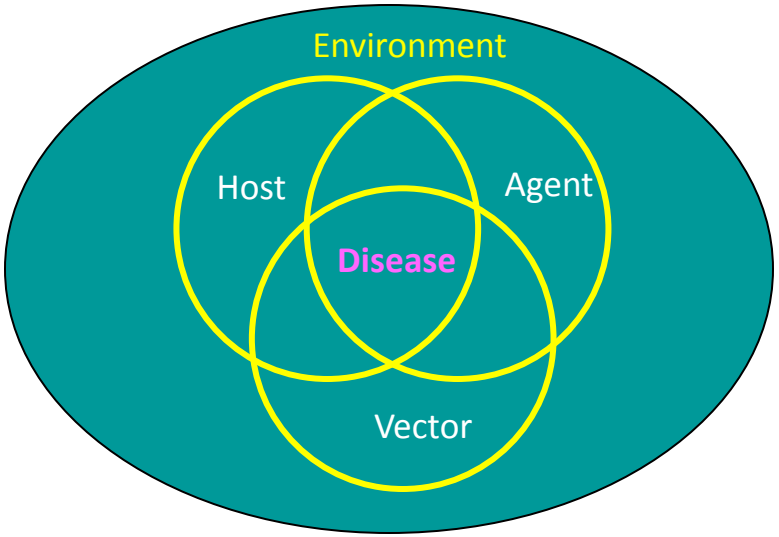
Application of an ecological approach for the study of the emergence of La Crosse encephalitis in Western North Carolina

For Ecology of infectious diseases (EID):

"EID is a sub-discipline of ecology focusing on the study of the interactions that determine the distribution and abundance of disease causing infectious agents and on the affect of these agents on other organisms and ecological systems"

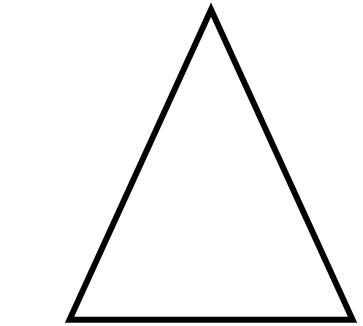
Goal: develop predictive models of diseases dynamics and occurrence and of the ecological impacts of diseases

Why is an ecological approach useful for the study of infectious disease?



1. Holistic – looks for general principles
2. Mechanistic
3. Predictive
4. Particularly useful with zoonotic and/or vector borne diseases

Anthropogenic effects and vector-borne diseases

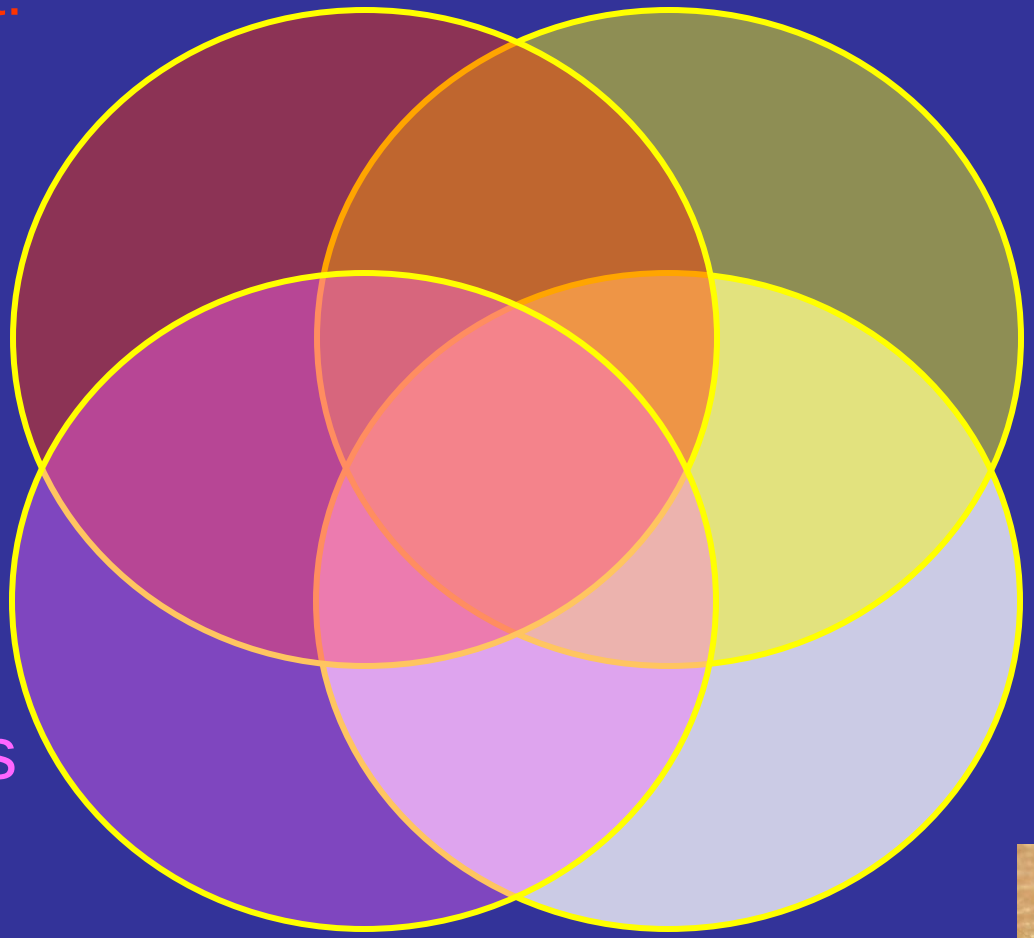


General interest: the effect of anthropogenic disturbance on the emergence of vector-borne zoonoses

The ecology of Cutaneous Leishmaniasis (CL)

Reservoir host: *Psamommys obesus*

Agent: *Leishmania major*



Incidental host: Humans

Vector: *Phlebotomus papatasi*

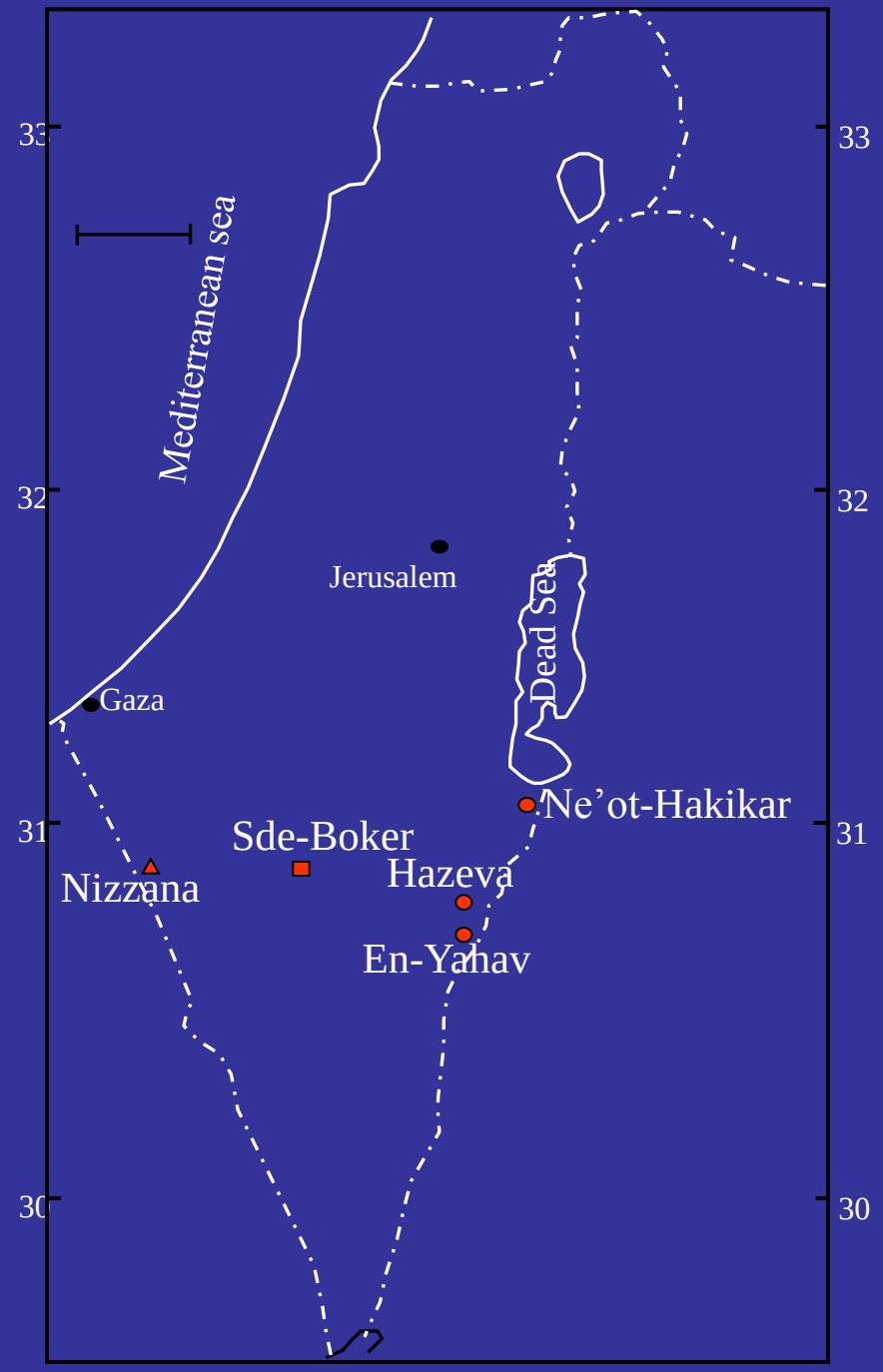
Survey design:

