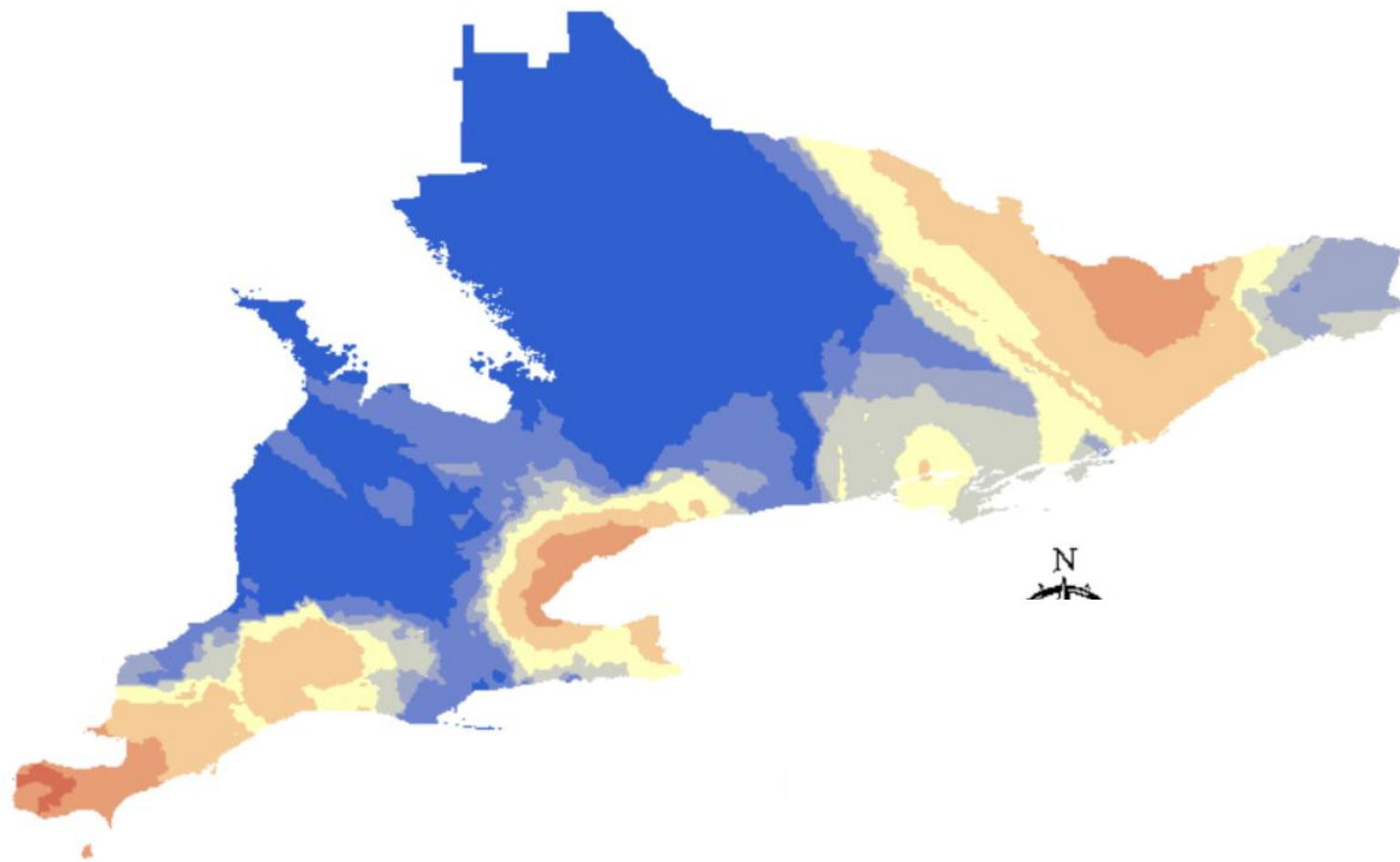




# FORECASTING WNV OUTBREAKS USING DEGREE-DAY ANALYSIS VS. RAW AVERAGE TEMPERATURE

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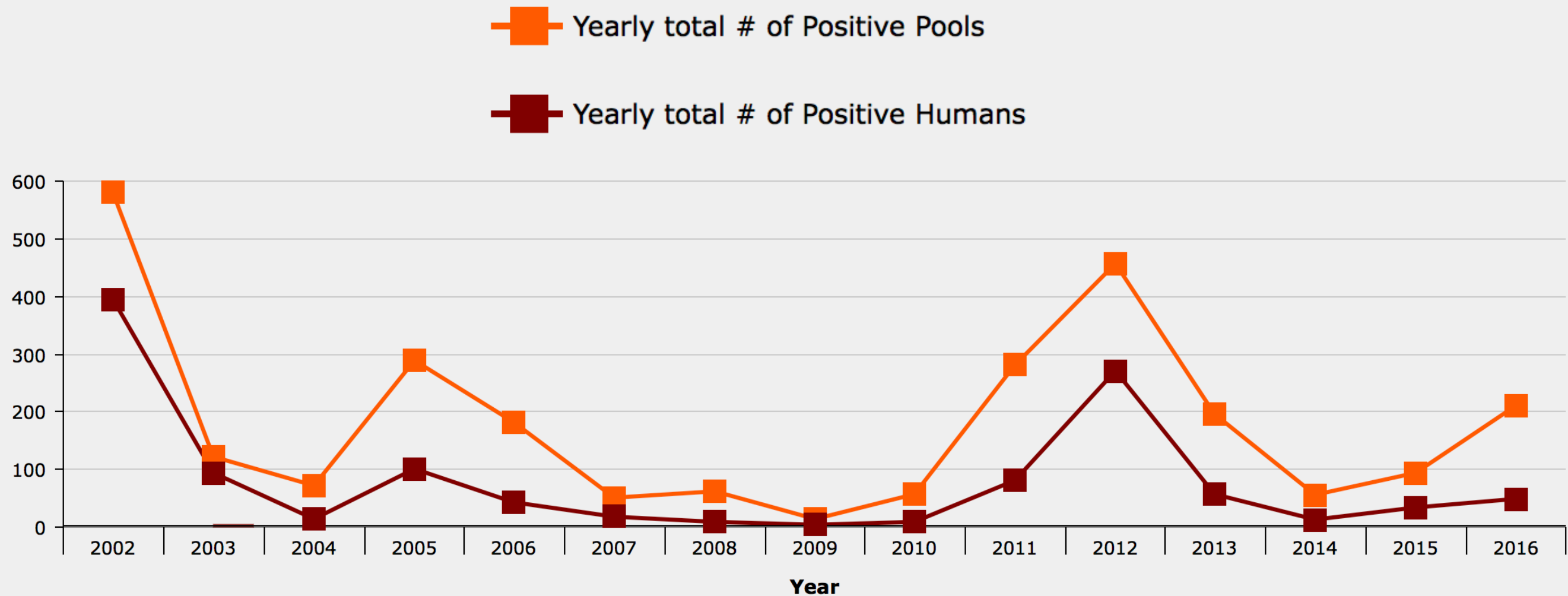
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Research Scientist



# WEST NILE VIRUS IN ONTARIO

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- First discovered in Peel Region, 2001
- ~1000 confirmed human cases



