

# Microclimate and mosquito-borne disease dynamics

Michelle Evans, Courtney Murdock

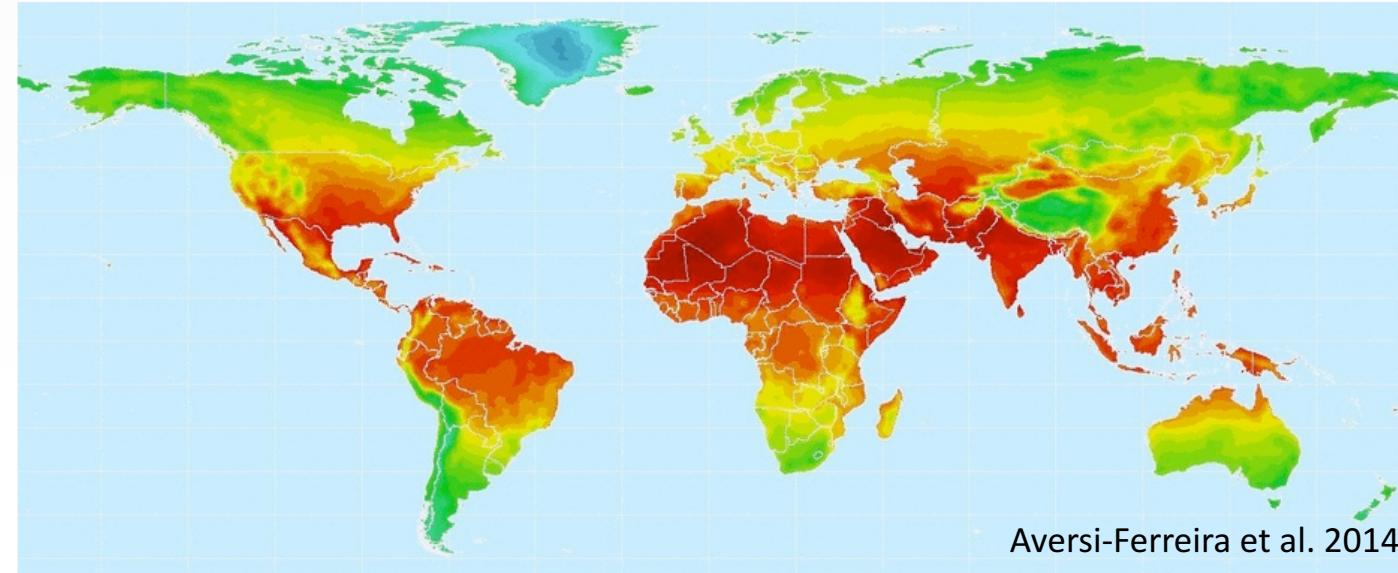
January 28, 2017

Odum School of Ecology Graduate Student Symposium

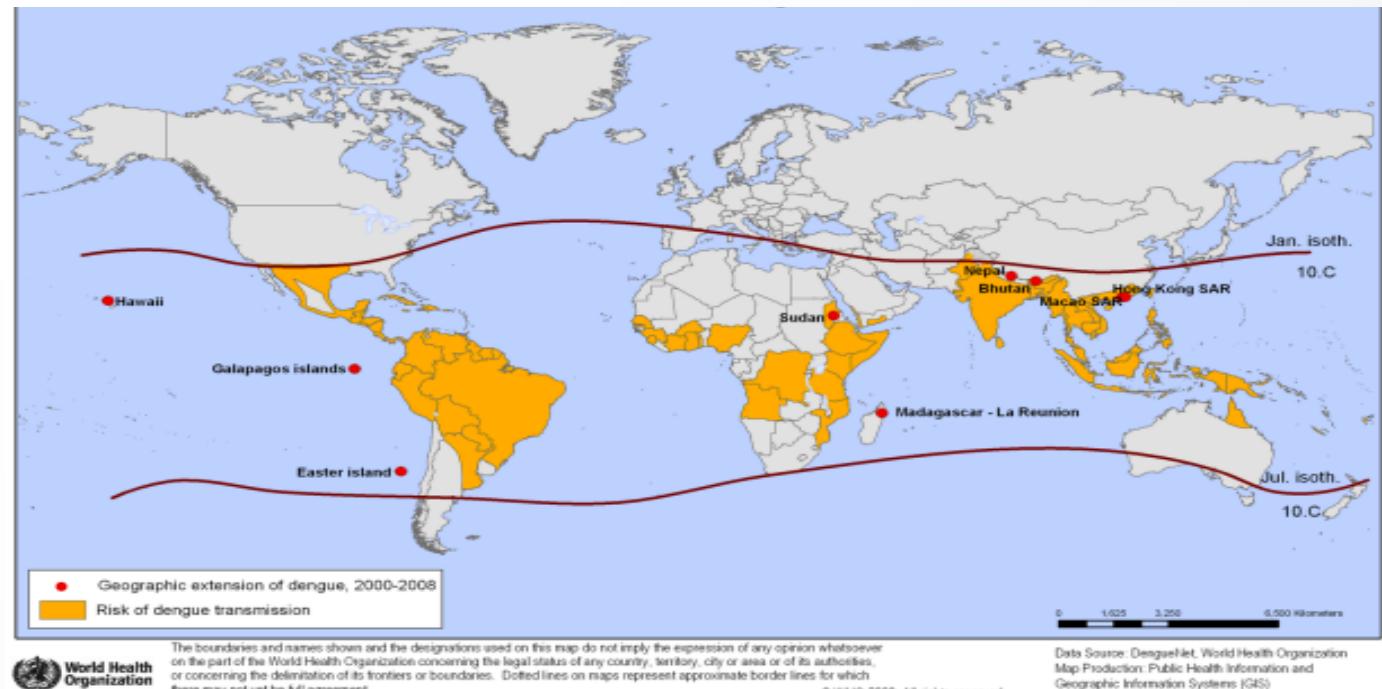
# Global Annual Mean Temperatures

The geographic distribution of mosquito-borne disease is highly correlated with temperature

