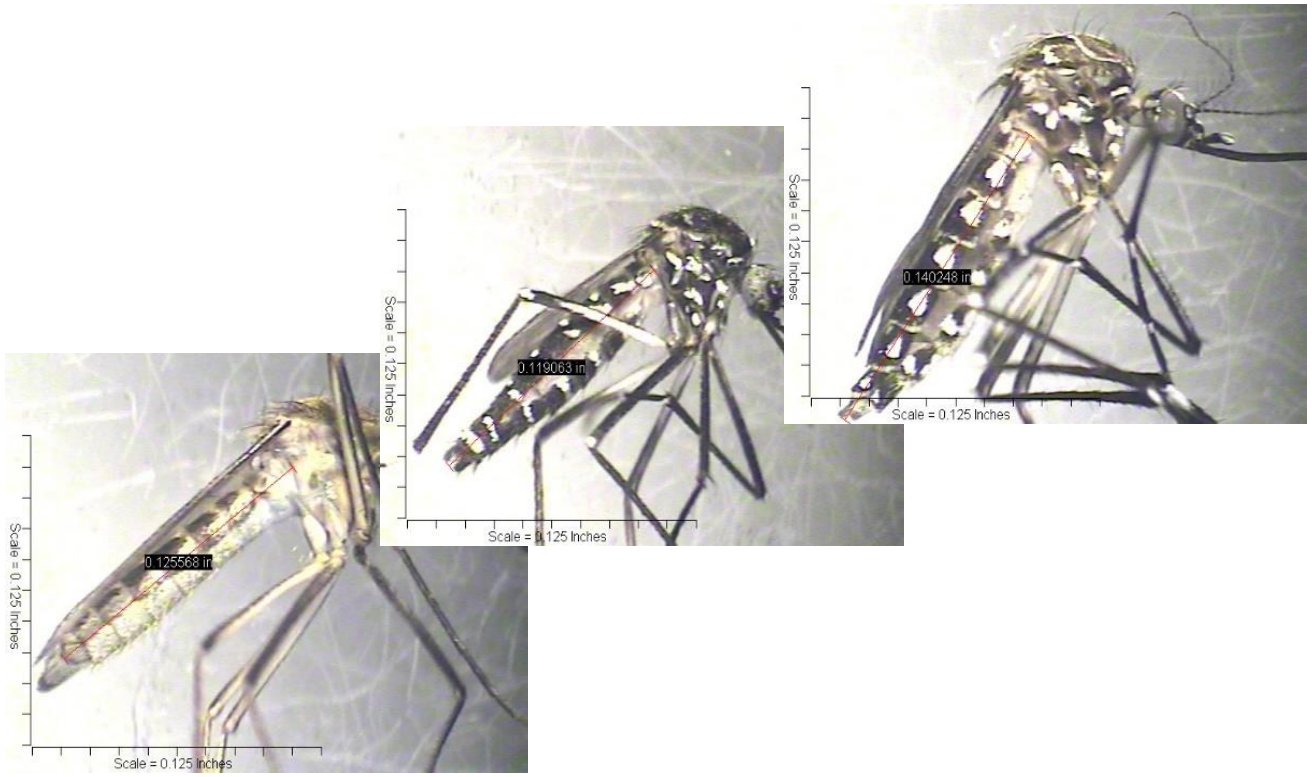
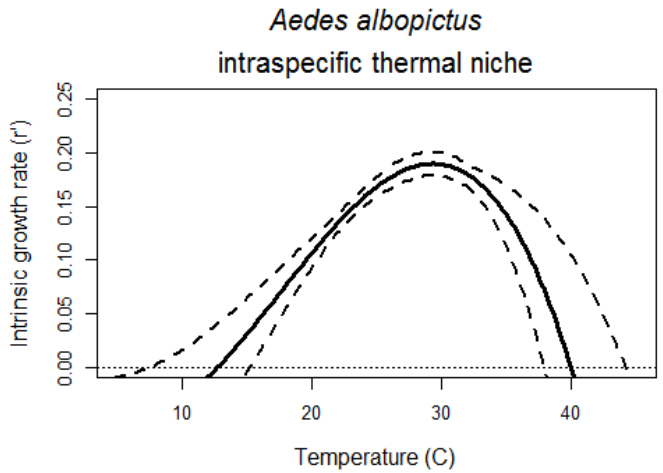
Estimating population growth rates and thermal niche

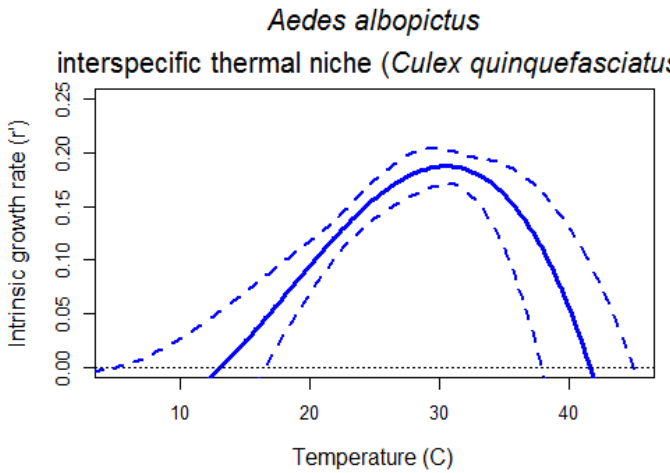
- For each emerged adult
  - Development time
  - Body size (proxy for fecundity)
- For each treatment
  - Egg-to-adult survival
- Used to estimate intrinsic rate of increase (Livdahl and Sugihara 1984)