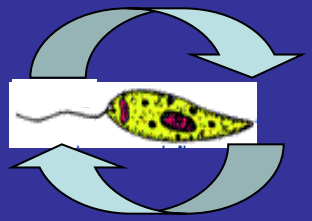
- 5 sites
- 12 plots per site:

6 in disturbed, 6 non-disturbed habitats.

In each plot

- Rodent trapping
- Sandfly trapping
- Measured environmental variables





Anthropogenic disturbance

Undisturbed habitat

Disturbed habitat

Dry soil

Moist soil

Sand flies t

Sand flies t + 1

Sand rats Susceptible

Sand rats Infectious

Sand flies Susceptible

Sand flies Infectious

Sand rats $N_{(t)}$

Sand rats $N_{(t+1)}$

Chenopod plant Dry

Chenopod plant Lush

Human Susceptible

Human Infected

Current study goal:

Study the role of anthropogenic effects on the activity of La Cross encephalitis virus within the sylvatic system

Ecology of the LaCrosse virus

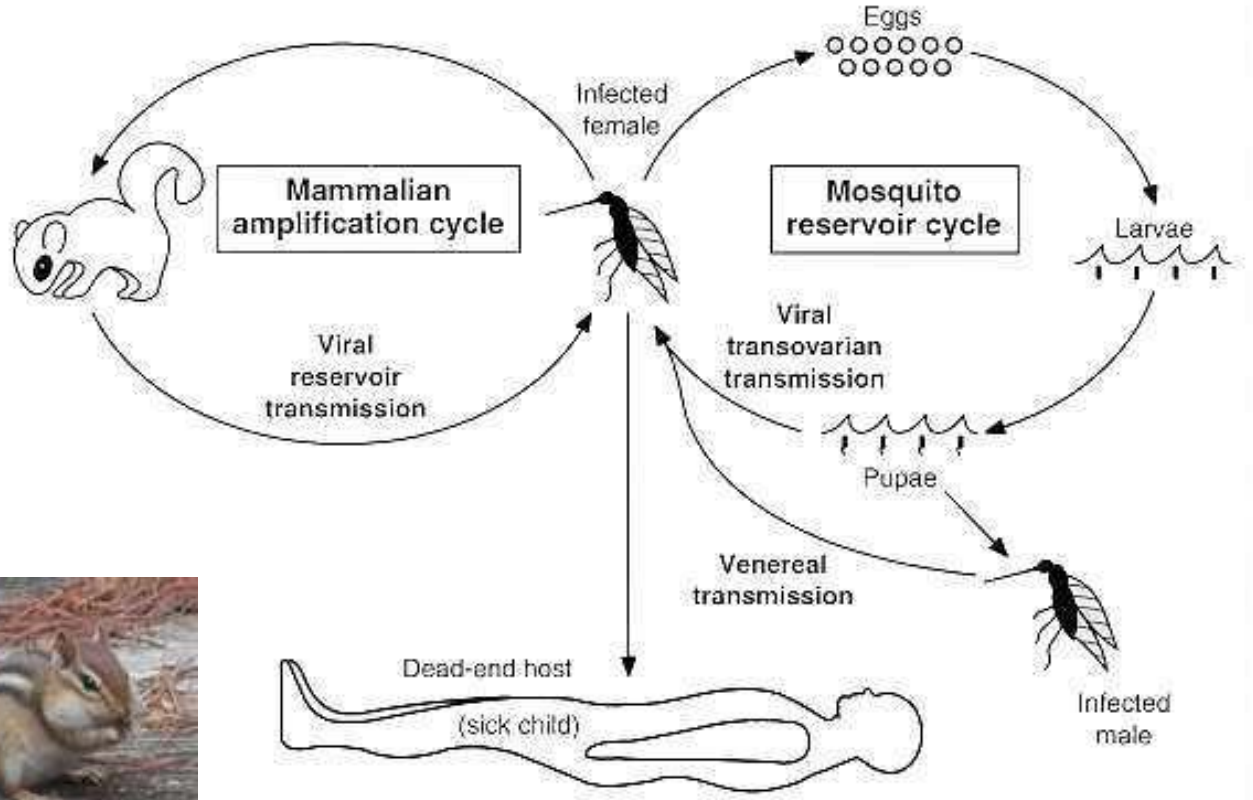
- Mosquito-borne virus
- RNA virus
- *Bunyaviridae* family
- California serogroup
- Isolated in 1964 in LaCrosse, Wisconsin
- Cause encephalitis (brain swelling)
- Children < 15 years are at higher risk
- There is no cure, only prevention

