Arthropods of Public Health Significance in California

Exam

Section C

Version 3.0, March 2016

Terrestrial Invertebrate Vector Control

An Interactive Tutorial

> EXIT

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How to Use this Guide

- This study guide is meant to *supplement* your reading of the manual, Arthropods of Public Health Significance in California, and is not intended as a substitute.
- You can navigate through the guide at your own pace and in any order.
- You can always return to the Main Menu if you get lost or want to skip to another section.
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Epidemiology of Vector-Borne Diseases

- Introduction
- Epidemiologic Terms
- Methods of Transmission
- Vectorial Capacity
- Landscape Epidemiology
- Assessment and Prediction of Disease Risk

Introduction

- Epidemiology is the study of human disease patterns
  - Some examples include malaria, plague, murine typhus, St. Louis Encephalitis, western equine encephalomyelitis and West Nile fever

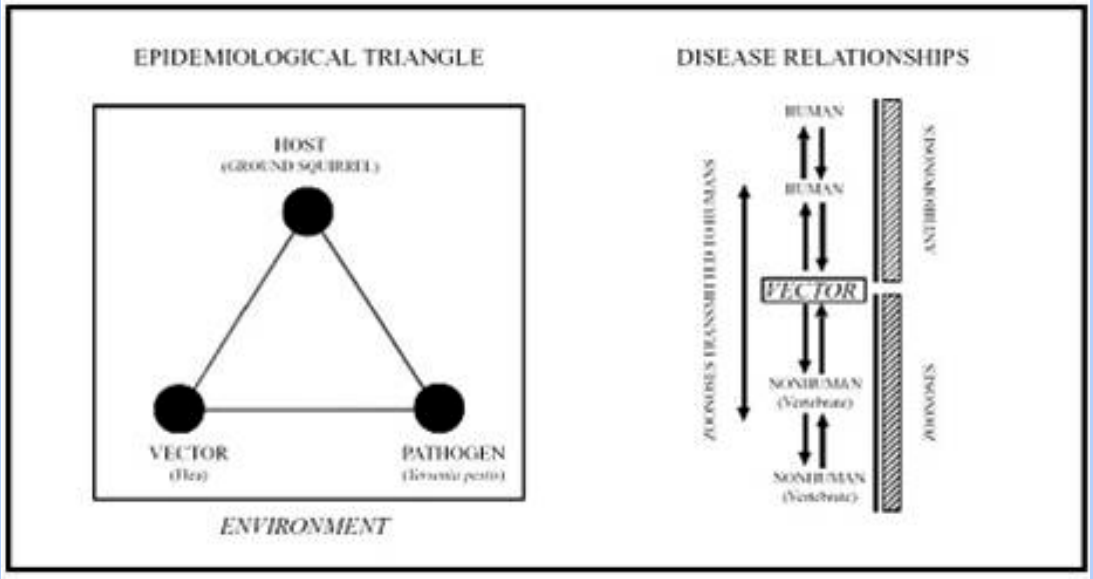
- Vector-borne diseases are infectious diseases in which the microorganisms that cause the symptoms are transmitted by insects or other arthropods

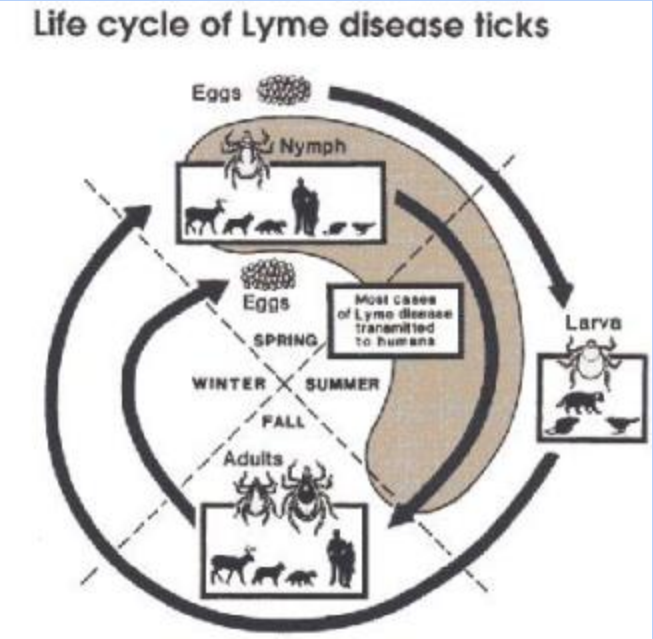
Epidemiological Terms

- An epidemic is an unusually large number of cases of a disease in humans occurring within a short period of time
- An epizootic is an outbreak of a disease in animals other than humans
- An endemic disease is the constant occurrence of an infectious or disease-causing agent in a given geographic area in humans
  - In animals this relationship is called enzootic
- Anthroponoses are diseases that affect only people
- A zoonosis is an infectious disease of nonhuman vertebrates that is secondarily transmissible to humans
- Among vector-borne diseases, zoonoses are more common

Epidemiological Terms continued

- 3 components to the life cycle of vector-borne diseases
  - A pathogen: the actual cause of disease
  - A host: the animal affected by the disease
  - A vector: an insect or arthropod capable of transmitting the disease





Epidemiological Terms continued

- A parasite is an organism that lives at the expense of another organism, e.g., a flea on a dog
- Parasites can:
  - Live inside the host (endoparasites)
    - e.g., Various microbial pathogens
  - Live on the skin of the host (ectoparasites)
    - e.g., Insects and arthropods
- Pathogenicity is the proportion of hosts that develop symptoms among those infected by a particular strain of pathogen
- Virulence refers to the proportions of cases of infection that develop severe symptoms
- Epidemiologic terms that refer to the presence of pathogens in the blood stream of infected hosts all end in "-emia"
  - Parasites – parasitemia; viruses – viremia

Methods of Transmission

- There are several ways in which arthropods transmit microorganisms.
  - Mechanical Transmission
  - Biological Transmission
  - Horizontal and Vertical Transmission
  - Vector Incrimination

Mechanical Transmission

- This is when the pathogen adheres to body hairs, spines, sticky pads, or other structures of insects
  - In the case of certain insects, transmission may be by regurgitation or defecation
  - Biting flies may transmit pathogens by biting with contaminated mouthparts

- Nearly all mechanically transmitted diseases can also be transmitted in other ways (e.g., contaminated food and water)

Biological Transmission

- There are three categories of biological transmission
  - Propagative Transmission
  - Cyclical Transmission
  - Propagative and Cyclical Transmission

Biological Transmission continued

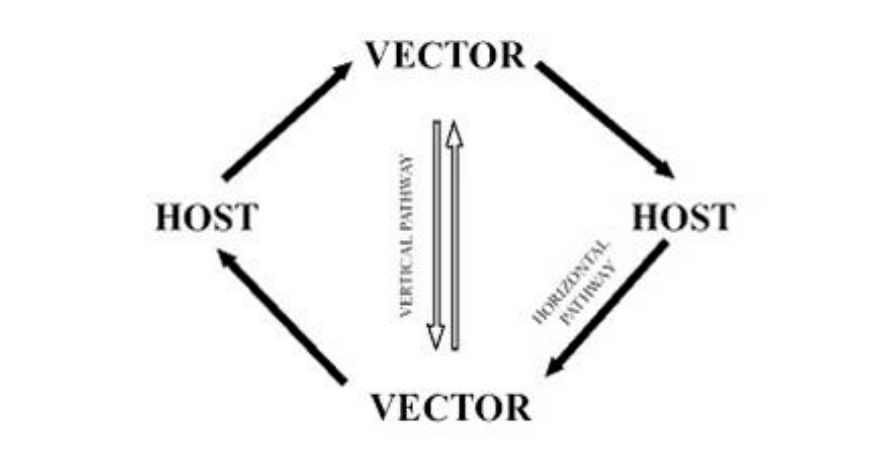
- Propagative Transmission
  - In this type of transmission, the pathogen multiplies within the body of the vector, but does not undergo any changes in form
  - Most viral diseases fall into this category
  - Plague (a bacterial disease) is also an example

- Cyclical Transmission
  - The parasites undergo several molts in the body of the vector
    - Start out as a microfilariae and develops into an infectious larvae
  - No multiplication takes place within the body of the vector
  - The only pathogens that are transmitted this way are filarial nematodes

- Propagative and Cyclical Transmission
  - Both multiplication and changes in the life form of the pathogen occur within the vector
  - Examples are malaria, leishmaniasis, both caused by protozoan parasites

Horizontal & Vertical Transmission

- Horizontal and vertical transmission are the pathway a pathogen takes among vectors and hosts
- Horizontal transmission involves the pathogen being transmitted by a vector to a host in a cyclical pathway
- Vertical transmission is more direct and does not involve a host, but occurs directly from infected mother/female to offspring
  - This is also called transovarial transmission (TOT)



Vector Incrimination

- Vector Incrimination is the process of knowing which species of arthropod is serving as a vector of a particular disease

- There are 4 major criteria for incriminating arthropods as vectors of human disease:
  - Identifying contact between arthropod and host
  - Having a biological association in time
  - Repeated demonstration of disease between arthropod and host
  - Replicable under experimental conditions

Vectorial Capacity

- Vectorial capacity is the potential of a group of arthropods to transmit a given pathogen

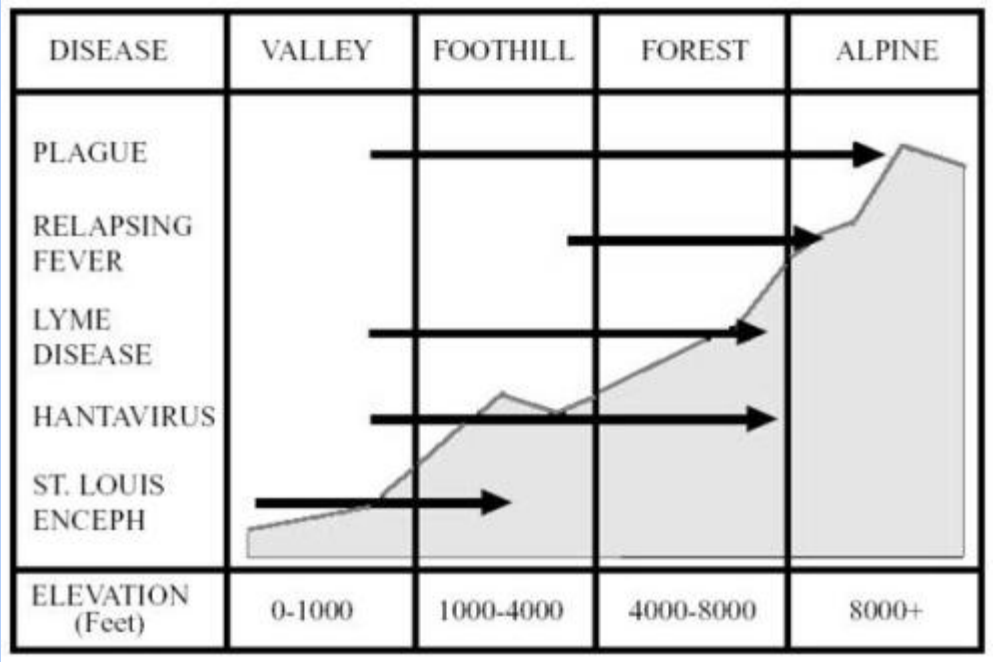
- There are 6 main determinants:
  - Abundance
  - Host Preference and Host-Feeding Patterns
  - Reproductive Capacity
  - Longevity
  - Dispersal
  - Vector Competence

Vectorial Capacity continued

- Abundance
  - The more vectors there are, the higher the probability of disease transmission
- Host Preference and Feeding Patterns
  - Knowing what the vectors feed upon allows for identification of disease transmission
- Reproductive Capacity
  - A measure of the rate at which a population of vectors increases
- Longevity
  - Longevity is knowing how long the stages of the vector's life cycle last
- Dispersal
  - Dispersal is knowing how far a vector can fly or move about freely
  - The greater the movement, the greater chance for spread of disease
- Vector Competence
  - The susceptibility of a group of arthropods to a given strain of pathogen and the ability of those arthropods to transmit the pathogen
  - This is a genetic characteristic for a particular vector for a given microorganism

Landscape Epidemiology

- The geographic distribution of vector-borne diseases is determined primarily by the geographic distributions of vertebrate hosts, disease pathogens, and arthropod vectors
- This can be divided into 3 sections
  - Weather and Climate
  - Vegetation
  - Human Culture and Behavior



Landscape Epidemiology continued

- Weather and Climate
  - Weather is important because of the strong influence temperature and rainfall can have on vector abundance and on the rate of development of pathogens within vectors
  - e.g., Epidemics of St. Louis encephalitis are generally associated with patterns of unusually high rainfall and unusually high spring temperatures

- Vegetation
  - Plants are considered to be the best indicators of climatic conditions and possible existing vectors

- Human Culture and Behavior
  - Reversion of agricultural land to secondary forests and the construction of housing developments in forested areas have contributed to the increase of diseases

Assessment and Prediction of Disease Risk

- Three fundamental reasons for studying the epidemiology of vector-borne diseases:
  - To predict the occurrence of epidemics
  - To prevent the occurrence of epidemics
  - To abate epidemics after an epidemic has occurred

- Prediction of disease outbreaks usually involves comprehensive disease surveillance programs

Fundamentals of Entomology

- Introduction
- What is an Insect?
- Insect Classification and Diversity
- Reproduction, Growth & Metamorphosis

Introduction

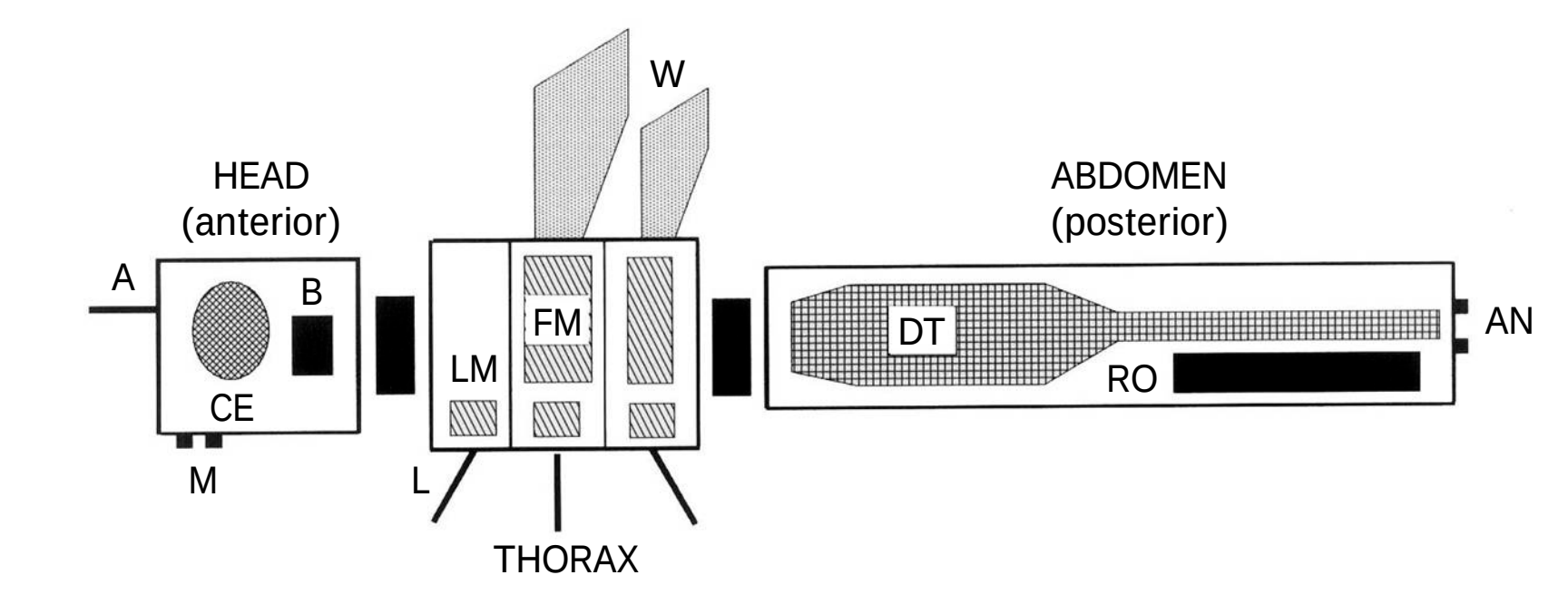
- The number of insects species found in North America is currently estimated at about 90,000 with new species being continuously added

- Attributes that contribute to their success:
  - Diverse form
  - Anatomy and physiology
  - Reproductive potential
  - Development and feeding strategies
  - Dispersiveness
  - Inherent capacity to adapt to changes in environment

What is an Insect?

- An insect is a highly specialized invertebrate with:
  - An impervious exoskeleton composed of chitin
  - A internally attached muscles
  - A segmented body movable only at the joints
  - A body that is differentiated into a head, a thorax, and an abdomen (figure 2-1)

What is an Insect? continued



Legend: A=antenna, B=brain, CE=compound eye, M=mouth, FM=flight muscle, W=wing, LM=leg muscle, L=leg, DT=digestive tract, RO=reproductive organs, AN=anus

Figure 2-1. General organization of an insect

Insect Classification and Diversity

- Insects are classified by their shared morphological and genetic characteristics
- Every species known to science is given a scientific name
- When organisms are identified they are referred by a Latin binomial
  - The first word is their genus and the second is their species
    - e.g., the human species – *Homo sapiens*, the domestic dog – *Canis familiaris*
- There is a larger hierarchy of classification that systematically subdivides either plant or animal life into various groups/categories that have common characteristics of form and organization

Insect Classification and Diversity continued

- Example of the taxonomic classification hierarchy of the common housefly (note capitalizations and italics)

1. Kingdom – Animalia
2. Phylum – Arthropoda
3. Class – Insecta/Hexapoda
4. Order – Diptera
5. Family – Muscidae
6. Genus – *Musca*
7. Species – *domestica*
8. Author (described by) – Linnaeus

Reproduction, Growth & Metamorphosis

- Insects reproduce via live young or from eggs deposited by the female. Most insects require mating to reproduce, though in rare cases insects can reproduce without mating. Example: The queen honey bee deposits unfertilized eggs to produce drones (males) but fertilized eggs to produce workers (females)

- Immature insects have two developmental patterns to become adults:
  - Incomplete metamorphosis means the immature insect (nymph) looks very much like a smaller version of the adult. The nymph and adult generally eat and compete for the same foods. The nymph adds adult features, such as wings, during its last molt. There is no pupal stage of development. Example: Bugs, cockroaches and crickets

  - Complete metamorphosis means the immature insect (larva) looks very different from the adult. The larva and adult generally eat and compete for different foods. The larva adds adult features during the pupal stage. Example: Butterflies, mosquitoes and wasps

Reproduction, Growth & Metamorphosis

- Insects do not grow as do vertebrates because their rigid exoskeleton (cuticle) does not expand to allow for continual growth. In a process called molting, insects must periodically shed their old cuticle to produce a new, flexible cuticle that gradually hardens

- The immature stage between molts is called an instar. The newly emerged nymph or larva is the called the first instar. The nymphal stage prior to attaining wings, or final the larval stage prior to pupation is called the last instar

- The number of instars for each species is predetermined by its physiology. Mosquitoes have four instars while some dragonflies can have over 20

Cockroaches

- Introduction
- Description and Bionomics
- Life Cycle
- Public Health Importance
- Species Summaries
- Management and Control

Introduction

- In the United States only two species of cockroaches live and breed exclusively indoors
- Three others infrequently invade and reside in structures
- The German cockroach, *Blattella germanica*, is the most widespread pest species
- Domestic cockroaches often live in close association with bacteria, fungi, and viruses, and should be considered significant potential public health pests when they invade or become established indoors

Description and Bionomics

- Cockroaches have an elongate oval shape and are somewhat flattened in appearance
- Most are uniformly black or brownish
- Of subtropical origin, some pest species of cockroaches have adapted to living indoors
- Cockroaches have a simple metamorphosis
  - Most adult cockroaches have wings, immatures do not
- Cockroaches are semi-social insects, aggregate in clusters guided by pheromones deposited directly and indirectly onto surfaces by nymphs and adults
- Cockroaches can develop anywhere there is moderate temperature and humidity and adequate food and water
- Immatures and adult cockroaches have essentially identical food and shelter needs

Description and Bionomics continued

- They may proliferate under conditions maintained in buildings
- The term domiciliary or “domestic” refers to their living in structures
- Some species have adapted to the urban condition to such an extent that they live only indoors
- Obligatory indoor species usually develop in occupied places where large quantities of food and water are available
  - e.g., substandard multi-unit housing, commercial kitchens, homes, hotels, hospitals, zoos, and prisons
- Their presence is usually indicative of poor sanitation
- Some species gain access to buildings from sewer system lines and manholes, subway tunnels, storm drains, or masonry meter boxes
- Their presence is often indicative of faulty and deteriorating construction