Areas with Known Dengue Transmission



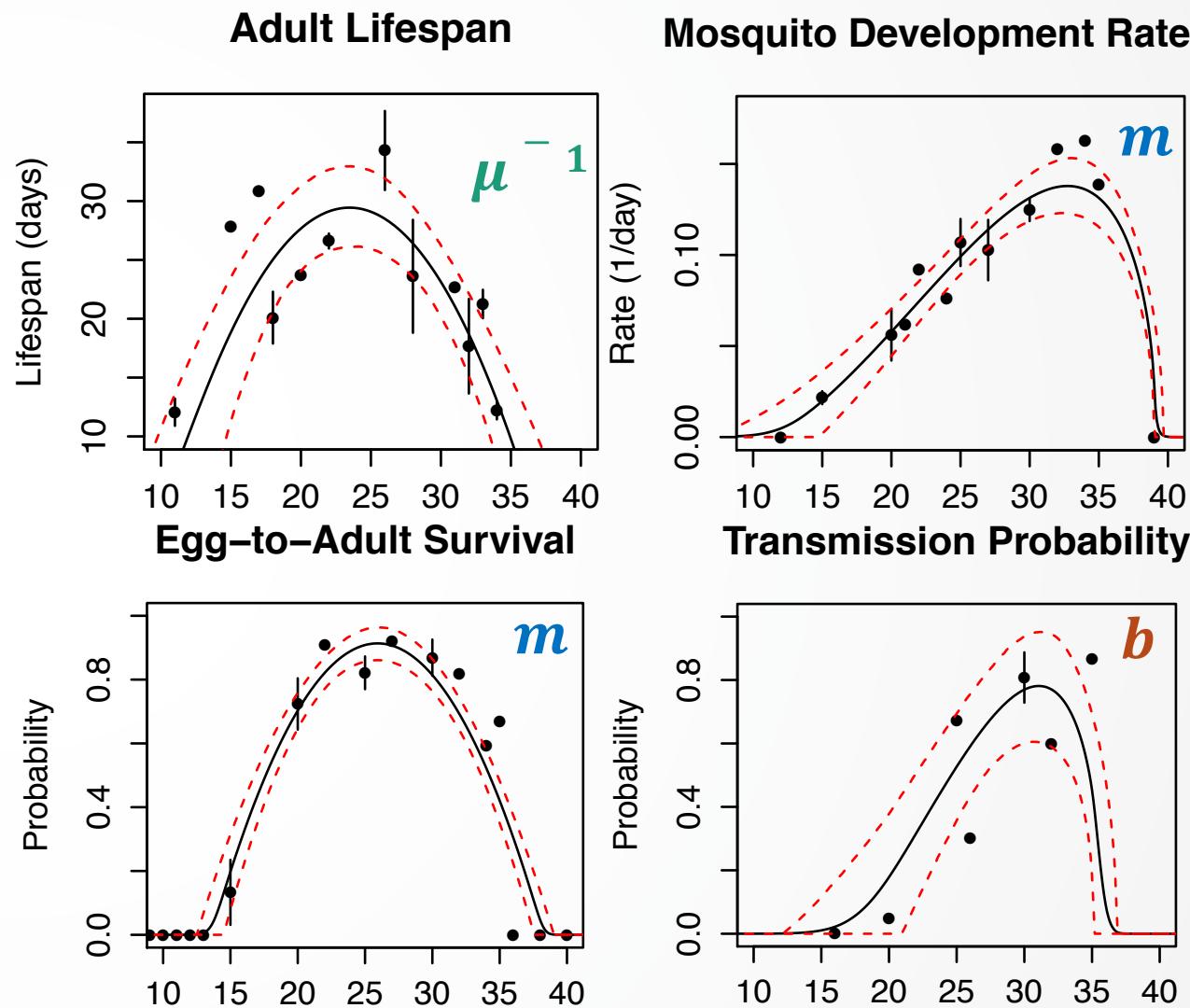
Aversi-Ferreira et al. 2014



# The relationships between temperature and mosquito traits are poorly understood

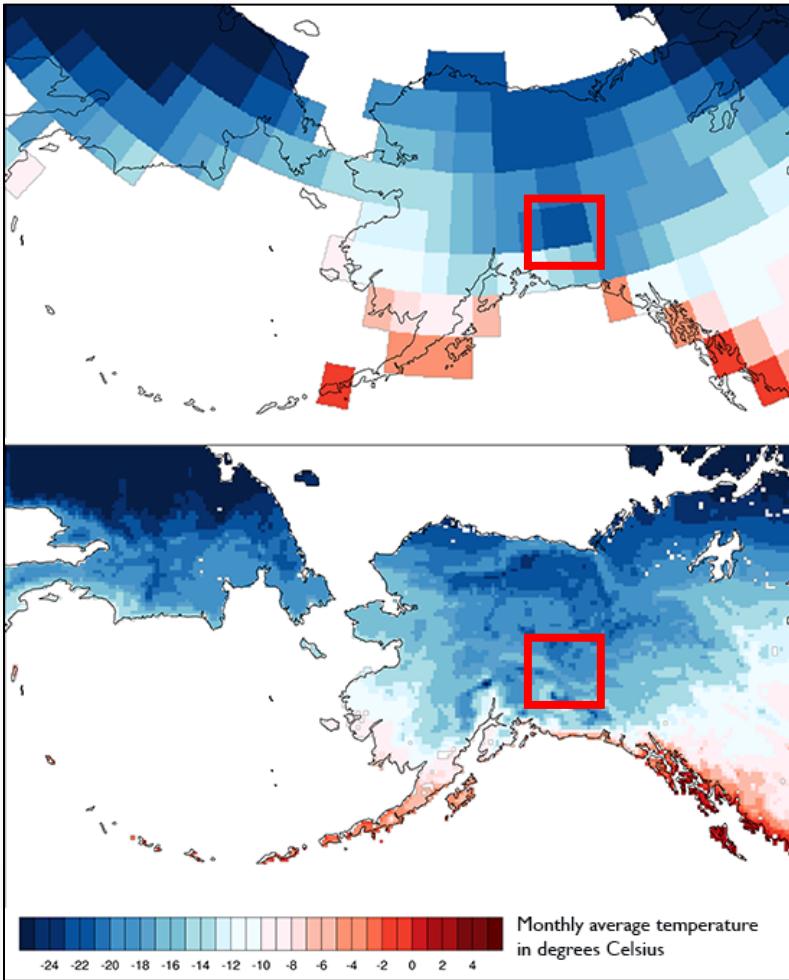
- Non-monotonic
- Most traits are not well known, often relying on other species or few data points
- Many traits contribute to the overall **vectorial capacity** of a mosquito, i.e. the rate at which future infections arise from one mosquito

