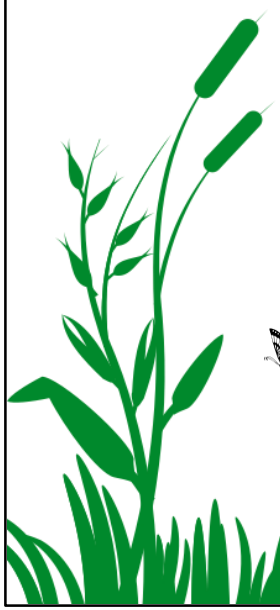
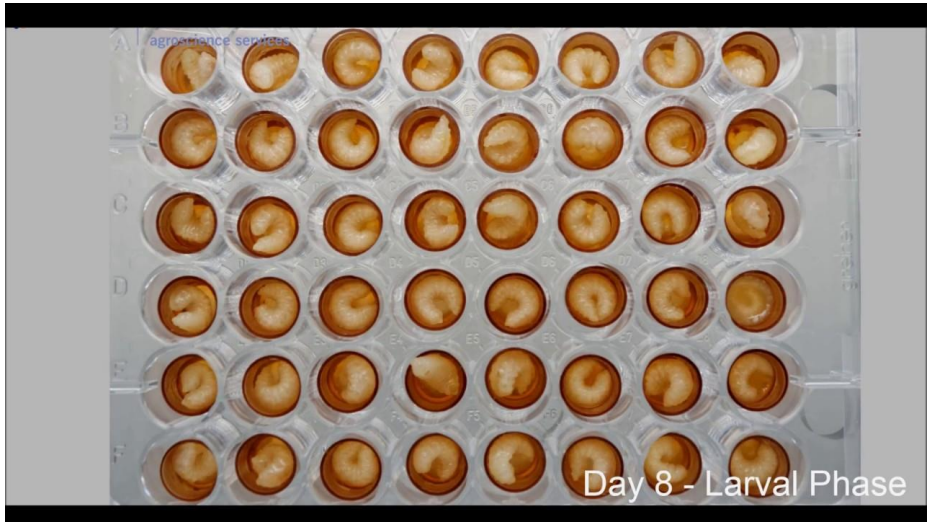
The Buzz on Mosquitoes

Plymouth County Extension

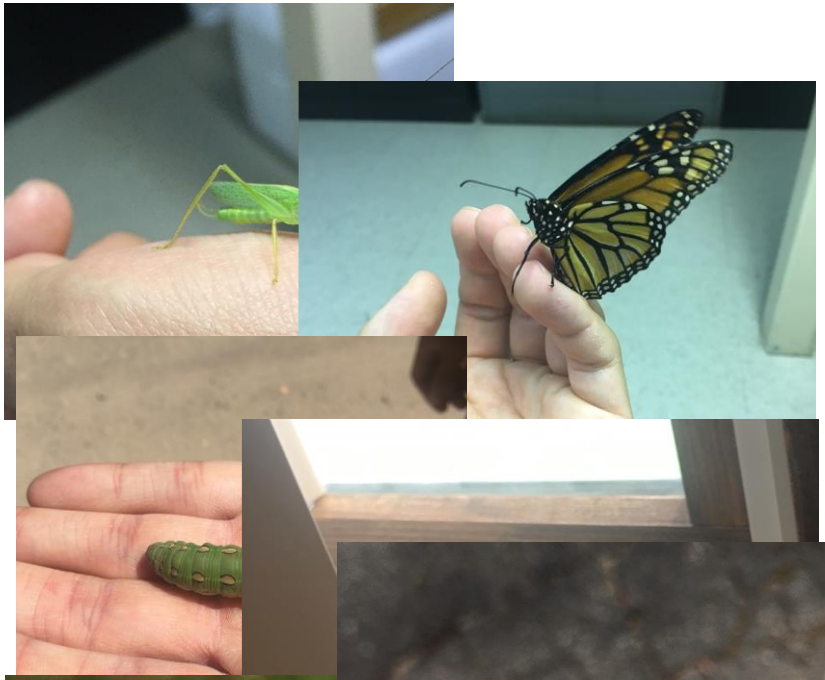


Blake Dinius
Entomologist Educator
bdinius@plymouthcountyma.gov
774-773-3404

Introduction

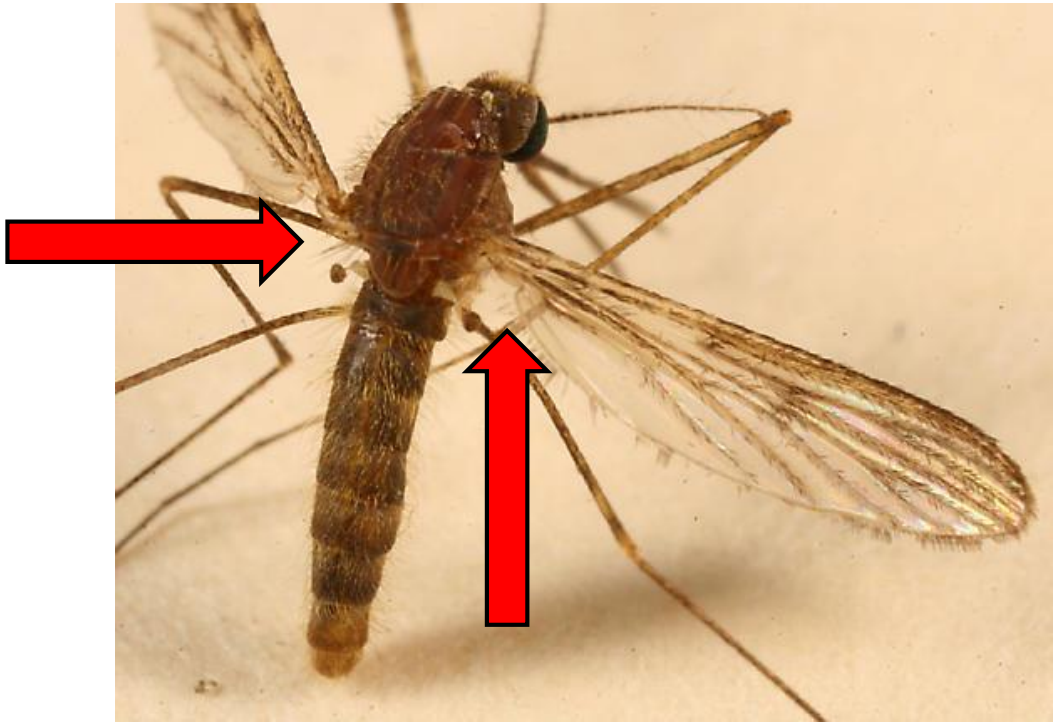


Introduction



What is a mosquito?

- Diptera: Two wings
- Family: Culicidae



- Scaled wings

Richard Migneault

Not mosquitoes

Robber fly

Midge

Crane fly

Mosquitoes are old

- Oldest fossils: ~30-60 mya
- Probably, older than birds and mammals (70-230 mya)

Mosquitoes are diverse

- 3,500 species of mosquitoes worldwide
- 6,495 species of mammals worldwide
- ~51 mosquitoes in MA

Ae. albopictus

Ae. canadensis

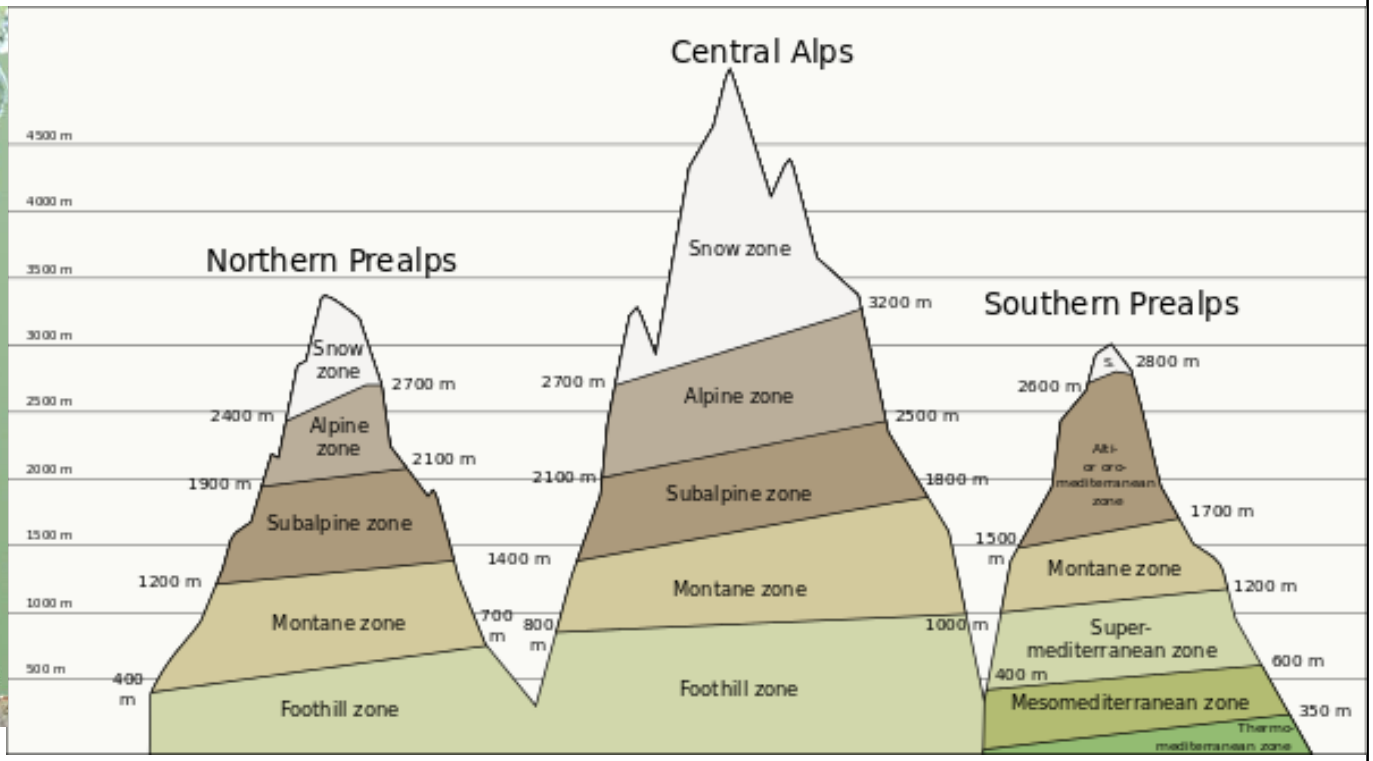
Ps. ferox

An. quadrimaculatus

Anopheles sergenti
Siwa-oasis, Egypt

Shehata, M., Kenawy, M., Said, S., Beier, J., Gwadz, R., and Shaaban, M. (1989). Anopheles sergenti (Theobald) a potential malaria vector in Egypt. Annales de parasitologie humaine et comparée. 64. 72-6.

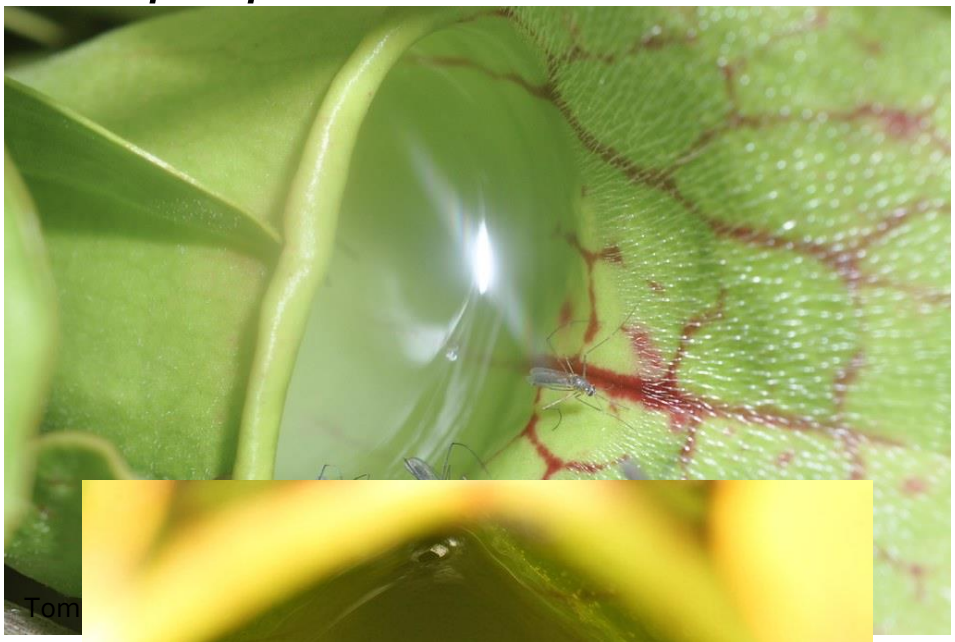
Ochlerotatus pullatus
2300-3400 m



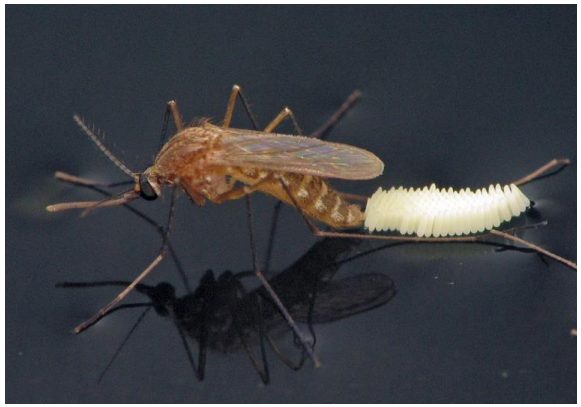
West, David & Black, W. (1998). Breeding structure of three snow pool Aedes mosquito species in northern Colorado. Heredity. 81 (Pt 4). 371-80.

Wyeomyia smithii

Purple pitcher plant (*Sarracenia purpurea*)

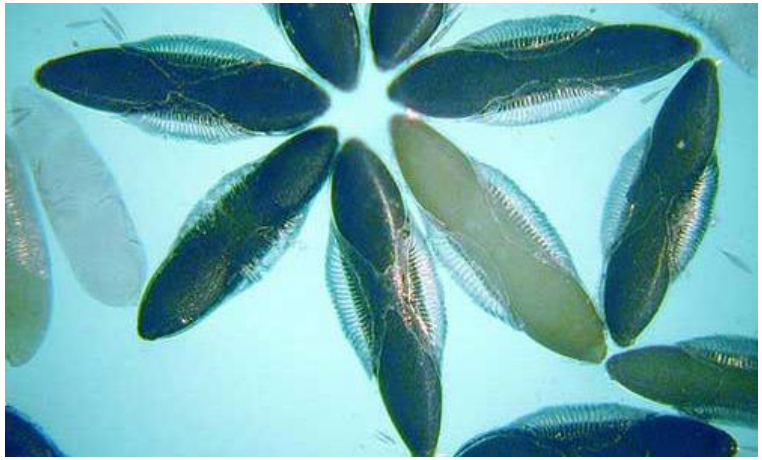


But, they all require water!

