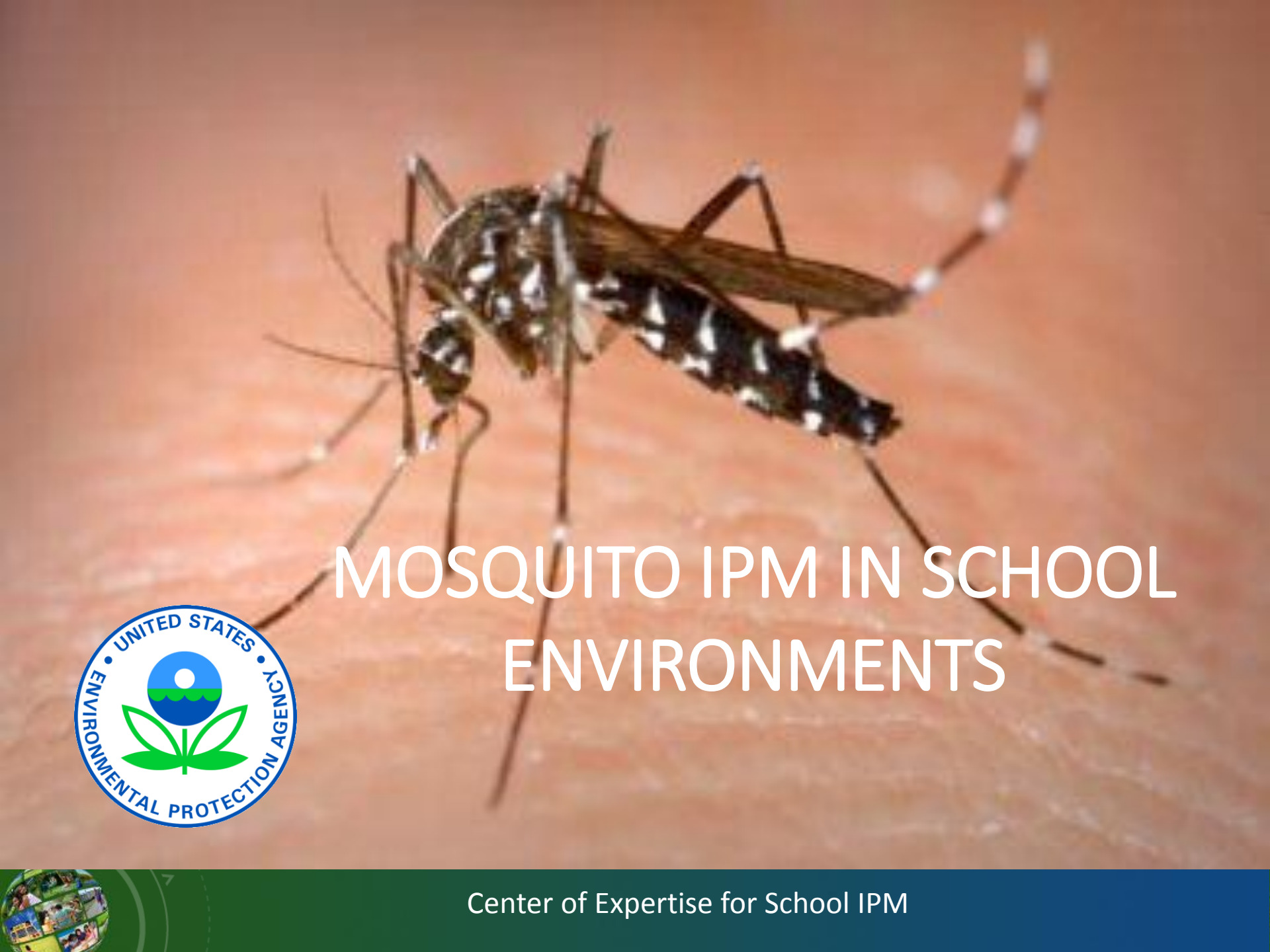
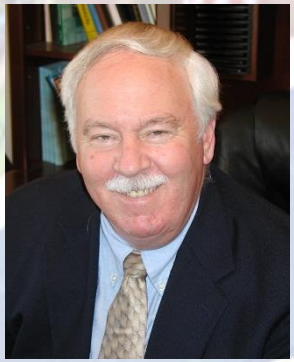


# MOSQUITO IPM IN SCHOOL ENVIRONMENTS

# Mosquito IPM in School Environments

- **Dr. Michael Merchant**

Mike is the urban entomology specialist ("bug expert") at the Texas A&M Research and Extension Center in Dallas. Mike received his Ph.D. in entomology from Texas A&M University, and M.S. in entomology from Purdue University. He has been a leader in promoting IPM in Texas schools and public housing and through his popular "insects in the city" blog.



**Mr. Joe Conlon**

Joe holds degrees in Parasitology, Medical Entomology and Secondary Science Education. During his naval career, he conducted vector control operations and consultations as US Navy entomologist in 37 different countries. As Technical Advisor, Mr. Conlon is responsible for drafting and submitting AMCA regulatory policy documents to local, state and national agencies, including EPA, USDA and USFWS and is a member of EPA's Pesticide Program Dialogue Committee.

- **Dr. Marcia Anderson**

Marcia is with EPA's Center of Expertise for School IPM in Dallas, Texas. She holds a Ph.D. in Environmental Management from Montclair State University along with degrees in Biology, Environmental Design, Landscape Architecture, and Instruction and Curriculum.

# Mosquito IPM in School Environments: Content

- Know your Vectors
- Habits / habitats
- Sanitation, Maintenance,
- Biological controls,
- Intro to Mosquito IPM
- Monitoring,
- Repellants
- Barriers,
- Larvicides/ biocides
- Insecticides
- Research and Resources