# WHAT SPECIES TEST POSITIVE FOR WNV?

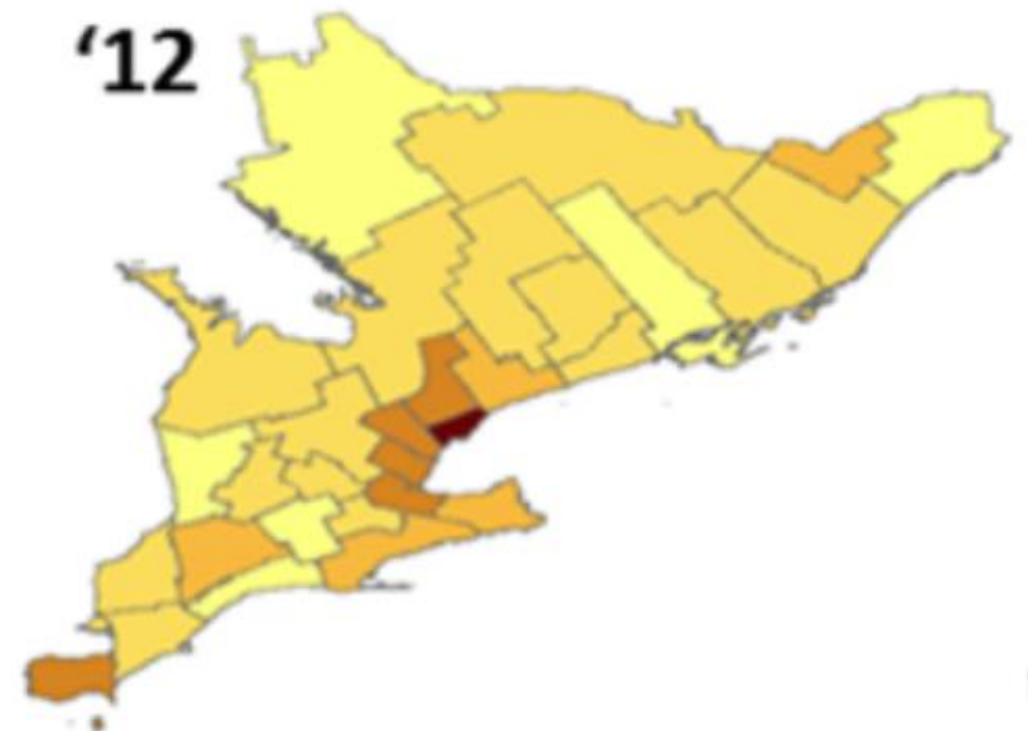
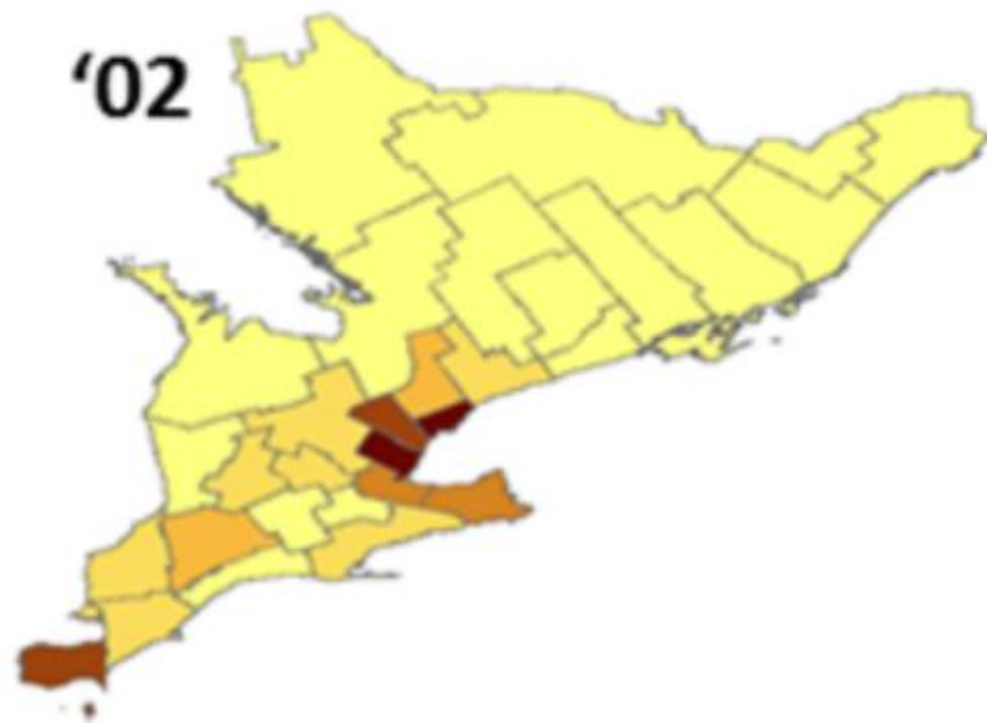
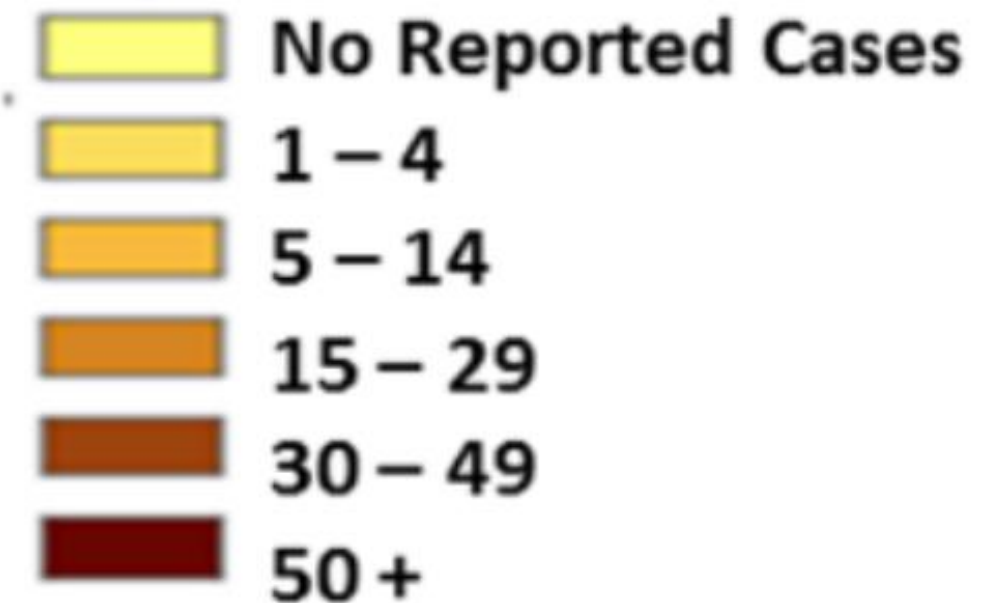
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|                             | '02        | '03        | '04       | '05        | '06        | '07       | '08       | '09       | '10       | '11        | '12        | '13        |
|-----------------------------|------------|------------|-----------|------------|------------|-----------|-----------|-----------|-----------|------------|------------|------------|
| <i>Ae. japonicus</i>        | 0          | 0          | 0         | 0          | 0          | 1         | 1         | 1         | 3         | 9          | 2          | 1          |
| <i>Ae. vexans</i>           | 41         | 3          | 3         | 17         | 17         | 10        | 3         | 2         | 5         | 15         | 10         | 8          |
| <i>An. punctipennis</i>     | 11         | 1          | 0         | 1          | 0          | 0         | 0         | 0         | 0         | 6          | 3          | 1          |
| <i>An. quadrimaculatus</i>  | 0          | 0          | 0         | 0          | 0          | 0         | 0         | 0         | 0         | 4          | 0          | 0          |
| <i>An. walkeri</i>          | 0          | 1          | 0         | 0          | 0          | 0         | 0         | 0         | 0         | 0          | 0          | 0          |
| <i>Cq. perturbans</i>       | 18         | 1          | 2         | 2          | 4          | 0         | 0         | 0         | 0         | 0          | 0          | 1          |
| <i>Cx. pipiens/restuans</i> | 301        | 105        | 60        | 260        | 156        | 38        | 56        | 11        | 48        | 237        | 436        | 184        |
| <i>Cx. salinarius</i>       | 23         | 1          | 0         | 0          | 0          | 0         | 0         | 0         | 0         | 0          | 4          | 0          |
| <i>Cs. melanura</i>         | 0          | 0          | 0         | 0          | 0          | 0         | 0         | 0         | 1         | 0          | 0          | 0          |
| <i>Och. excrucians</i>      | 2          | 0          | 0         | 0          | 0          | 0         | 0         | 0         | 0         | 0          | 0          | 0          |
| <i>Och. sollicitans</i>     | 0          | 0          | 0         | 1          | 0          | 0         | 0         | 0         | 0         | 0          | 0          | 0          |
| <i>Och. stimulans</i>       | 0          | 1          | 0         | 0          | 0          | 0         | 0         | 0         | 0         | 1          | 0          | 0          |
| <i>Och. triseriatus</i>     | 8          | 1          | 0         | 0          | 0          | 1         | 2         | 0         | 0         | 8          | 1          | 0          |
| <i>Och. trivittatus</i>     | 11         | 1          | 1         | 2          | 3          | 0         | 0         | 0         | 0         | 1          | 1          | 0          |
| <b>Total</b>                | <b>415</b> | <b>115</b> | <b>66</b> | <b>283</b> | <b>180</b> | <b>50</b> | <b>62</b> | <b>14</b> | <b>57</b> | <b>281</b> | <b>457</b> | <b>195</b> |