$$VC = \frac{ma^2be^{-\mu EIP}}{\mu}$$

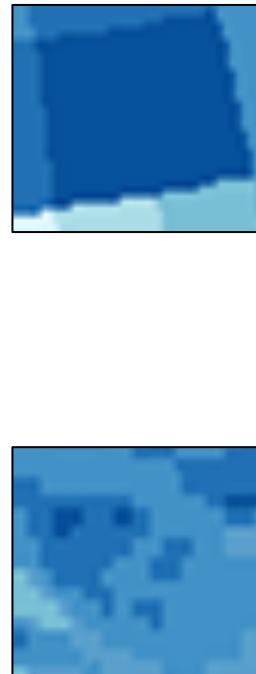


# The issue of scale-mismatch in prediction

150 mi  
resolution



12 mi  
resolution

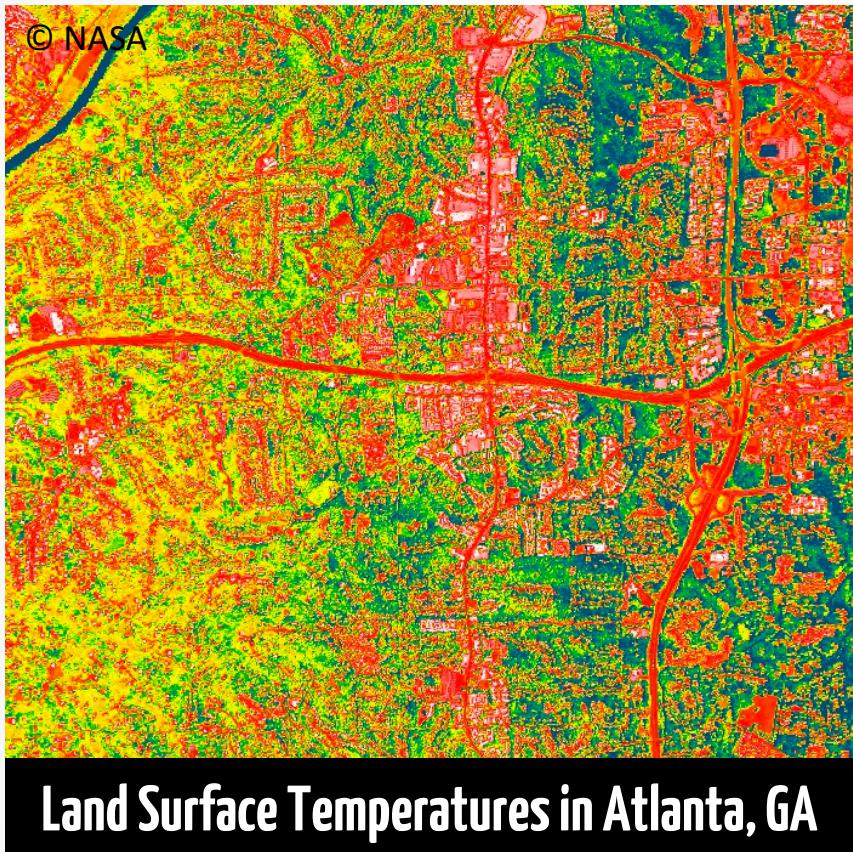


Climate data is often recorded at a coarser scale than mosquitoes experience...

Leading to incorrect predictions of disease risk

Photo Credit: Univ. of Alaska - Fairbanks

# Mosquitoes require an even finer scale



- Developed landscapes have a wide range of climates, termed **microclimates**
- Current predictions of vector borne disease focus on a much coarser scale, ignoring the heterogeneity of the landscape

**Main Question:** How are mosquito-borne disease dynamics impacted by fine-scale changes in microclimate across a heterogeneous landscape (e.g. a city)?

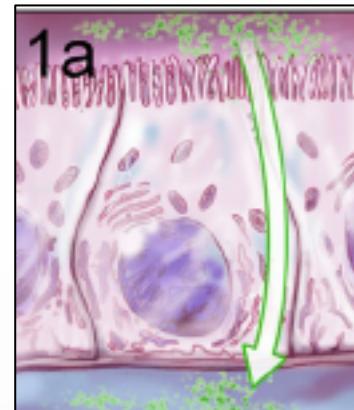
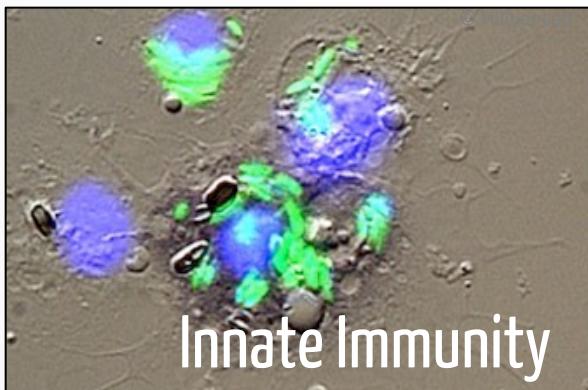
# How does microclimate influence mosquito population dynamics?

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# How does microclimate affect infection dynamics within the mosquito?

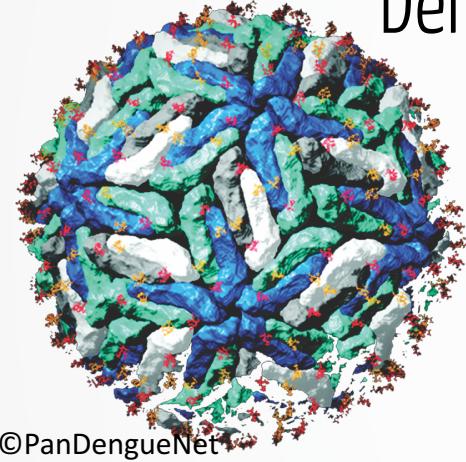
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Development  
of the midgut  
escape barrier