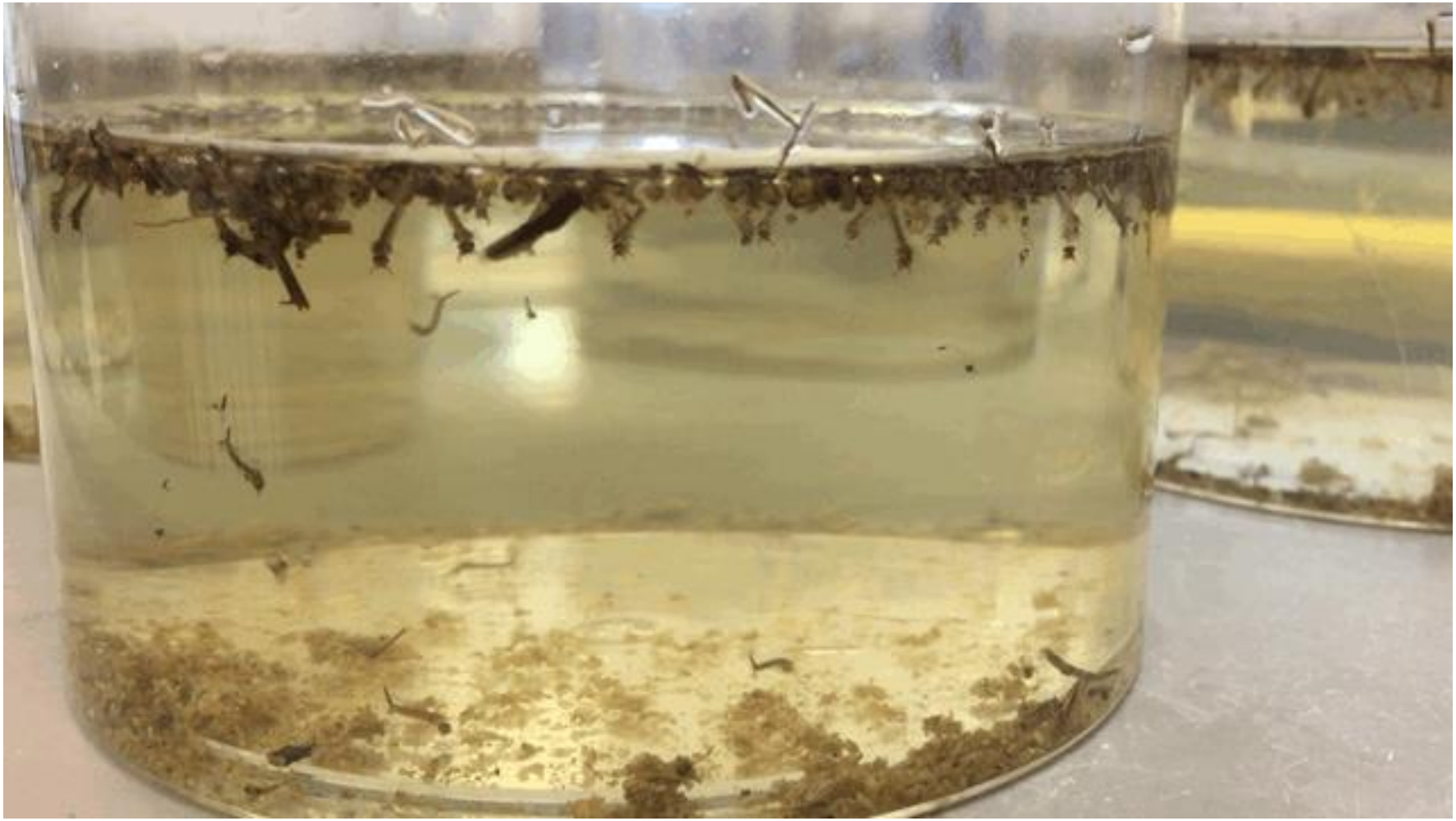


Eggs

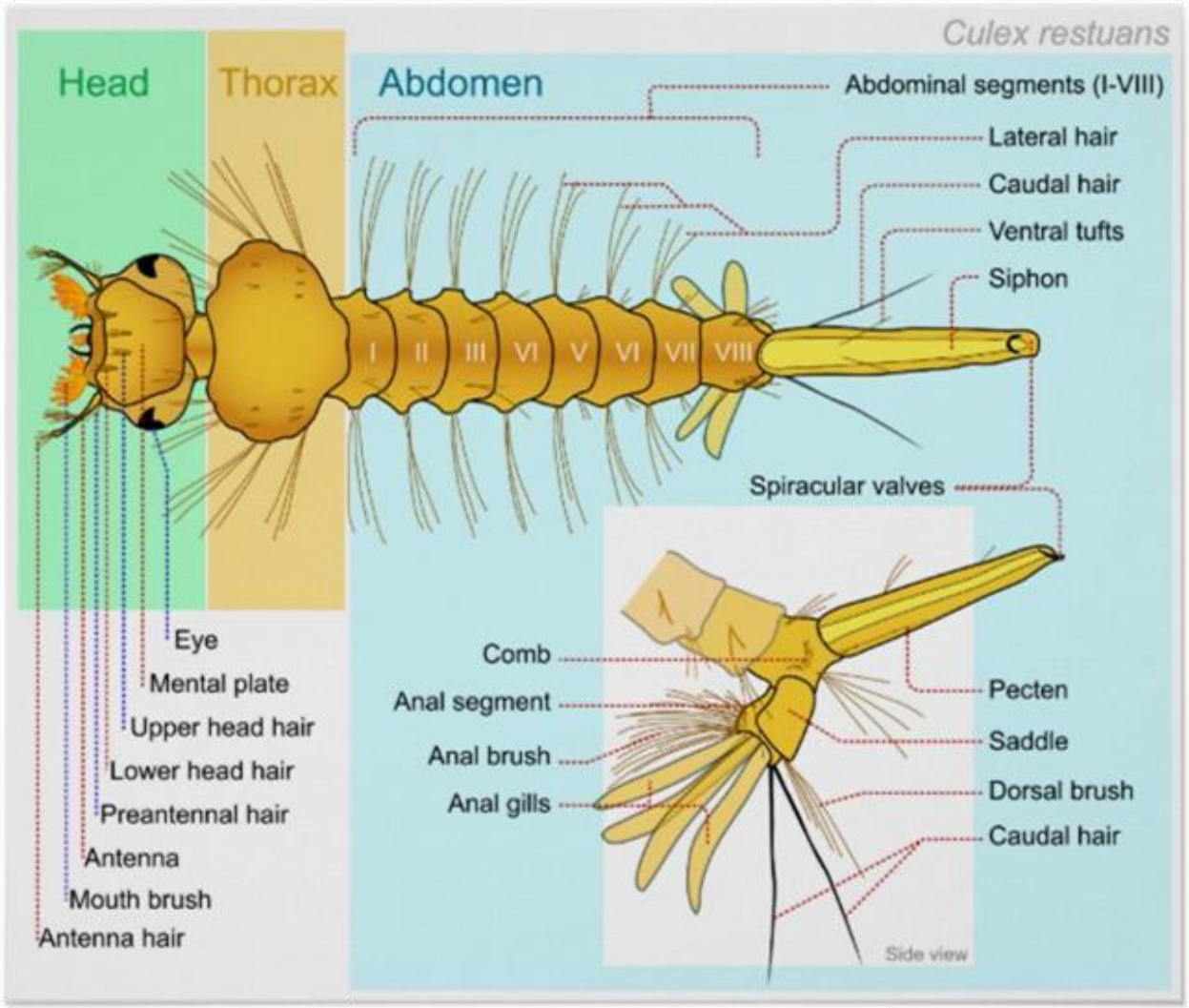
Laid in or near water



Larva
"Wrigglers"
Develop in water

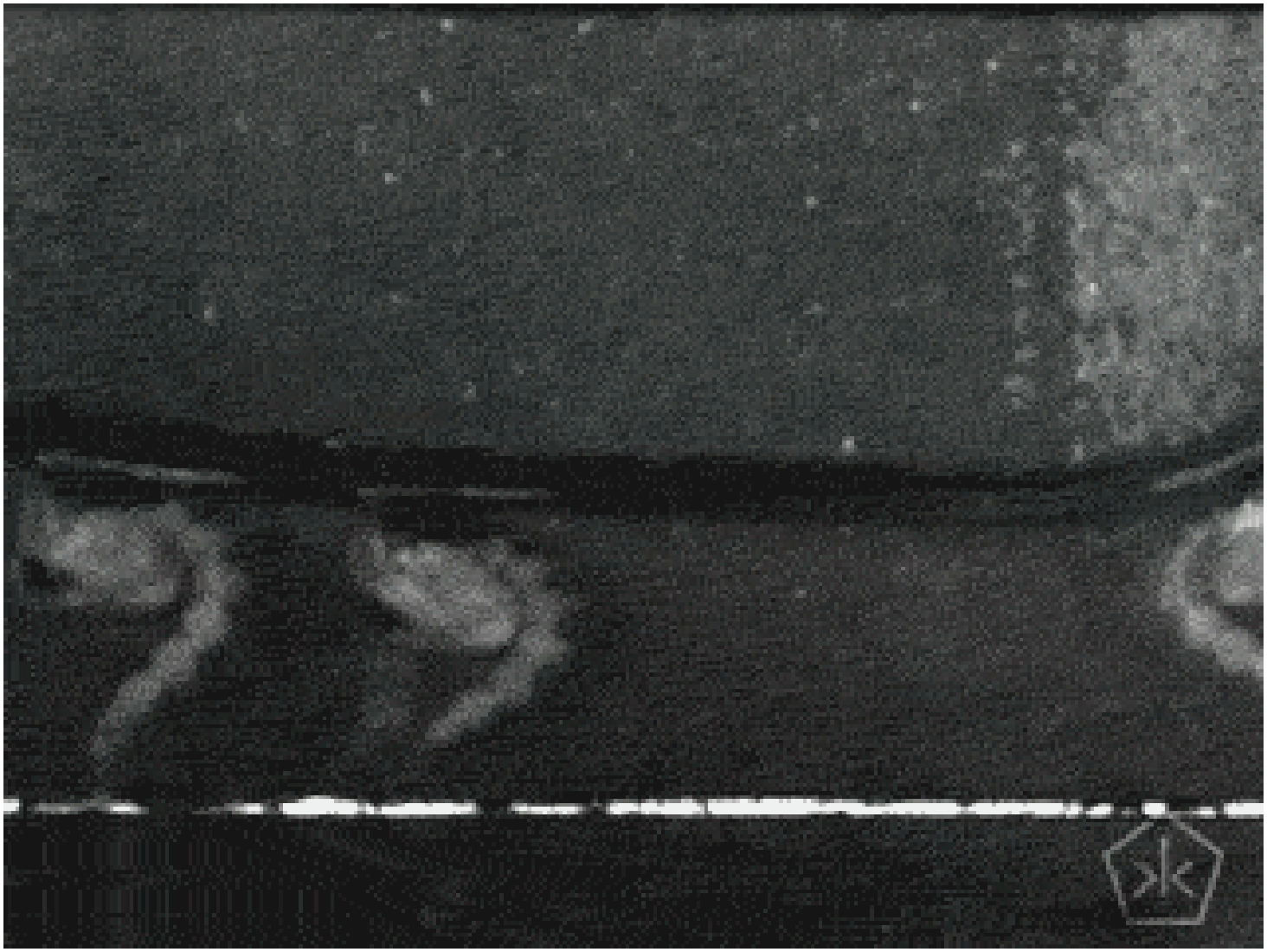


Algae, plankton, fungi, bacteria, and other micro-organisms



Some eat other mosquitoes!

Pupa (active)
"Tumblers"
Also, develop in water



Adult

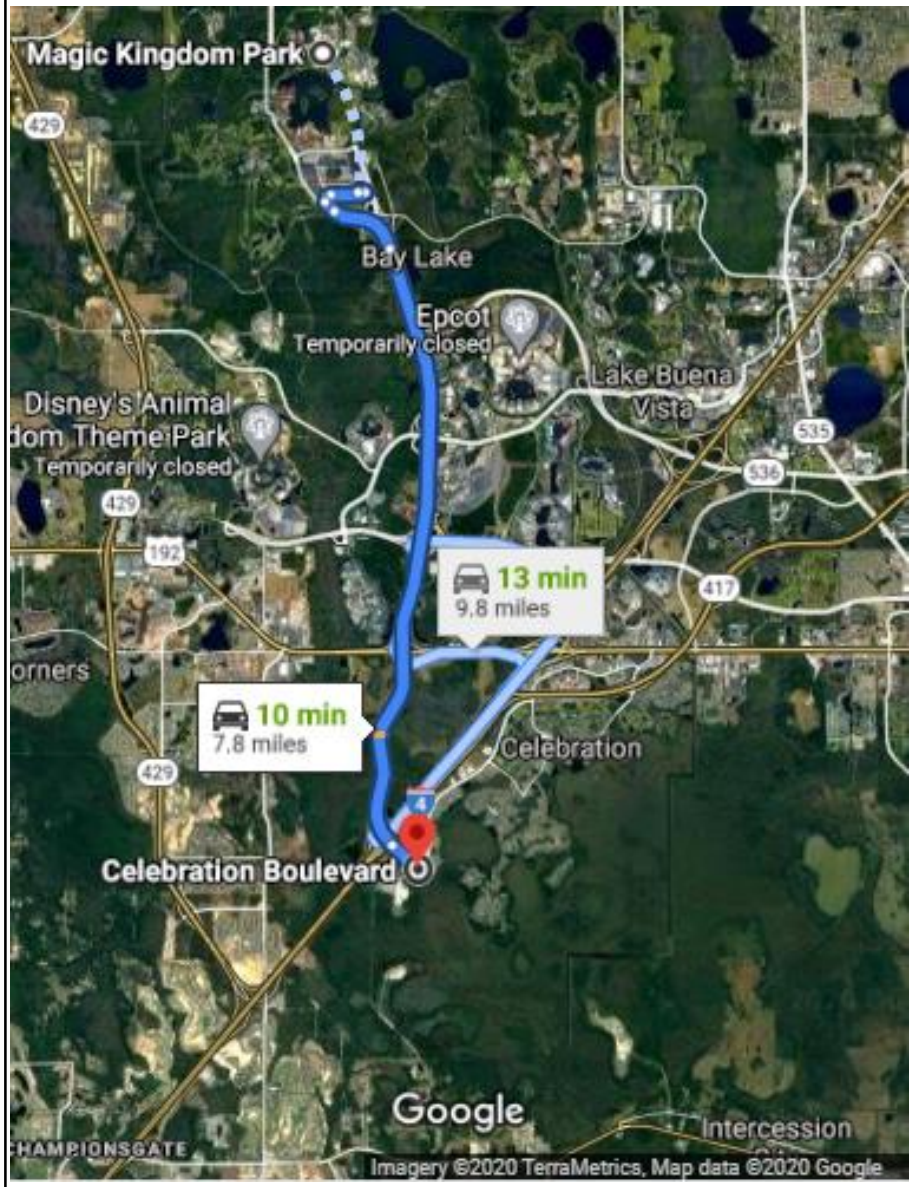
Emerge from water and lay eggs in/near water

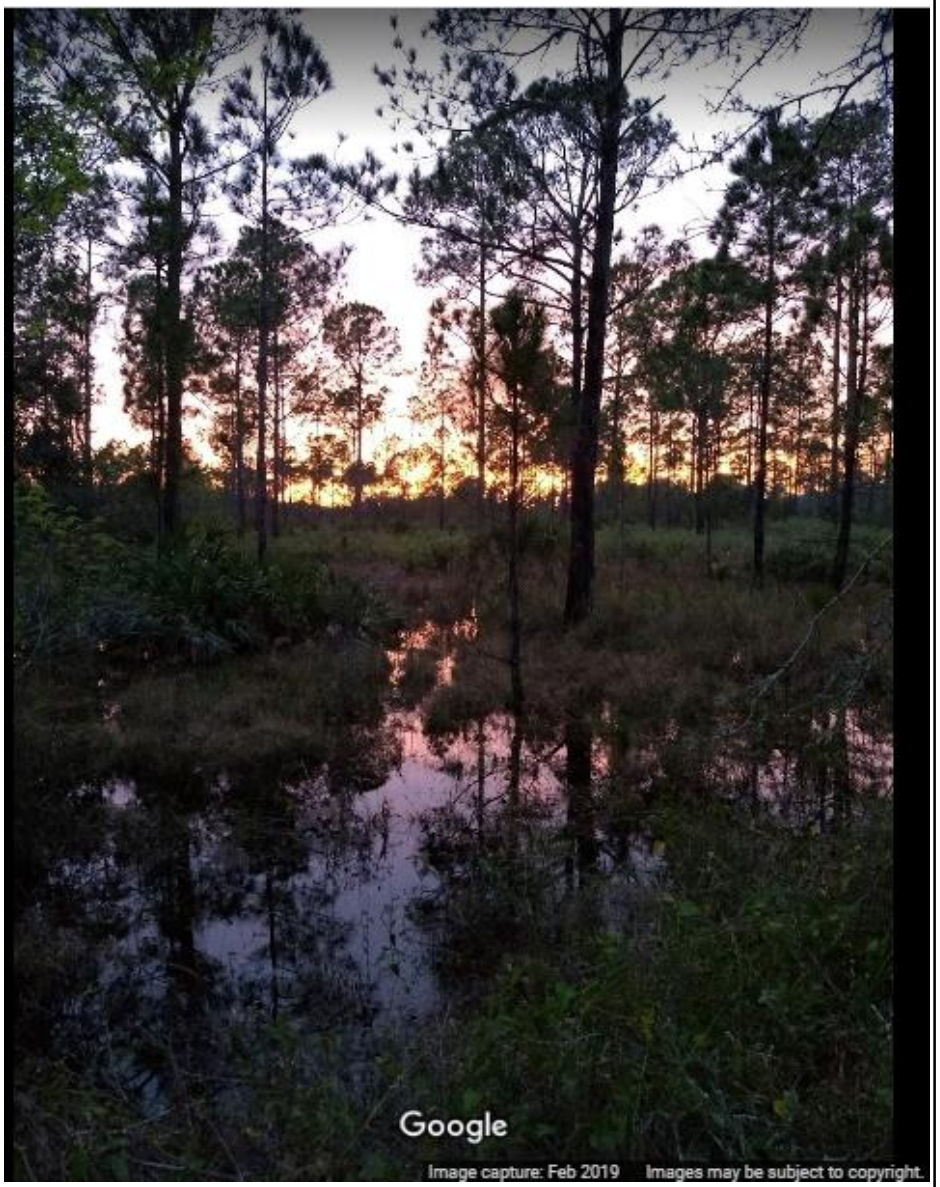
MOSQUITOES DO NOT SIMPLY

LIVE WITHOUT WATER

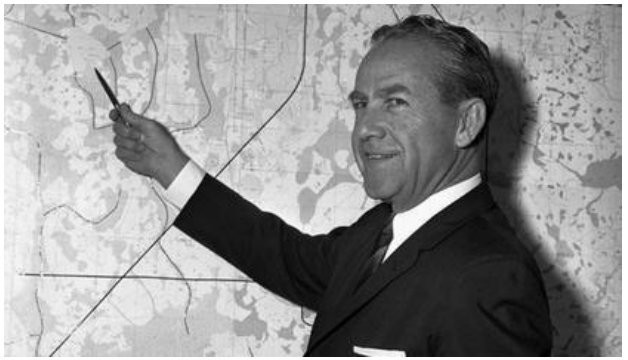
Ever wonder why there are never mosquitoes in Disney?

