

Mosquito Associated Microbes and Implications in Mosquito Control

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**Tribal Vector-Borne Disease Prevention & Control Workshop,
Albuquerque NM, June 28-29, 2018**



Mosquito Species

- Over 3,500 species of mosquitoes in the world,
- At least 176 of them are found in the United States.
- The most common, and most dangerous, are some species in the genera.
 - *Culex*,
 - *Anopheles*
 - *Aedes*



Culex



Anopheles



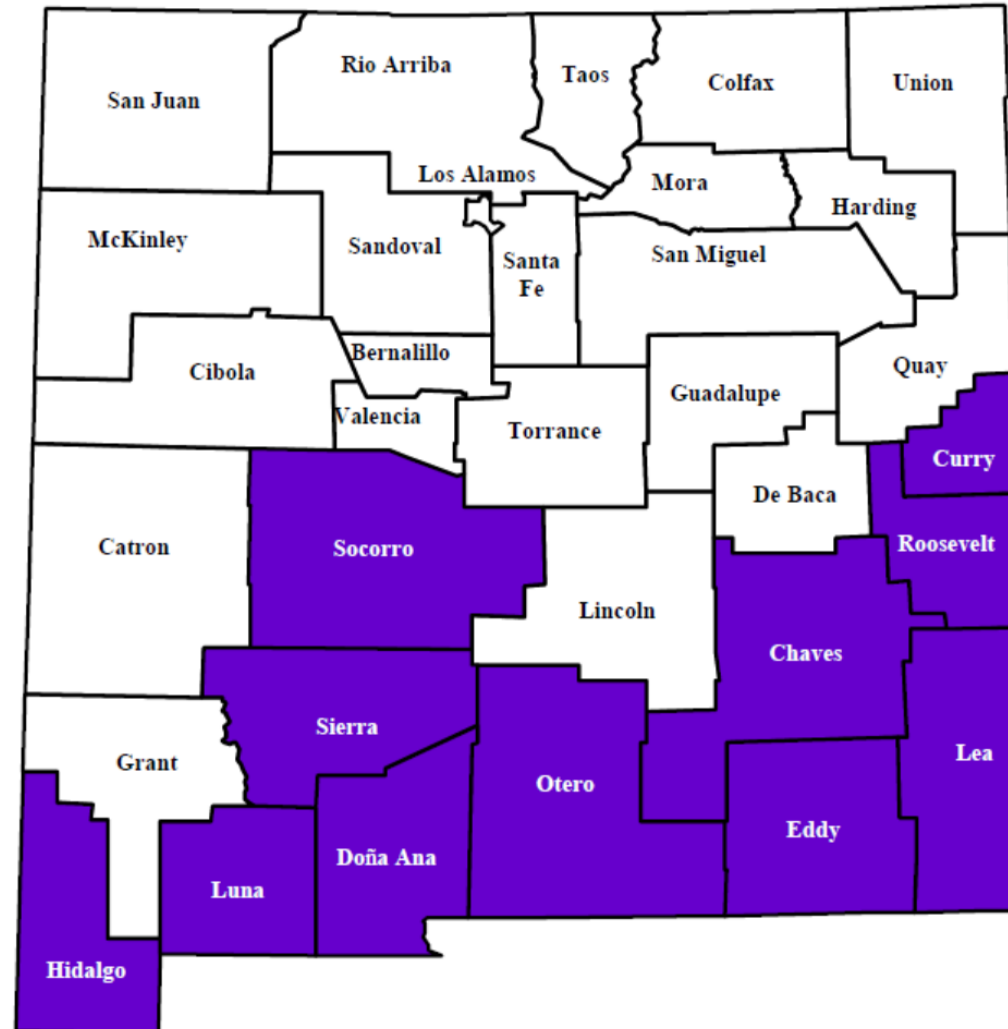
Aedes

Aedes aegypti and *Aedes albopictus*

Map in New Mexico



Dr. Kathryn Hanley
Dr. Michaela Buenemann
Dr. Immo Hansen
Dr. John Xu



Aedes aegypti

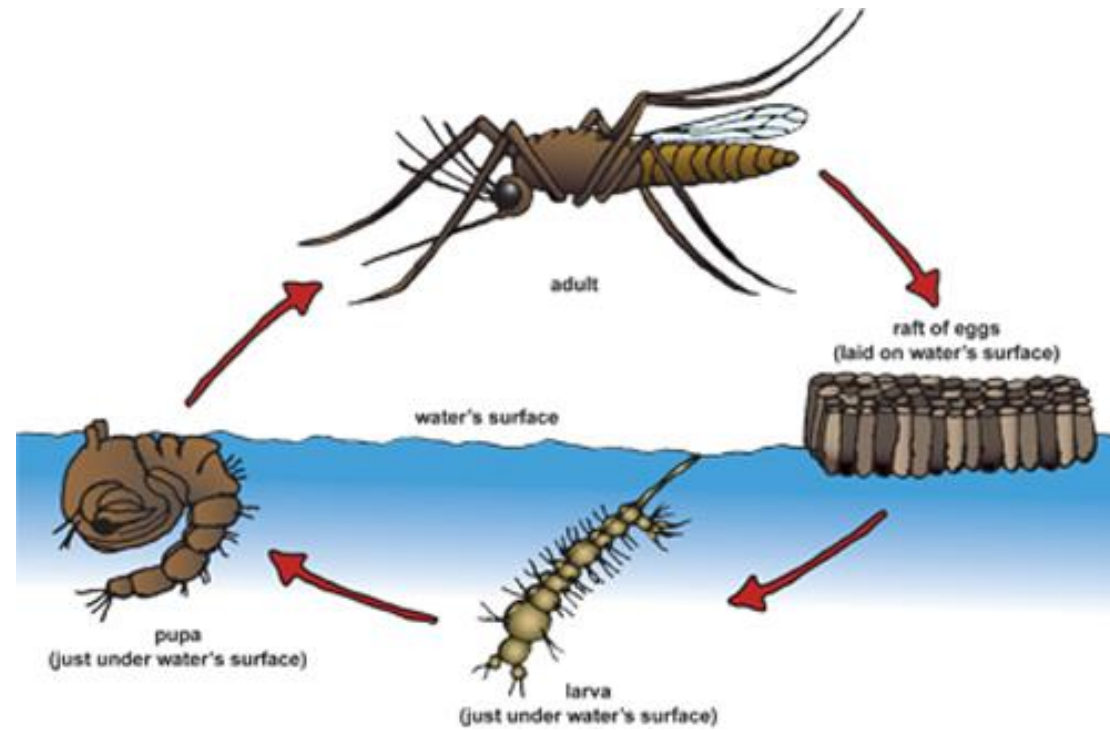