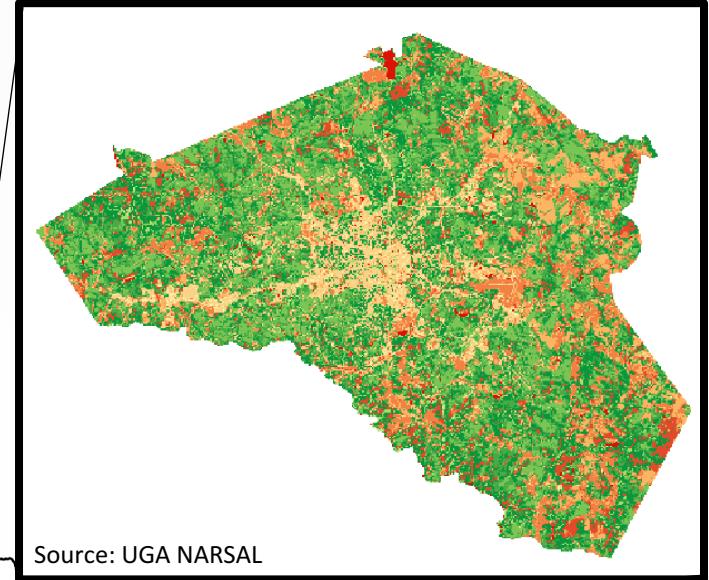
# The Model System

Dengue virus

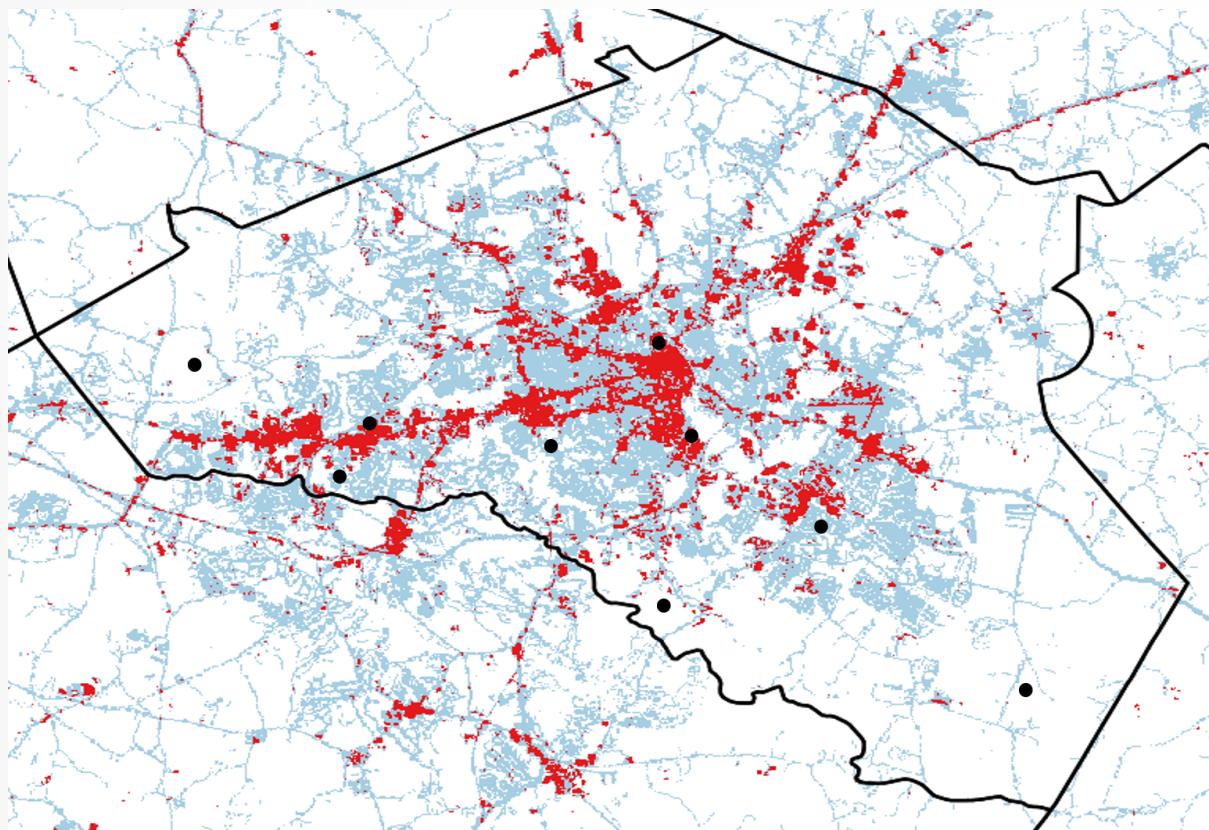


©PanDengueNet

*Aedes albopictus*



# Three Land Classes to Incorporate Microclimate Range



Rural



Suburban



Urban

Summer & Fall Trials, 2016

# Experimental Design cont.

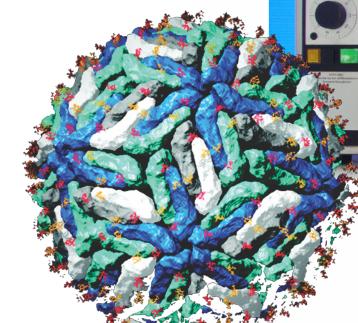
At each 30 x 30 m site:

100 1<sup>st</sup> instar *Ae. albopictus* larvae

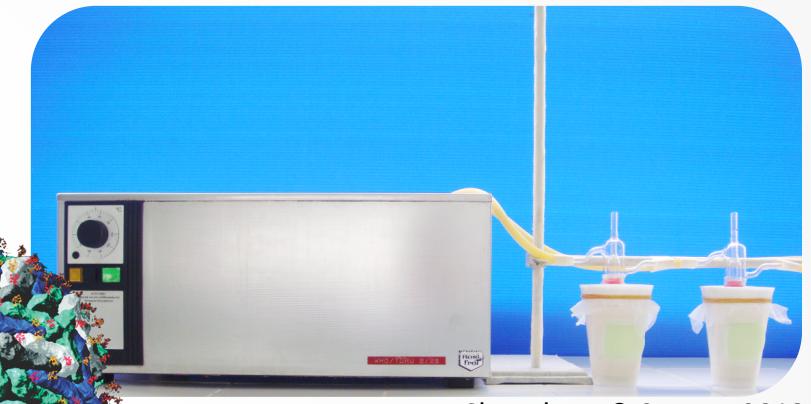
1 L leaf infusion

x4

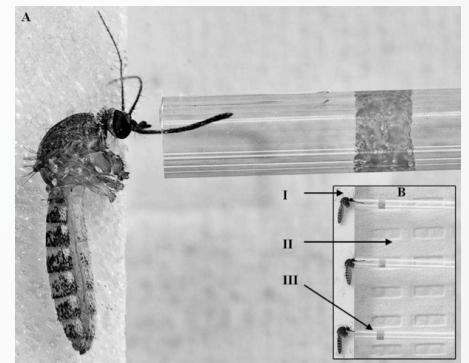
Survival  
Body Size  
Sex Ratios



Offered dengue infectious blood meal  
to *Ae. albopictus* aged 4-6 days old



Tested mosquitoes for dengue infection,  
dissemination, and infectiousness after 21 days



