



# VERTEBRATES OF PUBLIC HEALTH IMPORTANCE IN CALIFORNIA



# Instructions

- As you go through this power point you will be able to navigate through the slides using the buttons located at the bottom of the slides.
- You can use the home  button to return to the main chapter menu at anytime.
- Next you can use the arrow keys to move to the previous slide  or the next slide  in the presentation.
- If you need to return to the current chapter opening slide click on the .
- When a glossary term is necessary, you can click on the  to bring you to the glossary

# Main Menu

## Introduction

- 1: [Snakes and Lizards \(Class Reptilia\)](#)
- 2: [Birds \(Class Aves\)](#)
- 3: [Opossums \(Class Mammalia, Order Didelphimorphia\)](#)
- 4: [Bats \(Class Mammalia, Order Chiroptera\)](#)
- 5: [Carnivores \(Class Mammalia, Order Carnivora\)](#)
- 6: [Rodents \(Class Mammalia, Order Rodentia\)](#)
- 7: [Safety Guidelines for Handling and Sampling Rodents](#)
- 8: [Zoonotic Diseases Associated with California Vertebrates](#)
- 9: [Glossary](#)



# Introduction

Because of our physiologic similarities, the ecologic niches humans and other vertebrates often abut or overlap. This close association can lead to competition for resources and space, physical confrontation and transmission of disease.

When the potential hazard posed by another vertebrate species exceeds an acceptable threshold, some manner of abatement or control of that species becomes necessary. Generally, integrated programs combining avoidance, exclusion, deterrence, habitat modification, reduction and removal are the most effective.

The following presentation is intended to provide individuals seeking certification in Category D, The Vertebrates of Public Health Importance in California, the fundamental understanding of the biology and ecology of many vertebrate species of concern and the ethics by which they should be managed.

# Chapter 1

## SNAKES AND LIZARDS



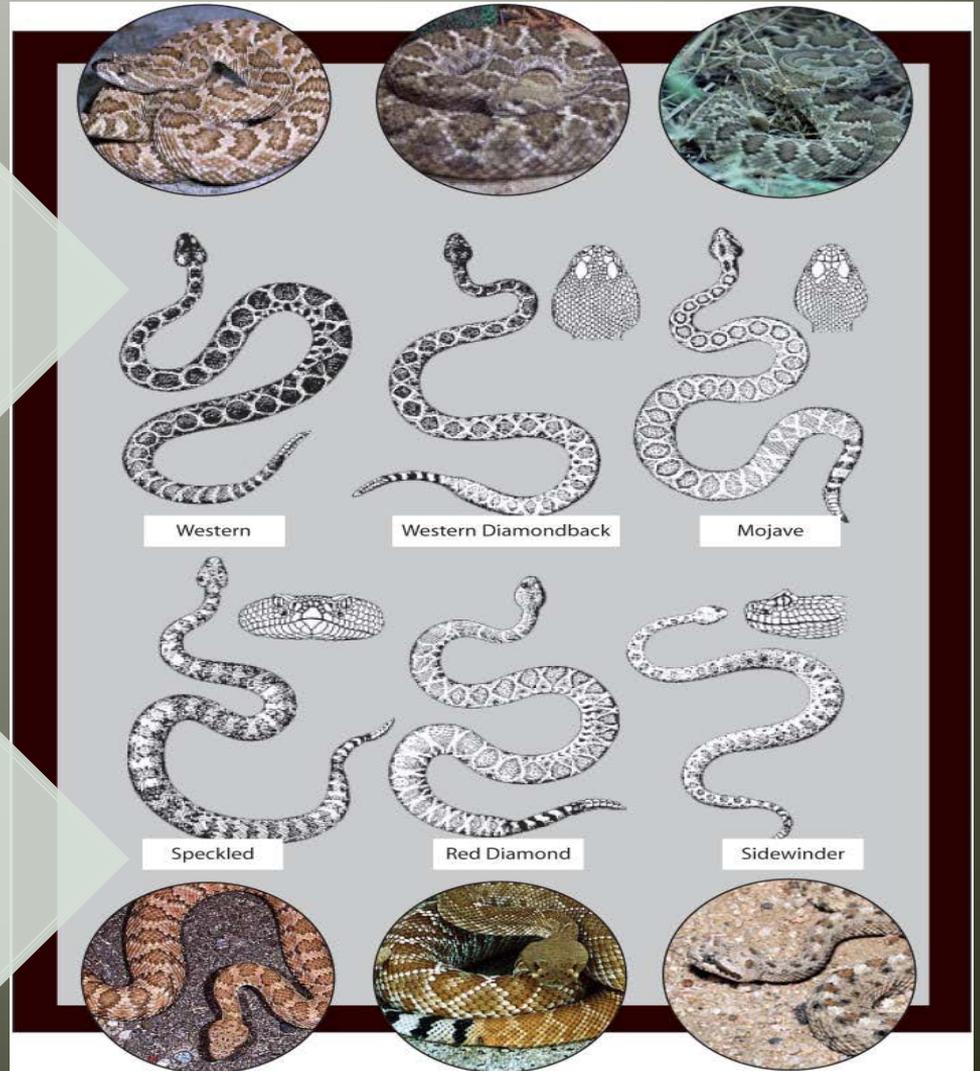
# Rattlesnakes

## Taxonomy

- Class Reptilia
- Family Viperidae (vipers)

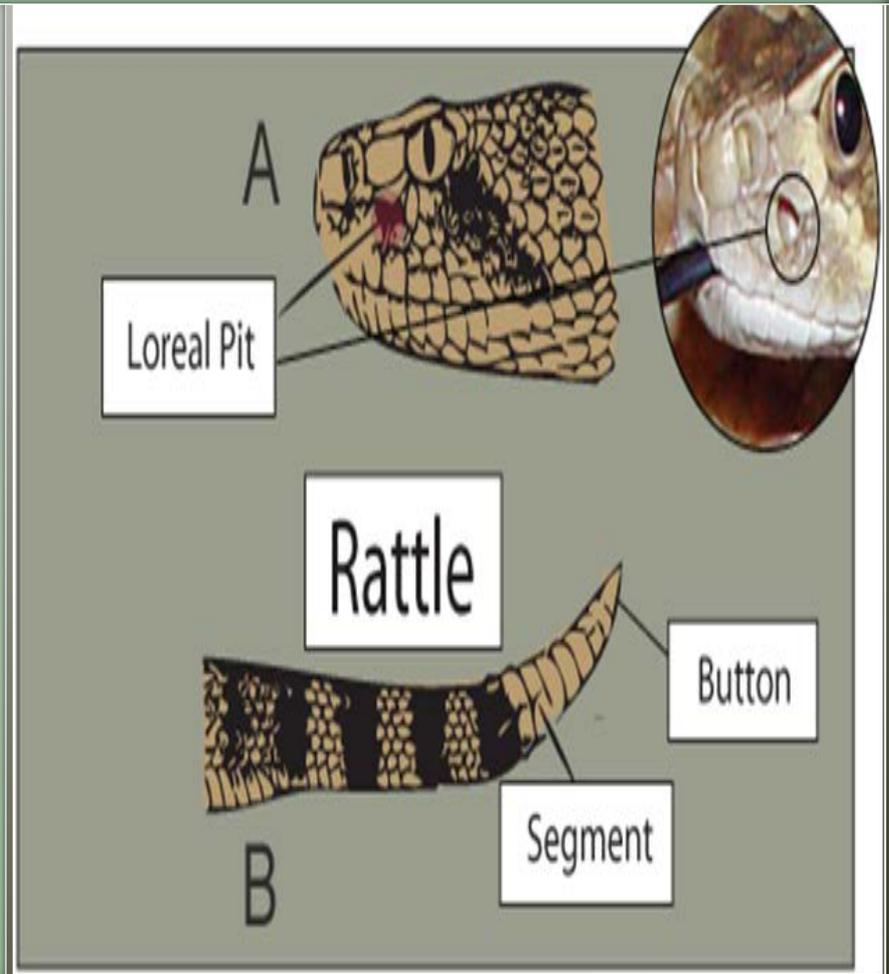
## Anatomy

- Rattlesnakes are easily identified by their noticeably triangular head, a heat-sensing (infrared) loreal pit organ located between the eyes and nostrils, keeled scales, vertical pupils and their namesake rattles.



# Rattlesnakes

- Rattlesnakes belong to the family Crotalidae, the pit vipers. These snakes have a specialized infrared sensory structure known as a loreal pit between the eye and nostril. Rattlesnakes use this organ to detect body heat of prey in close range.
- Rattlesnakes have an audible warning signal (the rattle) to ward off mammals and predators. Young rattlesnakes are born with only single rattle or button that cannot make sound.
- Rattle segments are dry, interconnected, hollow scales. A single segment is added each time the snake molts.



# Rattlesnakes

## Ecology

- All reptiles are “cold-blooded” vertebrates and are dependent upon environmental temperatures to regulate their mobility and physiological activities like feeding, digestion, and reproduction.
- Rattlesnakes are active during the warm months, and they will hibernate during the colder months. These patterns are dependent on the environment and can change with the climate.
- Shared underground hibernation dens with a southwestern sun exposure is favored. When rattlesnakes emerge from hibernation, they will begin searching for food during the day but as seasonal temperatures increase they will move towards more nocturnal activity.



# Rattlesnakes

- Reproduction

- Rattlesnakes are different than most reptiles, they produce live young, instead of laying eggs.
- The number of young is dependent on environmental factors such as availability of prey. The numbers are also dependent on species, size and age of the female. The litters usually fall between 4-15 young that are born in the summer months.
- Normally the females have one litter per year, but in colder environments it maybe one litter every two years.

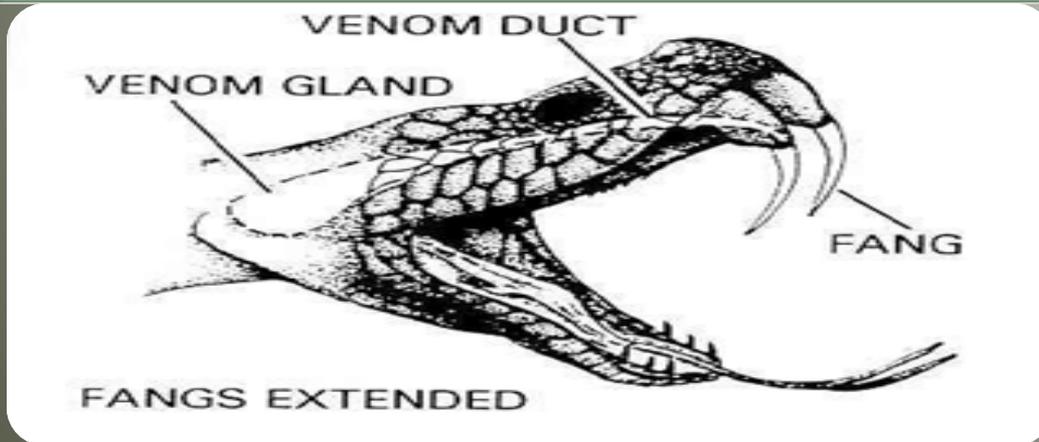


# Public Health Significance

- Bacterial infections may result from contact with reptile fecal material, contaminated surfaces, or through bites. Individuals who are accidentally bitten when handling large lizards and non-poisonous snakes typically receive a tetanus shot and are given antibiotics.
- Transmission of *Salmonella* to humans has been documented for persons handling contaminated turtles, and other pet reptiles, like iguanas imported from outside California and sold locally in pet stores.
- An estimated 45,000 snake bites occur per year in North America, with 15-20 of these bites being fatal. Most often these fatal bites occur in the southern states where rattlesnakes are common.
- The victims of non-fatal bites frequently suffer debilitating or disfiguring side effects from bites because the venoms can produce massive amounts of tissue destruction and scars.



# Public Health Significance of Rattlesnakes



The venom injected by the fangs of most rattlesnakes are complex mix of proteins. Some of these proteins are enzymes that initiate the digestive process before the prey is swallowed. Other venom components may affect the nerves by reducing the ability of nerves to transmit impulses. The toxicity of rattlesnake venom can vary between species and among populations of the same species. Larger snakes have potential to inject greater quantity of venom. More venom = greater tissue destruction.

Venom toxicity (LD50 mg/kg) is rated by the quantity of venom required to kill 50% of a target animal (e.g., laboratory rat) population as a function of the animal's weight. Among California rattlesnakes, the venom of the Mojave rattlesnake (*Crotalus scutulatus*) is potentially more toxic than other species. Some studies have demonstrated an LD50 of only 0.21 mg/kg. The reason for this is because the venom may contain both hemotoxic and neurotoxic compounds that produce both blood and tissue degradation, as well as disruption of nerve function.



# Outdoor Safety



Rattlesnakes do not strike as a consequence of instinctive aggressive behavior, but either as a defensive or hunting action. The best prevention against rattlesnake bite is to:

- Avoid contact.
- Wear protective clothing.
- Use common sense when in "rattlesnake country".

The following is a list of bite avoidance suggestions recommended by the Southwestern Herpetologists Society:

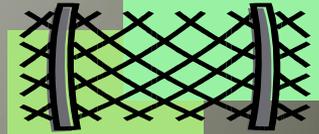
- Do not handle or provoke rattlesnakes and keep a safe distance once encountered.
- Watch where you place your feet; do not step "blindly" over rocks, logs and twigs.
- Watch where you place your hands; do not reach "blindly" over rocks and ledges, into crevices or animal burrows.
- Wear a sturdy pair of leather boots that extend above the ankle or don protective chaps in areas known to be heavily populated with rattlesnakes to prevent bites to feet, legs, and lower torso.



- If a snake bite occurs, the victim should be kept calm, covered with a warm blanket, and transported immediately to an emergency medical facility.
- Cutting and suctioning venom from the bite or applying tourniquets are not recommended due to a variety of complications that arise as a consequence of these radical first-aid procedures, including incipient bacterial infection.
- Administration of specific antivenin and support of life sustaining systems are the only appropriate and effective treatments for snake envenomation.
- If the biting snake was observed and its species can be identified, this information should be conveyed to the attending medical staff as it may provide information valuable toward the proper medical management of the patient. However, rattlesnake species identification is not necessary for proper treatment. Attempts to capture or kill the snake should never be attempted because these actions often result in additional bites.



# Management & Control



Exclusion: The most effective means for homeowners to prevent rattlesnakes from occupying their properties is to construct a “snake-fence” around the yard or smaller areas where children and pets play. A rattlesnake fence is usually a one-meter high ¼ inch hardware cloth/mesh screening supported by conventional fence posts. The bottom edge of the screen should extend 10-15cm (4-6in) below the surface of the soil to make sure that rattlesnakes will not enter through gaps below the base of the fence. Additionally to the fences, residents should inspect their homes and garage for gaps (5mm or wider) in access doors, vents, and windows. All possible entry points should then be sealed, weather stripped, or screened with ¼-inch hardware cloth.





# Management & Control



Habitat Modification: Rattlesnakes in the wild use existing vegetation and other natural cover to hide from predators and to hunt for prey. Weeds, trash, lumber and wood piles as well as abandoned rodent burrows all can be used by rattlesnakes for shelter. Eliminating these areas can significantly reduce the attractiveness of a residence for snakes.



Trapping: In some areas in the United States, rattlesnakes are trapped at den sites during the time that they are entering or exiting the den for overwintering. Snake traps are designed to funnel the snakes to a central collecting location like a pitfall where a experienced handler can then remove them. This technique does not happen often in residential or rural areas because it is difficult to predict the snakes movement.

Public Awareness: The most important way to manage rattlesnakes is to inform the public about the proper steps and attitude to avoid interaction with rattlesnakes in their environment. When the proper clothing, property management, and taking suitable precautions traumatic rattlesnake encounters can be easily avoided.



# Lizards

Class: Reptilia



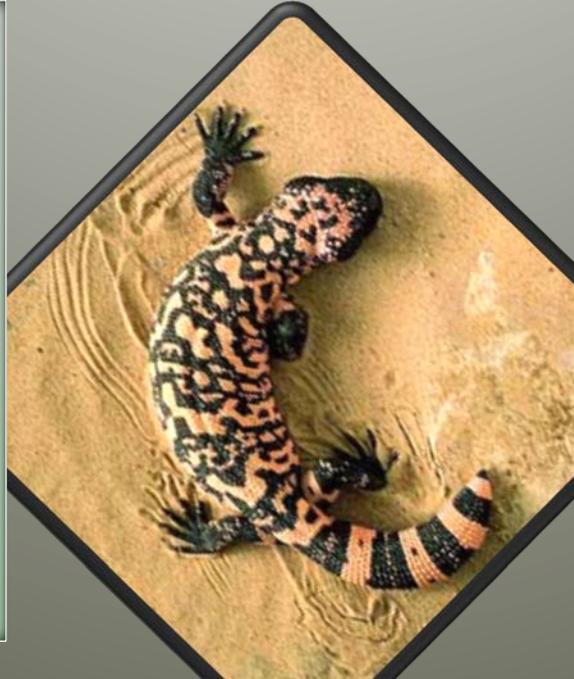
Lizards in California are generally not a threat to public health.

