Mosquito Behavior

- Aquatic-breeders
- 4-14+ days from egg to adult
- Most important urban species breed in polluted stagnant water
- Active mostly in evenings and at night, adults rest in shady areas during the day
Female (ONLY) takes a blood meal for egg development

- Vector by taking blood meal

- Life span
  - Males ~ 1 or 2 weeks
  - Females ~ up to a month
Two basic types
- Floodwater mosquitoes
- Standing water (container) breeders
  - natural sites
  - artificial sites

Photo: M. Merchant, Texas A&M AgriLife
Prefers polluted water in artificial containers or other standing water (ground water, sewer catch basins)

Mostly feeds on birds, but thought to be principal vector of WNV to humans

Also vectors of SLE, heartworm
Container breeder
Daytime, evening biter
Vector of yellow fever, Dengue fever, CHIK, Zika Virus
Being replaced by tiger mosquito?
- Artificial container, treehole breeder
- Since early 1990s in eastern Texas
- Aggressive daytime biter
- Vector of CHIK, Dengue fever, Zika Virus
West Nile virus
Encephalitis
  - SLEV
  - EEEV
  - WEEV
  - LACV
Dog heartworm
Dengue Fever
Chikungunya
Zika
West Nile Virus
Birds are amplifying hosts
- Source of virus for feeding mosquitoes
- Some species, e.g. crows, jays, experience high mortality rate (bird die off events)

Humans are dead end hosts for the mosquito-vectored cycle
- Low virus level in blood, so not a source of virus for feeding mosquitoes
- HOWEVER, human to human transmission occurs without mosquito involvement
  - Blood product transfusion
  - Mother to fetus
  - Organ transplant
  - Occupational (lab)
  - Breast milk (1 probable case)

Horses are dead end hosts
Virus Entry Into the USA - 1999

Modification of CDC map at:
http://www.cdc.gov/ncidod/dvbid/westnile/Mapsactivity/surv&control99Maps.htm

Avian, animal or mosquito infections.

Indicates human disease case(s).
Virus Movement through 2001

Modification of CDC map at:
http://www.cdc.gov/ncidod/dvbid/westnile/Mapsactivity/surv&control01Maps.htm

- Green: Avian, animal or mosquito infections.
- Dark Green: Indicates human disease case(s).
Rapid Spread of Virus - 2002

Modification of CDC map at:
http://www.cdc.gov/ncidod/dvbid/westnile/Mapsactivity/surv&control02Maps.htm

Avian, animal or mosquito infections.
Indicates human disease case(s).
West Nile neuroinvasive
West Nile fever
Horses
Mosquitoes
All 4
Or all but Horses
248 total human cases

Texas Counties with West Nile Virus Activity, 2015

177
71
1533
28

Positive County
County with positive blood donor

N = 98

Map updated by the Zoonosis Control Branch on: 12/9/2015
Asymptomatic

~80% of infections

IgG can persist for many years

WNV Human Infection “Iceberg”

<1%
WNND disease

~20%
West Nile Fever

~80%
Asymptomatic
West Nile Fever
10-30% of infections
Fever, headache, rash, fatigue
WNV Human Infection “Iceberg”

WNV Neuroinvasive Disease (WNND)

1/150 of all infections

- Meningitis (25-35%)
- Encephalitis or meningoencephalitis (60-75%)
- Myelitis or flaccid paralysis syndrome (rare)
Zika Virus
Zika Virus

- Member of the Flavivirida virus family
  - Hundreds of Thousands! confirmed cases – 31,555 in Colombia (5,013 pregnant); 400,000 – 1.3 million in Brazil (estimated)
  - 10 in TX, 52 US
- Related to dengue, yellow fever, Japanese encephalitis and WNV
- Linked to microcephaly
  - 4,300 suspected cases in Brazil
  - 51 babies have died

- Most common symptoms of disease are
  - Fever
  - Rash
  - Joint pain
  - Conjunctivitis
- Usually mild with symptoms lasting days to a week
Prior to 2015, outbreaks in areas of Africa, Southeast Asia, and Pacific Islands.