Aedes albopictus



Mosquito life history

Mosquito biting

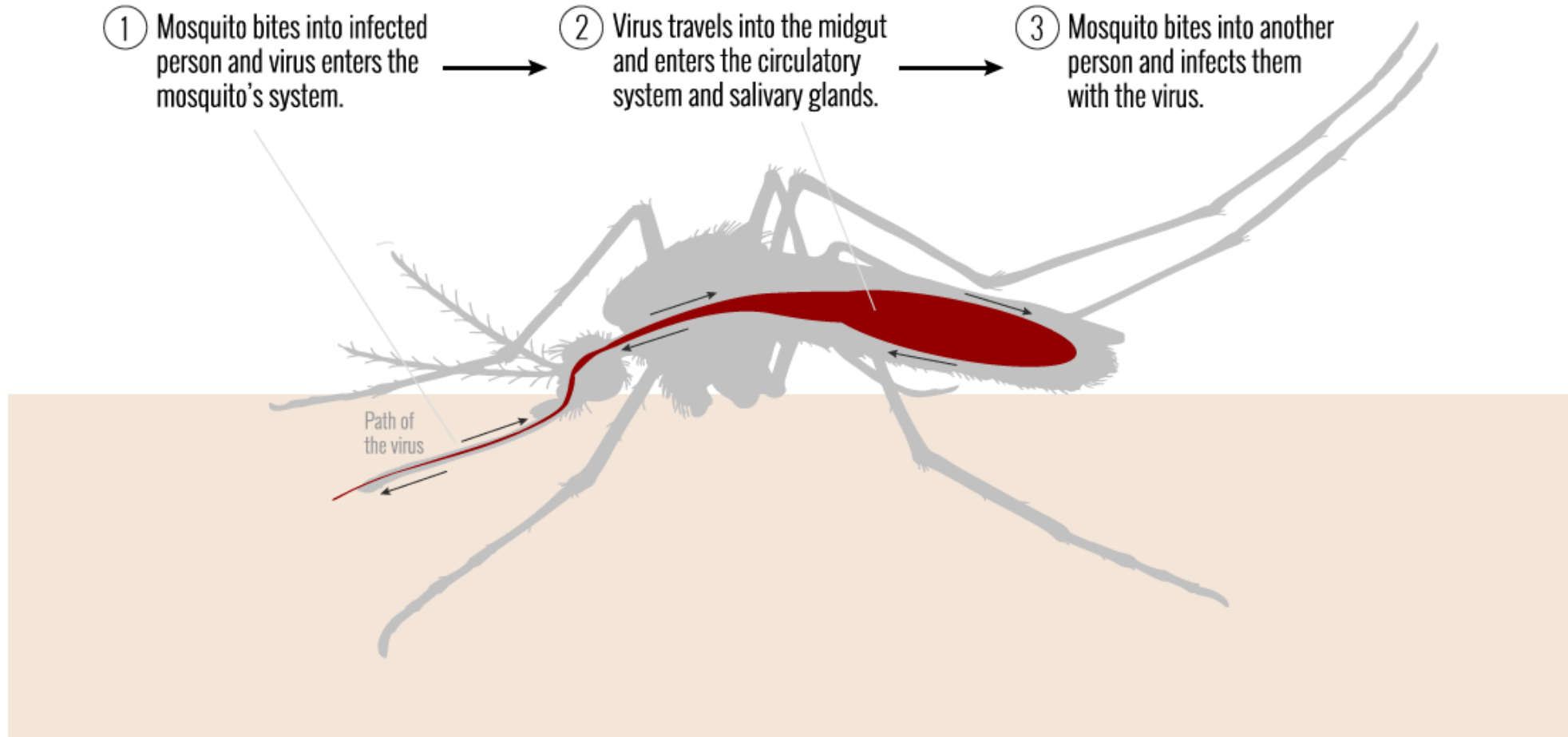


Disease transmission via blood feeding

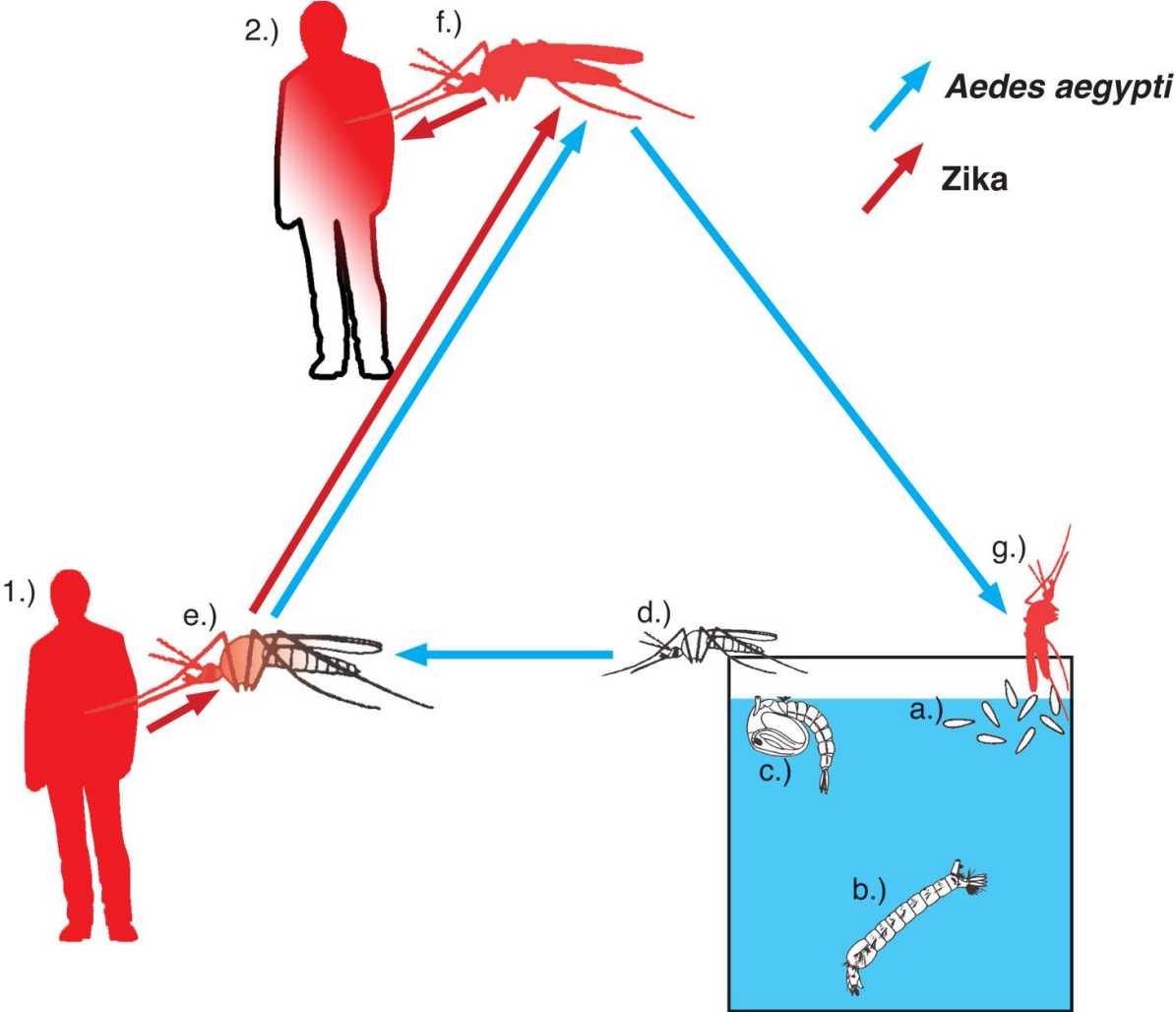
① Mosquito bites into infected person and virus enters the mosquito's system.

② Virus travels into the midgut and enters the circulatory system and salivary glands.