The western fence lizard and the southern alligator lizard are lizards of public health interest because they play a role as secondary hosts of immature *Ixodes* ticks which transmit the bacterial agent of Lyme Disease in California.



# California Lizards of Public Health Importance

Description: The gila monster (9-14 in.) is the only venomous lizard in North America. This species is easily identified and unmistakable due to its heavy body, large head, swollen tail, beaded appearance with blotches of red, orange, and pink with brown to black contrasting blotches.



Significance: Little to none. The venom of the gila monster is moderately toxic. Unlike rattlesnakes, the venom is not injected into the prey by fangs, but expelled into the mouth from glands in the lower jaw, from which it flows down the grooves in the teeth and enters the victim when the lizard bites down with a chewing motion.

Range: Extremely rare in California. Historically found in the extreme eastern Mojave Desert of San Bernardino County in the Clark, Kingstone, and Piute Mountains. Once collected from the Providence Mountains and at Imperial Dam along the Colorado Desert.





# Western fence lizard

(*Sceloporus occidentalis*)

# Southern alligator lizard

(*Elgaria multicarinata*)



**Description:** The western fence lizard is one of the most common lizards in California. Measuring 5-18cm, 2-7in. in length. It is also known as the “blue belly” or “fence swift”. The females also have the blue but it is not as bold, or even absent. The females also have dark crescent bars across the back.

**Range:** The fence lizard is found throughout most of California with the exception of the deserts where it is replaced other *Sceloporus* species.

**Habitat:** This common lizard resides in a variety of habitats from grasslands, chaparral, sagebrush desert, woodlands, coniferous forest, and farmland.

**Significance:** This lizard may play an important role as an alternative host to tick species that are known vectors of Lyme disease in California.

**Description:** A short-legged, heavy bodied lizard with a large triangular head measuring up to 50cm, 20 in. in length. Back is brown to reddish with checked black and white. The distinguishing characteristics for the alligator lizard is its long prehensile tail and large triangular head.

**Range:** Southern Washington to central Baja California.

**Habitat:** Occurs in most non-desert habitats; prefers area where there is shade and water. They have adapted to urban life and are found in backyards and vacant lots.

**Significance:** Just as the western fence lizard the alligator lizard may play an important role as an alternative host to tick species known as vectors for Lyme disease. Alligator lizards are not easily intimidated by humans and can inflict a vigorous and painful bite.



# Chapter 2



## BIRDS (Class Aves)

# Introduction

- From the view of public health, birds pose little direct threat to humans when compared with other vertebrates; however, it is important to be aware of the potential health and safety risks that contact with birds could pose.
- The class of Aves has nearly 10,000 species.
- Birds can also be organized into six groups based on their physical features, habitat, and lifestyles.
- In California there are more than 600 wild bird species.

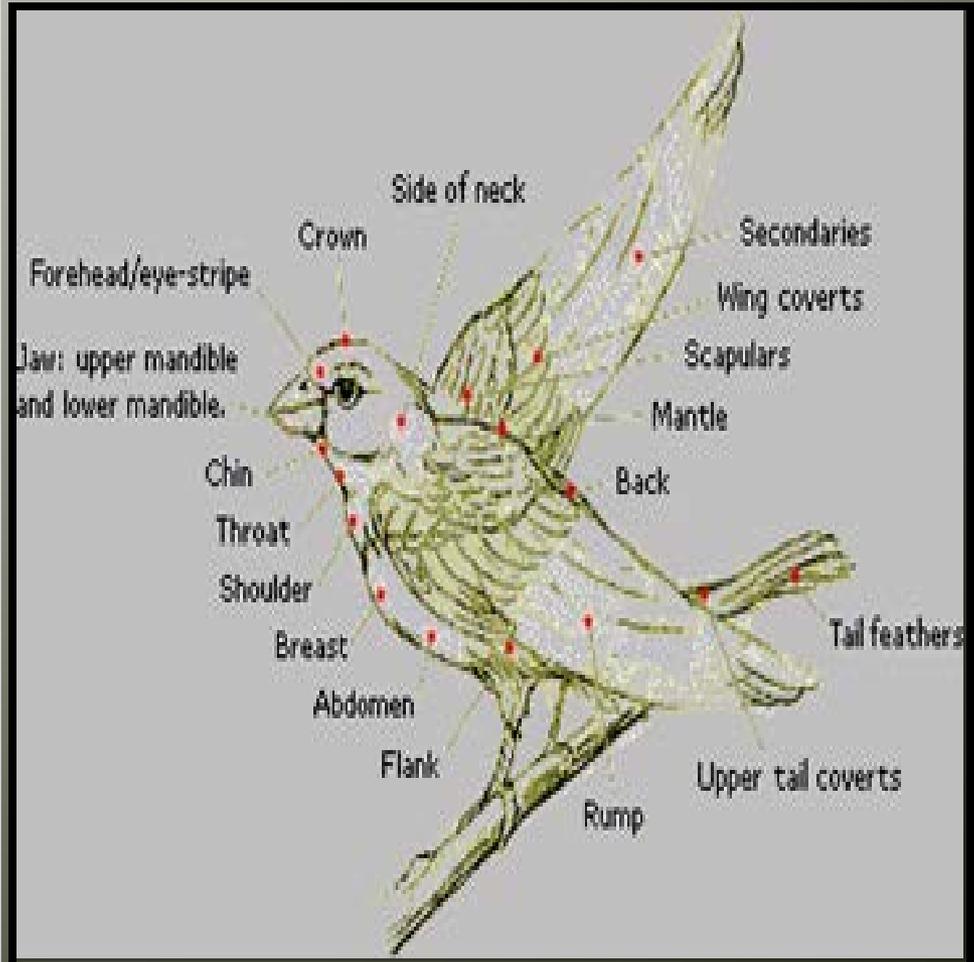


# Characteristics

- The six groups that birds can be categorized into are:
  - Perching birds: sparrows, crows, finches, swallows, blackbirds.
  - Birds of prey: hawks, falcons, vultures, owls.
  - Running birds: quail, turkeys, pheasants, grouse.
  - Wading birds: herons, storks, spoonbills, ibises.
  - Aquatic birds: ducks, geese, swans, gulls, pelicans.
  - Other land birds: pigeons, hummingbirds, woodpeckers.

# Anatomy

1. Epidermal covering of feathers and leg scales.
2. Skeleton fully ossified with air cavities and beak with no teeth.
3. Paired limbs with the forelimbs usually adapted for flying and posterior pair adapted for perching, walking, or swimming.
4. Internal fertilization with large-yolked, hard shell eggs.
5. Homeothermic (warm-blooded).
6. Four-chambered heart.
7. Respiration by slightly expansible lungs with thin air sacs.



# California Birds of Public Health Importance

## American Crow (*Corvus brachyrhynchos*)



- Range: Common throughout California.
- Habitat: Developed and undeveloped areas, agricultural land, forests and parks. May nest or roost in urban areas.
- Biology: Nest between February and May. Lay 3-9 eggs; incubation is approximately 18 days.
- Crows flock after fledglings leave the nest. Crows congregate in large communal roosts at night.
- Significance: Important sentinel species for surveillance of West Nile virus in North America.
- Legal Status: Classified as migratory non-game birds and may be taken only by property owners or tenants to avoid health hazard or nuisance.



# California Birds of Public Health Importance

## House finch

(*Carpodacus mexicanus*)



- Range: Common throughout California. Most abundant in valleys and foothills.
- Habitat: Woods, deserts, farmlands, suburban and urban areas.
- Biology: Nest in nearly any sheltered area between March and July. Lay 2-6 eggs which hatch in 13-14 days. Broods of young and adult birds band together during the summer. Feed primarily on seeds, buds, and berries.
- Significance: Important reservoir of mosquito-transmitted encephalitis viruses.
- Legal Status: Classified as a migratory nongame bird by Federal Regulations. A U.S. Fish and Wildlife Service permit must be obtained before control measures can be implemented.



# California Birds of Public Health Importance

## House sparrow

(*Passer domesticus*)



- Range: Common throughout California.
- Habitat: Developed and agricultural areas.
- Biology: Nest building begins in February. Lay 2-7 eggs.
- in up to three broods per year. Eggs hatch in 10-14 days. Young birds and adults flock together in late summer. Feeds primarily on grain, human discards in urban areas.
- Significance: Reservoir for pathogens of veterinary and human medical importance, including western equine encephalomyelitis virus and diverse fungal and protozoal parasites.
- Legal Status: Classified under California Fish & Game Code as a nongame bird which may be taken at any time.



# California Birds of Public Health Importance

## Canada goose

(*Branta canadensis*)



- Range: Migratory. Summer breeding grounds in Canada and Alaska, but geese of the Pacific flyway overwinter in California and other western states.
- Habitat: Can be found near any body of water, be it natural or man-made (e.g., city park pond).
- Biology: Feed on grasses, grains, and seeds along the water's edge. Form life-long breeding pairs. Lay 3-7 eggs which take 25-30 days to hatch.
- Significance: While goose feces can contain pathogens capable of causing disease in humans, the risk of infectious disease to humans through contact with goose feces is considered quite low. Accumulated fecal material from large flocks can deface public areas (e.g., golf courses) and create hazard of injury on walkways. Because of their large size (up to 24 lb) and aggressive disposition when defending a nest, Canada geese present a risk of biting injury, especially to small children.
- Legal Status: Protected by state and federal law (Migratory Bird Treaty Act). A permit must be obtained from the U.S. Fish and Wildlife Service before geese may be taken.



# California Birds of Public Health Importance

## Rock dove, aka. city pigeon

(*Columba livia*)



- Range: Widely distributed within and around developed areas of California.
- Habitat: Cities, suburbs, and farmland.
- Biology: Use shelters and ledges, commonly on man-made structures, for nesting sites. Lay 1-2 eggs which hatch in 16-19 days. Five or more broods are raised each year. Feed mostly on seeds and grains. In cities, may subsist on foods intentionally or inadvertently offered by humans.
- Significance: Host for several pathogens of veterinary and medical importance, including *Toxoplasma* and *Salmonella*. Pigeon feces can deface buildings, automobiles, walkways, and public art. Pigeon feces also provide an ideal medium for growth of *Histoplasma* and *cryptococcus* fungi, both of which can cause respiratory illness in humans. Their nests can interfere with drain pipes and awnings.
- Legal Status: Rock doves are not protected by federal or state law.

# Public Health Significance

**Avian Influenza** (bird flu). Influenza is caused by RNA viruses that come in many varieties and are constantly evolving. Pathogenicity and transmissibility to different species is determined principally by the virus's hemagglutinin (H1-H16) and neuraminidase (N1-N9) type. Whereas most species are susceptible to only a few virus types, birds can carry and transmit virtually all influenza viruses. Avian influenza viruses are further classified as either High Path or Low Path, based on their mortality amongst birds.

Most avian influenza viruses cause no or mild symptoms in humans. However, when avian influenza viruses mix with other influenza viruses, e.g., in swine, viruses can swap genetic material and change their pathogenicity and ease of transmission to other species.

Introduction of novel avian influenza viruses from their reservoir in wild waterfowl to domestic poultry can cause significant mortality as well as restrictions on movement and marketing of birds.



# Public Health Significance

Psittacosis (parrot fever, ornithosis). *Chlamydophila psittaci* is a bacterium transmitted from birds to humans that affects primarily the respiratory system. *C. psittaci* has been isolated from approximately 120 bird species and is most commonly identified in psittacine birds, especially cockatiels and parakeets.

Approximately 75% of cases result from individuals exposed to caged pet birds, the majority of whom are bird fanciers or pet shop employees. However, transmission has also been documented from wild birds, including doves, pigeons, raptors, and shore birds. The infection is acquired by inhaling dried secretions (including feces) from infected birds. The incubation period is 6-19 days. The clinical features in humans include fever, chills, headache, muscle aches, and a dry cough. The infection usually resolves with appropriate antibiotic therapy, but rarely heart, liver, and neurologic complications may occur and fatal cases have been reported.



# Public Health Significance

Dermatitis. Mites (e.g., *Ornithonyssus* spp.) that infest wild and domestic birds can occasionally infest and bite humans, causing pruritic (itchy) rashes. Persons who handle wild birds or their nests are at potential risk of infestation. Avian mites can be controlled by treating the birds and wearing protective clothing and or spraying clothing with insect repellents prior to entering infested areas.

Hypersensitivity pneumonitis. Some persons may experience an allergic reaction to bird antigens present in dander. Exposure may cause respiratory inflammation when the antigens are inhaled. Sensitive persons can protect themselves by wearing respiratory protection and by working in well-ventilated areas.

Gastroenteritis. A variety of disease agents that cause diarrhea and vomiting, such as *Salmonella* and *Campylobacter*, may be present in bird feces. People can get these diseases by ingesting the bacteria present as surface fecal contamination on undercooked meat or poultry. People can also become infected by handling infected birds or bird feces and then contaminating food items or other surfaces by touching them without first washing their hands.



# Public Health Significance

Arboviral encephalitides. Birds can serve as reservoir hosts for several of the viruses associated with mosquito-borne viral encephalitis.

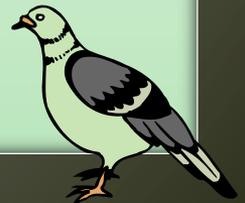
In California, house finches and house sparrows are the most important reservoirs for western equine encephalomyelitis virus (WEE) and St. Louis encephalitis virus (SLE). These species are important to arbovirus transmission because they a) are abundant, b) live in close association with many human communities, c) have a relatively high proportion of infected birds, and d) maintain a persistently high viremia. Birds remain generally unaffected by infection, but mortality can be significant with the more virulent (e.g., eastern equine encephalomyelitis) or exotic (e.g., West Nile) arboviruses.



# Public Health Significance

Fungal infections. Bird feces can serve as an ideal environment for the growth of a number of fungi that can cause severe disease in some humans. Growth of certain fungi, normally present in the soil, may be promoted in the presence of bird fecal matter.

In California, *Cryptococcus neoformans* is often isolated from pigeon feces. Individuals can become infected following inhalation of aerosolized dust or soil that is contaminated with pigeon feces. Only a small percentage of exposed persons develops respiratory illness; however, the risk of severe illness is increased for immunosuppressed individuals. Precautionary measures include controlling urban pigeon populations, avoiding highly contaminated areas, working in well-ventilated areas, wetting down contaminated areas prior to entry to minimize aerosolization, and the use of respiratory protection.



# Management and Control



- Waste management

- Management and control of bird populations and their waste products can be difficult, but efforts should be taken especially around areas where susceptible people are like hospitals and nursing homes.
- Cleanup should take place at times when risks to passersby are at the lowest. Barricades should be placed to deter pedestrians.
- If cleanup is taking place on a roof, close all air ducts into the building before beginning to clean.
- Persons conducting cleanup should wear appropriate clothing, eye, and respiratory protection.
- Bird droppings pose the biggest risk of infection when they are dried and able to get stirred up into the air where they can be inhaled. Before cleanup begins dropping should be saturated with a low-pressure fine mist of disinfectant solution (e.g., diluted bleach).



# Management and Control

- Bird control

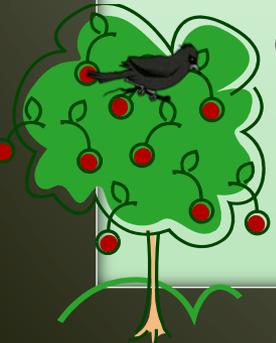
- Control actions depend on the species involved, the habitat, and the level of infestation. Bird control is rarely achieved with a single product or treatment so a combination of habitat modification, use of repellents and removal of problem birds should offer adequate control.



# Management and Control

- Habitat modification

- Birds are attracted to areas where food, water, and shelter (for nesting and roosting) are available to them. Eliminating or restricting access to these resources will help to limit the number of birds in the area.
- Typical food sources are fruit, nuts, seeds and insects. netting can be draped over producing plants to keep birds away.
- Removing unneeded water sources will help limit bird numbers.
- Repellents use both audio and visual techniques. Effective with some bird species like the European starlings, but ineffective with other species such as the rock dove. Statues made to look like predators like owls or raptures have been shown to scare some birds away.



# OPOSSUMS

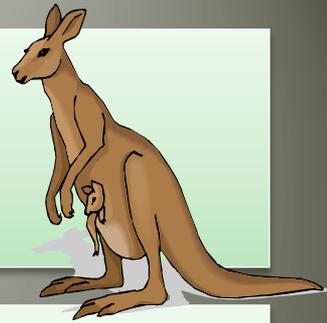
(CLASS MAMMALIA, SUPERORDER MARSUPIALIA)



Chapter 3



# Introduction



- Marsupials are the pouched mammals. Based on the fossil record, it is hypothesized that marsupials originated in North America and spread to South America and eventually to Australia, via Antarctica. The opossums are sometimes called "living fossils" because they have remained virtually unchanged for 50 million years.



# General Characteristics

- Taxonomy

- The Virginia opossum, *Didelphis virginiana* (Family: Didelphidae), is the only marsupial that lives in North America.