# How does microclimate influence mosquito population dynamics?

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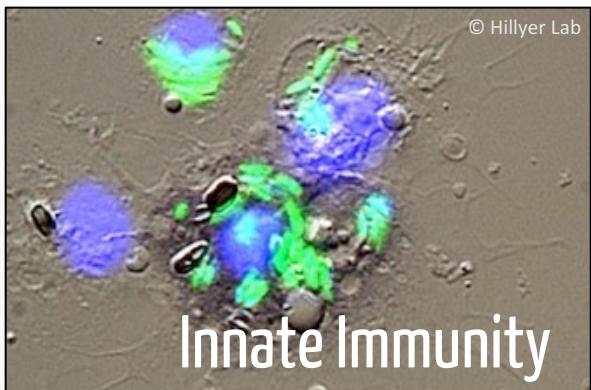


Larval Survival

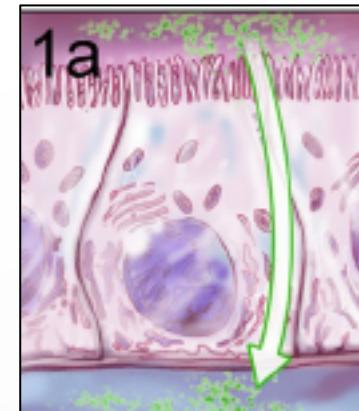


# How does microclimate affect infection dynamics within the mosquito?

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Innate Immunity



Development  
of the midgut  
escape barrier

# How does microclimate influence mosquito population dynamics?

How doe

quito?

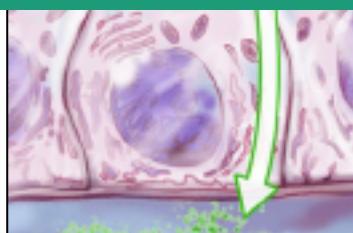


Does microclimate differ across  
an urban landscape?

...And how?

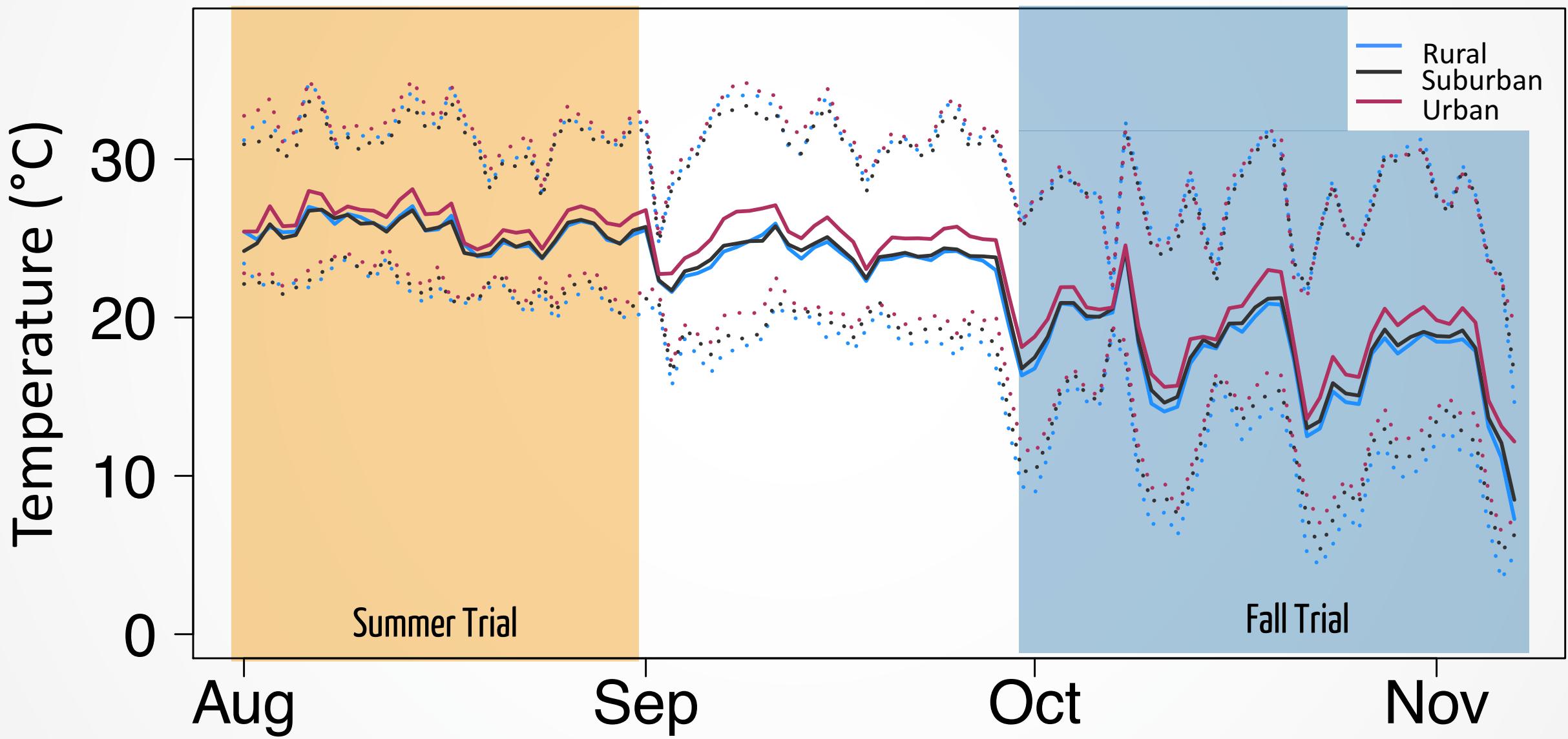


Innate Immunity



of the midgut  
escape barrier

# Microclimate differed across land use and season



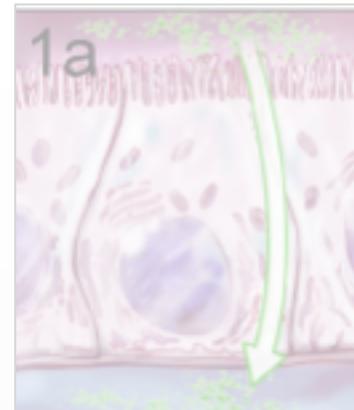
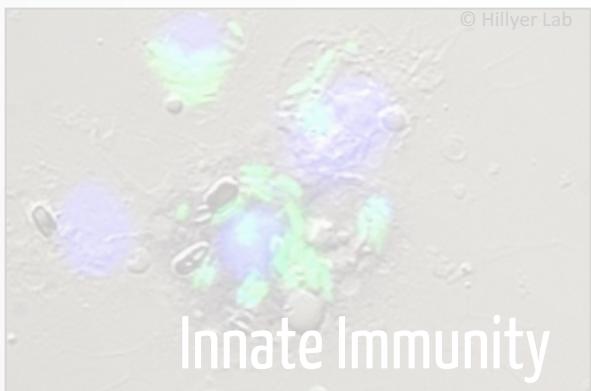
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## How does microclimate affect infection dynamics within the mosquito?