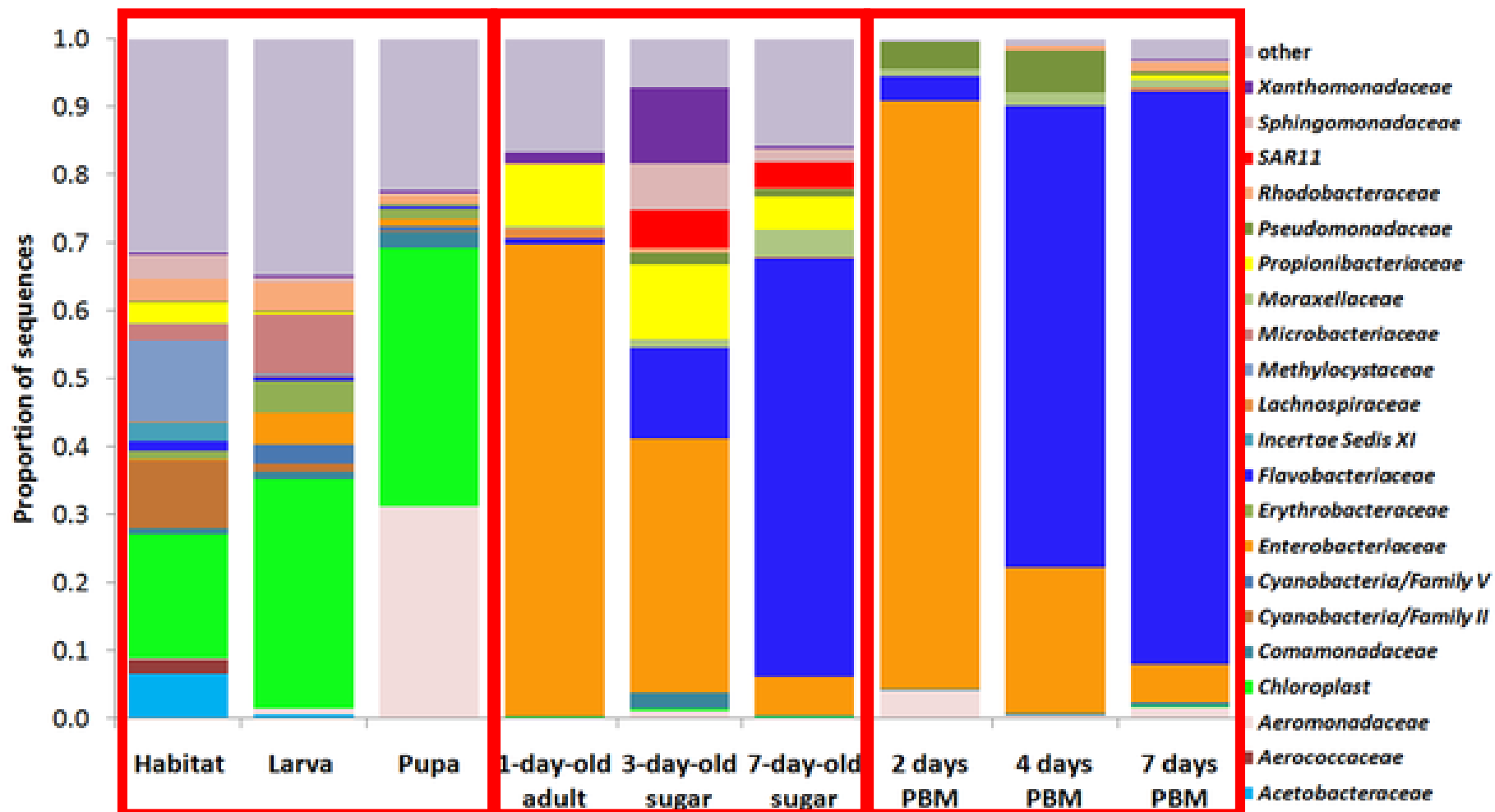
③ Mosquito bites into another person and infects them with the virus.



Disease transmission via blood feeding

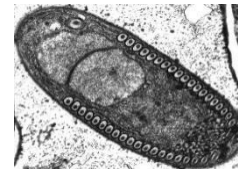
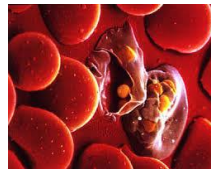
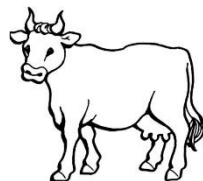


Gut bacterial composition in different life stages of *An. gambiae* in Kenya



Ecological interactions with animals, plants, microbes

Contig ID	Taxon	Size (bp)
Contig 10277	<i>E. anophelis</i> (bacteria)	3960
Contig 194	Human mitochondrial genome	16249
Contig 2941	Cattle mitochondrial genome	16375
Contig 10316	<i>Gluconobacter oxydans</i> (bacteria)	9000
Contig 10506	<i>P. falciparum</i> mitochondria	5946
Contig 90184	Tomato chloroplast genome	19975
Contig 226491	Tomato chloroplast genome	15426
Contig 190653	<i>Datura stramonium</i> (Jimson weed)	10962
Contig 411360	Microsporidia	11852



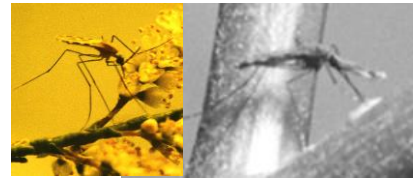
Mosquito ecology and mosquito control



Aquatic
Habitats



Larva
(pupa)



Plants
(nectar, sap)



Adult
Sugar meal



Vertebrates
Birds, humans



Adult
Blood meal

Larvicides
***Bti* toxins**
Cyanobacteria

**Attractive toxic
sugar bait (ATSB)**

**Blood sources,
Pathogens**

Symbiotic bacteria
Nutrients, priming basal immunity,
paratransgenesis for mosquito control

Keteoglu and Bouwer Parasites & Vectors 2012, 5:220
http://www.parasitesandvectors.com/content/5/1/220