- Anatomy

- Opossums look almost rat-like, with a long narrow pointed snout and a white face, along with prominent grey to black guard hairs.
- You can easily see the difference from rodents and opossums by their large distinctive canine teeth and prehensile tail.
- Opossums are about the size of a domestic cat with a body 12-20in., tail 10-21in. and weighing 4-10lbs.
- Their prehensile tails are long with sparse hairs and prehensile (i.e., capable of grasping).
- Their hind feet also have a fifth prehensile toe, the tail is used for balance and stability while climbing.
- Males are usually larger than females and do not have a stomach pouch.



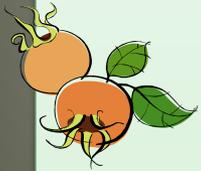


- **Reproduction**

- Opossums usually mate between January and July. They typically have 2 litters of 4-10 young per year. The young are born almost embryonic. About the size of a bumblebee, they crawl unaided to their mother's marsupium, or pouch, where they attach to a nipple. The young emerge from the pouch after approximately two months, then may stay with their mother for awhile longer, often riding on her back.



## • Behavior



- Opossums are omnivorous and prefer to eat insects, snails, carrion, fruits (especially overripe), grains, mice, bird eggs, and small snakes. Compost piles, garbage cans, and pet food provide attractive meal opportunities for opossums. Opossums are solitary and nocturnal mammals. They usually move slowly and may exhibit an involuntary shock-like state when frightened ("playing possum"). If threatened, opossums will hiss or growl and bare their teeth, but are generally shy animals that prefer to avoid confrontation. An opossum that seems overly friendly, aggressive, or is active during the daytime is probably sick, possibly rabid, and should be avoided.



- Opossums have many predators including dogs, cats, owls, coyotes, and humans. The lifespan of an opossum in the wild generally does not exceed 2 years, but in captivity they may live up to 10 years.





- Distribution and habitat

- Opossums have an extensive range in North America.
- The opossum was introduced from the southeastern United States into California near San Jose in the early 1900s, and thereafter rapidly expanded its range to include the coast, from San Diego north to Oregon, and eastward to the Sacramento Valley and San Joaquin Valley.
- Opossums typically inhabit regions below 1000 meters elevation. Opossums thrive in many environments. The natural habitat of opossums is woodland areas near streams and rivers.
- Opossums also adapt well to agricultural areas and backyards of suburban neighborhoods. They will use hollow trees, woodpiles, rock piles, and abandoned underground burrows as dens. In a peridomestic setting, they will live under buildings and in attics.

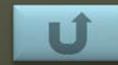


# Public Health Significance

- Opossums are a potential threat to human health through direct injury or as a reservoir of infectious disease.



Enteric  
infections



# Public Health Significance

- Bite wounds
  - Opossums are normally shy and will avoid contact with humans, but if they are aggravated either by being touched, picked up, or attacked by dogs or cats they may bite.
  - Bacterial infections can develop rapidly at the bite site. Wounds should be immediately cleaned with soap and water and medical attention sought.



# Chagas' Disease

- **(American trypanosomiasis)** Chagas' disease is a febrile illness caused by a protozoal parasite, *Trypanosoma cruzi*, and transmitted by the bite of an infected kissing bug (cone-nosed bug, family Reduviidae).
- In South America, where Chagas' disease is endemic, members of the genus *Didelphis* are important reservoirs of *T. cruzi*. *T. cruzi* has been identified in approximately 15% of opossums in the southeastern United States.
- The role of opossums in the maintenance and transmission of *T. cruzi* to humans in North America is unclear.



# Enteric infections

- Enteric bacteria such as *Salmonella* spp. are commonly found in the feces of many species of mammals and birds, including opossums.
- These bacteria and other enteric pathogens may be shed in feces and transmitted to humans by the fecal-oral route (e.g., via ingestion of pathogens in food or fomites contaminated with feces).
- Enteric infections are characterized by fever, malaise, and diarrhea. In the very young, the elderly, and persons with compromised immune systems, these infections may be severe or even fatal.



# Murine Typhus (Flea-borne typhus, Endemic typhus fever)

- Classic murine typhus occurs worldwide, most often as a rat-flea-rat cycle where humans represent an abnormal or "dead end" host. In suburban areas of the United States, especially southern California and south central Texas, the ecology of the disease has shifted to a peridomestic animal cycle involving opossums, cats, and their fleas. Seropositive opossums and cats have been found during human case-patient investigations in Los Angeles and Orange Counties. Infected opossums do not appear ill, to our knowledge.
- The cat flea (*Ctenocephalides felis*) is the suspected vector of murine typhus in southern California and opossums likely serve as reservoir hosts.
- Humans are at risk of bites by infected fleas which infest domestic animals and backyard wildlife.

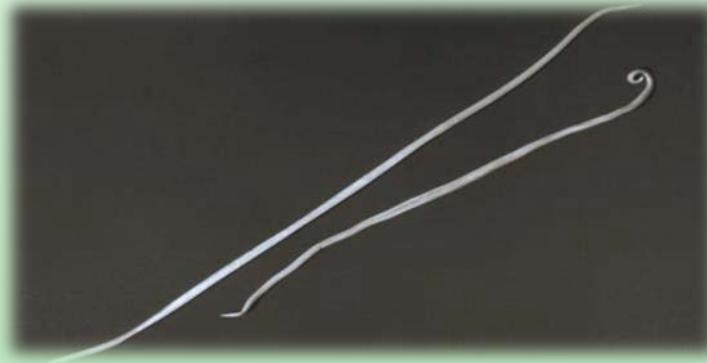
# Rabies

- Opossums are susceptible to skunk and bat strains of rabies, but represent less than 1% of animal rabies cases in California.
- A rabid opossum will generally exhibit unusual behavior such as daytime activity, aggression, weakness, and neurologic signs (circling, seizures, etc.).
- Potential exposure to a rabid opossum requires immediate medical attention.
- Dogs or cats that are bitten or scratched by an opossum should be placed in quarantine in accordance with local and state regulations. If available, the biting opossum should be tested for rabies at a public health laboratory.



# Visceral and Ocular Larval Migrans

- Carnivores (dogs, raccoons) are the primary carriers of roundworms that cause larval migrans in humans. *Baylisascaris* spp. and other roundworms have occasionally been documented in opossums as well.



# Management and Control

- Never pet or pick up opossums.
- If an injured or sick opossum is found, call animal control for assistance. Do not handle the animal yourself.
- Keep pets away from opossums.
- Eliminate or reduce opossum temptations such as food sources and den materials
  - Keep feed stores on farms and stables tightly covered.
  - Keep pet food and water covered at night or bring indoors
  - Tightly cover garbage cans, compost piles, and grain containers
  - Remove piles of rock, wood, vegetation, and lumber as these are all sources of shelter.
  - Block openings into houses and other building with strong wire mesh material.





# Bats

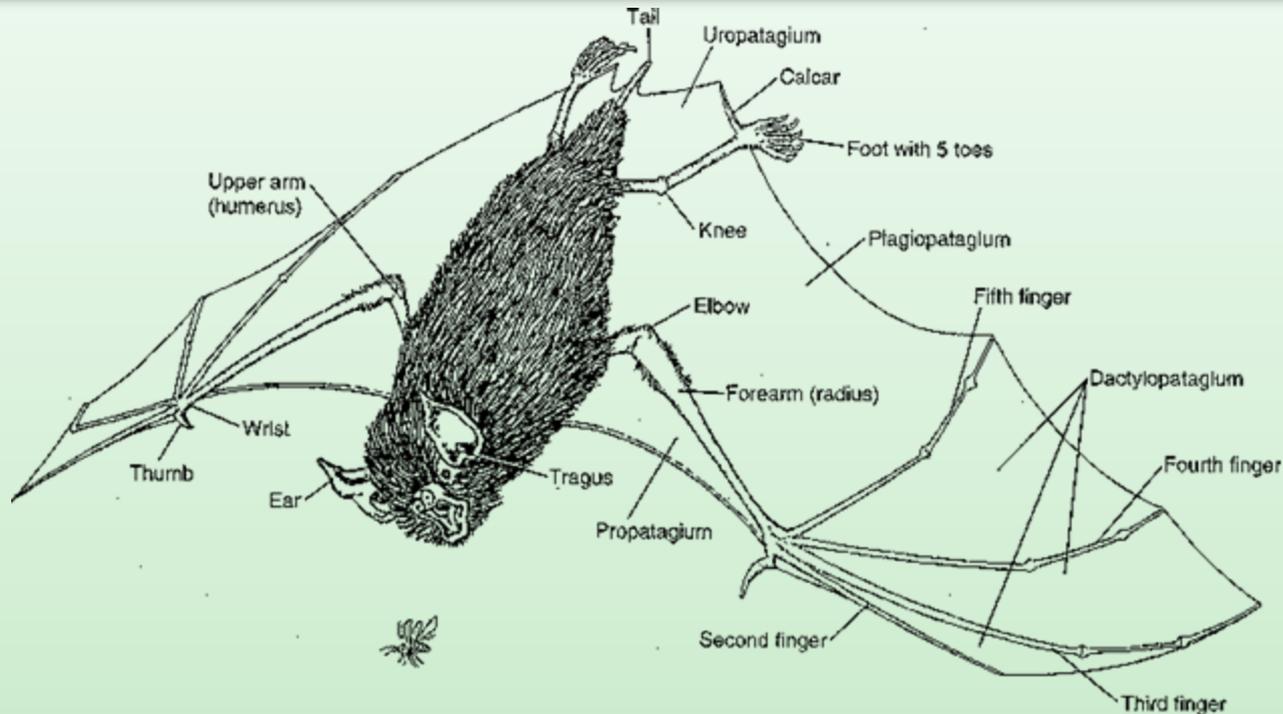
( Class Mammalia, Order Chiroptera)



Chapter 4



# INTRODUCTION/CHARACTERISTICS



Bats, like humans and other mammals, are warm-blooded and have fur or hair. They give birth to live young, feeding them with milk from mammary glands. Bats are the only mammals that are able to fly, and their wings make any of the >900 species in the world instantly recognizable.

- **Taxonomy**

- Class *Mammalia*
- Order *Chiroptera*
- (3 families – 23 species in California)

- Bats comprise the order of mammals called *Chiroptera*, a name derived from Greek meaning "hand wing."
- Bats are subdivided into two major groups or suborders, the *Megachiroptera* (megabats) and the *Microchiroptera* (microbats).
- Megabats do not rely on echolocation, they have large bodies and eyes, eat primarily fruit, and are limited in their distribution to the Old World tropics.
- In contrast, microbats rely on echolocation for foraging and maneuvering, have small bodies and eyes, eat primarily insects, and are widely distributed throughout the world.

- Forty-two species of bats are found in the United States, all microbats. In California, there are 23 species within 3 families. Bats are the only mammals that fly, consequently many of their unique features relate to flight. (The wing is formed from skin stretched between the arm, wrist, and finger bones. Although the skin on the wings is very thin and appears delicate, it is fairly resistant to tears or punctures.
- Bats exhibit a great range of body sizes, from the tiny hog-nosed or bumble bee bat of Thailand (2 g) to the fruit-eating flying foxes (1,600 g) which have a wing-span of 2 m. However, most bats are relatively small, weighing 10-100 g. The western pipistrelle is the smallest bat in California and one of the smallest mammals at 2-6 g. The largest bat in California, the western mastiff bat, weighs 45-73 g (1.5-2.5 oz) and has a wing-span of 53-57 cm (21-23 in).



- Roosting Behavior

- Bats are active and feed at night. During the day, bats roost in dark, sheltered places such as caves, mine tunnels, rock crevices, hollow trees, under loose tree bark, in trees and understory vegetation, in buildings, under bridges, and in other protected places. Some species roost alone, while others form colonies that vary from a few to millions of individuals. Roosts can be subdivided into day and night roosts, hibernation roosts, summer roosts, nursery roosts, feeding roosts, and transient or resting roosts. The roosting habits of bats are adaptations that reflect the interrelationships of social structure, diet, flight behavior, predation risks, and reproduction of each species.

- Feeding Habits

- Flight has allowed bats to occupy many feeding niches. Most species of bats eat insects, often taking insects in flight, but occasionally from plants or from the ground. All bats in California are insectivorous with the exception of the Mexican long-tongued bat which feeds primarily on fruit, pollen, and nectar.

- Navigation (Echolocation and Feeding Behavior)

- In order to find prey items and to maneuver within their environment, most bats echolocate. Bats emit high-frequency sound impulses and discern information about objects in their path from rebounding echoes. Many of the structural characteristics of bats, including their varying shapes and sizes of ears and their occasionally bizarre facial features, relate to echolocation. Many aspects of echolocation are specific to each species and relate to foraging for food.



- **Reproduction, Litter Size, and Longevity**

- Some bat species breed in the spring while others breed in the fall and delay fertilization until spring. In either case, birth coincides with the emergence of insects in the spring.
- While many small mammals have several large litters each breeding season, most bats produce only a single litter per year, with typically only one, or less frequently two, young per litter.
- Bats have much longer life spans than is typical for small mammals, sometimes exceeding 30 years. Prolonged life spans may be a function of reduced metabolic rates on the bases of daily torpor, seasonal hibernation, or both.



- **Hibernation and Migration**

- Because most bats in California eat only insects, they are active primarily during the warmer months when insect populations are more abundant and active. In the winter, bats either migrate south to a warmer climate or hibernate in a protected location. The migration patterns and the seasonal distribution of many bats are unknown. In California, some migration patterns may be limited to changes of elevation.



## • Distribution

- Bats are the most widely distributed group of terrestrial mammals. Representatives inhabit every continent except Antarctica. While as many as 90% of species reside in tropical regions, bats are also abundant in temperate regions during the summer. Bats also utilize a wide variety of ecosystems. In the US they are abundant in both forests and deserts, and range from sea level to 15,000 feet elevation.
- Twelve of the 23 species in California are found throughout California, with the exception of the south-eastern deserts and the San Joaquin Valley. Seven species inhabit principally southern California, especially the southeastern desert regions. The remaining four species have limited or separate distributions which do not fit the other two basic patterns.



## Ecological and Economic Value

- Bats play an important beneficial role as the major consumers of night-flying insects, as pollinators of plants, and in the dispersal of seeds of fruits. Bats consume staggering quantities of insects every night. Mosquitoes comprise a high percentage of some bats' diets; individuals may consume as many as 1,000 mosquitoes per hour. Bats serve as pollinators and seed dispersal agents for hundreds, and probably thousands, of species of plants.
- A few of the better known economically valuable crop plants which rely on bats for survival are bananas, avocados, dates, figs, mangoes, cashews, and agave (tequila). Bats often account for as much as 95% of tropical forest regrowth by dispersal of seeds from consumed fruit.

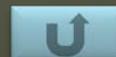


# Public Health Significance

- Bats are known to transmit to humans only two diseases in California.
  - Rabies
  - Histoplasmosis

# Rabies

- Rabies is a viral infection of the central nervous system that is almost always fatal.
- Bats and striped skunks have replaced the dog as the primary maintenance species of rabies in California. Bats are generally not aggressive and will bite only in self-defense. There are no records of house dwelling bats transmitting rabies through the air, feces, or urine. Humans are rarely attacked or bitten by bats except when handled.



# Rabies

- Bats are susceptible to rabies, but only a small proportion of a population is infected. They seldom become aggressive when infected, but rather generally become paralyzed and die within a few days of onset.
- Rabid bats can be found anywhere in California; rabies has been detected in bats from all 58 counties and from below sea level to over 3000 m elevation in the Sierra Nevada mountains.
- Bats found on the ground, active during the day, in a place where bats are not normally seen (for example, in a swimming pool, caught by a cat or dog, etc.), or unable to fly are more likely to be rabid.
- Persons bitten by a bat, or who experience contact with bat saliva, should wash the affected area thoroughly with soap and water and seek immediate medical attention. Whenever possible, the bat should be retained and sent to the local county public health laboratory for rabies testing. Although most people recognize when they have been bitten by a bat, bite marks from bats' small teeth may not always be evident. Therefore, persons awakening to find a bat in their room should seek medical attention and have the bat tested. The bat should be removed by animal control.



# Histoplasmosis

- Histoplasmosis, infection with the fungus *Histoplasma capsulatum*, most commonly manifests as a flu-like respiratory disease. If infection becomes circulated, symptoms can be severe and occasionally fatal. Histoplasmosis can be contracted by breathing dust stirred up from areas where bat or bird (especially pigeon) droppings accumulate. Buildings, attics, caves, and other enclosed areas where bats congregate can present a particular risk. Persons working in these areas should always use a properly fitted respirator capable of filtering particles as small as two microns in diameter. Histoplasmosis occurs most commonly in the Midwestern U.S., and infrequently in California.



# Parasites

- Like all mammals, bats may harbor ectoparasites such as fleas, ticks, mites, and other parasites, including bat flies and a specific bed bug. In most cases, these parasites are host-specific to bats and usually only confined to a specific bat species.