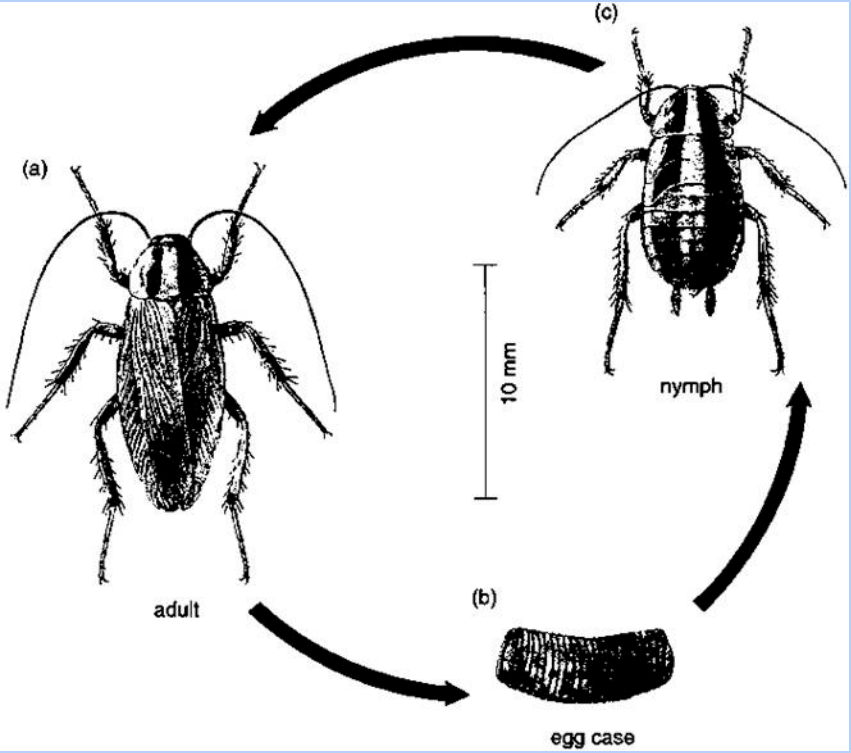
Description and Bionomics continued

- Cockroaches have significant adaptive features
  - They can survive harsh conditions by adjusting to the conditions
  - They can readily endure stressful situations
  - They can survive extended periods of times without food or water
  - They can adapt to a wide range of temperature, moisture and light regimens
  - They can tolerate high doses of noxious substances
- Cockroaches exhibit repetitive circadian patterns of activity whereby they are quiescent in light and become active in the dark
- They remain hidden during daylight hours
- Cockroaches prefer and seek dark places
- They aggregate in groups in cracks, crevices, and other protected places, usually near food and water

Life Cycle

- The generalized life cycles for the species of domestic cockroaches are similar, the differences being the number of instars to adulthood and whether the egg case (ootheca) is deposited versus remaining attached to the female while it develops

- Nymphs grow through a series of five to seven growth stages called instars
  - This process can take several weeks to more than a year to reach adulthood



Public Health Importance

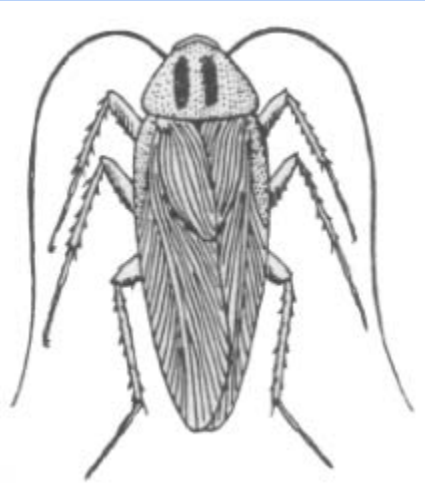
- All domestic species of cockroaches have pest status by virtue of being an offensive nuisance
  - Some are also associated with filth, transmission of disease, and with contact and inhalant allergies
- Cockroaches are a sign of unsanitary conditions
  - Special attention should be taken wherever food is prepared, served, or stored

Species Summaries

- German cockroach, *Blattella germanica*
- Brownbanded cockroach, *Supella longipalpa*
- Oriental cockroach, *Blatta orientalis*
- American cockroach, *Periplaneta americana*
- Smokybrown cockroach, *Periplaneta fuliginosa*

German Cockroach, *Blattella germanica*

- The most troublesome and widespread domestic cockroach species in the United States
- Lives exclusively indoors
- Adults are about 1.5 cm long, are tawny brown, and have two longitudinal, parallel dark streaks that course the length of their pronotum
- Prefer dark, moist conditions near 84°F and near food and water (e.g., kitchens)



Brownbanded cockroach, *Supella longipalpa*

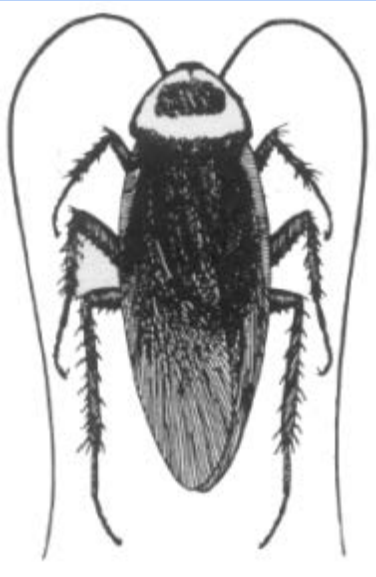
- Lives exclusively indoors
- Similar in size to *B. germanica* but more colorful and with two transverse bands
- Prefers temperatures of 80°F and higher for optimal development
- *S. longipalpa* tend to be found near the ceiling or in the upper rooms of multistory buildings where the temperature is usually warmer

Oriental Cockroach, *Blatta orientalis*

- Also known as the “water bug” or “water beetle”
- Adults are 1 – 1.25 inches long
- Females are wingless
- Primarily found outdoors
- Prefers cool moist and dark environments with vegetation
- Often enters structures from nearby vegetated plantings
- Differ from other species in that they cannot climb smooth surfaces
  - Often found trapped in jars, sinks, and bathtubs

American Cockroach, *Periplaneta americana*

- Large in size with reddish brown wings and paler area around the pronotum
- Adults are 1.5 – 2 inches
- Prefer dark warm areas with high humidity
- Most common domestic species associated with sewer systems
  - Also associated with steam and subway tunnels
  - May access structures from pipes and sewer lines
- Long lived species that may survive several years



Smokybrown cockroach, *Periplaneta fuliginosa*

- Slightly smaller, but similar in appearance to *P. americana* but has a uniform dark coloration
- Lives primarily outdoors in trees or dense vegetation
- When infesting indoors they can be in an area that is usually heated

Management and Control

- Domestic cockroaches usually live near food, people, and in environmentally sensitive locations, so it is best to prevent them from gaining initial access into these places
- Cockroaches prefer to live in undisturbed dark enclosures
- Nymphs may hide in cracks and crevices less than 1 mm wide
- Preventing continuous invasion or suppressing established infestations usually involves a long-term program of surveillance, exclusion, improved sanitation, management practices, and chemical treatment
- Once cockroaches become established, insecticides alone have little long-term effect unless accompanied by improved sanitation and structural upgrades

Management and Control continued

- Cockroaches cannot survive without food and water
- Food scraps should be cleaned up
- Garbage should be placed in containers with tight-fitting lids
- Dirty dishes should be cleaned
- Openings that may harbor cockroaches should be caulked or sealed
- It is particularly important to keep cockroaches out of commercial buildings, apartments, and other sites where they may establish sites of infestation and come in contact with people
- Doors, windows, and screens should fit well and even small points of entry should be closed, caulked, or sealed

Management and Control continued

- Aggregation makes them vulnerable to so-called search-and-destroy techniques, such as direct sprays and vacuuming
- Removal of cockroaches with a high velocity vacuum cleaner equipped with a HEPA filter is becoming increasingly popular
- This technique may be appropriate in repetitive maintenance situations where absolutely no chemicals are permitted
- Some sprays and powders are designed to be applied into cracks and crevices where they provide control for long periods of time
- It is important to note that any control product must be used in accordance with its label

Biting and Sucking Lice

- Introduction
- Human Lice
- Mammal Feeding Lice
- Life Cycle
- Bionomics
- Control and Management

Introduction

- Lice are:
  - Small (1 – 8 mm)
  - Wingless
  - Dorsoventrally flattened
  - Generally host-specific
  - Ectoparasites of mammals and birds
- In general there are two orders of lice
  - Mallophaga or biting (chewing) lice
  - Anoplura or sucking lice

Mallophaga or Biting (Chewing) Lice

- Biting lice infest the pelage (feathers or fur) of either birds or mammals
- They have chewing mandibulate mouthparts
- Some are true blood-feeders, others subsist on particles of host feathers, fur, or skin

Anoplura or Sucking Lice

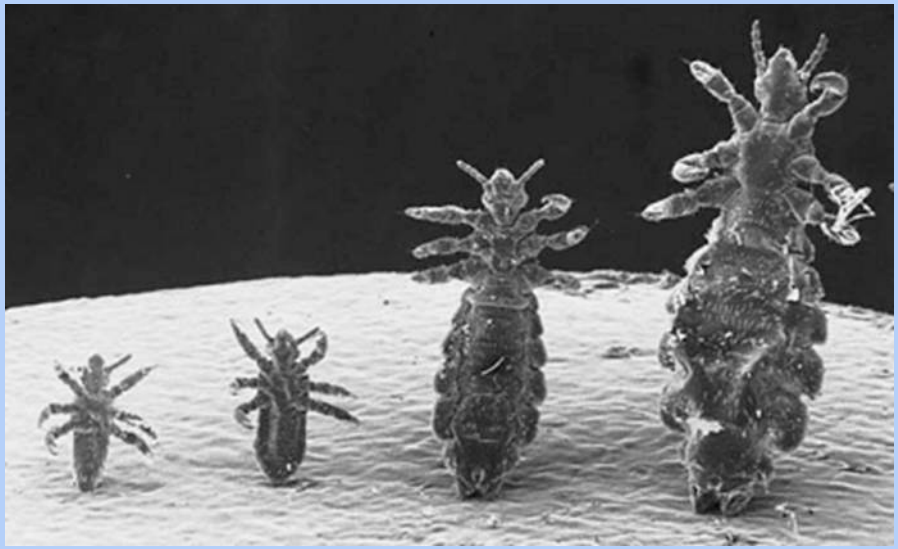
- Sucking lice are considered important vectors of pathogens because they are blood-feeding ectoparasites of placental mammals
- They have sucking mouthparts
- They have tibiotarsal claws which are adapted to grasping host hairs

Human Lice

- Head Louse
- Body Louse
- Crab Louse
- Table 4-1 Differentiation of Head, Body, and Crab Lice of Humans

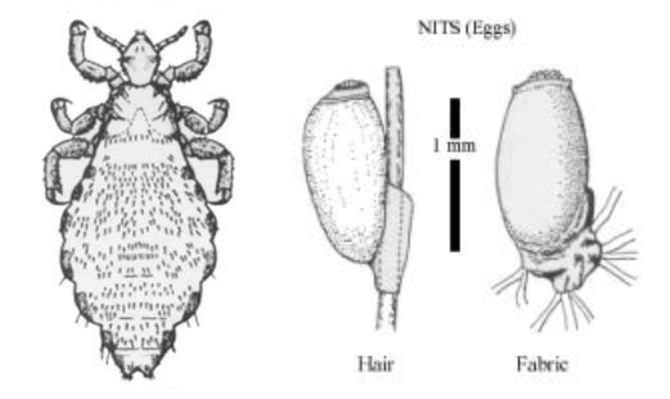
Human Head Louse, *Pediculus humanus capitis*

- Head louse occur on the scalp and head hair
- Gravid females typically deposit their eggs in individual hairs in the nape region or behind the ears
- Female head lice glue their eggs close to the bases of hair shafts usually within 1 mm of the skin
- See Table 4-1 for morphological features



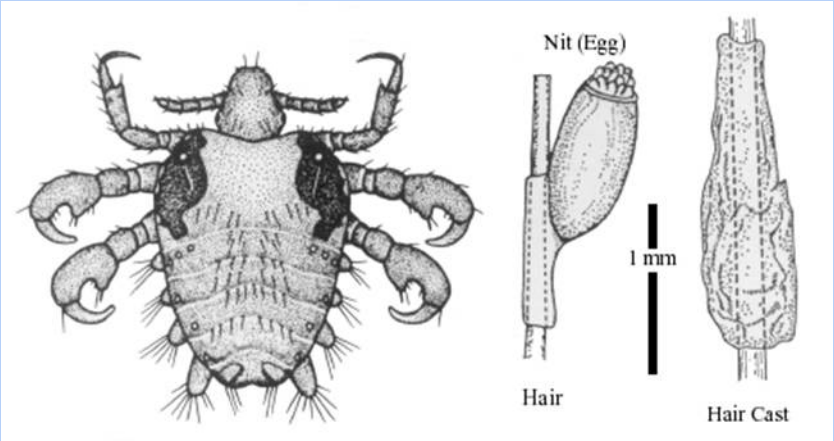
Human Lice
Body Louse, *Pediculus humanus*

- Body Louse tend to be larger in length than other human lice
  - See Table 4-1 for morphological features
- This louse can infest body and associated hairs, but is also found in clothing
- Female body lice preferentially deposit their eggs on clothing rather than on host, a unique trait among lice



Human Lice
Crab Louse, *Pthirus pubis*

- See Table 4-1 for morphological features
- The tibiotarsal claws are adapted for grasping courser hairs
  - Pubic hairs, eyelashes, eyebrows, beard, mustaches, and chest hairs
- Infestation of the pubic region is most common
  - It is not unusual for these other sites to be infested
  - There are also several reports of crab lice infesting scalps of babies



Differentiation of Body, Head, and Crab Lice of Humans

	Body louse	Head louse	Crab louse
♂ body length	2.0-3.0 mm	1.0-1.5 mm	0.8-1.0 mm
♀ body length	2.0-4.0 mm	1.8-2.0 mm	1.0-1.2 mm
Abdomen	Elongate and lacking hairy lateral processes	Elongate and lacking hairy lateral processes	Short and broad with hairy lateral processes
Legs	About equal in size	About equal in size	1st pair smaller and narrower than 2nd and 3rd pairs
Body color	Grayish white	Grayish white with dark margins	Grayish white
Length of nits	0.8 mm	0.8 mm	0.6 mm

Table 4-1 Differentiation of Body, Head, and Crab Lice of Humans

Mammal Feeding Louse

- Tropical Rat Louse
  - This sucking louse parasitizes domestic rats (*Rattus* spp.) throughout tropical, subtropical, and warm temperate regions of the world

Life Cycle

- All lice have a gradual (hemimetabolous) development in that their three nymphal instars resemble miniature adults
- Following sufficient feeding and growth, each instar must attach itself to the substrate (hair or clothing) and molt to the next instar

	Body louse	Head louse	Crab louse
Total no. nits/♀	270-300	50-150	ca. 25
Mean nits laid/♀/day	4.6	6.0	3.0
Nit incubation time	8-10 days	5-10 days	7-8 days
1st nymphal instar	4-6 days	2 days	4-7 days
2nd nymphal instar	3-4 days	2 days	4-6 days
3rd nymphal instar	4-5 days	2 days	4-6 days
Mean adult longevity	18 days	16 days	15 days

Life cycle parameters for head, body, and crab lice of humans

Bionomics of Lice

- Under optimal conditions human lice can undergo one complete generation in a month
- Lice transfer from one individual to another during close host physical contact
- Head lice can also be transferred via shared objects such as caps, combs, hair brushes, or head phones
- Lice can rarely survive for more than a few days off the host
- Large louse populations, although rare today in developed countries, can cause intense irritation and also may result in anemia or louse bite allergies
- Bite site redness is frequent during early stage infestations
- Long-term infestations associated with exposure to huge numbers of body louse bites may produce a “Vagabond’s Disease”

Diseases Associated With Lice

- Epidemic (louse-borne) Typhus
  - Also known as “classic epidemic typhus”
  - Caused by the rickettsial bacterium *Rickettsia prowazekii*
  - Exclusive to humans and body lice
  - Signs of disease occur 10-14 days after exposure and include headache, malaise, a blotchy rash on the chest or abdomen, and rapid fever onset

- Trench Fever
  - Caused by the bacterium *Bartonella quintana*
  - Body lice become infected while feeding on an infected person, and the bacterium is transmitted to the next host via infective feces as with epidemic typhus
  - Infection can either be asymptomatic, mild, or severe with clinical symptoms of headache, myalgia, nausea, and fever

Diseases Associated With Lice continued

- Louse-Borne (epidemic) Relapsing Fever
  - Caused by the spirochete bacterium, *Borrelia recurrentis*
  - Does not currently occur in North America
  - Spirochetes are transmitted when an infected louse is crushed and abraded into the skin by a louse-infected person
  - Humans are the only proven vertebrate reservoir of *B. recurrentis*

- Endemic (flea-borne or murine) typhus
  - Caused by the rickettsial bacterium, *Rickettsia typhi*
  - Domestic rats are the most common reservoir of infection
  - Typically the pathogen is transmitted to humans by rat fleas
    - Two species of sucking lice can transmit this pathogen from rat-to-rat

Control and Management

- Chemicals that kill lice are called “pediculicides”
  - DDT used to be a commonly applied pediculide in the United States
- Various formulations (e.g., gels, shampoos, sprays, fogs), currently registered can be used to control human lice
- Behavioral control is an important louse suppression mechanism
  - Avoidance of close physical contact and avoidance of sharing clothes, sheets, headphones, hats, combs, hair brushes, and other items used by infested individuals are good first lines of defense
- Washing clothes of louse infected individuals in piping hot, soapy water will usually kill lice
- Control of rats and their lice in domestic settings and exclusion of flying squirrels from attics may decrease the incidence of endemic typhus and sporadic epidemic typhus, respectively, in humans
- Ectoparasite control on dogs, which may harbor tapeworm-infected lice, is advisable

True Bugs

Introduction

Assassin and Kissing Bugs

Bed Bugs

Introduction

- The true bugs of the Order Hemiptera are represented by a large group of widely distributed insects readily identified by their piercing-sucking mouthparts and partial membranous wings
- True bugs are generally distributed throughout North America and California and occupy a wide variety of habitats
- Among the bugs most likely to bite humans are the assassin and kissing bugs and the bed and bat bugs

Assassin and Kissing Bugs

- Species of Medical Importance
- General Bionomics
- Public Health Significance
- Control and Management

Assassin and Kissing Bugs
Species of Medical Importance

- Assassin bugs are generally considered a beneficial group of insects, used as biological control agents for aphids, leafhoppers, and lepidopterous (e.g., moth) larvae. Examples include the western corsair bug (*Rasahus thoracicus*)

Western corsair bug

- The assassin bug subfamily, the Triatominae, contains medically important species, which are commonly referred to as conenose bugs

- These bugs are external parasites of wood rats (*Neotoma* spp) and other smaller rodents

Assassin and Kissing Bugs continued General Bionomics

- Conenose bugs do not normally bite during the day, but instead, will take a blood meal secretly when the human victim is sleeping and unprotected
- Bites to the victims' lips and localized swelling have given these bugs their notoriety as kissing bugs
- The bug may deposit parasite infested feces at the site of the bite, which can be rubbed into the wound or onto the conjuctiva when the site of the bite begins to itch (response to injected saliva)

Assassin and Kissing Bugs continued
Public Health Significance

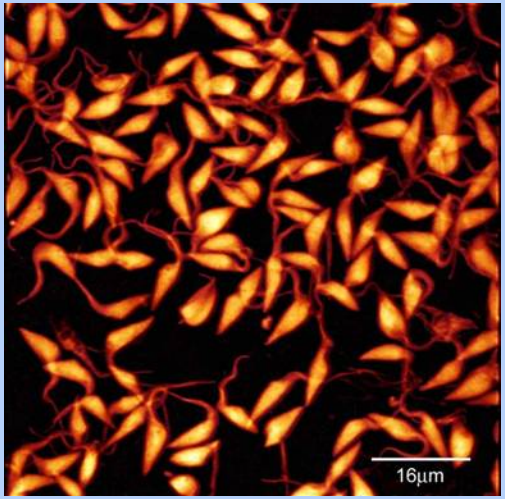
- The bugs appear to be attracted to the lights around dwellings during their dispersal flights, but seek out dark and secluded areas after they land
- They usually find the human host by heat receptors and chemical receptors sensitive to carbon dioxide
- In many cases the victim is usually not aware that there has been a bite from a conenose bug
- Physicians must be informed of the habits of these insects and consider conenose bug bites in the determination of their diagnosis

Western conenose

Assassin and Kissing Bugs continued
Public Health Significance continued

- Allergic Reactions
  - The conenose bug bite causes an allergic reaction due to the foreign protein in the injected saliva
  - The severity of the bite can vary depending on the sensitivity of the victim
  - Symptoms include itching of scalp, palms or feet; swelling of eyes, tongue, or larynx; impeded speech capability; welts or rashes; nausea; fainting; pain; vomiting; fever; cramps; and death

- Chagas Disease
  - This is a condition resulting from an infection of *Trypanosoma cruzi*, a flagellate (image on right) deposited at the site of the conenose bite by contaminated feces
  - The feces are immediately rubbed into the wound in response to an itching sensation
  - Some early signs of disease are fever, fatigue, and anorexia
  - The disease is treatable with Bayer 2502, a drug available from the Center for Communicable Disease Control in Atlanta, GA



Assassin and Kissing Bugs continued Control and Management

- The most successful method to reducing the likelihood of a conenose bite is to prevent their access to dwellings and outbuildings
- All windows should be screened and outdoor lighting intensity should be reduced
- In areas of high wood rat populations, efforts should be made to control the wood rat population in proximity to the dwelling
- Conenose bugs encountered inside the residence can be sprayed with non-residual sprays or captured and destroyed