# WEST NILE VIRUS IN ONTARIO

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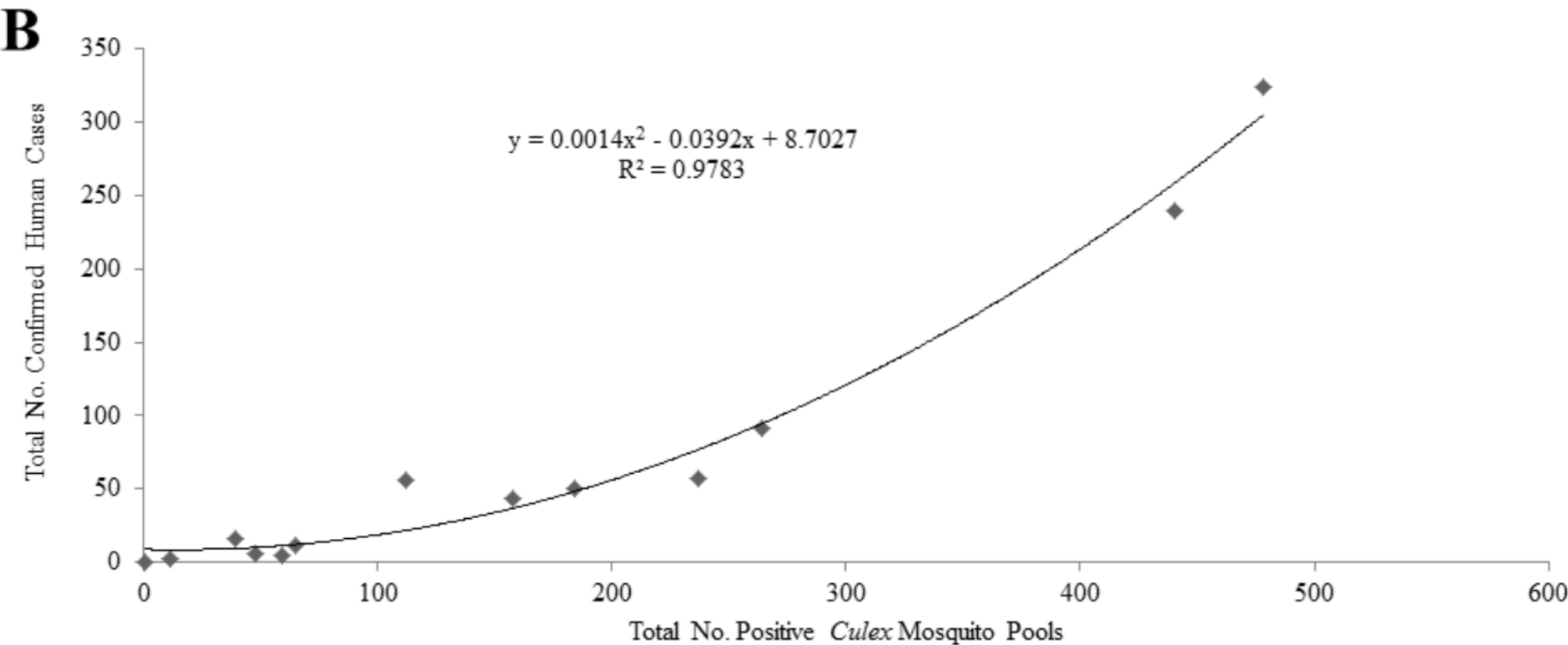
- First discovered in Peel Region, 2001
- ~1000 confirmed human cases
- Epidemic years:
  - 2002 and 2012



# CULEX POOLS AND HUMAN CASES

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- Strong correlation between the number of positive Culex pools and human cases each year



# PREDICTING OUTBREAKS IN ONTARIO

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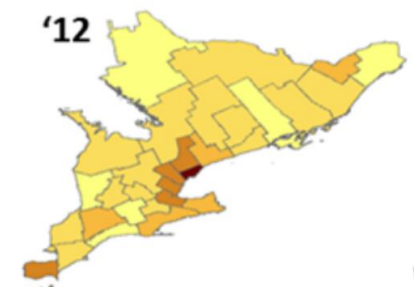
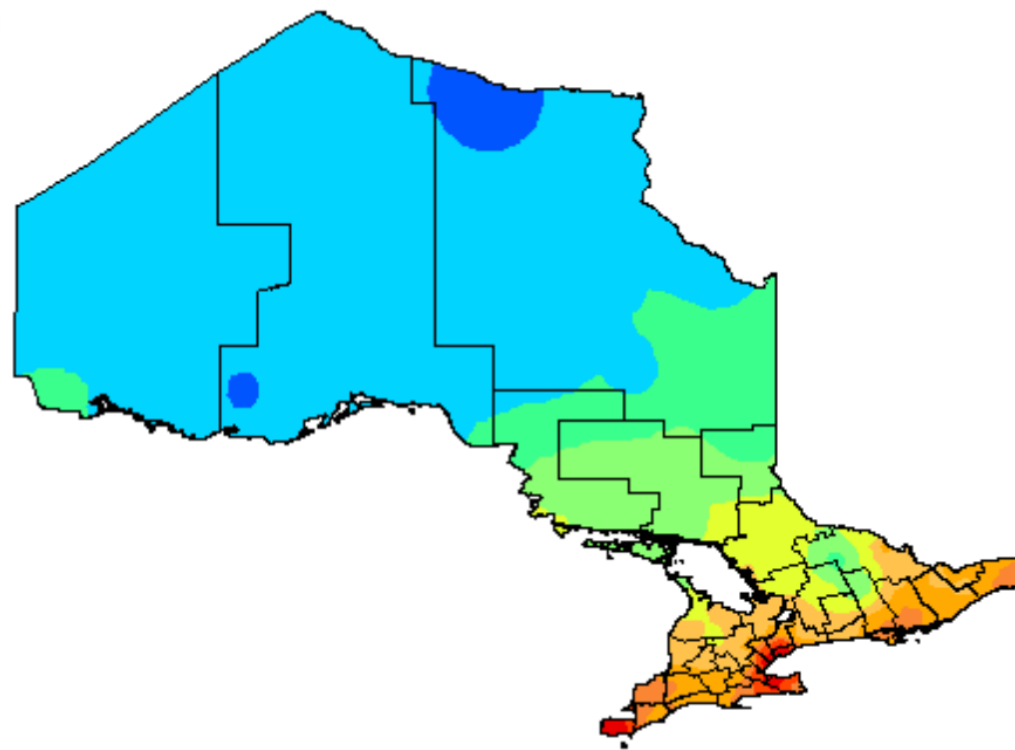
- Few published results with Ontario data
- Beroll et al. (2007) created risk distribution maps of southern Ontario with dead bird surveillance data
  - ~~Dead bird submission program~~
- Wang et al. (2011) discovered that WNV vector abundance on any one day can be predicted with **degree days**