SHORT REPORT

Open Access

The susceptibility of five African *Anopheles* species to *Anabaena* PCC 7120 expressing *Bacillus thuringiensis* subsp. *israelensis* mosquitocidal cry genes

Irene Keteoglu and Gustav Bouwer*

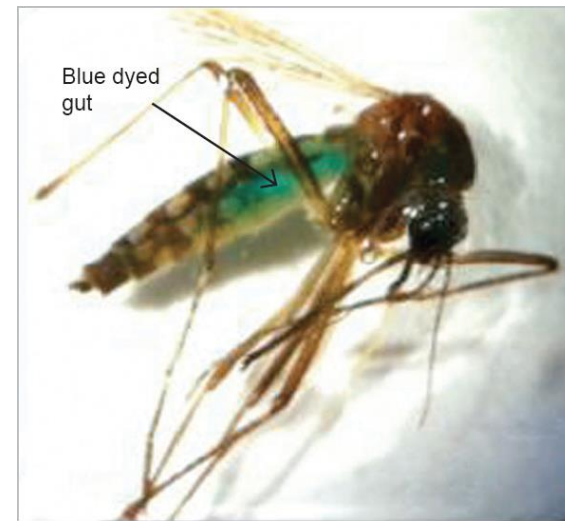
Microbes and larvae control

- The presence of microbes in the gut is essential for mosquito development
 - No microbes, no growth
 - Microbes lower O₂ level in the gut, which triggers larval molting to grow
- Larvicidal bacterial toxins from *Bacillus thuringiensis* (Bti)
 - cyanobacterium *Anabaena* PCC7120

Adult control: Attractive toxic sugar baits

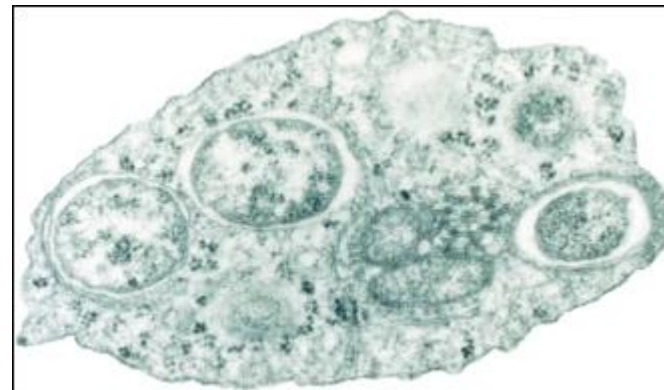
- ATSB

- Adult mosquitoes, both males and females, live on sugar daily.
- Only females take blood meal 3-5 times entire life
- Attractive sugar bait traps
 - Attractants: plant flower scent, microbial scent?
 - Toxin: Boric acid



Bacteria endosymbionts: *Wolbachia* infection

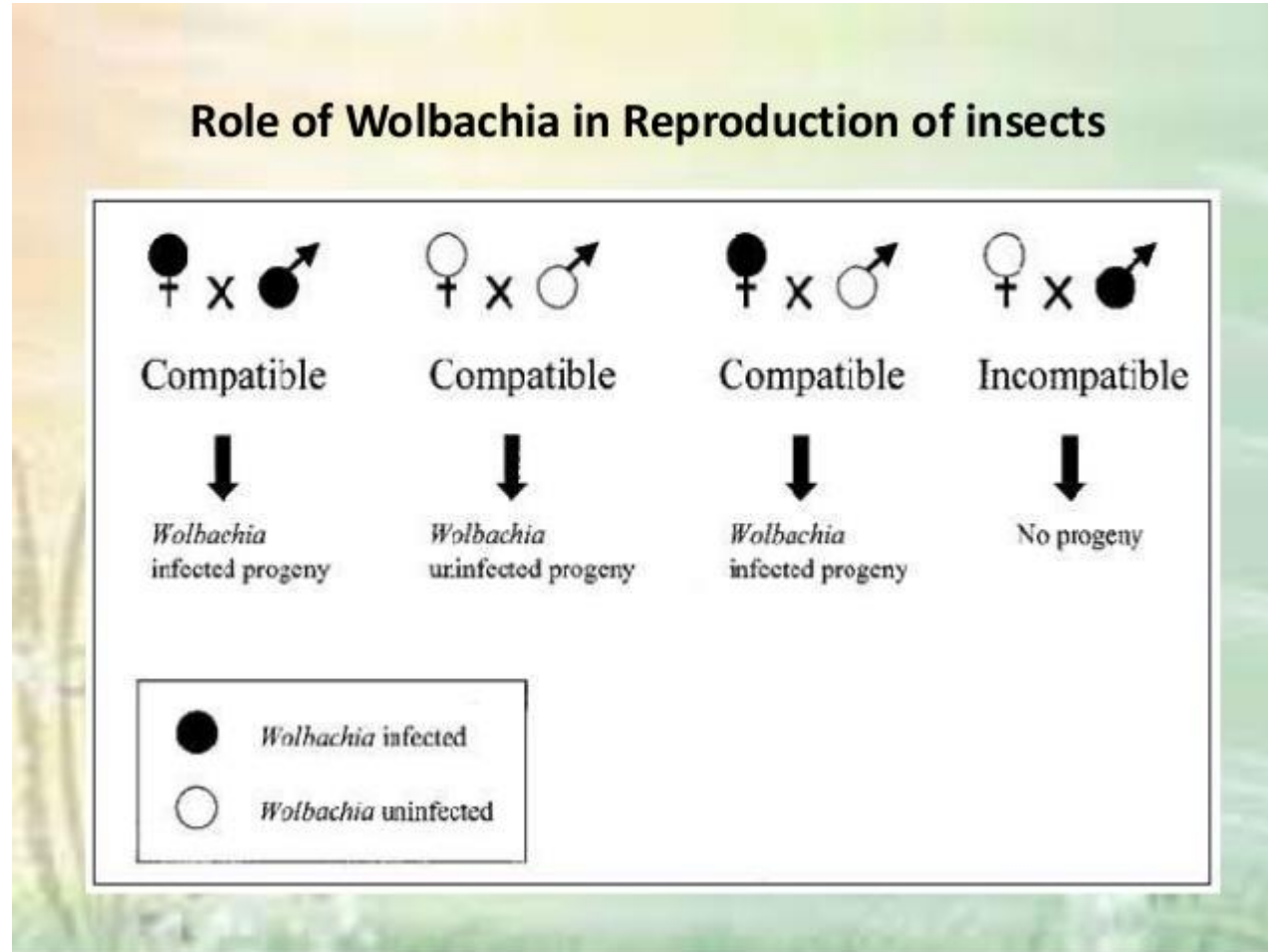
- *Wolbachia* is one of the most common intracellular bacteria in insects
- *Wolbachia* induces cytoplasmic incompatibility (CI), a type of conditional sterility between hosts harboring incompatible infection types.