Bed Bugs

- Species of Medical Importance
- General Characteristics
- Distribution
- Public Health Significance
- Control and Management

Bed Bugs
Species of Medical Importance

- There are two genera and six species of “bed bugs” in California
- The species of most public health importance in California is the common bed bug (*Cimex lectularius*)

Bed Bug (*Cimex lectularius)*

Bed Bugs
General Characteristics

- The common bed bug is wingless with a flattened oval shape and changes from a dusky red color to a more vivid red when actively feeding

- Bed bugs have a four-segmented antenna and a beak specialized to suck blood

Common bed bug

Close up of bed bug head

- Swallow bugs feed primarily on swallows, but are known to feed on humans in the absence of their typical bird host

- Bat bugs are similar in their behavior to swallow bugs, but feed exclusively on bats and rarely on humans

Bed Bugs Distribution

- Most bed bugs are moved about in infested clothing, mattresses, and upholstered furniture
- Their presence is indicated by the appearance of small blood spots on the bed linen or nightwear
- Bed bugs are active at night and when disturbed they emit a disagreeable musky odor

Bed Bugs
Public Health Significance

- Although bed bugs may acquire diseases during feeding, there is no scientific evidence to indicate that bed bugs can transmit diseases to humans
- Bed bug bites leave a small hard wheal that is white in color accompanied by swelling and inflammation
- The injection of the saliva can cause an allergic reaction
- In addition to the allergic reaction, there is possibility of a secondary infection appearing should one excessively scratch the wound

Bed Bugs
Control and Management

- Good sanitation practices are important in the prevention of bed bugs in the home and sleeping areas
- Some infestations can be prevented by washing clothing and bedding immediately after returning from a trip
- Inspect all used beds, box springs, sofas, upholstered chairs, and bedding for signs of bed bugs before bringing them into your home
- Once infestation is confirmed, pesticide application and heat treatment of homes and items are ways to eradicate bed bugs

Flies

An Overview

Primitive Flies (midges and gnats)

Brachyceral Flies (horse flies, snipe flies, and relatives)

Higher Flies (house flies, blow flies, and relatives)

Flies
An Overview

- Flies on a worldwide scale are responsible for transmitting and causing millions of vector-borne disease deaths and morbidity in humans
- Flies of public health importance are found in virtually every habitat from high artic tundra to the equatorial rain forests
- Flies are typically divided into their respective suborders based upon both their larval and adult morphological characteristics
  - Primitive flies (suborder: Nematocera)
  - Advanced flies (suborder: Brachycera-Orthorrhapha)
  - Higher flies (suborder: Brachycera-Cyclorrhapha)

Primitive Flies (Midges and Gnats)

- Introduction
- Public Health Importance
- Primitive Flies of Public Health Importance
- Non-blood Feeding Gnats, Midges, and Mosquito-like Flies
- Management and Control
- Surveillance

Introduction

- In general the primitive flies are the flies that take blood from vertebrates
  - For example: biting gnats, mosquitoes, and sand flies
- Their association with a number of diseases and a habit of attacking “en masse” makes these flies formidable vectors where encountered
- These flies lack the diagnostic characteristics of body and/or wing scales in combination with an elongated proboscis adapted for piercing skin and sucking blood

Public Health Importance

- Besides mosquitoes, other forms of primitive flies also are involved with the transmission of disease agents that have a debilitating effect on humans, causing occasional fatalities
- In California, there are no recorded instances of primitive biting flies, other than mosquitoes, that have been shown to transmit pathogens to humans

Public Health Importance continued
Allergic Reactions to Gnat Bites

- The bites of “blackflies” and “punkies” often produce a severe localized reaction at the site of the bite
- Sensitive individuals may experience intense itching, swelling, and seeping ulcerations that may persist for weeks if not treated
- Most people will notice some localized discomfort at the site of the bite that usually subsides in less than a week

Public Health Importance continued Allergic Reactions to Midge Products (Dried Body Parts)

- Sensitive individuals either contacting or inhaling the fragments may experience allergic reactions
- Suspended midge body fragments contacting the skin can cause a rash to appear or blister in extreme cases

Public Health Importance continued
Bite Prevention

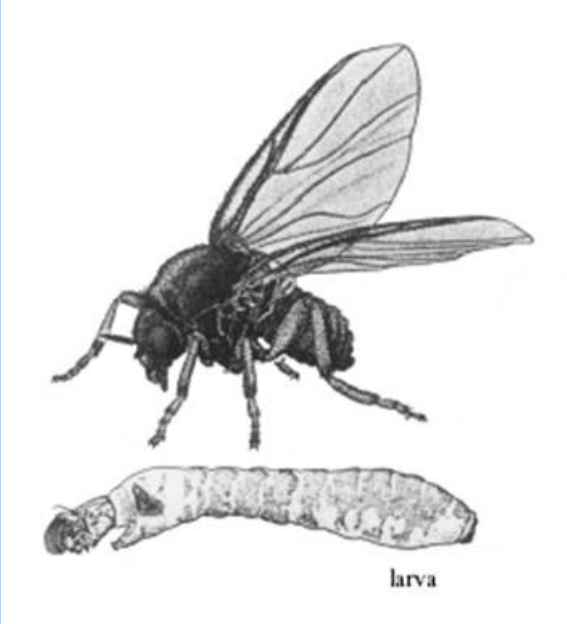
- When gnats are actively feeding, protective clothing covering the exposed arms and legs along with a fine mesh mosquito/gnat head net can deter most gnat bites
- When applying repellents containing DEET, do not apply to the sensitive areas of the face around the lips and eyes
- Apply the product to your hands and then rub it onto the cheeks, forehead, ears, and back of the neck

Primitive Flies of Public Health Importance

- Midges and Blood-Feeding Gnats
  - Blackflies or “Buffalo Gnats”
  - Punkies or “No-See-Ums”
  - Sand Flies

Primitive Flies of Public Health Importance continued

- Blackflies or “Buffalo Gnats”
  - Are in the family Simuliidae
  - The adults have a distinct humpback
  - A majority of the species emerge in the spring and early summer from running water sources
  - Upon hatching, the young larvae attach themselves to objects in the swift currents where they will usually remain for the duration of their development
  - Unlike females, males do not take blood

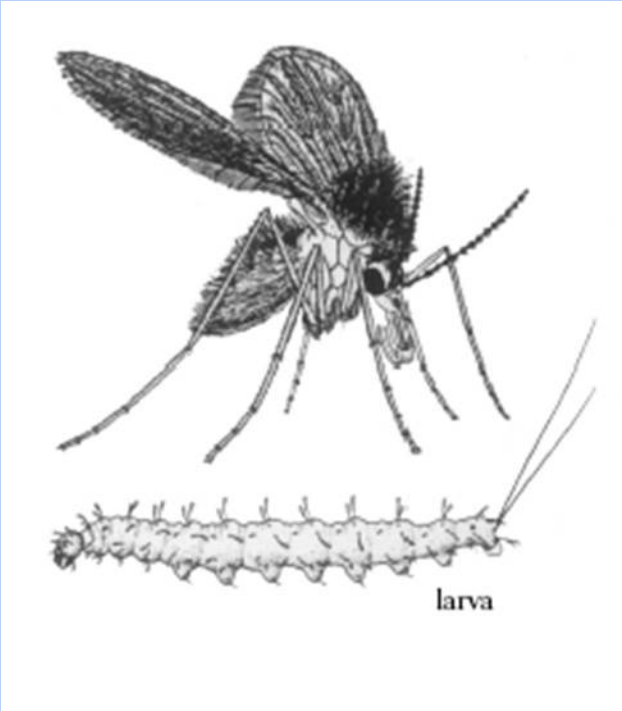


Primitive Flies of Public Health Importance continued

- Punkies or “No-See-Ums”
  - Punkies (family Ceratopogonidae) are another group of minute biting flies; adults in the genus *Leptoconops* are colored black with either clear or milky wings; adults in the genus *Culicoides* are variously colored in blacks, grays, and tans with the wings often patterned in diagnostic concentric blotches and spots
  - Females are notoriously painful biters that are seldom noticed biting until after they have engorged
  - This attribute of their “stealthy” feeding behavior prompted their alias as “no-see-ums”

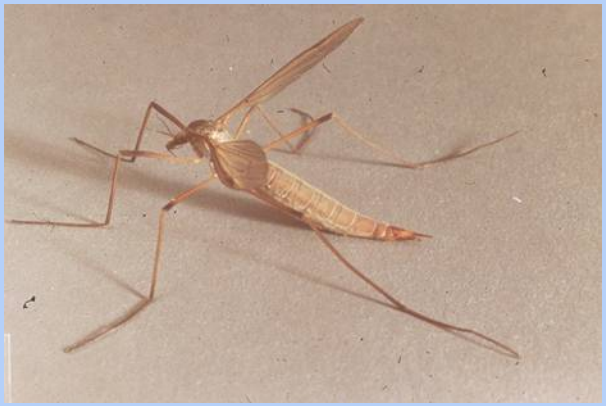
Primitive Flies of Public Health Importance continued

- Sand Flies
  - The blood-feeding sand fly (family Psychodidae) belong to the genus *Lutzomyia*
  - They have a “hairy” body and wings that give them their “moth-like” appearance



Non-Blood Feeding Gnats, Midges, and Mosquito-Like Flies

- Many flies may be confused as mosquitoes and can be nuisances
  - Crane Flies
  - Moth Flies
  - Fungus Gnats
  - Midges



Crane Fly

Moth Fly

Midge

Management and Control

- The integrated approach to managing primitive flies, particularly, blood-feeding species, presents a number of impracticalities to applying both non-chemical and chemical measures

- Treatment of blackflies in the larval stage is feasible if chemicals (e.g., Bti) can be applied to moving water sources prior to pupation after which control is not possible using either an insect growth regulator (IGR) like methoprene or with biological control represented by Bti

- Environmental management
  - Environmental management application requires augmenting existing environmental circumstances in a manner that either precludes target species colonization or exposes sensitive life stages to conditions that cause their timely death
  - Examples of environmental management are tilling of soil, controlling water flow, level, and pH

Management and Control continued

- Exclusion
  - In areas where insect pests are seasonal annoyances exclusion becomes effective
  - Denying these flies access to activity areas, such as, porches, patios, and picnic areas using small mesh screening or tent will provide an effective barrier
  - Changing light bulbs from white to yellow incandescent can reduce the number of flies
  - “Bug zappers” are not recommended because they attract more than they can kill

- Public Education
  - Informing residents of primitive flies increases the awareness and what precautions one can make towards these nuisance species
  - The public will be able to anticipate when to plan their outdoor activities to avoid flies
  - Providing information on nuisance species is important for lessening the concern with gnats and midges that do not blood feed, but “appear” as forms that are associated with attacks and subsequent itching bites

Surveillance

- Surveillance of primitive flies is important because some species directly impact human welfare
- These are the flies that take blood and/or transmit disease agents
- Surveillance is performed using various trap mechanisms, particularly the CDC-type CO_2 (dry ice) baited trap
- Knowing the approximate number of flies, both larval and adult stages, allows for preventive measures to be taken in sensitive areas

Brachyceral Flies (Horse Flies, Snipe Flies, and Relatives)

Introduction

Bionomics

Public Health Importance and Disease Relationships

Taxonomy

Species of Public Health Significance

Management and Control

Introduction

- Brachyceral flies resides mostly in the northern latitudes and in the mountains
- These flies have mouthparts that slice into the skin of the host to sever capillaries and cause the blood to pool at the skin's surface where it is ingested by the sponging action of the labellum

Bionomics

- Horse and deer flies (family Tabanidae) are considered aquatic to semiaquatic insects because larval development of most known species occurs in water (mud and moist soil)
- Horse flies are distinctly larger and more robust than deer flies
- Deer flies are recognized by the presence of brown to amber patches on the wings of most species
- Horse flies have either clear, smoky, or opaque black wings
- Males typically do not feed on blood, but obtain nutrition by feeding on nectar
- Males have a large compound eye that converges at the top of the head, “holoptic,” and females are “dichoptic”, eyes are separated
- Certain species of horse flies can fly up to 40 mph

Bionomics continued

- The snipe fly (family Rhagionidae) are smaller than horse and deer flies
- Snipe flies have noticeably more elongate and thin legs
- Their wings are clear without dark colored markings
- Blood-feeding species' body is uniformly gray to light brown without contrasting patterns on the thorax and abdomen
- Most species are aquatic
- The soldier fly (family Stratiomyiidae) are distributed worldwide
- Larvae are found in aquatic to terrestrial environments
- Adults are brightly colored in shades of yellow, green, red, brown, and rarely blue and black
- Have a wasp-like appearance due to the color and pattern of their wing venation and their flight behavior

Public Health Importance and Disease Relationships

- Bite Trauma and Allergic Responses
  - Horse, deer, and snipe flies bite using mandibles that have a cutting action causing localized tissue damage and bleeding
  - The saliva introduced from the fly can also promote bleeding and cause severe allergic reaction that can last for several days
  - These biting attacks are known to seriously impact the vigor of horses and cattle
    - Blood loss due to repetitive bites produces a number of clinical and behavioral side effects that collectively reduce the animal's ability to combat disease

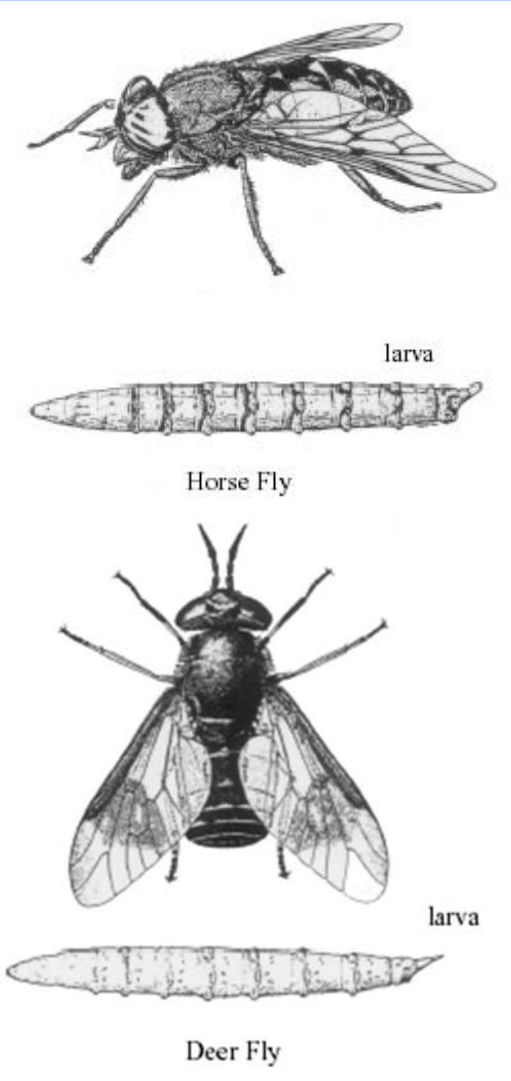
- Vector-Borne Diseases
  - Although most species of Brachyceral flies occasionally bite humans, their actual involvement with transmitting disease agents is restricted to large mammals with humans being infected rarely by accidental bites
  - Among the more well-known pathogens transmitted are those that cause Anthrax, Tularemia, and Anaplasmosis

Public Health Importance and Disease Relationships continued

- Enteric Myiasis
  - This is the occurrence of insect larvae (maggots) in the gastrointestinal tract of either an obligate or accidental host
  - When ingested, the larvae pass through the stomach and enter the intestine where they can cause some discomfort and associated gastrointestinal disorders
  - The larvae are eventually passed with little or no permanent post-infection side effects

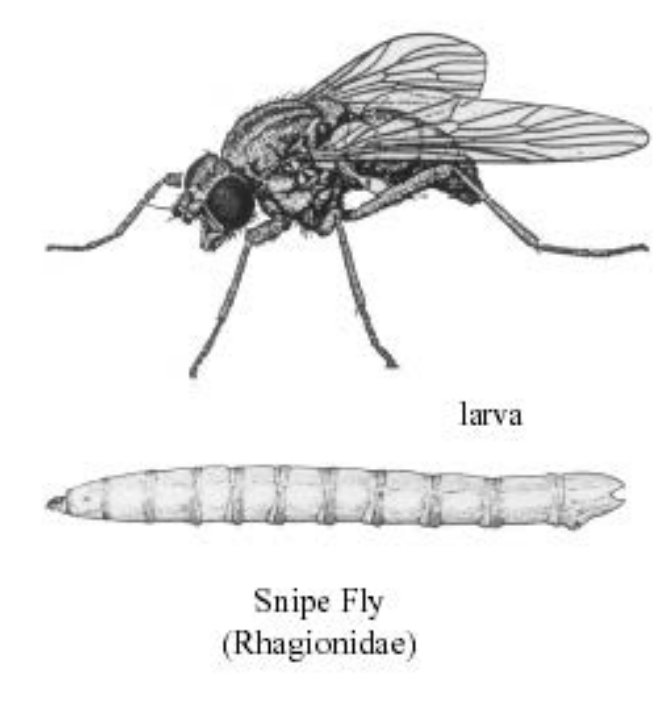
Taxonomy

- Horse and Deer Flies
  - Family Tabanidae
  - Eyes of the horse fly are often colored in solid shades or cross-banded with browns, greens, blacks, and yellows
  - Deer fly eyes are patterned with metallic greens and golds
  - The abdomen can be variously colored with different arrangements of spots and bands that complement the thorax, which is either unmarked or striped in contrasting darker colors
  - Wings can also vary from smoky to clear wings with contrasting spots or patches
  - A majority of deer flies are sexually dimorphic
  - Eggs are deposited on either emergent vegetation, mud, or overhanging tree branches
  - Larval development varies among species, some require 1-3 years to mature and others 1-2 months during the summer
  - Adults emerge from pupae in 5 days to 3 weeks depending upon the species
  - Adults can survive several weeks or longer



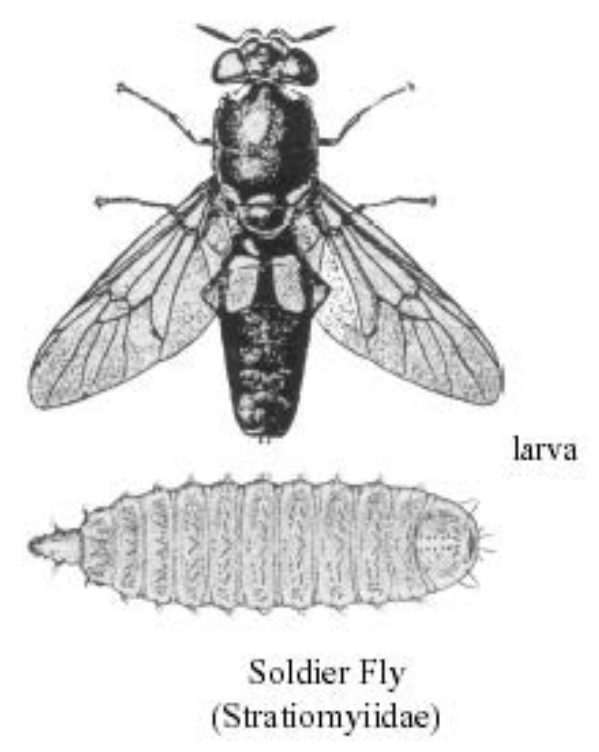
Taxonomy continued

- Snipe Flies
  - From the family Rhagionidae
  - Snipe flies are similar in appearance with little differentiation in gross morphology
  - Differences in species is largely associated with the uniqueness of adult genitalia combined with the subtle differences in coloration, patterns of body hairs and spines, antennal morphology, and wing venation
  - Adults of blood-feeding *Symphoromyia* are active from March through June
  - Most species only produce one generation per year
  - Eggs are deposited on the surface of vegetation or on other alternative substrates that line temporary woodland streams
  - Adults live for several weeks under favorable conditions and perhaps longer in moist shaded canyons where blood meals are easily obtained from deer, cattle, and other vertebrates



Taxonomy continued

- Soldier Flies
  - Family Stratiomyiidae
  - The morphology of solider flies is substantially diversified in comparison to other closely related families with species that do not show significant variation in both form and color
  - Soldier flies are separated on the basis of differences in their antennae, body form, wing coloration, and wing form
  - Eggs are deposited on the moist surfaces of decaying fruits, “digesting” grass clipping compost, and other similar organic substrates
  - Eggs hatch in 2-5 days, and larval development requires an additional 1-2 weeks
  - Adults are relatively long-lived (about one month) and capable of dispersing several miles to mate and reproduce



Species of Public Health Significance

- The Western Horse Fly (*Tabanus punctifer*)
  - Found in California predominantly in cooler environments associated in foothill and montane habitats
  - Eggs hatch into larvae in 5-7 days and swim to the bottom mud where they feed on macroinvertebrates
  - Adults are colored black, including the wings with the pronotum bright gray
  - Adults cause discomfort to humans and wildlife

- Deer Flies (*Chrysops* spp.)
  - Found predominantly in association with wetlands and riparian environments in the Central Valley and eastern Sierra
  - The species of greatest concern is *C. discalis*
    - Breed in alkaline situations and is known to transmit tularemia causing bacteria to humans and wildlife
    - Males are dark brown with heavily mottled wings
    - Females are colored light brown to tan with mottled light brown wings

Species of Public Health Significance continued

- Snipe Flies (*Symphoromyia* spp.)
  - Found widespread in California with *S. atripes* being the most prevalent species involved with biting humans in woodland and riparian habitats
  - Adults have an overall gray body coloration and clear wings
  - A noticeable forewing spot is located just beyond the middle of the leading edge (costal region) of the wing

Management and Control

- Source Reduction
  - Modifying breeding sites is the best method of managing horse and deer flies in peridomestic situations
  - Water and vegetation management in roadside ditches, filling swales in pastures, and increasing the embankment to limit shoreline in farm ponds can reduce the suitability of these site to breeding
- Exclusion
  - This involves the application of barriers that prevent horse, deer, and snipe flies from contacting host animals and humans
- Repellents and Other Protective Measures
  - Wearing protective clothing that covers exposed skin, or applying DEET based repellents directly to clothes and sparingly to the face and exposed arms and legs can help prevent contact with Brachyceral flies

Higher Flies (House Flies, Blow Flies, and Relatives)

- Introduction
- Bionomics
- Disease and Public Health Relationships
- Species of Public Health Importance
- Species Associated with Human Activity
- Species Causing Myiasis
- Management and Control
- Surveillance and Inspection Procedures

Introduction

- The higher flies are represented by an assemblage of different species adapted to obtaining nutrients as adults and immatures from a variety of resources including host blood and live tissues, carrion, feces, and decomposing vegetable matter
- Their reproductive capacity, their diet of blood and filth, coupled with their affinity for man and animals, make the higher flies reservoirs and disseminators of fly-borne parasites and microbial pathogens.