# ACCUMULATED DEGREE DAYS

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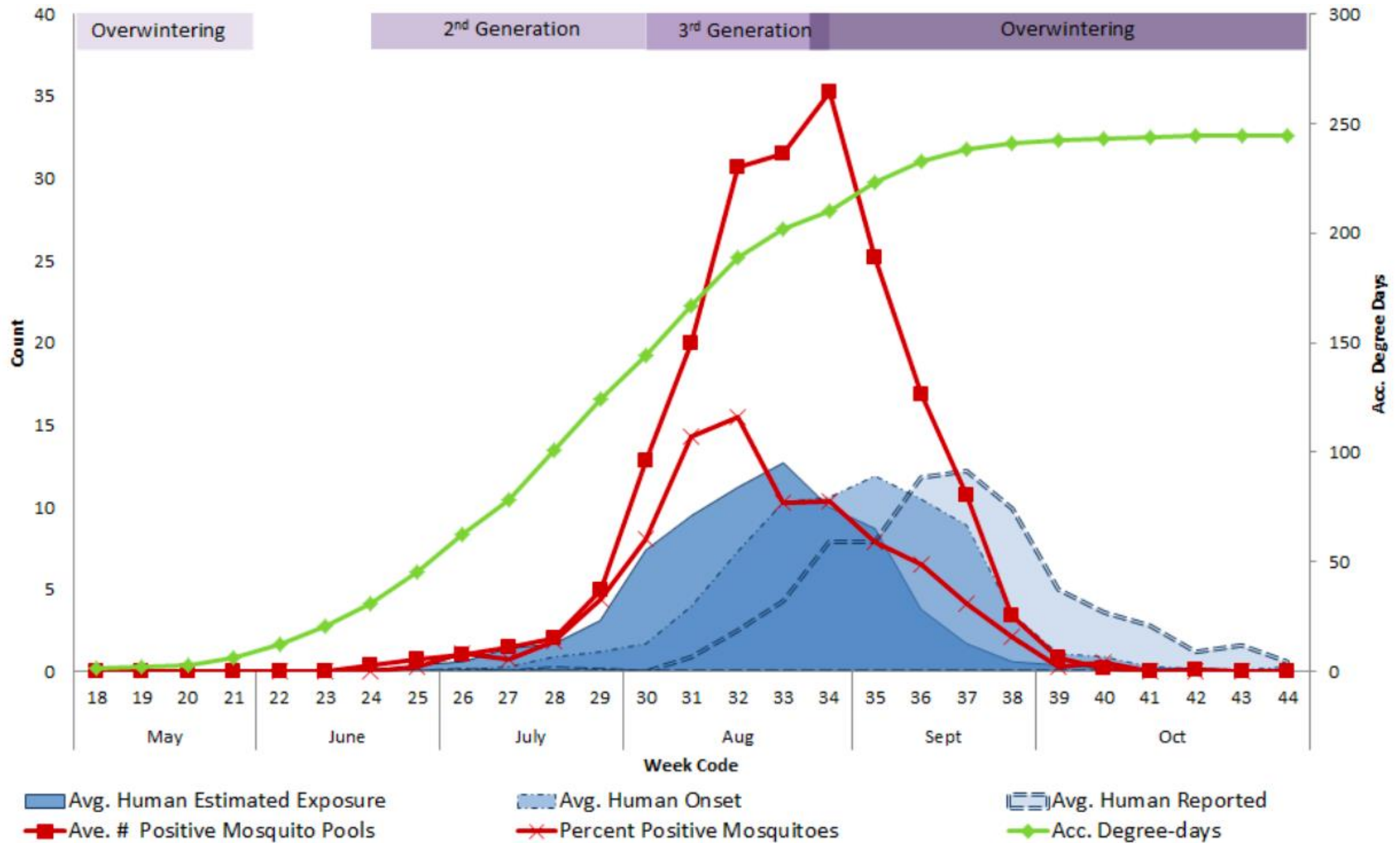
- 1 Degree Day: When average temperature for a single day is 1C above 18.3C
  - Ex. Average T = 20.3C → DD = 2
- Accumulated Degree Days are the continuous addition of consecutive Degree Days

Legend  
Accumulated  
Degree Days





# ACCUMULATED DEGREE DAYS





# ACCUMULATED DEGREE DAYS

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- 1 Degree Day: When average temperature for a single day is 1C above 18.3C
  - Ex. Average  $T = 20.3^{\circ}\text{C} \rightarrow \text{DD} = 2$
- Accumulated Degree Days are the continuous addition of consecutive Degree Days
- Problems:
  - Only takes into considerations increasing temperatures or consecutively warm days
  - Changes in temperature are known to affect BOTH the mosquito vector and the virus

# EXTRINSIC INCUBATION PERIOD (EIP)

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- Time required from infection of the vector to infectivity

# INFECTIVE LIFE EXPECTANCY (ILE)

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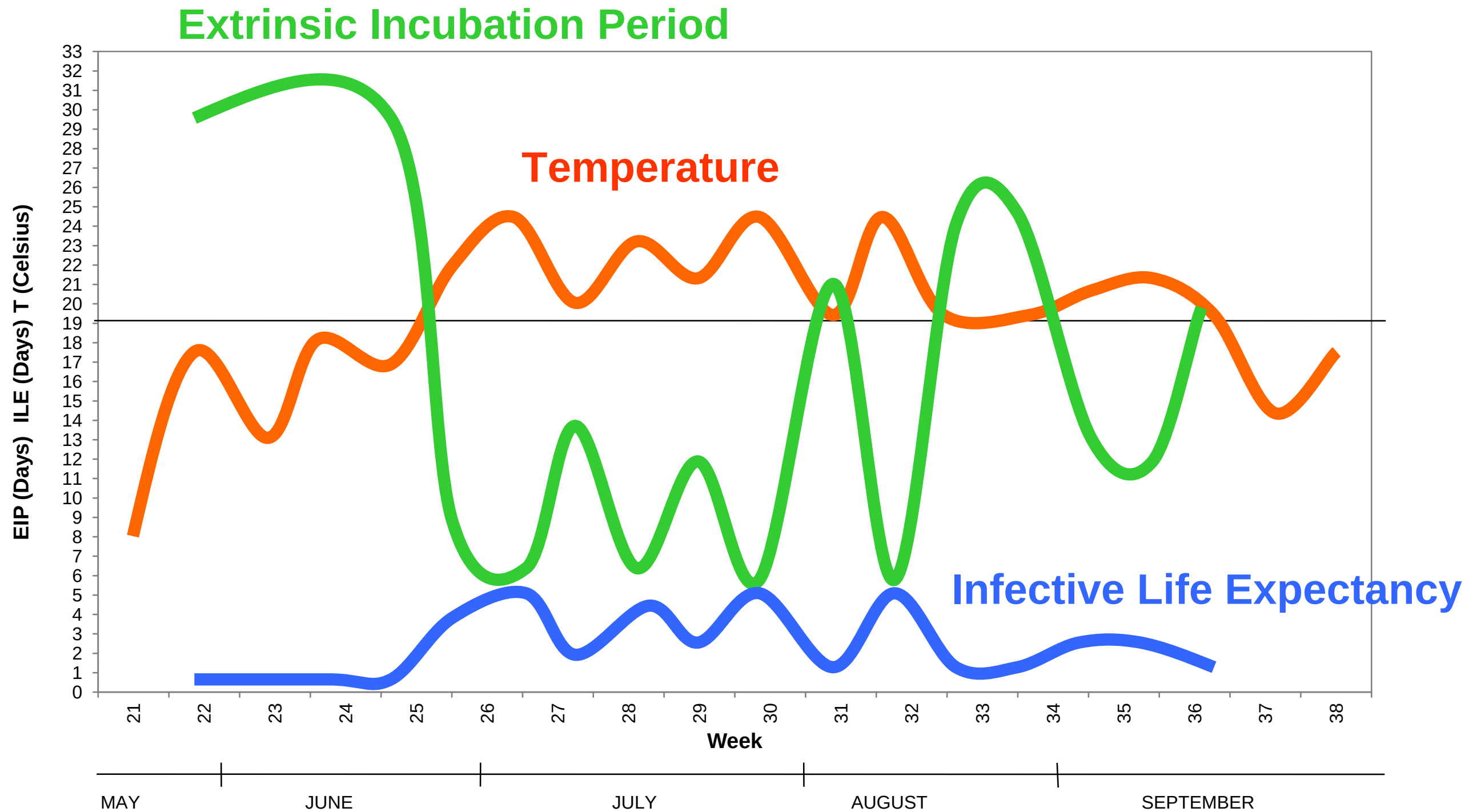
- Expectation of Life
- The probability the vector will infect again after it has survived the EIP
- ILE is modelled with both pathogen and vector biology taken into consideration
  - Survivorship
  - Replication
  - Temperature