# INTRODUCTION TO MOSQUITO BIOLOGY AND KEY SPECIES

MICHAEL MERCHANT, PHD, BCE

PROFESSOR AND URBAN ENTOMOLOGIST

TEXAS A&M AGRILIFE CENTER AT DALLAS

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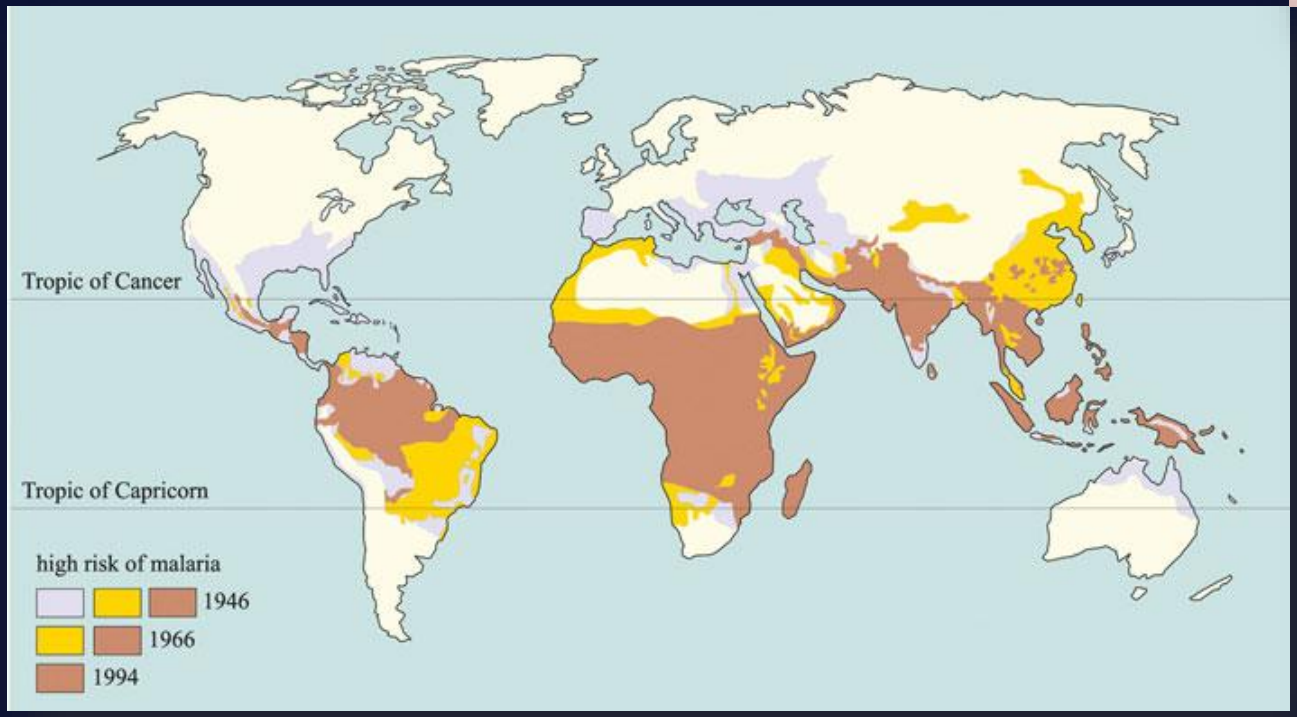
# MOSQUITOES: CULICIDAE

- 3,500 species worldwide
- Occur on every continent except Antarctica.
- Most important arthropod affecting human and animal health.
- Diverse habitats; some have become “domesticated”.
- Hundreds of millions of dollars spent on control in U.S. for nuisance reasons alone.

Courtesy G. Hamer, Dept. Entomology, Texas A&M University

# *ANOPHELES*
# MALARIA MOSQUITO

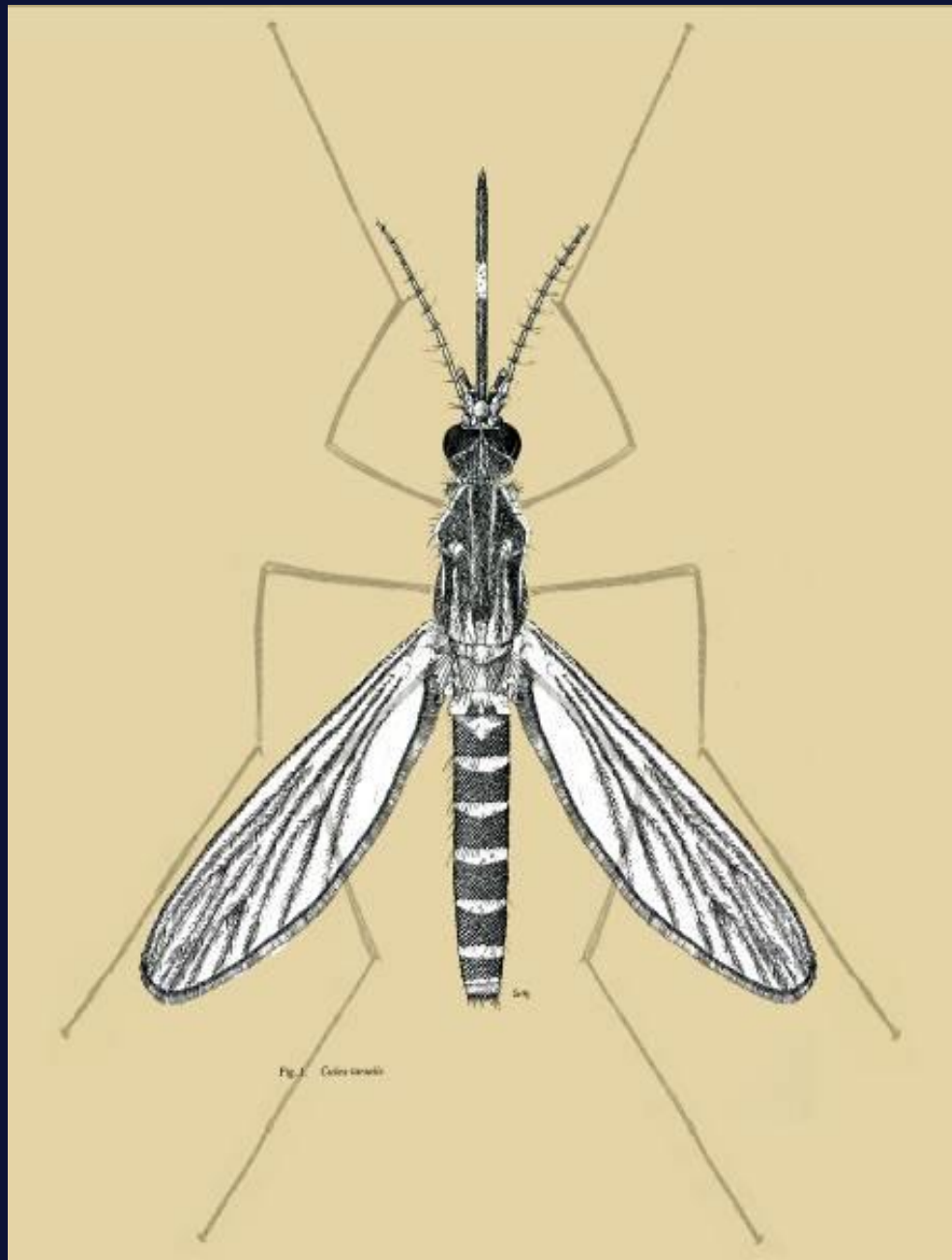



- 219 million cases in 2010 (cf. 34 m AIDS cases)
- 660,000 deaths annually
- 90% cases in Africa
- $1.84 b international aid

# RECOGNIZING MOSQUITOES

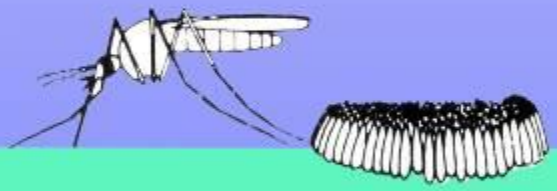
- The fly order (Diptera)
  - Family Culicidae
  - long proboscis
  - long legs
  - scales on wing veins
- 172 species in U.S.

from Bohart and Washino. Mosquitoes of California

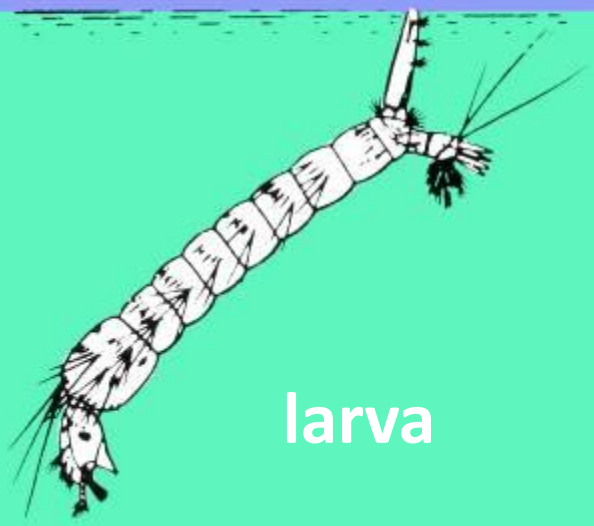


# MOSQUITO LIFE CYCLE

adult



eggs



larva

pupa

# CULEX EGGS

Photos: Institute for Clinical Pathology and Medical Research, University of Sydney, Australia