Bionomics

- Most species of flies proliferate under warm conditions that accelerate larval development and maximize adult activity, including mating, feeding, and flight
  - Tropical environments afford year-round breeding
- Most higher flies are capable of sustained flight that enables them to fly upwards of 5-20 or more miles from breeding areas
  - Even greater dispersal distances are possible if assisted by strong tail winds associated with storm fronts and seasonal changes

Disease and Public Health Relationships

- The feeding habits, high reproductive rates and their attraction to humans and other animals make this group logical carriers of vertebrate pathogens
- Annoyance Factors
  - Most humans are intolerant of house flies hovering around patios, landing on exposed food, and more so when they land on exposed skin of the face, arms, and legs
- Diseases produced by Microorganisms and Helminths
  - Some species, particularly house flies, are incriminated in contaminating exposed food with the bacteria that causes salmonellosis, shigellosis, typhoid, and cholera
  - The poliovirus can also be transmitted by flies
  - Diseases that are caused by intestinal helminths or protozoa such as *Giardia*, can also be passed on by flies

Disease and Public Health Relationships continued

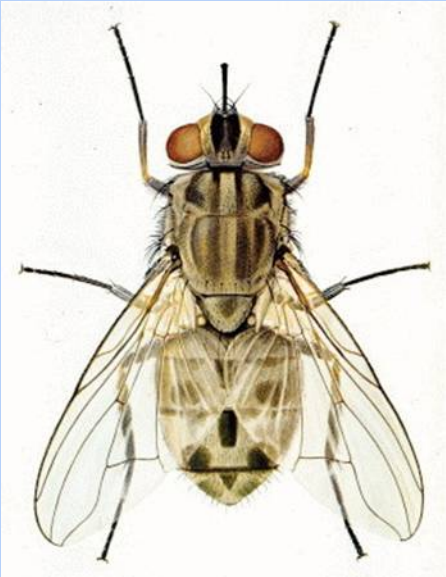
- Myiasis
  - Myiasis is a condition caused by one or more fly larvae feeding upon the living or dead tissue, fluids or ingested food of a living vertebrate. Can be broadly divided into obligatory and facultative myiasis.

- Obligatory Myiasis
  - Involves species that require living tissue for development.
  - Furuncular myiasis: bot fly larvae infesting a human torso

- Facultative Myiasis
  - Involves species that require necrotic tissue, carrion or decomposing organic matter for development but will opportunistically feed upon vertebrates
  - Dermal myiasis: black blow fly larvae infesting a human scalp wound

Species of Public Health Importance – Blood-Feeding Species

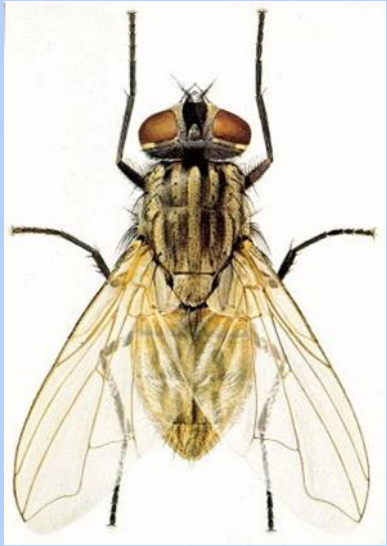
- Stable Fly
  - A barnyard species commonly associated with stables, corrals, and stockyards
  - This fly has piercing mouthparts as compared to the characteristic sponging-type mouthparts of the house fly
  - Maggots develop in the moist mixture of straw, hay, and manure that accumulates in stalls and along the margins of corrals and feed lots



- Horn Fly
  - These flies are common during the late spring and summer in the Central Valley of California where they are often observed feeding in masses on the flanks, rump, and belly of cattle and horses
  - Overwhelming infestations can seriously decrease animal vigor and reduce milk production in dairy cattle

Species Associated with Human Activity

- House Fly
  - Other than the mosquito, this insect is perhaps the single worst nemesis of humans worldwide
  - Millions of house flies can be produced in just a couple of days in poorly maintained landfill sites, piles of rotting fruit, and exposed animal feces



- False Stable Fly
  - Slightly larger than the house fly, but similar in appearance
  - Like house flies they are capable of long-range dispersal and at times can become quite annoying to residents living near dairies and stables
  - Adults over winter either singly or in small groups that aggregate in woodpiles, outbuildings, and sometimes in the attics of houses

Species Associated with Human Activity

- Lesser House Fly
  - These flies breed predominantly in moist accumulations of decaying vegetable matter, bird droppings, and animal droppings/manure
  - Instead of flying out in the open as adult house flies do, lesser house flies aggregate in swarms in the shaded spaces on porches, walkways, patios, and beneath the overhanging limbs of shade trees
  - The males are territorial and tend to fly at eye level in either an irregular or abrupt back-and-forth elliptical pattern

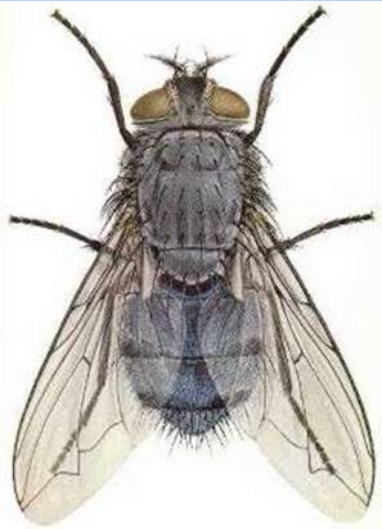
Species Associated with Human Activity

- Face Fly
  - Often mistaken for a house fly, but larger in size like the false stable fly
  - They characteristically aggregate on the face of horses and cattle where they readily feed on the lacrimal secretions associated with the eyes
  - Cattle ranching operations in the Central Valley of California are prone to “pinkeye” (*Moraxella bovis*) epidemics that can seriously affect herds grazing along the foothills of the Sierra Nevada and Coast Ranges

- Green Bottle Fly
  - Perhaps the most well-known and widely distributed blow fly in California and elsewhere in North America
  - They are found throughout California from sea level to 11,000 feet in the Sierras and Cascades
  - Adults are metallic green to slightly bronze in color
  - Populations reach peak numbers in late spring and decline thereafter

Species Associated with Human Activity

- Common Blow Fly
  - Found throughout California
  - Most commonly late spring
  - Breeds in garbage and carrion, commonly in the carcasses of commensal rodents (e.g., roof rats and house mice)



- Black Blow Fly
  - This fly is most abundant during spring
  - Adults are colored a deep metallic blue to almost black
  - Breeds in garbage and carrion.

Species Associated with Human Activity

- Introduced Blow Fly ("Latrine Fly")
  - Adults are colored bronzy-green and have an exaggerated large head and compound eyes

- Red-Tailed Flesh Fly
  - Most abundant at lower elevations exclusive of the deserts in California
  - Adults are large with distinctive gray and black marks with 3 black stripes on the thorax and a contrasting checkered pattern on the abdomen
  - Females deposit larvae, not eggs, directly into the food resource
  - This fly feeds on feces, but will occasionally feed on carrion and is involved with intestinal and rectal myiasis

Species Causing Myiasis

- Rat-Tailed Maggot
  - Also known as the “drone fly”
  - Closely resembles a honeybee and likes to hover around flowers in backyards
  - Humans are accidentally parasitized when either rotten fruit or foul water containing larvae is ingested

- Common Horse Bot Fly
  - An intestinal parasite of equines
  - Larvae are deposited on the esophageal portion of the stomach
  - Adults are hairy and resemble honeybees

Species Causing Myiasis

- Screwworm Flies
  - Have larvae that produce trauma as a consequence of feeding in the open sores and wounds of mammals
  - Primary screwworm fly has been eradicated from the U.S. by the release of sterile males but the secondary screwworm fly still remains

- Warble Fly
  - A common cutaneous parasite
  - Adults resemble a bumblebee with four prominent polished lines on the dorsum of the thorax
  - The entire life cycle requires approximately 1 year to complete

Species Causing Myiasis

- Sheep Bot Fly
  - The parasitic larvae develop in the nasal cavities/sinuses of sheep and goats
  - Adults are colored in yellows, browns, with a variegated gray and brown abdomen

- Rodent and Rabbit Bots
  - Typically colored black with the abdomen variegated in grays, blacks, and whites
  - Larvae bore into the skin and encyst at that site for the remainder of their development, approximately one year

Management and Control

- Overview of Integrated Pest Management (IPM) Strategies in Fly Control
  - The explosive reproductive potential of these flies and their ability to disperse makes these vectors difficult to control
  - Balanced IPM fly programs include
    - Source Reduction
    - Exclusion
    - Biological Control
    - Chemical Control (includes chemoprophylaxis)
    - Public Education

Management and Control

- Source Reduction
  - The best overall method of fly control is to either prevent or significantly reduce access to larval breeding resources
  - Reduction of adult resources is often next to impossible in most situations leaving the only remaining alternative of denying flies access to larval food sources
    - Carrion
    - Garbage
    - Manure and Animal Droppings
    - Decaying Vegetable Matter

- Exclusion
  - This is the practice of keeping flies from entering homes and food establishments
  - A combination of screening, fans, sticky traps, and chemical lures have been used
  - Of the above methods, screening is perhaps the best barrier against flies gaining access to the inside of structures
  - Outdoors, traps that either capture or entangle adults appear to be most effective

Management and Control

- Biological Control
  - Some common predators of flies are species of mites and parasitic wasps that feed on the eggs; hister beetles and ants that prey upon eggs and larvae; and parasitic wasps that feed on the internal tissues of pupae
  - The laboratory released colonized sterile males has also been effective
    - The strategy here involves releasing these sterile males in massive numbers so that they overwhelm the mating capacity of wild males
    - Females that mated with sterile males will thusly release unfertilized eggs that will not develop

- Chemical Control
  - These strategies are most commonly applied in suppressing fly infestations and preventing adult flies from contacting humans and domestic animals
  - Chemicals can kill by disrupting nerve actions or by preventing the transformation of pupae to adults
  - Chemicals can be an oil base, aqueous, wettable powders, or liquid concentrates of the product

Management and Control

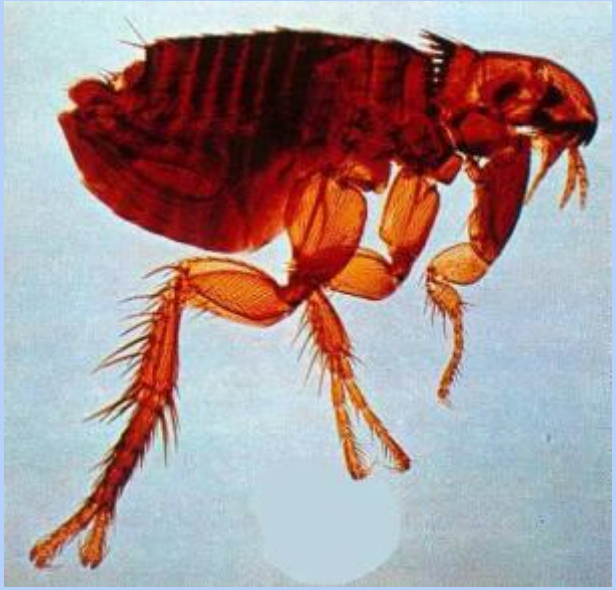
- Public Education
  - Public education techniques are used to increase both resident awareness of what conditions breed flies and what actions they can take to effectively reduce fly breeding on their property
  - Fly breeding can be reduced by simply educating residents to remove pet droppings daily, properly compost grass clippings and other landscape prunings, as well as having weekly garbage pickups

Surveillance and Inspection Procedures

- Before control procedures are initiated, a fly infestation and associated health problems may require quantification as a determining factor in the selection of management options available to the control technician
- Substrates that can produce larvae are inspected for the existence of breeding
- Adults are monitored using various attractant-type traps
- Surveillance is also dependent on being able to locate a fly infestation
  - Knowing the species of fly and its habitat is crucial in order to obtain a reliable reading

Fleas

- Introduction
- Distribution
- Bionomics
- Life Cycle
- Public Health Importance
- Management and Control



Introduction

- Adult fleas are bloodsucking ectoparasites of birds and mammals
- Adults are hard-bodied, usually brownish in color, lack wings, and have long legs for jumping
- Their mouthparts are used for piercing skin and sucking blood
- Fleas are distinguished from other insects by having laterally flattened bodies and backwards projecting bristles and spines, which enable them to easily move through feathers or hairs of their host and cling to their host

Distribution

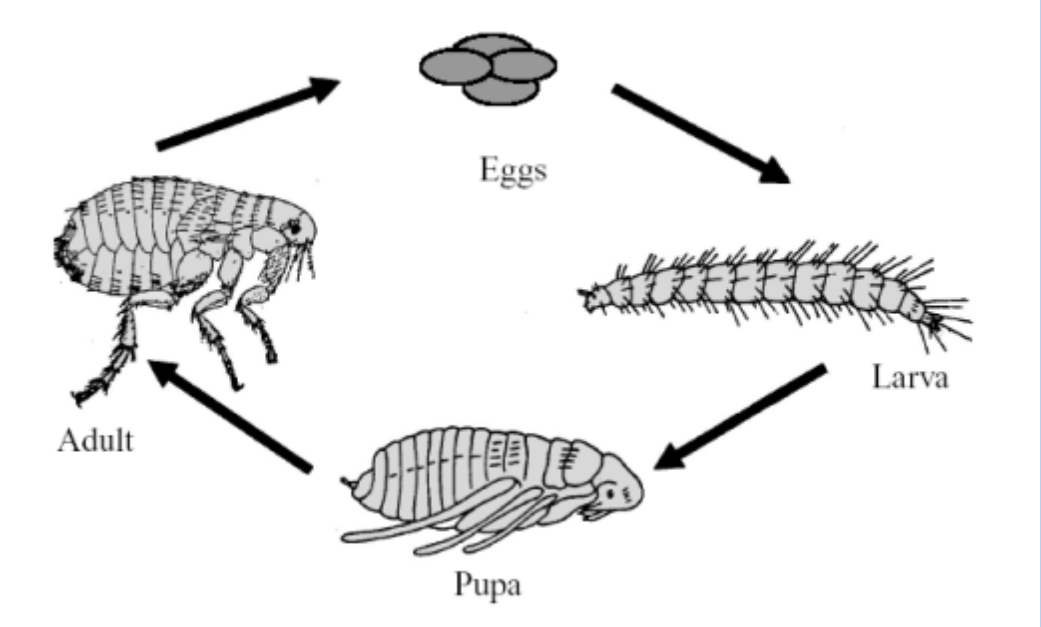
- Fleas occur on every continent
- Fleas occur primarily on mammals which utilize fairly permanent nests or dens, such as rodents or lagomorphs, but can also occur on insectivores, bats, and carnivores
- They can also be found on birds which mostly nest on or near the ground or in burrows
- They rarely infest mammals which do not nest, such as ungulates and marine mammals

Bionomics

- Most species of fleas usually feed on a single host species, while a few may feed on various host
- Adult fleas locate their host by specialized sense organs (sensillae) located on their antennae and bristles
- A flea can jump vertically and horizontally 150 times its own length
- Fleas may be categorized by their behavior and host preference

Life Cycle

- Fleas exhibit complete metamorphosis
- Fleas characteristically leave the host to deposit their usually whitish eggs in the host's nest or sleeping site
- Eggs are sometimes laid on the host but will eventually fall off and develop on the ground or in the nest

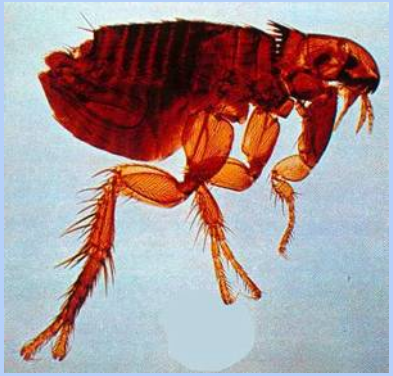


Public Health Importance

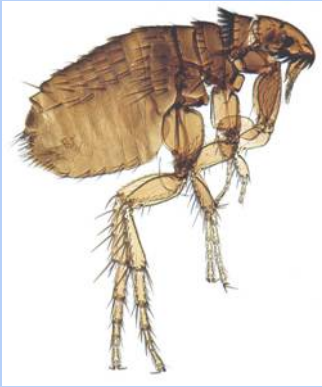
- Fleas can be a public health concern by being nuisances as well as vectors
- Their attack on humans and domestic animals can cause irritation, loss of blood, and severe discomfort, while some individuals may suffer severe allergic reactions or secondary infections from their bites
- Fleas can vector disease organisms which cause bubonic plague, murine typhus, myxomatosis, trypanosomiasis, and possibly other diseases
- Fleas also serve as intermediate hosts for tapeworms and filarial worms

Public Health Importance

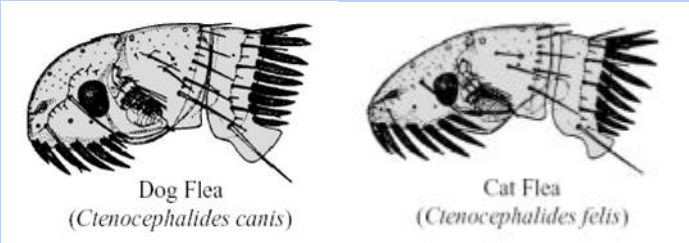
- In California, the dog and cat flea are more abundant in the summer months and in the more humid coastal areas than in arid ones
- Both can be serious pest to humans with bites usually occurring on the ankles and legs
- The cat flea, *C. felis*, is usually the most abundant and more generally distributed on both cats and dogs
- The cat flea is not host specific and will try to feed on almost any warm-blooded animal
- Besides domestic dogs, the dog flea also occurs on slylvatic carnivores
- The cat flea can be distinguished from the dog flea by having the first 2 anterior spines of the genal comb being about equal in length to the other spines on this comb
- The head of the cat flea is also twice as long as wide



Dog Flea
Ctenocephalides canis

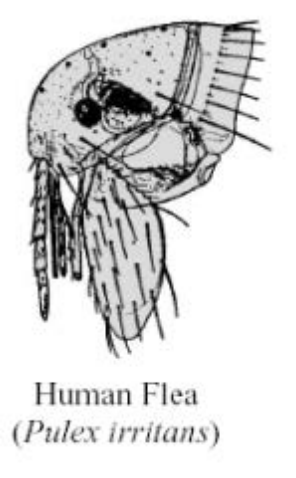


Cat Flea
Ctenocephalides felis



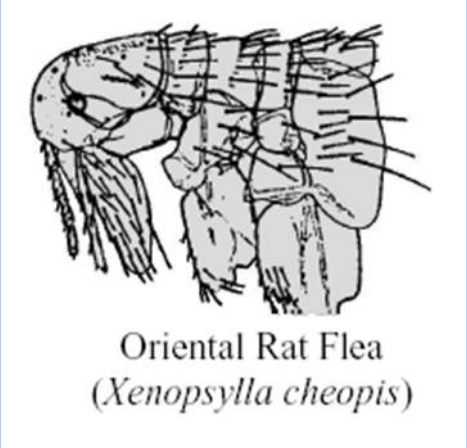
Public Health Importance

- The human flea can be distinguished by the absence of both genal and pronotal combs, and by having the ocular bristle located below the eye
- It is located throughout the world and infests humans, domestic animals, and large carnivores
- This flea has not been shown to be an important vector for plague or other disease agents