Cytoplasmic incompatibility (CI)
a natural mechanism for pest and vector sterility

- Sperm from *Wolbachia*-**infected** males is **incompatible** with eggs from females that **do not harbor** the same *Wolbachia* strain(s).

Fighting mosquito with *Wolbachia*



Releasing *Wolbachia* infected males to induce Cytoplasmic Incompatibility

	♂	♂
♀	○	⊗
♀	○	⊗

- No infection
- Natural infection
- Artificial infection

Two main strategies of using *Wolbachia* for mosquito vector control

- Exploit cytoplasmic incompatibility as natural source of sterility
- *Wolbachia* infections help mosquito fight against viruses, therefore reduce dengue and Zika transmission

Fighting mosquito with *Wolbachia*

- Releasing one million sterile, non-biting male mosquitoes every week for 20 weeks. They aren't genetically modified in any way. Instead, they're infested with *Wolbachia*, a bacterium that is “naturally found in at least 40 percent of all insect species.

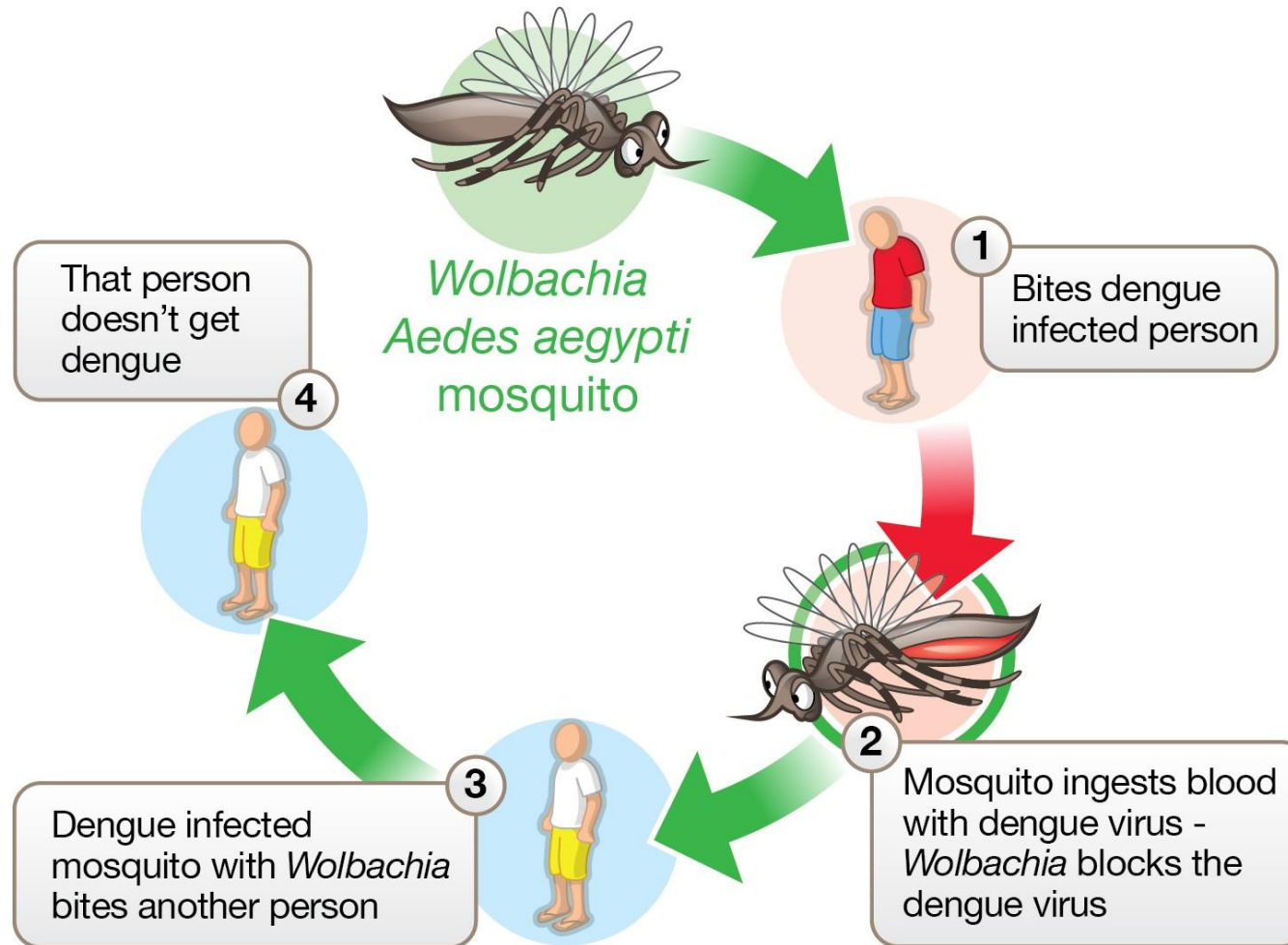
[Debug project](#)