# Management and Control

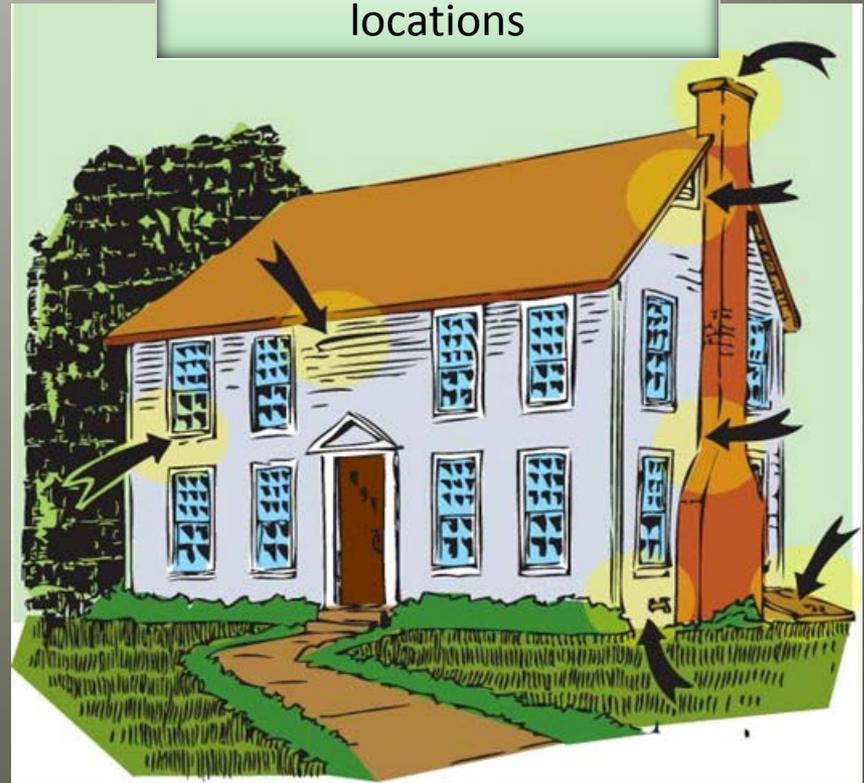
- In the U.S., six bat species are federally listed as Endangered. In California, eight species and three sub-species of bats have experienced declining populations and are designated Species of Special Concern by the Department of Fish and Wildlife.
- When called upon to take care of "bat problems" the person should be knowledgeable in the special care and restrictions required when working with these species.



# Removal

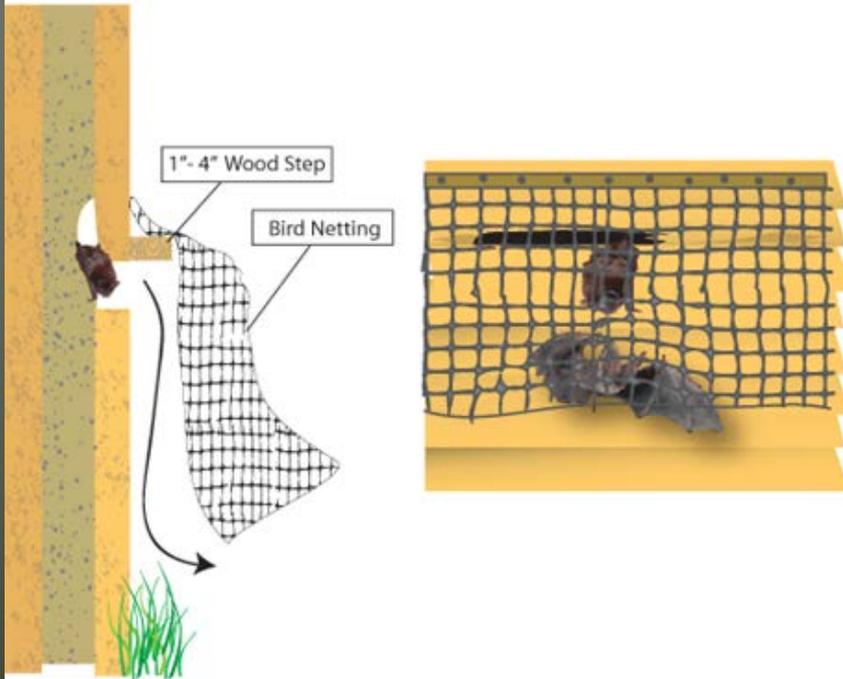
- Bats are reclusive by nature and will attempt to avoid human contact, and more likely will seek to escape an encounter.
- If found roosting in the daytime or during winter months, bats will most likely be torpid (asleep) or hibernating. Torpid bats have a much lower body temperature and metabolic rate, and may not awaken immediately.

Possible bat entry locations



# Exclusion

Exclusion Technique



Exclusion technique for bats. Bird netting properly suspended over entry locations, allows emerging bats to crawl under and out, but returning bats are unable to find their way back under.

- Bats that suddenly appear in houses or other buildings have usually entered through rather predictable routes, the most obvious of which are an open door or window. Other common routes are unguarded chimneys, loose window or door screens, or uncovered air vents.
- A piece of  $\frac{1}{4}$ - or  $\frac{1}{2}$ -inch mesh hardware cloth over the top of the chimney or air vent or a tighter fitting screen should eliminate most accesses. Any hole or opening more than  $\frac{1}{2}$  by 1 inch should be closed or sealed, especially those leading to the attic or outer walls. Small holes and cracks can be sealed with silicone caulking, and larger openings with a foam sealant, or even duct tape.
- Unlike rodents, bats do not chew holes or electrical wiring. Large numbers of bats living in an attic or wall space can become a nuisance resulting from their odor, noise, or both.



# Exclusion

- Exclusion is best to do during late fall or winter when the bats have migrated or changed their roosting location.
- If there are no young non-flying bats, then a simple exclusion technique is the use of ½ inch polypropylene bird netting to block bat entry to structures. See the hardware cloth slide for proper use.
- Harmless repellents, such as ultrasound devices have never been proven to be effective, despite the seeming sensitivity of bat's acute hearing.
- Although advocated as a repellent in the past, naphthalene (moth balls) has proven ineffective and potentially toxic to humans.





# Safety Precautions



- Bats of all sizes will bite in self-defense, but rarely attack people without provocation. By not handling bats, you avoid the risk of being bitten and possibly contracting rabies.
- If you must handle a bat, wear thick gloves, wrap the bat in a heavy towel, or capture and retain the bat in a net or other container. If you are bitten or handle a sick or dead bat with your bare hands, wash your hands thoroughly with soap and water and see a physician immediately.
- Do not discard the bat. It should be retained for possible rabies testing.
- It is illegal and dangerous to keep bats as pets.
- Wear a respirator while working in a confined area that contains bat droppings.
- Persons who have frequent contact with bats or other potentially rabid animals should consider receiving pre-exposure rabies vaccination.
- Poisons and chemicals are illegal and ineffective against bats, and potentially hazardous to humans.
- The only safe, permanent solution is exclusion.



# Carnivores

(Class Mammalia, Order Carnivora)

## Chapter 5



# General Characteristics

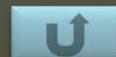
- **Taxonomy**

- Eleven families and approximately 271 species of carnivores are currently identified. In California, there are approximately 23 species, including feral dogs and cats.



- **Anatomy**

- Carnivores are quite diverse in size and appearance. Terrestrial carnivores range from the least weasel, at 35 g (1.3 oz), to the grizzly and polar bears weighing as much as 800 kg (1760 lb).
- Common to all North American carnivores are three pairs of small incisor teeth and one pair of large strong canine teeth on the upper and lower jaw. These canine teeth are the most characteristic feature of the Order Carnivora.



# General Characteristics

## Reproduction

Most species produce one litter per year. Young are born blind and dependent on parental care for an extended period of time. Carnivores do not truly hibernate but will "winter sleep" or remain in their dens during periods of exceptionally cold weather.

## Food

"Carnivore" means "flesh-eating", but this label is overly restrictive in that the diets of many carnivores also contain large amounts of fruits, berries, roots, and vegetation. Bears, for example, subsist almost exclusively on plant material. Some carnivores require freshly killed prey; others will scavenge and eat carrion.

## Habitat/Distribution

Carnivores inhabit all continents and have adapted to a variety of terrestrial and aquatic habitats. The distributions of individual carnivore species naturally follow the distribution and density of their prey.



# California Carnivores of Public Health Importance

**FAMILY CANIDAE: DOGS, COYOTES, FOXES,  
AND WOLVES**

## Coyote *Canis latrans*

Description: Coyotes are grizzled gray or reddish gray with a buff color on their underside. They have rust or yellowish legs with a dark vertical line on lower forelegs; their tails are bushy with a black tip. They weigh 20-40 lb with a total length of 41-52 in. Tail length is 12 -16 in.

Distribution/habitat: Coyotes are found in eastern Alaska, northwestern Canada, all of the western United States east to Louisiana, Tennessee, Ohio, and northern New York.

Coyotes are very adaptive predators that are tolerant of human activities. They can rapidly adjust to changes in the environment. In the West, they inhabit mostly open plains.

Food: Coyotes are opportunists that will eat insects, birds, reptiles, amphibians, fruit, and eggs, but their primary diet is mice, rats, ground squirrels, and carrion.

Reproduction: Pairs tend to remain together for life. They have one litter per year, with an average of 5-6 offspring per litter.

Significance: Occasionally prey on domestic pets and livestock. Can serve as reservoir for disease agents infectious to humans and domestic dogs. Important sentinel species in plague surveillance programs. Protected Status: Non-game species.



## Red Fox (*Vulpes vulpes*)



- Description: Red foxes are small, dog-like canines that are rust-red in color with white underneath the chin and throat. Coat can be reddish-brown, with a dark cross on the shoulders, or black with silver-tipped hair. They have black feet. These foxes weigh 8-15 lb. Their height at the shoulders is about 16 in. Their total length is 35-40 in with the tail 14-17 in.
- Distribution/habitat: Red foxes are found in most of Canada and the United States except for southwest California, northern Nevada, and Arizona. *Vulpes vulpes necator* are found in the Cascades, Siskiyou Co., and from Lassen Co. to Tulare Co. Preferred habitat includes mixed cultivated and wooded areas.
- Food: They are opportunists that feed on insects, earthworms, fruit, carrion, birds, and rodents.
- Significance: Occasionally preys on domestic pets and livestock, particularly fowl. Can serve as reservoir for disease agents infectious to humans and domestic dogs.
- Protected Status: California Subspecies (*V. v. necator*): California Threatened. Introduced Populations: Fur-bearing species.



# Kit Fox

(*Vulpes macrotis*)

- Description: Kit foxes are smaller than red foxes. Their color is buff-yellowish above and white underneath. The tail is black or it is the color of the body with a black tip. Feet are light in color. Kit foxes weigh approximately 3-6 lb. Their total length is 24-32 in. The tail length is 9-12 in. The height at the shoulders is about 12 in.
- Distribution/habitat: Kit foxes inhabit the arid regions of the southern half of California. Kit foxes inhabit open level areas where there is little human disturbance. Preferred habitat is a loose-textured soil with scattered shrubby vegetation.
- Food: The principal foods of kit foxes are black-tailed hares and desert cottontails, rodents, insects, reptiles, small birds, and eggs.
- Reproduction: Kit foxes have one litter per year with an average of 4 offspring per litter.
- Significance: Rarely presents a nuisance or disease threat.
- Protected Status: San Joaquin Kit Fox (*V.m. macrotis*): Federal Endangered and California Threatened.



# Gray Fox

*(Urocyon cinereoargenteus)*



Description: Gray foxes are grizzled gray above and red-brown underneath and on the back of the head. The throat is white. The tail is black on the top and black at the tip. The feet are rust-colored. The total length is 32-44 in. Tail length is 9-17 in. Height at the shoulders is 14-15 in. Gray foxes weigh 7-13 lb.

Distribution/habitat: Gray foxes inhabit the eastern United States to eastern North and South Dakota, Nebraska, Kansas, Oklahoma, most of Texas, New Mexico, Arizona, California, northern Colorado, southern Utah, southern Nevada, and western Oregon. They inhabit shrub lands, brushy and open-canopied forests that are interspersed with creeks, streams, rivers, ponds, or lakes.

Food: Gray foxes are opportunists that feed on fruits, cottontail rabbits, mice, voles, and insects.

Reproduction: Gray foxes have one litter a year with an average of 4 offspring per litter.

Significance: Occasionally preys on domestic pets and livestock. Can serve as reservoir for disease agents infectious to humans and domestic dogs.

Protected Status: Fur-bearing species.



# Feral domestic dog (*Canis lupus*)



- Description: Feral dogs are domestic dogs that no longer have a commensal relationship with humans for more than one generation. They are more independent of and more aggressive toward humans than stray or abandoned dogs.
- Distribution: May be found anywhere that domestic dogs are abandoned and uncontrolled.
- Food: Unlike stray dogs which usually scavenge on garbage, feral dogs typically prey on small to medium- sized wild or domestic animals.
- Reproduction: Feral dogs often form well-organized packs that communally rear litters of pups. Because of uncontrolled inter-breeding, feral dogs tend to resemble a hybridized mongrel breed of domestic dog.
- Significance: Aggressive disposition and habituation to humans pose an increased risk of injury and disease transmission to humans and domestic animals compared to wild canids. Feral dogs may serve as a reservoir for disease agents infectious to domestic dogs in areas of human habitation.
- Protected Status: None



# Family Ursidae: Bears

## Black Bear

*(Ursus americanus)*

- Description: In the west, the black bear's color ranges from black to cinnamon with a white patch on the chest. Total length ranges from 5-6 ft. Tail is 3-7 in. Height at the shoulders is about 3 ft. Black bears weigh from 200-600 lb.
- Distribution/habitat: Black bears inhabit most of Canada, Alaska, Washington, and Oregon; parts of California, Rocky Mountain states to Mexico; northern Minnesota, Wisconsin, and Michigan; in New England, New York, Pennsylvania south through the Appalachians; in the South, most of Florida, parts of Arkansas, and southern Louisiana. In the West, black bears inhabit forests and wooded mountains below 2100 m (7000 ft) elevation. In the East, these bears inhabit forest and swamps.
- Food: Black bears are opportunists that feed on roots, fruits, nuts, insects, fish, rodents, and carrion.
- Reproduction: Black bears have one of the lowest re-productive rates of the large land mammals in North America. Females give birth to young about every two years. Usually twins or triplets are born.
- Significance: May become a nuisance or destroy property when they enter human habitations in quest of food. Infrequently present risk of physical injury. Important sentinel species in plague surveillance programs, particularly in montane forest habitat.
- Protected Status: Game species



# Ringtail

## (*Bassariscus astutus*)

- Description: Ringtails have a catlike body with a fox-like face. They are yellowish-gray in color above and whitish-buff underneath. Their tail is bushy, very long, and black and white banded. Ringtails weigh about 2 lb. Their total length is 24-32 in. Tail length is 12-17 in.
- Distribution/habitat: Ringtails are found in southwestern Oregon, California, and southern Nevada. Ring-tails inhabit forests and shrub lands in close association to rocky areas or areas adjacent to bodies of water. They are primarily active at night (nocturnal).
- Food: Ringtails primarily feed on rodents, rabbits; birds, eggs, insects, fruit, nuts, and some carrion.
- Reproduction: Ringtails have one litter per year with an average 3 offspring per litter.
- Significance: Minimal public health importance.
- Protected Status: California: Fully Protected: May not be taken under any circumstances





# Raccoon

## *(Procyon lotor)*



- Description: Raccoons are reddish-brown and black above and gray underneath. They have a bushy tail with alternating bands of black and brown or brownish gray. Their most distinguishing characteristic is the black mask or band across the eyes. Their body length is 24-37 in. The tail is 8-16 in. Raccoons weigh 12-48 lb.
- Distribution/habitat: Raccoons are found throughout the United States except portions of the Rocky Mountain states, central Nevada, and Utah; they are also found in the southern portions of the Canadian provinces bordering the United States. Raccoons inhabit wetlands and the areas along bodies of water in forestlands and shrublands. They are most common along wooded streams. They are nocturnal.
- Food: Raccoons are opportunists that feed on crayfish, fish, insects, amphibians, small mammals, birds, and eggs in the spring. During the summer and fall, they feed primarily on fruits, nuts, acorns, and grains.
- Reproduction: Offspring are born between March and May with an average of 3-4 young per litter.
- Significance: Large peridomestic populations may present a nuisance and destroy property. Occasionally may cause injury (bite, scratch) to humans and domestic pets. Present risk of infectious disease transmission, including rabies and *Baylisascaris*.
- Protected Status: Fur-bearing species.