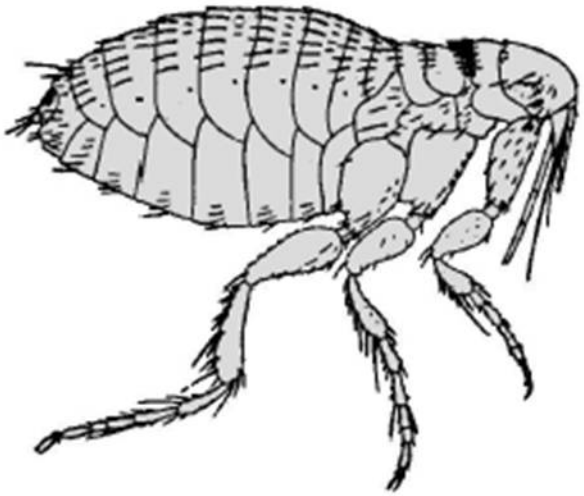
Public Health Importance

- The oriental rat flea lacks both genal and pronotal combs and has the ocular bristle located in front of the eye
- This flea is the only one in North America that has a pigmented spermatheca
- This flea is an important vector of urban plague bacteria and murine typhus ricketssiae



Public Health Importance

- The ground squirrel flea has a pronotal comb, a genal comb with four teeth, and lacks eyes
- This flea prefers cold weather and ground squirrels as host
- This flea will bite humans in place of its normal host
- This species is considered the primary sylvatic vector for plague in the western United States



Ground Squirrel Flea
(*Oropsylla montana*)

Management and Control

- Flea suppression can be divided into two main categories which include controlling primarily cat and dog fleas and controlling sylvatic fleas in urban and rural areas for disease control and prevention
- Control requires simultaneously treating pets or sylvatic animals and their premises
- Use of pesticides and environmental modifications work best to manage and control fleas

Yellow Jackets, Hornets, and Wasps

- Introduction
- Bionomics
- Seasonal History
- Public Health Significance
- Control and Management

Introduction

- Members of the Hymenoptera are probably the most beneficial of all arthropods
- Many species are either parasitic or predatory in their habits, while others are beneficial as pollinators of staple food crops
- Most of the approximately 4000 species of wasps known to occur in the USA are solitary and nonpestiferous, stinging other arthropods to obtain their food
- Yellow jackets can be a pest species at outdoor activities, especially where food is available
- Yellow jackets are widely distributed in North America except in desert regions and in the higher Alpine forests

Bionomics of Yellow Jackets

- Yellow jacket workers are medium sized insects, with a body length of about ½ inch
- They have either black/yellow or black/white patterns on the gaster (dorsal surface of the abdomen)
- Eleven species of yellow jackets occur in the western United States
- *Vespula pensylvanica* (figure 10-1)
  - This is the most prevalent and widespread pest yellow jacket
  - It occurs in savannah, oak woodland habitats and typically uses abandoned animal burrows, soil cracks, and depressions as nest sites
  - They respond to both meat baits and chemical butyrate lures
- *Vespula vulgaris* (see right and figure 10-1)
  - It occurs in the wooded areas of northern California and is considered a major pest in the oak/madrone woodland habitat of the northern coast and wooded area of the Sierra mountains
  - It constructs its nests in ground cavities, in hollow trees, and logs, and in the wall voids
  - They respond to meat baits, not to chemical butyrate lures

Bionomics of Yellow Jackets

- *Vespula atropilosa* (figure 10-1)
  - Lives in small nests usually at higher elevations and more northern latitudes
  - Predators only on live prey
  - Foragers will respond to both chemical butyrate lures and meat baits
- *Vespula sulphurea* (figure 10-1)
  - Widespread in California often along riparian creeks where they can be observed taking in water at the water's edge
  - This ground nesting species is not considered a pest species
  - This ground-nesting species does not respond to either meat baits or chemical butyrate lures
- *Vespula germanica* (see right and figure 10-1)
  - Found in the high mountains of the Sierra Nevada and has been reported along the coast of the western states
  - Large nests are often found in Italian Cypress, palm trees, and inside buildings, especially attics, wall voids, and electrical boxes
  - This species can be confused for *V. vulgaris* in both habit and appearance
  - Will respond to meat baits, but not chemical butyrate lures

Bionomics of Yellow Jackets

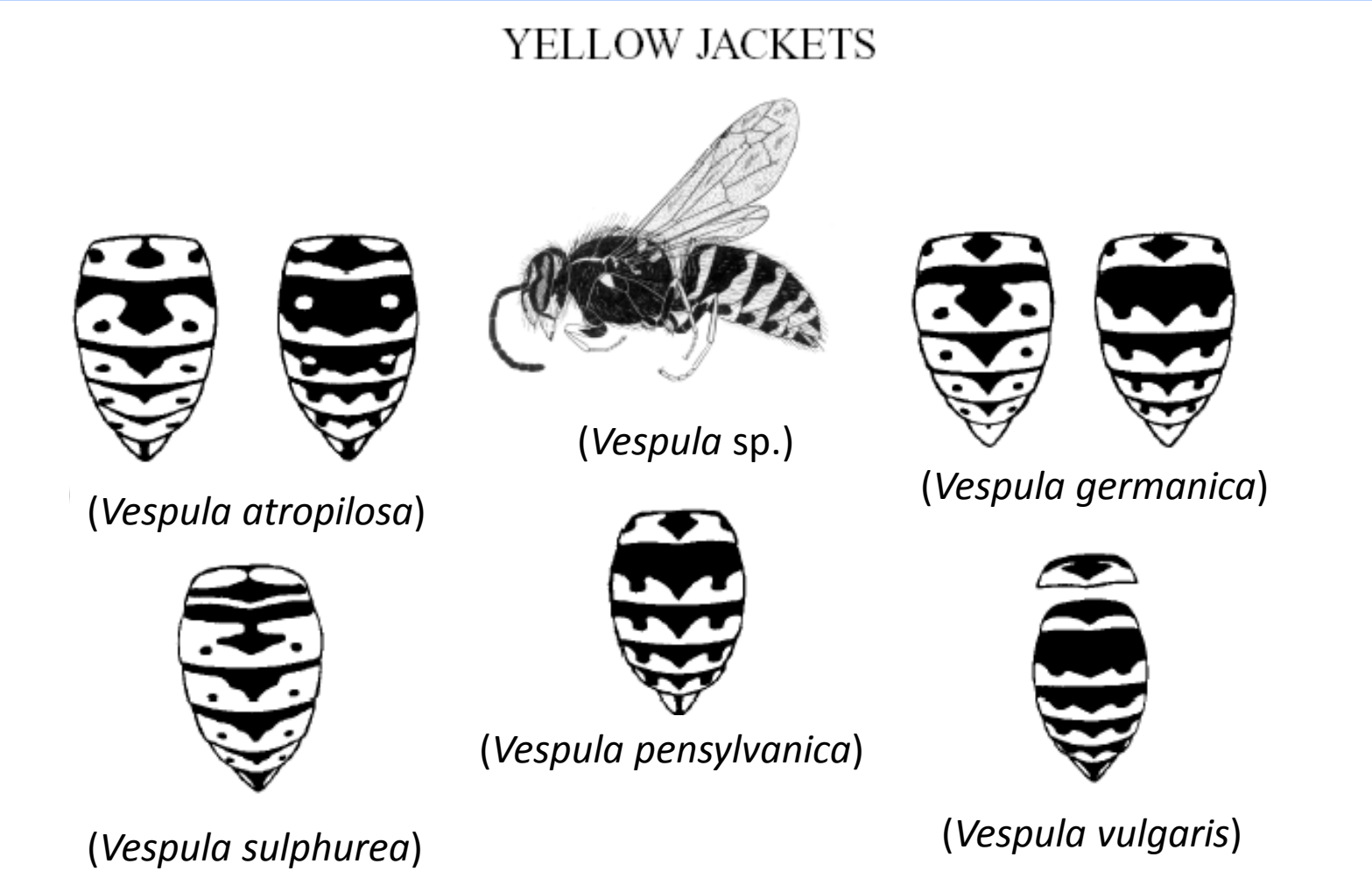


Figure 10-1 Distinguishing yellow jacket body patterns

Seasonal History

- After having mated in the fall, the queen yellow jacket over winters in sheltered crevices, ground depressions, under the bark of trees, or in buildings
- In the spring the founders queen emerges and selects a nesting site where she lays her eggs and nurtures them
- Yellow jackets normally feed upon live insects and spiders, plant and insect nectars, and carrion
- Should the population of yellow jackets become larger than the food carrying capacity of their habitat, then they might become aggressive and search for food near human activity

Bionomics of Hornets

- *Dolichovespula maculata* (figure 10-2)
  - This large aerial nesting species constructs an oval-shaped paper nest attached to trees and eaves of buildings
  - Often referred to as the “white-faced” or “bald-faced hornet” because of its cream and black color and size
  - Occurs in wooded and forested areas in California and is a summertime pest
  - Responds to meat baits, but not to chemical butyrate lures

- *Dolichovespula arenaria* (figure 10-2)
  - This large aerial nesting species, which is yellow and black in color, is prevalent in northern California in wooded and suburban areas
  - It also constructs oval paper nest attached to trees or buildings
  - It is not considered a pest
  - This species does not respond to either meat baits or chemical butyrate lures

Bionomics of Hornets

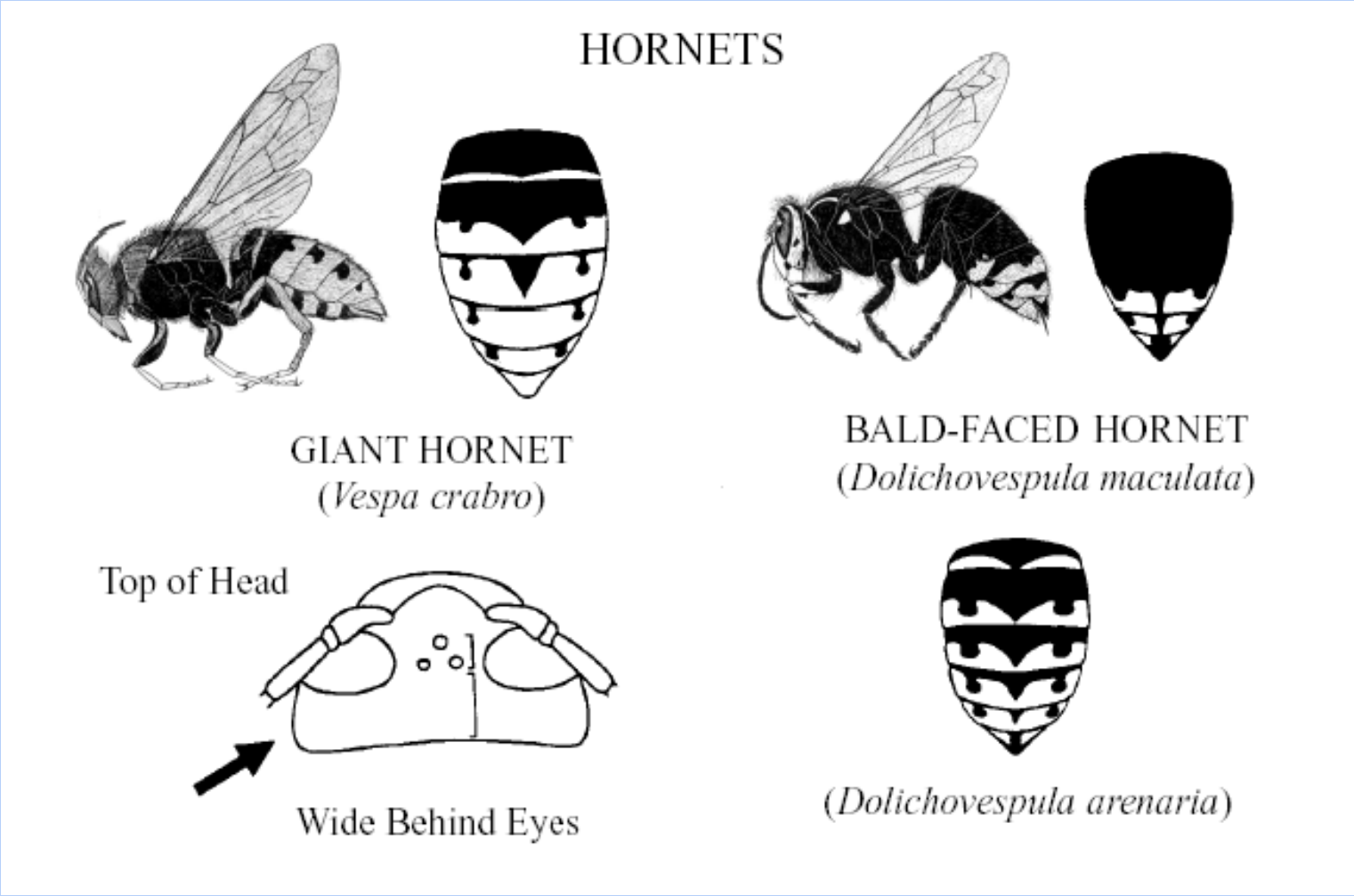


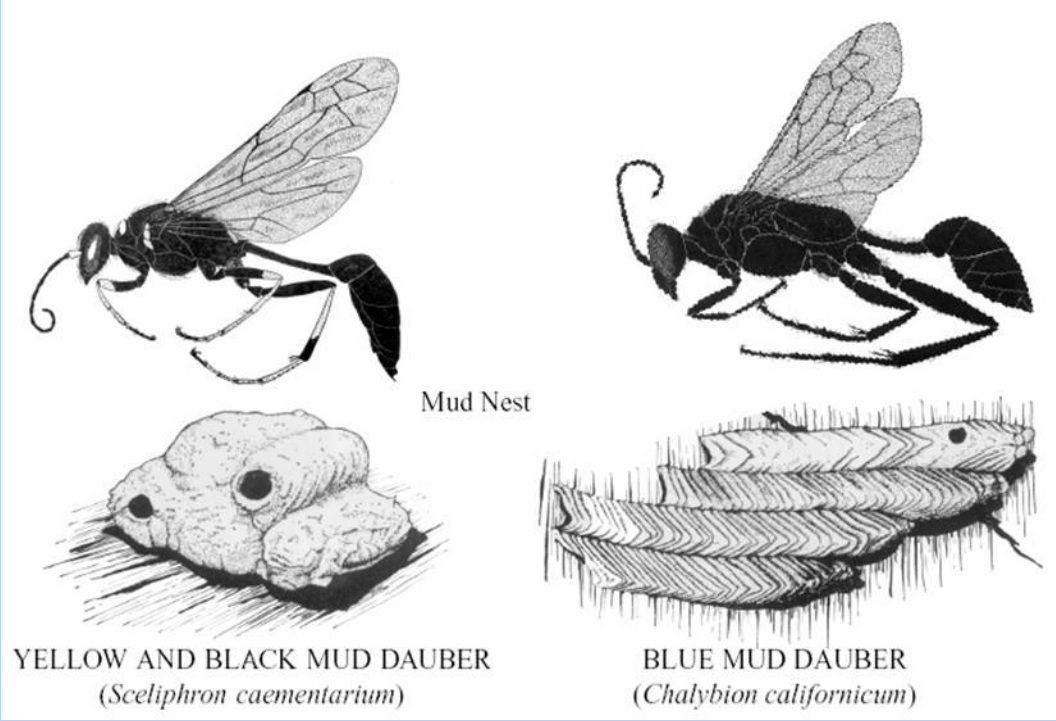
Figure 10-2 Distinguishing body patterns of hornets

Bionomics of Wasps

- Paper wasps (*Polistes* spp.)
  - Widespread in the Nearctic region and are represented by many color forms and subspecies but few species
  - These wasps are brightly colored, usually black, yellow, white or orange striped, but distinguishable from yellow jackets by their large size and tapered abdomen where it joins the thorax
  - These wasps are generally considered economically beneficial but are well-known for their painful stinging ability and may become a nuisance by their presence near human habitation or activities
  - *Polistes* queens overwinter in sheltered crevices and buildings
  - There are at most several hundred *Polistes* in a nest
    - The nest consist of a single comb without an outer covering
  - They feed on soft bodied insects and on juices of fruits

Bionomics of Mud Daubers

- Mud Daubers (*Sceliphron* spp. And *Chalybion* spp.)
  - Widespread throughout California and are easily recognized by the long, narrow “waist”



Public Health Significance

- Only the queen and worker caste have a sting
- The stinger of social bees and some wasps may be barbed
- The sting apparatus of yellow jackets, paper wasps, and other wasps, is relatively smooth or with few barbs and is rarely left in the skin
- As a result they can sting repeatedly

Public Health Significance

- The sting is primarily used against vertebrates as a defensive weapon because the venom injected by the act of the sting contains one or more components that cause intense pain and local tissue damage
- Reaction to Stings and Treatment
  - Hymenoptera venoms contain a number of components that cause a variety of responses including allergenic and non-allergenic reactions
  - Normal reactions to the venom following a sting include immediate pain and local swelling
  - In moderately sensitive persons reactions vary and may appear in the form of widespread swellings or hives, wheezing, faintness, dizziness, vomiting, etc.
  - A small percentage of the population is highly allergic to Hymenoptera venom and may develop anaphylactic shock following even one sting
    - Emergency treatment of generalized allergic reactions should be treated promptly with aqueous epinephrine

Control and Management

- Precautions
  - One should wear protective clothing
    - Wear high shoes which cover the ankles, a pair of heavy coveralls, veiled head wear and heavy gloves
  - Control should also be performed at night when the insects are in the nest
  - Persons who are allergic to hymenopteran stings should not undertake control

- Control Methods
  - The control of pest ground-nesting or aerial yellow jackets, may be considered under three general headings
    - A nest that is located and accessible
    - Infestation in a small area
    - Infestation in a large area
  - The distinction among these three situations cannot always be clearly made, nor can the recommendations be limited exclusively to one situation
  - It is very important to know the species of yellow jacket/wasp in question
    - Most yellow jacket/wasp species are not considered pests or may not respond to known control measures

Control and Management continued

- Accessible ground or aerial nest
  - Mark the position during the day and at night introduce an appropriate dust or spray intoxicant into the opening of the nest taking all precautions to prevent a mass exit of the disturbed yellow jackets or wasps
- Foraging yellow jackets
  - When the nest is not located and the nuisance is due to the presence of the foraging yellow jackets, temporary relief may be obtained by trapping and destroying them in traps baited with chemical lures and protein or carbohydrate attractants
  - A water trap consisting of a container of water (to which detergent has been added) with a protein attractant suspended a few inches over the water will remove large numbers of scavenging pest yellow jackets
- Controlling a large area, such as a park or picnic ground
  - Areas such as these can be protected by using a poison-baiting program

Common Pest Ants

Introduction

General Characteristics of Ants

General Life Cycle

Important Pest Species of Ants

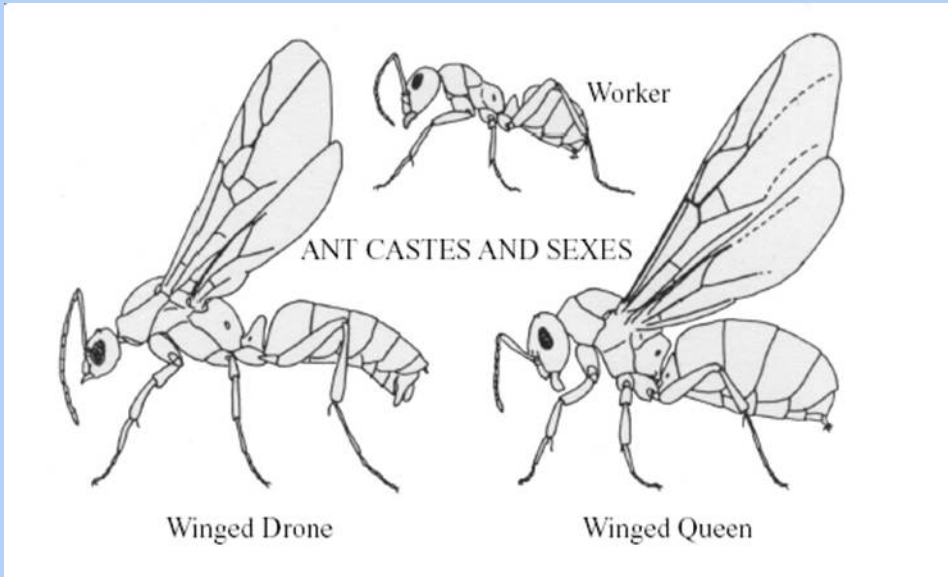
Ant Control

Introduction

- Ants are ubiquitous pests throughout the United States and are common pests especially noted for their persistence
- Of the more than 500 species in the US, only a few may be ranked as true pests
- Most homeowners consider ants to be unwelcome visitors, attracted to leftover or spilled food
- A few house-invading ants, most notable the fire ants, can deliver painful or troublesome stings
- Other ants may protect plants from plant pests
- A few species can cause serious damage to wooden structures

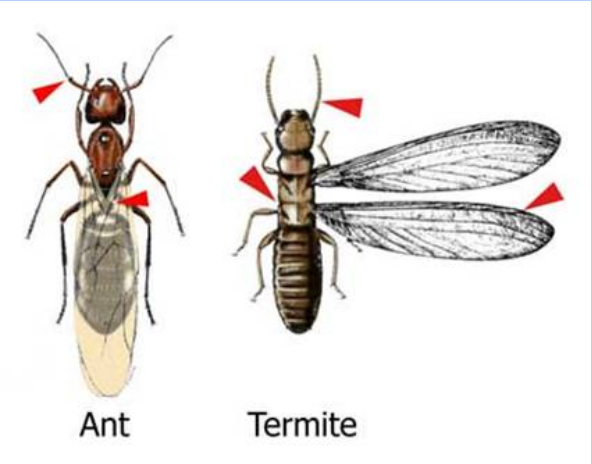
General Characteristics of Ants

- Differences between ants and similar insects
  - All ants are social insects, and usually live in populous colonies in soil or in dead wood
  - There are three distinct castes
    - Worker, Queens, and Males or Drones
  - Workers forage for food and defend the nest
  - Queens start a colony and lay eggs
  - Males or drones live only to mate with the virgin queens



