Update on the invasive mosquito, *Aedes j. japonicus* in North America

Mid-Atlantic Mosquito Control Association/North Carolina Mosquito and Vector Control Association Conference

Courtyard Marriott, Carolina Beach, NC
13 February 2018
Mike Hutchinson

Tom Wolf, Governor

Patrick McDonnell, Secretary

Taxonomy

- Type specimen collected in Tokyo, Japan in 1901
- First described as *Culex japonicus*
- In 1921, reclassified as *Aedes japonicus* (Dyar 1921)
- In 2000, renamed as *Ochlerotatus japonicus* (Reinert et al. 2000)
- In 2006, renamed as Hulecoeteomyia japonica (Reinert et al. 2006)
  - (*Ochlerotatus atropalpus* was renamed as *Georgecraigius atropalpus* in same paper)
- In 2015, species name was restored to *Aedes japonicus*
  - (Wilkerson et al. 2015)

Taxonomy

- Larvae and adults are distinctive compared to other local species

Setae on head are all frontal

Distinctive pattern on thorax

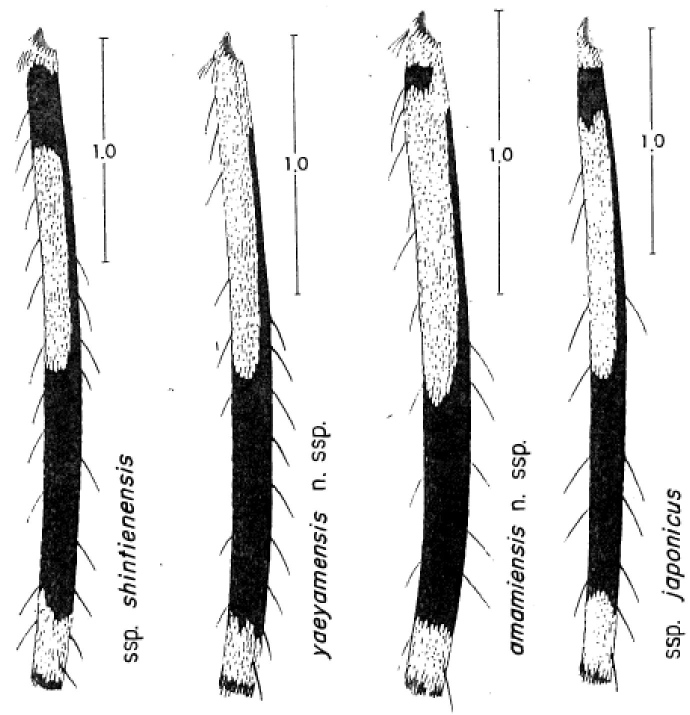
Taxonomy

But, there are look-alikes to watch out for.

Aedes koreicus

Photo credit: Schaffner

Aedes japonicus subspecies



Tanaka 1979

Initial Discovery in the U.S. - 1998

- First detected in NY and NJ
- CT checked preserved samples from that year and identified specimens

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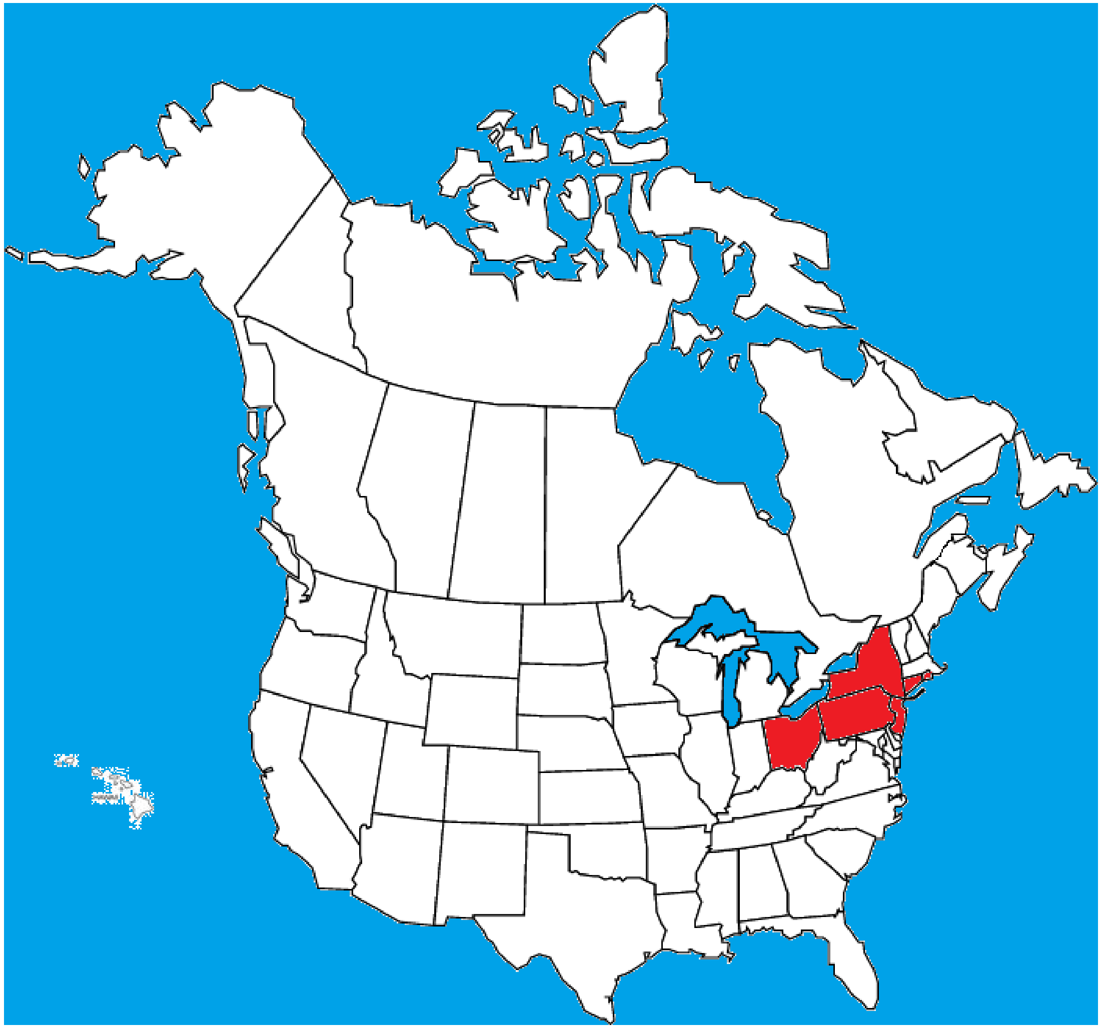
Interest in *Ae. japonicus* elevated after North American introduction

