Underestimation of WNV?

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West Nile Disease

• Caused by a virus of a family of *Flaviviridae*.  
• Vector-Borne disease transmitted by mosquitoes to humans and some animals.  
• First identified in 1937 in eastern African and first discovered in the summer of New York in 1999.  
• Since then, the virus has spread all over United States.
Ecologic Surveillance

Goal: predict and prevent human and domestic animal infections.

- Detection of WNV in dead bird and infected mosquito populations.

Failure of predictions

- Failure of sampling data
- Factor being estimated doesn’t have a strong biological relationship with human disease cases.
Research Questions

1. Would the prevalence of the West Nile virus be underestimated by surveillance programs that target only the numbers of positive dead birds due to many mosquitoes feeding more often on sick birds with WNV?

2. Would this be true if the surveillance program targets only the numbers of infected mosquitoes?
Modeling with SEIR

Mosquitoes:
- $L_M \rightarrow M \rightarrow S_M \rightarrow E_M \rightarrow K \rightarrow I_M$

Birds:
- $S_B \rightarrow E_B \rightarrow I_B \rightarrow D_B \rightarrow R_B$

Transitions:
- $\beta_M - \nu_A$
- $\beta_M - \nu_L$
- $\gamma_B$
- $\alpha_B v_B$
- $\alpha_B (1 - v_B)$
Differential Equations for Birds

\[
\frac{dS_B}{dt} = (\beta_B - (\beta_B - m_B) \frac{N_B}{K_B})N_B - \frac{S_B + I_B}{S_B + xI_B} abI_M \frac{S_B}{N_B} - m_B S_B
\]

\[
\frac{dE_B}{dt} = \frac{S_B + I_B}{S_B + xI_B} abI_M \frac{S_B}{N_B} - \gamma_B E_B - m_B E_B
\]

\[
\frac{dI_B}{dt} = \gamma_B E_B - \alpha_B I_B - m_B I_B
\]

\[
\frac{dR_B}{dt} = (1 - v_B)\alpha_B I_B - m_B I_B
\]

\[
\frac{dD_B}{dt} = v_B \alpha_B I_B
\]
Differential Equations for Mosquitoes

\[
\frac{dL_M}{dt} = \beta_M(S_M + E_M + I_M)(1 - \frac{S_M + E_M + I_M}{K_M}) - ML_M - \nu_L L_M
\]
\[
\frac{dS_M}{dt} = -x \frac{S_B + I_B}{S_B + xI_B} \alpha c S_M \frac{I_B}{N_B} + ML_M - \nu_A S_M
\]
\[
\frac{dE_M}{dt} = x \frac{S_B + I_B}{S_B + xI_B} \alpha c S_M \frac{I_B}{N_B} - kE_M - \nu_A E_M
\]
\[
\frac{dI_M}{dt} = kE_M - \nu_A I_M
\]
Simulation’s Initial Values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>values</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_M$</td>
<td>499900</td>
<td>Number of susceptible mosquitoes</td>
</tr>
<tr>
<td>$S_B$</td>
<td>11000</td>
<td>Number of susceptible birds</td>
</tr>
<tr>
<td>$I_M$</td>
<td>100</td>
<td>Number of infectious mosquitoes</td>
</tr>
</tbody>
</table>
As the attraction scale $c$ of the sick bird increases, the number of positive dead birds and the number of infected mosquitoes tend to increase.
Simulation Result I.II

As the attraction scale $c$ of the sick bird increases, the number of positive dead birds and the number of infected mosquitoes tend to increase.
Simulation Result II.1

As the attraction scale $c$ of the sick bird increases, the percentage of positive dead birds and the percentage of infected mosquitoes tend to increase for the same time. However, the WNV has a greater effect on the population of birds than that of mosquitoes.
Simulation Result II.II

Effect of Attraction Scale $c$ to the Subgroups of Birds.
Simulation Result III

Effect of Attraction Scale to the Percentage Change of Birds and Mosquitoes in Their Populations
Conclusion

The prevalence of the WNV will be underestimated if the surveillance programs only record the number of positive dead birds with the assumption that the mosquitoes feed more often on the birds with WNV.
Reference


Thank You !!