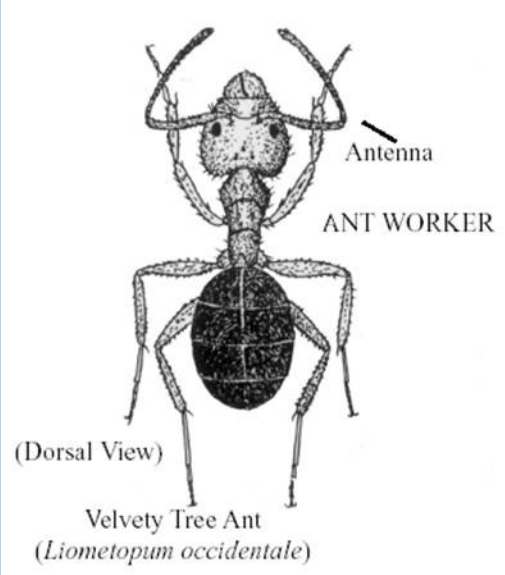
General Characteristics of Ants

- Ants are sometimes mistaken for termites (see right and figure 11-1)
  - Ants have distinctively “elbowed” antennae; the antennae of termites are not “elbowed”
  - Ants have a distinct one or two-segmented waist between the mesosoma (thorax) and the gaster (abdomen); termites have no waist-like constriction
  - Termites do not have eyes

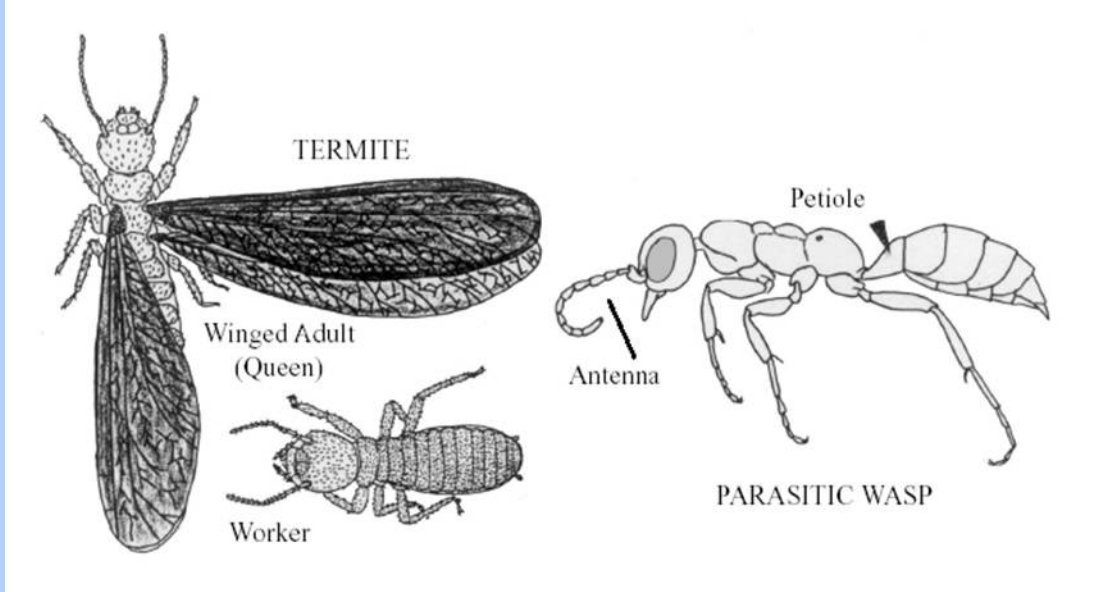


- Winged ants have the front pair of wings much longer than the hind pair; in termites the two pairs are equal in size and appearance
- Ants are yellowish, reddish, brownish, and blackish in color; termites are dirty-white in color

Ants and Ant-like Insects



A1



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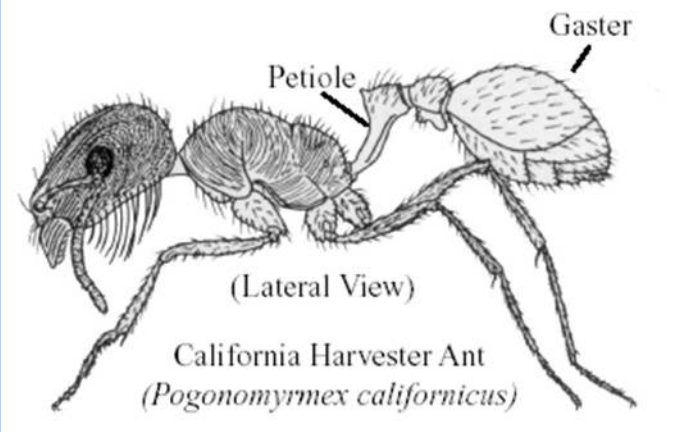


A2

Figure 11-1 Differences between Ants (A1 and A2) and ant-like insects (A3)

General Life Cycle

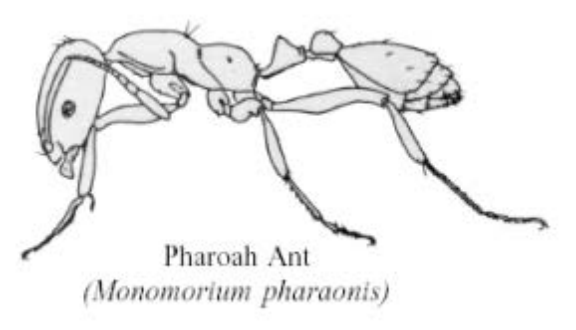
- Development
  - Ants experience a complete metamorphosis
- Ants can have a two or one-segmented waist
- Behavior
  - Worker ants devote most of their time to enlarging or repairing damage to the nest tunnels and chambers, tending to the brood, attending to the needs of the queen(s), gathering food, and, when necessary, defending the nest from invaders or other disturbances
  - Argentine ants are attracted to sweet substances
  - Fire ants and thief ants are attracted to oils and fats

Important Pest Species - Species with Two-Segmented Waist

- California Harvester Ant (figure 11-1, A2)
  - This is one of several species of red harvester ants found in California
  - They are distinctly red in color with a fringe or “beard” of long hairs on the underside of the head
  - They do not have a pair of spines on the hind part of the mesosoma
  - They are large and live in populous colonies and can be pests of yards
  - They rarely invade homes

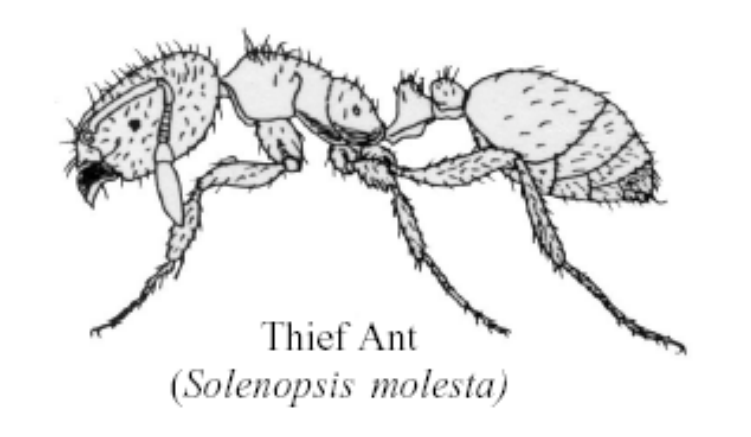
Important Pest Species - Species with Two-Segmented Waist

- Pharaoh Ant
  - This is a common pest species in indoors
  - It somewhat resembles the southern fire ant, but is more yellowish in color; the tip of the gaster is not black, the integument is dull, rather than smooth and shiny as in the fire ant
  - It is attracted to a wide variety of food stuffs, particularly meats
  - This ant cannot sting



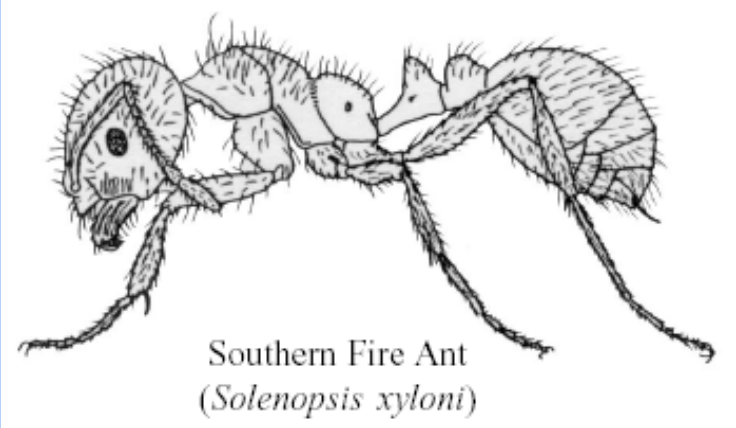
Important Pest Species - Species with Two-Segmented Waist

- Thief Ant
  - These are minute, inconspicuously yellowish ants
  - They are called thief ants because they often live within, or very near, the nest of larger ant species and prey upon the larvae and pupae of the larger ants
  - The majority of these species are house-infesting
  - They are fond of fatty and oily foods



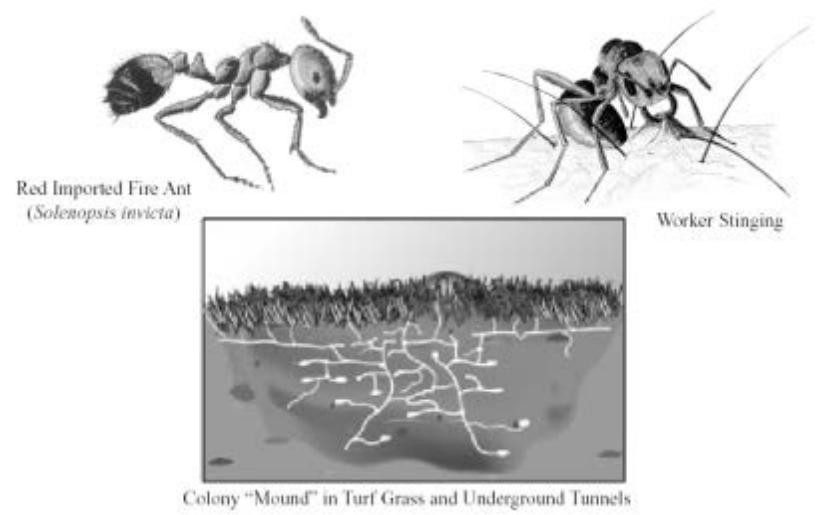
Important Pest Species - Species with Two-Segmented Waist

- Southern Fire Ant
  - This is the most serious ant species with a two-segmented waist
  - These ants are usually shiny red, with the end of the gaster blackish
  - When a colony is disturbed, the workers rush out by the hundreds, ready to defend the nest with their fiery sting
  - Stings almost always result in painful itching
  - This ant is attracted to sweets and fatty foods, but will also prey on other insects
  - Does not usually occur in areas where Argentine ants exist



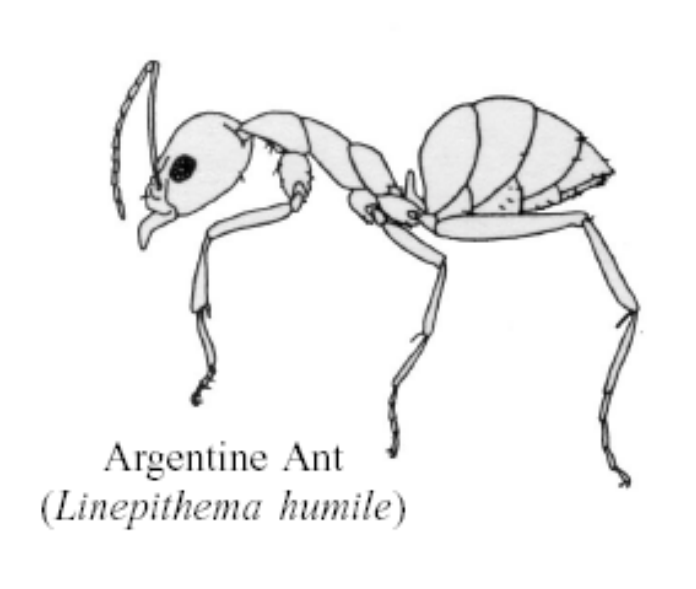
Important Pest Species - Species with Two-Segmented Waist

- Red Imported Fire Ant (RIFA)
  - RIFA is recognized from most other ants by the colony "mound" and the variable size of the worker caste, which contains both large and small individuals
  - The typical RIFA colony or mound is recognized by its characteristic dome shape and granular surface appearance
  - In abundance RIFA can consume much of the ground dwelling wildlife within its range
  - Control of RIFA is best approached with a "two-step" method that uses a combination of bait formulations of insect growth regulators combined with metabolic inhibitors



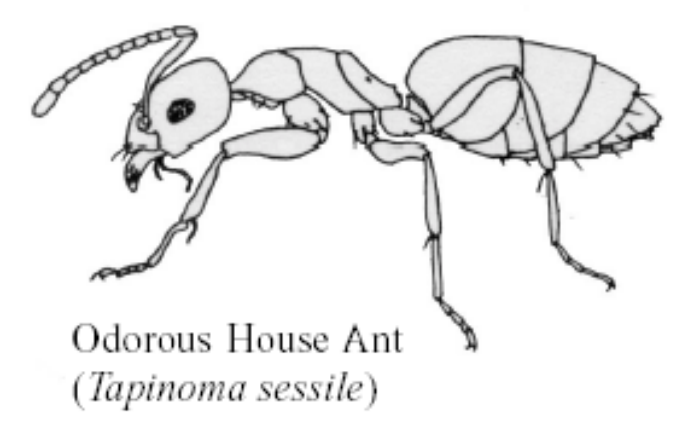
Important Pest Species - Species with One-Segmented Waist

- Argentine Ant
  - These ants are uniformly light to dark brown, often appearing black and they are nearly devoid of hairs except a few on the tip of the gaster
  - It thrives in urban and suburban environments and indoors and outdoors
  - Indoors it feeds as an omnivore, outdoors it feeds on any insects
  - This ant species out-competes and overwhelms any other nearby ant species, repeatedly attacking their nests until the other species is eliminated
  - Because of their enormous colony size, their omnivorous habits, and great adaptability, this is an especially difficult species to control



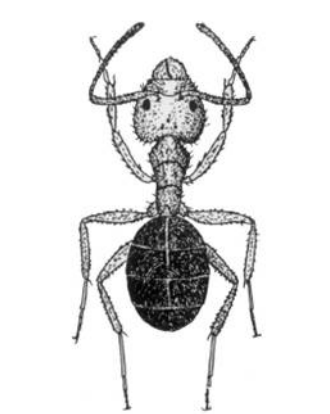
Important Pest Species - Species with One-Segmented Waist

- Odorous House Ant
  - Similar to the Argentine ant, but darker in appearance
  - When crushed it produces a foul odor
  - Generally a ground-nesting ant, but can be found invading structures, often nesting in wall voids particularly around hot water pipes and heaters



Important Pest Species - Species with One-Segmented Waist

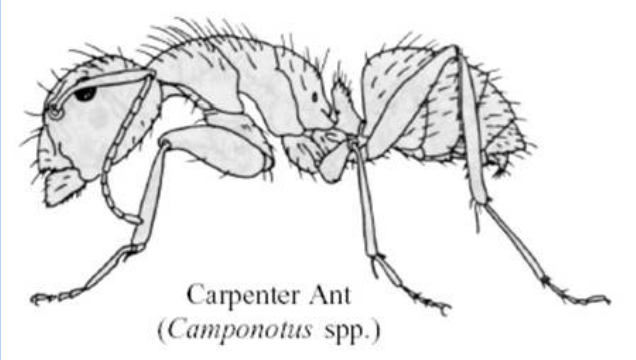
- Velvety Tree Ant
  - This ant is found from oak woodlands in central California to moderate elevations in the mountains
  - The head and mesosoma are usually dull reddish and the gaster is blackish
  - When crushed these ants have an unpleasant odor
  - Colonies are large and may be located in dead logs, in stumps, in soil, among piles of rocks, or in dead tree limbs
  - They can become pests in picnic or barbeque settings



Velvety Tree Ant
(*Liometopum occidentale*)

Important Pest Species - Species with One-Segmented Waist

- Carpenter Ants
  - There are basically two types of "carpenter ants"
    - Those that nest in wood and
    - Those that nest in soil
  - The wood damaging ants are the largest ants
  - These ants are omnivorous, but with a predilection for sweet carbohydrates
  - The workers can bite, but do not sting



Ant Control

- In order to control ants, the technician must identify what ant species need to be controlled
- Control procedures
  - Ants that frequently nest indoors are the southern fire ant, odorous house ant, carpenter, and the thief ant
    - The technician should try to locate the nest by following trails of ants back to their source
  - If ants are nesting outdoors, try to locate the colony by following workers back to the nest
    - If nests can be found, they can be treated directly
    - Other measures may be required, such as power spraying the entire infested area

Honey Bees

Introduction

Bionomics

Classification

Medical Importance

Management and Control

Introduction

- Honey bees can be found in hives managed by hobby or commercial beekeepers or living on their own, in locations that provide adequate forage and shelter, including voids in buildings and dense vegetation, as well as hollow trees
- Honey bees pollinate flowers and produce honey
- Africanized honey bees (AHB) are an experimental cross of European and central African bees and become more easily disturbed at the nesting site
- AHB react more quickly than honey bees, and many more bees are apt to fly out and sting
- AHBs also follow a “marked” (stung) target much further away (1/4 mile) from the hive than honey bees (50-100 ft)

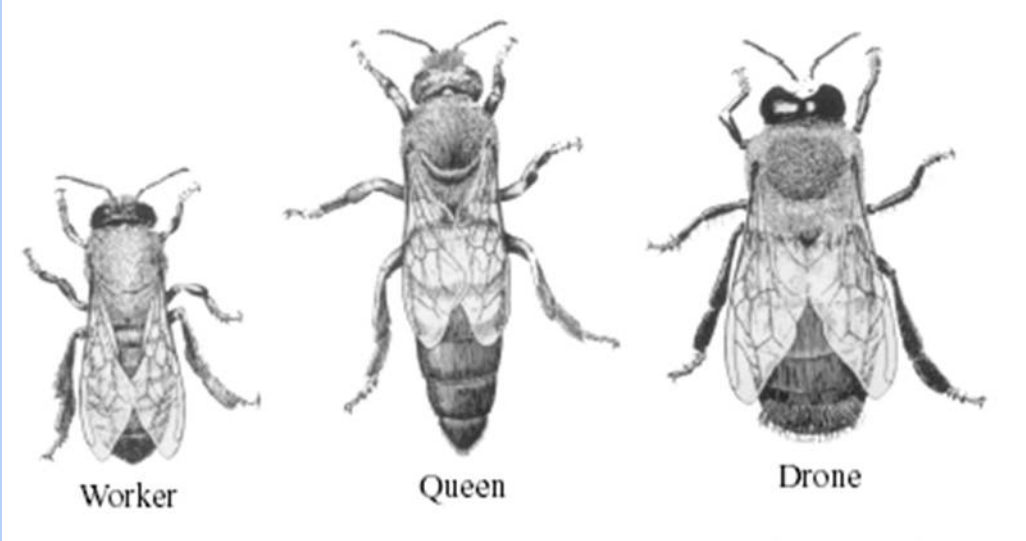
Bionomics

- Honey bees are long, fairly robust, and have a brown or black background color that is covered with thick masses of hair which can impart a striped appearance (figure 12-1)
- Honey bees have a complete metamorphosis (figure 12-2)
- Honey bees can tolerate nearly every microclimate in California and are found almost everywhere, except on the top of the highest mountains

Bionomics

- Honey bees can survive only within colonies having a long-lived queen (5 yrs)
- Colonies reproduce by swarming when the old queen and half the workers fly off to start a new colony
  - The original colony completes rearing a replacement queen
- Honey bees fly only during daylight hours, when temperatures reach 13°C (55°F), there is no rain, and winds are below 19 kph (12 mph)
- They defecate only in flight and leave tan colored spots and streaks on any object in the area
- For this reason and the fear of being stung, many municipalities have a nuisance ordinance allowing them to evict bees upon complaint