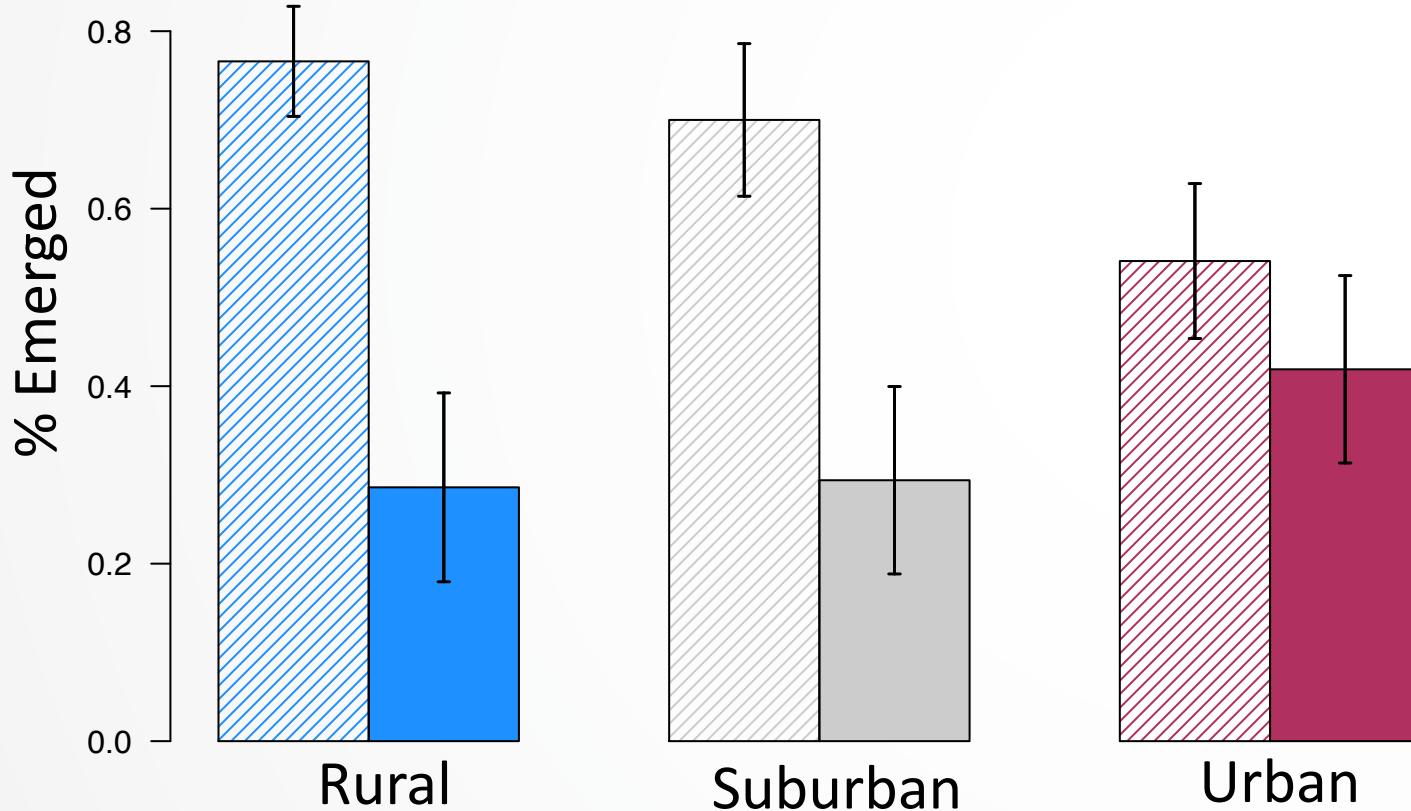
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Development  
of the midgut  
escape barrier

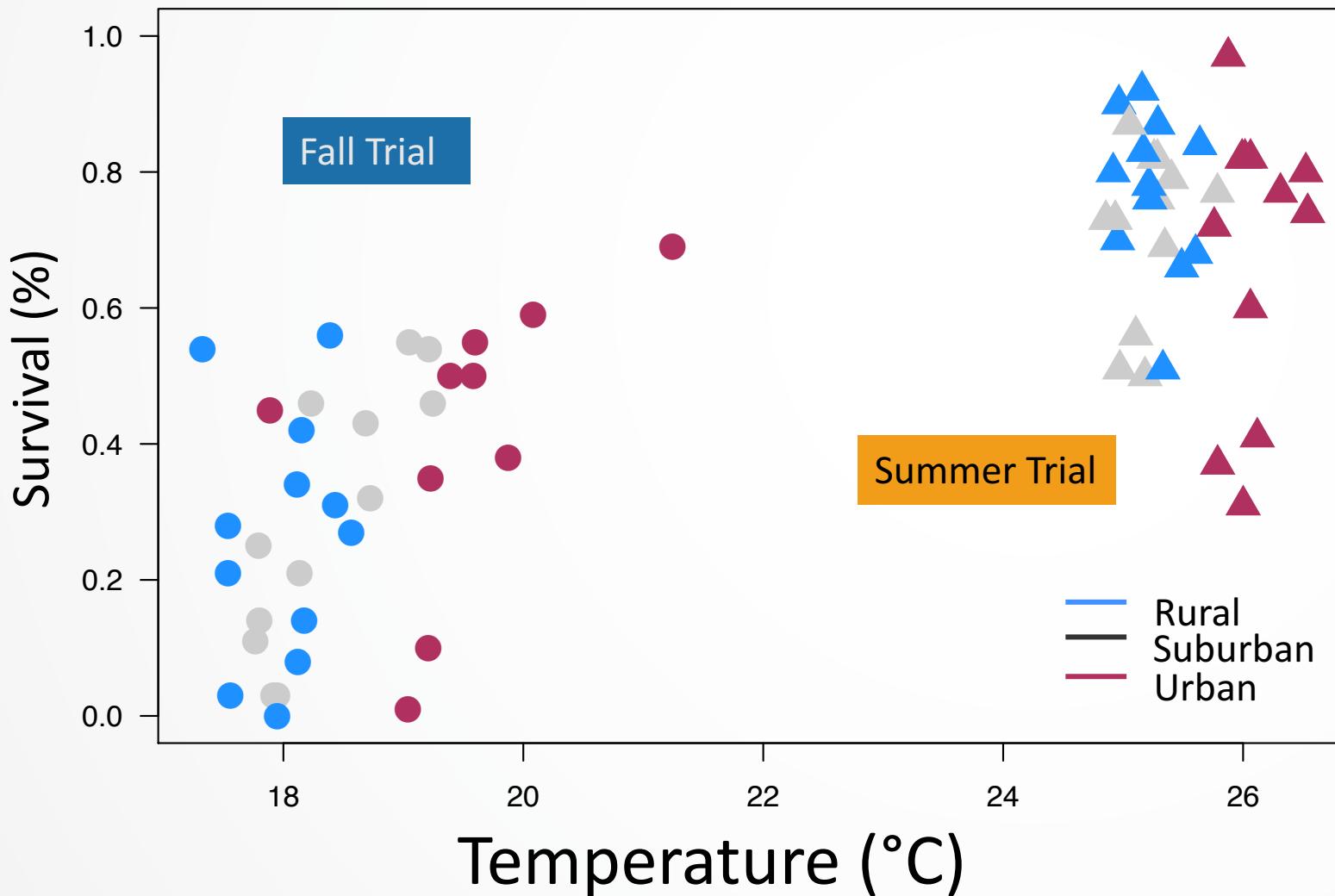
# Survival differed by land use and season