- Only 12 scientific papers mentioned *Ae. japonicus* from it's native range in Asia and in only 4 of those was *Ae. japonicus* the focus of the research.
  - Was not seen as an important species – low populations and did not seem to bite humans much
- But no guarantee that would be the case in its expanded range
- Areas of interest
  1. How far would it spread
  2. Could it be a bridge vector for endemic mosquito-borne viruses?
  3. How would it interact with local mosquito species . Would it outcompete local species, which could change the dynamic of existing diseases?
  4. Would it be a major nuisance pest similar to the Asian Tiger Mosquito?
  5. Would it be capable of transmitting diseases that might be introduced to North America in the future?

Early Expansion - 1999



- Detections in Ohio, Pennsylvania and Rhode Island (5 total states)

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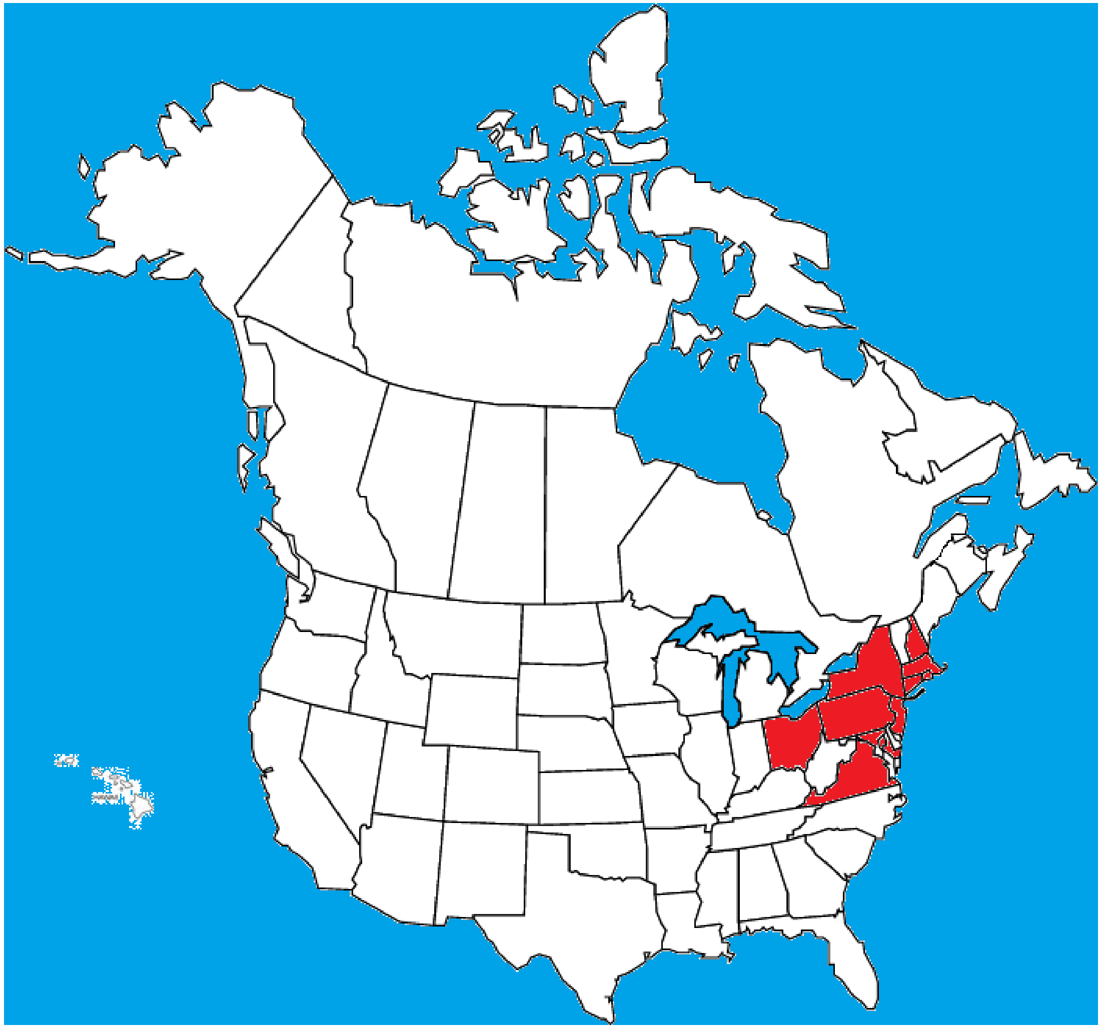
Early Expansion - 2000