Basically a swamp





William "Joe" Potter



- Governor of the Panama canal zone
- Engineer
- Knew A LOT about mosquitoes

Food for other animals

- Dragonflies
- Damselflies
- Fish
- Other insects!

Jakob, C. and Poulin, B.. (2016). Indirect effects of mosquito control using Bti on dragonflies and damselflies (Odonata) in the Camargue. Insect Conservation and Diversity. 9.

- Sprayed BTi
- Reduced food (midges)

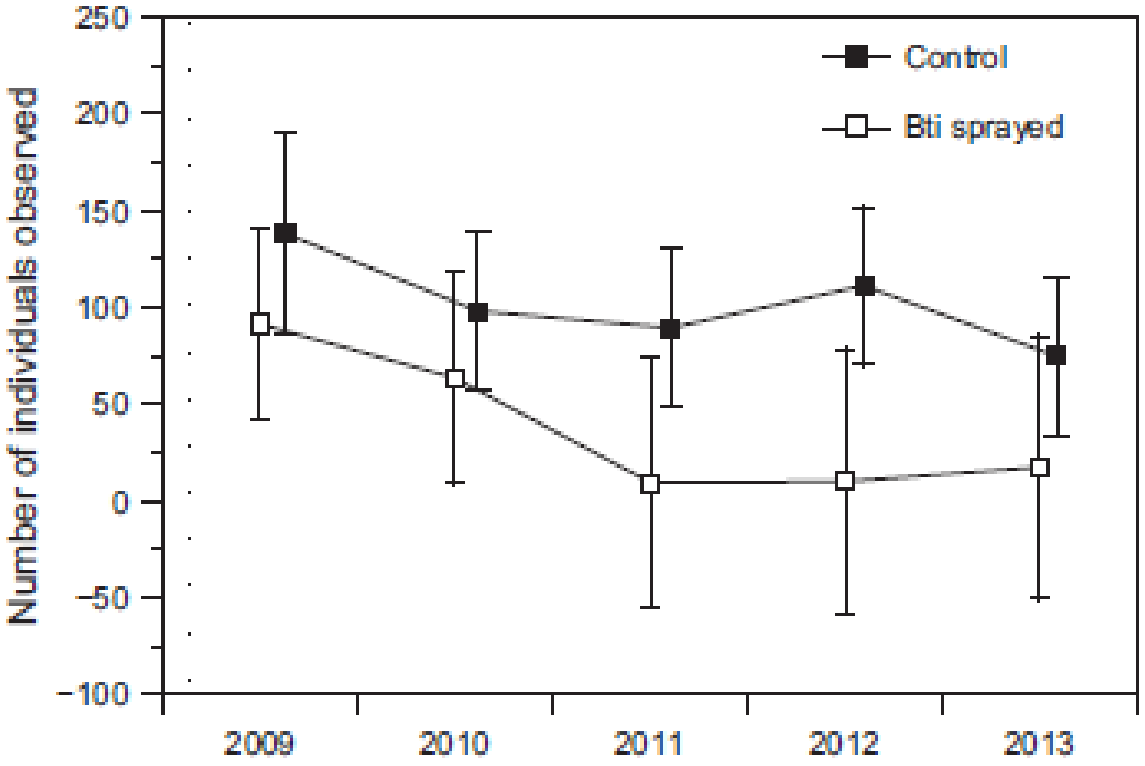
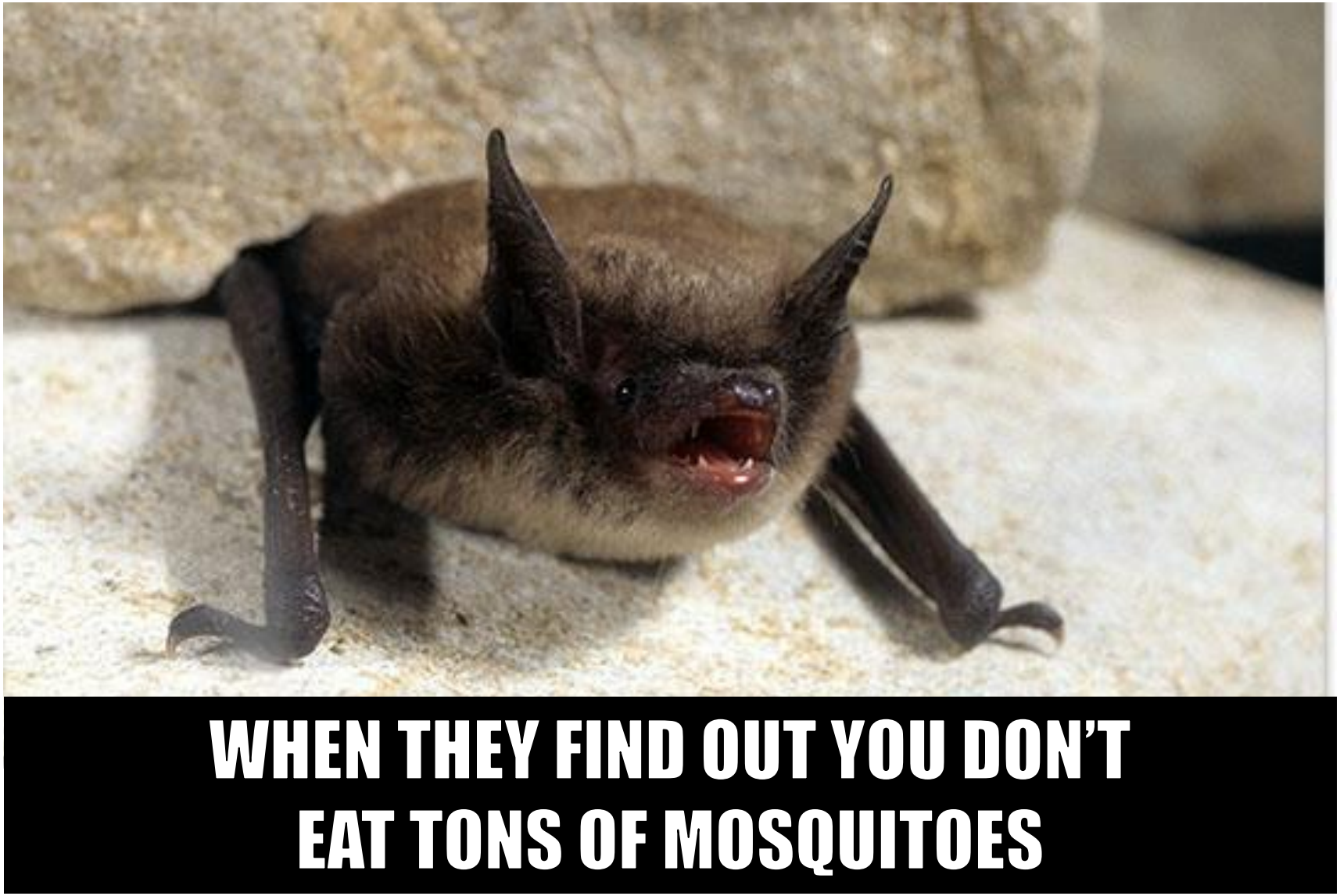


Fig. 4. Annual trends in mean Odonata abundance (95% CI) estimated along the transects at *Bti*-sprayed and control areas over the 5-year study period according to the nested-ANOVA designed GLM.

Jakob, C. and Poulin, B.. (2016). Indirect effects of mosquito control using Bti on dragonflies and damselflies (Odonata) in the Camargue. Insect Conservation and Diversity. 9.

Bats? A bit overstated



Griffin, D.R., Webster, F.A., Michael, C.R., 1960. The echolocation of flying insects by bats. Anim. Behav. 8, 141–154

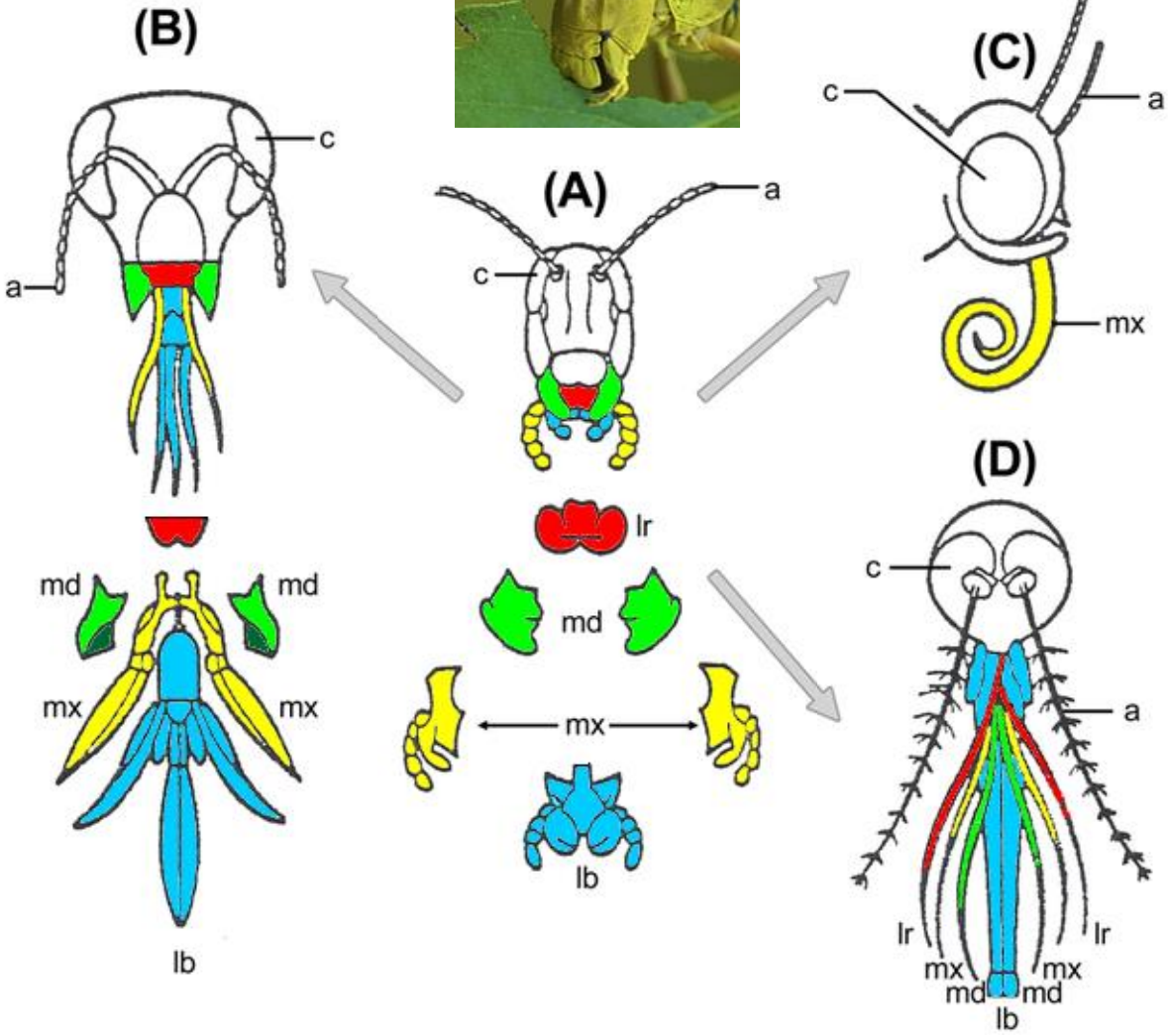
- Adults are nectar feeders
- Pollinate flowers
- *Platanthera obtusata* mosquito pollinated plant

Thien, Leonard. (1969). MOSQUITO POLLINATION OF HABENARIA OBTUSATA (ORCHIDACEAE). American Journal of Botany. 56. 232-237.

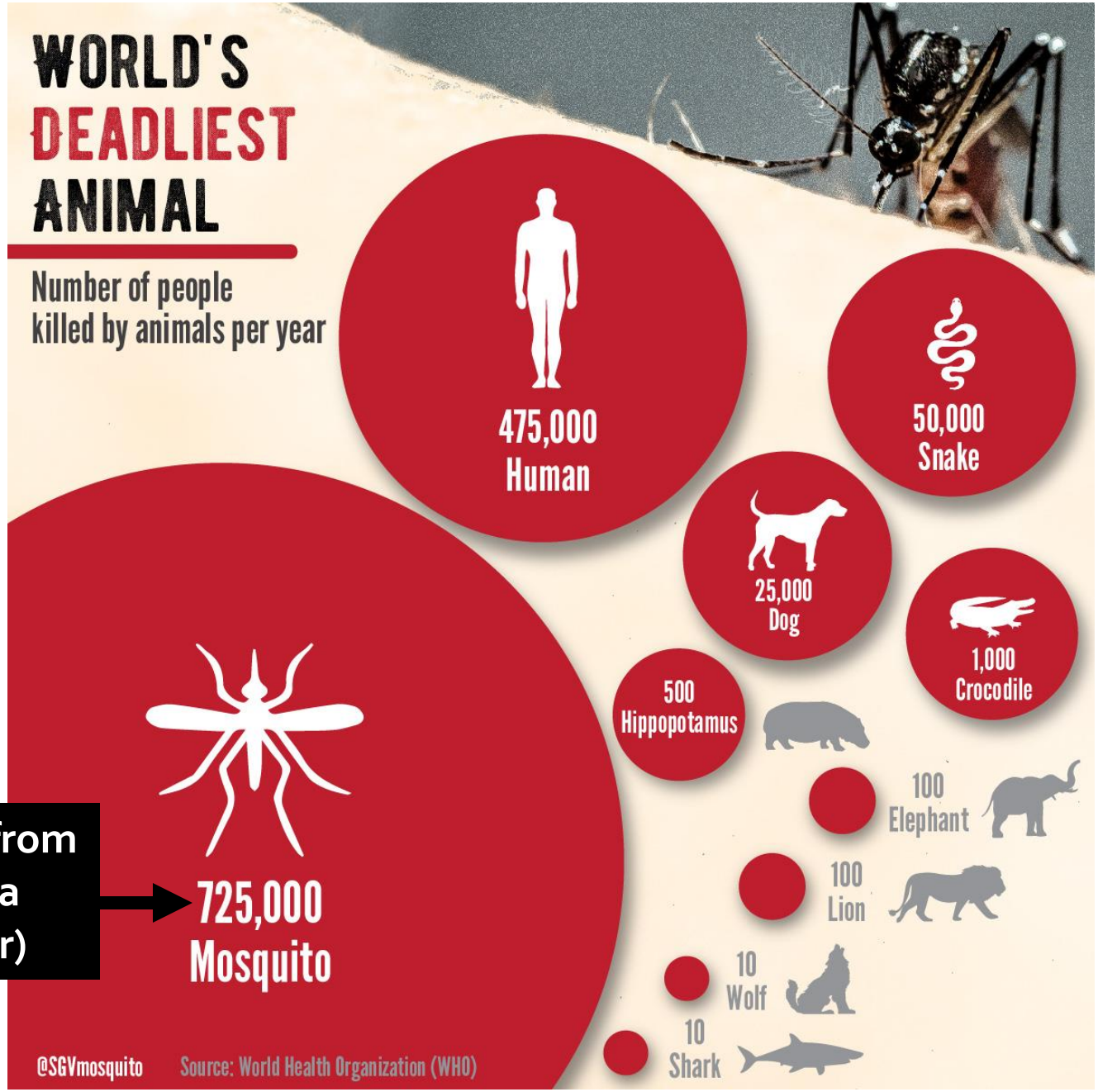
- Only females feed on blood
- Egg production
- This is where mosquitoes get their reputation!