Aedes triseriatus

Life Cycle of LACV

Horizontal transmission

Vertical transmission



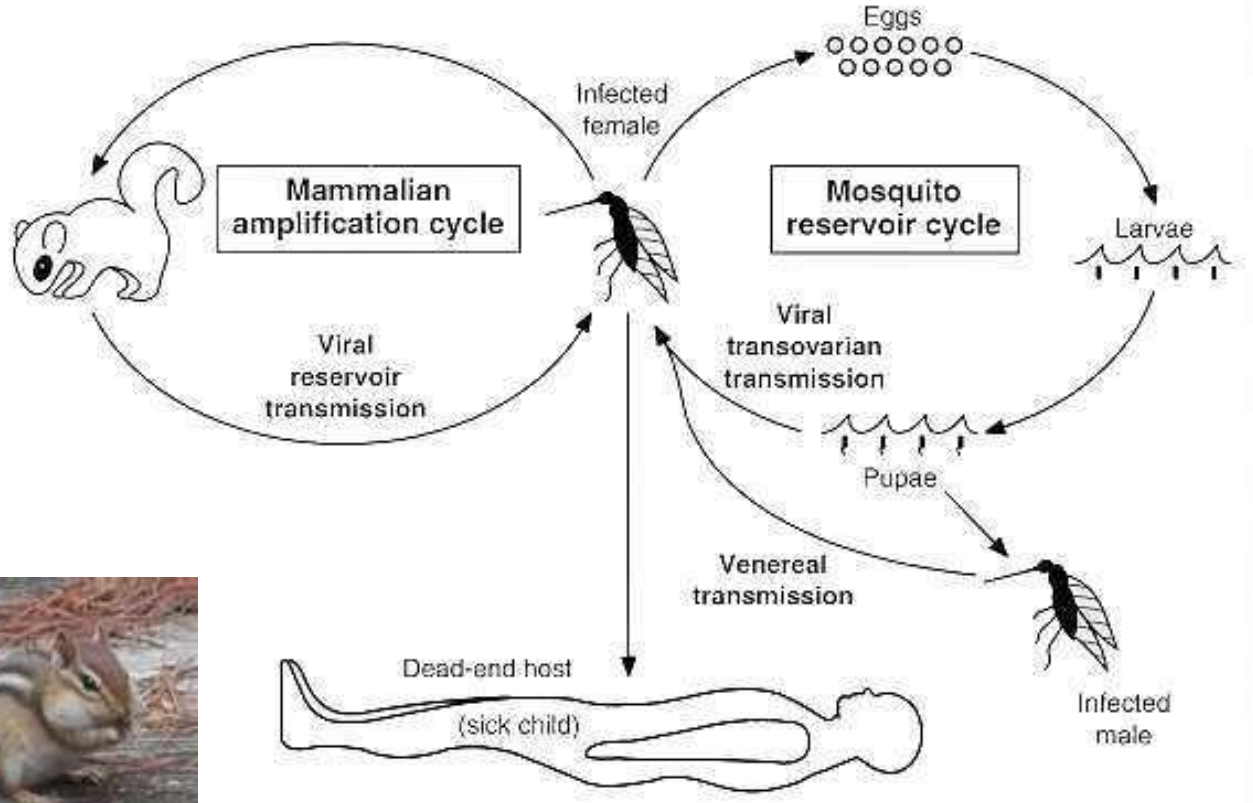
http://www.ncbi.nlm.nih.gov

Aedes triseriatus

Life Cycle of LACV

Horizontal transmission

Vertical transmission



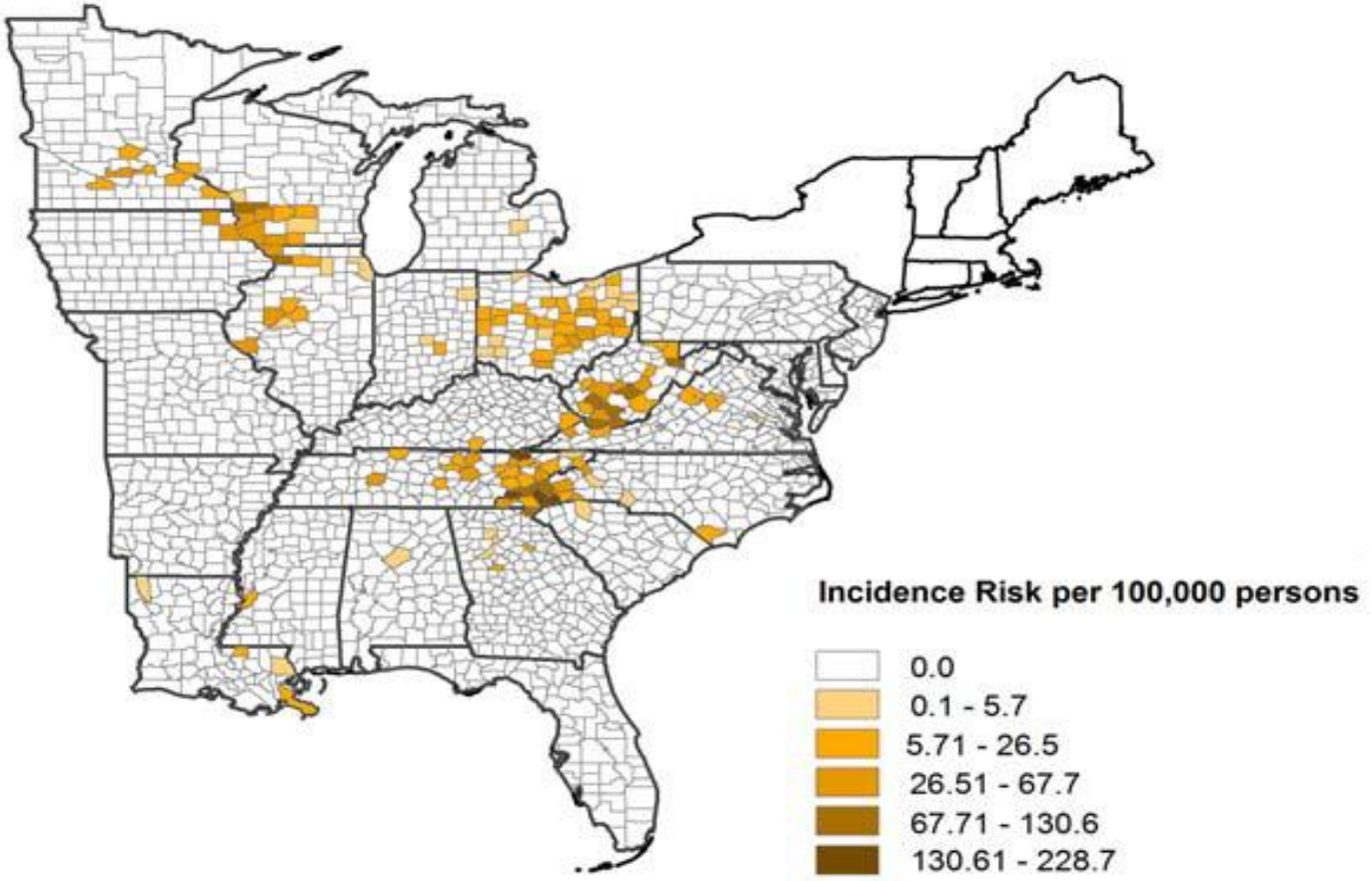
Ae. albopictus

?

Ae. japonicus

http://www.ncbi.nlm.nih.gov

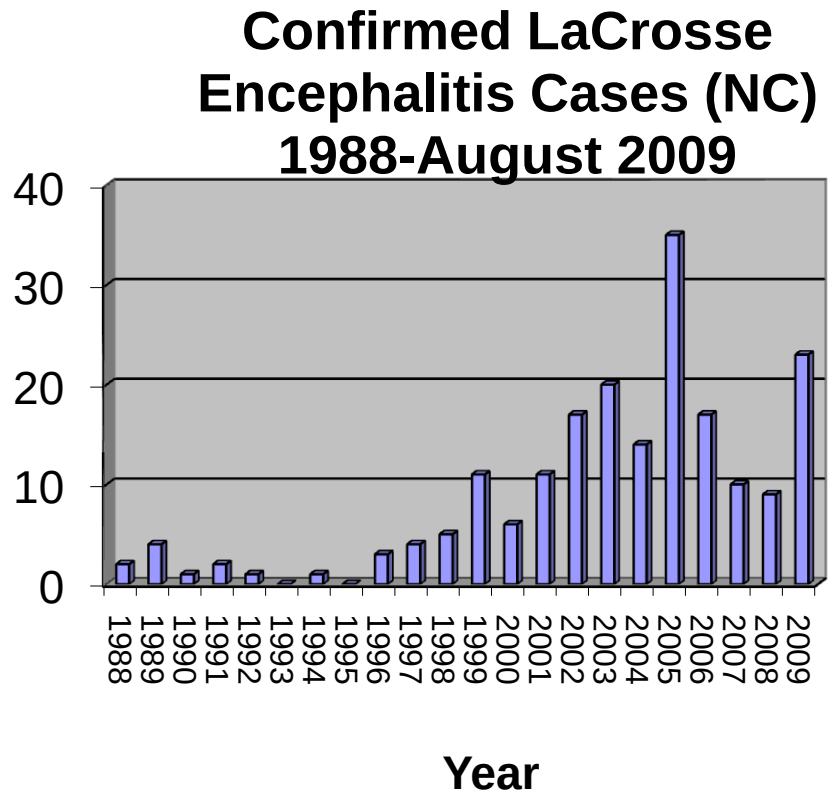
LACV Infection Cases Distribution within the USA



Haddow and Odoi, 2009

Emergence of LACV in NC

- First confirmed reported in the Southern-Appalachians states in the 1980's
- Steadily increasing in incidence
- Drivers for this increase in incidence are unknown
- Possibly associated with regional development



Study Question

- Is the increase of LaCrosse Encephalitis incidence driven by anthropogenic changes of the ecology of the system, and if so - how?