## FAMILY MEPHITIDAE: SKUNKS

# Skunks

### Striped Skunk (*Mephitis mephitis*)



- Description: Striped skunks are black with two broad, white stripes on their back that meet on top of the head. There is a thin white stripe down the middle center of the face. They have a bushy black tail that is either tipped with or fringed with white. Their total length is 21-32 in, and their total tail length is 7-16 in. Striped skunks weigh 6-14 lb.
- Distribution/habitat: Striped skunks are distributed throughout the United States and southern Canada. They are found throughout most of California except parts of the Mojave and the Colorado deserts. These skunks inhabit deserts, woodlands, grassy plains, and suburbs. Striped skunks are nocturnal.
- Food: The striped skunk's diet is primarily insects, small mammals, birds, eggs, amphibians, reptiles, fruits, and some carrion.
- Reproduction: They have one litter per year with an average of 4 offspring per litter. Young are usually born from April through June.
- Significance: An important reservoir for rabies in California. Occasionally damage property and prey on laying fowl and their eggs. Defensive spraying can be irritating to humans and domestic pets. Predation on rodents may locally decrease the risk to humans of some infectious diseases carried by rodents.
- Protected Status: Non-game species.



# Western Spotted Skunk (*Spilogale gracilis*)



Description: Spotted skunks are smaller than other skunks. They are black with horizontal white stripes on the neck and shoulders, and irregular vertical white stripes and elongated spots on their sides. The tail has white spots on the top and a white tip. Spotted skunk's total length is 13-22 in in length. The tail is 3-9 in in length. Spotted skunks weigh about 2 lb.

Distribution/habitat: Western spotted skunks are found in the western United States except in the high mountains and very dry areas such as the Mojave and Colorado Deserts. These skunks inhabit moderately open shrub and forest habitats that have streams or bodies of water associated with them. They are also found in areas with rocky lava rims and outcrops. Spotted skunks are nocturnal.

Food: Spotted skunks' diet is primarily insects and small mammals; they will also eat fruits, grains, reptiles, birds, eggs, and carrion.

Reproduction: They have one litter per year with an average of 4 offspring per litter. The young are usually born in April or May.

Significance: An important reservoir for rabies in California. Important sentinel species for plague surveillance in lava rim and rocky outcrop habitats. Occasionally damage property and prey on poultry and their eggs. Defensive spraying can be irritating to humans and domestic pets.

Protected Status: Non-game species. Subspecies *S. g. amphiala*: California Species of Special Concern



Family Mustelidae: Weasels, Minks, Martens, Wolverines, Badgers, Otters



# Badger

(*Taxidea taxus*)

Description: Badgers have a flattened body that is wider than long. Their legs are short and bowed, with dark feet. They have a shaggy grizzled grey to brown coat. There is a white stripe that runs from the shoulder down the forehead to the tip of the nose. Males are larger than females. The total length is 21-34 in. The tail is 4-6 in long. Badgers weigh from 8-25 lb.

Distribution/habitat: Badgers are found in the western United States east to eastern Texas, Oklahoma, northern Illinois, northern Indiana, and northern Ohio. In Canada, they inhabit southeastern British Columbia, Alberta, Manitoba, and southern Saskatchewan. Badgers inhabit plains, farmlands, and occasionally the edge of woods where the soil is usually dry and friable.

Food: Badgers primarily feed on rodents. Occasionally, they feed on reptiles, insects, earthworms, birds, eggs, and carrion.

Reproduction: Offspring are usually born in March or April. On average, there are 2-3 offspring per litter.

Significance: May respond aggressively to threats, causing physical injury. May infrequently prey on domestic fowl. Extensive burrows may destroy property and pose risk of hazardous injury. An important sentinel species in plague surveillance in areas where they live in close association with large ground squirrel populations.

Protected Status: Fur-bearing species.



# FAMILY FELIDAE: CATS, MOUNTAIN LIONS, AND BOBCATS





# Mountain Lion

( *Puma concolor* )

- Description: Mountain lions are yellowish to tawny. The underneath side of the body is white overlaid with buff. The tail is long with a black tip and the same color as the body. Their total length is 59-108 in. The tail is 21-36 in in length. The adult mountain lion weighs from 75-275 lb.
- Distribution/habitat: Mountain lions are found in western North America from British Columbia and southern Alberta south through western Wyoming to California and west Texas. They are also found in southern Texas, southern Louisiana, parts of Tennessee, southern Alabama, and the southern tip of Florida. Mountain lions inhabit mountainous regions, hilly northern forests, semiarid regions, tropical and subtropical forests and swamps.
- Food: They feed primarily on deer, but will also feed on coyotes, porcupines, beaver, marmots, rabbits, raccoons, mice, and insects.
- Reproduction: Litters are produced every 2 years with 1-6 offspring per litter. Offspring are usually born mid-summer.
- Significance: May occasionally prey on domestic pets and livestock. Infrequently reported as a cause of human injury and death. Valuable sentinel species in plague surveillance programs.
- Protected Status: Specially protected species. May not be taken except by the California Department of Fish & Game or their specifically authorized agent. Property owner may take a mountain lion only if it poses an immediate threat of injury or death to livestock or domestic animals. (Fish & Game Code: Section 4800-9) *F. c. browni*, California Species of Special Concern.



# Bobcat

## *(Lynx rufus)*

- Description: Bobcats are tawny with indistinct black spotting. The upper legs have black or dark horizontal bars. The tail is short with a black tip and 2-3 black bars. The total body length is 28-49 in. The tail length is 4-7 in. Bobcats weigh 14-40 lb.
- Distribution/habitat: Bobcats are found from southern Canada into Mexico, though their distribution is spotty. They are absent to scarce in the Midwest. Bobcats are most plentiful in the Far West. Bobcats inhabit scrubby country, broken forests, swamps, farmlands, and rocky or brushy arid lands.
- Food: Bobcats eat rodents, young deer, birds, reptiles, amphibians, and invertebrates. They will also eat fruits and vegetation.
- Reproduction: Bobcats have one litter per year with 2-3 offspring per litter. Young are born in April to early May.
- Significance: Valuable sentinel species in plague surveillance. May occasionally prey on domestic pets, small livestock, and poultry.
- Protected Status: Non-game species



# Feral Domestic Cat

## *(Felis silvestris)*



- Description: Feral cats are domestic cats that have been abandoned and adapted to the wild. Physically, they share the variety of colors and coat lengths present in their domestic kin. Due to their feral existence, most are slightly thinner than domestic cats, averaging 3-8 lb.
- Distribution: May be found in any urban or suburban area where domestic cats are abandoned. They prefer vacant or infrequently used buildings or other structures for shelter.
- Food: Opportunistic feeders that will prey on any small animal, especially rodents and birds. They will also consume garbage and uneaten pet food.
- Reproduction: Feral cats can be quite fertile, capable of 3-4 litters a year of 3-6 off-spring each. However, due to harsh environmental pressures, only a small percentage of offspring likely survive to sexual maturity.
- Significance: Source of injury and infectious disease to humans and domestic cats. Depredation on native bird species may be significant if large, unregulated colonies are present.
- Protected Status: Domestic cats are personal property of their legal owner. If ownership cannot be established, they are the property of the landowner on whose property they reside. Local ordinances vary in their legal consideration of feral domestic cats.



# Public Health Significance

- Bites & physical trauma

- All carnivores will attack if cornered or threatened in an attempt to defend themselves. In many cases these attacks result in bites and trauma.

- Disease

- Any mammal can pose a theoretical risk of rabies transmission. However, because of their well-developed dentition and efficient anatomy designed for hunting, carnivores are of particular concern as carriers of rabies. Also, because of their relatively large size, carnivores are more likely to survive an encounter with a rabies-infected animal and thus more likely to develop disease and shed virus weeks to months later. The primary reservoirs for rabies in California are skunks and various species of bats.
- In California, carnivores are an important component of surveillance programs for plague in enzootic areas. Most large carnivores do not develop illness when exposed to the plague organism. However, they usually develop antibodies to the plague bacillus which can be detected on blood test.
- Raccoons are probably the most notorious of the carnivores for being a pest and a health threat to humans and domestic animals. Besides killing domestic live-stock and destroying crops, they carry rabies, tularemia, leptospirosis, Chagas' disease, trichinosis, and canine distemper. Raccoons commonly are infected with intestinal roundworms (*Baylisascaris procyonis*) the larvae of which can be spread to humans through ingesting or inhaling roundworm eggs from the feces of infected raccoons. While rare, the disease caused by these migrating larvae can be devastating, leading to brain or vision disorders, coma, and death.



# Management & Control

- The control and relocation of carnivores should be left to professionals. Harassment, injury, or removal of many of these animals is restricted by federal and state legislation. Failure to abide by these restrictions can result in fines and imprisonment. All wildlife in California are classified as game (e.g., bear), non-game (e.g., skunk), fur-bearing (e.g., raccoon), or specially protected (e.g., mountain lion) (California Fish and Wildlife Code, Sections 2000-2085, 3950-4190).
- It is critical before implementing any carnivore control program that one consult the CDFG, local animal control agencies, the County Agriculture Commissioner, law enforcement authorities, U.S. Fish and Wildlife, the United States Department of Agriculture Wildlife Services, or State/National Park Service personnel to ensure that the proposed program complies with all current laws and regulations.



- **Badgers**

- Professional control is recommended. Mesh fencing buried to a depth of 30-46 cm (12-18 in) can be an effective exclusion technique. Eliminating the badger's principal prey (gophers, squirrels) can reduce problems associated with badger diggings. Bright lights can frighten badgers from certain areas.

- **Bears**

- Installation of electrified fencing is an effective means of excluding bears from sensitive areas, but is expensive and requires constant maintenance. Deployment of bright lights and placement of human effigies can be used to frighten bears away from areas of human activity. However, these scare methods may lose their effectiveness over time as bears become accustomed to them. It is important to vary the type, location, duration and hour of deployment of scare methods to prolong their effectiveness.
- Sources of food that can attract bears should be eliminated or placed in containers that reduce attractive odors and prevent access. Garbage should be buried or regularly removed. Capsaicin repellent and use of strong fences and bear-proof buildings and garbage containers can reduce food odors and further dissuade bear activity around human dwellings.
- Removal of problem bears should only be attempted by professionals.



# Felids



- Bobcats.

- Fencing at least 2 m tall around sensitive areas (e.g., poultry coops) can dissuade bobcats from preying on domestic animals. Bobcats shy from open areas that lack cover; keeping trees and shrubs cleared for several meters around homes and building can reduce the attractiveness of these areas to bobcats. Loud noises and bright, flashing lights can temporarily frighten bobcats.

- Mountain lions.

- Because mountain lions are a protected species in California, any and all management and control programs must be conducted by, or in full collaboration with, California Department of Fish and Wildlife officials. Exclusion and frightening techniques as described above for bobcats may be effective for mountain lions as well.



- Feral domestic cats

- Feral cats must be differentiated from stray cats. Feral cats should be maintained in well managed colonies by an informed and responsible caretaker. Colonies should be restricted to a defined geographic area that minimizes risk to human health and sensitive wildlife species. Individual colony members should be identifiable by tag or subcutaneous micro-chips.
- Caretakers should adhere to a written protocol describing how the colony is to be fed, watered, and provided health care. The contribution and cooperation of local veterinarians toward the monitoring the health of the colony should be documented. Health care programs should include routine examinations, vaccinations, deworming, serologic screening for infectious diseases, sterilization surgery, and euthanasia of cats for which ill health or other factors prevent their reintroduction to the colony.
- Abandoned and stray cats that are not part of a managed colony should be removed from the environment and dealt with in accordance with local animal control regulations.



# Canids



- Coyotes and Foxes



- Prevention of damage and predation by coyotes relies on appropriate exclusion and avoidance methods; efforts to remove all coyotes is neither practical nor effective.
- Solid fencing can often reduce, though usually not permanently eliminate, predation of livestock by coyotes. Fencing should rise 2 m above the ground and extend 0.8 m below the ground. Installation of electrically charged wire, particularly at the top of the fence, can provide additional deterrence. Steady, intermittent, or strobe lights which automatically turn on at dusk may be placed around livestock enclosures or other sensitive areas. Lights should be relocated at irregular intervals to minimize accustomation by coyotes. Auditory, olfactory, and gustatory repellants have been less successful in frightening coyotes.



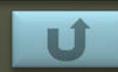
- Feral domestic dogs. Control methods are similar to those used for wild canids. Abandoned and stray dogs should be dealt with in accordance with local animal control regulations.
- Successful long-term management and elimination of feral dogs is dependent upon responsible ownership of domestic dogs, including confinement, health care, sterilization, and appropriate disposition of unwanted dogs.





- **Raccoons**

- Exclusion is the most effective means of counteracting raccoon damage. Doors, windows, and other potential entry points to buildings should be tightly closed. Fences should be placed around sensitive areas and an electrically charged "hot wire" positioned at the top of the fence.
- Raccoons can be deterred from activity in and around areas of human habitation by removing attractive sources of food. Garbage cans and grain storage bins should be securely sealed. Unconsumed pet food should be regularly removed from around human residences.





- **Skunks**

- Skunks can be excluded from sensitive areas through installation of fencing that is buried 40-60 cm (1.5-2 ft) below the surface. Garbage containers should be securely sealed and garbage regularly disposed of to remove the attraction of food for skunks. Wood and debris piles provide shelter for skunks and should be removed from around human residences.





# Rodents

(Class Mammalia, Order Rodentia)



Chapter 6





Rodents are the most common group of mammals in the world. It is estimated that over 40% of all mammals living today are rodents, with over 2000 species and 28 families.

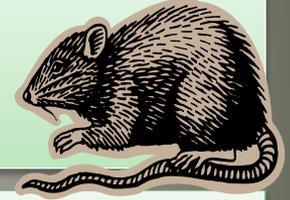
Among the vertebrates, they represent one of the most successfully adapted groups, but also one of the most notorious. The history of western civilization, if not mankind itself, is inextricably linked with that of the rodent. Arguably the most important public health event of the last millennium was the Black Death of the 14<sup>th</sup> century which reduced the world's human population by a third. And yet, this pandemic of plague, fomented by the rat and its baggage the fleas, set the stage for the social transformation that followed, including the end of feudalism, the Renaissance, and the Reformation.

Today, rodents continue to be both boon and bane to human health and economy. Fur bearing rodents like the beaver and chinchilla provide a natural source of income for some societies. On the other hand, rodents wreak billions of dollars of damage to agriculture every year. Pet hamsters, gerbils, and other small rodents provide companionship to many households, while their brethren simultaneously cause considerable consternation as intrusive pests.

Finally, rodents are useful models and subjects in scientific research which advances the quality of human life, but are also reservoirs and vectors for numerous infectious disease agents. In the animal kingdom, only insects surpass the importance of rodents to contemporary human civilization.



# General Characteristics



Rodents are a diverse group, ranging from miniscule mice of just a few inches, to the South American capybara which can get up to 4 feet in length and weigh 120 lbs.

- Feet, legs, and other body parts can also be highly specialized for digging, climbing, swimming, or even gliding. As a group, rodents are readily distinguished from other mammals by their large incisor teeth two upper and two lower. The incisors have a hard enamel on the front surface with a softer dentine in the back. The incisors grow continually making it necessary for the rodents to constantly gnaw to keep their teeth sharp and a manageable length.
- California rodents may be classified into two groups which are distinct in their phylogeny, behavior, and habitat. The commensal, or domestic, rodents are Old World rodents which were imported to North America. The native, or wild, rodents include various species of squirrels, chipmunks, field mice, meadow mice, and woodrats. Because the ecology, behavior, and public health significance of these rodent groups are distinct, each group will be discussed separately.



# Taxonomy

- Class Mammalia
- Order Rodentia, Family Muridae
- Subfamily Murinae (Old World rats and mice)
- Subfamily Sigmodontinae (wild mice, wood rats, and others)
- Family Sciuridae, (ground squirrels, tree squirrels, and marmots)



# COMMENSAL (DOMESTIC) RODENTS (FAMILY MURIDAE, SUBFAMILY MURINAE)

- The three species of domestic rodents are also correctly referred to as commensal rodents because they live in close association with humans. These commensal rodents are not indigenous to North America, but accompanied humans as stowaways on their ships of emigration and trade.
- The roof rat, *Rattus rattus*, originated from the southeast Asian mainland, spread along the ancient caravan routes from India across the Middle East, to East Africa and the eastern Mediterranean. By the Middle Ages, this species was distributed throughout most of Europe. Roof rats were probably introduced to the New World during the 15th or 16th Century, first reaching South America in the mid 1500s. The first record of roof rats in the United States was in the early 1600s.
- The Norway rat, *Rattus norvegicus*, was introduced later, migrating westward from Central Asia, first appearing in the beginning of the 18th Century. The first record of its introduction into the United States (possibly from Europe) was in the late 1700s.
- The house mouse, *Mus musculus*, also spread westward from central Asia, through the Middle East, to the Mediterranean shores and Europe. These mice were probably introduced into Latin America aboard ships from Spain and Portugal and subsequently spread into the southern United States and California.



# General Characteristics

## Sensory abilities

Vision. Commensal rodents are nocturnal (active at night). Though their eyes are specialized for vision in low light, acuity is generally poor. Most rodents are color blind, perceiving light in shades of gray.

Taste. The sense of taste is well developed in commensal rodents. They prefer fresh food to old or spoiled food. Some species seem especially sensitive to extremely minute quantities of bitter or other unpleasant substances included in toxic baits. Hence, repeated sub-lethal applications can lead to bait-refusal or bait-shyness among survivors.