Guillaume Lacour

Mouthpart modification



- Cannulate blood vessels
- Quick feeders



435, ooo from malaria (bad air)

Eastern Equine Encephalitis

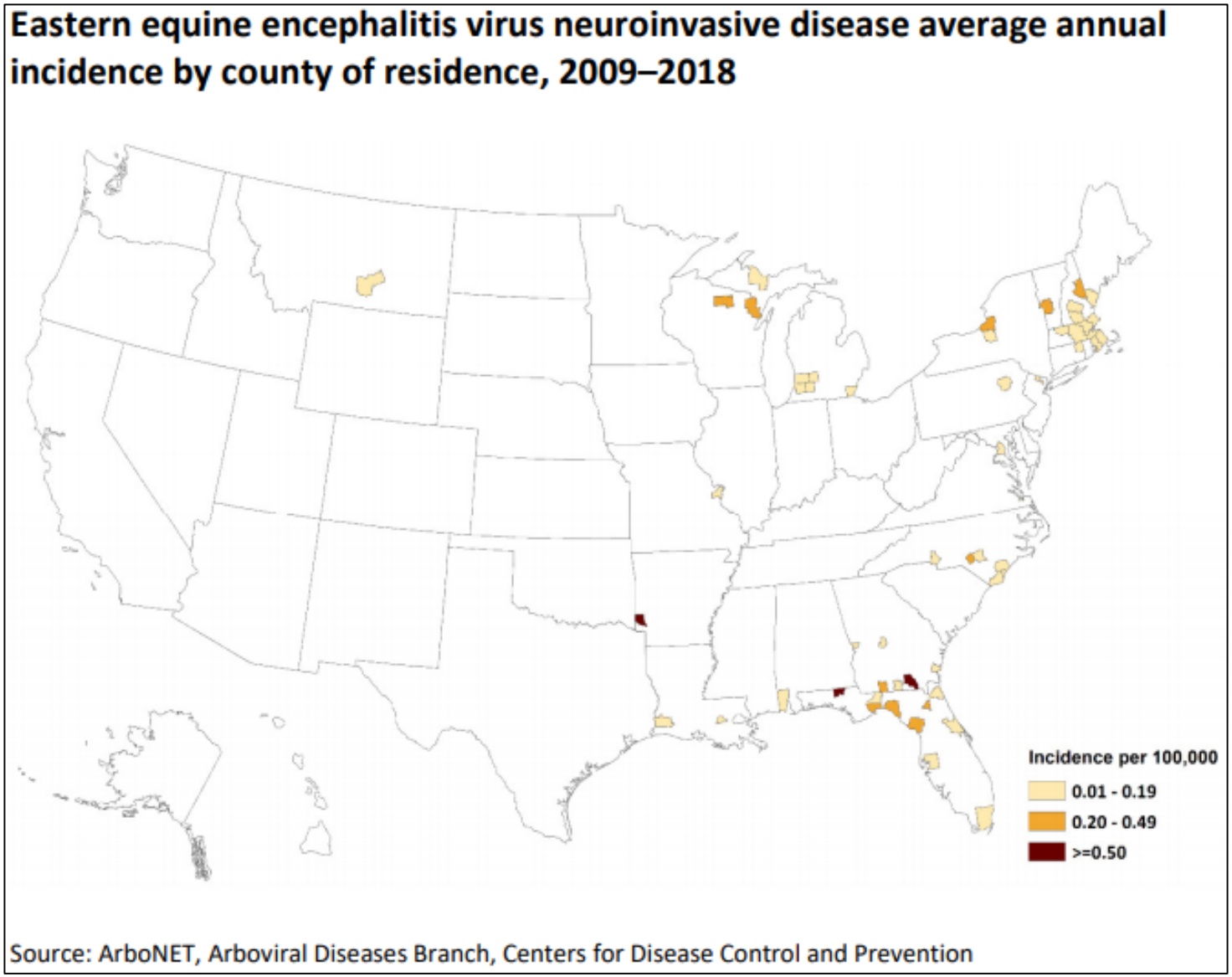
- Rare
- But, very serious

Eastern equine encephalitis virus disease cases and deaths reported to CDC by year and clinical presentation, 2010-2019*

	Neuroinvasive disease			Non-neuroinvasive disease			Total		
	Cases	Deaths		Cases	Deaths		Cases	Deaths	
Year	No.	No.	(%)	No.	No.	(%)	No.	No.	(%)
2010	10	5	(50)	0	0	(0)	10	5	(50)
2011	4	3	(75)	0	0	(0)	4	3	(75)
2012	15	5	(33)	0	0	(0)	15	5	(33)
2013	8	4	(50)	0	0	(0)	8	4	(50)
2014	8	2	(25)	0	0	(0)	8	2	(25)
2015	6	4	(67)	0	0	(0)	6	4	(67)
2016	7	3	(43)	0	0	(0)	7	3	(43)
2017	5	2	(40)	0	0	(0)	5	2	(40)
2018	6	1	(17)	0	0	(0)	6	1	(17)
2019*	38	19	(50)	0	0	(0)	38	19	(50)
Total	**107**	**48**	**(45)**	**0**	**0**	**(0)**	**107**	**48**	**(45)**

Source: ArboNET, Arboviral Diseases Branch, Centers for Disease Control and Prevention
*2019 data are provisional and subject to change

- Not found everywhere in US
- Certain focal locations, like MA



- EEEV starts in Florida
- Moves up to MA

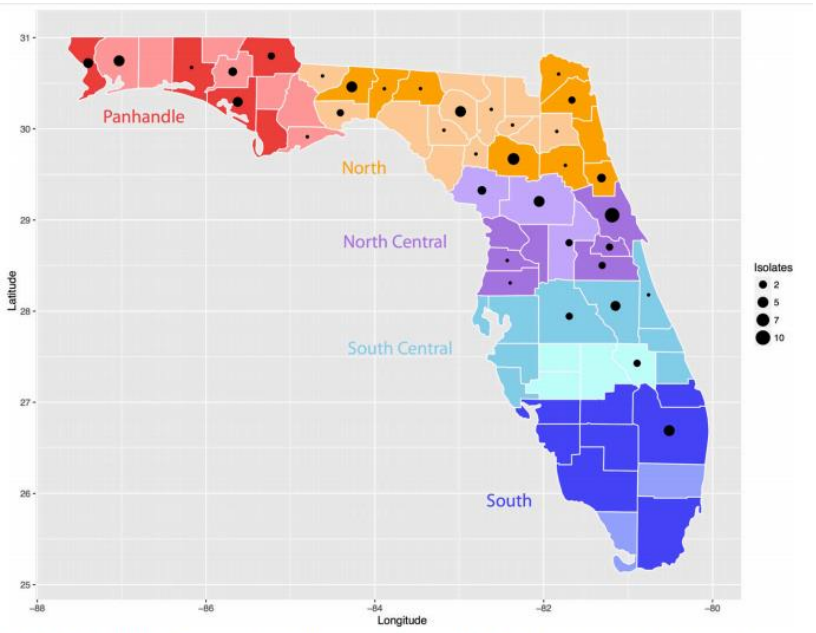
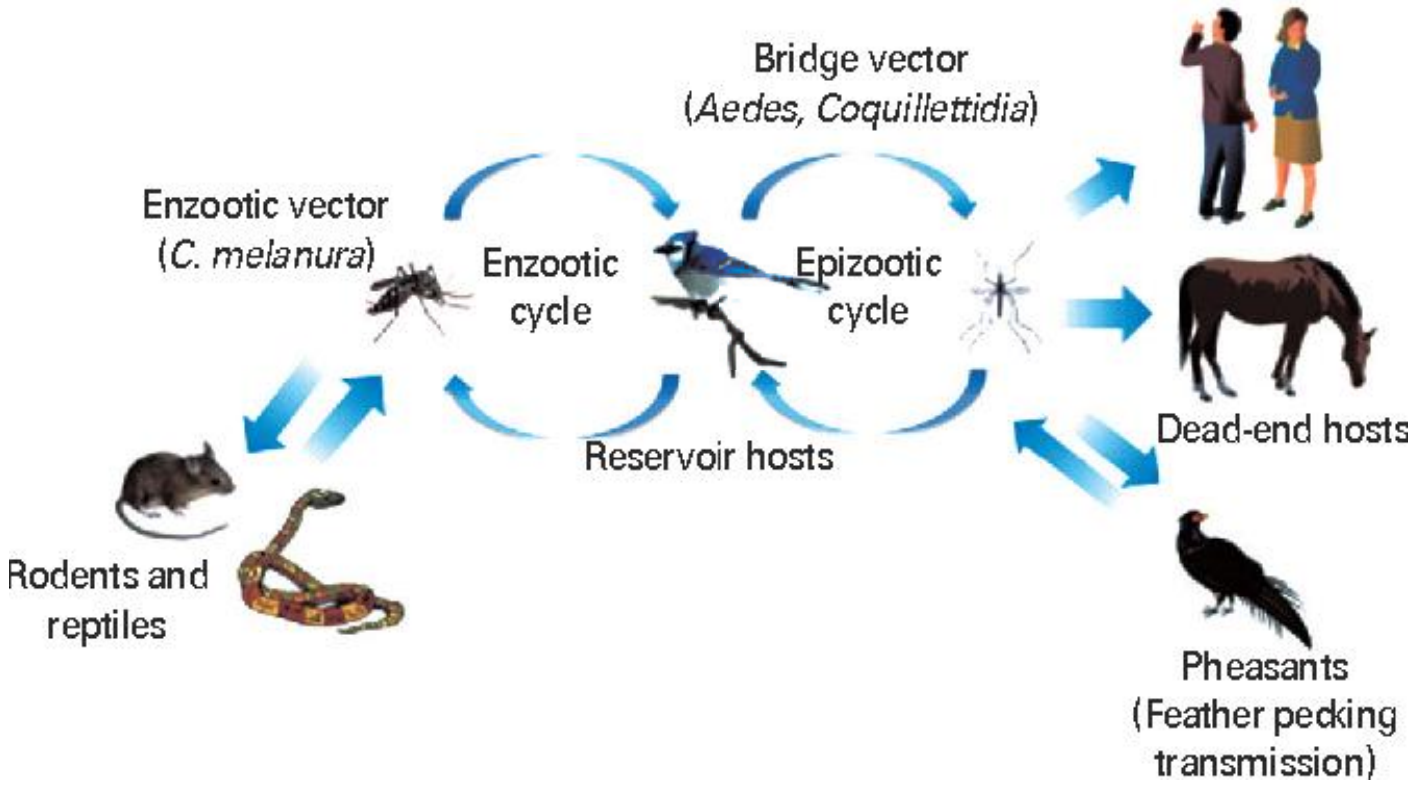


FIGURE 1. Map of Florida with five regions from which the eastern equine encephalitis virus (EEEV) isolates and sentinel chickens were sampled. The *x* axis represents longitude and *y* axis represents latitude. The five regions in Florida are colored and marked in the figure. The darker shading in each region indicates counties in the region participating in the sentinel chicken surveillance program during the study period, 2005 to 2016, whereas the lighter shade indicates no chicken surveillance data were available from those counties. Black dots in each county represent EEEV isolates and size of the dot represents the total number of isolates. This figure appears in color at www.ajtmh.org.

Heberlein-Larson, Lea & Tan, Yi & Stark, Lillian & Cannons, Andrew & Shilts, Meghan & Unnasch, Thomas & Das, Suman. (2019). Complex Epidemiological Dynamics of Eastern Equine Encephalitis Virus in Florida. The American Journal of Tropical Medicine and Hygiene. 100.

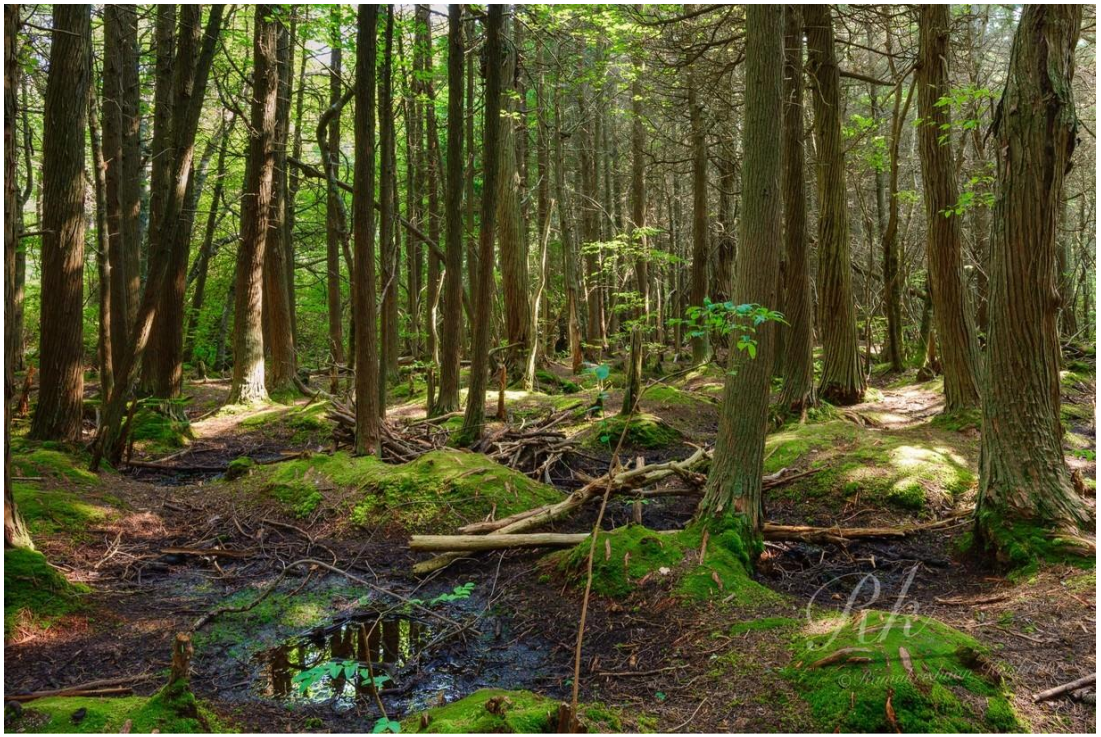
- Complicated cycle
- Many moving parts



Black-tailed mosquito (*Culiseta melanura*)

- Underground crypts
- Mainly, Atlantic white cedar swamps
- **Very** difficult to manage as larvae

Cs. melanura



Wellfleet, MA

Cattail mosquito (*Coquillettidia perturbans*)

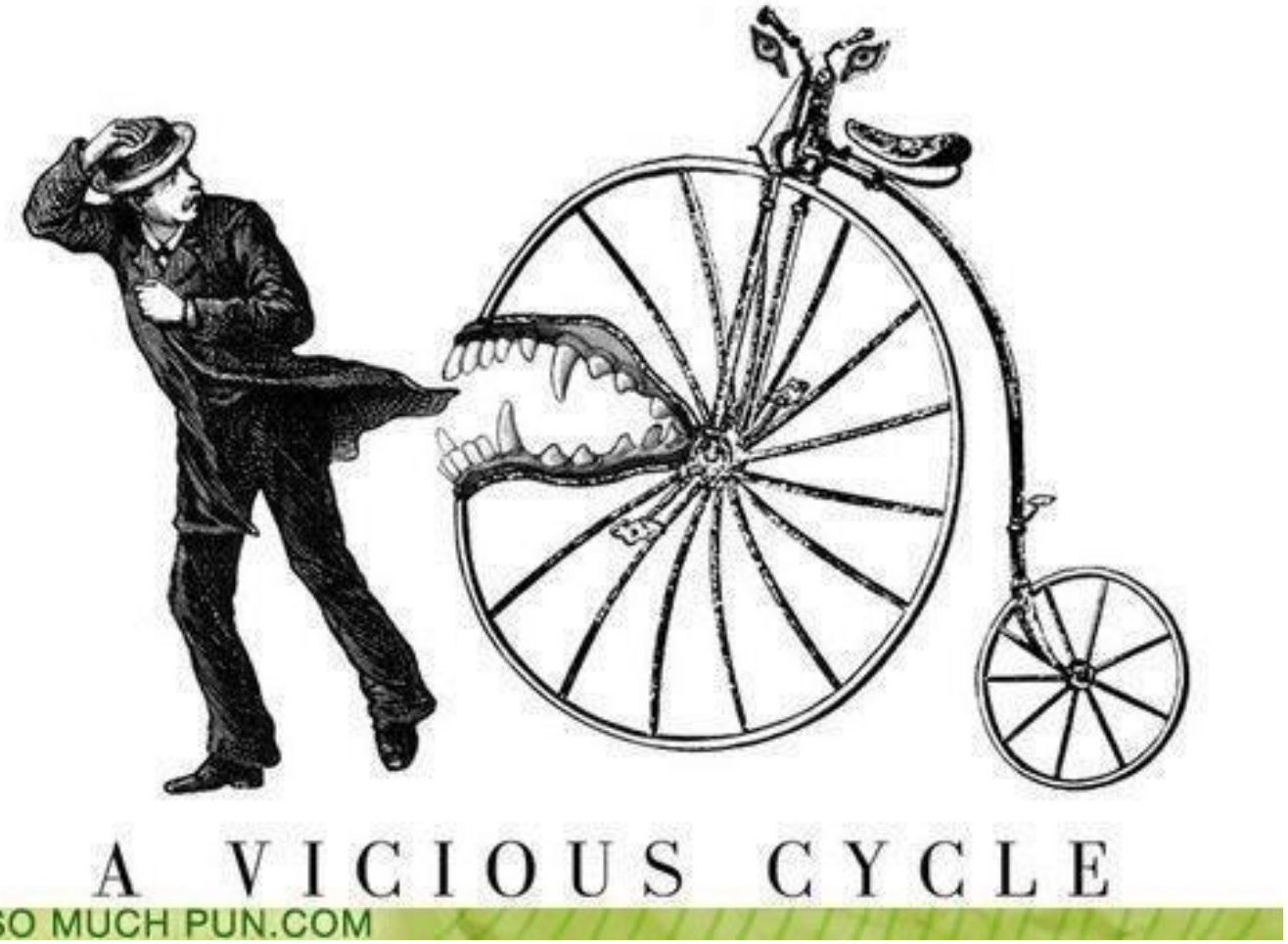
- Univoltine
- Eggs are laid near aquatic vegetation (cattails)
- Also, difficult to manage larvae

Cq. perturbans

John Lynch

Cyclical?