Study Goal

- To determine the association between anthropogenic activity and the distribution and abundance of the ecological drivers of LACV

General Hypothesis

- Anthropogenic effect will generate habitats that are conducive to pathogen transmission

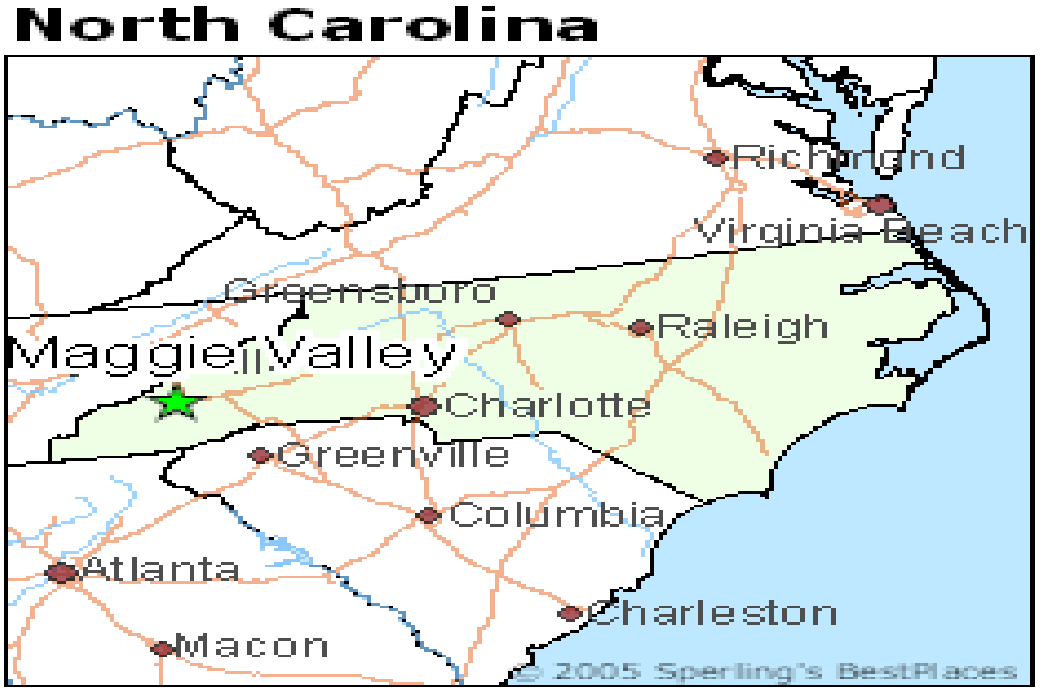
Potential Mechanisms

1. Effect on vector abundance or identity
2. Effect on vector survival
3. Effect on host abundance
   a. Availability of blood meal sources
   b. Change in the relative abundance of the competent host

Methods and Materials

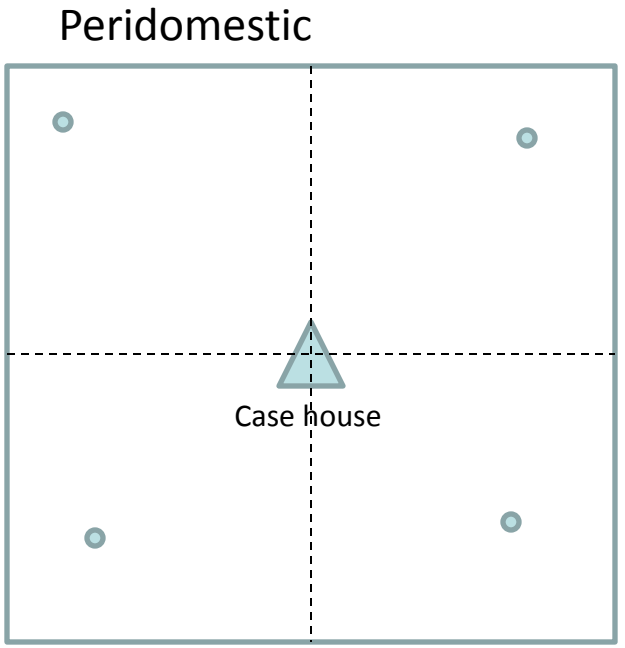
Study Site

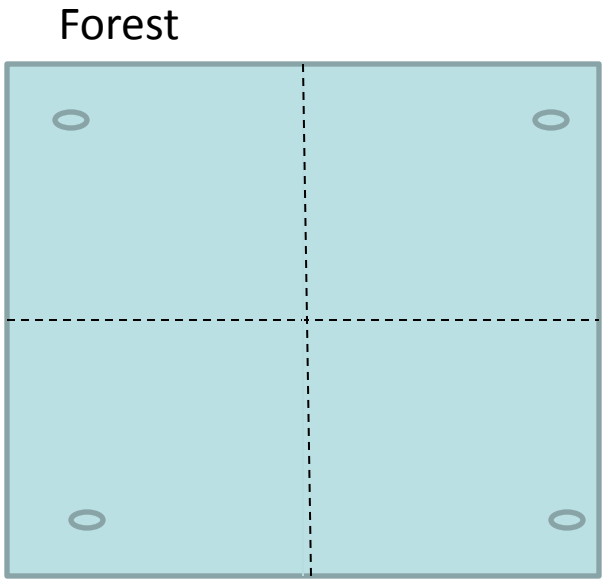
- Maggie Valley, North Carolina



Study Design

- Six historical-case sites in Maggie Valley
- One plot surrounding the case house (peridomestic habitat)
- One plot in a nearby forest habitat





Field sampling

- Oviposition traps
  - Twice/month for two consecutive weeks
  - throughout the season (May – September)
- Collection of resting mosquitoes (Nasci aspirator)
  - Once a week
  - Throughout the season (May – September)

Lab work

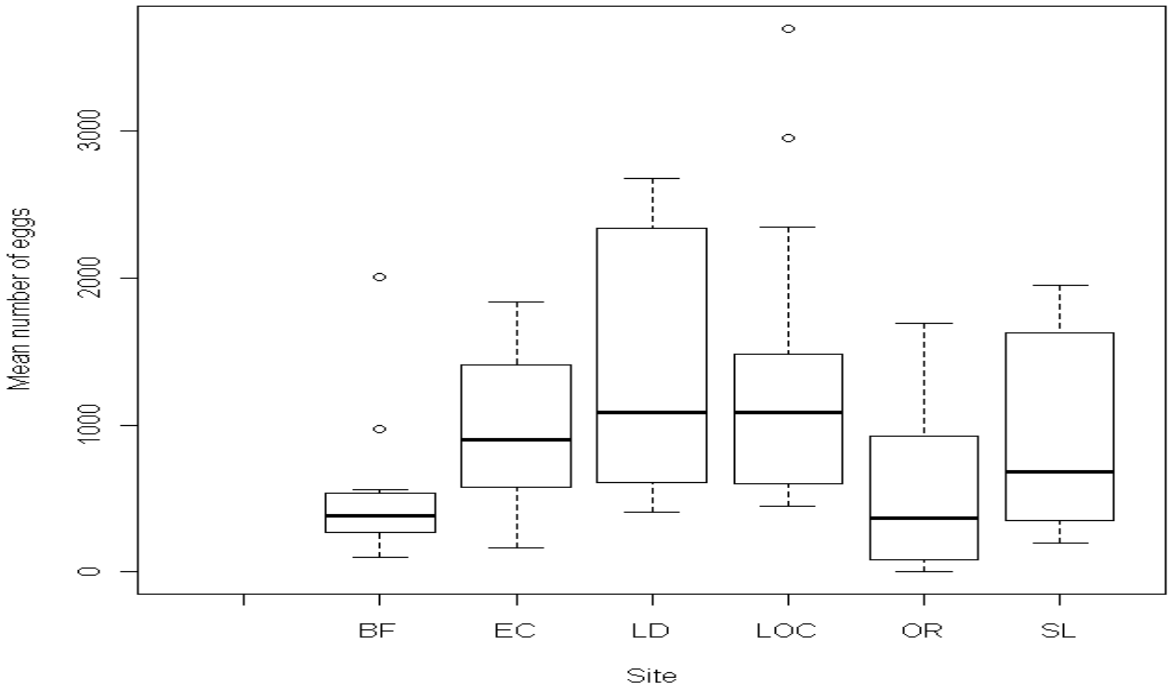
- Blood-meal analysis
  - Starts at the end of field collection season (Mainly during spring semester)
- Parity dissection
  - During the season (May – September)
  - Spring semester
- Virus detection
  - In mosquitoes or in chipmunks' blood sample
  - Performed in Western Carolina University