- New Hampshire, Massachusetts, Delaware, Maryland and Virginia added

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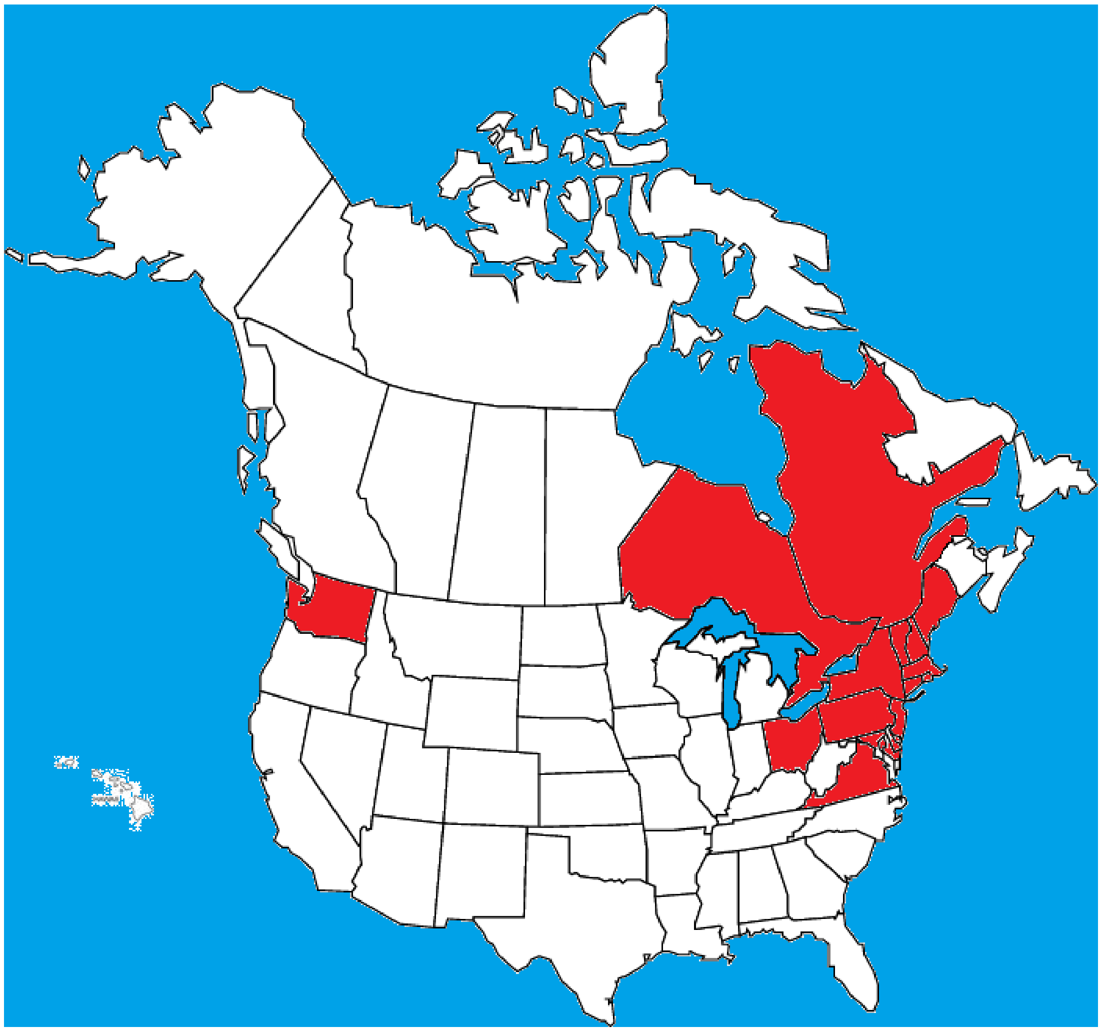
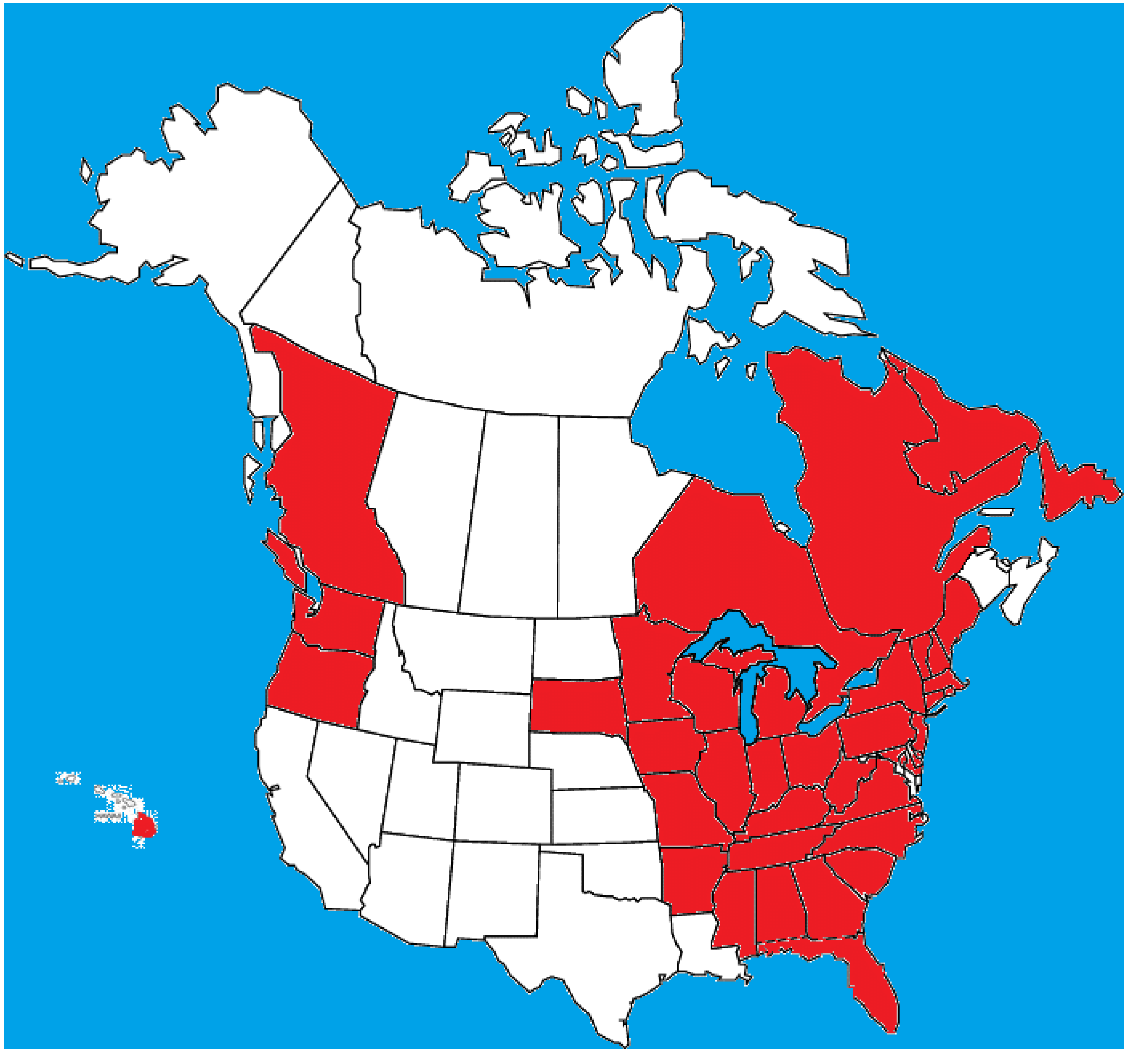
Early Expansion - 2001