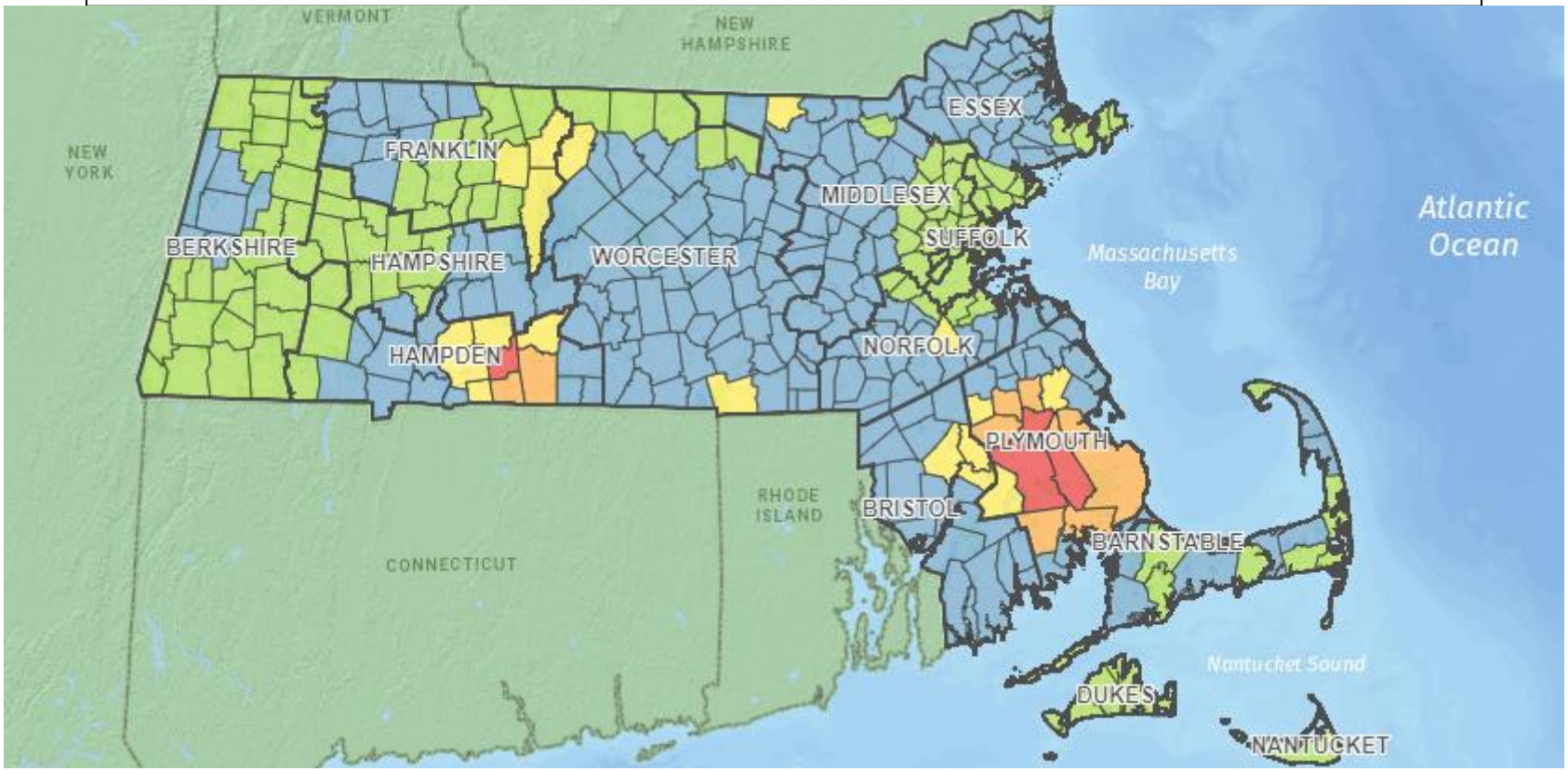
- 3-year cycles
- 2004-2006, 2010-2012, 2019-?



2020 results

Arbovirus results summary

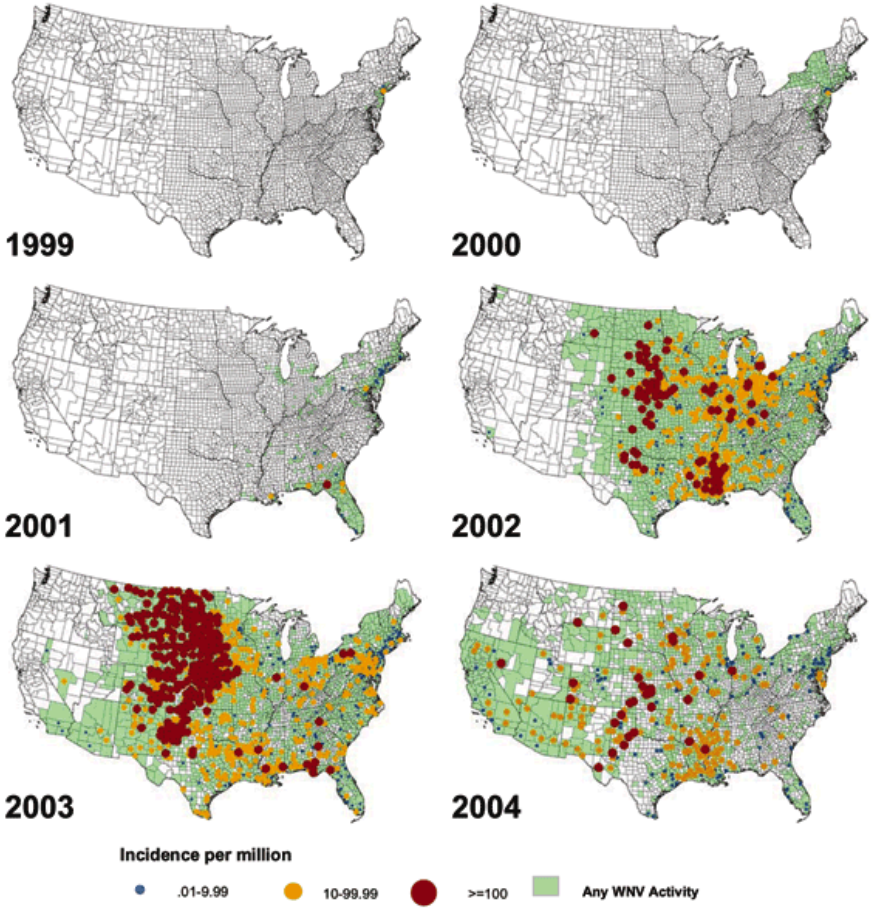
	Mosquito samples positive	Animals positive	Humans positive
WNV	90	0	7
EEE	65	0	4



www.mass.gov/info-details/massachusetts-arbovirus-update

WNV

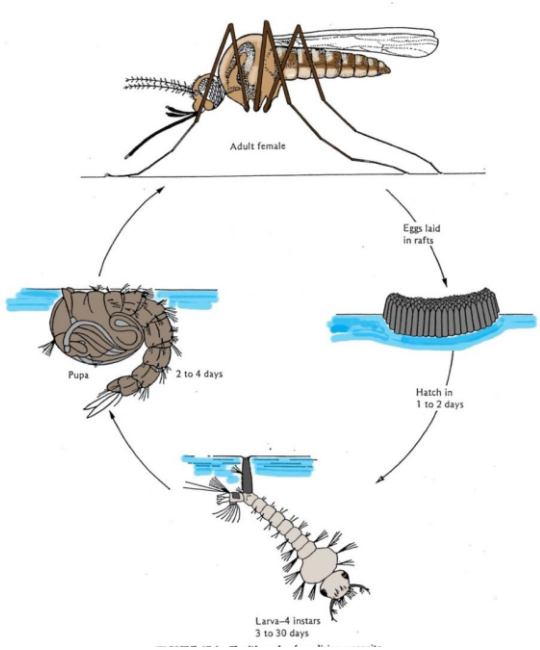
- Northern house mosquito (*Culex pipiens*)
- More widespread than EEEV



- Nasty water
- Degraded habitats

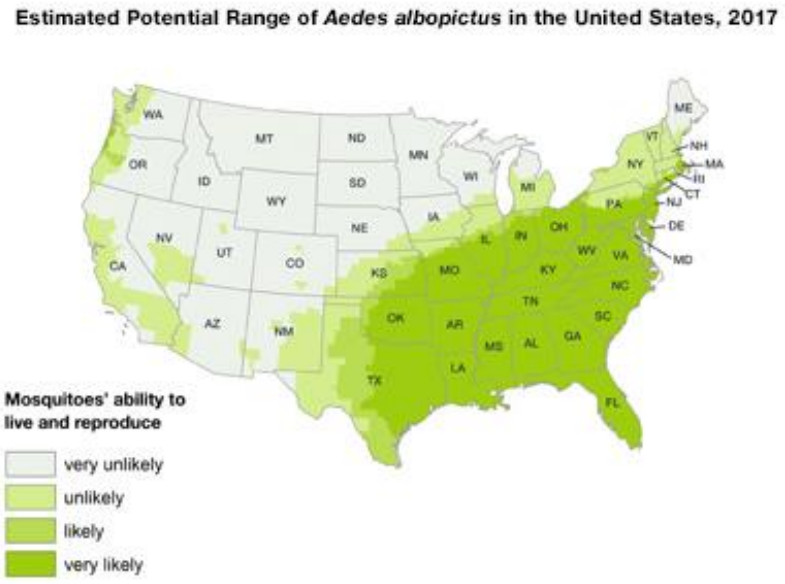
Impact of increased temperatures:

- Reproduction cycles
- Faster extrinsic incubation period (EIP)
- Warm-weather species moving north



Culex tarsalis
14 days at 70° F
10 days at 80° F

Culex pipiens	20 °C (68°F)	30 °C (86°F)
West Nile EIP	15 days	5 days



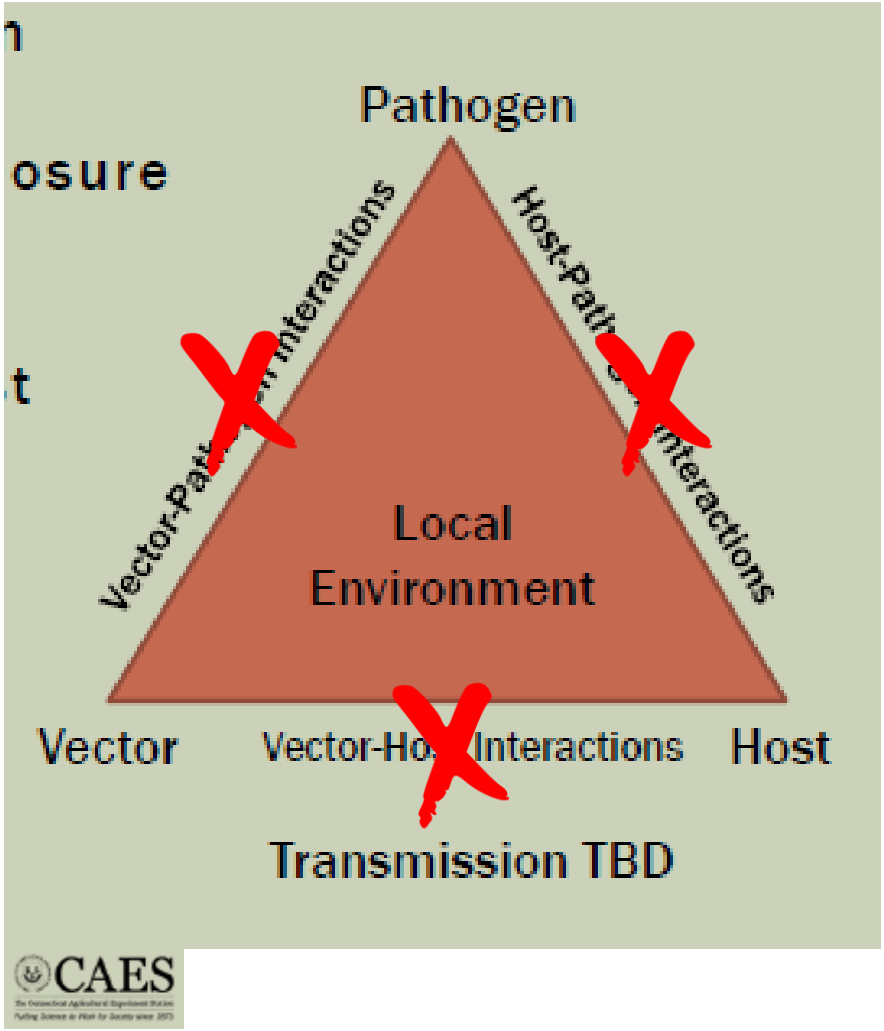
Where Do We Go From Here?