- Summer
- Fall

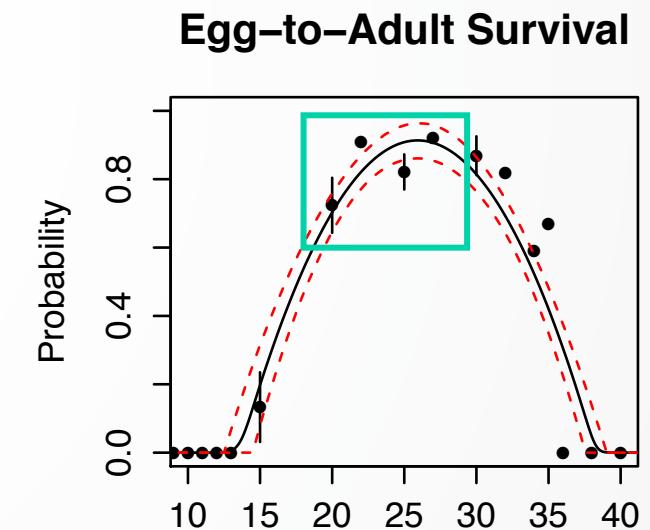


- » Survival to emergence was higher in the **summer**
- » Urban sites had significantly lower survival in the summer, relative to other land classes
- » Could these trends be driven by microclimate?