- Detections in Vermont, Ontario, Quebec and Washington

- Monroe County historical samples
- PSU treehole study

2017 North American Distribution



- By 2017, 34 states, DC, and 4 Canadian provinces with established populations

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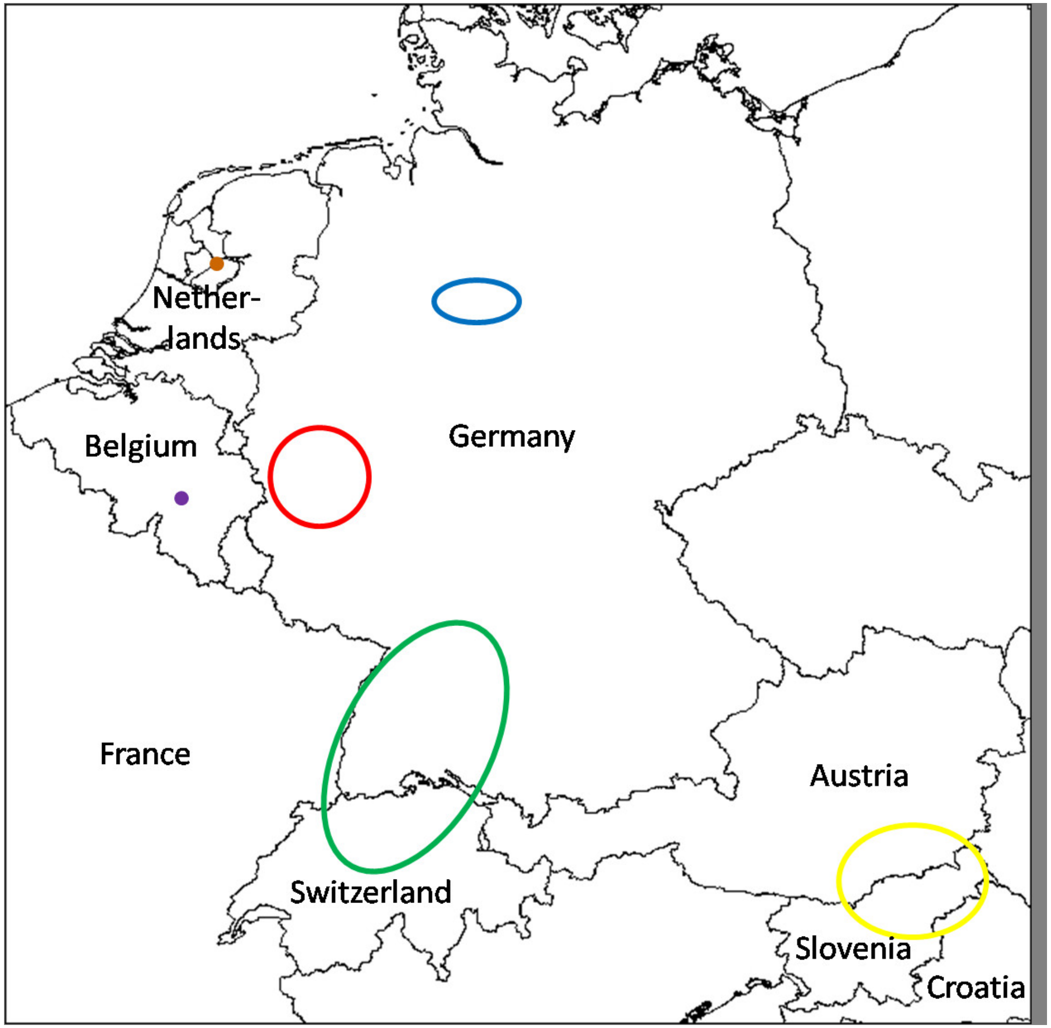
Simultaneous invasions in Europe



- Since an early detection in France in 2000 that did not establish, *Ae. j. japonicus* has invaded at least 7 European countries, including a subsequent French invasion

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Vector potential criteria

- Important factors that determine a species ability to vector diseases:
    1. Relative abundance
    2. Vector Competence
    3. Host/Vector contact rate
    4. Many other factors (temperature, length of gonotrophic cycle, etc.)

Relative abundance and changing species dynamics in containers

- *Ae. japonicus* introduction presented a unique opportunity to study invasion dynamics and interspecific competition within artificial containers among native and introduced container species, in rock pools with *Ae. atropalpus* and in tree holes with *Ae. triseriatus.*
- At least 14 such studies have been performed in the U.S. – summarized here:
  - Competition with *Ae. atropalpus*
    - *Ae. atropalpus* is primarily a rock pool mosquito that will inhabit tires and is the ecological equivalent of *Ae. j. japonicus*, which is a rock pool mosquito in Asia.
    - 6 studies demonstrate a reduction in *Ae. atropalpus* following *Ae. japonicus* introduction
    - 2 studies showed a similar reduction in tire habitats
    - 2 lab studies suggested they were similar competitors
    - *Ae. atropalpus* is autogenous, which is likely disadvantageous in interspecific competition

