Associations between biotic and abiotic factors and Chagas disease vector abundance in palm trees across different habitat types

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INTRODUCTION

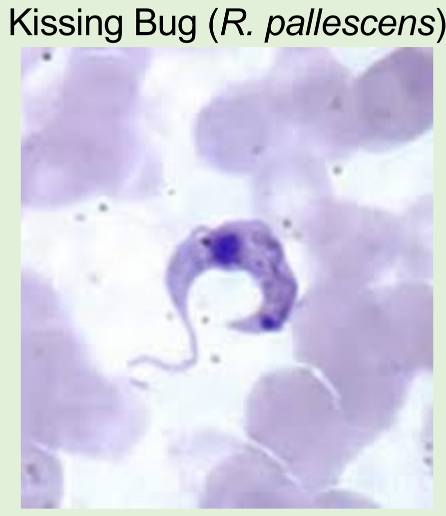
Chagas disease is a vector-borne infectious disease caused by the protozoan *Trypanosoma* cruzi, transmitted by triatomine insect vectors known as "kissing bugs" (*Rhodnius pallescens*).

Around 8 million people are infected with Chagas disease in the Americas, which can be life threatening if not treated.

In Panama, sylvatic transmission of *T. cruzi* commonly occurs in the crown of the *Attalea butyracea* palm, where kissing bugs live, but can often spillover into human populations when infected vectors come into contact with humans.

Previous studies[1,3] demonstrate that land use change (e.g. deforestation) increase *R. pallescens* abundance, but the underlying mechanisms driving vector abundance are unknown.

Kissing Bug (*R. pallescens*)

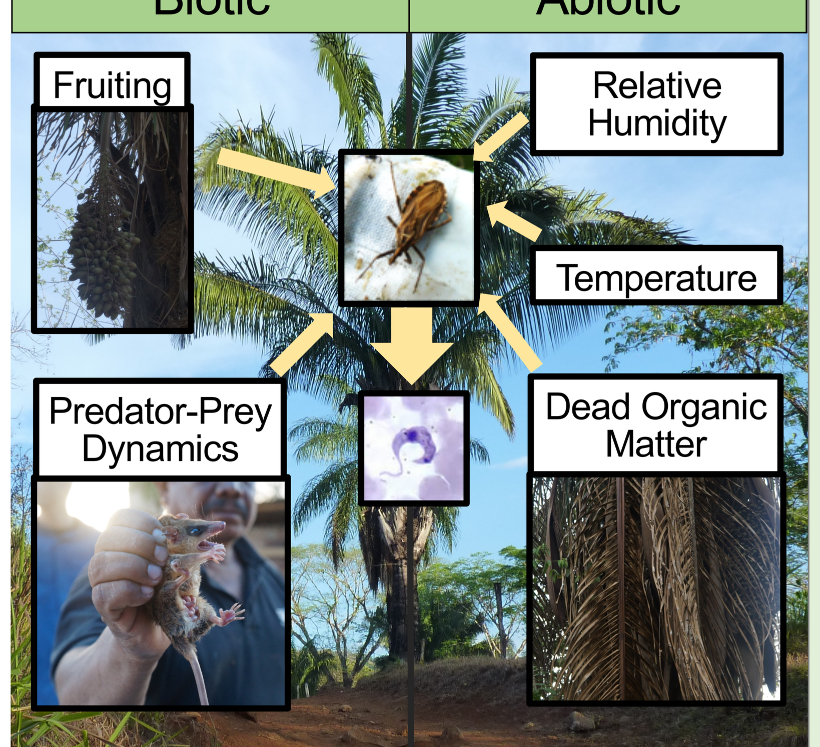


Chagas parasite (*T. Cruzi*)

Romaña's sign: characteristic marker of acute Chagas disease

OBJECTIVE

To evaluate how biotic and abiotic factors influence *R. pallescens* abundance in palm trees across different land cover types and geographic locations in Panama.



(Right) Interaction diagram of mechanisms that play a role in determining kissing bug abundance and ultimately Chagas disease transmission.

Potential mechanisms causing the increase in *R. pallescens* abundance across habitat types

Mechanism	Scale		Expected effect on vector abundance
1. Dead Organic Matter (DOM)	Microenvironment	↑	More space, attracts prey
2. Relative Humidity (%)	Microenvironment	~	Maximizes at optimal RH
3. Temperature (C°)	Microenvironment	~	Maximizes at optimal Temp
4. No. of Connected Trees	Microenvironment	↑	More space, attracts vertebrates
5. Fruiting	Microenvironment	↑	Attracts vertebrates
6. Predator biomass (g)	Community	↓	Increases predation
7. Prey-insect biomass (g)	Community	↑	Increases food supply for predators
8. Species Richness	Community	↓	Biodiversity regulates population
9. Habitat Type	Ecosystem	↑	Increases anthropogenic disturbance
10. Location	Ecosystem	~	Varies with location

METHODS

(Left) Map of Panama zoomed in where field data was collected.