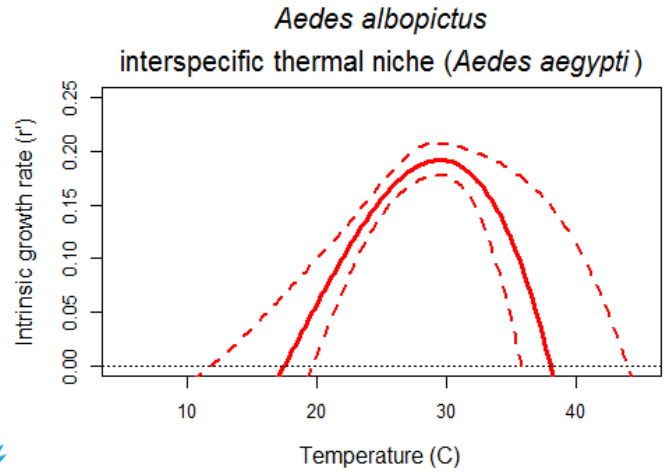
$$r' = \frac{ln\frac{1}{N_0}\sum A_x f(\overline{w}_x)}{D + \frac{\sum xA_x f(\overline{w}_x)}{\sum A_x f(\overline{w}_x)}}$$

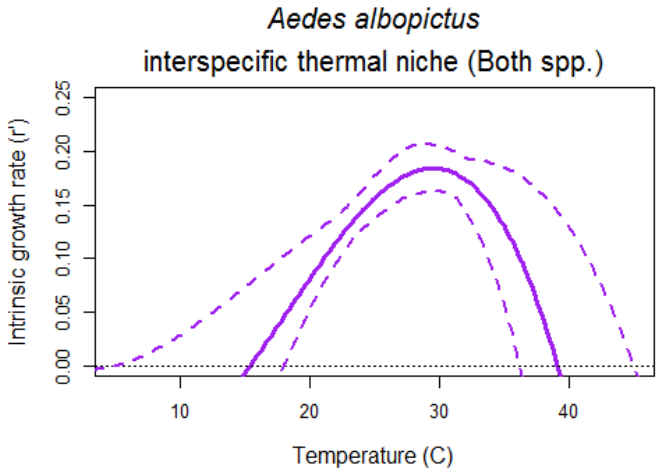


Estimating the thermal niche for population growth









Fit Briére curves to intrinsic growth rate estimates

$$y = cT(T - T_0)(T_m - T)^{1/2}$$

Bootstrapped growth rate estimates x10,000 and fit curves to each to estimate uncertainty around thermal niche

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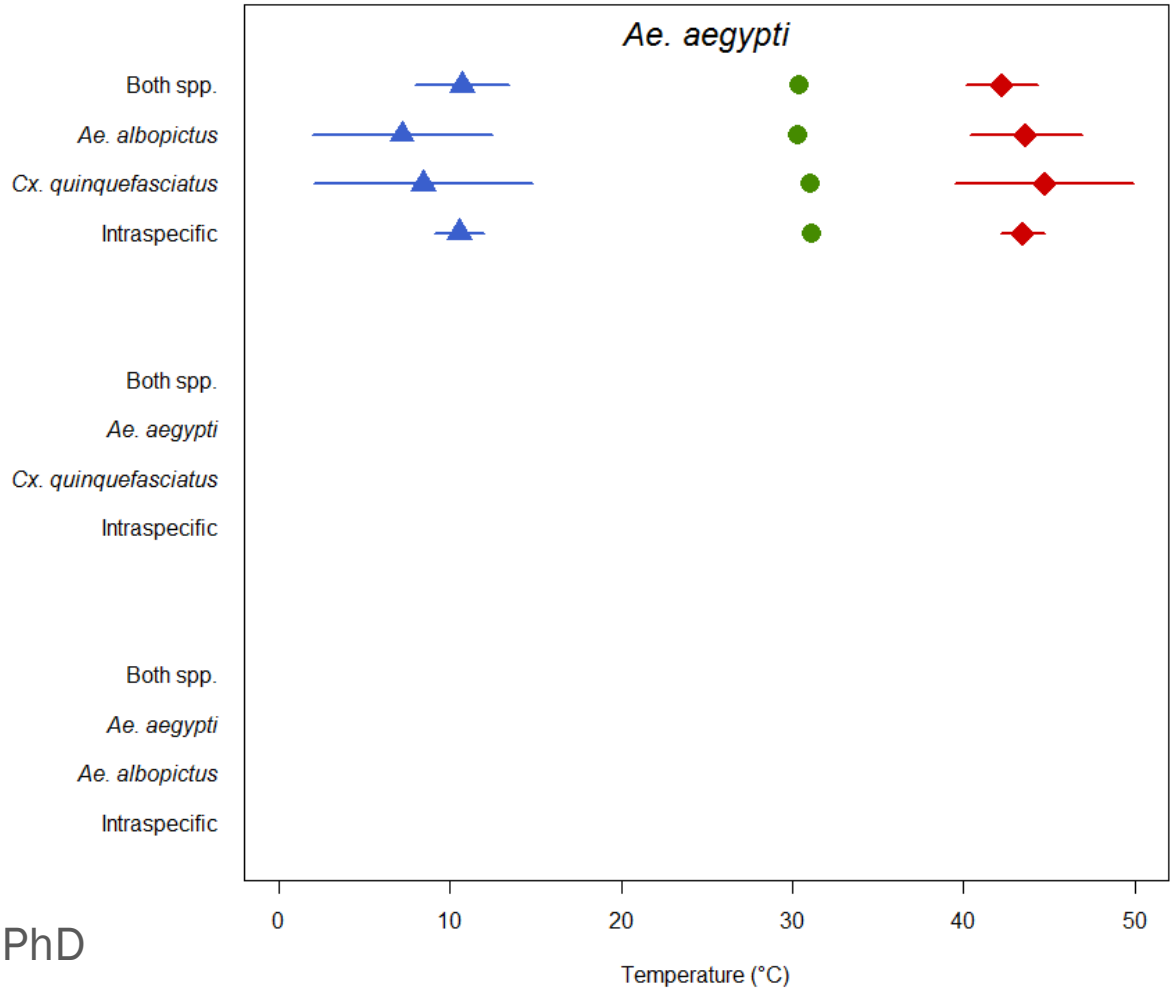
Temperature-dependent effects of interspecific competition on intrinsic growth rates



