Medical & Veterinary Entomology

Michael Riehle
Department of Entomology
What is Medical Entomology

“The study of insects, insect-borne diseases, and other associated problems that affect human and public health.” (Also arachnids)

This can include:
- Insects that transmit disease
- Insects that bite, sting, blister, or irritate
- Allergies to insects
- Entomophobia and delusional parasitosis
- Forensic entomology
Why study Medical Entomology?

Deaths from vector-borne disease

VBD Deaths/million
- 0 - 1
- 1 - 20
- 20 - 50
- 50 - 200
- 200 - 500
- 500 - 1900
- No Data

The boundaries shown on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted lines on maps represent approximate border lines for which there may not yet be full agreement.
©WHO 2005. All rights reserved.
The Global Emergence and Re-emergence of Infectious Diseases

Red = newly emerging; blue = re-emerging/resurging; black = a 'deliberately emerging'.

We can divide the medically important effects of insects into direct and indirect effects

**Direct Effects – Host Reactions**

- Mechanical reactions (dermatosis, dermatitis, itching)
- Exsanguination (loss of blood, annoyance)
- Myiasis (fly larvae invading living tissues)
- Toxin & Paralysis (envenomization)
- Allergic reactions (anaphylaxis)
Mechanical reactions
(dermatosis, dermatitis, itching)

Chigger and Chigger bites
Mechanical reactions (dermatosis, dermatitis, itching)
Texas Woman Claims to Have Found Mythical 'Chupacabra'
Myiasis
(fly larvae invading living tissues)

Botfly
Toxin & Paralysis (envenomization)
Toxin & Paralysis (envenomization)

Fire Ant

Brown Recluse
Allergic reactions (anaphylaxis)

US prevalence 0.4 – 0.8% of bee allergies

50-200 deaths annually

However, this is less than deaths caused by penicillin allergies or lightning strikes.
Indirect Effects – Disease Transmission

Three things are required for vector-borne disease transmission:

1. A competent arthropod vector
2. A susceptible host
3. A pathogen
Mechanical transmission occurs when the parasite is transmitted between hosts without amplification or development within the vector, usually by contaminated mouthparts.

Biological transmission occurs when the parasite has an obligate developmental or amplification period within the vector.
Black Flies (Simulidae)

Vector of Onchocerciasis (River Blindness)
Onchocerciasis (River Blindness)  
*Onchocerca volvulus*

- Cause by a filarial worm
- Adult worms live in Subcutaneous nodules (females live for more than 14 years)  
Males migrate between nodules
- Females produce 1000 mf per day which migrate to the Skin
- Mf taken up in the blood meal of a blackfly
- ~18 million infections leading to more than 0.5 million cases of blindness
Onchocerciasis (River Blindness)

Pathology

Adults form large nodules, but microfilaria cause the pathology.

Large numbers of microfilaria can cause intense itching, lesions, loss of skin elasticity, and if they invade the eye, blindness.

Some villages experience >15% blindness.
Bloodfeeding Arthropods

Tabanidae

Rhagionidae
Tabanid flies (Tabanidae)

Vector of Loiiasis (Loa Loa) and Tularemia (Rabbit Fever)
Loa loa - the tropical eye worm

Biologically Transmitted

Migrating nematodes can cause pain and irritation
Bloodfeeding Arthropods
Tsetse flies (Glossinidae)

Vector of African trypanosomiasis (sleeping sickness) and nagana
Distribution of all tsetse flies
African trypanosomiasis

Major epidemics occurred in the late 19th century killing 750,000 people between 1896 and 1906.

50 million people in 38 countries are at risk.

25,000 new infections annually.

Thousands of deaths annually
Last decade had many raging epidemics throughout subSahara

Plagues of old reclaim continent

Health care is regressing, life expectancy is going down.
Sleeping sickness, once vanquished, is killing again.
And in a post-Cold War world, few appear to care.