(Right) Collection of a few specimen brought back to the lab.

- Collected dry weight biomass measurements of hundreds of individual invertebrate specimens caught directly from palm tree crowns.
- Assessed species diversity of 50 palms.
- Explored and modeled field data regarding microhabitat/climate and the species relationships (predator/prey) within the palm community.

RESULTS

Abiotic Factors

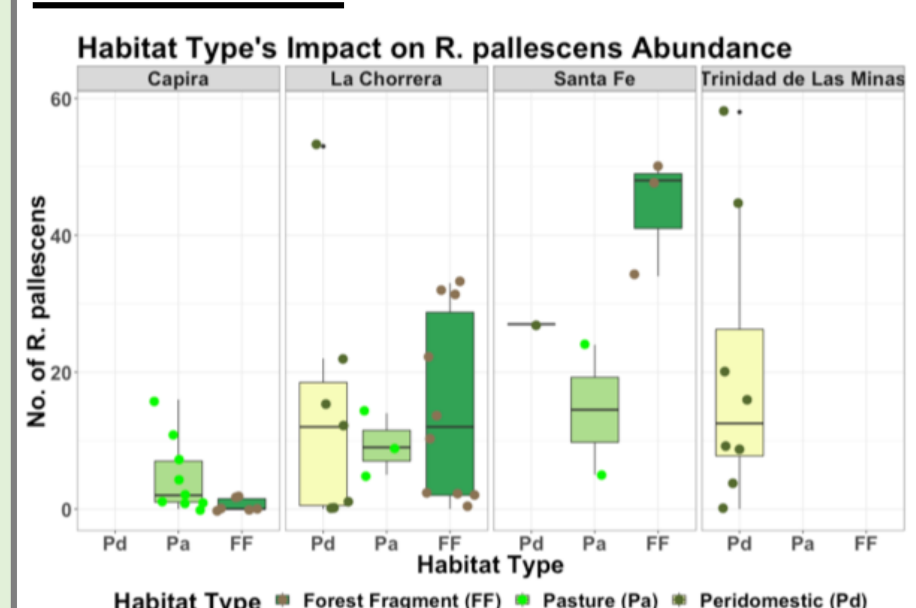


Figure 1.
Relationship between habitat type, location, and number of *R. pallescens* found per palm tree. Conditions in peridomestic habitat are positively associated with vector abundance (glmm**, p<0.005) while pasture habitats are negatively associated with vector abundance (glmm**, p<0.00001).

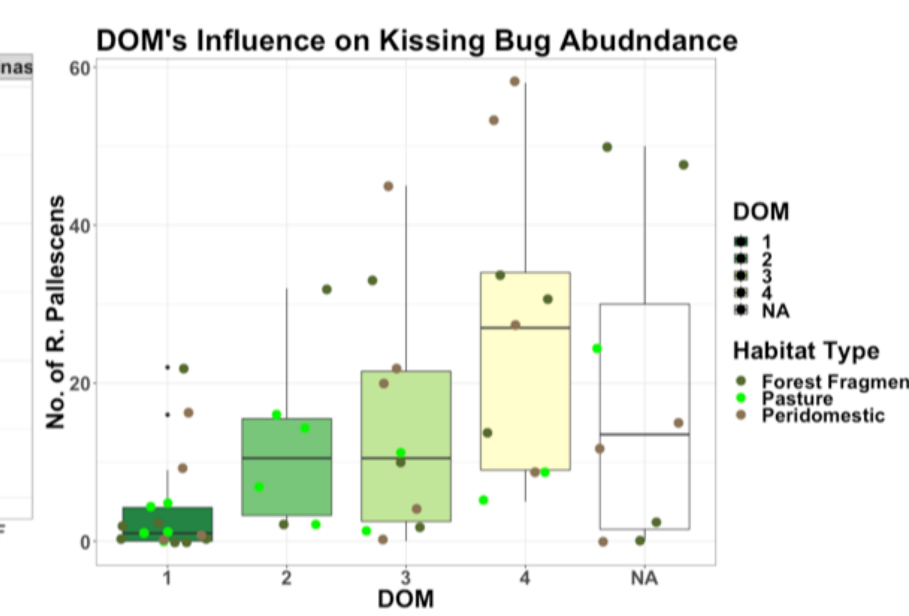


Figure 2.
Kissing bug abundance is positively associated with the dead organic matter score in the palm crown (1=low, 4=high). P-value below suggests that the *R. pallescens* abundance and DOM have a significant relationship.
(Kruskal Wallace test, p = 0.00166)