52 travel associated cases

- Bolivia
- Colombia
- Curacao
- Ecuador
- French Guiana
- Guatemala
- Haiti
- Jamaica
- Mexico
- Panama
- Puerto Rico
- Suriname
- US Virgin Islands
- Venezuela
- Cape Verde
- Tonga
Effective, environmentally sensitive approach to Mosquito Management

Combines several control tactics for best possible results

Must know your pest – biology, ecology, and habitat

1. Surveillance
2. Mapping
3. Set Action Thresholds
4. Physical Control or Source
5. Biological Control
6. Public Health Mosquitocides
7. Public Education
8. Record Keeping
IMM does not emphasize mosquito elimination or eradication

Methods are specifically tailored to safely control each stage of the mosquito life cycle
3 Main Principles of IMM

1. Start by identifying your pest

2. Pests are managed to acceptable levels based on the use of thresholds

3. The best way to manage pests is to use multiple control tactics
1. Identify Pest

- Survey
- Identify genera / species
- Locate ecological habitat
Points which pest populations are large enough to justify commencing control measures

Are set for a specific pest and site

Goal is to protect human health
3. Use Multiple Control Tactics

- Promote a rational use of pesticides.
- Utilize biological controls (native, noninvasive predators) to conserve and augment other control methods.
- Utilize source reduction (elimination, removal or reduction of larval mosquito habitats) where practical and prudent.
- Use target specific pesticides at the lowest effective rates to the extent possible.
Larvicides
Target immature mosquitoes in aquatic habitats

Killing immatures prevents
  - adult emergence,
  - biting, and
  - disease spreading

Oviposition sites are localized and concentrated
  - Makes them more efficient to control
Control mosquito populations naturally in their oviposition habitats without harming the environment

- Mosquito fish – *Gambusia affinis*

- Predatory aquatic insect nymphs and larvae
To use, must have basic knowledge of

- Mosquito biology & ecology
- The agents to be used
Larvasonic devices (acoustic larvicides)

- Kill larvae by emitting sounds
- The sonic frequency travels through the water
- Disrupts the mosquito larvae’s air bladder
Larvasonic devices

- By the bladder absorbing the energy of the acoustics
- Then the base of the larva’s heads ruptures
- Larvae die
Source Reduction

- Attack mosquitoes at the source
  - Eliminate potential larval habitats

- Tactics
  - Improve land drainage
  - Shred tires
Urban areas pose a problem
  - Eliminate open sewage / septic systems
  - Artificial containers – public knowledge

But efforts must commence
Effective and safe methods

- Insect growth regulators (IGR)
- Biological insecticides
- Oils & Films
- Organophosphate

Generally affect the environment less than adulticides
Bti

- Need higher rates of application
  - Older larvae
  - Polluted septic water
  - Heavy algae grow

- No effect on pupae

- Does not harm other insects, fish or animals
Many formulations
- Wettable powders
- Liquids
- Capsules
- Granules
- Briquettes

Granules break down in 48 hrs

Briquettes last up to 30 days
Bacillus sphaericus

- Effective against larvae
- Occurs worldwide naturally
- Causes damage and paralysis to the gut of larvae, they starve to death
- Not harmful to people, mammals or aquatic life if applied following label directions
 Comes in a granular form that must be mixed with water
  o Spray on ground or by air

 Residual - 1 to 4 weeks

 Is a bit more expensive than Bti
  o Contains living spores
  o Recycles in water pools
  o Persists more than 30 days
  o More effective in dirty water
Spinosad

- Based on naturally occurring bacteria
- Highly effective by contact and ingestion
- Diminished effectiveness in polluted waters and full sunlight
- More expensive than Bti and Bs

Can be used in
- Catch basins
- Woodland pools
- Fresh floodwater areas
- Polluted or impounded waters
- Marshes
Chemicals that kill insects by interfering with their growth and development

- (s)-methoprene, acts like a hormone, prevents:
  - normal molting
  - egg-laying
  - egg hatching
  - and life cycle development
Does not harm non-target species or fish

Use in multiple locations
- ditches
- lakes
- ponds
- tires
- catch basins
- cattail marshes

Several formulations:
- Liquid – 7 – 10 day residual
- Granular
- Briquettes – 30 and 150 day

- flooded areas
- irrigated cropland,
- rice fields,
- storm drains
- swimming pools
Adulticides
Conducted by trained applicators when
- Source elimination or larval control measures are not feasible
- Or are clearly inadequate
- Or when faced with imminent mosquito-borne disease

Adulticide products are chosen based upon
- Efficacy against species targeted for control
- Resistance management concerns
- Minimization of potential environmental impact
Adulticides

- Insecticides targeted at adult mosquitoes
- Needed to kill adult mosquitoes
- Can be deployed quickly and produce immediate results
- Conducted correctly, insecticides can reduce the risk of disease transmission
- Can be costly but necessary

Photo courtesy Dallas Morning News
Pyrethroids

- Synthetic chemicals
  - like pyrethrins
- Block movement from brain to muscles
- Last longer in the sunlight than pyrethrins
- Do not harm most people
- Can kill fish in high concentrations
Pyrethrins