Environmental variables

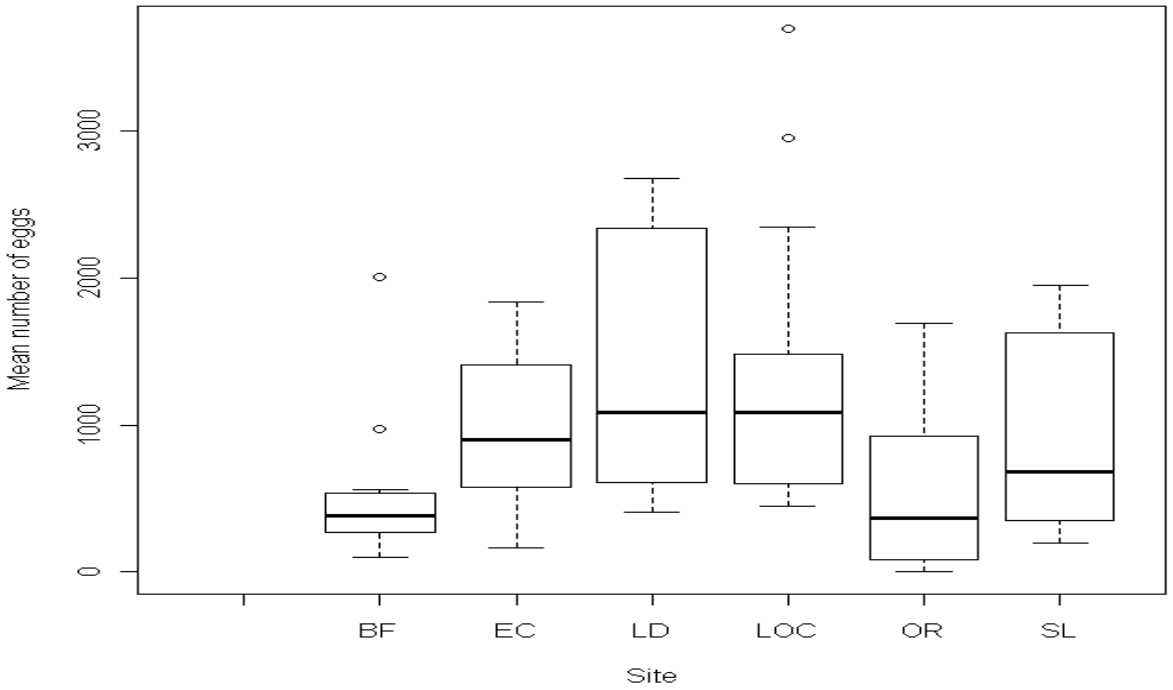
- Containers survey (artificial and natural)
- Plant characteristics
  - Plant percent coverage
  - Dominant genus
  - Forest age (DBH)