US Armed Forces Pest Management Board

# AEDES EGGS


Ovitrap with eggs of *Aedes aegypti*

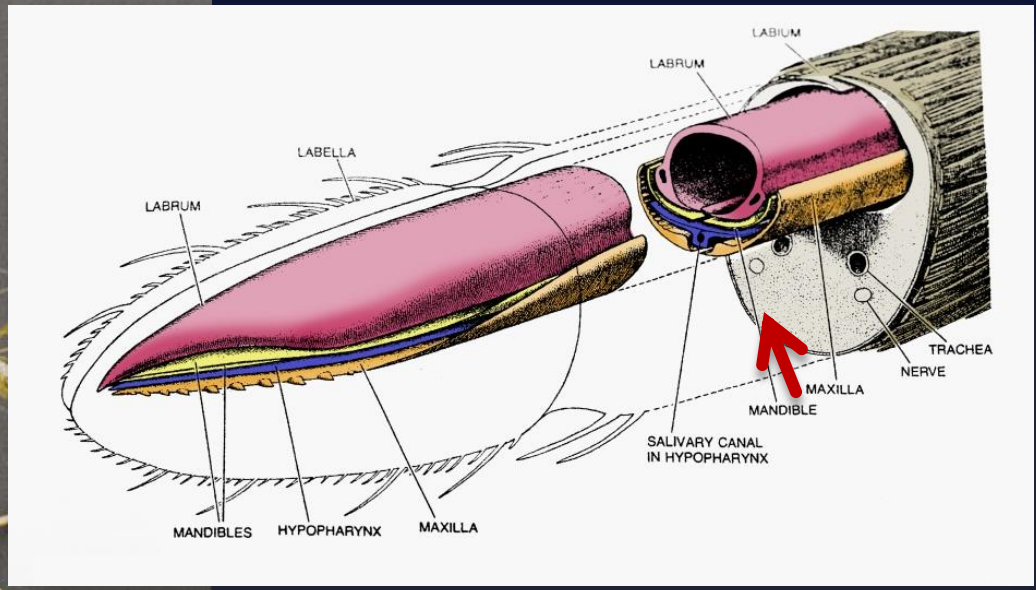
# MOSQUITO LARVAE

- Aquatic insects
- 4-14+ days from egg to adult
- Adults may be strong to weak fliers, depending on species

Photo: M. Merchant, Texas A&M AgriLife

Marin/Sonoma Mosquito and Vector Control District

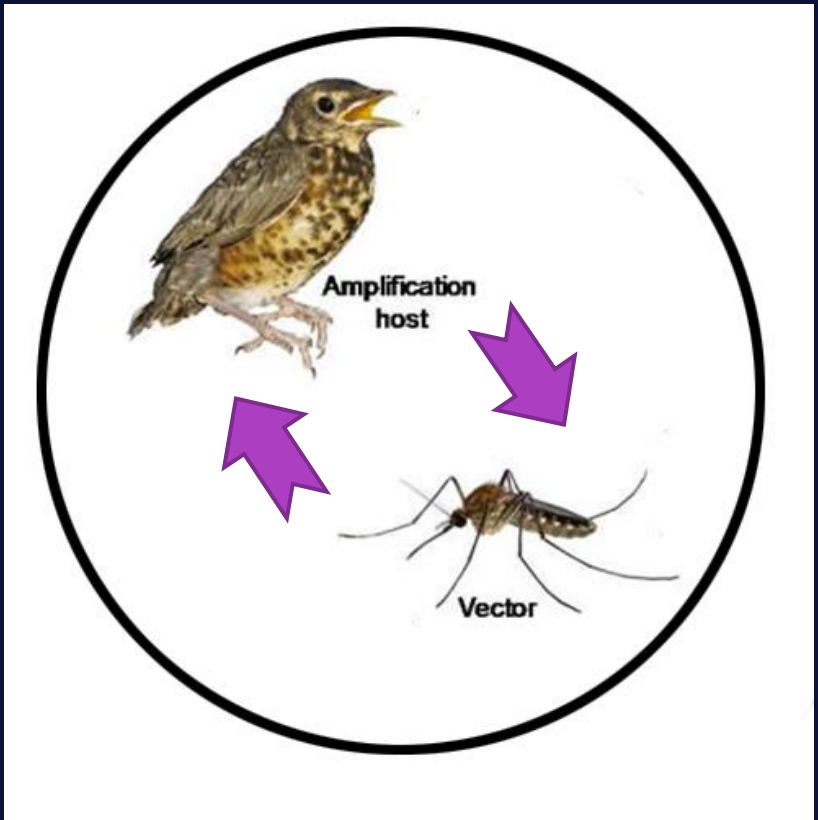
# MOSQUITO MOUTHPARTS




Modified from Scientific American, Tom Prentiss

# Mosquito feeding

## MOSQUITO HOSTS




- Plant nectar or honeydew for first 3-5 days after emergence
- Blood of vertebrate hosts need for most species to initiate egg development
  - Birds
  - Mammals
  - Reptiles
  - Amphibians

# MOSQUITO DIVERSITY

- Two basic types
  - Floodwater mosquitoes
  - Standing water (container) breeders
    - natural sites
    - artificial sites

# COMMON PEST SPECIES IN TEXAS

- Floodwater species
  - *Psorophora columbiae*
  - *Aedes vexans*
- Standing water species
  - *Aedes albopictus/aegypti*
  - *Aedes solicitans*
  - *Culex pipiens/quinquefasciatus*
  - *Culex tarsalis*

# FLOODWATER SPECIES

## *PSOROPHORA SPP.*

## *AEDES VEXANS*

- Typically live 4-5 days (up to one month)
- Excellent fliers (5-10 miles or more)
- eggs survive up to 2 years in soil
- painful bites

# FLOODWATER SPECIES

- Difficult to control
  - drainage of marshes
  - floodwater control
  - community fogging
  - avoidance
- Water only needs to stand 3-4 days to successfully breed mosquitoes
- Not important disease vectors