Different Strategies

Pathogen-vector
- Control animal host populations

Human-pathogen
- Vaccines

Vector-human
- Repellents



- Cover up
- Head nets

- Limit activity to daytime
- Found more often in night and twilight biting mosquitoes

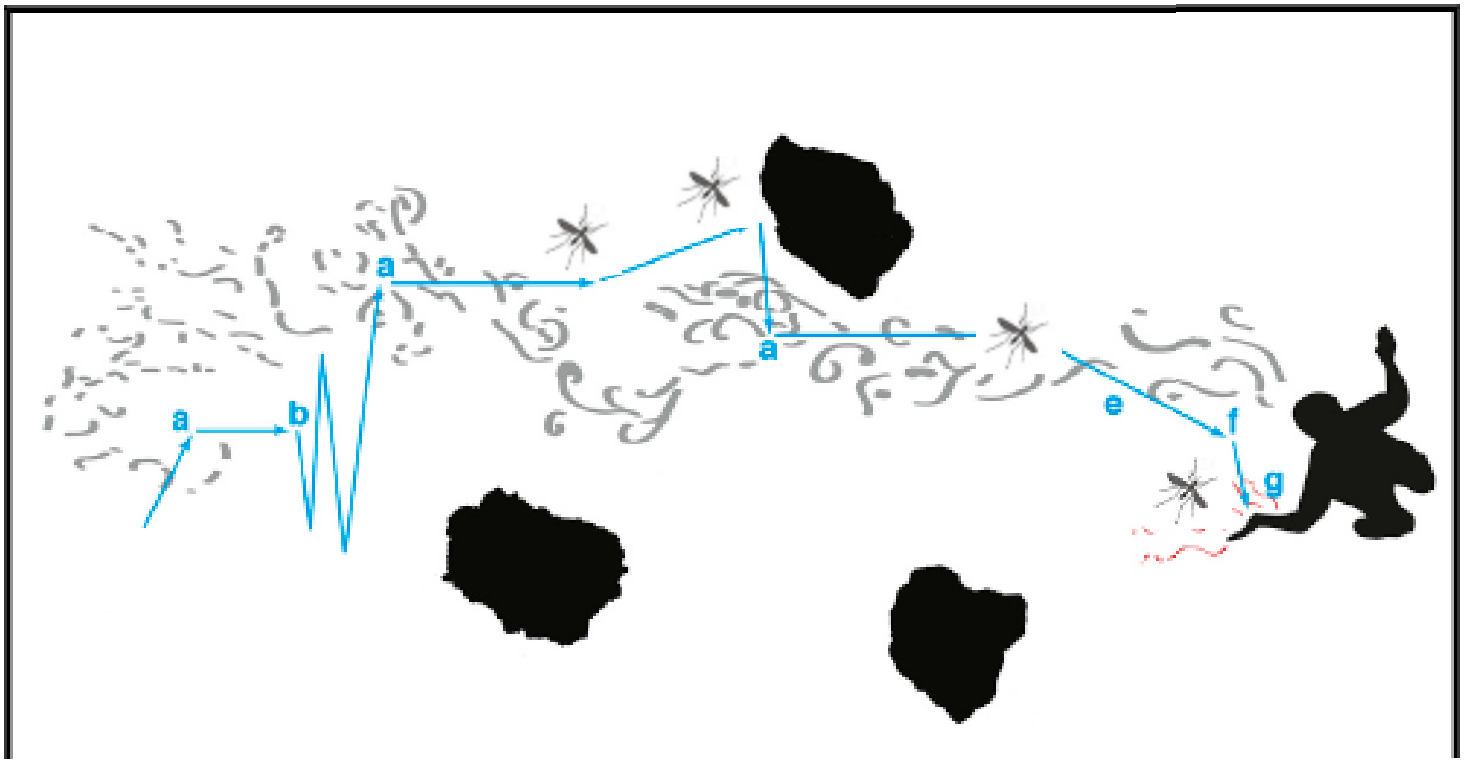
For EEEV, out of 428 pools in 2019:

- 34 pools were day biting mosquitoes
- 394 pools were night/twilight biting mosquitoes
- Note: trapping methods and timing can skew results

Ae. vexans

Cq. perturbans

Mosquitoresults.com



- >10 m: scent (CO_2)
- 5-10 m: vision
- >1 m: heat, skin volaties
- If not host, switch back to scent
- Continue until you find a host

van Breugel, F., Riffell, J., Fairhall, A., and Dickinson, M. (2015). Mosquitoes Use Vision to Associate Odor Plumes with Thermal Targets. Current biology : CB. 25. 10.1016/j.cub.2015.06.046.

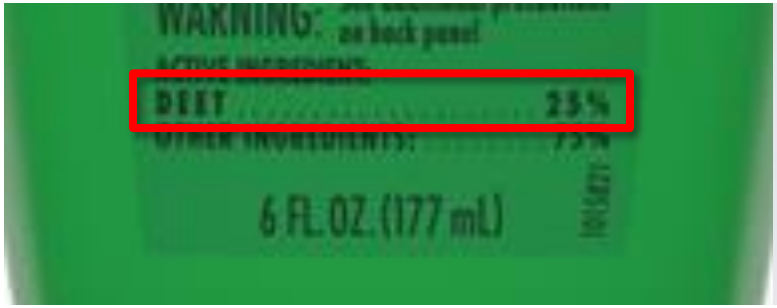
Choosing the right repellent

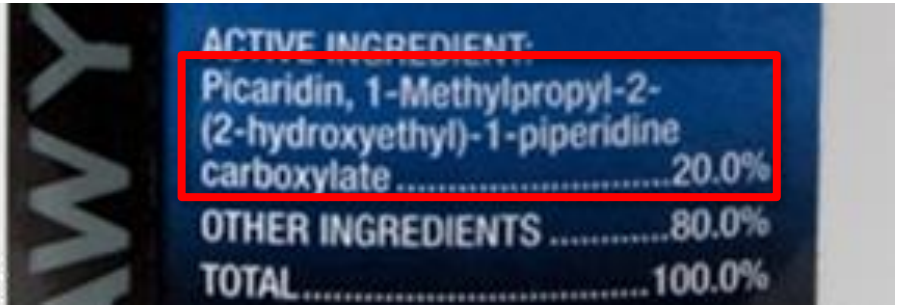
Make sure it's EPA registered

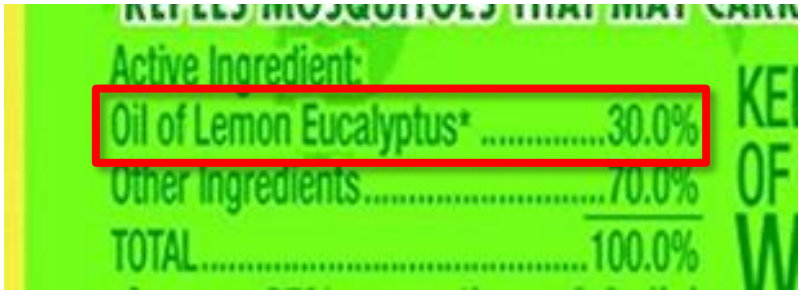
Look for the active ingredient

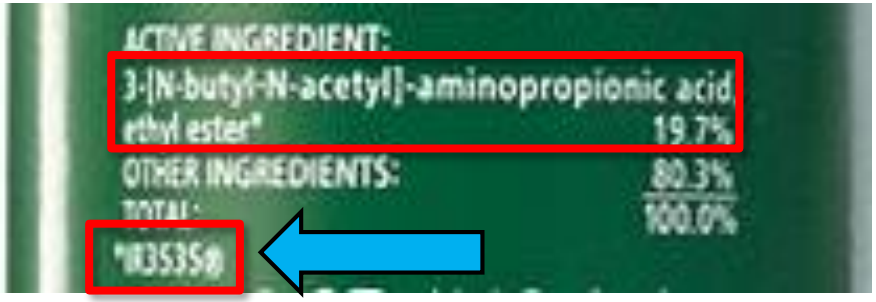
ACTIVE INGREDIENTS

- **DEET**
- **Picaridin** or Icaridin
- **IR3535**
- **Oil of Lemon Eucalyptus** or PMD (p-menthane-3,8-diol)
- **2-undecanone**









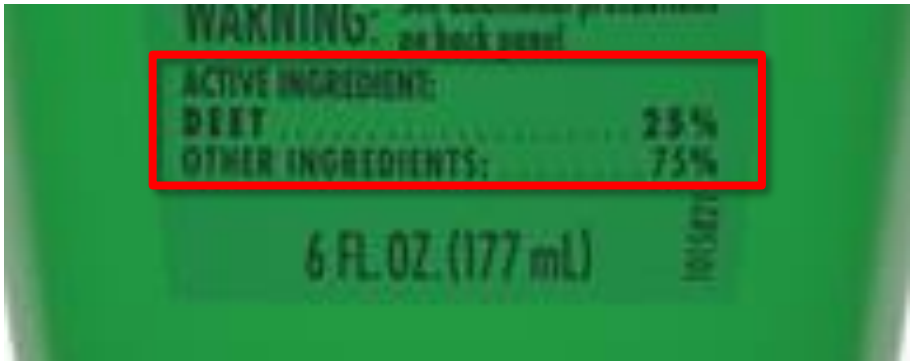
Schreck et al, 1995; Gardulf et al, 2004; Bissinger et al, 2008; Bissinger et al, 2009; Bissinger and Roe, 2010; Carroll et al 2010; Bissinger et al, 2011

DEET – Most common repellent

- 60 years of use (73 in the military)
- ~200 million people annually (WHO estimate)
- >8 billion human applications (2002)

- 4 deaths associated with DEET
- Never confirmed

- Mosquitoes kill 725k-1 million people/year
- Falling coconuts kill 150 people/year



Fradin and Day, 2002; Perkins, 2006; Chen-Hussey, 2014; Kuehn, 2013

Follow the directions

Treatments for Cats and Dogs

- Dog heartworm (can even be in cats!)
- **Proper** treatment to protect

25(b) exempt ("all natural")?

- "All natural" does not mean safe or effective
- Often don't last as long
- Often don't protect as well
- Contain known allergens (health effects unknown)

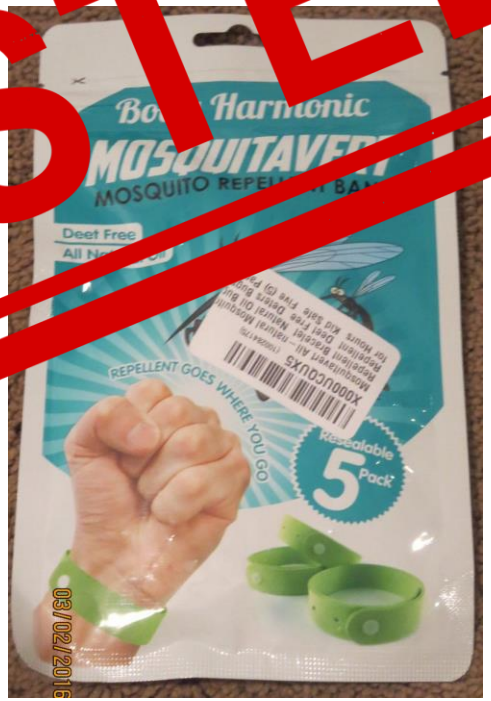
Eisen and Dolan, 2016

Citronella candles

- Not acceptable levels of repellency

Mosquito bracelets

- Metofluthrin… worked OK
- Others… zero protection



BUSTED

Mosquitoes are aquatic organisms

Only need as much water as a bottle cap

Bartlett-Healy, Kristen & Healy, Sean & Hamilton, George. (2011). A Model to Predict Evaporation Rates in Habitats Used by Container-Dwelling Mosquitoes. Journal of medical entomology. 48. 712-6.

Most fly 2 km or less

Mullen and Durden, 2019

Unlu, Isik & Faraji, Ary & Indelicato, Nicholas & Fonseca, Dina. (2014). The hidden world of Asian tiger mosquitoes: Immature Aedes albopictus (Skuse) dominate in rainwater corrugated extension spouts. Transactions of the Royal Society of Tropical Medicine and Hygiene. 108.

Risk of mosquito bites related to socio-economic status

Socio-Ecological Mechanisms Supporting High Densities of Aedes albopictus (Diptera: Culicidae) in Baltimore, MD
E. Little, D. Biehler, P. T. Leisnham, R. Jordan, S. Wilson, and S. L. LaDeau


ASK THE BUILDER

Mosquito sprays

Do they work?

Large scale review on sprays 1944-2018

- Some work!
- Temporary (5 days to 6 weeks)
- Highly variable (0% to >90%)
- Lots of factors to consider!

Stoops, Craig & Qualls, Whitney & Nguyen, Thuy-Vi & Richards, Stephanie. (2019). A Review of Studies Evaluating Insecticide Barrier Treatments for Mosquito Control From 1944 to 2018. Environmental Health Insights. 13. 117863021985900..

Remember, we have many different mosquitoes

- Fly at different heights
- Active at different times of day
- Different times of year

Table 1. Vertical distribution of adult mosquitoes collected at the stratification tower.

Species	Location of CDC light trap			Totals
	Ground level	7.8 m	15.5 m	
Aedes canadensis	109	2	1	112
Ae. sticticus	25	1	1	27
Ae. stimulans	475	5	3	483
Ae. triseriatus	33	6	2	41
Ae. trivittatus	137	19	9	165
Ae. vexans	988	43	28	1059
Anopheles punctipennis	6	2	2	10
An. quadrimaculatus	14	2	2	18
Culex erraticus	0	1	1	2
Cx. p. pipiens	5	97	358	460
Cx. restuans	0	0	1	1
Cx. salinarius	4	2	24	30
Cx. tarsalis	0	3	1	4
Culiseta inornata	1	0	0	1
Coquillettidia perturbans	1	1	1	3
Psorophora ferox	3	0	0	3
Totals	1801	184	434	2419

Mammal feeding

Bird feeding

VERTICAL STRATIFICATION PREFERENCES OF ADULT FEMALE MOSQUITOES IN A SYLVAN HABITAT (DIPTERA: CULICIDAE)
Lee Mitchell and C. Lee Rockett

Adult Mosquito Yard Spray

Plymouth County Mosquito Control Project

- FREE
- Up to 8x/season

Plymouth County Mosquito Control Project

Phone	Location
Hours: 7:30 am - 2:30 pm Office: (781) 585-5450 Fax: (781) 582-1276	272 South Meadow Rd. Plymouth, MA 02360

Free tire recycling

How many tires are here?

4617

Don’t google symptoms and try to diagnose yourself

See a medical professional

Symptoms may appear 2-14 days after exposure to the virus. People with these symptoms may have COVID-19:

- Fever or chills
- Cough
- Shortness of breath or difficulty breathing
- Fatigue
- Muscle or body aches
- Headache
- New loss of taste or smell
- Sore throat
- Congestion or runny nose
- Nausea or vomiting
- Diarrhea

https://www.cdc.gov/

Symptoms of EEE generally occur four to 10 days after a person has been infected and include:

- high fever
- headache
- tiredness
- nausea/vomiting
- neck stiffness

The symptoms of encephalitis depend on the part of the brain that is inflamed, the amount of inflammation and the person's age and overall health.

Some of the most common symptoms of encephalitis include:

- seizures
- confusion (disorientation)
- coma

http://www.childrenshospital.org/

Bottom Line

With the right knowledge and awareness…

Vector-borne diseases are preventable.

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Questions?

Mosquitoes

Agrarian (Edman, 1988)

200k+ populations to sustain some viruses (Anderson and May, 1979, 1991)

Robin Migration
Kilpatrick AM, Kramer LD, Jones MJ, Marra PP, Daszak P. 2006. West Nile virus epidemics in North America are driven by shifts in mosquito feeding behavior. PLoS Biol. 4:e82

Mosquitoes

Robin Migration

Kilpatrick AM, Kramer LD, Jones MJ, Marra PP, Daszak P. 2006. West Nile virus epidemics in North America are driven by shifts in mosquito feeding behavior. PLoS Biol. 4:e82

History of Mosquitoes

Many are food for other animals

- Bats? A bit overstated (See Griffin et al. 1960)

In April, 1958, at the invitation of E. T. Nielsen several bats were brought to his 8 ft. × 16 ft. flight chamber at Vero Beach, Florida, which contained initially about 2,000 mosquitos (*Culex quinquefaciatus*). Several *Myotis lucifugus*, one *M. subulatus*, one *M. subulatus leibii*, two *Pipistrellus subflavus*, and two *Plecotus rafinesquii* were set free in this room for 10-15 minutes at a time, and certain of the *Myotis* hunted actively. These were left in the chamber overnight, and in the morning the mosquito population had fallen to roughly 200-300. Although none of the *Pipistrellus* or *Plecotus* was ever observed to hunt actively, a few of the *Myotis* were so successful that we could estimate the rate of insect capture not only by counting audible buzzes, but also by measuring the rate at which the bats gained weight (See Table I).

Mosquitoes

Flight distance of mosquitoes (Culicidae): A metadata analysis to support the management of barrier zones around rewetted and newly constructed wetlands

Piet F.M. Verdonschot , Anna A. Besse-Lototskaya

Table 3
Number of species per Culicidae genus, distributed over flight capacity classes based on the maximum flight distance reported.

Genus	No. of species	No. of observations	Average maximum distance (m)	Number of flyers				
				Very weak	Weak	Moderate	Good	Strong
Aedes[a]	24	104	2959	7	1	4	3	9
Ochlerotatus[b]	9	23	7631	1		1	1	6
Anopheles[c]	46	144	3490	3	11	6	13	13
Coquillettidia	5	11	2271		1	1	3	
Culiseta	3	3	14,043					3
Culex	13	58	5014		1	2	7	3
Psorophora	5	9	4256		2		1	2

[a] Except *Aedes cantator* and *Ae. sollicitans* with a maximum of 48.3 km.
[b] Except *Ochlerotatus taeniorhynchus* with a maximum of 32.0 km.
[c] Except *Anopheles freeborni* with a maximum of 35.0 km.

2959 m = 1.8 miles

14043 m = 8.7 miles

Mosquitoes

Table 4
Average flight distance (m) based on mark-recapture experiments.