Battling the deadly bite of the tsetse fly

February 28, 1996
Web posted at 2:06 p.m. EST (0906 GMT)

(CNN) -- On the African continent, in the narrow band between the 15th parallels that bound the equator, a tiny fly is jeopardizing the lives of 55 million people and could be responsible for one of the largest epidemics of this century.

The narrow arc along the equator runs through 36 sub-Saharan nations, 22 of which are among the most underdeveloped in the world. In every land, the tsetse fly thrives.

Number of deaths from sleeping sickness

![Graph showing number of deaths from sleeping sickness](image)
Bloodfeeding Arthropods
Sand flies (Psychodidae)

Vector of leishmaniasis, sand fly fever, Oroya fever
Leishmaniasis

Protozoan parasite

Two forms cutaneous and visceral

Threatens 350 million men, women and children in 88 countries around the world
Clinical manifestations of leishmaniasis

Cutaneous leishmaniasis caused by *Leishmania major*

Visceral leishmaniasis caused by *Leishmania donovani*

Mucocutaneous leishmaniasis caused by *Leishmania braziliensis*

Canine leishmaniasis caused by *Leishmania infantum*
Mosquitoes (Culicidae)

Vector of:
Viruses – yellow fever, dengue, Rift Valley fever, myxomatosis, eastern equine encephalitis, western equine encephalitis, Venezuelan equine encephalitis, St. Louis encephalitis, LaCross encephalitis, Japanese encephalitis, West Nile encephalitis, Murray Valley encephalitis, Chikungunya fever, O’nyong nyong fever, Ross River fever (~250 mosquito-borne, ~100 cause human disease)

Protozoans – Malaria

Filarial nematodes – Wuchererian filariosis, Bancroftian filariosis, dog heartworm
Mosquitoes (Culicidae)

- 3000 species world-wide

- ~150 in North America and ~50 in Arizona

- Only females consume blood and thus transmit disease

- Holometabolous life cycle with immature stages being aquatic
Malaria (*Plasmodium*)

1.6 billion people at risk

300-500 million new cases annually

1-3 million deaths annually, mostly children

Both the mosquito and the parasite have developed resistance to insecticides and drugs respectively.

In malaria endemic countries up to 40% of the public health expenditure goes to treat malaria.

The annual “cost” of malaria, in both direct and indirect costs, is ~$1.8 billion
Malaria (*Plasmodium*)
Life cycle in the mosquito
Lymphatic filariasis

Wuchereria bancrofti & Brugia malayi

1.2 billion people at risk

120 million infections per year

• Adults live in lymphatic vessels for 5-10 years or more (reproductively active for 4-6 years).

• Female releases 50,000 or more microfilariae a day, which circulate in the blood to be transmitted by blood feeding mosquitoes.

• Microfilariae circulate in the blood for 1-2 years, and are only found in peripheral circulation at night.
Dog Heartworm

A mosquito picks up some microfilaria when it feeds from an infected dog. Cats rarely have circulating microfilaria.

Microfilaria live about 2 weeks in mosquito salivary gland and then become infective.

The mosquito bites a dog or cat releasing heartworm larvae into the wound.

Heartworm Preventatives Kill the Larvae Here!

This is microfilaria magnified about 1000 times.

Microfilaria are tiny! They circulate in the infected animal’s bloodstream.

Adults give birth to live offspring called microfilaria. (Like a Guppy fish)

Adult Heartworms (About the size of spaghetti strands)

Larvae finally reach the right heart where they impede blood flow and cause damage to the heart and lung vessels.

Larvae molt and grow as they migrate through tissue heading to the heart and lung vessels.

Heartworm Life Cycle
Mosquito-borne Viruses
Encephalitis

In 1998......

- St. Louis encephalitis
- Rocio and St. Louis (Brazil)
- West Nile virus
- Japanese encephalitis
- West Nile and Japanese encephalitis
- Japanese and Murray Valley encephalitis
- Murray Valley and Kunjin
In 1999......
West Nile Virus 1999
West Nile Virus
2001
West Nile Virus
2003
West Nile Virus
2005
West Nile Virus
2006
Mosquito-borne Viruses
Dengue & dengue haemorrhagic fever

Transmitted by *Aedes aegypti* (found in Tucson)

Two forms dengue and dengue haemorrhagic fever

Dengue fever is a flu-like illness. It can be quite painful, but rarely fatal.