# MAJOR STANDING WATER SPECIES

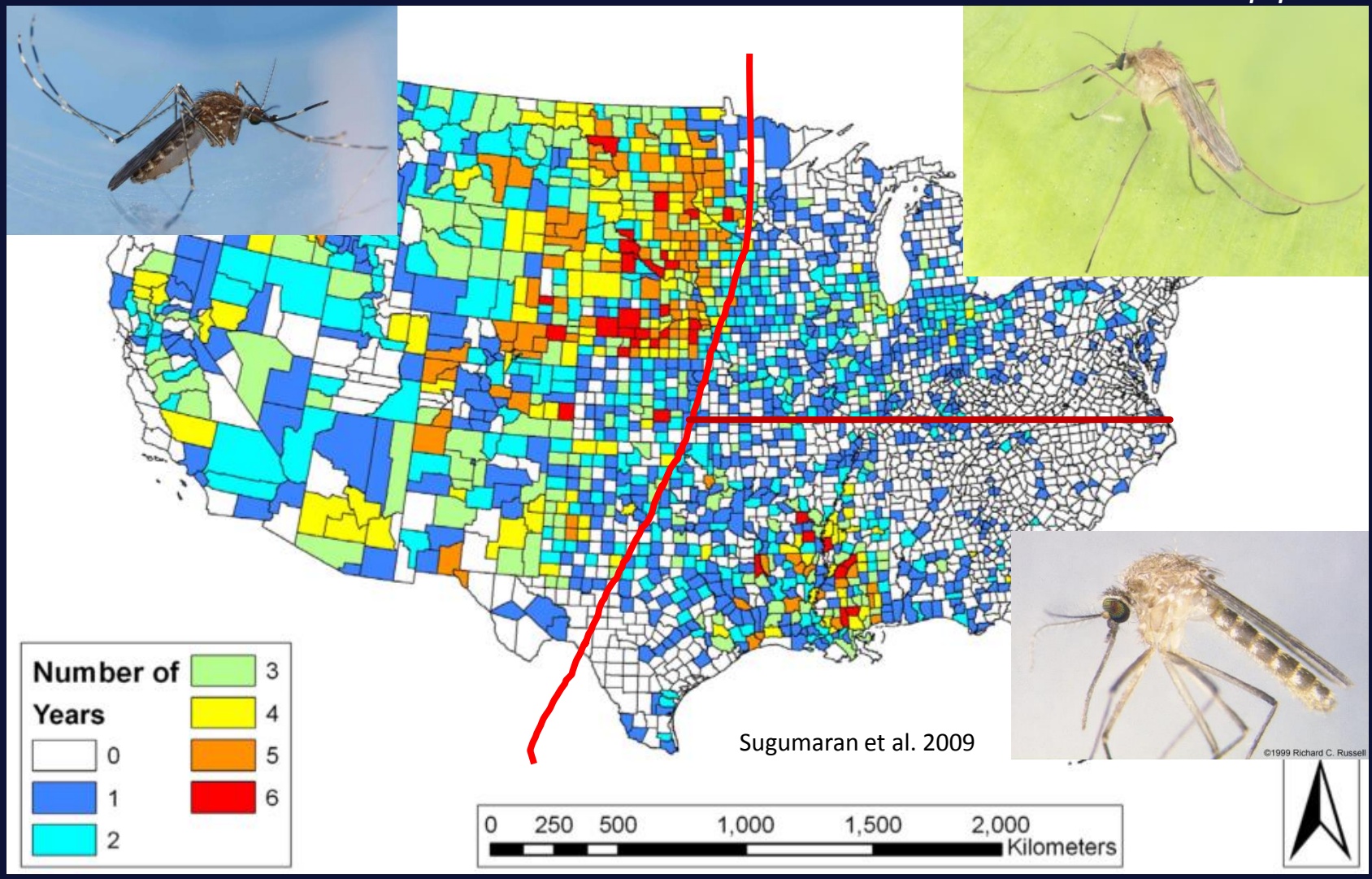
*CULEX, AEDES*

- Culex quinquefasciatus
- Culex tarsalis (West TX)

# *Culex* spp. mosquitoes responsible for WNV human incidence

*Culex tarsalis*

*Culex pipiens*




*Cx. quinquefasciatus*

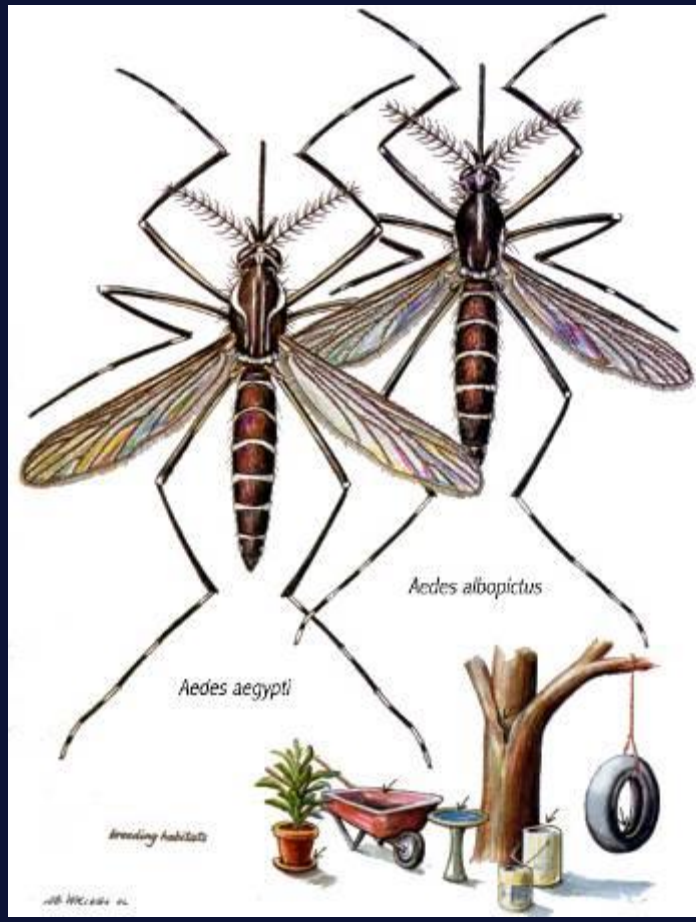
Courtesy G. Hamer, Dept. Entomology, Texas A&M University

# *CULEX PIPIENS/QUINQUEFASCIATUS*
# HOUSE MOSQUITO

- delicate, dull brown mosquito; lacks bands on tarsi and proboscis
- prefers polluted water in containers or other standing water
- mostly feeds on birds, but thought to be principal vector of WNV to humans

# OTHER STANDING WATER SPECIES

- *Aedes albopictus** - *Asian tiger mosquito*
  - Since early 1990s in eastern Texas
  - Daytime biter
- *Aedes aegypti* – yellow fever mosquito
  - container breeder
  - vector of yellow fever, dengue fever
  - being replaced by tiger mosquito?
- *Aedes solicitans* – salt water mosquito
  - saline/brackish water
  - vicious, daytime biter