[Debug Fresno demo](#)

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Wolbachia infection reduces viral transmission in *Aedes aegypti*



RESEARCH ARTICLE

The *Wolbachia* strain *wAu* provides highly efficient virus transmission blocking in *Aedes aegypti*

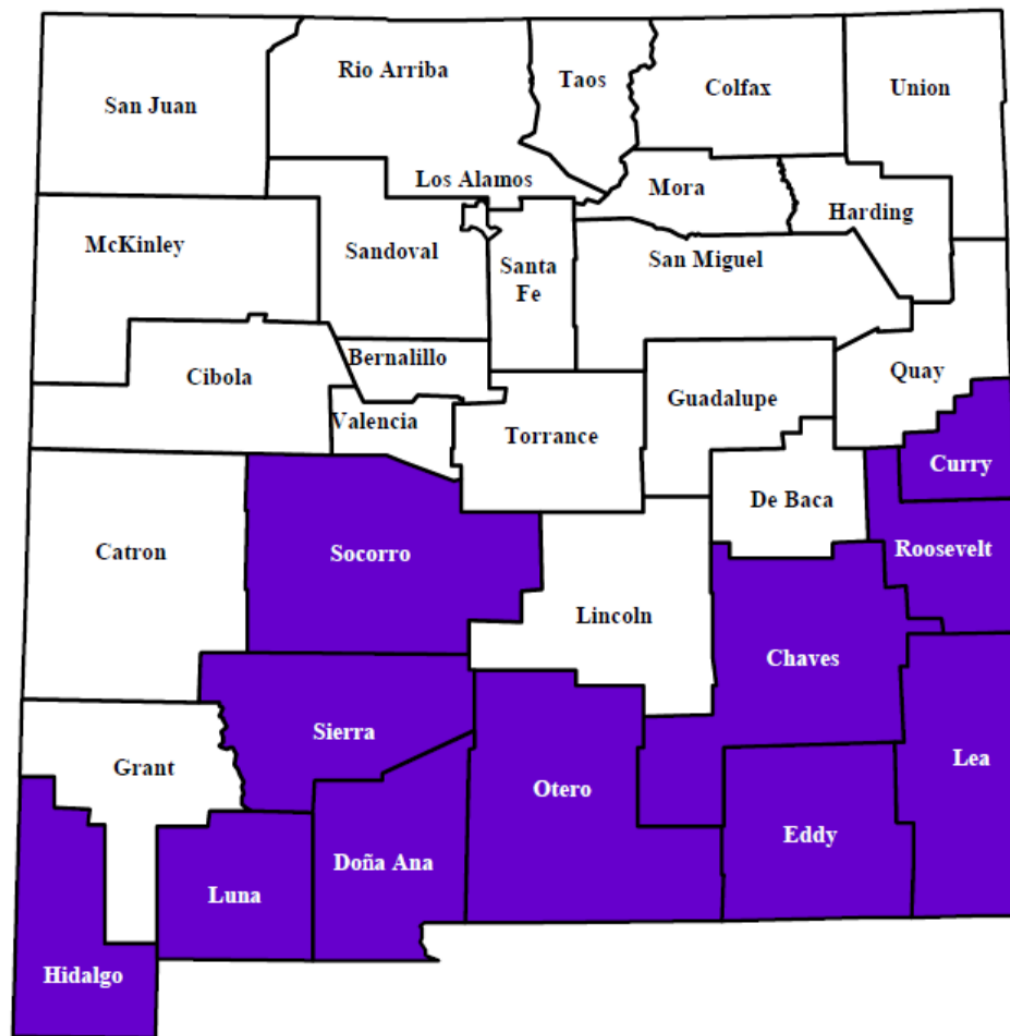
Thomas H. Ant^{1,2}, Christie S. Herd^{1,2}, Vincent Geoghegan^{1,2}, Ary A. Hoffmann³, Steven P. Sinkins^{1,2*}