Taxon	Number	Average	SD
Genus *Aedes*	30	89.0	50.1
Ae. aegypti	23	83.4	52.2
Ae. africanus	1	50.0	
Ae. albopictus	1	75.0	
Ae. melanimon	1	121.0	
Ae. notoscriptus	3	130.1	43.1
Ae. vexans	1	113.6	
Genus *Ochlerotatus*			
Oc. communis	2	156.0	76.8
Genus *Anopheles*	18	541.9	381.8
An. albimanus	3	576.5	125.6
An. crucians	1	450.0	
An. culicifacies	2	234.1	234.6
An. funestus	1	300.0	
An. gambiae	4	846.3	396.7
An. maculatus	1	420.0	
An. minimus	1	1249.0	
An. pharoensis	1	1087.0	
An. stephensi	3	144.5	53.0
An. subpictus	1	24.4	
Genus *Culiseta*	2	4500	707.1
Cs. melanura	1	4000	
Cs. morsitans	1	5000	
Genus *Culex*[a]			
Cx. annulirostris	5	6220.0	1775.4
Genus *Culex*[a]	17	609.5	437.0
Cx. erraticus	1	730.0	
Cx. nigripalpus	1	850.0	
Cx. pipiens fatigans	1	475.0	
Cx. pipiens pallens	1	402.0	
Cx. quinquefasciatus	7	767.6	560.4
Cx. salinarius	1	760.0	
Cx. tarsalis	3	544.6	347.9
Cx. tritaeniorhynchus	2	68.4	4.9
Genus *Mansonia*	4	457.5	568.3
Ma. annulata	1	65.0	
Ma. Indiana	1	275.0	
Ma. titillans	1	1300.0	
Ma. uniformis	1	190.0	
Genus *Coquillettidia*			
Cq. pertuberans	1	1670.0	
Genus *Psorophora*	*2*	*3175*	*4207*
Ps. columbiae	1	200	
Ps. confinnis/Ps. discolor	1	6150	

[a] Only a portion of the species within this genus.

75 m = 0.046 miles
1670 m = 1.03 miles

Adult Mosquito Yard Spray

A Review of Studies Evaluating Insecticide Barrier Treatments for Mosquito Control From 1944 to 2018
Stoops et al. 2019

ACTIVE INGREDIENT	ASSOCIATED PRODUCT AND/ OR MIXTURE	MOSQUITO SPECIES EVALUATED	METHOD OF APPLICATION	METHOD OF ASSESSMENT	FINDING	REFERENCE
Pyrethrum	Kerosene Piperonyl cyclohexenone	*Aedes taeniorhynchus* *Ae sollicitans* *Psorophora* spp.	Compression sprayer	Landing count	23% reduction at 53 d post treatment	Madden et al[7]
DDT	Fuel oil	*Ae taeniorhynchus* *Ae sollicitans*	Compression Sprayer	Landing count	88%-99% reduction 48-72 h post treatment	Madden et al[8]
DDT	Dust	*Ae taeniorhynchus* *Ae sollicitans*	Hand rotary dust sprayers	Landing count	100% reduction at 3 h post application	Madden et al[9]
DDT solution DDT suspension	Fuel oil Talc Water Piperonyl cyclohexenone	*Ae taeniorhynchus* *Ae sollicitans* *Psorophora* spp.	Compression Sprayer	Landing count	41% reduction at 53 d post treatment 64% reduction 53 d post treatment	Madden et al[7]
DDT	Fuel oil	*Ae taeniorhynchus* *Ae sollicitans*	Compression Sprayer	Leaf bioassay	86% mortality at 46 d post treatment	Madden et al[7]
DDT with xylene, emulsifier, and rosin	Water	*Anopheles quadrimaculatus*	Unknown	Mark, release, recapture	0.12% of mosquitoes recaptured within 8 wk post treatment	Ludvik[10]
DDT	Water	*Ae communis* *Ae fitchii* *Ae hexodontus*	Compression sprayer Mist blower	Landing counts	65%-100% control at 45 d post treatment	Hoffman and Lindquist[11]
DDT and emulsifier	Water	*Psorophora confinnis* *Ps discolor*	Airplane	New Jersey light traps	No satisfactory control	Quarterman et al[12]
DDT	Rosin Triton X-155 Xylene	*Ae taeniorhynchus* *Ae sollicitans*	Compression sprayer	Landing counts	6-9 wk of control	Bidlingmayer and Schoof[13]
BHC	Kerosene Piperonyl cyclohexenone	*Ae taeniorhynchus* *Ae sollicitans* *Psorophora* spp.	Compression Sprayer	Landing count	26% reduction at 53 d post treatment	Madden et al[7]
BHC	Triton X-155 Xylene	*Ae taeniorhynchus* *Ae sollicitans*	Compression sprayer	Landing counts	0-2 wk of control	Bidlingmayer and Schoof[13]
Methoxyclor	Water	*Ae stimulans* *Ae eudes* *Ae vexans*	Battery-operated pump	Leaf bioassay	3% mortality at 19 d post treatment	Helson and Surgeoner[14]
Lindane	Water	*Ae communis* *Ae fitchii* *Ae hexodontus*	Compression sprayer Mist blower	Landing counts	55%-93% reduction at 42 d	Hoffman and Lindquist[11]

Adult Mosquito Yard Spray

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Stoops et al. 2019

ACTIVE INGREDIENT	ASSOCIATED PRODUCT AND/ OR MIXTURE	MOSQUITO SPECIES EVALUATED	METHOD OF APPLICATION	METHOD OF ASSESSMENT	FINDING	REFERENCE
Lindane	Triton X-155 Xylene	*Ae taeniorhynchus* *Ae sollicitans*	Compression sprayer	Landing counts	0-2wk of control	Bidlingmayer and Schoof[13]
Dieldrin	Triton X-155 Xylene	*Ae taeniorhynchus* *Ae sollicitans*	Compression sprayer	Landing counts	0-2wk of control	Bidlingmayer and Schoof[13]
Chlorpyrifos	Water	*Ae stimulans* *Ae eudes* *Ae vexans*	Battery-operated pump sprayer	Leaf bioassay	5.7% mortality at 19d post treatment	Helson and Surgeoner[14]
Iodofenfos	Water	*Ae stimulans* *Ae eudes* *Ae vexans*	Battery-operated pump sprayer	Leaf bioassay	0.5% mortality at 15d post treatment	Helson and Surgeoner[14]
Malathion		*Ae taeniorhynchus* *Ae sollicitans*	Buffalo Turbine mist blower	Human landing counts	Control for 8d post treatment	Anderson et al[15]
Malathion	Water	*Ae stimulans* *Ae eudes* *Ae vexans*	Battery-operated pump	Leaf bioassay	8.9% mortality at 15 d post treatment	Helson and Surgeoner[14]
Carbaryl	Water	*Ae stimulans* *Ae eudes* *Ae vexans*	Battery-operated pump	Leaf bioassay	60% mortality at 12d post treatment	Helson and Surgeoner[14]
Permethrin (25%) Permethrin (1.25%)	EC EC	Multiple species	Compressed air sprayer	Human landing counts	Significant differences between treated vs untreated plots 2 d post treatment	Helson and Surgeoner[14]
Permethrin		*Ae taeniorhynchus* *Ae sollicitans*	Buffalo Turbine mist blower	Human landing counts	Control for 8d post treatment	Anderson et al[15]
Permethrin	Water	*Ae stimulans* *Ae eudes* *Ae vexans*	Battery-operated pump	Leaf bioassay	7% mortality at 33 d post treatment	Helson and Surgeoner[14]
Permethrin and PBO	Water	*Ae albopictus* *Cx Quinquefasciatus*	RLFlow master 1025HD	Leaf bioassay	4.7% 3wk post treatment (pooled species)	Cilek and Hallmon[16]
Permethrin PBO	Water	*Cx quinquefasciatus*	Twister XL backpack sprayer	Leaf bioassay	90% control up to 3 wk post treatment	Amoo et al[17]
Deltamethrin	Mineral oil	*An albimanus*	Aerial Micromist 900 Spray System	Light traps	Control for 8d post treatment	Perich et al[5]

Adult Mosquito Yard Spray

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Stoops et al. 2019

ACTIVE INGREDIENT	ASSOCIATED PRODUCT AND/ OR MIXTURE	MOSQUITO SPECIES EVALUATED	METHOD OF APPLICATION	METHOD OF ASSESSMENT	FINDING	REFERENCE
Deltamethrin	Water	*Ae albopictus* *Ps columbiae*	Backpack mist blowers	CDC light traps baited with CO_2 Black oviposition cups	Applications every 21 d for 23 wk suppressed adult mosquito populations, but degree of effects depended on species and time of year.	Richards et al[16]
Deltamethrin	Water	*Ae albopictus* *Cx quinquefasciatus*	RLFlowmaster 1025HD	Leaf bioassay	99.8% 3 wk post treatment (pooled species)	Cilek and Hallmon[16]
Deltamethrin	Water	*Ae albopictus*	STIHL SR 200	Leaf bioassay	60 min exposure < 70% for 10 wk 5 min exposure 60 min knockdown < 40% up to week 6	McMillan et al[19]
Deltamethrin	Water	*Ae albopictus*	Hand compression Solo 423 backpack sprayer	Leaf bioassay	Mortality for 5 d post treatment	Bengoa et al[20]
Deltamethrin	Water	*Ae albopictus*	Hand compression Solo 423 backpack sprayer	Leaf bioassay	Mortality for 12 d post treatment	Bengoa et al[20]
Deltamethrin	Water	*Ae albopictus*	700 mL spray bottle	Leaf bioassay	>90% control up to 4 wk post treatment	Qualls et al[21]
Bifenthrin	Water	*Ae albopictus* *Cx pipiens*	STIHL SR 420	Human landing counts Sweep nets Ovitraps CDC gravid traps CDC light traps with CO_2	Control of *Ae albopictus* for up to 6 wk; no control for *Cx pipiens*	Trout et al[22]
Bifenthrin	Water	18 mosquito species	Modified pressure washer using Teejet nozzles	ABC light traps	91% reduction in mosquito abundance	Cilek[23]
Bifenthrin	Water	Field mosquito populations	Electrostatic applications	Encephalitis virus surveillance traps	Control up to 28 d	Britch et al[24]
Bifenthrin	Water	*Ae vigilax*	600 L truck Mounted quick spray unit with a 3mm T400 nozzle	Light traps Human landing counts	Control up to 8 w post treatment	Hurst et al[25]

Adult Mosquito Yard Spray

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Stoops et al. 2019

ACTIVE INGREDIENT	ASSOCIATED PRODUCT AND/ OR MIXTURE	MOSQUITO SPECIES EVALUATED	METHOD OF APPLICATION	METHOD OF ASSESSMENT	FINDING	REFERENCE
Bifenthrin	Water	*Ae atlanticus* *Ae infirmatus* *Ps columbiae*	Flo-jet pump with a 40° flat fan nozzle	CDC light traps baited with octenol	Control up to 6wk post treatment	Qualls et al[3]
Bifenthrin	Water	*Ae taeniorhynchus* *Ae sollicitans* *Ae atlanticus* *Ae infirmatus* *Cx nigripalpus* Culiseta *melanura* *Ps columbiae*	Hand compression sprayer and flo-jet pump with a 40° flat fan nozzle	Human landing counts CDC light traps baited with CO_2 Mosquito Magnet X trap with CO_2	Regardless of site or collection methods, control up to 3wk post application	Qualls et al[26]
Bifenthrin	Water	*Ae* spp. *Cx* spp. *An* spp. *Cs* spp.	Backpack mist blower	CO_2-baited traps CO_2-baited BG Sentinel traps Larval surveillance	54%-74% reduction over the 16wk post treatment period	VanDusen et al[27]
Bifenthrin	Water	Floodwater mosquitoes	3WC-30-4P American Long Ray; novel sprayer	CDC light traps	Mean reduction of 77% up to 4 wk post treatment	Fulcher et al[28]
Bifenthrin	Water	*Ae albopictus*	STIHL SR 420	BG Sentinel traps baited with BG-lures Black oviposition cups	Significant reduction in eggs and adults up to 4 wk post treatment	Bibbs et al[29]
Bifenthrin	Water	*Ae albopictus* *Ps columbiae*	Backpack mist blowers	CDC light traps baited with CO_2 Black oviposition cups	Applications every 21d for 23 wk suppressed adult mosquito populations; but degree of effects depended on species and time of year.	Richards et al[18]
Bifenthrin	Water	*Ae albopictus*	STIHL SR 420	Leaf bioassay	50%-80% mortality over 8wk	Trout et al[30]
Bifenthrin	Water	*Ae albopictus*	Compression sprayer	Leaf bioassay	77% mortality up to 35d post treatment	Doyle et al[31]
Bifenthrin	Water	*Ae albopictus* *Cx quinquefasciatus*	Modified pressure washer fitted with Teejet nozzles	Leaf bioassay	>70% control at 4 wk post treatment	Cilek[23]
Bifenthrin	Water	*Ae aegypti*	STIHL SR 420	Leaf bioassay	70% (wax myrtle) and 40% knockdown (azalea) 4 wk following treatment	Allan et al[32]
Bifenthrin	Water	*Cx tarsalis*	STIHL SR 420	Leaf bioassay	>50% reduction for 28 d	Britch et al[24]

Adult Mosquito Yard Spray

A Review of Studies Evaluating Insecticide Barrier Treatments for Mosquito Control From 1944 to 2018
Stoops et al. 2019

ACTIVE INGREDIENT	ASSOCIATED PRODUCT AND/ OR MIXTURE	MOSQUITO SPECIES EVALUATED	METHOD OF APPLICATION	METHOD OF ASSESSMENT	FINDING	REFERENCE
Bifenthrin	Water	*Ae albopictus*	STIHL 200	Leaf bioassay	>90% knockdown 60 min exposure for 2 wk 5 min exposure, 60 min knockdown > 80% for 2 wk	McMillan et al[19]
Bifenthrin	Water	*Ae albopictus*	700 mL spray bottle	Leaf bioassay	>90% reduction up to 4 wk post treatment	Qualls and Xue[21]
Bifenthrin	Water	*Ae albopictus*	700 mL spray bottle	Leaf bioassay	>90% reduction up to 4 wk post treatment	Qualls and Xue[21]
Bifenthrin	Water	*Ae aegypti*	3WC-30-4P American Long Ray Sprayer	Leaf bioassay	80% mortality at 2.7 m 51% mortality at 5.5 m	Fulcher et al[23]
Lambda-cyhalothrin	Water	*Ae albopictus* *Cx pipiens*	STIHL SR 420	Human landing counts Sweep nets Ovitraps CDC gravid traps CDC light traps with CO_2	Control of *Ae albopictus* for up to 6 wk; no reduction of *Cx pipiens*	Trout et al[30]
Lambda-cyhalothrin	Water	*Cx pipiens*	Power sprayer	CO_2-baited traps Gravid traps	8 wk reduction in *Cx pipiens* in tree canopies	Trout and Brown[22]
Lambda-cyhalothrin	Water	*Ae albopictus*	Marumaya MD6026 backpack sprayer	Human landing Rate	98% reduction 24 h after application/95% reduction after 9 wk	Li et al[33]
Lambda-cyhalothrin	Water	*Verrallina sp.*	STIHL SR 420	Sweep net	87%-100% reduction for up to 9 wk post treatment	Muzari et al[34]
Lambda-cyhalothrin	Water	*Ae albopictus*	STIHL SR 420	Leaf bioassay	40%-60% mortality over 8 wk	Trout et al[30]
Lambda-cyhalothrin	Water	*Ae albopictus*	STIHL SR 200	Leaf bioassay	60 min exposure >90% up to 8 wk 5 min exposure, 60 min knockdown > 75% to 8 wk	McMillan et al[19]
Lambda-cyhalothrin	Water	*Ae albopictus*	700 mL spray bottle	Leaf bioassay	>90% control up to 4 wk post treatment	Qualls and Xue[21]
Cypermethrin Tetramethrin PBO	Water	*Ae albopictus*	Elite 14S-300 SprayTeam Machine Tartaruga 300/3	Human landing counts	Control up to 14 d post treatment	Marini et al[35]

Adult Mosquito Yard Spray

A Review of Studies Evaluating Insecticide Barrier Treatments for Mosquito Control From 1944 to 2018
Stoops et al. 2019

ACTIVE INGREDIENT	ASSOCIATED PRODUCT AND/ OR MIXTURE	MOSQUITO SPECIES EVALUATED	METHOD OF APPLICATION	METHOD OF ASSESSMENT	FINDING	REFERENCE
Etofenprox Tetramethrin PBO	Water	*Ae albopictus*	Elite 14S-300 SprayTeam Machine Tartaruga 300/3	Human landing counts	Control up to 14d post treatment	Marini et al[35]
Pyriproxyfen Pyriproxyfen and Lambda-cyhalothrin	Water Water	*Ae albopictus*	STIHL SR 420	BGS trap baited with BG lure	>70% control up to 4 wk post treatment	Unlu et al[36]
Pyriproxyfen	Water	*Ae albopictus*	STIHL SR 420	BGS trap baited with BG lure	No decrease in *Ae albopictus*	Suman et al[37]
d-phenothrin and PBO	Water	*Cx quinquefasciatus*	Twister XL backpack sprayer	Leaf bioassay	90% control up to 1 wk post treatment	Amoo et al[7]
Resmethrin	Water	*Cx quinquefasciatus*	Twister XL backpack sprayer	Leaf bioassay	90% control up to 1 wk post treatment	Amoo et al[7]
Cyfluthrin	Water	*Ae albopictus*	700 mL spray bottle	Leaf bioassay	>90% control up to 4 wk post treatment	Qualls and Xue[21]
Beta-cyfluthrin	Water	*Ae albopictus*	700 mL spray bottle	Leaf bioassay	>90% control up to 4 wk post treatment	Qualls and Xue[21]

Abbreviations: BHC, β-hexachlorocyclohexane; CDC, Centers for Disease Control and Prevention; DDT, dichlorodiphenyltrichloroethane; EC, emulsifiable concentrate; PBO, piperonyl butoxide.