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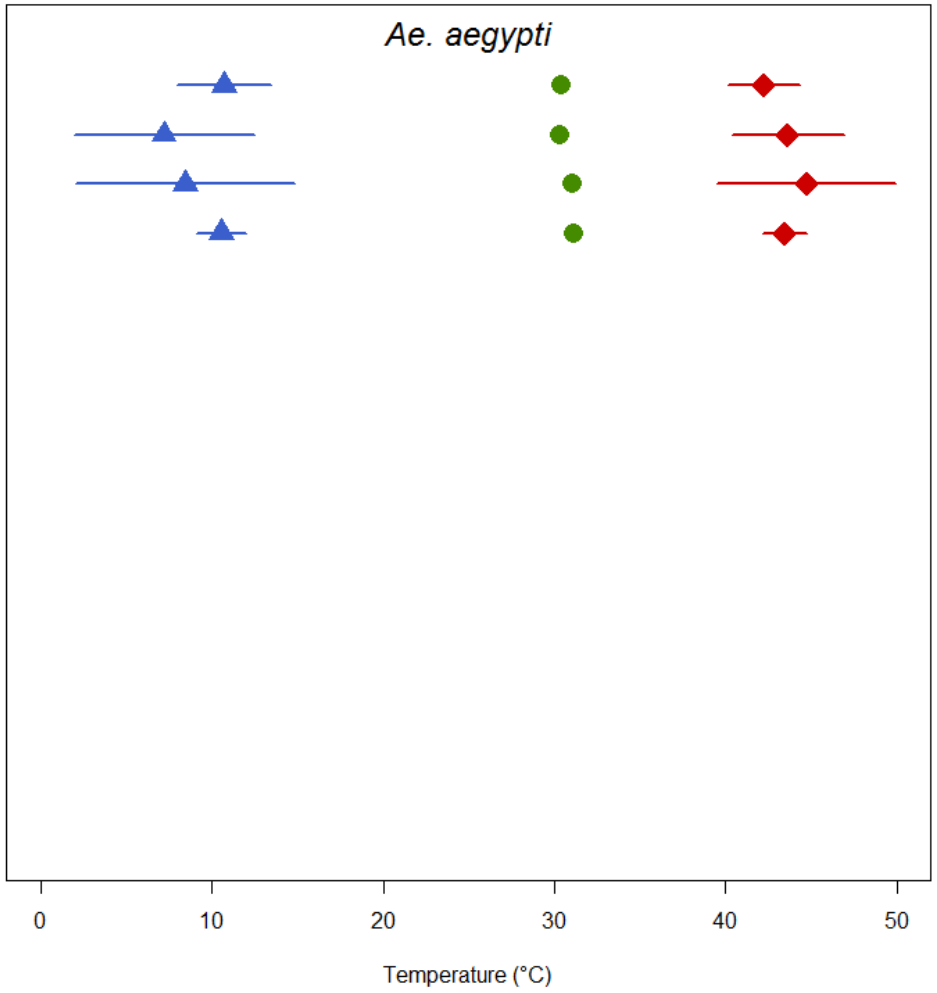
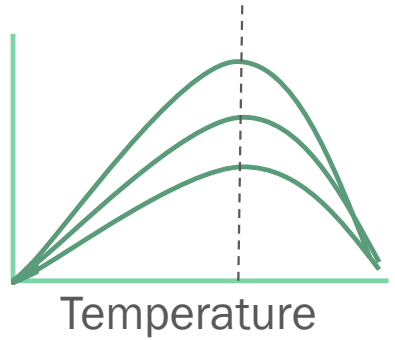


No effect of interspecific larval competition on thermal niche



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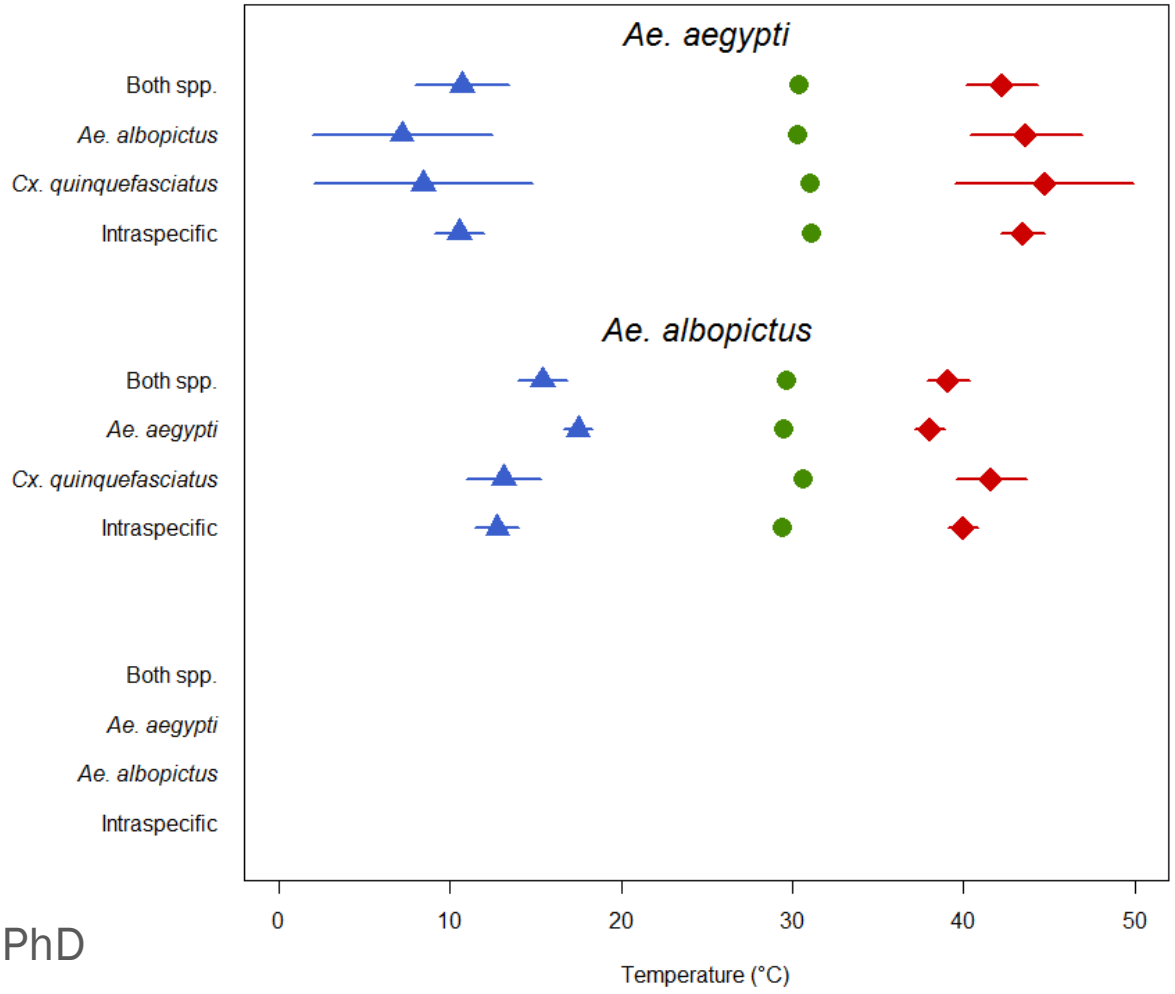

