Predicting interannual variation in West Nile virus risk: IS IT FOR THE BIRDS?

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Climate and Vector-borne Disease

Cool Temperature  Warm Temperature  Precipitation:

Precipitation is crucial for the survival of mosquitoes. In cool temperatures, mosquitoes can be active year-round, whereas in warm temperatures, they may be less active. Precipitation provides standing water, which is necessary for mosquito larvae to develop.
West Nile Virus Transmission
West Nile Virus Interannual Variability
Can we improve local-scale predictions of WNV risk by including information about the birds?
Contribution of a bird species to transmission:

- **High transmission efficiency**
  - Low relative abundance
  - Low mosquito preference
- **Medium transmission efficiency**
  - High relative abundance
  - Low mosquito preference
- **Low transmission efficiency**
  - Medium relative abundance
  - High mosquito preference
How do we measure each of these contributions?

1. Existing data on bird infections
2. Field counts of birds, corrected for densities
3. Collecting bloodfed mosquitoes
2016 Field Sites

High percent infected

Low percent infected
2016 Field Season: Mosquitoes

Credit: Carlye Calvin
2016 Field Season: Birds

Detection Probability

Distance (m)

Blue Jays = Loud and hear a long ways off

Detection Probability

Distance (m)

House Finches = Quiet, only notice within ~ 30 m
Calculating the Bird Transmission Efficiency Index:

\[
\sum_{b=1}^{n} \text{Transmission Efficiency}_b \times \text{Relative Bird Abundance}_b \times \text{Fraction of Bloodmeals}_b^2
\]

(From literature)  (From historical bird surveys)  (From 2016 mosquito collections)

\[
.13 \times .75 \times 1.3 + .22 \times .25 \times .09 = 0.13
\]

\[
.13 \times .25 \times 1.3 + .22 \times .75 \times .09 = 0.05
\]
Interannual Variation Model:

Response Variables (over all sites for each year):

- Mosquito abundance = 9
- Percent infected = 0.3

Predictor Variables:

- Temperature
- Palmer Drought Severity Index
- Bird Efficiency Index
Mosquito Abundance Results:

- The graph shows the relationship between abundance residuals and the Palmer Drought Severity Index.
- There is a positive correlation between drier conditions (lower index values) and higher abundance residuals.
- Wetter conditions (higher index values) are associated with lower abundance residuals.

The graph indicates that as the Palmer Drought Severity Index decreases (becomes drier), mosquito abundance increases.
WNV Infection Percentages and Drought:

![Graph showing the relationship between WNV prevalence and Palmer Drought Severity Index.](image)

Drier: Palmer Drought Severity Index of -4 to -2

Wetter: Palmer Drought Severity Index of 0 to 1
Drought Increases WNV Risk?! 

Low drought = Low stress  
Low viremia & bite rate

High drought = High stress  
High viremia & bite rate
WNV Infection Percentages and Birds:
Summary and Significance:

- Consistent with previous counter-intuitive drought findings
- Simplified complex host contributions into a single metric
- Use June host abundance to predict percent WNV infected mosquitoes
- Improved measure could help public health efforts
Future Work: Is Predicting WNV for the birds?

- Testing to see if monthly measures or lags are appropriate
- Planning to look at spatial variation in WNV risk at these sites in 2016
  - Compare explanatory power of morning/evening bird surveys, and bird surveys at different times of season
- Future Question = How does mosquito feeding preference vary across sites and over time?
Some Practical Public Health Tips:

**THE FOUR D’S OF WEST NILE VIRUS PREVENTION**

**DRAIN**
Drain any standing water, the ideal mosquito breeding ground, in your yard or neighborhood.

**DAWN & DUSK**
Stay indoors at dawn & dusk when mosquitoes are most active.

**DRESS**
Dress in long sleeves & pants when outside.

**DEET**
Wear a DEET, oil of lemon eucalyptus, or picaridin repellent when outdoors, according to label instructions.
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Drought and WNV Hypothesis 2:

Low drought = more nestlings
Lower vector:host ratio
Lower transmission risk

High drought = fewer nestlings
Higher vector:host ratio
Greater transmission risk
Meteorological Predictors of WNV

Colorado

South Dakota

Human cases vs. Year

Year
Number of WNV Infected Mosquitoes:

![Graph 1: Palmer Drought Severity Index vs. Number of WNV Mosquitoes]

![Graph 2: Bird efficiency index vs. Number of WNV Mosquitoes]