- Break down within an hour of sunlight exposure when used on mosquitoes
- Formulated so not to harm most people
- Do not kill fish, when used correctly
Organophosphates

- Treatment for adults
  - cause paralysis
  - death
- Use as little as possible
  - rotate products regularly
  - adults become resistant
- Two available
  - Malathion
  - Naled
Involves a concerted effort by both control personnel and the community
- Manage mosquito populations based upon informed decision-making

Educate by encouraging resident support
- Disposing of (or modifying) oviposition habitat
- Proper screening methods
- Proper application of personal protective measures

Keep public informed of surveillance and control measures

Personnel should maintain and upgrade their professional knowledge through continuing education training and/or attendance at professional conferences
Applicators must maintain records of each pesticide application.
  - For 2 years

Include information
  - Date of application
  - Time of application
  - Name of person applying
  - Location of application

Pesticide information
  - Product name
  - Product EPA reg #
  - Rate of product / unit
  - Total vol. of spray mix, dust, granules, other materials
  - Name of pest being treated

Treatment site
  - Total number of acres or volume of area treated

Wind direction & velocity
  - Air temp

Name and license # of applicator responsible
Follow the Four Ds

- Drain standing water
- Stay indoors during Dawn and Dusk
- Dress in long sleeves and pants
- Defend with repellents
What is a repellent?

Anything that repels, or disrupts the normal host seeking behavior of a pest.
Some insect repellent products for sale in the US do not currently require EPA registration.

In the 1990s,
- EPA evaluated these active ingredients for safety
- Determined they posed minimal risk to human health
  - Note these products have not been evaluated for effectiveness

Examples of ingredients
- Citronella oil
- Cedar oil
- Geranium oil
- Peppermint and peppermint oil
- Soybean oil
EPA Registered Repellents:
- DEET
- Picaridin
- IR3535
- Citronella
- 2-undecanone
- Oil of Lemon Eucalyptus
- Catnip Oil

CDC Approved Products:
- DEET
- Picaradin
- IR3535
- Oil of Lemon Eucalyptus
U.S. military discovered repellency of DEET in 1953

Broad spectrum repellent effective against all mosquitoes, some flies and ticks

Est. 78 million people in U.S. use DEET safely each year

US troops receiving repellents at the end of WWII. Malaria and other insect born diseases were a major source of casualties in the Pacific theater, leading to ground breaking research on repellents.
Principal, most effective repellent available today

The standard against which all other repellents are compared

Most thoroughly studied and tested with protection documented up to 6-8 hours
Picaridin

- Registered by US EPA 2003
- High level of control comparable in many studies to DEET
- Low odor, not oily
- EPA lists as 3-8 hours repellency for different concentrations
Oil of Lemon Eucalyptus
Para-menthane-3,8-diol

黾 Derived from leaves of eucalyptus plant
黾 Similar smell and cooling to menthol
黾 EPA lists protection time at 6 hrs for most products containing 30-40% active ingredient
Used in Europe for 20 years prior to US registration in 1999

Relatively short complete protection time, less than one-hour in some studies

Among recommended products by CDC, for those needing shorter protection times than DEET
Registered 2007 by EPA

Originally derived from wild tomatoes

North Carolina State University 2008 lab studies

- Arm cage studies compared favorably to DEET for Aedes

Not yet on recommended list from CDC
Releases vaporized form of metofluthrin (pyrethroid) and expels via small fan. To be clipped on a belt.
- Spatial repellency
- Mortality of mosquitoes

Wind, personal movement may reduce effectiveness

Limited studies
- 77% to 80%, Aedes albopictus, A. taeniorhynchus, more recent (Kline, CMAVE)
- 70% & 79% protection, Aedes albopictus, A. taeniorhynchus (Xue et al, 2012)
Certain products containing permethrin are recommended:
- on clothing
- shoes
- bed nets
- camping gear

Permethrin products should not be applied directly to skin.

Repellent treated clothing good for 30-40 washings.
American Academy of Pediatrics recommends

- Using products containing no more than 30% DEET
- On children over 2 months of age

DEET products have no age restrictions

Oil of lemon eucalyptus products should not be used on children under the age of three.

The CDC does not recommend use of products that combine a sunscreen with an insect repellent.
Apply and re-apply a repellent according to the label instructions.

The label is your guide to product safety and effectiveness.

Don't overuse the products,

If you don't follow the label directions, the product may not be as effective as you expect.