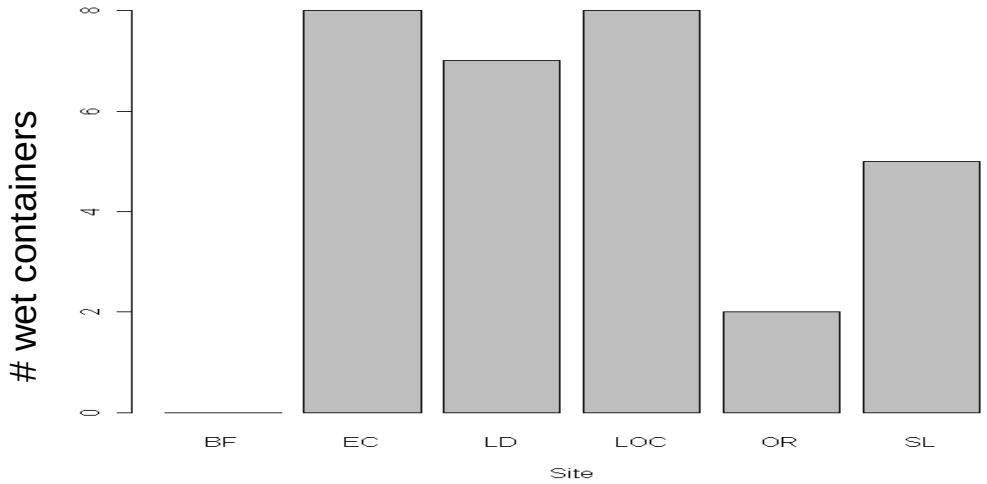
PRELIMINARY RESULTS

The effect of site on number of eggs laid

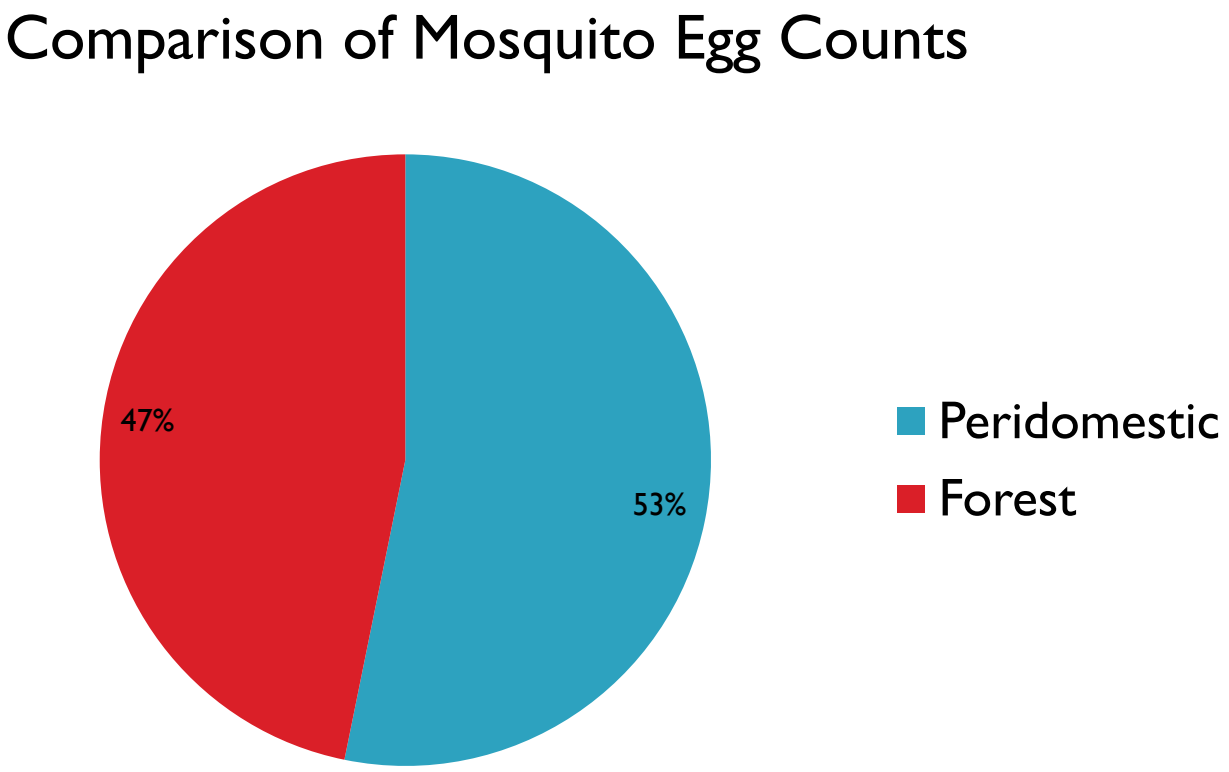


The effect of site on number of eggs laid

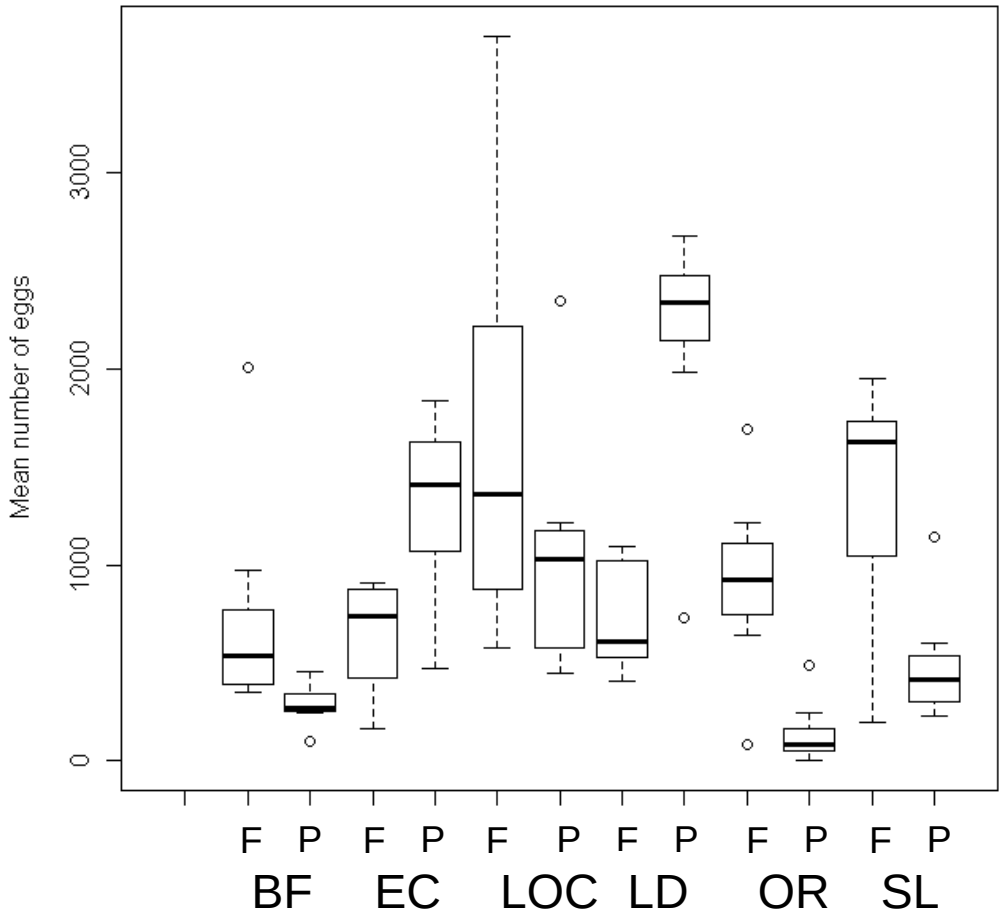




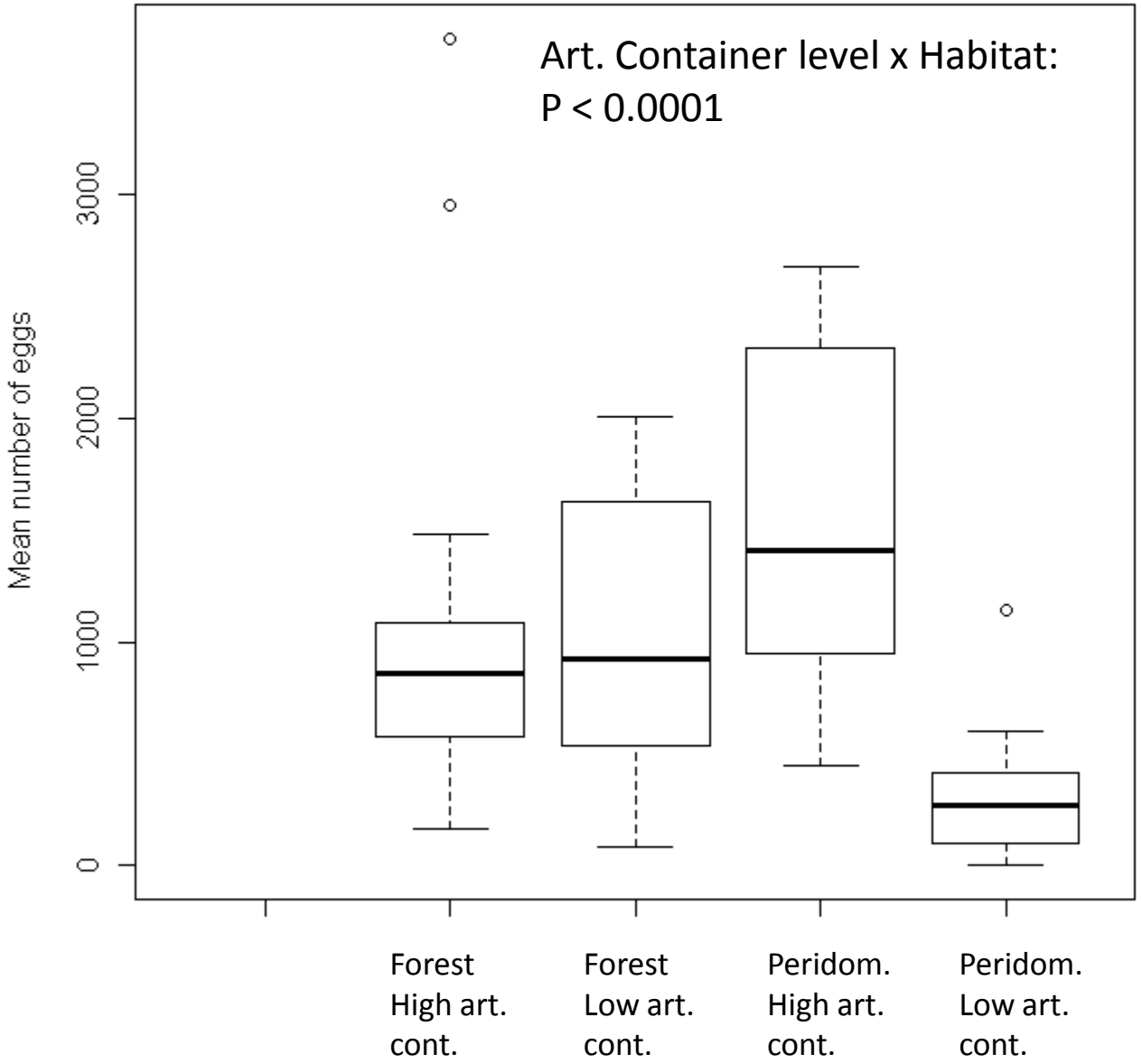
Peridomestic effect - general



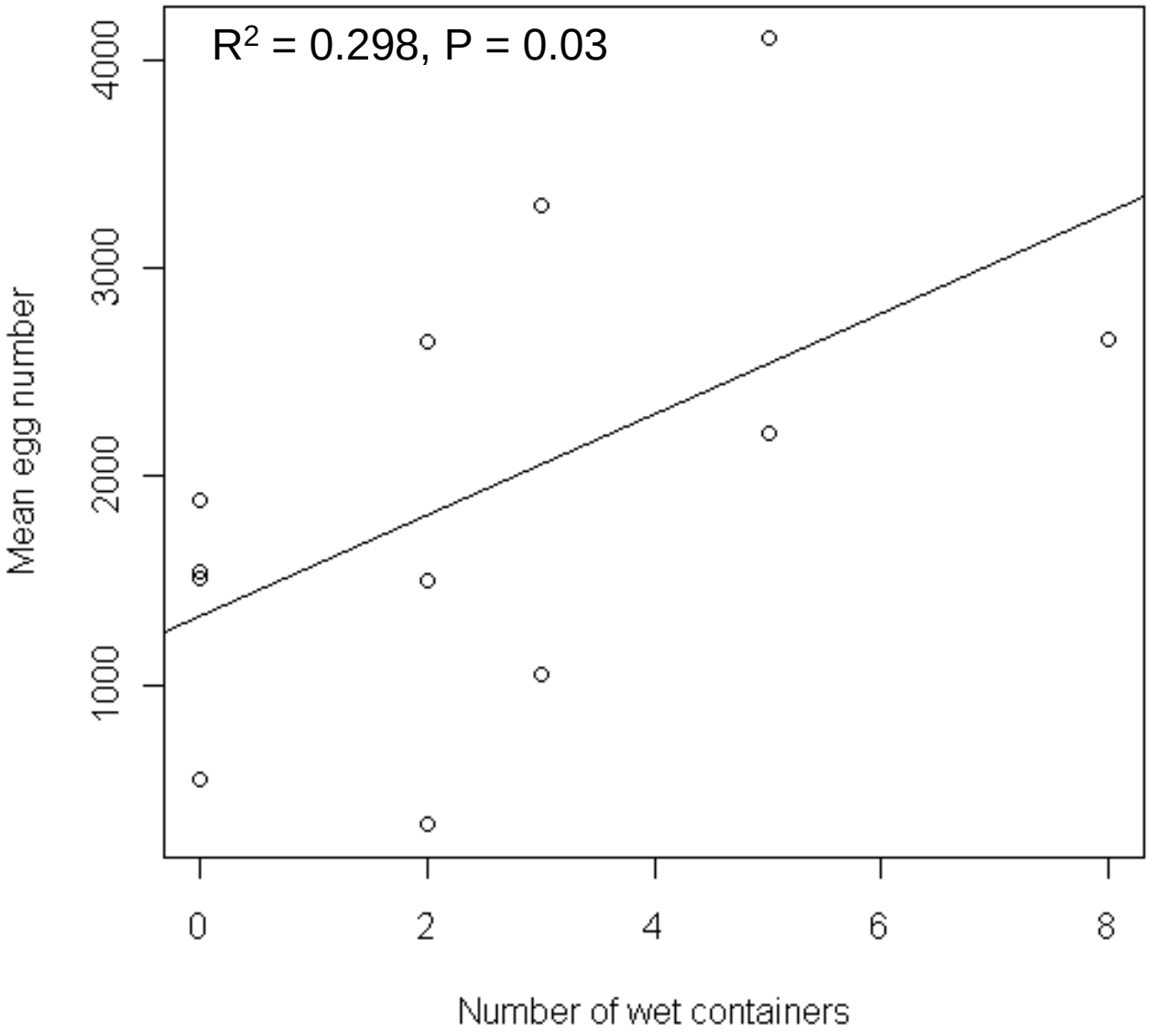