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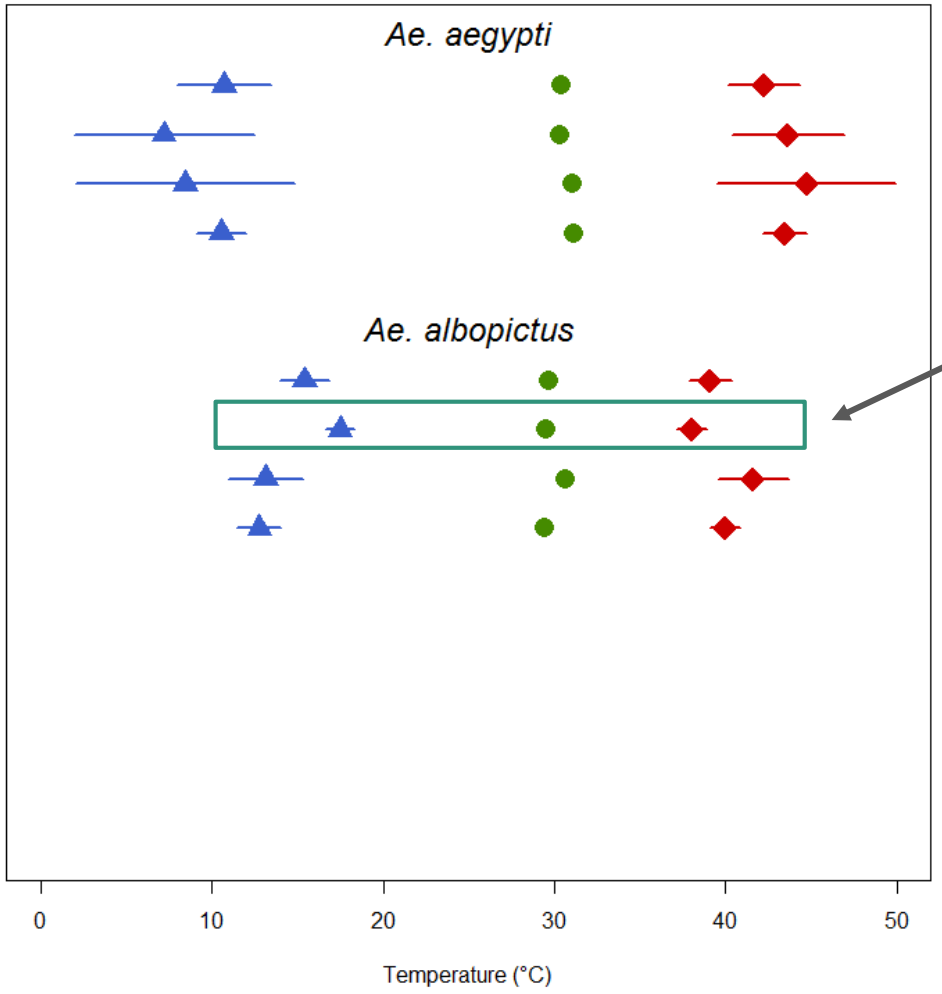