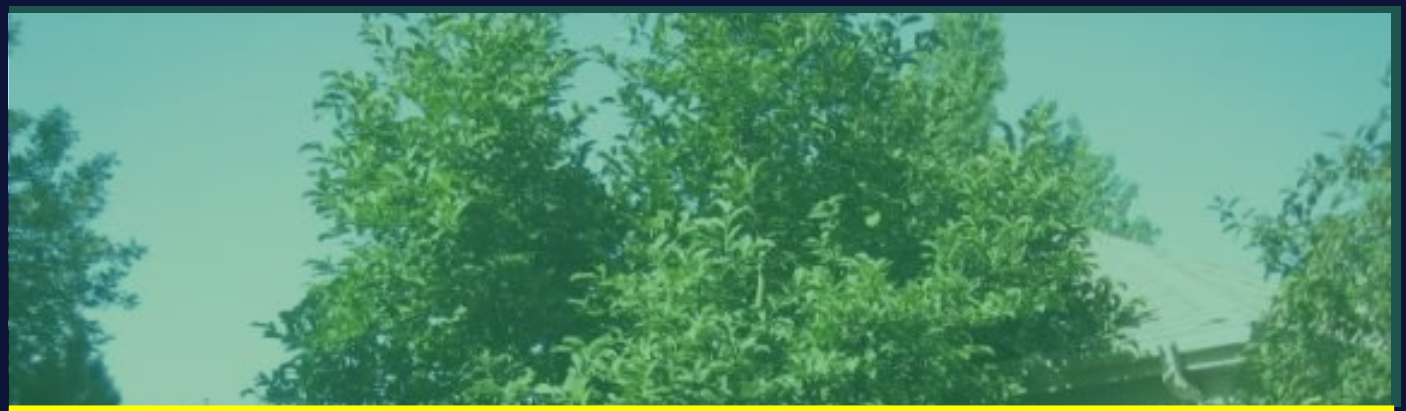
*AEDES ALBOPICTUS*
ASIAN TIGER MOSQUITO

# WHY THE DIFFERENCE BETWEEN *AEDES* & *CULEX*?

*Culex*

Culex resting sites

8 – 10 feet



*Aedes*

# Mosquito Adaptation and Expansion

## *Aedes albopictus,*
## Asian Tiger Mosquito

- **Native to tropical and subtropical regions**
- **Successfully adapted to cooler regions**
- **Hibernate over winter in temperate regions**
- **One of world's 100 worst invasive species**
- **Vectors of dengue, DHF, Chikungunya, yellow fever**

# How do cold-adapted mosquitoes overwinter?

- *Culex pipiens*

- *Aedes aegypti*

- ***Culex sp.***
  - **Adult females mate and build fat body by feeding on carbohydrates**
  - **Females find refuge in protected areas that stay above freezing**
  - **Metabolism slows considerably and winter is spent in a state of torpor**
- ***Aedes aegypti***
  - **Eggs viable for over a year in a dry state**

# How Do Mosquitoes Choose their Feeding Targets?

- **Chemical, thermal, and motion sensors, and sight**
- **Detect movement up to 10m away**
- **Attracted to heat/body warmth**
- **Sense exhalation of water vapor and $CO_2$**
- **Attuned to ammonia and lactic acid in concentrations**

# Aedes Feeding Preferences

- **An aggressive biter, especially in early morning and late afternoon**
- **Prefers shady areas, or cloudy weather**
- **Bite more frequently in warm and humid weather**
- **Bite around the ankles**
- **Feed only once every 3-4 days**


*Aedes aegypti*, left; *Aedes albopiticus*, right

# Aedes Breeding Sites

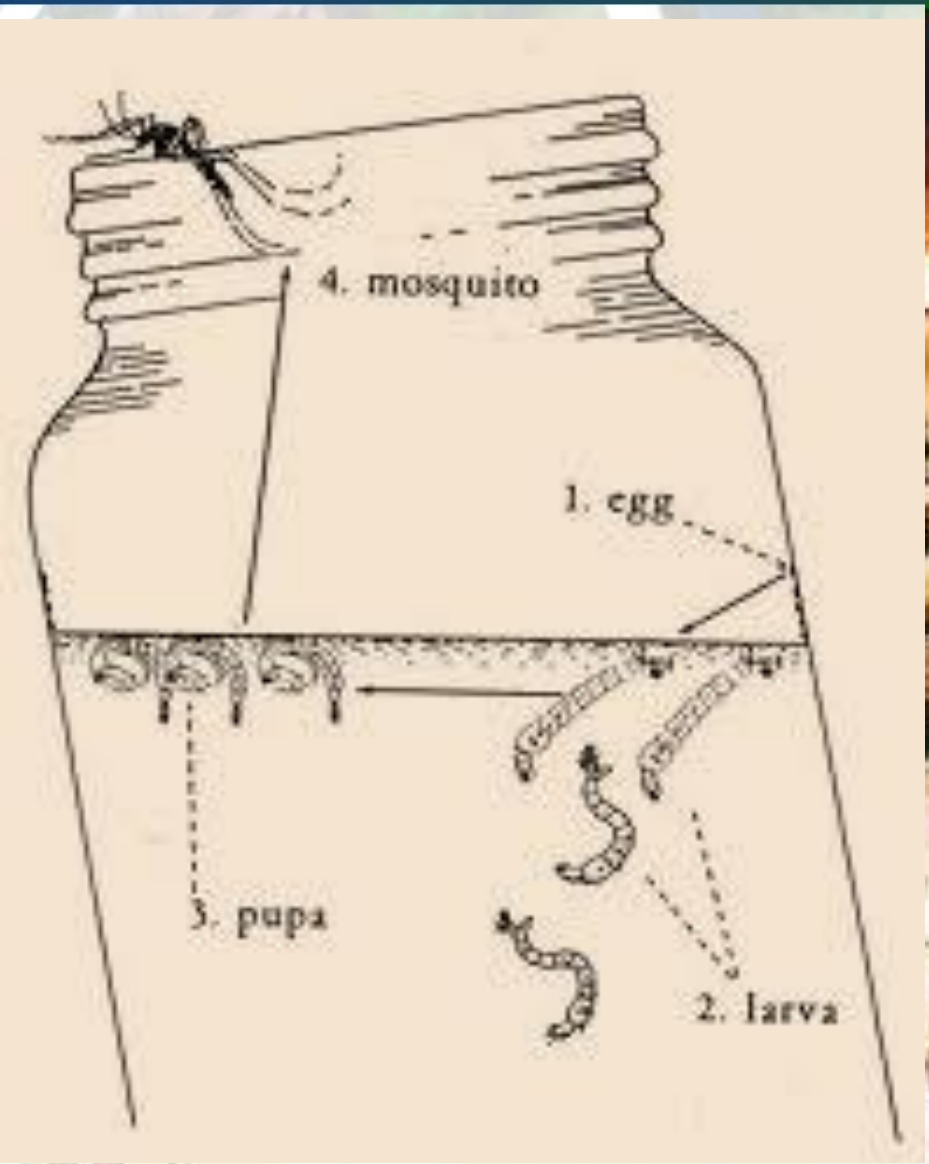
- Primarily man-made containers - cans, jars, cisterns, fountains, planters, plastic food containers, used tires, and tarps.
- Prefer clean water
- Need only ¼” of water - bottle caps or puddles




# *Culex* Breeding Sites

- **Prefer standing water rich in decomposing organic material**
  - Dead leaves, grass clippings, and algae break down to produce an attractive organic infusion
- **Flooded wooded areas, catch basins, storm sewers, cisterns, and flood water pools**

# Just One Example…




# Natural Breeding Sites

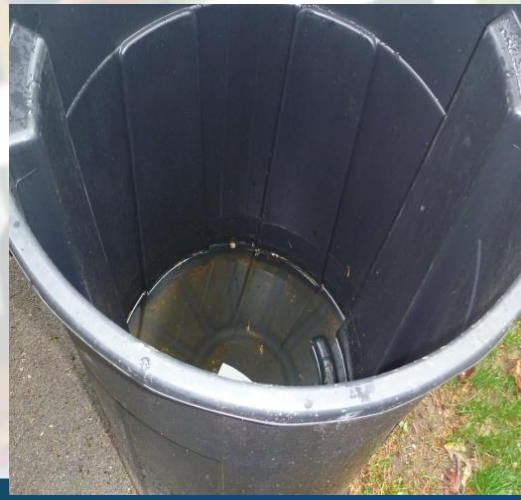
- Tree holes
- Leaves that gather to form "cups"
- Long standing puddles
- Potholes

# Clogged / Damaged Stormwater Drainage Systems

- **Standing water occurs when drainage is blocked**
- **Standing water = prime larval habitat**
- **Monitor swales, ditches and drains**

# Community Habitats

- Rain gutters
- Flat roofs
- Garbage cans and dumpsters without proper drainage

# Tree Holes

- Mosquitoes breed in water found in tree holes
- Prevent by filling holes with insulating foam
  - Do not use concrete, or bricks

# Other Mosquito Habitats

Toys and children's play equipment that collect water

# Biological Controls

**Biological control agents may be indigenous mosquito eating fish, insects, or other native predators.**

# Fish

- Does your school have:
  - open water on the grounds?
  - decorative fountains or pools?
  - ponds or containers to collect rainwater?