Honey Bee Castes



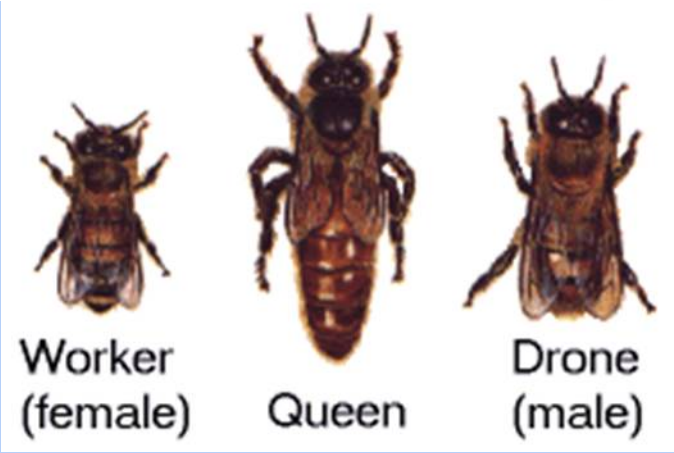


Figure 12-1 Honey bee characteristics and castes

Honey Bee Bionomics

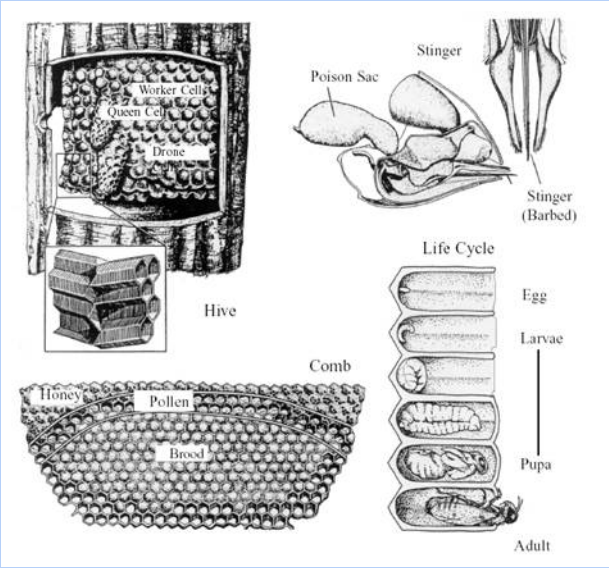


Figure 12-2 Honey bee hives, combs and bionomics

Classification

- Bees belong in the Order Hymenoptera, Suborder Apocrita, Superfamily Apoidea, and Family Apidae
- There are 3 genera and 54 species of bees in North America, and California has 3 genera and 28 species
- In the Subfamily Apinae, California only has one genus and species, *Apis mellifera*, the honey bee
  - It can be distinguished from other social bees by their vestigial maxillary palpi and absence of hind tibial apical spurs

Medical Importance

- Honey bees have stingers that become embedded in the tissue that is stung
- When the bee leaves, the sting is pulled from her abdomen, including the sting shaft, venom sac, parts of the abdominal exoskeleton, muscles, and nerves
- This allows the severed organs to continue working the sting deeper into the flesh and delivering more venom into the wound for about 2 minutes
- The most biologically active compounds of honey bee venom are the enzymes hyaluronidase and phospholipase and the peptide mellitin
  - These enzymes help the venom spread through the tissues, and mellitin causes the pain associated with stings

Medical Importance

- In hypersensitized individuals, the enzymes can bring on anaphylactic shock
- Lowered blood pressure and impaired respiration can lead to death in minutes
- Injected epinephrine usually relieves the symptoms rapidly
- Enzymes continue to break down tissue in patients after treatment, so medical observation (blood test) should continue for many days following a bad stinging event by either bees or wasp

Management and Control

- Any global control measures directed at honey bees as organisms would also eliminate European honey bees, upon which we rely for approximately one-third of our daily diet (crop pollination of fruits and vegetables)
- Efforts should be made by the general public to reduce or prohibit access to potential nesting sites
- Swarms should be destroyed before they have a chance to find new nesting locations and become established
- Newly established colonies should be removed before they increase in size and become unmanageable
- Bees in walls, ceilings, under floors, down chimneys, etc. should be removed by professional pest control operators

Scorpions

- Introduction
- Biology
- Life Cycle
- Notable Species
- Public Health Significance
- Management and Control

Introduction

- Scorpions are a very ancient order of Arthropoda
- Relatives of these animals were among the first life forms to emerge from the sea onto land about 425 million years ago
- Study of fossil specimens has shown that scorpions have survived relatively unchanged since the time of the dinosaurs

Vaejovis spinigerus

Biology

- Scorpions are easily recognized by their lobster-like pincers and/or long tail terminating in a bulbous stinger
- Like other arachnids, scorpions have 4 pairs of legs
- The body consists of three parts: the cephalothorax, the preabdomen, and the post-abdomen
- Body coloration varies according to the species and ranges from pale yellow or cream to black
- Scorpions are nocturnal and can detect predators and prey by sensory vibrations in the air and on the ground

Vaejovis redelli

Smeringus vachoni

Life Cycle

- Courtship and mating activity is initiated by the male during the spring
- Scorpion young are born alive (ovoviviparous) with the number of young per litter being affected by local conditions and species
- The period of gestation is also quite variable
- Young scorpions will leave the mother usually after their first molt

Scorpion young on mother's back

Close-up of scorpion young on mother's back

Notable Species

Burrowing Scorpion, *Anuroctonus phatodactylus*

Striped Tailed Scorpion, *Vaejovis* sp.

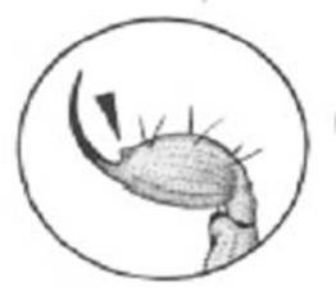
Desert Hairy Scorpion, *Hadrurus* sp.

- Most of the approximately 75 species recognized in the United States occur in the Southwest
- Species in the genera *Vaejovis*, *Paruroctonus*, *Serradigitus*, *Anuroctonus*, *Hadrurus*, and *Superstitionia* comprise most of the California fauna in the Central Valley and desert areas
- Species of the genus *Uroctonus* are found in moist regions of the Sierra Nevada and coastal California

Notable Species continued

- The species of most medical concern to man, *Centruroides exilicauda*, occurs in western New Mexico, Arizona, in adjacent Mexico, and along the Colorado River in California
- This species has thin long pincers, and a stinger that releases a lethal venom
- This species has been reported with increasing frequency in Los Angeles, Riverside, San Bernandino, and Orange Counties
- These species crawl up into recreational vehicles, boats, trailers, beddings, and other belongings, and are easily transported by vacationing returning to the urban environment from indigenous desert areas

Bark Scorpion, *Centruroides exilicauda*



Note the stinger, this is where the lethal venom comes from

Public Health Significance

- When a scorpion strikes defensively, the tail is lashed forward in a quick but well directed thrust, embedding the stinger momentarily into its victim
- At the same time, venom is forced into the puncture wound
- Scorpion venom may be rapidly fatal to invertebrate prey, but its effects on vertebrates are highly variable
- In most cases, the victim experiences localized pain and swelling
- Except for stings produced by certain *Centruroides* species and imported dangerous species, few stings are serious enough to warrant medical attention
- There are no first aid measures of established value in the treatment of scorpion stings

Management and Control

- Since human exposure to scorpion stings is greatest during the spring breeding season, preventive measures initiated before or during that time can be effective
- Outside dwellings
  - Accumulation of rocks, rubbish, lumber, and firewood should be moved away from living quarters
- Inside dwellings
  - Minimize access into homes by weather stripping; and seal all cracks and crevices from the exterior, particularly those near ground level
  - Scorpions cannot climb smooth surfaces, so walls should be constructed in this fashion

Spiders

Introduction

Morphology

Bionomics

Species of Public Health Significance

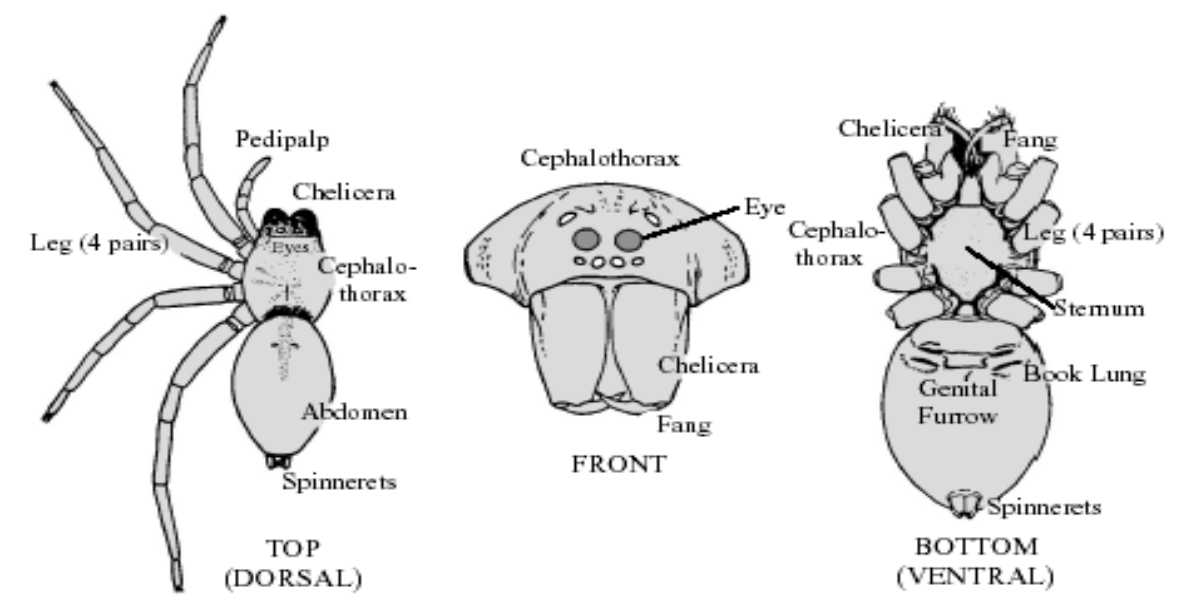
Suppression and Management

Introduction

- Only a very few of the approximately 3000 species of spiders that occur in North America are considered harmful to man
- These few species are capable of inflicting painful bites and the various reactions caused by the venom
- Since most species are nocturnal and because of their small size, spider bite cases are usually accidental and rare occurrences

Morphology

- Spiders belong to the class Arachnida; Order Araneae
- All are wingless and have four pairs of legs
- The body is divided into two main regions (cephalothorax and abdomen); joined by a narrow connection, the pedicel
- The fangs are located at the terminal end of the two-segmented chelicerae (jaws)
- The poison glands are usually located in the basal segments of the chelicerae
- The captured prey is usually paralyzed by the venom, or crushed by the strong chelicerae, and digestive fluids are introduced via the maxillary glands
- The predigested fluids of the prey are then consumed



Bionomics

- Females lay their eggs in a sac
  - The eggs emerge when the temperature is warm enough
- Spiders undergo a gradual or incomplete metamorphosis
  - Depending on the species, they undergo several molts until they reach the adult stage
- The males usually do not live very long after reaching maturity and mating, whereas, the adult females may outlive the males by several weeks to months
  - Female tarantulas may live up to 20 years or more

Molting spider

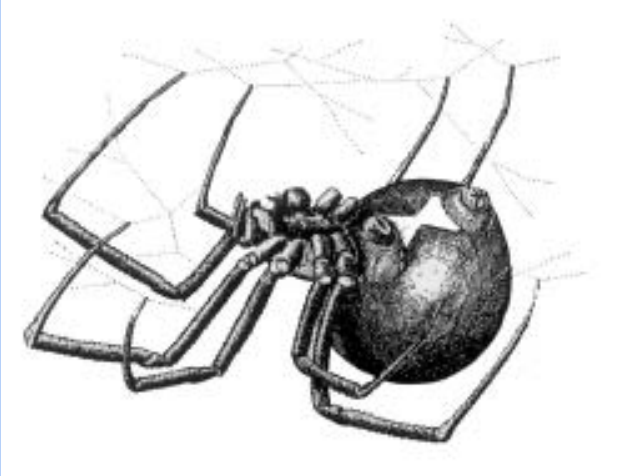
Species of Public Health Significance

- Almost all spider bite cases occur when humans accidentally come in contact with them
- They do not “attack” people as is popularly visualized
- The effects of the spider bite range from benign to severe, depending upon a complexity of factors, such as site of bite, amount of venom injected, age, and physical health of the person

Brown Recluse Spider Bite (case was imported from outside of California) – day 3 to day 6 to day 10

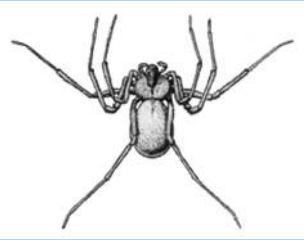
Species of Public Health Significance

- Black Widow Spiders (Family Theridiidae)
  - The black widow spider of the western United States is recognized as *Latrodectus hesperus*
  - Adult females are black and shiny with a red “hourglass” marking on the underside of the pea-sized abdomen
  - The males are usually black and much smaller with brightly colored chevron-like bands and spots on the abdomen



Species of Public Health Significance

- Brown Recluse Spiders, Brown Spiders, Violin Spiders (Family Siciariidae=Loxoscelidae)
  - This is NOT a common species in California
  - All past brown recluse spider bite cases have been imported incidences
  - Thirteen species of the genus *Loxosceles*, including two exotic species, are found in the United States
  - All species of *Loxosceles* spiders possess venom capable of causing skin necrosis
  - *Loxosceles* spiders generally lack integumental patterns of heavy spines; the cephalothorax and legs are usually tawny brown; the abdomen may be slightly darker or grayish in coloration
  - All members in this genus have six eyes arranged in three pairs in a semicircle around the front of the cephalothorax



Species of Public Health Significance

- Tarantulas (Family Theraphosidae)
  - These are large hairy spiders with stout bodies and legs, and brown to black in color
  - Several species occur in the more arid regions of California where they inhabit subterranean burrows and spaces under rocks

Columbian Brown Velvet
Pamphobeteus vespertinum

Giant White Knee
Acanthoscurria geniculata

Pink Toe
Avicularia avicularia

Suppression and Management

- Spiders usually reside where arthropod prey and adequate shelter are available
- Most prefer outdoors, but the periodic appearance or presence of wandering spiders inside dwellings is seasonal, and usually related to their mating habits
- Frequent house cleaning and control of other insect pest often will limit their numbers
- If pesticides are used, it is imperative that only currently registered materials specifying the actual pest you are attempting to control is listed on the label

Mites

- Introduction
- General Life Cycle
- Species of Public Health Significance
  - Suborder Acariformes
  - Suborder Actinedida
  - Suborder Acaridida
  - Order Parasitiformes; Suborder Gamasida

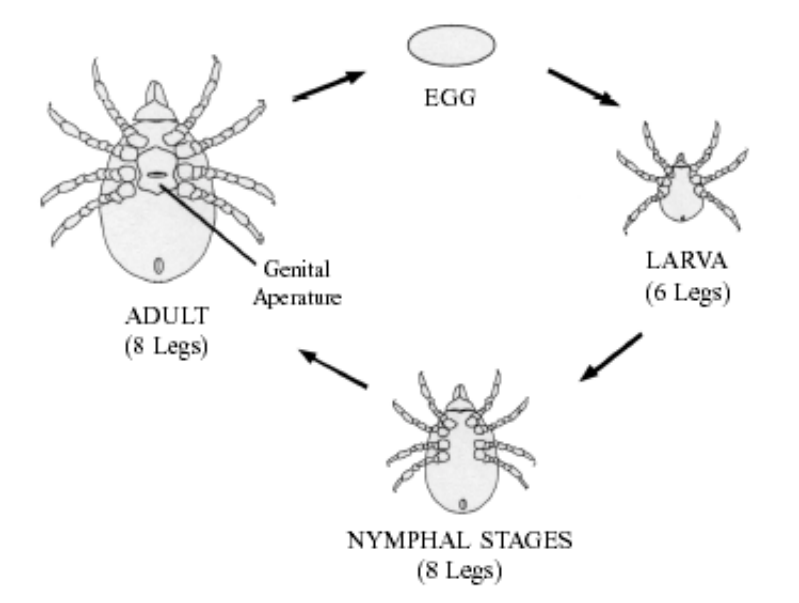
Introduction

- Mites are distant cousins of insects and are distinct from them in having a fused cephalothorax joined broadly with an unsegmented abdomen
- Mites also have 4 pairs of legs, placing them in the class Arachnida
- Most mite species are of no public health importance
  - A large number of them are plant-feeders, proportionately fewer are predators, and fewer still are parasites of animals

Follicle mite (*Demodex folliculorum*)

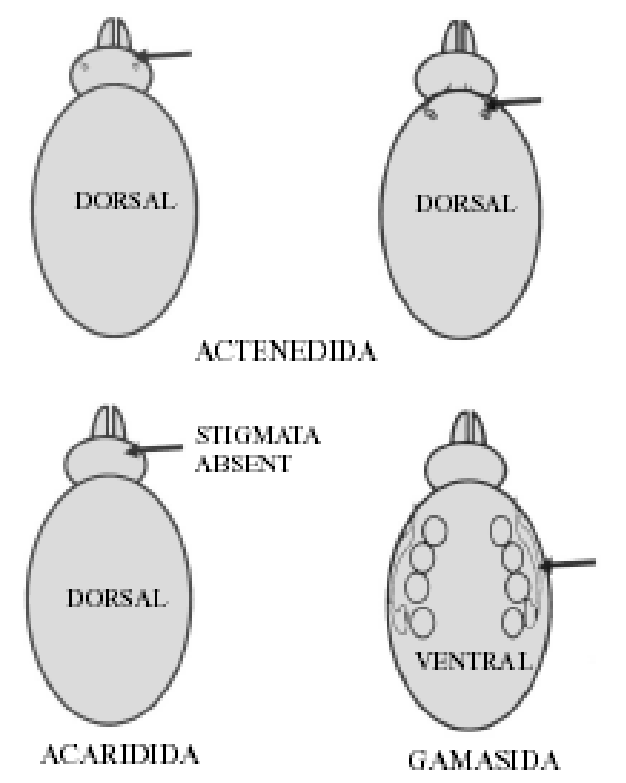
General Life Cycle

- Mites undergo a complete metamorphosis
- They pass through six stages on their way to adulthood, prelarva, larva, protonymph, deutonymph, tritonymph, and adult
- The typical mite larvae is six-legged; the protonymph is when it develops eight legs



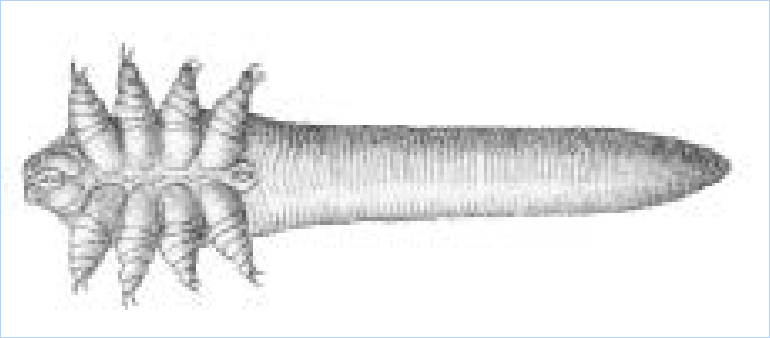
Species of Public Health Importance

- Mites of medical importance are systematically placed in three suborders based upon the presence or absence and body placement of the respiratory organs (stigmata)



Suborder Acariformes

- Family Demodicidae (Follicle Mites)
  - Two species in this family are known to be of medical importance, *Demodex folliculorum* (see images) and *D. brevis*
  - Both species have annulated, worm-like bodies
  - Both have been recovered from the surface of the skin
  - The topologic distribution of *Demodex* on humans includes the scalp, forehead, eyelids, ear canal, nasolabial folds, nose, and perianal area
  - Some investigators attribute certain skin diseases to *Demodex* species whereas others contend there are no proven detrimental effects due to the presence of these mites

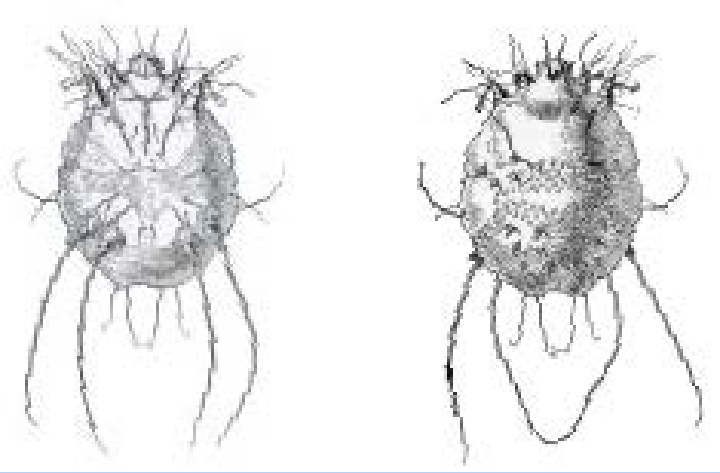


Suborder Actinedida

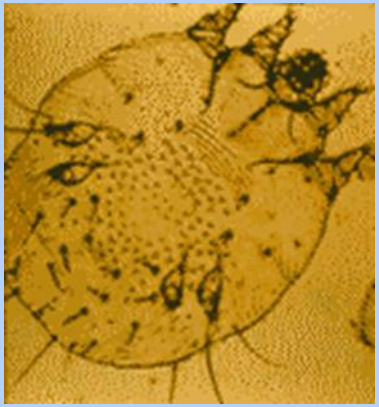
- Family Trombiculidae (Chigger Mites)
  - Two species of chiggers are known in California that bite man and cause extreme skin discomfort, *Eutrombicula belkini* and *E. batatas*
  - *E. belkini* is known from northern, central, and southern California, *E. batatas* is known in central California
  - *E. belkini* are associated with coastal sage and chaparral plant communities; *E. batatas* are associated with more moist conditions and herbaceous grasses
  - *Eutrombicula* species larvae are small, red, and six-legged, mouthparts are modified for grasping and piercing the skin
  - Nymphs and adults have eight legs
  - Adults live in the ground litter or soil where they are predators on small arthropods and their eggs
  - The best treatment is preventing the mites from climbing onto a person
  - Pesticide use is not feasible or practical