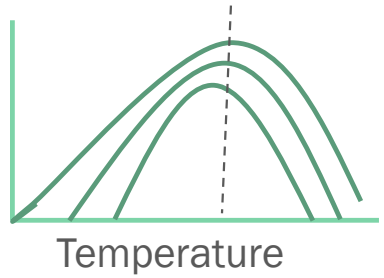

Competition with *Ae. aegypti* increases T_0 and decreases T_m

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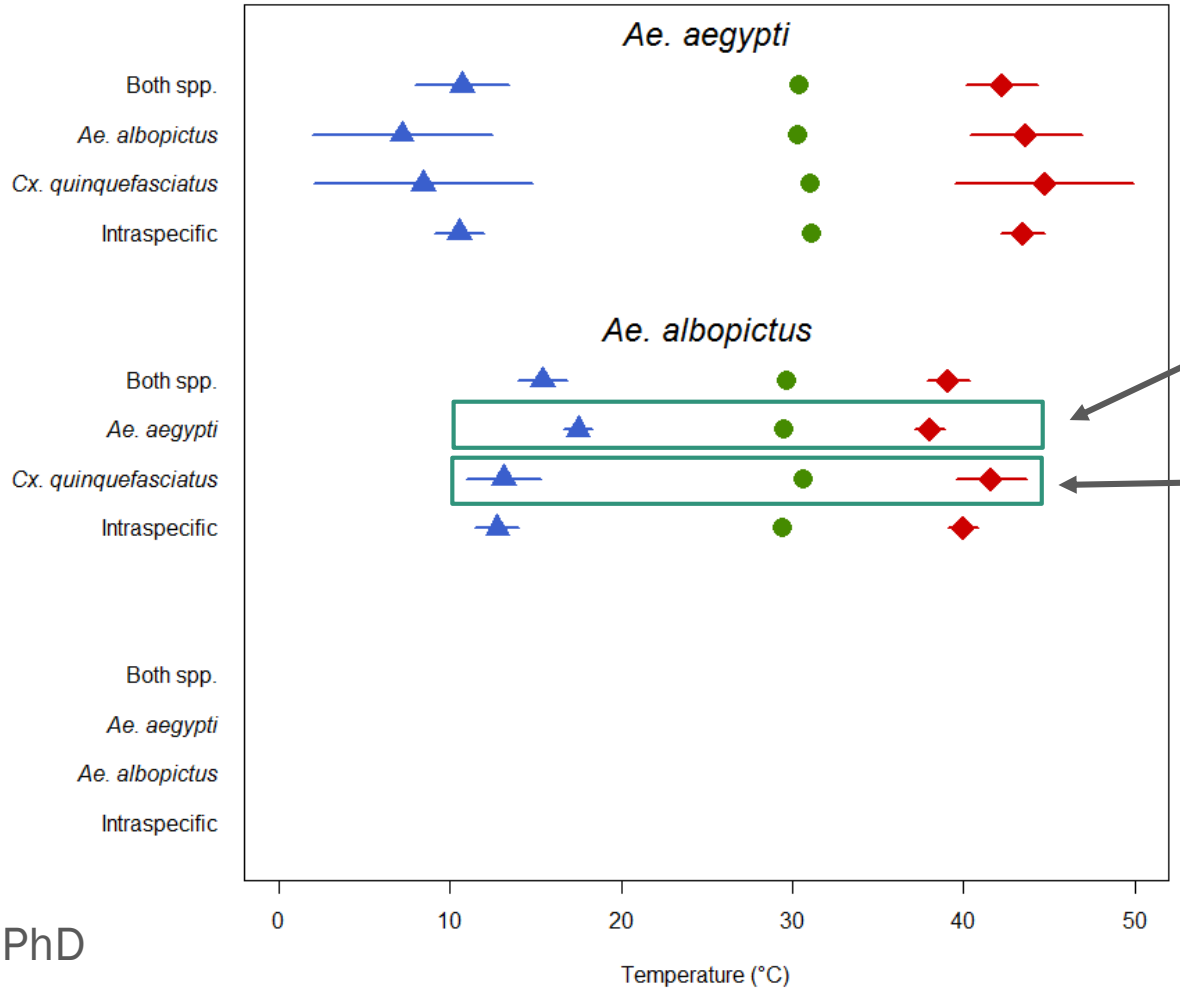
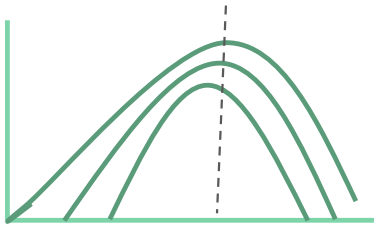
Temperature-dependent effects of interspecific competition on intrinsic growth rates