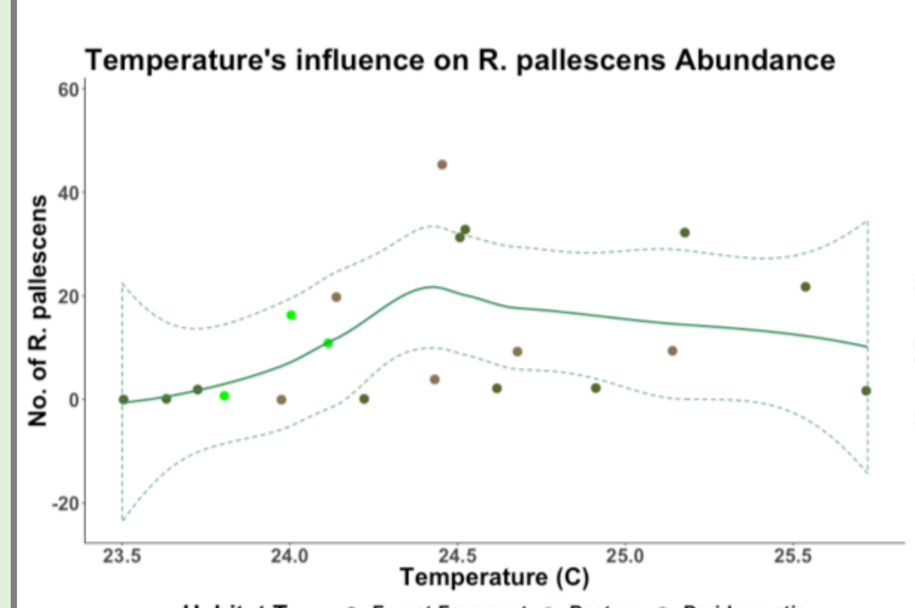


Figure 3.
Relationship between bug abundance and temperature with a maximum abundance at 24.5 C°.
(pcc*: corr = 0.2845, p = 0.2240)

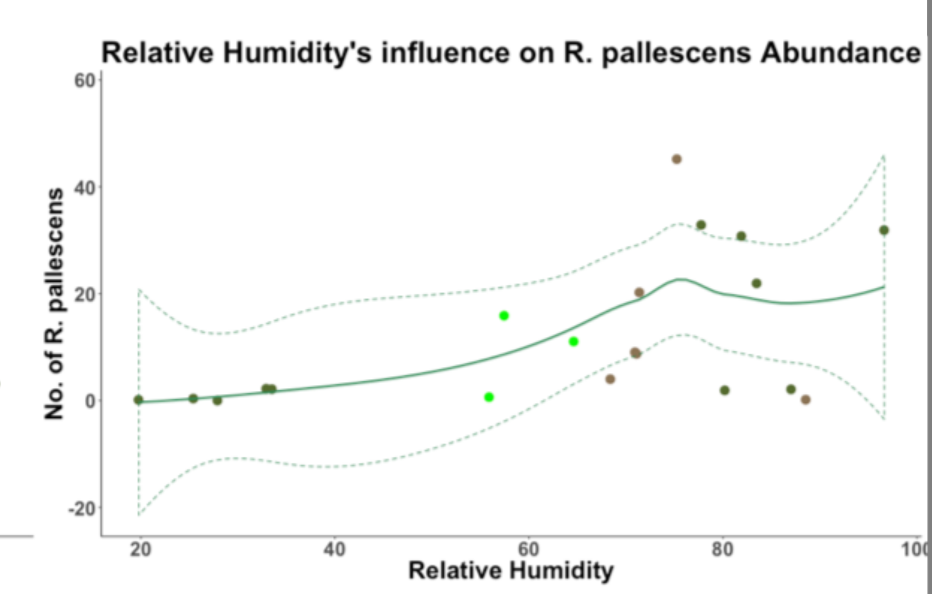


Figure 4.
Association between relative humidity and bug abundance with an optimal humidity of 80%.
(pcc*: corr = 0.5269, p = 0.0170)

* pcc – Pearson Product-Moment Correlation Coefficient
** glmm – Generalized Linear Mixed Model Fit by Maximum Likelihood (Laplace Approximation)