Smell Commensal rodents have an acute sense of smell. They leave odor trails as they move about. These odors aid them in recognition of kin and in locating sexually active mates. Commensal rodents are accustomed to human activity and thus lingering human odors do not usually dissuade them from traps and baits.

Touch. The vibrissae ("whiskers") and the long guard hairs on their bodies are extremely sensitive to tactile stimuli. The vibrissae and guard hairs serve as guides ("thigmotaxis") along vertical walls and nearby objects, providing compensation for rodents' poor vision.

Hearing. Commensal rodents have a keen sense of hearing and can detect vibrations in the ultrasonic range. They are extremely sensitive to sudden or loud noise.



# Physical capabilities

- Gnawing

- The incisors of rodents grow throughout their lifetime requiring constant gnawing to keep the length down. Rodents can gnaw through any material that is softer than their enamel, including wood, aluminum, sheetrock, poor quality concrete, asphalt, hard rubber hoses, electrical wiring, and plastic tubing. Since they cannot gnaw through galvanized sheet metal and galvanized hardware cloth, these materials can be used as rodent exclusion materials in structures.

- Climbing

- Rats and mice have prominent footpads and well developed claws. They have four toes on their front feet and five on their hind feet. They use their tails, which are usually scaly and lacking of hair to balance their bodies while climbing. Commensal rodents are excellent climbers and have little or no difficulty climbing rough surfaces of vertical wooden beams or walls, and can traverse utility and telephone wires with relative ease. Norway rats can ascend vertical pipes up to 7cm in diameter.





- Jumping.

Rats are known to jump vertically over 75 cm (2 ft). Adult house mice can jump vertically up to 35 cm (1 ft).

- Swimming.

All three species of commensal rodents are good swimmers. Rats can swim continuously from one to almost three days if necessary, and can remain submerged for almost 30 seconds. Rats have been known to enter homes by swimming through the water seal in toilets

- Burrowing.

Norway rat nests are located up to about 50 cm (18 in) underground. They may dig much deeper in loose soil. Their burrows consist of several connecting tunnels and have more than one exit. They may burrow into poultry and other animal manure or into the ground when infestations are encountered on ranches and in animal quarters. When living outdoors, house mice will construct shallow burrows in the open or cultivated fields, or live under piles of rubbish.





# Behavior/ Reproduction

## Periods of activity / Home ranges

- Commensal rodents are primarily nocturnal and usually have two peaks of night-time feeding activity. Weaker and less-dominant individuals may be forced to be active during daytime. Significant daytime activity observed among primarily nocturnal species may indicate increased population density.
- Home ranges may overlap with individuals of one or more other rodent species, depending on the type and carrying capacity of the environment. Commensal rodents are relatively tolerant of changes to the environment given their association with human habitation. House mice are by nature curious and less neophobic than rats, tending to investigate objects that are recently introduced in their environment.

## Seasonal movements/migration

- Weather can significantly affect rodent movement. In cooler weather, during late fall or early winter, commensal rodents tend to move indoors to warmer areas. In late spring or early summer they return to the outdoors, or might remain indoors if food and suitable harborage are available.

## Reproduction.

- Rodents are, in general, prolific breeders. Most species reach sexual maturity in 3-5 months. Gestation is generally no more than 3-4 weeks, so sexually active females can have several litters during a single breeding season. Number of young per litter ranges from one to a dozen or more. Rodents in the wild rarely live more than a single year; however, in captivity some species may live up to 3-4 years.



# California Commensal Rodents of Public Health Importance





# Roof Rat

( black rat, fruit rat, ship rat)

*(Rattus rattus)*

- Description

The roof rat is a moderate-sized rodent, slightly smaller than the Norway rat. The body is slender, adults averaging 8-10 oz. The total length (tip of nose to tail-end) is approximately 14-18 in. Tail is longer than the head and body, measuring 7-10 in, sparsely haired, and uniformly colored. The body is covered with softer fur and long, prominent guard hair. Roof rats in California vary in color from black with a gray belly to brownish- black with a whitish belly.

- Food

While omnivorous, they prefer vegetables, fruit, nuts, and cereal grains.

- Reproduction

Sexual maturity in 3-5 months. Gestation period averages 22 days. 6-8 young per litter with 2-6 litters per year.

- Habitat

Roof rats are semi-arboreal species, preferring to live in fruit and nut orchards, in the crowns of palm trees, in shrubs and vines, and dense growths of Algerian ivy. They prefer to nest above ground, often in attics, within walls, and in enclosed spaces of cabinets and shelving. Older residential neighborhoods with overgrown vegetation and newer residential suburban developments amidst former orchards are likely habitats.

- Significance

Roof rats can cause considerable damage to building and vegetation. They are associated with infectious diseases including *Salmonella*, *Streptobacillus*, and *Leptospira*, and are natural hosts for *Ornithonyssus bacoti*.



# Norway Rat

( brown rat, sewer rat, wharf rat, house rat, barn rat)

## *(Rattus norvegicus)*



- Description

The Norway rat is the largest of the commensal rodents. The body is heavy and stocky, averaging 7-20 oz in adults. The total length is approximately 13-18 ½ in. The tail is bicolored (dark above and lighter below), 6-8 ½ in in length, and sparsely covered with stiff hairs.

- Food

Norway rats are omnivorous, but prefer meat, poultry, fish and other sea food, garbage, and cereal grains.

- Reproduction

Sexual maturity in 3-5 months. Gestation period averages 22 days. 8-12 young per litter. 2-7 litters per year. Life expectancy of 9-12 months.

- Habitat

Norway rats are primarily a burrowing species. They burrow in the ground, under foundations of buildings, in soil banks, rock piles, along the banks of ditches, streams, rivers, and marshes. They also occupy poorly managed rubbish and garbage dumps. They can also be encountered in sewers, in wharf areas, and in the riprap of shores. In older urban communities they frequent cellars, stores, warehouses, slaughterhouses, and rendering plants.

- Significance

The Norway rat is the natural host of the oriental rat flea, *Xenopsylla cheopis*, the classic vector of plague. Plague-positive Norway rats were found in four San Francisco Bay area counties and two southern California counties between the early 1900s and the 1940s.



# House Mouse

## ( *Mus musculus* )



- **Description**

The house mouse is small and resembles a young roof rat. The body of the house mouse is slender, averaging 0.5-0.75 oz. The total body length is 5½ -7½ in. The tail is uniformly gray in color and equal to, or slightly longer than the head and body, measuring 3-4 in. Fur is gray to brown with the underside slightly lighter, varying from white to gray.

- **Food**

They prefer cereal grains, but feed on many edible materials.

- **Reproduction**

Sexual maturity in 1 ½ -2 months. Gestation is about 19 days, with 5-6 young per litter and as many as 8 litters per year.

- **Habitat**

House mice will occupy any convenient space between walls, inside cabinets, in or under furniture, warehouses, and storage areas. Their home range is very limited usually 10-30 ft. as they like to have nesting sites close to food sources.

- **Significance**

Cause damage through consumption and contamination of food stores. Damage walls, cup- boards, electrical boxes which they use for nest sites. Principal reservoir for lymphocytic choriomeningitis virus. They are also often infected with *Salmonella* and carry mites capable of transmitting rickettsial pox.



# Public Health Significance

- Because of their close association with human habitat, commensal rodents pose a substantial risk for transmission of infectious disease agents. In addition to fecal contamination of foodstuffs, commensal rodents serve as a reservoir or vector for numerous microbiologic pathogens that are potentially infectious to humans.
- Rodent-borne diseases are transmitted directly by contamination of human food with their feces or urine, contact with infected body fluids and/or rodent blood, or indirectly by way of rodent ectoparasites such as fleas or mites.
- Rats are also a potential source of traumatic injury through bites defensive bites.



# Management and Control

## Recognizing evidence of infestation

Commensal rodents are habitually nocturnal and usually secretive. They are rarely seen during daytime unless their populations are large. Usually it is the evidence from their activity is what sheds light on their presence. Looking at the evidence of infestation will tell you what type of rodent is present, the population density and whether the infestation is old or new.



# Evidence of Rodent Activity

Fresh droppings are usually shiny, soft, and moist. Color of droppings may vary with the food eaten. Older droppings are usually dull, grayish, hard, dry, and will crumble easily.

Rodents will generally use the same, familiar pathways from their harborage to obtain food and water, navigating by continual body contact with a vertical wall, fence, or other surface.

Norway rat rub marks are usually near ground or floor level, rub marks caused by roof rats are more common overhead among beams in attics. "Swing marks" can be seen at the juncture point of cross beams as the roof rats travel along rafters, or where the rafters connect to the walls

Sounds of running, gnawing, and scratching between walls and floors, and in attics and crawlspaces, may provide evidence of rodents, especially roof rats.

Because they are nocturnal and secretive, live rodents are rarely observed. However, when infestations are heavy, rodents may be seen during daytime. Carcasses may indicate either a current or past infestation.

Depending upon the species encountered, burrows may or may not be seen. Burrow systems are usually located near a source of food and water. The presence of fresh food fragments and freshly dug earth will indicate current activity.

Rodents gnaw to gain entrance, to obtain food, and to keep constantly growing incisors in check. The gnaw marks made by these incisors are very characteristic of rodents. Freshly gnawed marks will show distinct tooth marks, but as they get older, the gnawed areas become darker with grease and smoother with repeated body contact.

Laying smooth tracking patches of flour or talc along runways may bring to light rodent activity. The five-toed hind feet may leave more distinct tracks than the four-toed front feet.

Urine stains may or may not be readily observed in normal light. A portable ultraviolet light usually helps fluoresce suspected urine stains. Rats and mice shed great amounts of hair. These may be found lodged around entry points, in their feces, and contaminated food products. Characteristic musty odors may be present when heavy infestations occur, especially in damp, poorly ventilated areas.



# Planning an Integrated Rodent Control Program

- Identify the rodent species and estimate the size and extent of infestation.
- Document extent of damage to property, contamination of food.
- Identify sources of food, water, harborage, and entry (reinfestation) points.
- Assess the motivation, knowledge, attitude, and acceptance of affected persons towards the control program.
- Cooperate with local and regional governmental agencies and community organizations.
- Consult with building code enforcement agencies.
- Consider potential legal implications.
- Estimate costs and relative benefits of control program.
- Implement rodent suppression measures (e.g., trapping).
- Evaluate the need for related ectoparasite control.
- Conduct environmental sanitation/modification, structural modification (exclusion), and preventive maintenance.
- Educate the public and encourage active participation by the community.
- Evaluate program efficacy.
- Establish ongoing monitoring and surveillance.



# Integrated rodent control

- **Trapping**
  - Trapping is often the preferred initial step for controlling small numbers of rodents within homes, schools, food processing/handling plants, hospitals and other environments in which sanitation and limited exposure to toxic agents is desired.
- **Glue boards**
  - Glue boards are commercially available, but they are not recommended because the user may be exposed to diseases such as hantavirus pulmonary syndrome.
- **Tracking powders**
  - Tracking powders containing toxic chemicals (e.g., diphacinone, chlorophacinone, zinc phosphide) are not consumed like bait, but collected on the fur of the animal and then it is ingested during grooming.
- **Anticoagulants**
  - These are used for commensal rodent control throughout the world. Anticoagulants are toxicants that disrupt the blood-clotting mechanism causing fatal internal hemorrhages.
- **Rodenticides**
  - Acute rodenticides are classified as extremely, moderately, or minimally hazardous; their use should explicitly follow label directions.
- **Ectoparasites control**
  - Ectoparasites of rodents, including fleas and mites, can be a health concern to humans. Deprived of their natural rodent hosts following a successful population control program, these ectoparasites will seek out a new host upon to feed on including humans. An insecticide needs to be used either before or during the rodent removal program.



# Environmental Modification

Environmental sanitation: The abundance of food, water, and harborage in a given environment determines the population size each environmental niche can support ("carrying capacity"). If the capacity of the environment is changed, a corresponding change in the rodent population may follow.

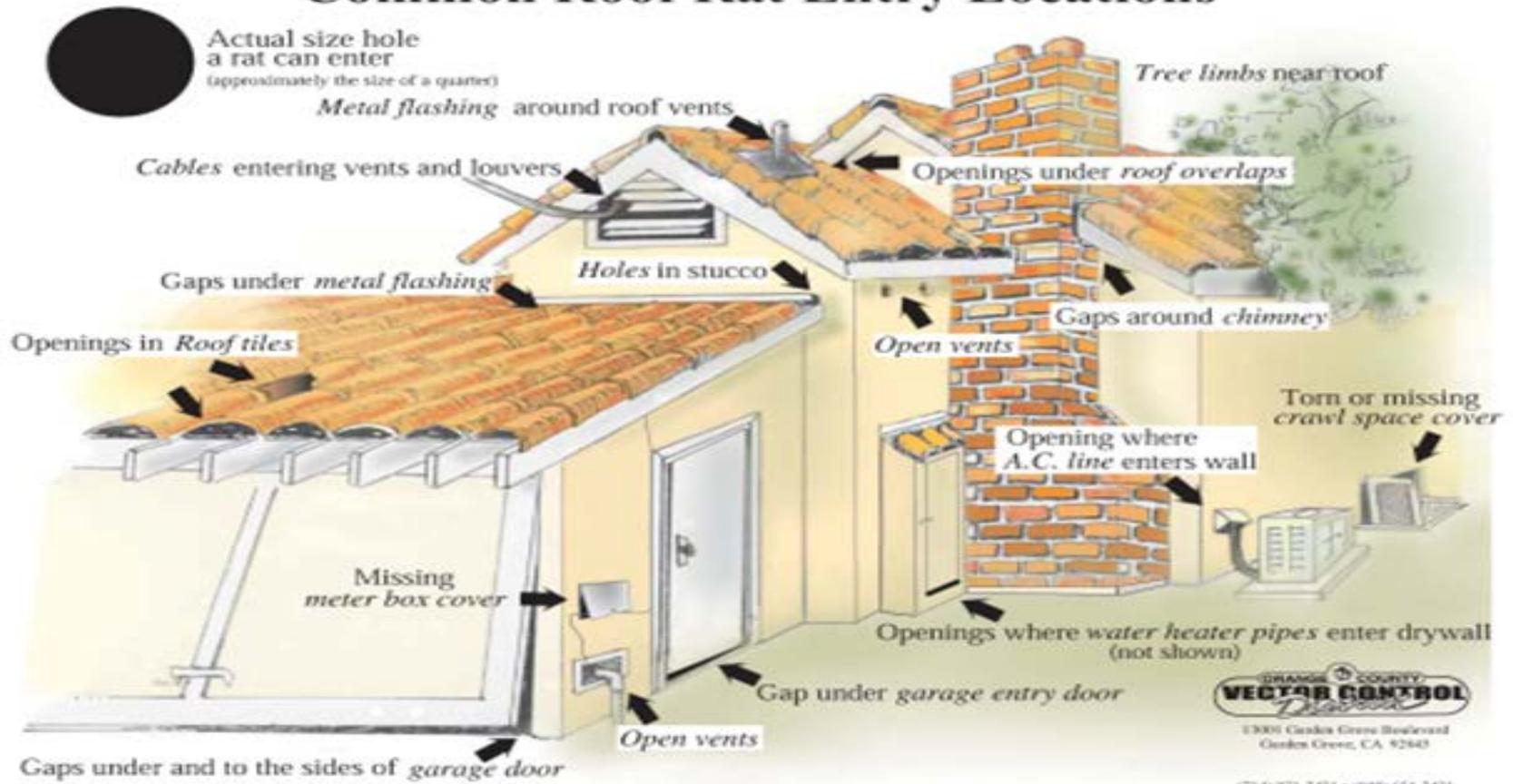
Environmental modification: The physical alteration of the environment to deny rodents a favorable habitat. Since suppressive measures such as poisoning or trapping provide only short-term solutions, integrated management concepts should incorporate good sanitation practices, environmental modification, and rodent exclusion measures to achieve long-term control.

Exclusion: Rodents, such as mice, can enter openings as narrow as 2 cm (0.75 inch) in diameter; therefore effective exclusion requires that all such potential points of entry, above ground and at ground level, be identified and corrective measures be implemented.