Peridomestic effect by site



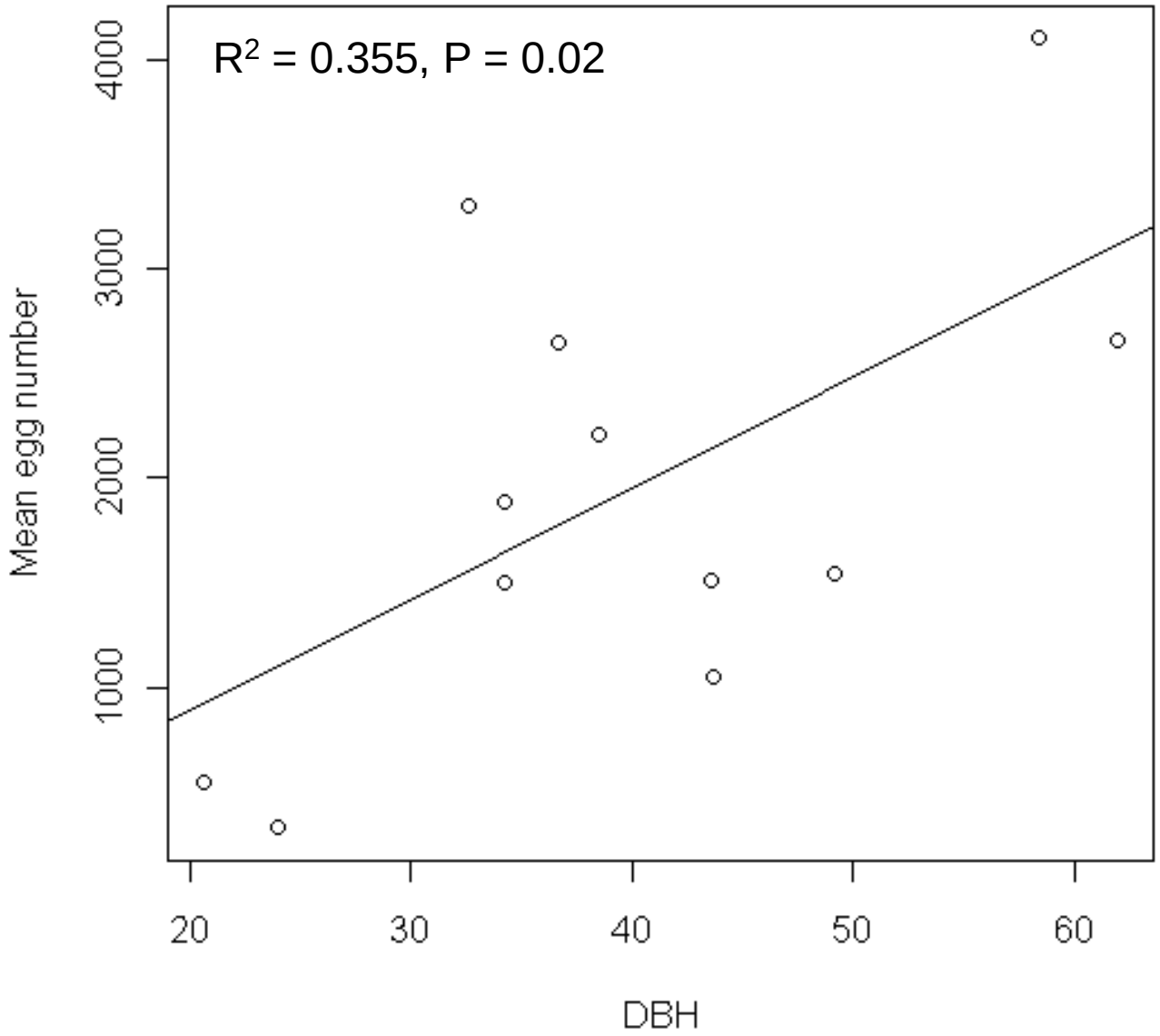
Peridomestic effect by abundance level of artificial containers



Correlation between egg number and total number of wet containers

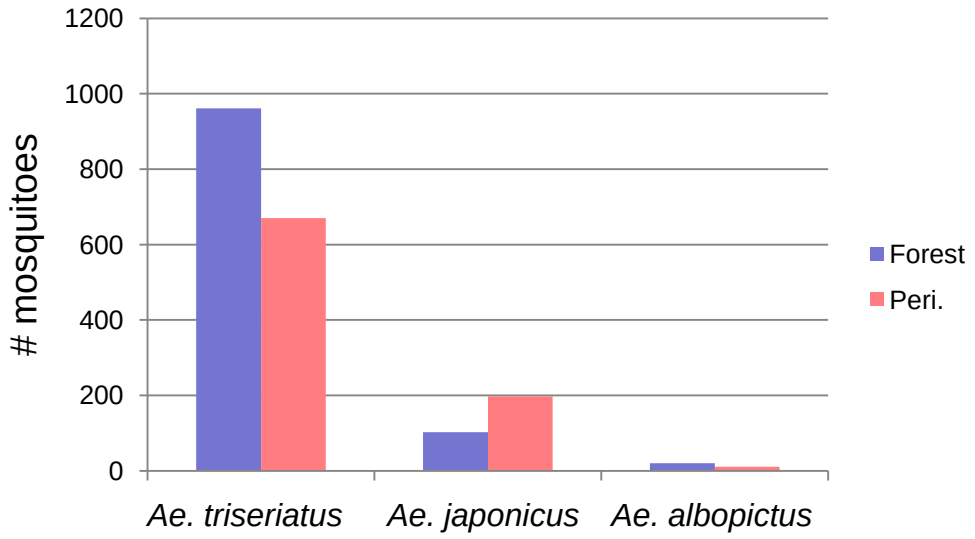


Correlation between egg number and diameter at breast height (DBH) (correlate of age)