Population growth rate

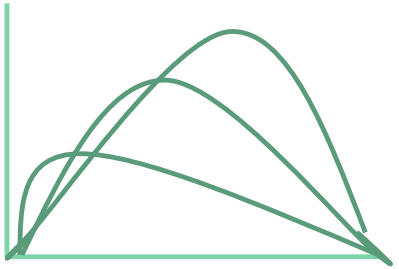


Temperature

Competition with *Ae. aegypti* **increases T_0** and **decreases T_m**

Competition with *Cx. quinquefasciatus* **increases T_{opt}**

Population growth rate



Temperature

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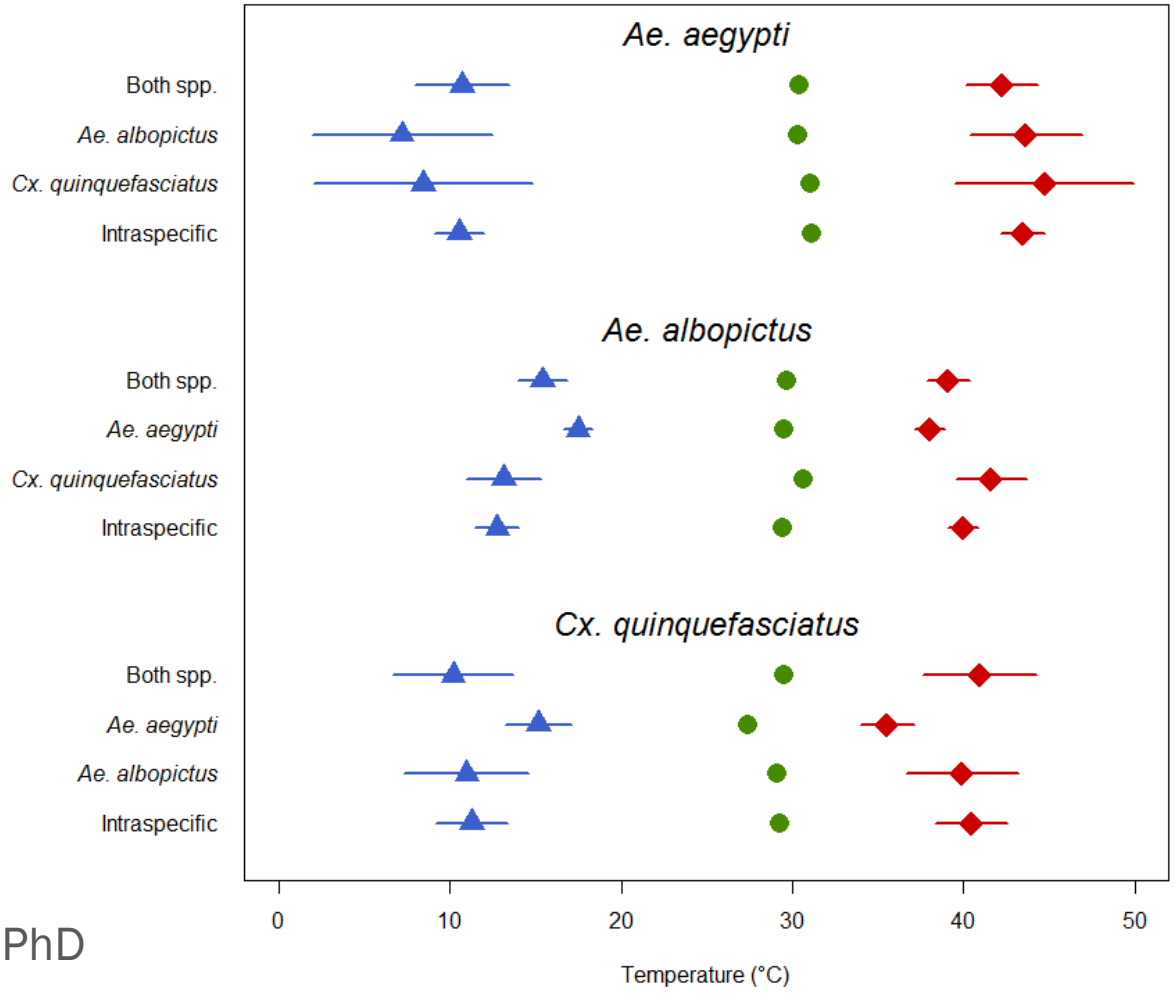
Temperature-dependent effects of interspecific competition on intrinsic growth rates



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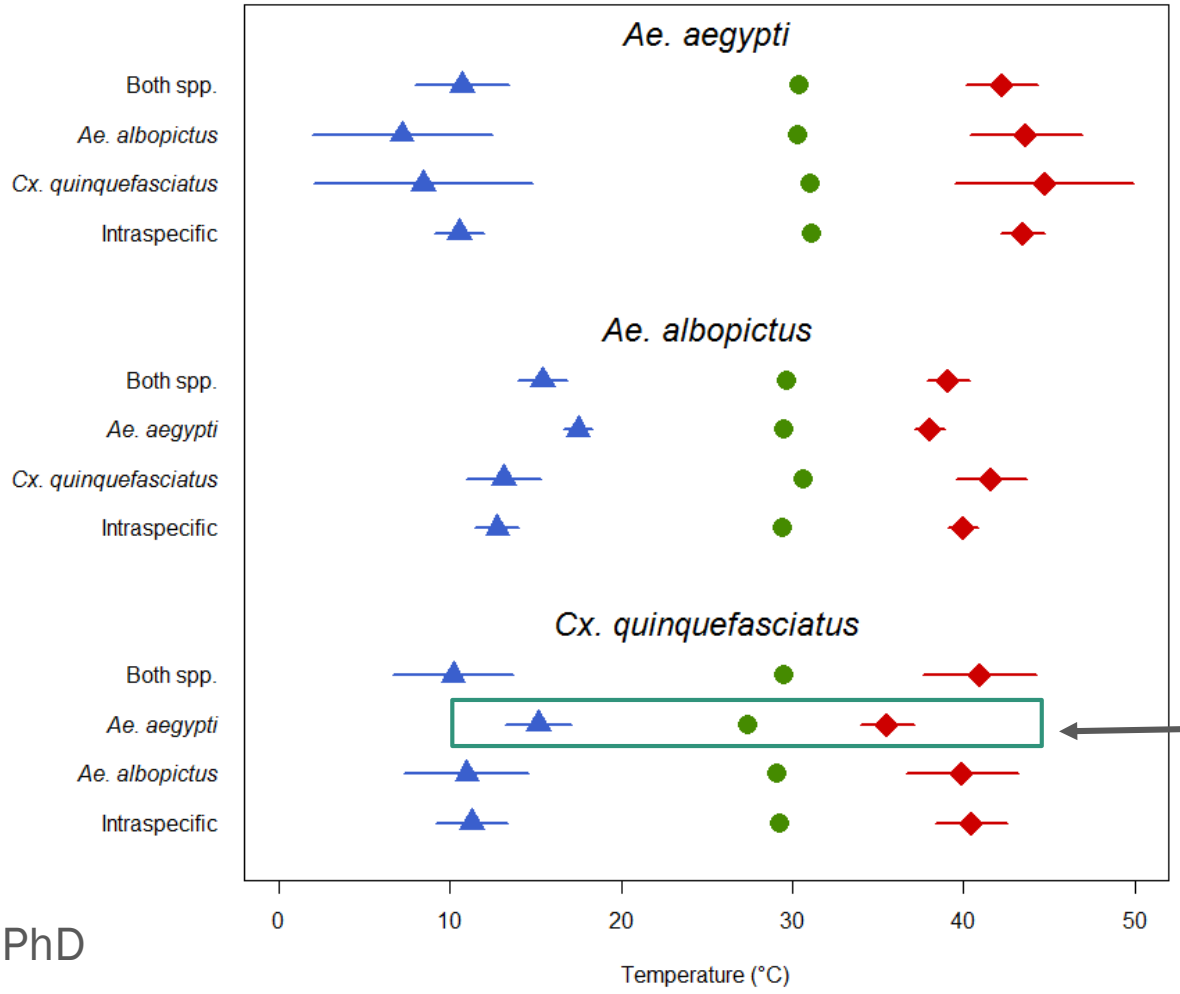