# Places to Keep in Mind Where Rodents May Enter a Location

## Common Roof Rat Entry Locations



ORANGE COUNTY  
**VECTOR CONTROL**  
*Division*

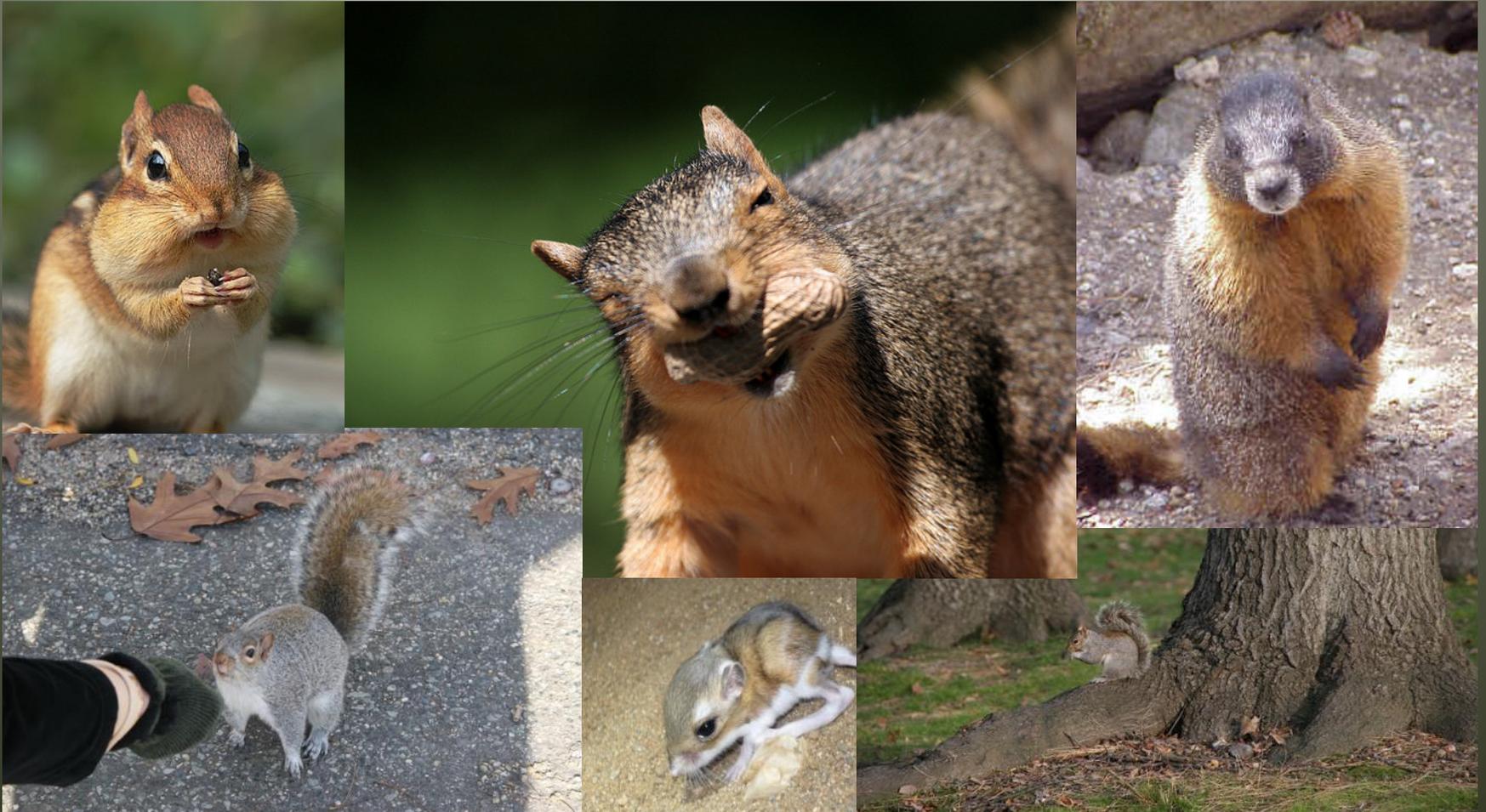
13001 Garden Grove Boulevard  
Garden Grove, CA 92643

(714) 971-2421 • (949) 454-2421  
Please Visit Our Web Site:  
[www.ocvc.org](http://www.ocvc.org)

2006.06

# WILD RODENTS

(FAMILIES SCIURIDAE, HETEROMYIDAE, AND MURIDAE [SUBFAMILIES SIGMODONTINAE AND ARCVOLINAE])



# California Wild Rodents of Public Health Importance

California has an abundance of wild native rodent species: 28 species in the family Sciuridae and 27 species in the subfamily Sigmodontinae. Several wild rodent species are important to public health as they are involved in maintenance or transmission of some serious and occasionally fatal infectious diseases to humans. Wild rodents of California that have public health or economic significance will be discussed.



# California Ground Squirrel (*Otospermophilus beecheyi*)

Description: California ground squirrels are large rodents with generally gray-brown fur, often with lighter-colored flecks. Total adult length is 15-20 in, weight is 11-22 oz.

Reproduction: The breeding season varies throughout California. Mating may occur as early as January and extend into June or July. Females produce one litter a year, with an average of 6-8 young per litter. Gestation period is 25-30 days. Young are weaned in 6 weeks and scatter to new territories in April or June. They are full-grown in 7-8 months and live five years or more in the wild.

Distribution: The squirrels are found throughout California with the exception of the Mojave and Colorado desert regions. The California ground squirrel is diurnal.



Food: Feed upon seeds, nuts, fruits, green herbage, insects, bird eggs, and carrion.

Habitat: They make elaborate burrow system with many entrances. Rocky areas, bases of trees, tree stumps, fallen logs and other ground cover are preferred sites for burrows. They prefer open areas, natural range- lands, meadows, pastures, grain fields, rocky ridges, embankments along roadsides, and terraced hillsides and other disturbed areas of newer housing developments. They avoid thick chaparral. Home range is usually limited to a 140 m (450 ft) radius. Population density averages 2-4 squirrels per acre.

Significance: In large numbers can become a nuisance, especially in parks and campgrounds. Can cause considerable loss of agricultural crops. The California ground squirrel is the most important wild rodent involved in plague epizootics in California. Sudden decreases in squirrel populations can indicate a plague epizootic and the need to implement control measures to reduce risk of disease transmission.





# Belding's ground squirrel (*Urocitellus beldingi*)

Description: Belding's ground squirrels are stout with gray brown fur, darker on the dorsum. Legs and underside are often pinkish. The tail is very short, reddish, and scantily furred. Total length is 26-30 in and weight is 5-10 oz.

Reproduction: Mating occurs soon after emergence from hibernation. Following a gestation period of about 28 days, the young are born in May to July.

Distribution: The Belding's ground squirrel ranges from Fresno, Tulare, and Inyo Counties along the high Sierra Nevada to the Oregon border. They are also prevalent north of the Sierra Nevada in the Cascade and Warner Mountains and the inter-mountain valleys of northeastern California.

Food: They feed on a variety of grasses, leaves, stems, bulbs, fruits, and seeds, and also insects and carrion.

Habitat: Prefer meadows, perennial grassy areas, alpine dwarf-shrub, bitterbrush, sagebrush, and chaparral with grassy understories. Their burrows are often found in open areas, commonly near water sources within patches of bunchgrass and shrubs. Belding's ground squirrels tend to occur in large, semi-colonial populations. They are diurnal, emerging from their burrows at sunrise and at dusk to avoid the midday heat. They tend to remain near their burrows.

Significance: Similar to California ground squirrel.



# Golden-mantled ground squirrel

## (*Callospermophilus lateralis*)



- Description: Golden-mantled ground squirrels are medium-sized (total length, 9-12 in) with distinct white stripes, bordered by black stripes, on their sides. They appear superficially like a large chipmunk, but lack stripes on the sides of their face.
- Reproduction: They mate from March-May. The gestation period is about 4 weeks and young are born in May-June. Females produce 1-2 litters per year, with an average of 5 young per litter. They reach sexual maturity in one year.
- Distribution: Golden-mantled ground squirrels are abundant in forested areas of Jeffery, ponderosa, and lodge pole pines. They are abundant in mountain forests and meadow edges of the Klamath, Siskiyou, Cascade, Sierra Nevada, and North Coast ranges, as well as the San Bernardino Mountains. They are found at elevations from 4800-11,000 ft. They will hibernate at the higher elevations from fall through winter, emerging in spring.
- Food: Preferred foods include underground fungi, pine nuts, seeds, bulbs, flowers, insects, bird eggs, and carrion.
- Habitat: They prefer to burrow under rocks, logs, tree stumps and They have a home range of 1-2 acres, with a territory of about 100 ft around the burrow entrance. Like other species of ground squirrels, they are diurnal.
- Significance: Similar to California ground squirrel. They can be significantly involved in plague epizootics in areas where they occur.





# Yellow-bellied Marmot (*Marmota flaviventris*)



- Description: The marmot is a large squirrel: total length is 18-28 in and weight 3-8 lb. Fur is rust-colored with lighter yellowish beneath. Tail is comparatively short.
- Reproduction: They mate in early spring soon after emergence. Young are born in late spring following a gestation period of about four weeks. They have one litter per year with an average of 4-6 young per litter.
- Distribution: Yellow-bellied marmots range from the Sierra Nevada and Cascades in southern Tulare County, north to the Oregon border. They are widespread in or near rocky areas within grasslands, meadows, sub-alpine conifers, alpine dwarf-shrubs and lodgepole pine forests. They are also common in the montane riparian, red fir, eastside pine, Jeffery pine, montane chaparral, sagebrush, bitterbrush and pinon-juniper habitats. At higher elevations, they hibernate from early autumn to spring; populations at lower elevations may aestivate in June and July.
- Food: They forage during mid-morning and again in the late afternoon on grasses, shrubs, seeds, flowers, leaves, and insects.
- Habitat: Their burrow systems are usually under rocks, at the bases of trees. They have a home range from ½-5 acres. Marmots may congregate in colonies or pairs, or be solitary. Yellow-bellied marmots are diurnal.
- Significance: Minimal public health significance





# Tree Squirrels

Western gray squirrel (*Sciurus griseus*)

Eastern gray squirrel (*S. carolinensis*)

Eastern fox squirrel (*S. niger*)

Douglas's squirrel (*Tamiasciurus douglasii*)

Description: Tree squirrels are easily distinguished from the ground squirrels and chipmunks by their long and bushier tails, uniformly grayish to dark grayish in color, and lack of dorsal spots or stripes.

Reproduction: They have 1-2 litters per year, with an average of 1-5 young per litter. Tree squirrels are long-lived and live up to six years in the wild.

Distribution: The Western gray squirrel is common and more widespread in California than the other species of tree squirrels. The Eastern gray squirrel was introduced from the eastern U.S. into Golden Gate Park in San Francisco, and established in niches in Calaveras, San Joaquin, and possibly Sacramento and Stanislaus Counties. The Eastern fox squirrel, also an introduced species, has been reported in many counties throughout California. The Douglas's squirrel is commonly encountered in the conifer-hardwood and riparian habitats of the Sierra Nevada, Cascade, Klamath, North coastal and Warner Ranges, from sea level to 11,000 ft elevation.

Food: Tree squirrels feed on the seeds and nuts of coniferous and deciduous trees. Leaves, buds, and fruits also occasionally comprise their diet.

Habitat: Tree squirrels are diurnal, most active in early morning or late afternoon. They are arboreal and usually nest high above ground in tree holes, enlarged woodpecker holes, and cavities of trees.

Significance: Tree squirrels can damage forest trees by removing bark or consuming cones and green stems. Around residences, they can damage power lines, destroy fruit and nut trees. In urban areas, they can damage buildings and other structures by gnawing into walls. Western gray squirrels frequently show evidence of infection with the Western equine encephalomyelitis virus (WEE) and thus may play a role as reservoir for WEE. They are important reservoirs for the agents of relapsing fever and plague in mountainous areas of northern California



## Chipmunks

Alpine chipmunk (*Tamias alpinus*)

Yellow-pine chipmunk (*T. amoenus*) Merriam's chipmunk (*T. merriami*)

Least chipmunk (*T. minimus*) California chipmunk (*T. obscurus*)

Redwood chipmunk (*T. ochrogenys*) Panamint chipmunk (*T. panamintinus*)

Long-eared chipmunk (*T. quadrimaculatus*) Shadow chipmunk (*T. senex*)

Siskiyou chipmunk (*T. siskiyou*) Sonoma chipmunk (*T. sonomae*)

Lodgepole chipmunk (*T. speciosus*) Uinta chipmunk (*T. umbrinus*)



Description: California chipmunks are smaller than other species of squirrel. Most species are brightly colored with four lightly colored stripes on their backs, separated by darker stripes, and dark stripes on the sides of their face.

Reproduction: Mating occurs from April to June. Females produce 1-2 litters per year, with 2-7 young per litter. Gestation is about 4 weeks and young are born in May-June.

Distribution: Chipmunks are found in most mountain ranges in California.

Food: Chipmunks have the same food preferences as ground squirrels.

Habitat: Like most other ground squirrels, chipmunks are common in campgrounds and outdoor recreational areas

Significance: They are an important indicator species for plague, though susceptibility varies with species. In northern California, *T. senex* and *T. quadrimaculatus* are relatively resistant to infection and may serve as reservoir species. In central and southern California, *T. amoenus* and *T. merriami* may function in a similar capacity.



# FAMILY HETEROMYIDAE

Approximately 10 species of pocket mice and 14 species of kangaroo rats occur in California.

Description: They are small to medium-sized rodents. Most have reduced forelimbs and enlarged hind limbs. Kangaroo rats are aptly named for both their appearance and their means of hopping on their enlarged hind limbs with a long tail. Cheeks have fur-lined pouches.

Reproduction: Breeding is highly dependent on food availability. In years with abundant food, females may have 2-3 litters of 5-7 young each.

Distribution: Typically abundant in sparsely vegetated, seasonally arid or desert areas. All are nocturnal. May hibernate in the winter and aestivate in the hot, dry summer.

Food: Seeds and vegetation comprise their diet. Water is obtained through metabolism of oils in seeds.

Habitat: Occur in sparsely vegetated and loose, sandy soils. Generally reside in underground burrows during the day, often plugging the entrance.

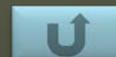


Kangaroo rats  
(*Dipodomys* spp)



Pocket mice  
(*Chaetodipus* spp.,  
*Perognathus* spp.)

Significance: Kangaroo rats can serve as a reservoir for *Borrelia burgdorferi*, the bacterial cause of Lyme disease. Six species and subspecies of kangaroo rat are listed as endangered or threatened by the U.S. Fish and Wildlife Service. Persons conducting rodent surveillance and collection should be skilled in identification of these species and familiar with the regulations regarding their capture and handling.



# Family Muridae, Subfamily Sigmodontinae



White-footed mice  
(*Peromyscus* spp.)

Six species of *Peromyscus* mice occur in California:

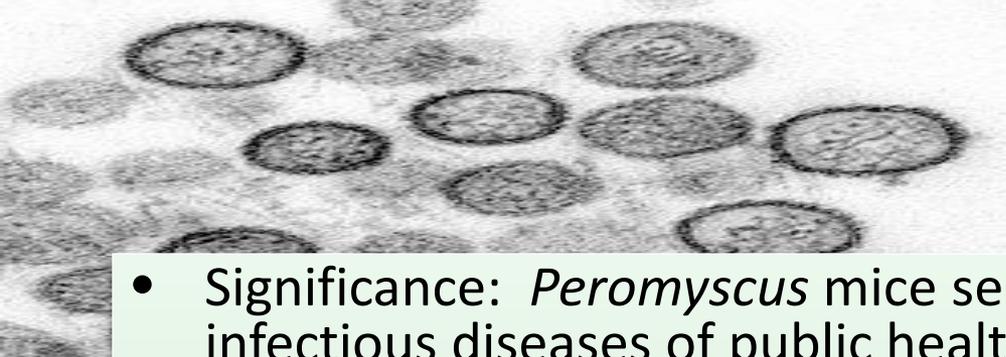
Brush mouse (*Peromyscus boylii*)

California mouse (*P. californicus*) Canyon mouse (*P. crinitus*)

Cactus mouse (*P. eremicus*) Deer mouse (*P. maniculatus*) Pinon mouse (*P. truei*)

- Description: All *Peromyscus* species are small (total length, 6-10 in), mouse-like rodents. Eyes are dark and beady; ears are membranous and often large. Fur is variably brown, rust, or gray on dorsum, white on ventrum and feet. Deer mice are relatively small (15-20 cm) with a bicolored tail that is <50% of body length. The pinon mouse is moderately large (18-20 cm) with very large ears. The California mouse is the largest of the *Peromyscus* spp. at 22-25 cm.
- Reproduction: They have an incredible reproductive ability, breeding year-round. Having 1-4 litters a year with 1-8 young per litter, and a gestation period of 22-25 days.
- Distribution: The deer mouse is the most abundant *Peromyscus* species and is found throughout California and most of North America, except the southeastern states. The California mouse is found along the coast from the San Francisco Bay to the Mexican border.
- Food: *Peromyscus* spp. are omnivorous, feeding on a wide variety of items including seeds, nuts, acorns, fruits, leaves, fungi, and insects.
- Habitat: *Peromyscus* can be found in a variety of habitats, especially woodlands, grasslands, brush, and chaparral.





- Significance: *Peromyscus* mice serve as reservoirs for several infectious diseases of public health importance. Deer mice are the principal reservoir for Sin Nombre virus, the cause of hantavirus pulmonary syndrome in the western United States, which they shed in urine and feces. Other *Peromyscus* mice may also become infected with Sin Nombre virus, but their capacity to maintain infection and shed virus in urine and feces is unknown.