# TEMPERATURE IS KNOWN TO ALTER BOTH EIP AND ILE

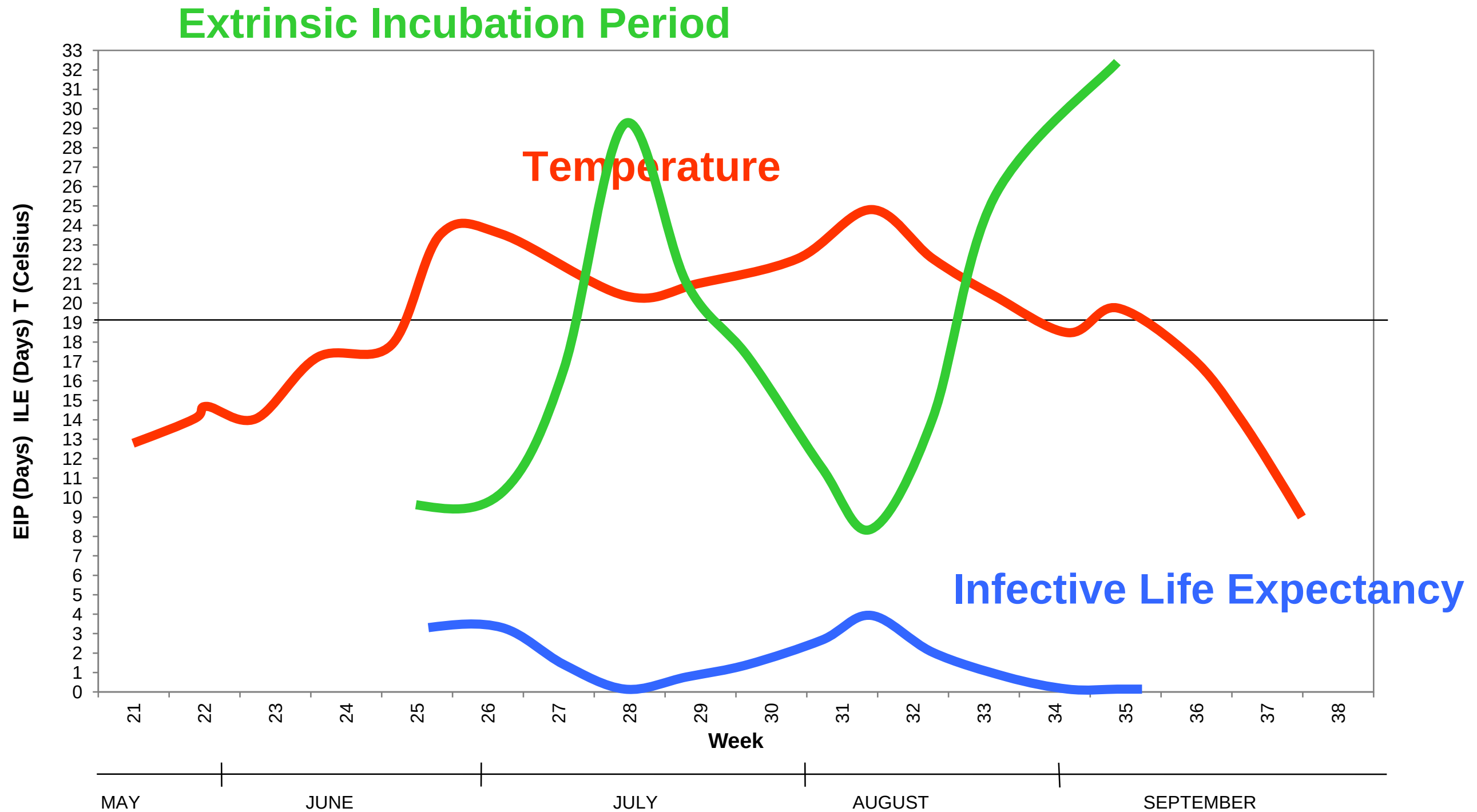
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- Increasing Temperature
  - Increases rate of viral replication —>Shortens EIP
  - Increases rate of mosquito metabolism
  - Shortens mean daily survival rate of Culex mosquitoes —>Increases ILE