Feeding

Probing

Cannulating a blood vessel

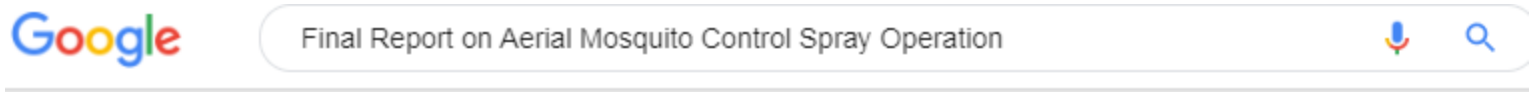
Aerial Spray

Massachusetts Department of Agricultural Resources

What is it?

- Anvil 10 + 10 (Pyrethroid + synergist)
- ~ 1 shot glass of active/8 acres
- Half-life: <24 hours

Aerial Spray



www.mass.gov › files › documents › 2018/11/14 ▾ PDF

important public notice - Mass.gov

Nov 14, 2018 - emergency **mosquito control operations** that relate to public relations. ... gov/eea/agencies/agr/pesticides/mosquito/**annual-operation-reports**.html ... Responds to all **reports** of potential fish kills following an **aerial spray** or other.

0201.nccdn.net › 2012-eee-aerial-spray-summary-1-23-13 ▾ PDF

Department of Agricultural Resources - nccdn.net

by CGC Watson - Related articles

Jul 30, 2012 - **Final** Summary **Report on Aerial Mosquito Control Spray Operation**, July 20-23, 2012 and August 13-14, 2012. Page 2 of 69. At the behest of ...

You've visited this page 2 times. Last visit: 1/29/20

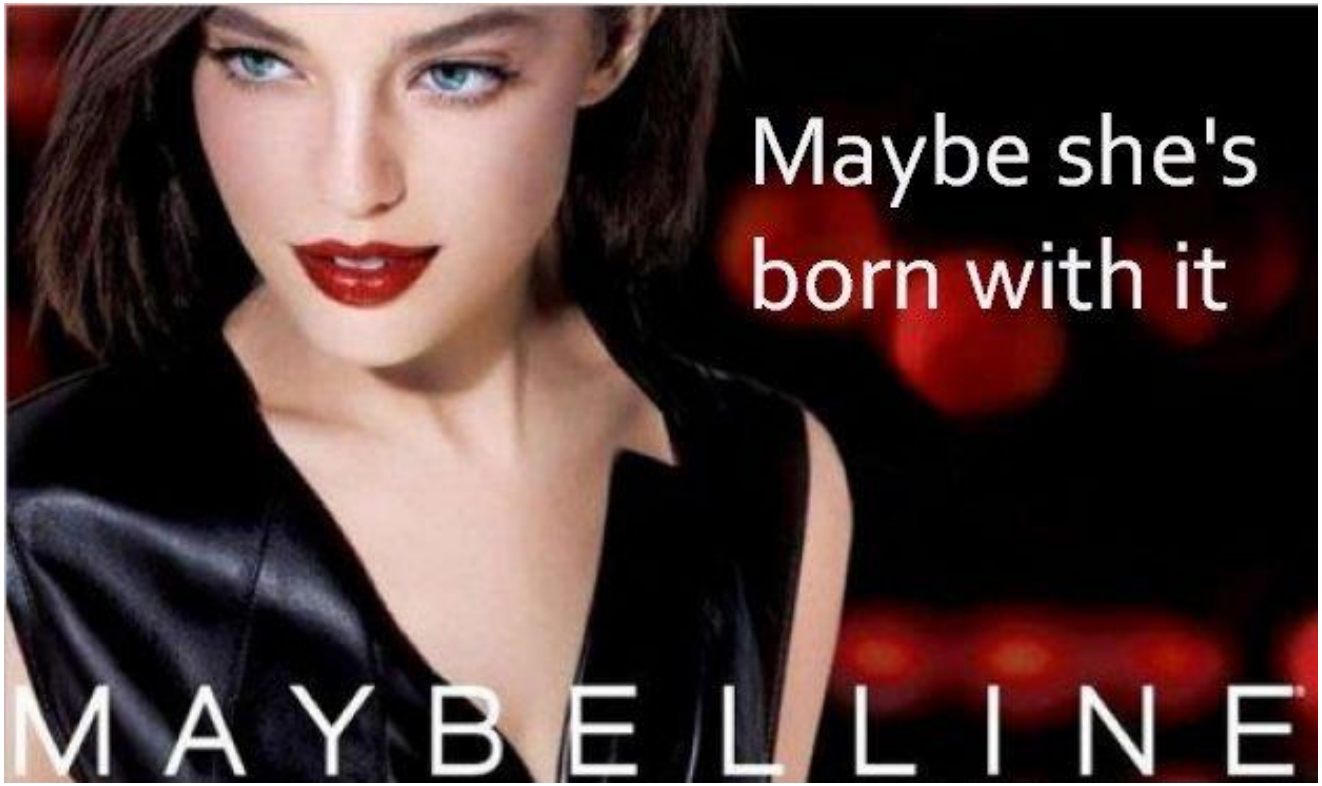
0201.nccdn.net › 2010-eeev-aerial-spray-summary ▾ PDF

Department of Agricultural Resources - nccdn.net

Dec 1, 2010 - **Final Report on Aerial Mosquito Control Spray Operation**, August 5-7, 2010. Page 2 of 17. Description of Aerial Mosquito Control Spray ...

Picking Up Germs?

- Born with it (WNV, Dengue, La Crosse)



Picking Up Germs?

- Venereal (La Crosse)

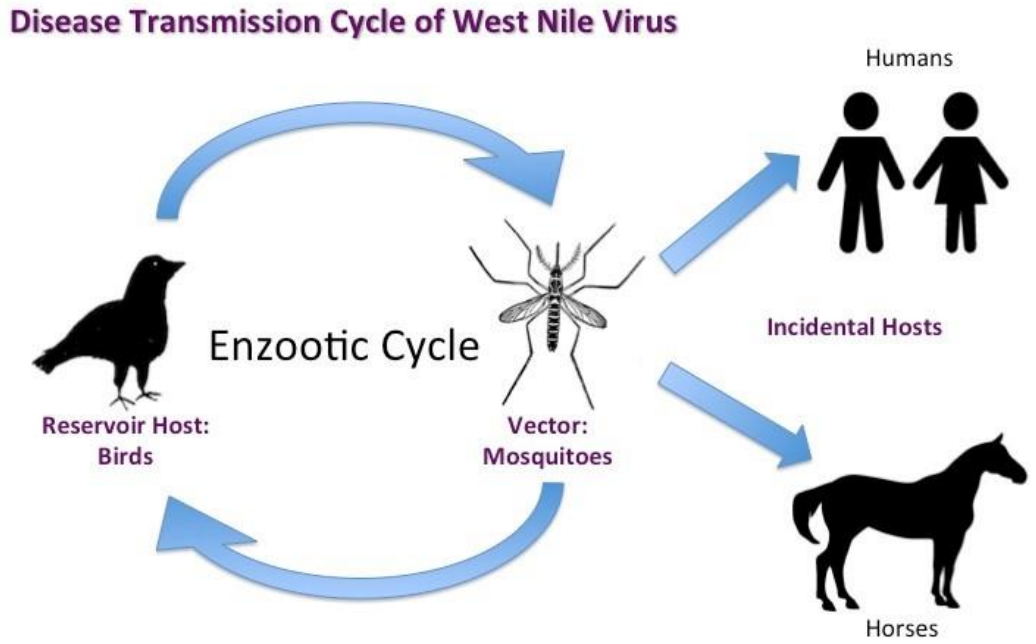
Picking Up Germs?

- Feeding/viremia (Zika, EEE, WNV)

West Nile Virus

Amplify in animal-mosquitoes

But, Culex pass to humans, as well



West Nile Virus is an arboviral, or vectorborne, disease that affects many bird species with corvids being most severely affected. WNV is transmitted by several species of mosquito, especially *Culex* species. The virus is picked up from infected hosts by mosquitoes during a blood meal. The mosquitoes go on to infect other hosts, thus continuing the enzootic cycle. Mammals, including horses and humans, are incidental (dead-end) hosts. Although they may develop clinical signs, the majority of infected individuals are asymptomatic and they do not contribute to the disease cycle because mosquitoes cannot pick up the virus from infected mammals.

West Nile Virus

Primary vector: Northern house mosquito (*Culex pipeins*)

- Multivoltine
- Larvae laid in nasty stagnant water – the nastier, the better
- "Rain barrel mosquito"

Cx. pipiens

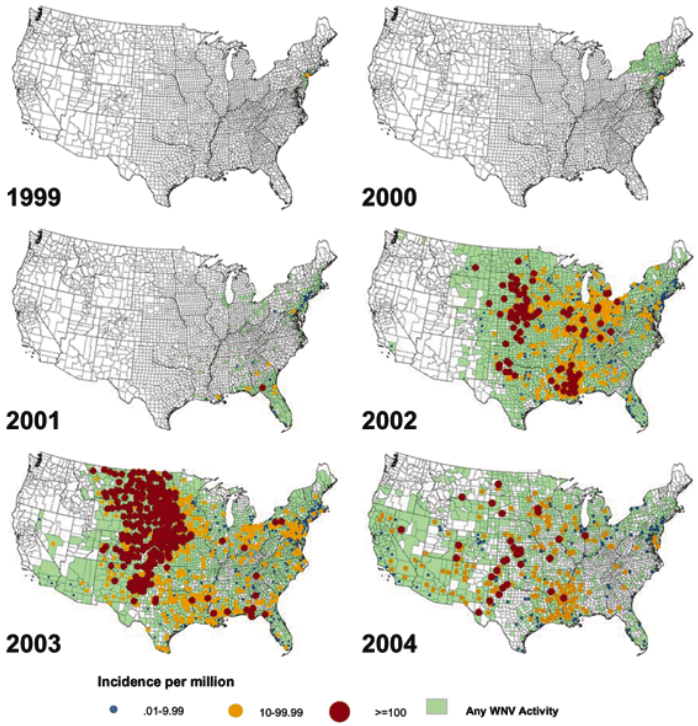
West Nile Virus

Cyclical?

- Different pattern than EEE

Why here?

- Widespread
- Dirty water



Vaccines?

- Not approved for human use
- May not be appropriate (Zika/Dengue)

Mosquitoes

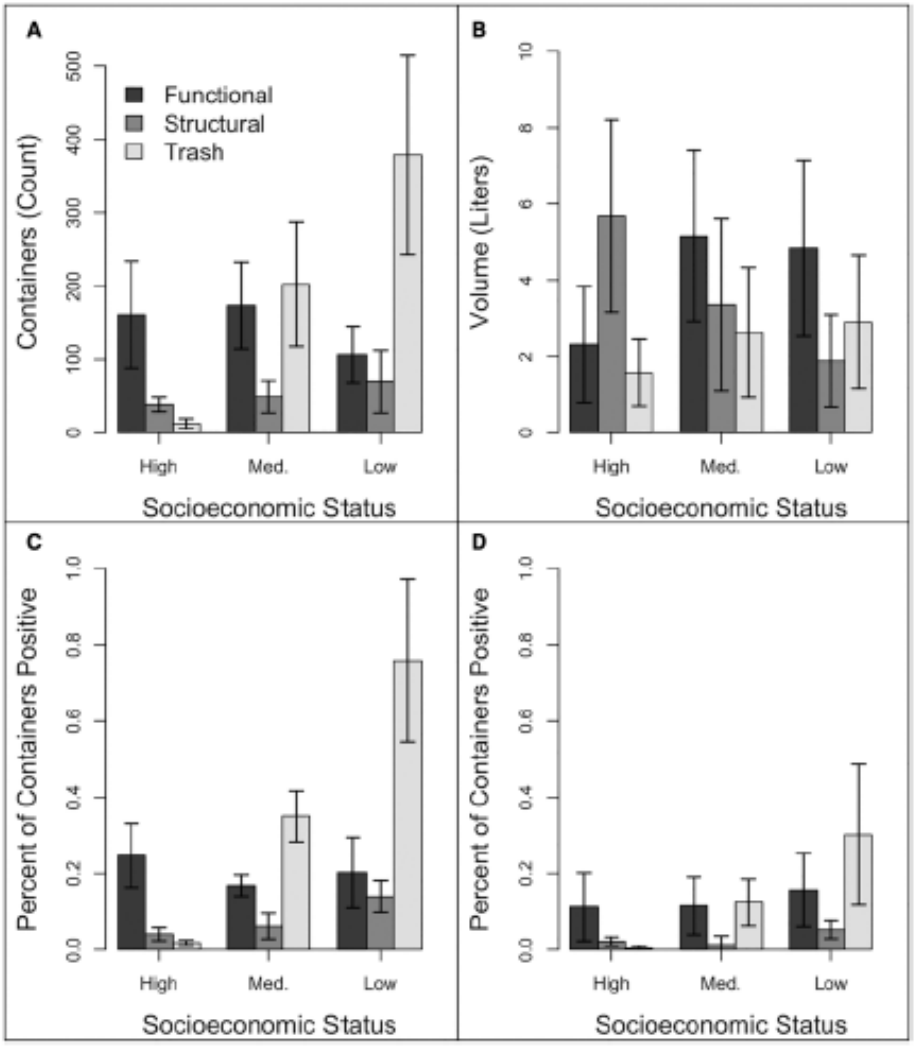


Fig. 2. (A) Mean containers per square kilometer; (B) Mean container size in liters; (C) Mean percent of containers positive for larvae; and (D) Mean percent of containers positive for pupae for each socioeconomic status and container type (functional, structural, or trash).

Socio-Ecological Mechanisms Supporting High Densities of Aedes albopictus (Diptera: Culicidae) in Baltimore, MD
E. Little, D. Biehler, P. T. Leisnham, R. Jordan, S. Wilson, and S. L. LaDeau

Is it a Bad Year?

Mosquitoes are tested all the time.

http://MosquitoResults.com/

2019 Massachusetts Arbovirus Daily Update

Killing frosts have occurred in all communities ending the threat of mosquito-borne disease transmission in Massachusetts. MDPH will conduct early season surveillance activities to assess the risk of WNV and EEE in 2020.

	Mosquito Samples Positive	Animals Positive	Humans Positive
WNV	87	0	5
EEE Virus	428	9	12

- Mosquito "pools" (e.g. 10-60 mosquitoes/pool)
- Mosquito species matters

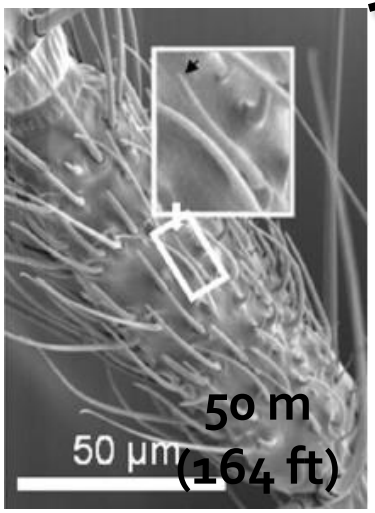
Barnstable	Falmouth	8/13/2019	Culiseta melanura	EEE
Barnstable	Truro	8/22/2019	Coquillettidia perturbans	EEE

Permethrin

- Ticks? Very effective
- Mosquitoes? Not as great

Detection

- Olfaction
- Vision
- Heat/humidity



Arctic (Toolik Field Station)

Eastern treehole mosquito
Ochelerotatus triseriatus

Ilona L.

Asian tiger mosquito (*Aedes albopictus*)
Tires/man-made structures