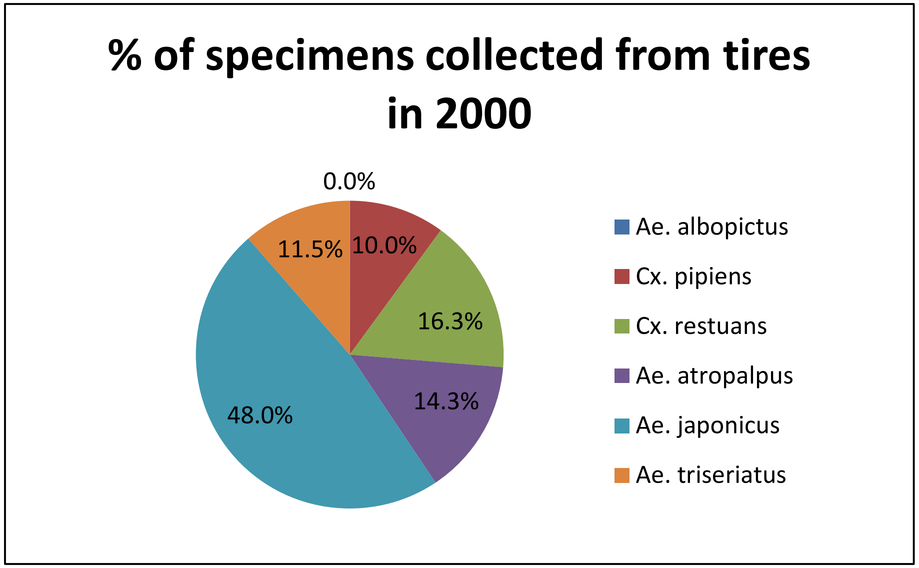
Relative abundance and changing species dynamics in containers

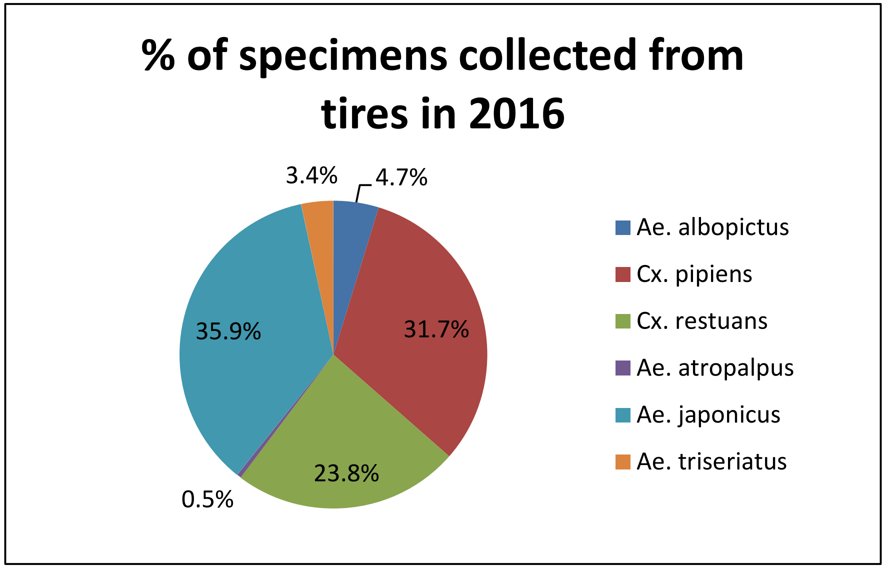
- Competition with *Ae. triseriatus*
  - 5 studies show that *Ae. japonicus* is performing better in tires
  - While 3 studies show *Ae. triseriatus* is doing well in tree holes
  - 2 lab studies showed no real evidence of a competitive advantage for either

- Competition with *Ae. albopictus*
  - Interesting dynamic because *Ae. albopictus* is a southern introduction that expanded northward, while *Ae. japoncus* is a northern introduction expanding southward. In general, *Ae. albopictus* is a superior competitor in most cases with most co-habiting container species.

- Competition with *Culex*
  - 2 studies found a reduction in *Cx. restuans*
  - 1 study found no effect on *Culex* populations