# Slightly positive relationship between temperature and survival



Similar to unimodal shape as predicted in models



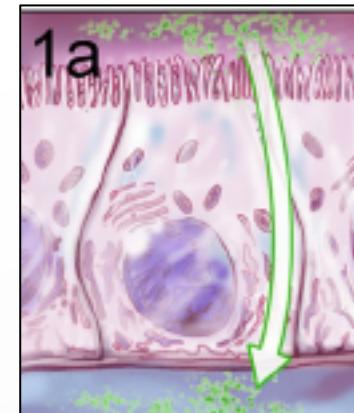
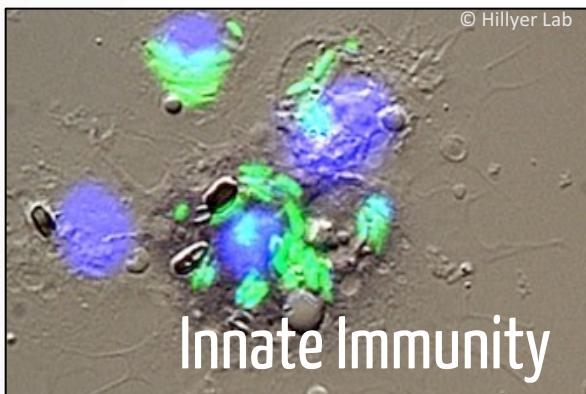
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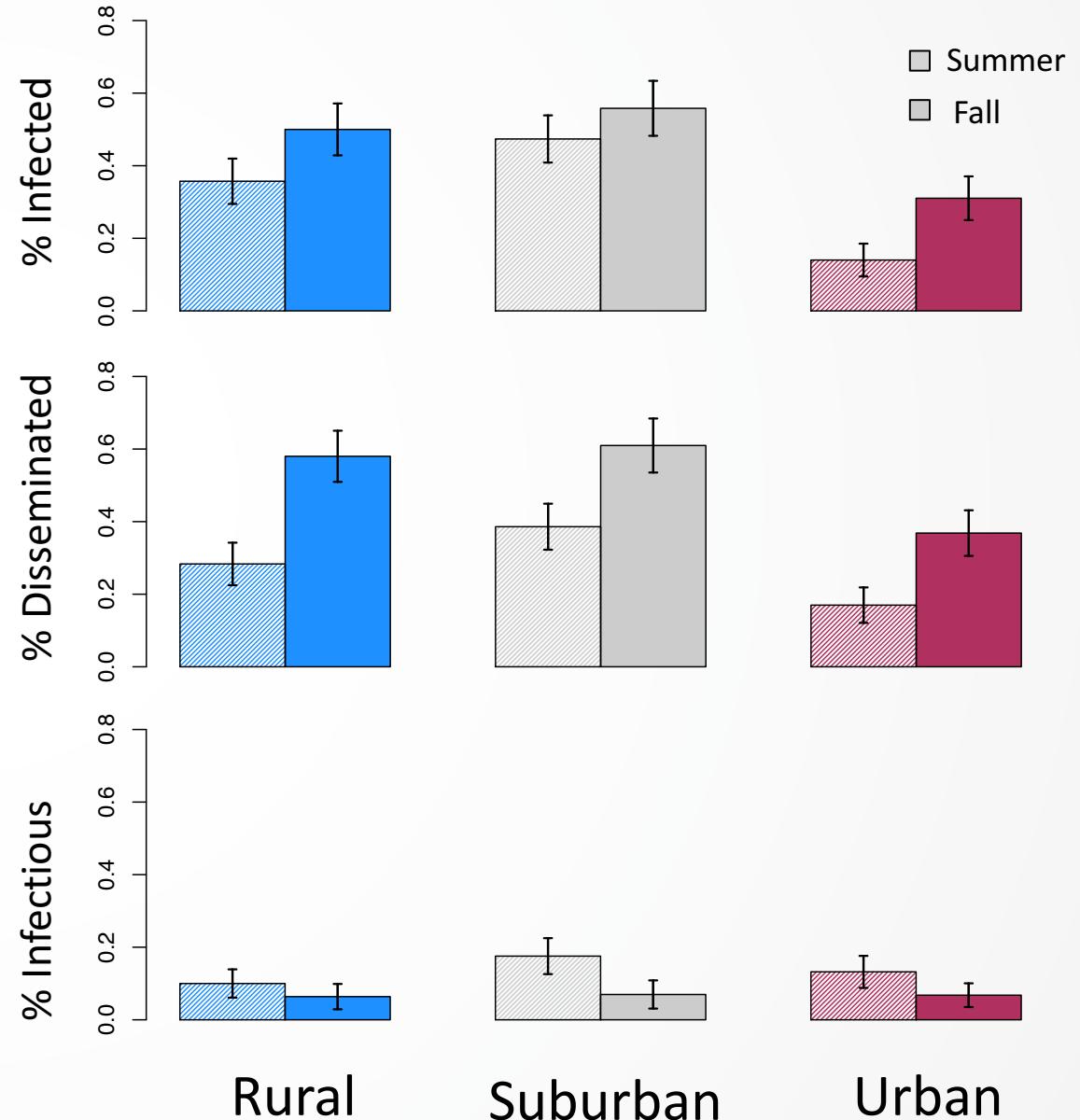
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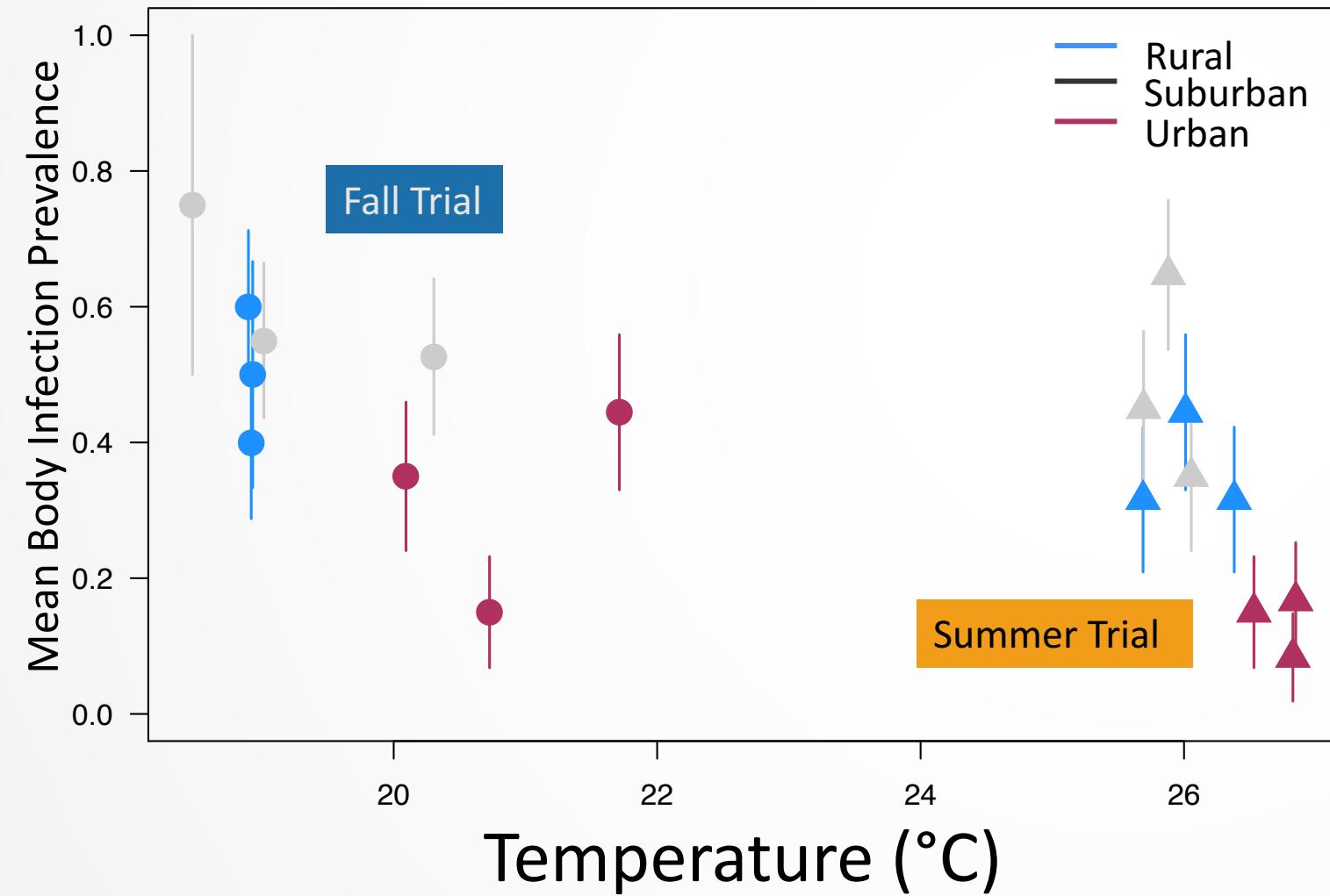
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# Infection dynamics differed across land use and season...

- » Mosquitoes in the fall had higher infection and dissemination than those in the summer
- » **Urban** mosquitoes had a lower probability of being infected and having a disseminated infection
- » Trends disappear when considering infectious
  - » Suggests a difference in efficiency
- » No interaction between land use and season
  - » Contrary to survival



# driven by differences in microclimate



- » Infection decreased with increasing temperatures across microclimates
  - » This relationship was stronger in the summer
- » Why?
  - » Larval stressors and nutrition
  - » Differential survival across temperatures

# Implications for Disease Risk

- » Urban and seasonal microclimates alter mosquito population and infection dynamics
  - » Often in **conflicting ways**
- » Infection and dissemination are not an accurate measure of infectious mosquitoes
- » Need to consider dynamics at **multiple scales** to accurately predict disease risk

Higher temperatures lead to...

Lower infection and dissemination

No change in infectiousness

Lower survival in the summer

Higher survival in the fall

Next step: Integrate these findings with measures of mosquito abundance from the field

# Thank you!

## The Murdock Lab

Nikki Solano  
(REU Student)

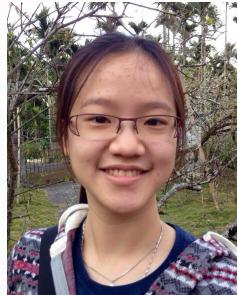


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