- Fish are the most important predator of mosquito larvae
- Mosquitoes are rarely a problem in water that contains fish
- Mosquito-eating fish have been used world-wide

# Mosquito Fish: *Gambusia affinis*

- **Predator of mosquito larvae in various aquatic habitats**
- **Used by mosquito control agencies from New Jersey to California to eliminate mosquitoes in unused swimming pools, abandoned sewers, mine pits and permanently flooded stormwater facilities**

# Guppy: *Poecilia reticulata*

- **Used for biological mosquito control since World War I**
- **Provide good control in polluted sources and slightly acidic pools**
- **Survive in waters with low dissolved oxygen levels**

# Mosquito Larvae Are Like Potato Chips To Goldfish!

- **Work well in birdbaths, decorative fountains and pools**

- **Hardy fish that quickly feast on the mosquito larvae**
- **Get along well with other fish**

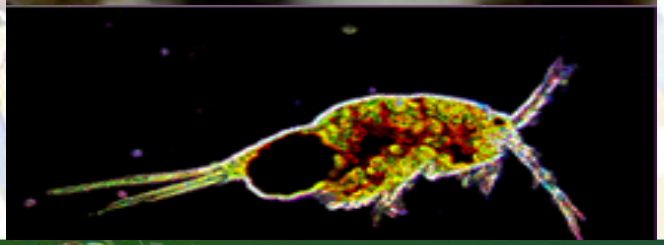
# Environmental Precautions

**Follow local regulations when introducing any species**

- **Do not to introduce non-native fish into natural aquatic environments**
- **Remember that flooding can easily translocate fish from an isolated small pool, pond, or gulley into a larger water system**
- **Non-native fish can outcompete native fish**

# School Rain Barrels

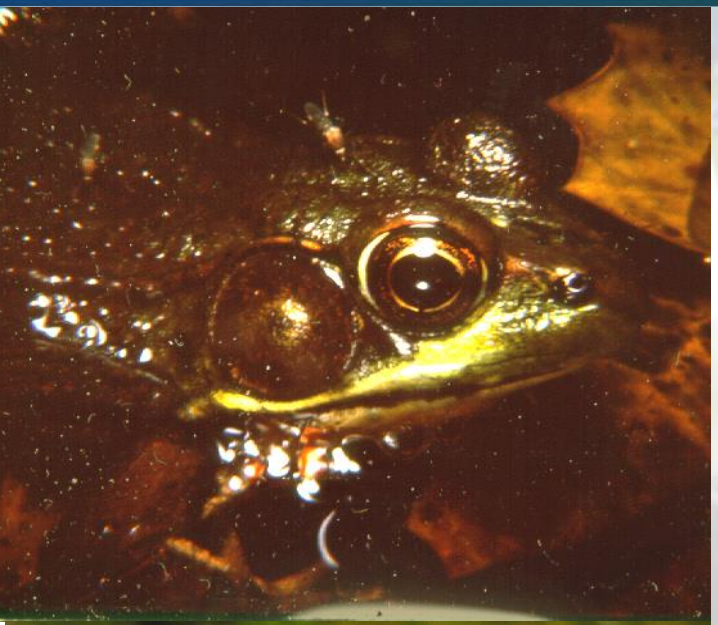
# Cyclopoid Copepods



- **Tiny crustaceans with an appetite for mosquito larvae**
- **Used successfully in many countries and in Puerto Rico, NJ and LA.**
- **More effective than any other predatory invertebrate**
  - **Nearly 100% effective in eradicating *Aedes* larvae**
- **Easy and inexpensive to mass produce**

# School Rain Gardens


# Frogs And Tadpoles



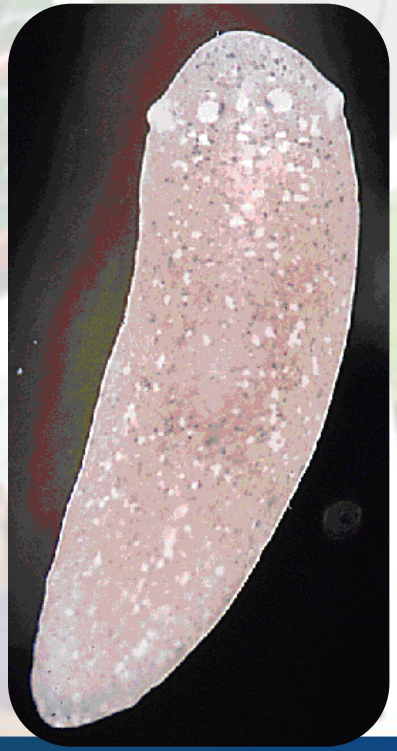
- Tadpoles reduce mosquitos in artificial containers
- Only a few tadpoles eat mosquito larvae but tadpoles compete with them for food

# Turtles

- Used in roadside ditches in Louisiana for control of *Culex* larvae
- Reduced larvae by 99% within 5 weeks
- Red-eared slider (*Trachemys scripta*) used effectively for mosquito larval control in water storage tanks in Honduras

# Flatworms

- Many found on the bottom of water bodies
- Terrestrial species are mostly nocturnal and live in humid areas (leaf littler or rotting wood)



- Three species (G*irardia*, *Mesostoma,* and *Bothromesostoma*) are natural mosquito larvae predators in temporary puddles and permanent pools
- In laboratory tests, flatworms killed 52%-100% of mosquitoes larvae

# Flatworms

- Some flatworms (*Mesostoma*) kill mosquito larvae just by brushing on them
- Used in association with other biological controls

# Dragonflies

- Predators that eat mosquitoes and other small insects
- Found around lakes, ponds, streams and wetlands
- Spend up to 5 years as aquatic nymphs

# INTEGRATED MOSQUITO MANAGEMENT WITHIN A SCHOOL ENVIRONMENT

**Joseph M Conlon**
**Technical Advisor**
**American Mosquito Control Association**

# INTEGRATED MOSQUITO MANAGEMENT PRINCIPLES

1. Knowledge based - bionomics

2. Surveillance driven – what is current situation/trends

3. Resource limited

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# INTEGRATED MOSQUITO MANAGEMENT ELEMENTS

1. Public Education/Community Involvement
2. Source reduction
3. Larvae
    - Surveillance
    - Control
4. Adult
    - Surveillance
    - Control

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# PUBLIC EDUCATION
# COMMUNITY INVOLVEMENT

**Students and Interns**

**Schools**

**Youth Programs**

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Source Reduction

# Surveillance-driven

- **Spray operations should NEVER be scheduled on a recurring basis!**
- **All control is governed by survey results indicating a specific need**