Relative abundance of tire-inhabiting species in 2000 and 2016 from PA





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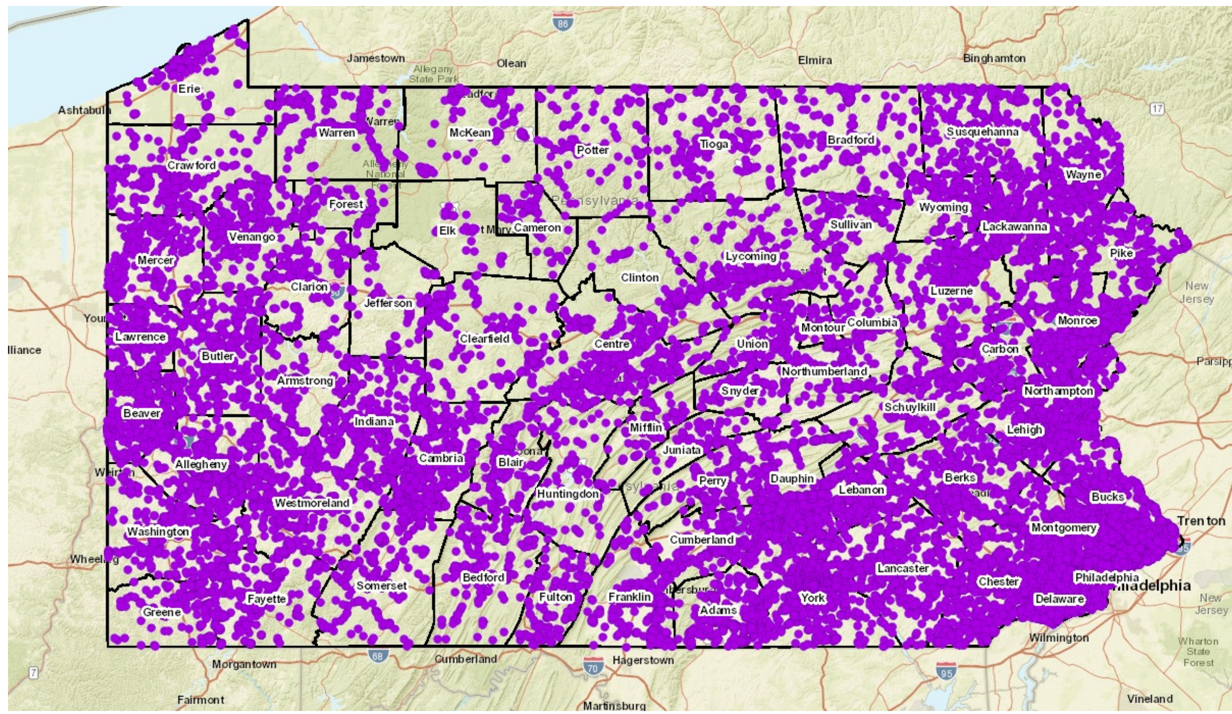
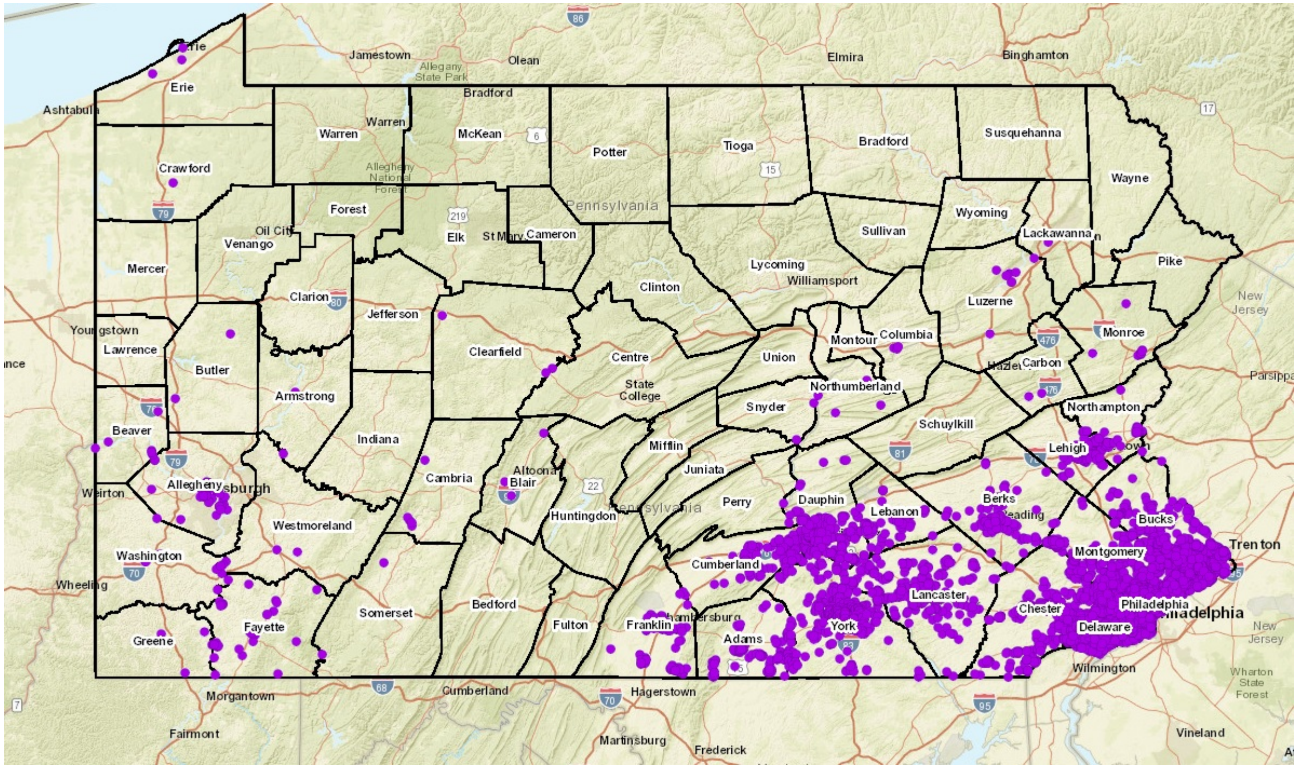
Pennsylvania Collection Records 2000-2017