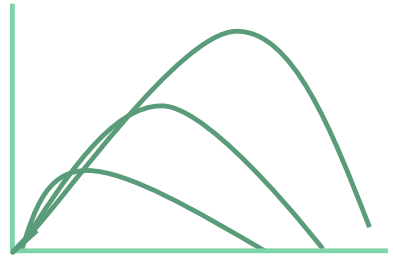

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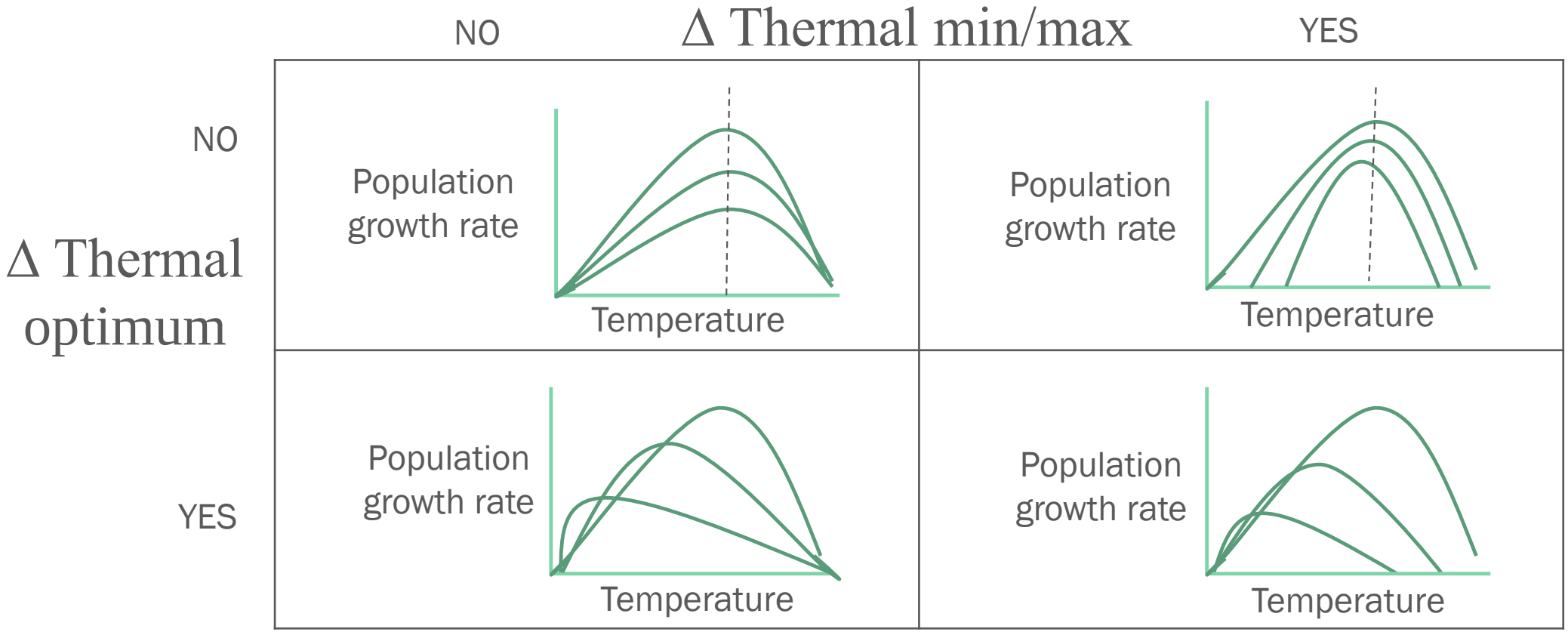
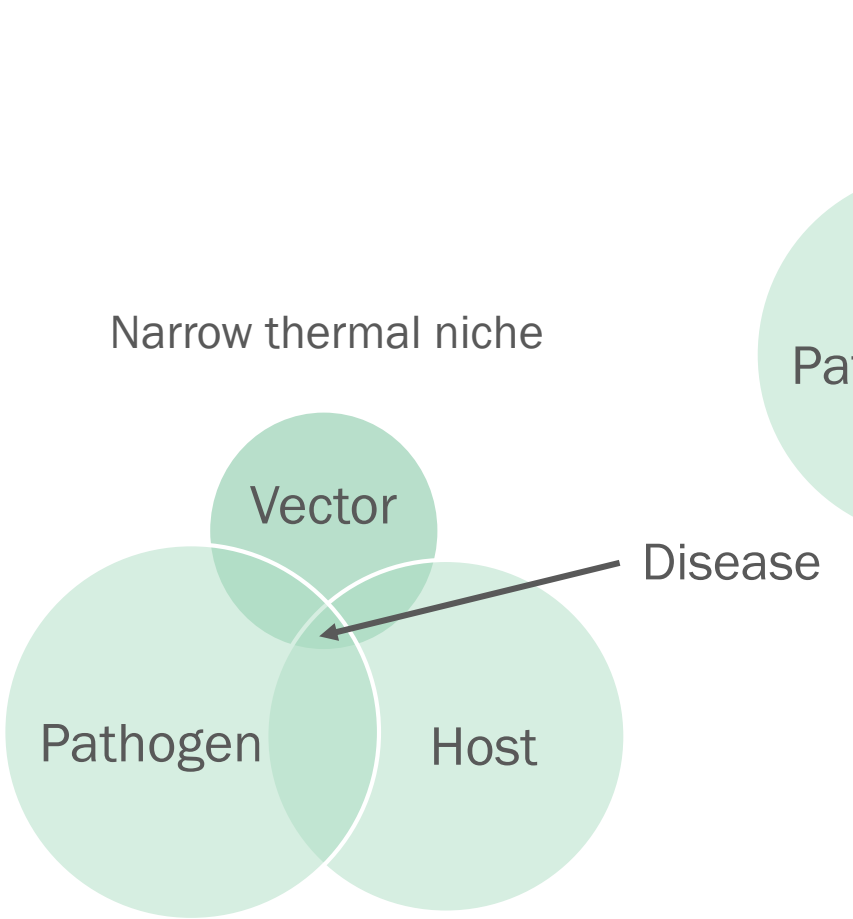
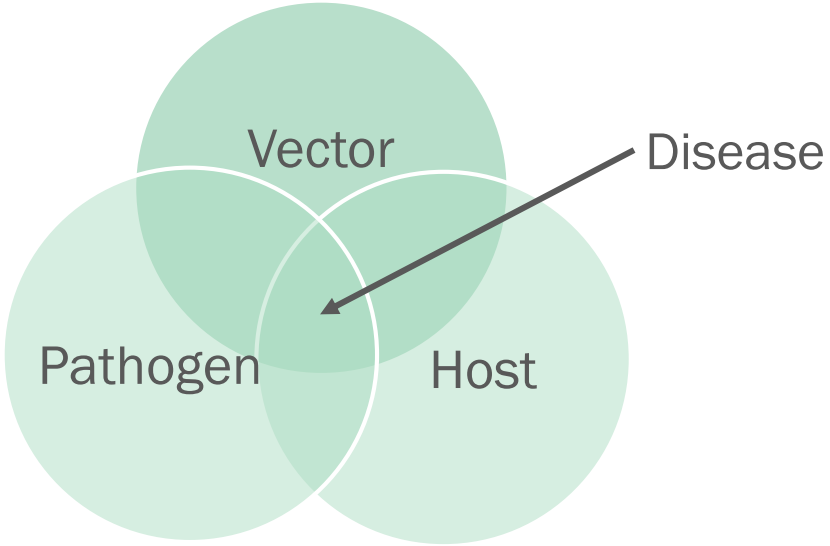
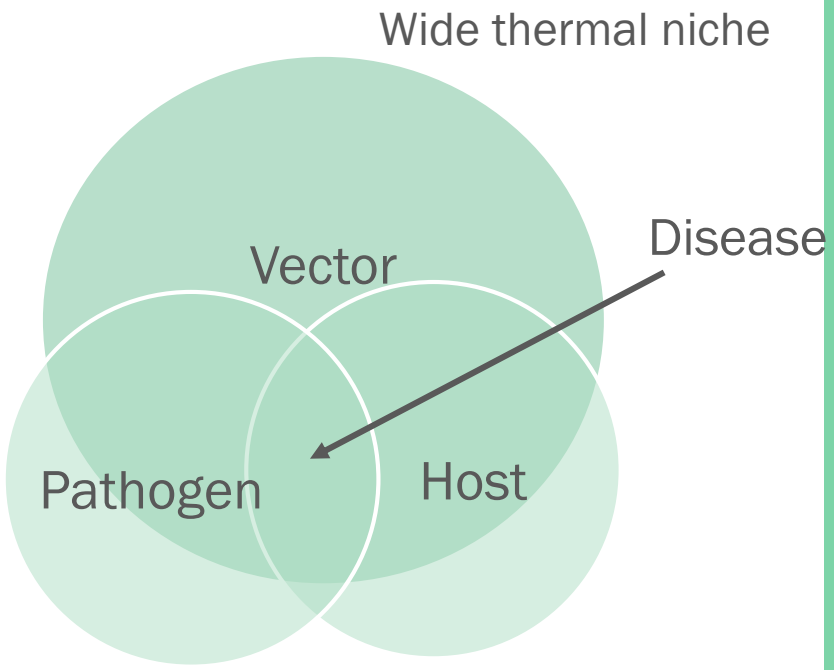