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# SURVEILLANCE-DRIVEN INTERVENTION THRESHOLDS

- Historical tolerance
- Political considerations
- Disease transmission history and potential
- Surveillance tool utilized
- Time of year utilized
- Species of mosquito
- Resistance situation

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# Larval Surveillance

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# Adult Surveillance

## Gravid Trap

## Landing Counts

## CO2- baited Light Trap

## New Jersey Light Trap

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# ADULTICIDING

- **Residual Barriers – Pyrethroids/Essential Oils**

# ADULTICIDING

## Ultra Low Volume (ULV)

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# ULV DROPLET SIZE

## THE VOLUME OF
## ONE BB SHOT

**WOULD MAKE;**

**9,761,000 20 µm DROPLETS**
**15,079,991 17 µm DROPLETS**
**74,088,000 10 µm DROPLETS**

# ULV ADULTICIDES

| Organophosphate | Active Ingredient/Acre |
|---|---|
| Malathion | 0.48 oz |
| Naled | 0.8 oz |
| **Pyrethroid** | |
| Pyrethrum | 0.028 oz |
| Permethrin | 0.056 oz |
| Sumethrin | 0.038 oz |
| Etofenprox | 0.028 oz |

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# INTEGRATED MOSQUITO MANAGEMENT WHAT IT IS NOT

- Does not seek eradication
- Pesticide Averse
- Unless circumstances dictate, sole reliance on:
  - Source Reduction
  - Biorational Larvicides
  - Chemical larvicides/adulticides
  - Traps
  - Repellents
  - Natural Predators

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# DIALOGUE WITH DOH/MCD!

**Outdoor event scheduling**

**Group projects with DoH/MCD**

**DoH/MCD presentations at PTA meetings**

**Commercial Operators?**

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# BOTTOM LINE

- **Maintain dialogue with DoH/MCD**
- **Remove/modify sources**
- **Educate parents/students**
- **Repellents – EPA registered**
- **Adulticiding not usually recommended**

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# EPA-REGISTERED REPELLENTS

- **DEET**
- **Picaridin**
- **Oil of Lemon-Eucalyptus**
- **IR3535**
- **Resources**
  - http://www.cdc.gov/features/StopMosquitoes/
  - http://www2.epa.gov/insect-repellents
  - http://npic.orst.edu/az.html#R

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# BAITS

- **Attractive Targeted Sugar Baits**
  - **Terminix**

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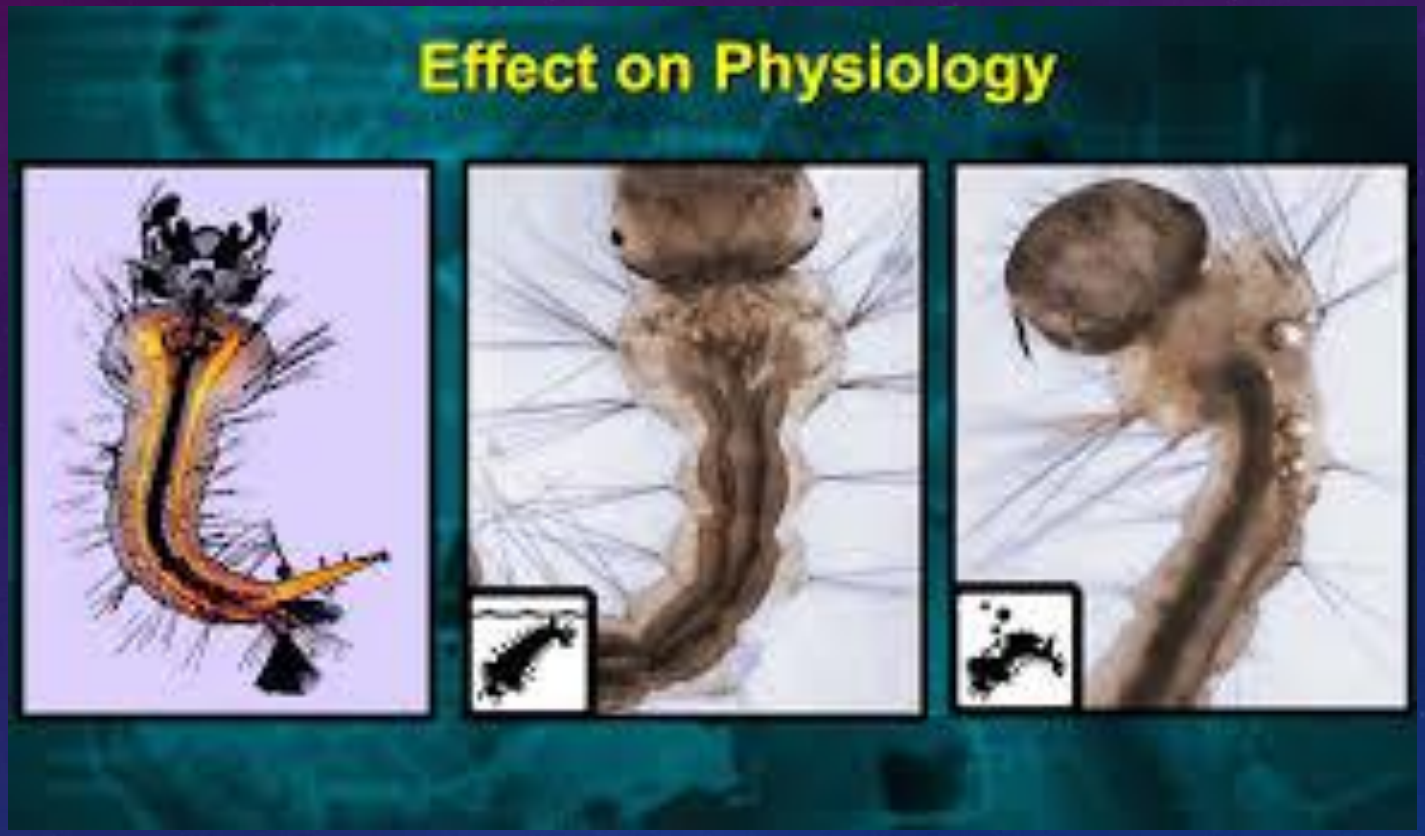
# ACOUSTIC LARVICIDES

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# ACOUSTIC LARVICIDES

TEXAS A&M AGRILIFE EXTENSION

# Other forms of mosquito control

MICHAEL MERCHANT, PHD, BCE
PROFESSOR AND URBAN ENTOMOLOGIST
TEXAS A&M AGRILIFE CENTER AT DALLAS
M-MERCHANT@TAMU.EDU

# Mechanical control: screening

# Bug zappers & other "sure-fire" mosquito remedies

- Zappers ineffective in reducing mosquito bites
- Citronella plants not known to repel mosquitoes