- 416,639 Adults collected
- 336,053 Larvae collected



Pennsylvania Collection Records for *Aedes albopictus*, for comparison, 2001-2016



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Vector Competence

Getah Virus

- Mostly mild virus affecting horses, mostly from Asia
- Also suspected to pathogenic to pigs
- *Ae. japonicus* is susceptible to this virus in the lab (Takashima 1985) and is thought to be a possible vector to horses and wildlife in Asia

Saint Louis Encephalitis Virus

- *Ae. japonicus* is a competent vector of this virus (Sardelis et al. 2003)
- No reported detections from field-collected specimens
- In PA, we have tested 2,249 *Ae. japonicus* specimens since 2001 – all negative

Japanese B Encephalitis Virus

- In it’s native range, *Ae. japonicus* has been implicated as a minor vector of Japanese B encephalitis virus in humans. The primary vector is *Cx. tritaeniorhynchus*.
- *Ae. japonicus* is capable of transmitting this virus vertically and horizontally
  - (Takashima and Rosen 1989)
- Japanese encephalitis causes over 50,000 human illnesses/year and is maintained in pigs and wading birds

Rift Valley Virus

- Some believe this could pose a significant threat to North America if introduced.
- Unusual for an arbovirus in that it can be transmitted by at least 40 mosquito species
- Worse than West Nile in that most people infected will show flu-like symptoms
- Threat to agriculture is significant, with almost 100% spontaneous abortions and a high rate of death among young animals
- *Ae. japonicus* are highly efficient laboratory vectors with infection rates and dissemination rates as high as 90% and 84%, respectively, and a demonstrated ability to transmit by bite once disseminated (Turell et al. 2013)

West Nile

- Positive pools have been detected in at least 9 states (CDC 2009)
- Infection rates are moderately high in PA with a 16 year average MIR of 1.49 from over 100k specimens tested, which is below the avian-feeding *Culex*, but higher than most other species tested.
- Neighboring NJ often sees MIR’s in a similar range (Reed, 2016)
- *Ae. japonicus* are highly susceptible to West Nile in the laboratory (Turell et al. 2001)

Eastern Equine Encephalitis Virus

- Competent laboratory vector as well as transovarial transmission (Sardelis et al. 2002)
- PA has tested 906 specimens – all negative
- No detections from field collected specimens anywhere

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La Crosse encephalitis virus

- Has been detected from field collected *Ae japonicus*, including from a specimen reared from an egg, suggesting both horizontal and vertical transmission in the field
- Sardelis et al. (2002) demonstrated that *Ae. japonicus* can transmit La Crosse in the laboratory
- In PA, we have tested 26,030 specimens since 2001 – all negative

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Host-feeding preferences

- No data available from native range except one laboratory report indicating *Ae. japonicus* would feed on mice and chicks, but not on reptiles or amphibians
- Another researcher noted this species was never collected in human landing counts
- In North America, 5 studies have reported on host-feeding preferences from a total of 110 wild-caught, blooded, female specimens with the following results:
  - White-tailed deer: 75
  - Human: 28
  - Fallow deer : 2
  - Horse: 2
  - Chipmunk: 1
  - Domestic cat: 1
  - Opossum: 1
- Recent research from the PA DEP and the CT Agricultural Experiment Station show similar results from another 101 specimens analyzed (manuscript in preparation)
- Interestingly, there has not been a single avian host identified to date in NA, although avian feeding was detected in a study from Switzerland (Schonenberger, et al. 2016)

Conclusions

- *Aedes japonicus* has been an extraordinarily successful invader. It's cold-hardiness is likely largely responsible for gaining a competitive advantage. It is often the earliest to hatch in the spring and gets a head start on other container species. It is also persistent into the fall, which may enable more generations than its competitors.
- For the more common North American arboviruses of public health concern, it has shown vector competency for WNV, LAC, EEE, SLE.
- It's actual status as a vector is still somewhat unknown, but it meets many of the criteria for being a good vector, so it should not be ignored. It has demonstrated vector competency for multiple viruses, it is abundant, it is peridomestic and feeds on humans
- It's lack of avian feeding and apparent preference for large mammals likely suppresses it's importance as a vector of SLE, WNV, EEE and LAC.
- It's propensity for feeding on deer and medium-sized mammals may allow this species to be a transmitter of Jamestown Canyon, Cache Valley, Trivittatus, Potosi and/or Keystone viruses where their ranges overlap.

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Thank you!
Questions/Comments?