# TORONTO 2002 - ONTARIOS FIRST EPIDEMIC YEAR

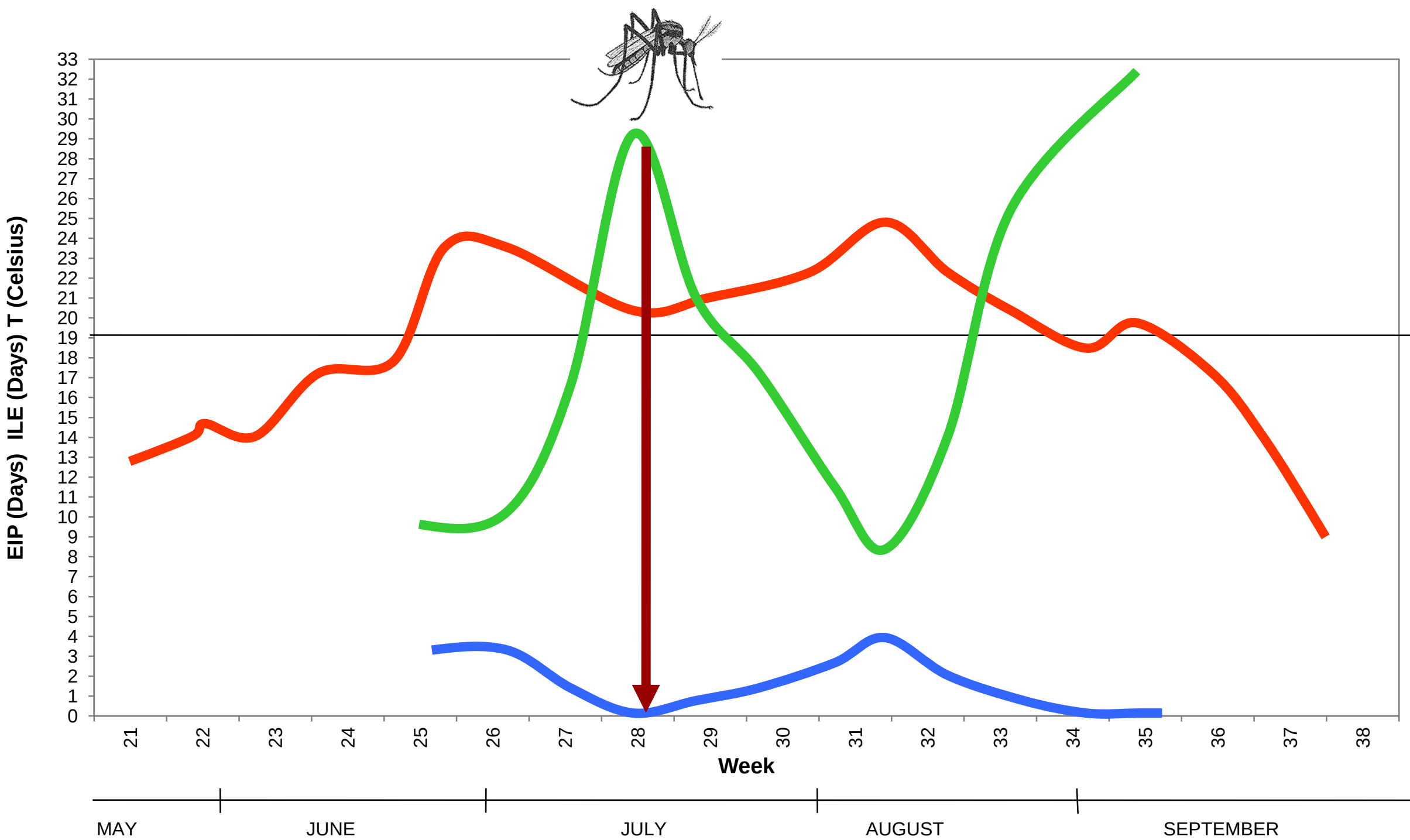


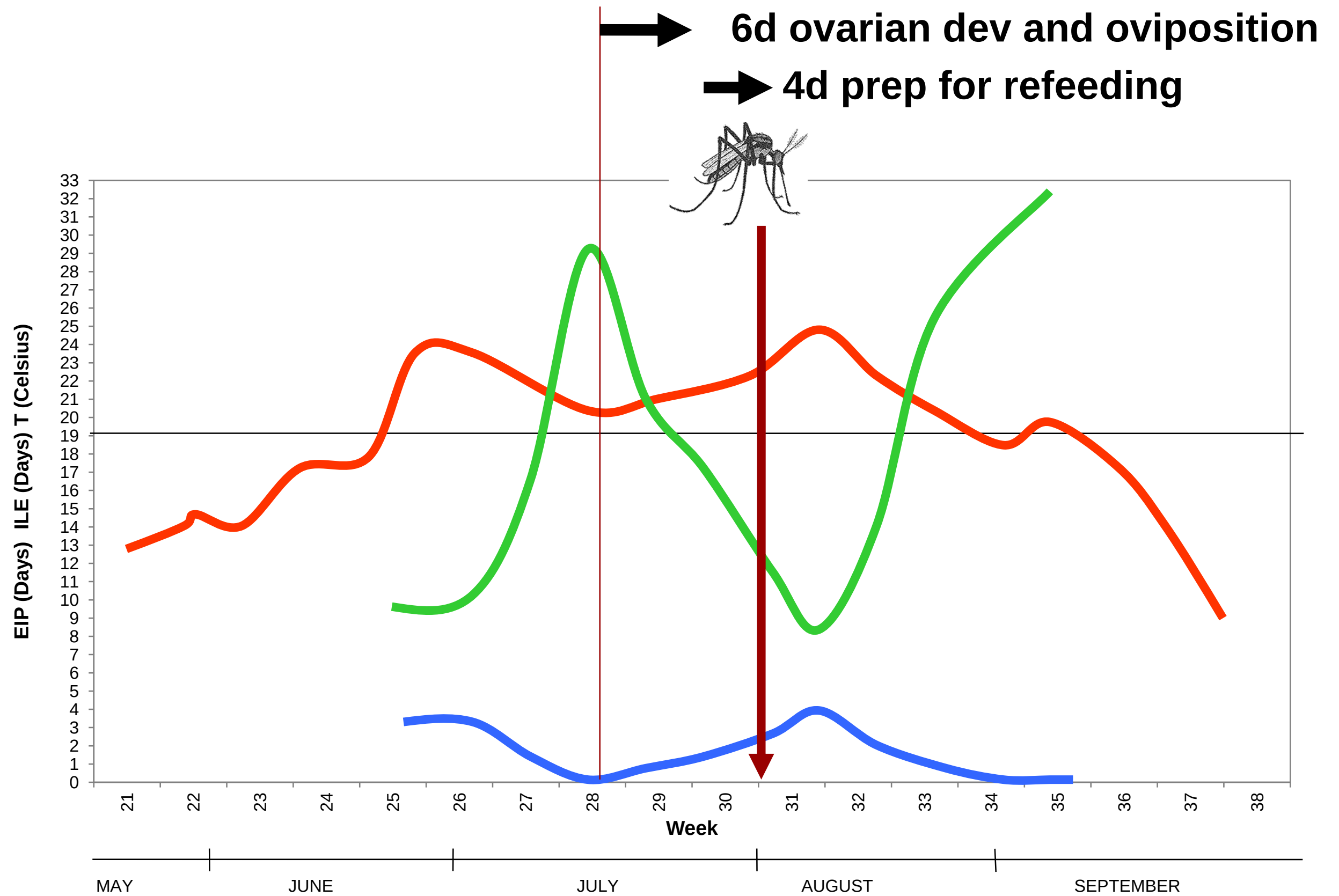
# TORONTO 2003 - NOT AN EPIDEMIC YEAR



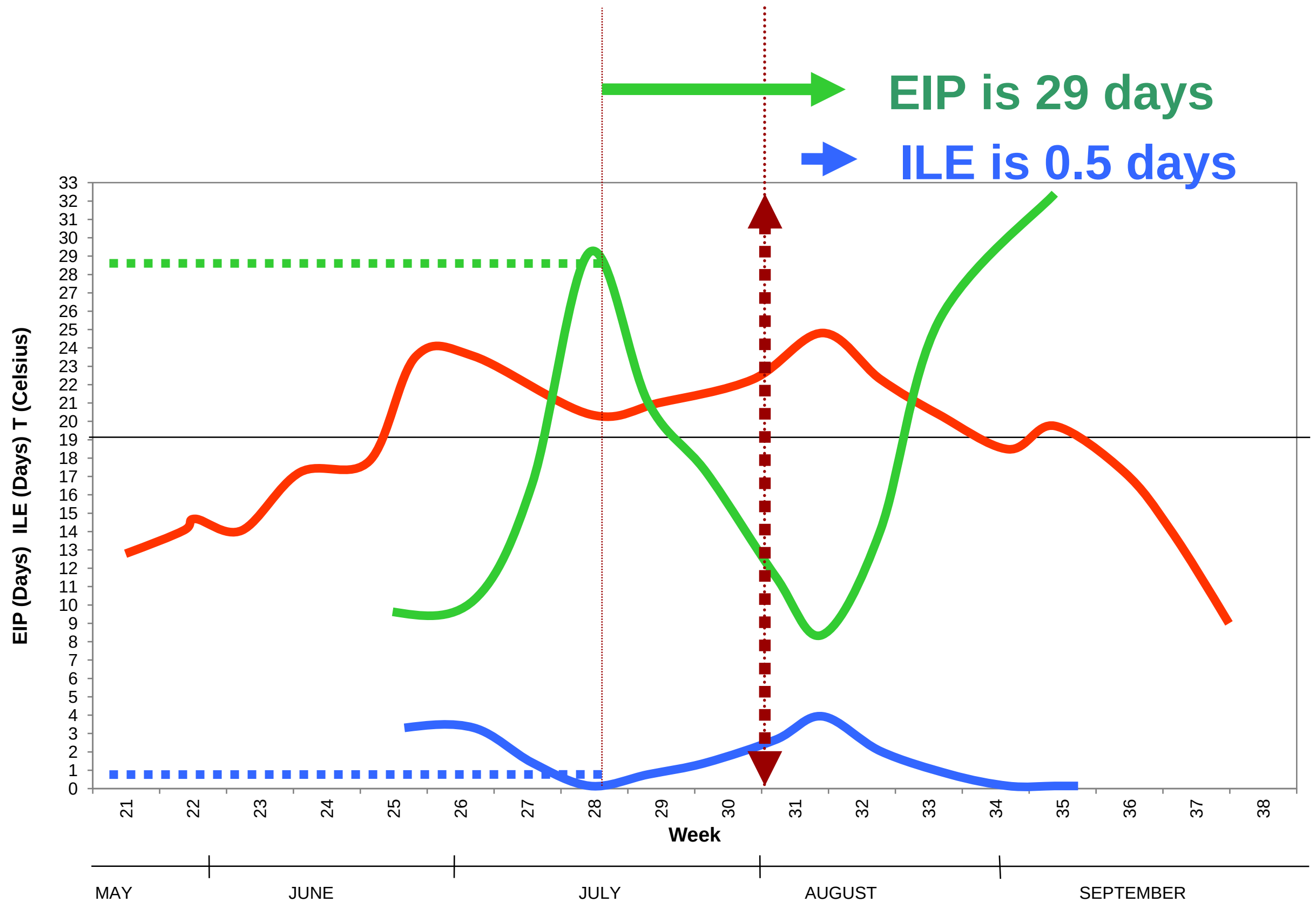


# BITE FOR FIRST TIME IN WEEK 28



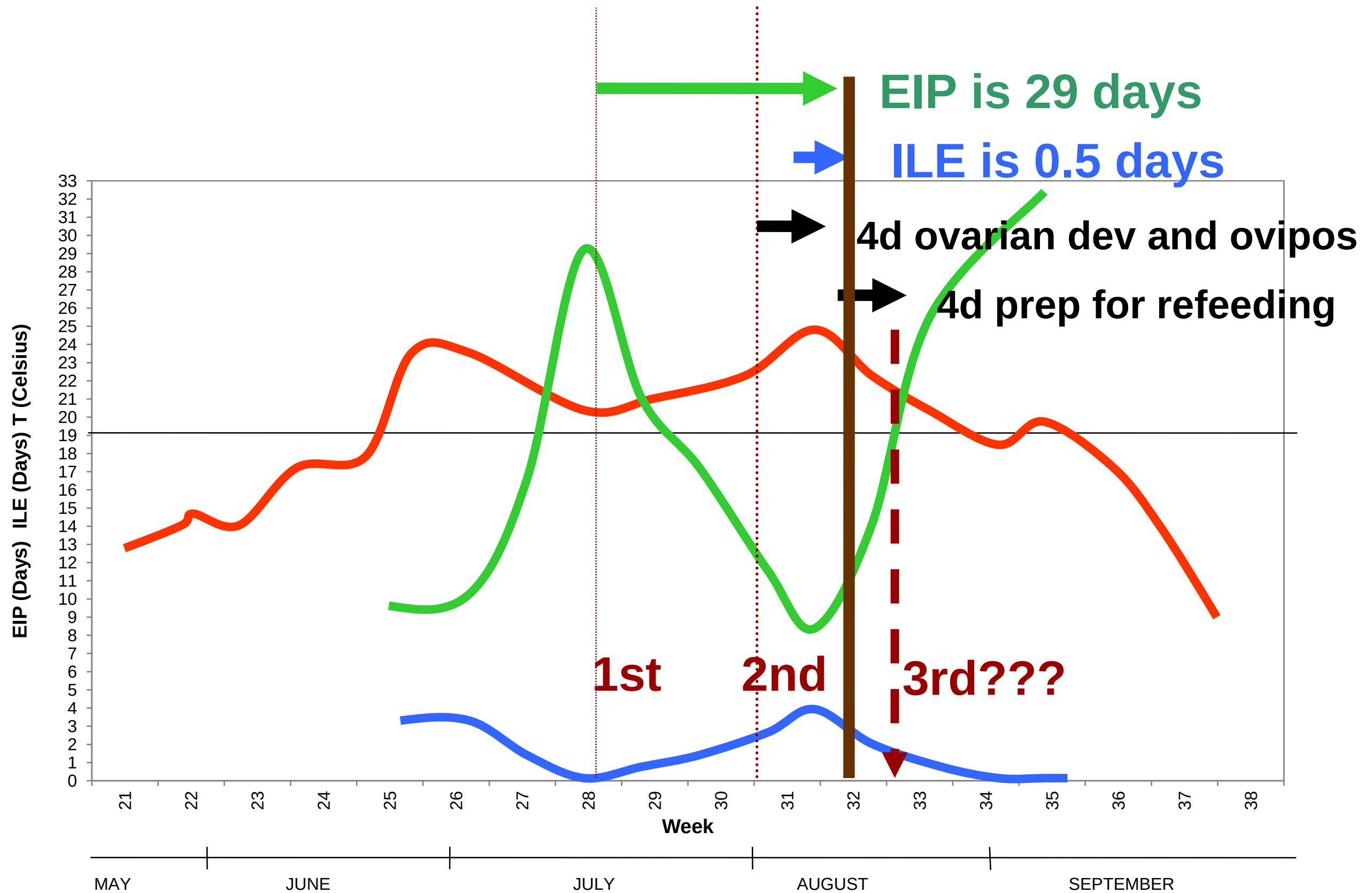


# CAN THIS MOSQUITO INFECT ANOTHER HOST?



**Answer: NOT in week 32**

# CAN THIS MOSQUITO INFECT ANOTHER HOST?



**ANSWER: NO, already dead**

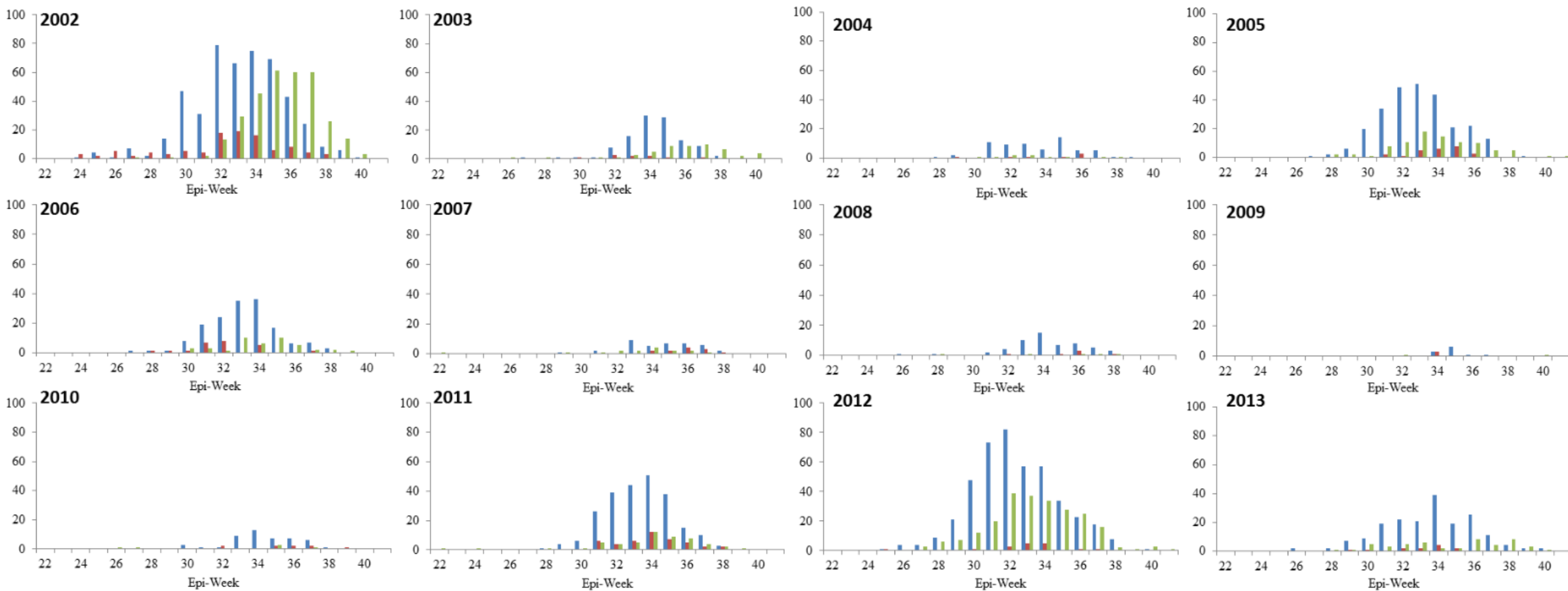
# REVIEW

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- Accumulated degree day analysis is useful BUT may be overestimating the risk
- Average temperature data ensures fluctuations are taken into consideration
- Important to note that Culex pipiens act as both enzootic and bridge vectors
  - feed on birds primarily in spring
  - feed on humans in late summer and fall

# WEEKLY HUMAN CASES AND POSITIVE POOLS

► Blue: Culex pools; Red: other species pools; Green: Human cases



# SPEARMAN RANK CORRELATION TESTS WITH RAW TEMPERATURE DATA

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- Measures degree of linear correlation via ranking
  - -1 (negatively correlated) to +1 (positively correlated)
- Aligned number of Human Cases to:
  - MIR
  - Mean weekly Temperature
  - Mean weekly amount of Rainfall (Precipitation)
- $MIR = [(Total\ No.\ positive\ pools) / (Total\ No.\ female\ mosquitoes\ tested)] * 1000$
- Lag periods of 0, 1, 2, and 3 weeks



# RESULTS

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- Toronto (2002 to 2013)
  - Human cases and MIR top score
  - 1 week lag (+0.6882,  $p < 0.001$ )
- Toronto (2002 and 2012 only)
  - Human cases and MIR top score
  - 1 week lag (+0.8668,  $p < 0.001$ )



# RESULTS

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- Toronto (2002 to 2013)
  - Human cases and Temperature
  - 3 week lag (+0.5154,  $p < 0.001$ )
- Toronto (2002 and 2012 only)
  - Human cases and Temperature
  - 3 week lag (+0.5519,  $p < 0.001$ )

# RESULTS

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- Toronto (2002 to 2013)
  - Human cases and Precipitation
  - No significant results
  