Aedes aegypti and *Aedes albopictus*

Map in New Mexico



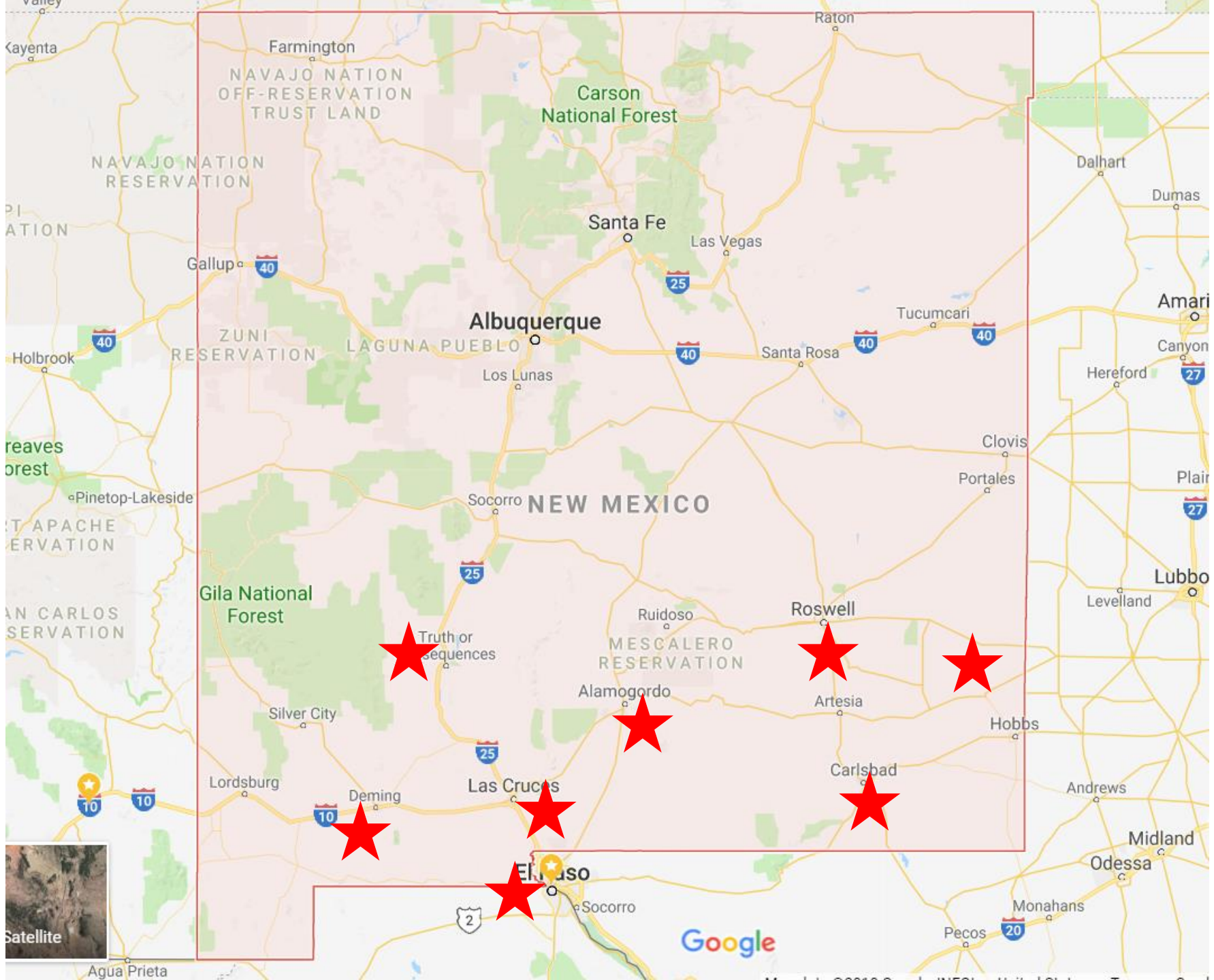
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Aedes aegypti



Aedes albopictus



Wolbachia infection in *Ae. aegypti* populations in New Mexico

Table 1. Prevalence of *Wolbachia* in *Aedes aegypti*

Collection site	positive/assayed (%)
Las Cruces	24/30 (80%)
Sunland Park	2/2 (100%)
Deming	26/29 (89.6%)
Lovington	7/9 (77.7%)
Roswell	8/8 (100%)
T or C	4/5 (80%)
Alamogordo	3/19 (15.7%)
Carlsbad	3/21 (14.2%)
Total	77/123 (62.6%)

Take home message

- Microbes are essential for mosquito development
- Biological larvicides: bacterial toxins
- Adulticidal attractive toxic sugar baits (ATSB)
- *Wolbachia* infection for *Aedes aegypti* control
 - CI reduce population size
 - Block viral transmission

Acknowledgements



SWARM

SouthWest Aedes Research and Mapping



Dr. Kathryn Hanley
Dr. Michaela Buenemann
Dr. Immo Hansen
Dr. John Xu