Why is thermal niche important?

Changes in vector thermal niche = Changes in disease transmission niche







Relevance to natural populations

- Mapping current and future differences in thermal niche-based geographic distribution under each competitive scenario
- **Where are distributions altered, and by how much?**

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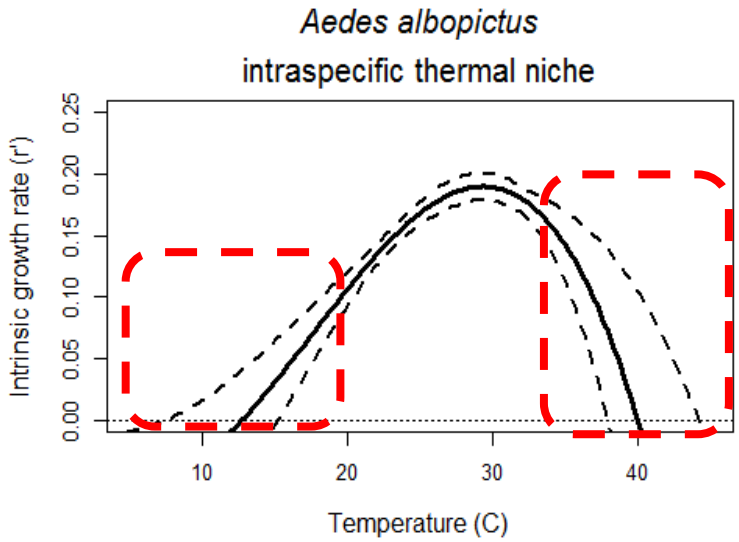
- **Need empirical data from "extreme" temperatures to decrease uncertainty in thermal niche estimates**



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QUESTIONS?

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