Dengue hemorrhagic fever is a severe, often fatal, complication of dengue fever.

Four dengue serotypes (*Den*1-4) exist.

DHF can occur when a person previously infected with dengue is infected with a new serotype.
Mosquito-borne Viruses
Dengue & dengue haemorrhagic fever

- Areas infested with *Aedes aegypti*
- Areas with *Aedes aegypti* and dengue epidemic activity
Dengue risk in the US


Dengue Vulnerability
- Number of suspected cases per state
- Counties reporting positive for one or both dengue mosquito vector species, as of 2005
- Areas vulnerable to dengue fever infection
Bloodfeeding Arthropods

[Diagram showing various classes of arthropods, with a red circle highlighting a specific species.]

- Prostigmata
- Trombiformes
- Acariformes
- Sarcopitiformes
- Chelicerata
- Myriapoda
- Mandibulata
- Holometabola
- Insecta
- Hexapoda
- Trilobata
- Diptera
- Hymenoptera
- Orthoptera
- Hemiptera
- Trichoptera
- Diptera
- Neuroptera
- Psocoptera
- Mantodea
- Holometabola
- Protura
- Zygoptera
- Odonata
- Coleoptera
- Mecoptera
- Trigoniidae
- Pyralidae
- Pyralididae
- Cyclorrhapha
- Pupipara
- Hippoboscidae
- Streblidae
- Nyceriidae
- Tabanidae
- Rhagionidae
- Nycteribiidae
- Culicidae
- Psychodidae
- Chloropidae
- Muscid
Fleas (Siphonoptera)

Vector of plague
Human infection most often occurs when a person is bitten by a rat flea.

Initial symptoms are chills, fever, diarrhea, headaches, and the swelling of the infected lymph nodes, as the bacteria replicate.

If untreated, the rate of mortality for bubonic plague is 30–75%.

Early treatment with antibiotics reduces the mortality rate to 4 to 15%.
Flea-borne diseases - plague

Arizona did not have any human plague cases from 2002-2007

In September of 2007 a woman in Apache County contracted plague by a flea bite. She recovered.

In November 2007, a wildlife biologist at Grand Canyon National Park contracted and died of plague.
Flea-borne diseases - plague

A 37 year old biologist was found dead at his residence.

The biologist was working with radio collared mountain lions.

One week before his death a radio collar indicated a dead lion.

He recovered the lion, brought it back to his garage, and performed a necropsy with no PPE.

Went to the doctor and was diagnosed with a respiratory illness.

He was told to return to the hospital if the symptoms got worse.
The biologist failed to show up for work and co-workers found his body the next day.

His roommates were out of town and he was unable to call for help.

What happened to the carcass?

The hind-quarters were used as bait in a mountain lion trap by the biologist.

The front quarters were never found.

Analysis of the *Y. pestis* in the biologist and carcass were identical.

Viable bacteria was found at the site of the animals death 24 days later.
Bloodfeeding Arthropods
Kissing Bugs (*Reduviidae*)

Vector of American trypanosomiasis (Chagas disease)
- Distribution from latitudes 42° North (North of California) to 46° South (So. Argentina and Chile).

- From 18 to 20 millions infected.