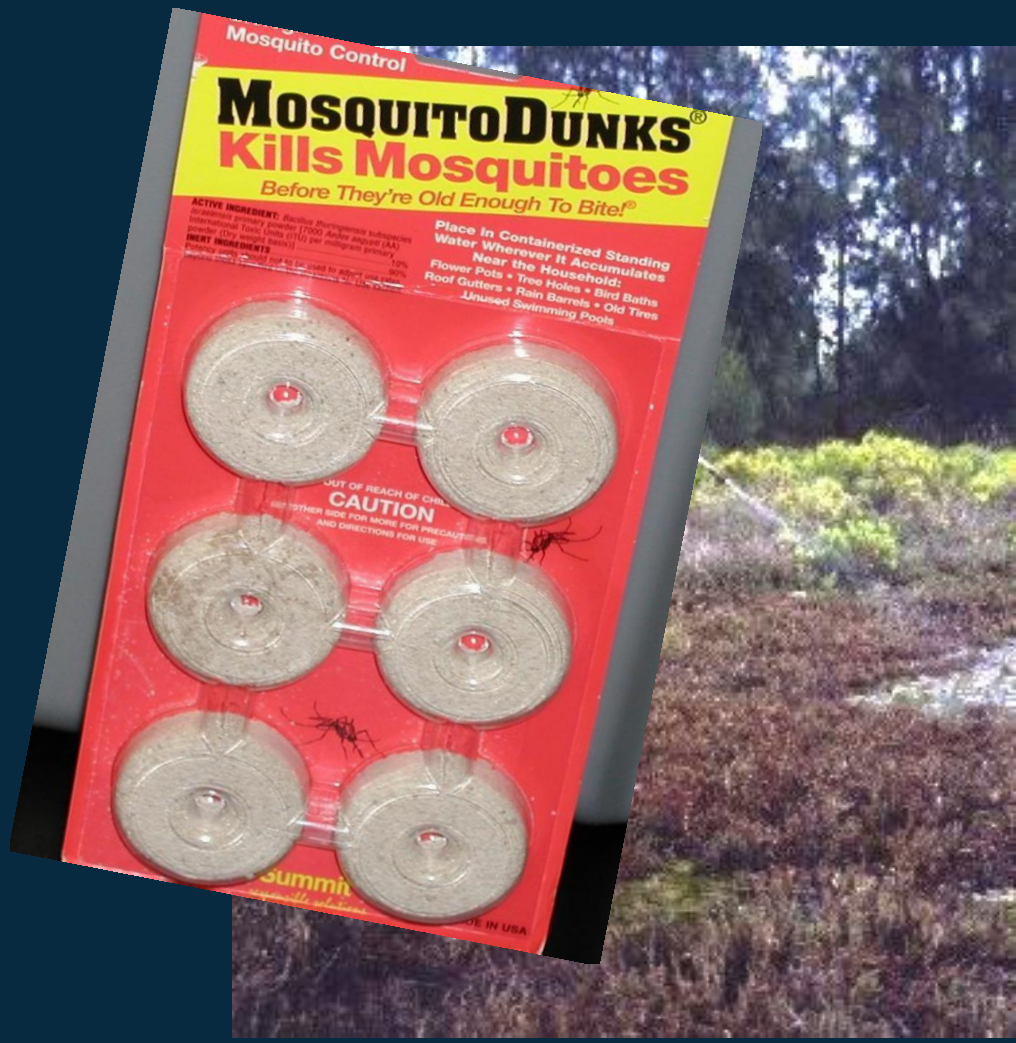
# Purple martins & bats not highly effective


Incompatible with effective mosquito control:

- Time of day
- Altitude
- Habitats where mosquitoes live not hunted by these predators

# Chemical controls: Larviciding

- Application of chemicals or organisms to kill immature mosquitoes in the water
- Oils
- Monomolecular films
- Insecticides
  - IGRs
  - *Bacillus thuringiensis (Bti)*



# *Bt* not true biocontrol

# *Bacillus sphaericus*

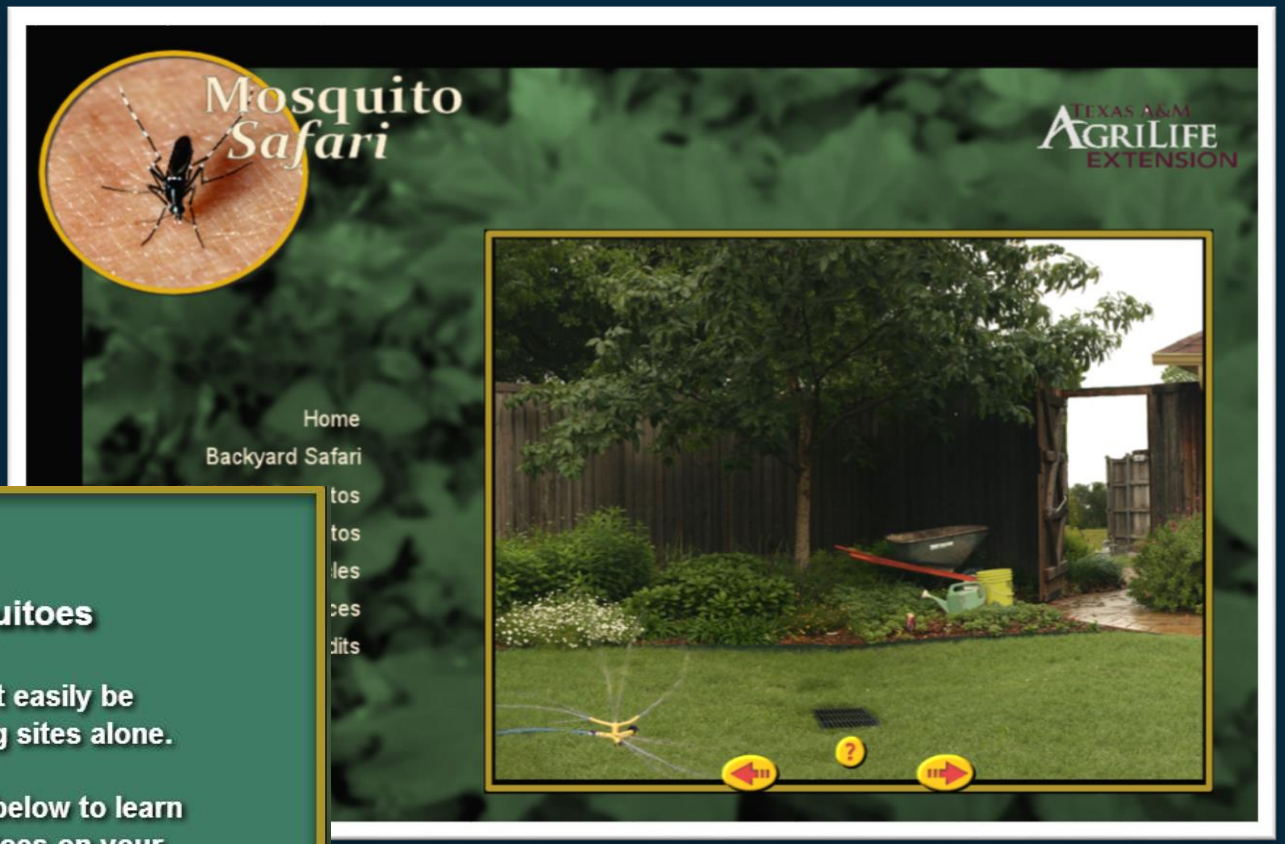
- Live bacterium
- More toxic to Culex and Anopheles
- Better choice for highly polluted sites
- Capable of persisting in mosquito population as it reproduces in mosquito population


Parasporal crystal within Bacillus sphaericus

# Insect growth regulators (IGRs)

- (s)-methoprene provides up to 30 days of control in standing water
- Toxic only to insects

# Mosquitosafari.tamu.edu




# Questions?