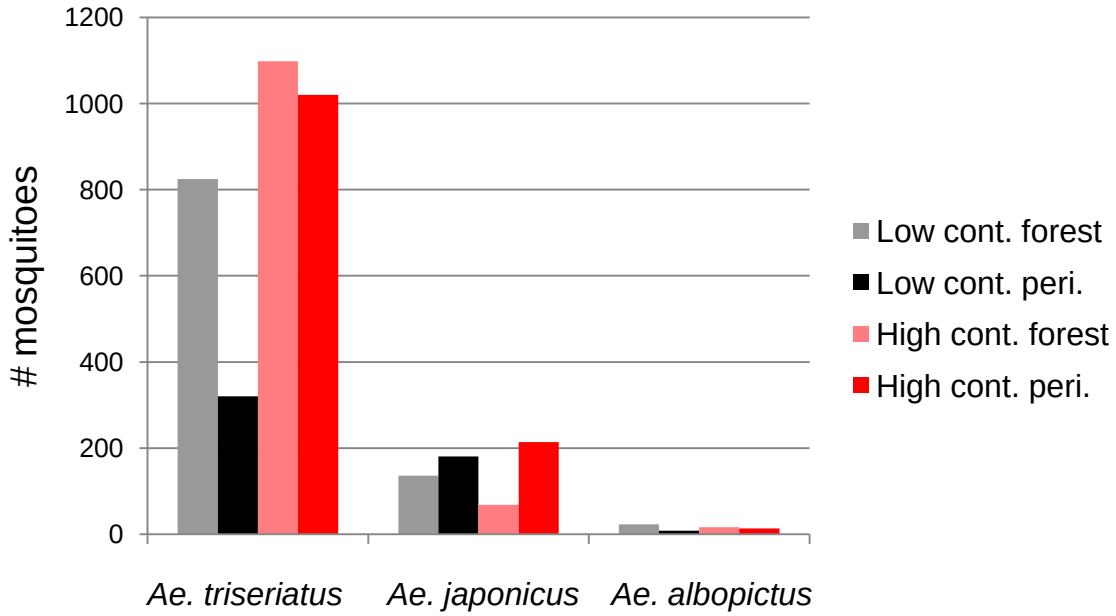


Species-specific response

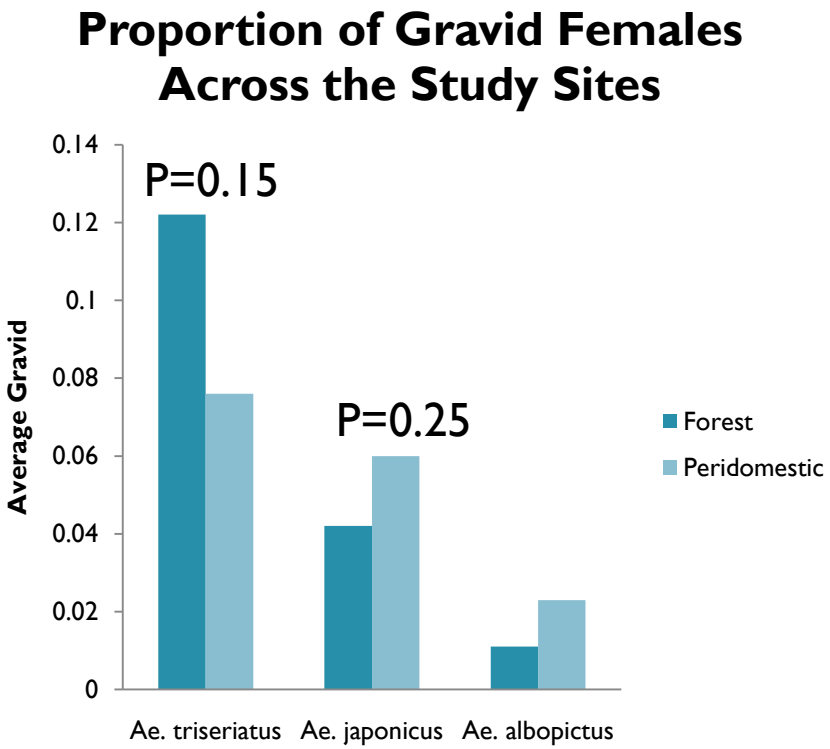
Effect of habitat type

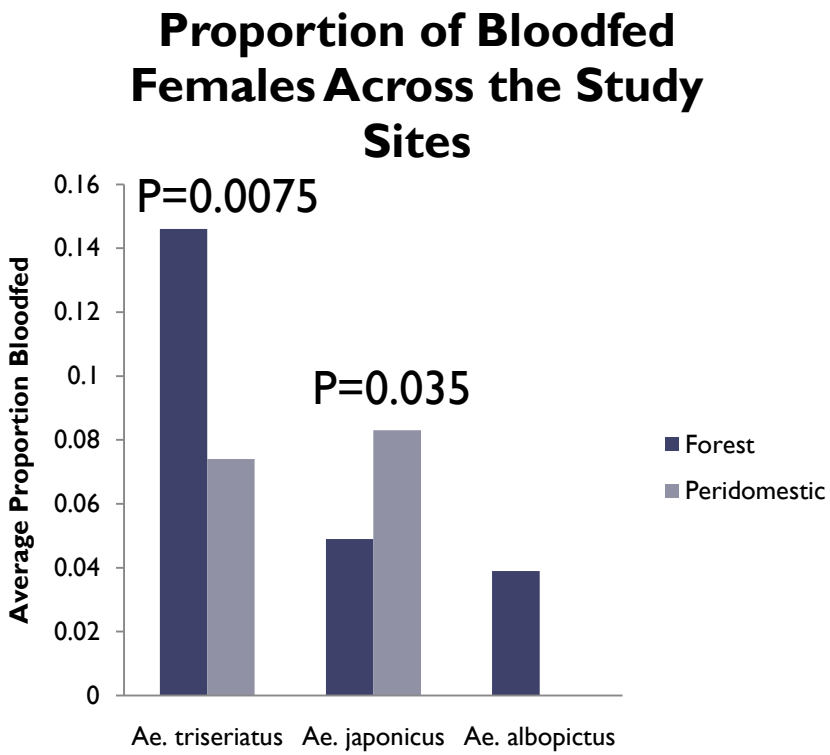


Effect of habitat type and artificial container level



Resting mosquitoes (NASCI)





- *Ae. Japonicus: proportion of bloodfed and gravid females appears* higher in the peridomestic habitat
- *Ae. triseriatus: proportion of bloodfed and gravid females appears* higher in the forest habitat

Further analyses:

1. Parity – physiological age
2. Size distribution
3. Bloodmeal analysis – host preference
4. Sugar-meal analysis
5. Potential host distribution
6. Infection distribution

DISCUSSION

Study Goal

- To determine the association between anthropogenic activity and the distribution and abundance of the ecological drivers of LACV

General Hypothesis

- Anthropogenic effect will generate habitats that are conducive to pathogen transmission

- No clear cut anthropogenic effect – in some site mosquito activity is higher at the sylvatic habitat and in other activity is higher in the peridomestic habitat.
- The anthropogenic effect also differ between mosquito species:
  - *Ae. triseriatus* - more sylvatic
  - *Ae. japonicus* – more anthropophilic

- There is a clear effect of container abundance (tree holes/artificial containers) on mosquito abundance.
- The anthropogenic effect is mediated via the effect on the number of artificial containers: in sites characterized by a high number of artificial containers
  - The typically sylvatic *Ae. triseriatus* is losing its preference for the forest habitat
  - *Ae. japonicus‘s* preference for the peridomestic habitat is amplified.

What's next?

1. Landscape ecology of LACV
2. Landscape genetic
3. Demographic predictors
4. Modeling

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