- Vector borne disease of greatest importance (economic impact and prevalence) in the Americas.
Bloodfeeding Arthropods
Lice (Phthiraptera)

Vector of epidemic typhus, trench fever, louse-borne relapsing fever
Bloodfeeding Arthropods

- Prostigmata
  - Trombidiiformes
    - Acariformes
      - Sarcoptiformes
        - Oribatida (A)
        - Oribatida (B)
  - Astigmata
    - Mesostigmata
    - Holothyrina

- Parasitiformes
  - Scorpiones
  - Opiliones

- Chelicerata
  - Myriapoda
    - Mandibulata
      - Nematocera
        - Brachycera
          - Cyclorrhapha

- Hexapoda
  - Insecta
    - Holometabola
      - Diptera (Flies)
      - Hymenoptera (Wasps, Bees, Ants)
      - Lepidoptera (Butterflies and Moths)
      - Siphonaptera (Fleas)
  - Protura
  - Japygina
  - Compodeina

- Orthoptera
  - Dermaptera (Earwigs)
  - Mantodea (Praying mantises)
  - Blattaria (Roaches)
  - Isoptera (Termites)

- Thysanoptera (Thrips)
- Pscoptera (Book lice)
- Mallophaga (Chewing lice)
- Anoplura (Sucking lice)
- Coleoptera (Beetles)
- Neuroptera (Lacewings)
- Megaloptera
- Raphidiidae (Ants)
- Nymphalidae
- Pyralidae
- Lepidoptera

- Collombola (Springtails)
- Ephemeroptera (Mayflies)
- Zygoptera (Dragonflies)
- Odonata (Dragonflies and damselflies)
- Araneae (Spiders)

- Phasmida (Walking stick flies)
- Ephemeroptera (Mayflies)
- Odonata (Dragonflies and damselflies)
- Zygoptera (Dragonflies)
- Odonata (Dragonflies and damselflies)

- Heterostigmata
- Rhiphielloidea
- Tetanychidae
- Tetranychidae

- Ixodida (Ticks)

- Raphignathoidea
- Labidostomatoidea
- Halacaroidea
- Bdelloidea
- Eupoidea
- Tydeoidea
- Eriophyoidea
- Endostigmata
- Astigmata
- Mesostigmata
- Holothyrina

- Trombiculidae (Chiggers)
- Grylloblattaria (Mole crickets)
- Embiidae (Webspinners)
- Plecoptera (Stoneflies)

- Cheyletiidae
- Anystidae
- Parasitengona
- Lygaeidae
- Reduviidae, Triatominae
- Cimicidae
- Polycenidae
Ticks

Vector of Lyme disease, Rocky Mountain spotted fever, tick-borne ehrlichiosis, babesiosis
Rocky Mountain spotted fever

Caused by *Rickettsia rickettsii* bacteria

Symptoms include a sudden fever (which can last for 2 or 3 weeks), severe headache, tiredness, deep muscle pain, chills, nausea, and a characteristic rash

Without prompt medical care, kidney failure and shock can lead to death

Rocky Mountain spotted fever affects about 800 persons in the United States each year
Lyme disease

Caused by *Borrelia burgdorferi*, a spirochete bacteria

Typical symptoms include fever, headache, fatigue, and a characteristic skin rash called erythema migrans.

If left untreated, infection can spread to joints, the heart, and the nervous system.
Symptoms of tick paralysis generally begin from five to seven days after a tick becomes attached, beginning with fatigue, numbness of the legs and muscle pains.

Paralysis rapidly develops from the lower to the upper extremities and, if the tick is not removed, is followed by tongue and facial paralysis.

The most severe complications may include convulsions, respiratory failure and, in up to 12% of untreated cases, death.

Treatment involves simply removing the feeding tick(s).
Delusional parasitosis

A mistaken belief that one is being infested by parasites such as mites, lice, fleas, spiders, worms, bacteria, or other organisms.

Stimulant drug abuse (particularly amphetamine and cocaine) can lead to delusional parasitosis.

People suffering from these conditions may scratch themselves to the extent of serious skin damage and bleeding.
Forensic Entomology

Insects can provide an objective estimate of the time of death as well as other valuable information concerning the circumstances surrounding the victim's demise.
A shameless plug for the Medical/Veterinary entomology course

A detailed look at:

• Vector-parasite interactions
• Disease pathology and treatment
• Control strategies – new and old
• The evolution of bloodfeeding
• Insecticide and drug resistance
• And much more!

ENTO 457 and EIS 557
T/Th at 9:30-10:45 AM – Spring 2010
Space still available!