RESULTS CONT'D

Biotic Factors

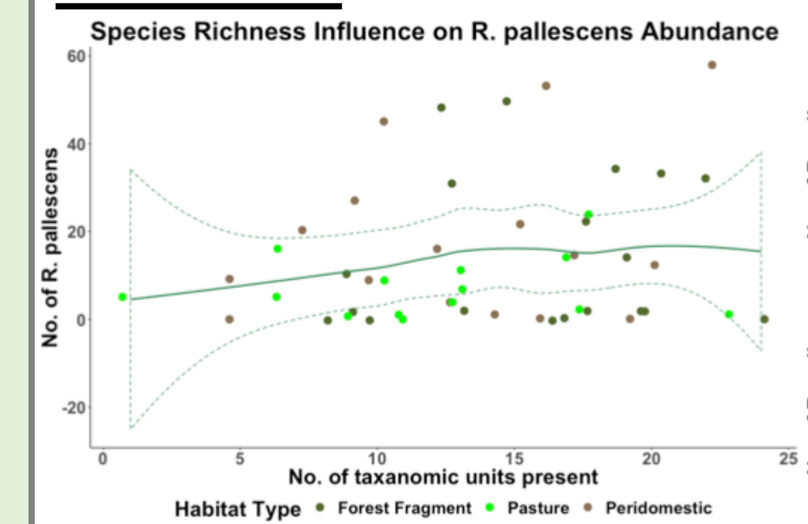


Figure 5.
Kissing bug abundance and invertebrate species richness within the palm crown.
(pcc*: corr = 0.1725, p = 0.2359)

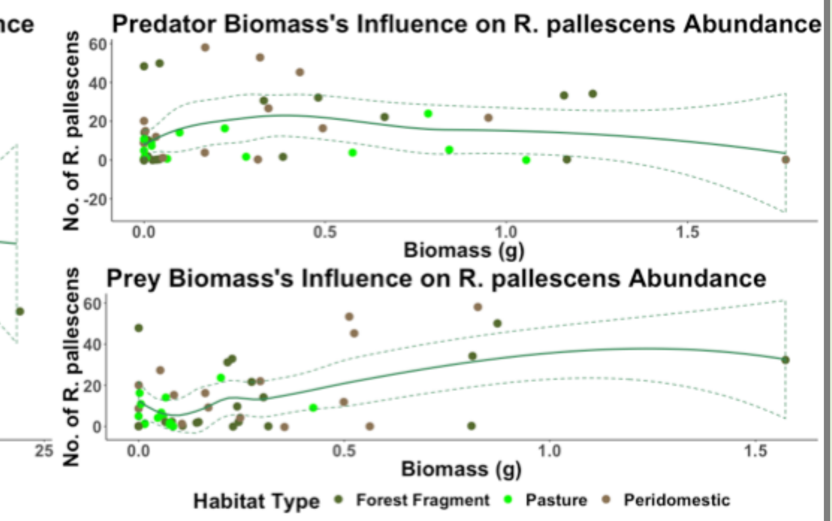


Figure 6.
Kissing bug abundance and predator (top) biomass and prey-insect (bottom) biomass.
(pcc*: corr = 0.4257, p = 0.0023)

CONCLUSIONS

- Significant factors associated with vector abundance were microenvironment-related: Dead Organic Matter, No. of Connected Trees, and Relative Humidity. Community mechanisms, such as species diversity, was not significantly associated with vector abundance.
- Habitat type also has a significant effect on *R. pallescens* abundance, but different degrees of disturbance have varying levels of effect, suggesting that the microclimate/habitat drive abundance over location.
- This knowledge will influence the design and testing of novel pest control strategies to reduce Chagas disease infection rates, incorporating selective palm management.

FUTURE DIRECTIONS

- Ecological experiments[2] evaluating effectiveness of DOM removal from palm crowns and monitoring crown temperature and relative humidity on vector abundance.
- Evaluate relationships between the presence of specific predator taxa and traits that might be additional mechanisms influencing kissing bug abundance.

REFERENCES

(1) Gottdenker, Nicole L., et al., *Am J Trop Med Hyg* 84.1 (2011): 70; (2) Gottdenker, Nicole L., et al., *EcoHealth* 11, 619–632 (2014); (3) Abad-Franch, et al., *Acta Tropica* (2015)

ACKNOWLEDGEMENTS

Thank you to the Population Biology of Infectious Diseases REU program at the University of Georgia for their support, and to the members of the Gottdenker Lab for their guidance and mentorship. Funding by the National Institutes of Health (NIH 1U54GM111274-01).

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