Suborder Acaridida

- Family Sarcoptidae (Scabies Mites)
  - Species of this genera have been found on man worldwide
  - *Sarcoptes scabiei hominis* adults are broadly, oval, translucent and brownish in color
  - They are difficult to see without a microscope
  - The entire life cycle of an adult is spent on its human host
    - They cause a fiercely itchy skin condition known as scabies
  - Most mite burrows occur in the skin between the fingers and on the elbows; the skin of the scrotum, penis, breasts, knees, and buttocks is also frequently infected
  - Scabies mites are transmitted from person to person only by close personal and prolonged contact, such as holding hands or sleeping together



Ventral View Dorsal View

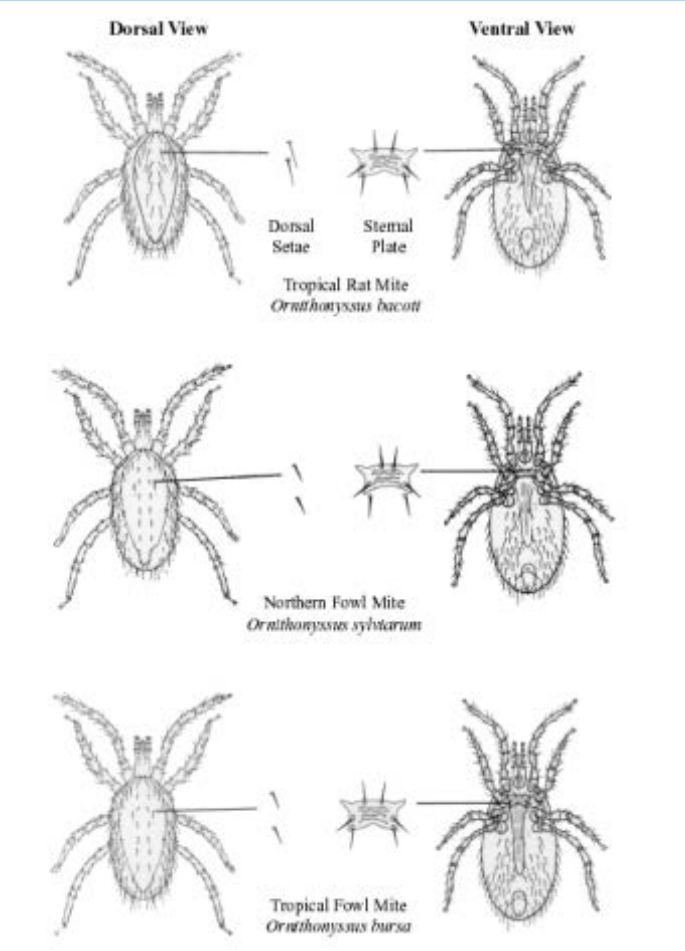


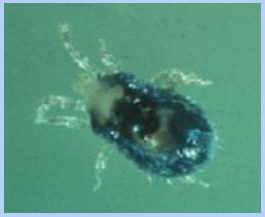
Suborder Acaridida

- Family Pyroglyphidae (House Dust Mites)
  - This family contains five genera including *Dermatophagoides*, which has species of considerable medical importance
  - *D. pteronyssinus* (the European house dust mite) and *D. farinae* (the American house dust mite) are the most impacting species on human health and are cosmopolitan in distribution
  - These mites are easily inhaled into the respiratory tract where allergic reactions occur resulting in long term allergy problems
  - These mites are small and found in the nests of mammals or birds, or free-living in dust and debris of buildings and other structures
  - Pyroglyphid mites have five distinct life stages: egg, larva, protonymph, tritonymph, and adult
  - Good housekeeping on a regular basis will prevent mites from taking harborage

Order Parasitiformes
Suborder Gamasida

- Family Macronyssidae
  - Macronyssid mites are blood-feeding species found worldwide on birds, mammals, and reptiles
  - There are three medically important species: *Ornithonyssus bacoti* (Tropical Rat Mite), *O. sylviarum* (Northern Fowl Mite), and *O. bursa* (Tropical Fowl Mite)
  - The *O. bacoti* is a parasite of roof rats and Norway rats
  - A number of microbial and viral pathogens have been shown to be isolated from and/or experimentally transmitted by *O. bacoti*, including ones that cause murine typhus, tularemia, and plague
  - Western equine and Newcastle disease viruses have been recovered from *O. sylviarum*
  - These three species have been implicated with bite attacks on people causing sever irritation and painful dermatitis
  - Rodent control is the best method of avoiding *O. bacoti*

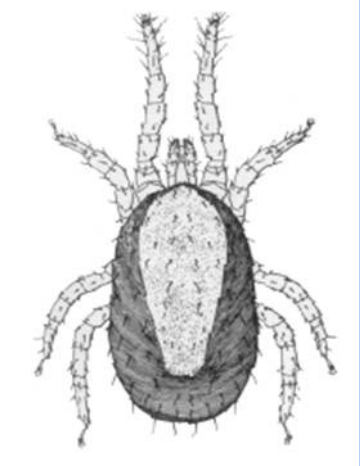




Order Parasitiformes
Suborder Gamasida

- Family Dermanyssidae (Chicken Mites)
  - *Dermanyssus gallinae* (the chicken mite) is the only mite in this family of known medical and economic importance; it is cosmopolitan in distribution
  - This is a medium-size mite with mouthparts for piercing and sucking, e.g., blood feeding
  - The female lays her eggs in cracks and crevices or under debris in chicken houses or in bird nests
  - Although encephalitis viruses have been isolated from wild-caught chicken mites, researchers conclude that *D. gallinae* is of no importance as a vector or reservoir of these viruses in nature
  - This species is one of the most common ones that causes painful skin irritation found in association with farms, ranches, poultry houses and live chicken markets
  - The removal of bird nests and maintenance of poultry houses in addition to the application of acaricidal pesticide usually eliminates the mite problem

Ventral View



Dorsal View

Ticks

Introduction

Bionomics

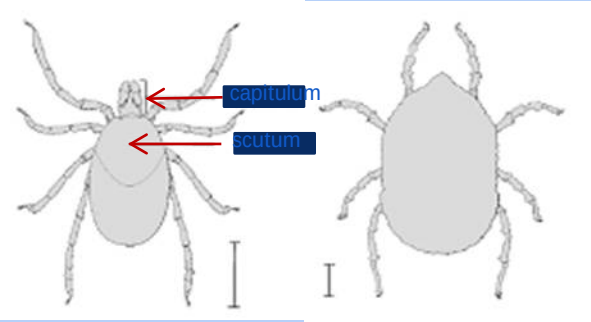
Public Health Significance

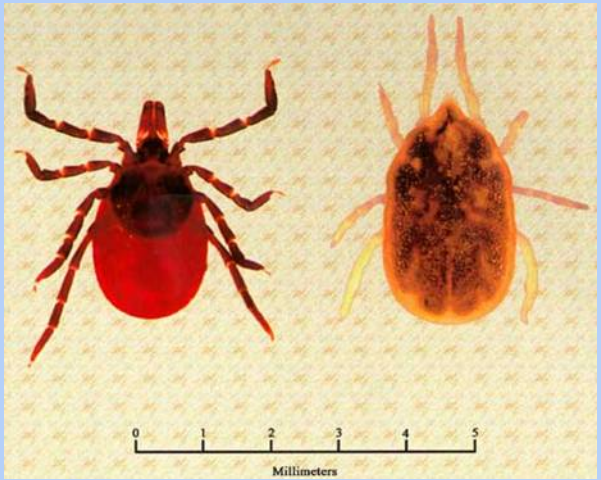
Table of Tick-Borne Diseases

Tick Control and Management

Introduction

- Ticks are bloodsucking ectoparasites of reptiles, birds, mammals, and rarely amphibians
- Ixodids and Argasids are referred to respectively as hard-bodied and soft-bodied ticks because of the presence or absence of the scutum
- Ixodids (hard ticks) and argasids (soft ticks) differ morphologically in several characteristics
  - The capitulum in argasids is situated anteroventrally, versus anteriorly in ixodids
  - The scutum, a prominent dorsal sclerotized plate, is absent in argasids, versus present in ixodids





Dorsal view of a female *Ixodes scapularis* (family Ixodidae, hard ticks), a vector of *Borrelia burgdorferi* (left), and a female *Ornithodoros hermsi* (family Argasidae, soft ticks), the vector of *B. hermsii* (right)

Bionomics

- As larvae, ticks have six legs; as nymphs and adults, they have 8 legs
- Slightly over 90% of hard-tick species undergo a three-host life cycle in which the larva, nymph, and adult each feed on a different vertebrate belonging to the same or two to three different species

Western black legged tick (*Ixodes pacificus*)

Public Health Significance

- Ticks are of public health significance for numerous reasons
  - Their attachments may cause various kinds of skin disorders
  - They may invade the auditory canal of humans producing a condition known as otocacariasis
  - Females of certain ixodids can cause a flaccid, ascending, and sometimes fatal paralysis known as tick paralysis
  - Individuals bitten repeatedly by some ticks may develop allergic or even anaphylatic reactions
  - They transmit numerous bacterial, viral, and protozoan diseases

Soft Ticks of Public Health Significance in California

- There are 4 soft ticks in California of public health significance
  - *Ornithodoros hermsi*
  - *Ornithodoros coriaceus* (Pajahuello tick)
  - *Ornithodoros turicata*
  - *Ornithodoros parkeri*
- These soft ticks can transmit Tick-Borne Relapsing Fever which occurs mainly at elevations of >5000 feet (1524 meters)
- The primary vertebrate host/reservoir for these soft ticks are rodents and lagomorphs.

Ornithodoros hermsi

Ornithodoros coriaceus
Pajahuello Tick

Hard Ticks of Public Health Significance in California

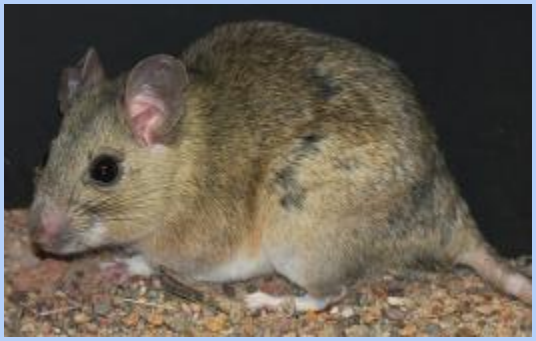
Western black-legged tick (*Ixodes pacificus*)
(L to R: nymph, adult male, adult female)

- There are many hard ticks in California of public health significance
- The Western black-legged tick is the most well distributed of the established tick species in California
- The adults are commonly encountered in open grass or chaparral, and along the margins of trails (especially the uphill vegetative borders of hillside trails) in parklands and wildlands, in semirural communities, and in some suburban areas that support surrounding domestic populations of deer and other wildlife, particularly in coastal counties and the foothills of the Sierra Nevada Mountain Range

Hard Ticks of Public Health Significance in California

- The western black-legged tick is the primary vector for:
  - Lyme disease (*Borrelia burgdorferi*)
    - The primary vertebrate hosts for *B. burgdorferi* are rodents (e.g., deer mice, woodrats, squirrels), deer, lizards, and lagomorphs
  - Human granulocytic anaplasmosis (*Anaplasma phagocytophilum*)
    - The primary vertebrate hosts for *Anaplasma phagocytophilum* are rodents, deer, lizards, and lagomorphs

Erythema migrans, the skin rash common in early stage Lyme disease



The dusky-footed wood rat (*Neotoma fuscipes*), a primary reservoir of *B. burgdorferi* in California

Hard Ticks of Public Health Significance in California

Other hard-tick borne diseases in California include:

- Tularemia (*Francisella tularensis*)
  - Vectored by *Dermacentor andersoni* and *D. variablis*
  - Primary vertebrate hosts include rodents, lagomorphs, and deer
- Rocky Mountain Spotted Fever (*Rickettsia rickettsii*)
  - Vectored by *Dermacentor andersoni*, *D. occidentalis*, and *D. variablis*
  - Primary vertebrate hosts include rodents and lagomorphs
- Colorado Tick Fever (Coltivirus)
  - Vectored by *Dermacentor andersoni and D. occidentalis*
  - Primary vertebrate hosts include rodents and lagomorphs

Pacific coast tick
Dermacentor occidentalis

Rocky Mountain wood tick
Dermacentor andersoni

The American dog tick
Dermacentor variabilis

Major Tick-Borne Diseases in California

Disease (agent)	Tick(s)	Primary vertebrate host for disease agent
TICK BORNE DISEASES VECTORED BY HARD TICKS (IXODIDS)		
Human granulocytic anaplasmosis (*Anaplasma phagocytophilum*)	*Ixodes pacificus* (Western black-legged tick)	Rodents (e.g., deer mice, woodrats, squirrels), deer, lizards, lagomorphs
Lyme disease (*Borrelia burgdorferi*)	*Ixodes pacificus* (Western black-legged tick)	Rodents, deer, lizards, lagomorphs
Tularemia (*Francisella tularensis*)	*Dermacentor andersoni* (Rocky Mountain Wood tick), *D. variablis* (American dog tick),	Rodents, lagomorphs, deer
Rocky Mountain Spotted Fever (*Rickettsia rickettsii*)	*Dermacentor andersoni* (Rocky Mountain Wood tick), *D. occidentalis* (Pacific Coast tick), *D. variablis* (American dog tick)	Rodents, lagomorphs
Colorado Tick Fever (Coltivirus)	*Dermacentor andersoni* (Rocky Mountain Wood tick), *D. occidentalis* (Pacific Coast tick)	Rodents, lagomorphs
TICK BORNE DISEASES VECTORED BY SOFT TICKS (ARGASIDS)		
Tick-Borne Disease Relapsing Fever (*Borrelia hermsi, parkeri, turicatae*)	*Ornithodoros hermsi*, *O.parkeri*, *O. turicata*	Rodents, lagomorphs

Brown Dog Tick

- The brown dog tick (*Rhipicephalus sanguineus*) is unusual among ticks because it can complete its entire life cycle indoors
  - This allows populations to establish themselves in colder climates
- In the US the Brown dog tick prefers to feed on dog, however can feed on a variety of mammals
- Infestation of these ticks can occur very quickly
  - Ticks can be brought home on dogs that were in a kennel or infested area
  - The first sign of an infestation is when you notice ticks crawling up the walls
- Although this tick rarely transmits diseases to humans or animals, it can cause skin irritation and damage
- To manage infestations of the Brown dog tick one should prevent the ticks from feeding on dogs and other hosts
  - Use acaricides as directed in the label
  - Use a tick control on treatment on the dog

Brown Dog Tick
(*Rhipicephalus sanguineus*)

Tick Control and Management

- Control measures directed against ticks consist of any method or combination of methods, which either interrupt or minimize contact between a tick and its host
- Control strategies vary considerably according to the species of tick targeted, its life stage, habitat, time of year, and the type, density, and distribution of its host
- Natural Control
  - Tick populations normally are regulated by climatological factors, availability of suitable vertebrate host populations, and by their natural enemies (parasites and predators)
- Chemical Control
  - Area-wide applications of acaricides to tick habitats may offer short-term control
  - Repellents can be applied to pets and humans to decrease the possibility of tick attachment
- Avoidance of Ticks
  - Individuals visiting tick-infested areas should stay in the center of trails and avoid sitting on the ground or on logs in brushy or woodland areas
- Environmental Modification
  - Habitat reduction can effectively decrease tick-host interaction

Tick Removal Technique

- Use tweezers to grab the tick close to your skin
- Pull the tick firmly, straight out, away from the skin (do not jerk, twist, or burn the tick)
- Wash your hands and the bite site with soap and water after the tick is removed and apply an antiseptic to the bite site

- The sooner a tick is removed, the less likely it is that a person will be infected
- Personal protection can be achieved by tucking pants into boots or socks, and shirts into pants

Personal Protective Measures

- Avoid tick-infested areas
- Wear light-colored clothes
- Wear a hat, long-sleeved shirt, and long pants
- Tuck shirt into pants, pants into boots or socks
- Remove attached ticks promptly and properly
- Apply DEET repellent to skin not covered by clothing
- Treat clothing with permethrin repellent as directed on the label
- Have a friend check your back for ticks

Field Safety

Introduction

Elements of a Safety Program

Protective Measures

Collection and Safe Transport of Arthropods

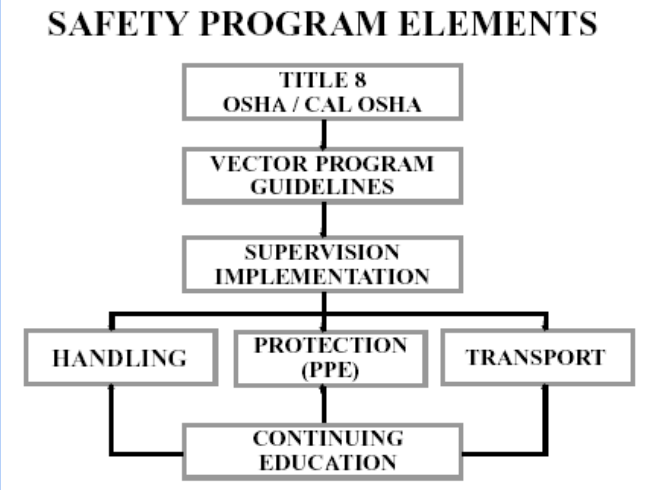
Introduction

- The uniqueness of vector surveillance and control activities includes performing routine functions that place the vector control technician and related professionals in direct contact with vectors and potential exposure to vector-borne disease microorganisms

- The risk associated with routine surveillance in most cases are acceptable with minimal likelihood of vector/pathogen exposure if the technician is:
  - Properly informed of those risks
  - Provided with an established set of procedures (protocols) intended to minimize any contact
  - Instructed on the correct use of personal protective and associated safety equipment

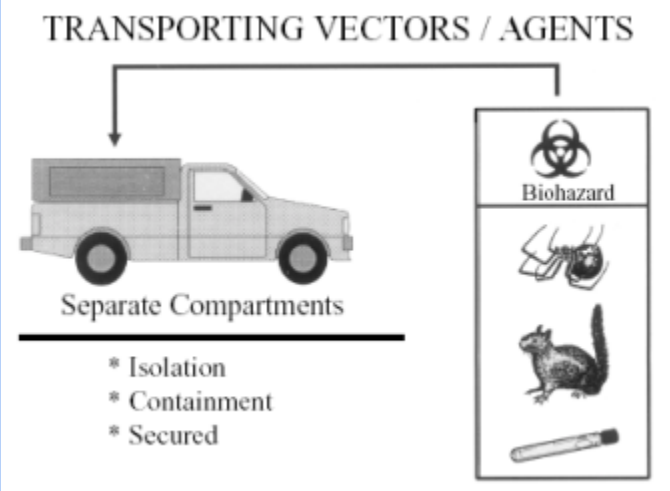
Elements of a Safety Program

- Title 8 (Generalized Industry Safety Orders) of the workers safety "Hazard Communication Program" entitles every vector control employee to a safe work place and the "right-to-know" of existing hazards associated with their job requirements
- A well balanced safety program for vector control personnel under Title 8 requirements should include the following elements:
  - Active supervision
  - Written safety instructions/protocols that detail actions for avoiding (e.g., proper handling) vector and vector-borne disease contact
  - Effective use of personal protective equipment
  - Safe methods for transporting vectors and etiological (e.g., infectious bloods) samples to the laboratory for processing
  - Continuing education training to reaffirm safety procedures along with the common sense "do's" and "don'ts" of field laboratory work



Elements of a Safety Program

- A complete safety protocol includes the following components:
  - Overview of the operation and attendant hazards
  - Types of possible exposure and their consequences
  - Proper use of required safety equipment
  - Proper use of surveillance and laboratory equipment
  - Emergency procedures in the event of an accidental exposure
- Safe Handling and Transportation
  - When transporting live vectors or whole blood samples back to the laboratory for further evaluation and testing, both “specimens” and “samples” should be transported in a manner that reasonably precludes any possibility of direct contact with the occupants of the transporting vehicle



Protective Measures

- Personal Protective Equipment
  - Clothing and Mosquito Netting
    - Protection from direct exposure to vectors simply requires wearing clothing that covers all exposed skin surfaces
  - Respirators
    - These are necessary when handling any disease agents that can potentially be transmitted via airborne particles
  - Insect Repellent
    - When around pest insects apply a repellent
  - Bee Suits and Accessories
    - These should be worn when dealing with insects that can cause harmful stings
    - In the event of allergic complications resulting from either single or multiple stings, a spring-loaded auto inject syringe (EpiPen®) with a single 0.3 mg intramuscular dosage of epinephrine should be used

Collection and Safe Transport of Arthropods

- Collecting Equipment
  - Overall protection from bites and stings is best provided by wearing gloves and using long forceps that afford a good grip for collecting large arthropods

- Containment
  - All pathogenic samples, including live vectors, should be transported in a manner that guarantees a low probability of escape in the event of a vehicular accident
    - Use of an ice chest, polycarbonate, polyethylene containers, or zip lock bags can be used depending on the sample
  - Containers with samples should be marked with “biohazard” warning signs