- Toronto (2002 and 2012 only)
  - Human cases and Precipitation
  - No significant results

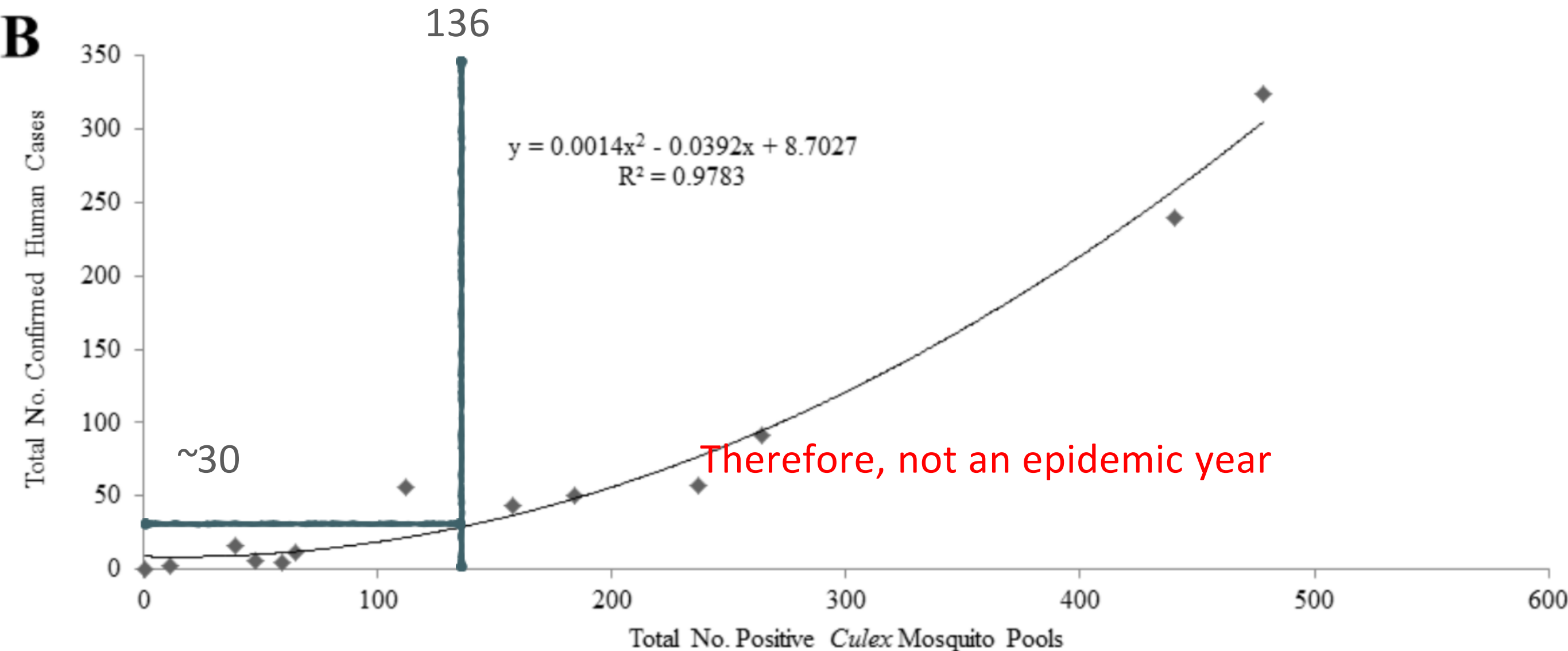
# EPIDEMIC THRESHOLD POSITIVE POOLS

- Can we predict the total year end number of human cases based on real-time surveillance data?...YES!!!

| Lag Period | Week                              | Spearman Rank |
|------------|-----------------------------------|---------------|
| 0          | 24 <— first human case in Ontario | 0.4691        |
| 1          | 25                                | 0.5187        |
| 2          | 26                                | 0.5697        |
| 3          | 27                                | 0.6249        |
| 4          | 28                                | 0.6817        |
| 5          | 29                                | 0.7412        |
| 6          | 30                                | 0.8021        |
| 7          | 31                                | 0.8454        |
| 8          | 32                                | 0.8798        |
| 9          | 33                                | 0.8953        |
| 10         | 34                                | 0.9040        |
| 11         | 35                                | 0.9064        |
| 12         | 36                                | 0.9078        |

# LETS TRY IT!

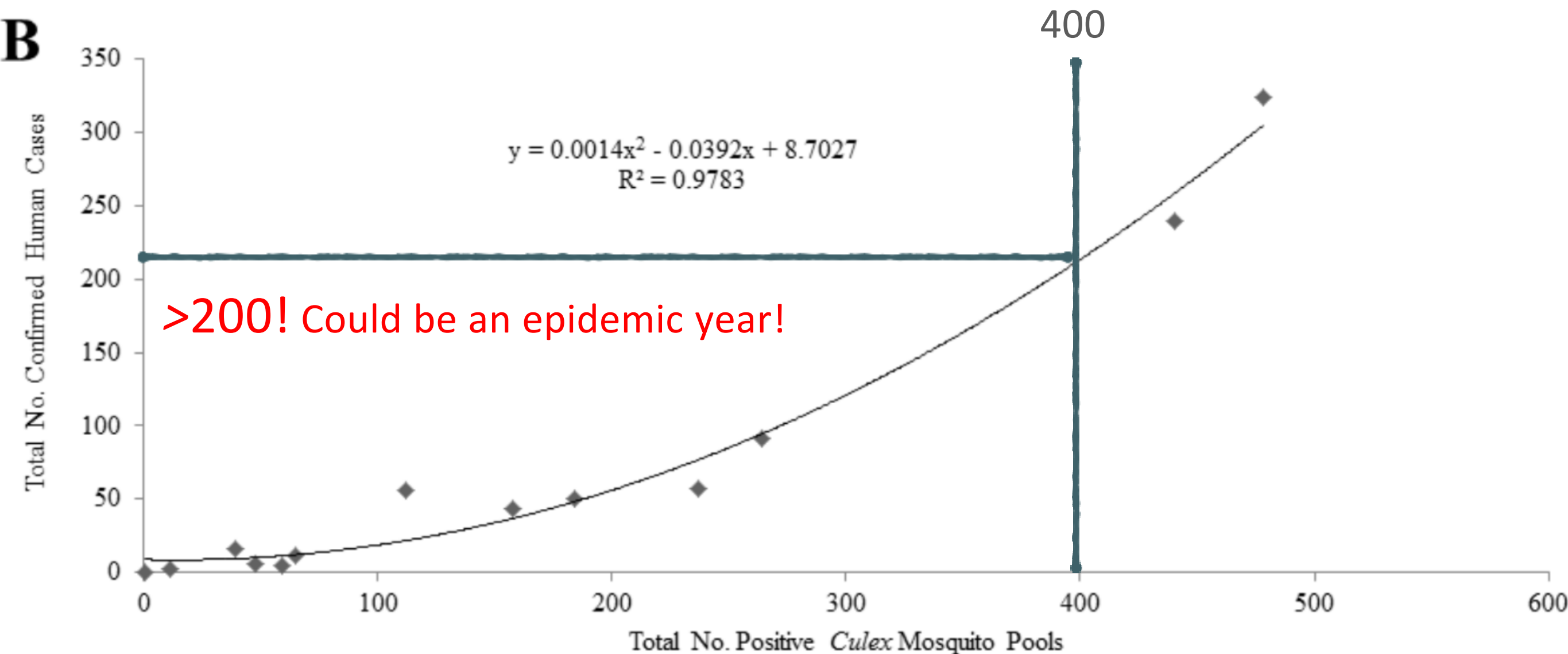
- 2016: Total Number of human cases = 46
- 2016 at epi-week 34: 136 Cumulative positive pools



# LETS TRY IT!

- 201X: Total Number of human cases = ???
- 201X at epi-week 34: 400 Cumulative positive pools

**B**



# QUESTIONS?

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- Acknowledgements
  - Dr. Fiona Hunter
  - Public Health Ontario
  - Public Health Agency of Canada's First Nations and Inuit Health Branch
  - Brock Biting Fly Lab