*Peromyscus* mice are also a reservoir for the bacteria that cause plague and can serve as a source of infection for epizootics among susceptible rodents (e.g., chipmunks). *Peromyscus* mice are involved in the enzootic maintenance cycle of *Borrelia burgdorferi*, the Lyme disease spirochete, in California, though probably to a lesser extent than woodrats. *Peromyscus* mice may also be involved in the maintenance of agents of other tick-transmitted diseases, such as *Anaplasma*, in California



# Woodrats

(*Neotoma spp.*)



Four species of woodrats occur in California: Dusky-footed woodrat (*Neotoma fuscipes*), Desert woodrat (*N. lepida*), Bushy-tailed woodrat (*N. cinerea*), and Big-eared woodrat (*N. macrotis*).

Description: Woodrats resemble a large (total length 10-17 in) deer mouse with prominent eyes and ears. Fur is gray to grayish-brown on dorsum and pale or white beneath. The tail is faintly bicolored and sparsely haired in *N. fuscipes*, distinctly bicolored in *N. lepida*, and bushy in *N. cinerea*.

Reproduction: Breeding season is usually from mid- spring to early autumn. Usually one litter per year, though *N. fuscipes* may have up to five if conditions permit. Average of 3-4 young per litter.

Distribution: The dusky-footed woodrat is a common inhabitant of the coastal range of California, from the Oregon border to the Mexican border, the northern interior, and the entire western slope of the Sierra Nevada. They are absent from agricultural and open grass-lands of the Central Valley.

Food: They forage on the ground as well as on bushes and trees, feeding on a wide variety of vegetation.



- Habitat: *N. fuscipes* prefer the moderate canopies of forest and chaparral; in the north, they are prevalent in juniper woodlands and oak chaparral. *N. lepida* prefer desert habitats, including Joshua tree, pinon-juniper, chaparral, and sagebrush. *N. cinerea* are found in rocky outcrops, rimrock and rockslide areas of high mountains, riparian, hardwood, conifer, and other montane habitats. *N. cinerea* are also common in lava rim and lava cave habitat in northern California. *N. macrotis* are found from central and eastern California (United States) south into northwestern Baja California.
- Woodrats build elaborate conical-shaped huts consisting of sticks and leaves, located at the base of trees or shrubs for *N. fuscipes*, cactus or creosote bushes for *N. lepida*, and at the entrance to rocky crevices for *N. cinerea*. Some woodrat huts reach a height of 2.5 m (8 ft). Woodrats are active year-round, mostly nocturnal, but may be active during the day.
- Significance: Principal California reservoir for *Borrelia burgdorferi*, the agent of Lyme disease. May also serve as reservoir for *Ehrlichia* spp and the arenavirus Whitewater Arroyo. Dusky-footed woodrats are an important host for the kissing bug, *Triatoma* spp., the bite of which can cause a severe allergic reaction or possibly transmit the agent of Chagas' disease. Woodrats are in general susceptible to plague and may serve as an early warning indicator for epizootics. Bushy-tailed woodrats are involved in plague epizootics in the lava rim habitat of northern California.



# Western Harvest Mouse

( *Reithrodontomys megalotis* )



- Description: Buff or brown on top; white underneath with occasionally a buff spot on chest. Tail is bicolored, with large ears and a length of 4.5-6in.
- Reproduction: Breeds in spring and maybe in autumn with a litter of 3-5.
- Distribution: Throughout California.
- Food: Grasses and seeds.
- Habitat: Grasslands and other uncultivated areas where grasses and weeds are present.
- Significance: Reservoir of El Moro Canyon virus, a hantavirus not yet associated with human disease.



# California Vole

( *Microtus californicus* )

Family Muridae, Subfamily Arvicolinae



- Description: Small (total length, 6-8 in), darkly colored rodent with small eyes and partially furred ears. Tail less than one-third of body length.
- Reproduction: May breed throughout the year. Gestation period is 20 days, 2-5 litters per year, with an average of 4 young per litter. Females reach sexual maturity in 1 month.
- Distribution: Common from Shasta County to San Diego County, from the Sierra Nevada and the Cascades west to the Pacific coast. They are active year-round.
- Food: Herbivorous, preferring leaves, grasses, and fresh seeds. They are capable of causing considerable damage to field crops and orchards.
- Habitat: Preferred habitats are wet meadows, montane riparian, and dense annual grasslands. They seek cover in the dense grass, brush piles and logs. Burrows are shallow and generally built in soft soil with obvious pathways.
- Significance: Reservoir of Isla Vista virus, a hantavirus not yet associated with any human disease. Also a reservoir species for plague and tularemia in some regions of California.



# Protected status

- A collecting permit must be obtained from California Department of Fish and Wildlife before surveillance or control actions are initiated for any rodent species, though certain disease surveillance activities may be exempted from such requirements. Most of the ground squirrels, chipmunks, *Peromyscus* mice, voles, and woodrats are classified as non-game mammals by the California Fish and Wildlife Code. Because they are considered economic and public health pests, they may be taken at any time or in any manner by the owner or tenant of the premises. They may also be taken by officers or employees of the California Department of Food and Agriculture or by federal, state, or county officials or employees when acting in their official capacities pursuant to the provisions of the Food and Agriculture Code pertaining to pests.
- Many species of kangaroo rat are listed as state or federal Endangered Species and are thus restricted in their collection or harassment. Some subspecies of pocket mouse, woodrat, and vole are considered California State Species of Special Concern. Although there are currently no restrictions on their collection, protection designations change frequently and one should discuss the status of particular species with California Fish and Wildlife officials when obtaining the collection permit and before initiating any rodent collection or control.



# Public Health Significance

- Plague: Wild rodents are the primary reservoir for *Yersinia pestis*, the plague bacillus, in California. Numerous rodent species have been associated with plague in California, including chipmunks, ground squirrels, woodrats, *Peromyscus* spp., voles, and, formerly, *Rattus* spp. In general, the California ground squirrels are an amplifying host for the plague bacillus (mortality usually occurs when they are infected), but in a few selected areas of California they may serve as a reservoir.
- Tick-transmitted disease: Wild rodents are the known or suspected maintenance host for several pathogens that are transmitted to humans by tick bites. The dusky footed woodrat is the principal reservoir for *Borrelia burgdorferi*, the spirochete that causes Lyme disease in humans. Woodrats may also serve as a reservoir for the rickettsiae (*Anaplasma* spp.) that cause anaplasmosis in humans. Chipmunks which enter and build nests in mountain cabins are a common source of soft ticks that transmit relapsing fever spirochetes to humans who later occupy the infested building after the rodents have abandoned it. Small rodents (e.g., *Peromyscus* spp.) are a common feeding host for larval and nymphal ticks and thus areas where these rodents are abundant may support a larger population of ticks.
- Hantaviruses: The deer mouse is the sole reservoir for Sin Nombre, the virus that causes hantavirus pulmonary syndrome in the western United States. Other species of *Peromyscus* may become infected with Sin Nombre virus, but their capacity to serve as competent vectors is unknown. The virus is shed in urine, feces, and possibly saliva. Humans are most susceptible to infection when they disturb enclosed, poorly ventilated areas contaminated with rodent excreta. Because of their ubiquity in western North America and propensity to enter human dwellings in search of food and nesting materials, deer mice and the hantavirus they carry are a considerable public health concern in California.



# Management and Control

- Control of wild rodents on a large scale is time consuming, expensive, and usually unsuccessful, and therefore is not generally recommended. However, when localized populations of certain species, such as California ground squirrels, golden-mantled ground squirrels, Belding's ground squirrels, or chipmunks become a nuisance or potential threat for disease transmission to humans, efforts to reduce population size may be attempted. Many of the techniques previously discussed for control of commensal rodents may also be implemented for localized populations of wild rodents.





# Safety



Rodent species are found everywhere in California and the potential for contact between rodents and humans is significant. While only a few California rodent species have been associated with human disease, it is a good general policy to consider any rodent as a potential source of disease. Activities that pose a potential risk for rodent-borne disease include:

- Occupying or disturbing rodent-infested areas during outdoor recreational activities
- Occupying buildings or dwelling that were previously vacant
- Visiting or residing in areas where there is a substantial sudden change in rodent population density
- Inhabiting or cleaning rodent infested dwellings, barns, outbuildings, intermittently occupied summer homes/cabins
- Working in rodent-infested structures

- For the general public, the opportunity for rodent contact, and transmission of rodent-borne pathogens, is greatest in and around the home or during outdoor recreational activities. Some of the areas in which recommendations can be made to the public on prevention of rodent-borne diseases include:
  - Recommendations on rodent and ectoparasite suppression techniques
  - Good hygiene and household sanitation practices
  - Use of gloves and respirators or dust-masks
  - Environmental modification and rodent exclusion recommendations
  - Guidance on proper clean-up of rodent-contaminated areas and household items
  - Proper disposal of possibly contaminated items, such as rodent carcasses, nesting materials and excreta
  - Avoiding contact with rodents
  - Use if currently recommended disinfectants such as 10% household bleach, hospital-grade Lysol, and other general-purpose household disinfectants



# Safety Guidelines for Handling and Sampling Rodents

## Chapter 7



# Infectious Disease Surveillance

- In the spring of 1993, a cluster of human cases of adult respiratory in the southwestern United States came to the attention of public health officials. The rapid progression of the disease and the high case-fatality caused alarm. Numerous agencies working together soon identified the infectious agent and how it was spread. It was identified as a hantavirus that infected rodents. The virus is named Sin Nombre virus (SNV) and the disease that it cause is called hantavirus pulmonary syndrome (HPS). The main reservoir species in the Southwest is the deer mouse, *Peromyscus maniculatus*. Although the deer mouse is the primary reservoir of SNV, other species if rodents may serve as hosts for SNV or other hantaviruses.
- The main mode of infections to humans is thought to be inhalation of infectious airborne virus excreted in urine, feces, and saliva from infective rodents. Exposure is most likely to occur when contaminated soil, litter, or nesting materials when they are stirred up into the air within a poorly ventilated space.
- Disease surveillance cannot be achieved by simple observation of rodents, but capturing is needed. People who handle rodents as part of surveillance efforts place themselves at an increased risk of contact with infectious materials. Those who participate in these surveillance activities should educate themselves on proper safety precautions and adhere strictly to them to reduce the risk of infection.



# Safety Guideline Objectives



These guidelines are informational and are intended for people who handle rodents as part of ecological and epidemiological studies of rodent or small mammal populations where exposure to an infectious zoonotic agent (e.g. hantavirus, plague) could be possible. Check with your agency if an approved institutional animal care and use protocol is required.

Individuals must obtain a Scientific Collecting Permit from the California Department of Fish and Wildlife.



# Trapping and Processing Rodents

- In addition to knowledge of the risks posed from handling live and dead rodents, principles of humane treatment of mammals should be practiced by all persons conducting disease surveillance and research.
- Care and handling of rodents.
  - Mammals should always be collected and handled using humane procedures and professional judgment that maximize the scientific data obtained from a minimum of individuals or samples, while causing minimal pain or distress. Trapped animals should be collected and processed in a timely manner to minimize the stress of capture. After processing, animals should be released at their site of capture as soon as possible.



- Threatened habitats and species.

- Local, state, and federal regulations govern scientific collecting, transport, and possession of all specimens taken. Individuals collecting mammals for scientific study must comply with all relevant laws and regulations. Ignorance of the law or inadvertent violation of regulations is never a valid excuse and may result in prosecution. Persons who survey mammals in threatened habitats must proceed with sensitivity and careful judgment so that populations will not be adversely affected. The welfare of the threatened species should be the foremost concern.

- Collecting and transporting rodents.

- Live-capture traps, suitable for the rodent species to be captured, are preferred over kill-type traps for collecting specimens when blood samples are required. Traps in which rodents were captured should be disinfected as part of normal processing cleanup. No special clothing or equipment is required for setting and baiting clean traps, although a long-sleeved long pants, socks, and sturdy lace-up shoes are recommended for all field work. Workers checking or retrieving traps should wear rubber gloves in addition to normal field attire. When a closed trap is encountered, workers may carefully peer inside while holding the trap at arm's length. Traps containing rodents of the desired species should be placed in a plastic bag before transporting to the processing site, and kept out of direct sunlight to prevent overheating. Gloved hands should be washed or disinfected, and hands thoroughly cleaned after removing the gloves. Transport bagged rodents in the back of a pickup truck or other compartment isolated from passenger sections.



- Choosing a processing site.

It is essential to locate a processing area before trapping is begun. The field processing site should be in a secluded area, away from other humans or domestic animals. A table and other work surfaces should be of a nonporous material that can be easily disinfected and cleaned. Weather permitting, outdoor processing is preferred because of greater ventilation and penetration of natural ultraviolet light. All required equipment and supplies should be placed inside the processing area within easy access of protected workers. Only workers wearing proper safety attire should be permitted in the designated area once processing has begun. If processing must be conducted indoors, there should be adequate ventilation to the outside.



# Personal Protective Equipment



- Respirators.

- Because the primary mode of transmission of hantavirus to humans is through inhalation of infectious airborne virus, it is important that anyone working closely with potentially infected rodents wear a proper respirator. There are several different types of respirators that provide adequate protection against viral particles: maintenance-free (disposable) half mask respirators, reusable half mask respirators full-face respirators, and supplied-air respirators. Regardless of which type is used, the respirator should fit well, not be clogged or damaged, and provide adequate filtering of the smallest particles (N-100 or REPA filter designation). Some of the respirators require a respiratory fit test and a medical evaluation. The supplied-air respirators reduce the dangers of a poor fit, especially for users with facial hair, by supplying a continuous flow of filtered air from a battery-powered source through a head covering, across the face, and out the base of the head covering. These supplied air units (powered air purifying respirators, PAPRS) are more comfortable than the other half or full-mask negative pressure respirators, and also provide protection for the head, eyes, nose, and face. Respirators should receive regular maintenance and be checked for proper functioning before entering a hazardous area.



- Clothing. While conducting any field work, wear a long-sleeved shirt, long pants, socks, and shoes or boots. Disposable or non-disposable coveralls provide an additional level of safety while handling rodents. If the coveralls are non-disposable, they should be removed soon after completing rodent handling activities, placed in a plastic bag, and thoroughly laundered with hot soapy water before reuse.





- Gloves. When handling traps that contain captured rodents or are potentially contaminated by rodents, a pair of thick rubber gloves should be worn. When handling rodents, disposable latex gloves (or another thin type of material that will not compromise dexterity) should be worn. If a tear occurs, a quick spray of disinfectant should be applied and a new glove placed over the tear. Gloves should be sprayed with a disinfectant before removal and hands washed after their removal.
- Eye protection. Individuals wearing a half mask respirator should also wear additional eye protection (e.g., safety glasses or goggles).
- Other. Rubber boots, disposable shoe covers, and other protective wear can be considered for use; all materials should be either disposable or readily disinfected.



# Anesthesia

- Invasive and non-invasive techniques can be used to sample tissues from live mammals. Humane considerations, professional judgment, and the scientific data desired will help determine which technique is appropriate. Any procedure that causes pain or significant distress mandates the use of an appropriate anesthetic.
- Animals should not be handled outside of traps unless they have been anesthetized. Inhalant anesthetics are recommended over injectables because they reduce or obviate the use of needles and legal logistics potentially required for using injectable drugs that are considered controlled substances.
- Animals in live-capture traps may be anesthetized by placing the entire trap into a plastic bag containing gauze or cotton soaked with an inhalant anesthetic.
- Anesthetics used in rodent surveillance are potentially hazardous to workers. Therefore, personnel should take care to minimize inhaling anesthetic during these procedures. Use inhalant anesthetics in well-ventilated areas and keep containers tightly closed.
- Currently Isoflurane is the more common inhalant anesthetic used because the animal is quickly anesthetized and also recovers quickly. Rodents should be carefully visually monitored for slowed respiration and lack of response to physical stimulation before removal from the jar.



# Blood Collection

- Aseptic techniques are challenging in the field, but cleanliness in all surgical and invasive techniques is essential to minimize the potential for infection and to provide reliable biological samples.
- Obtaining blood samples. Small blood samples (<1 ml) can be obtained from the retrobulbar sinus of anesthetized rodents. This technique requires practice and dexterity. Sampling from the retrobulbar sinus has the advantage of reducing the risk of needle-stick injury to the worker and being least injurious to the rodent. Cardiac puncture can also yield moderate amounts of blood from anesthetized rodents that will be euthanized (non-release studies).



# Syringes and Syringe Safety

- All syringes and needles should be kept in sterile condition and never be reused. Match the syringe and needle size to the approximate size of the rodent. For small rodents (e.g., deer mice) it is best to use a 1cc syringe with a 5/8-inch 25 gauge needle or approximate equivalent. For larger rodents (e.g., woodrats and squirrels) it is best to use a 3cc syringe with a 1-inch 23 gauge needle or approximate equivalent.
- Extreme caution should be used to avoid needle-stick injury. Use a clean needle and syringe for each animal, never replace the plastic cap on the needle, never remove the needle from the syringe after use, and never place your hand or finger in the path of the needle. Dispose of the needle and syringe in a leak-proof, puncture-resistant sharps container immediately after use. Use extreme care when expelling the blood sample into a blood tube/vial or onto a filter paper strip to avoid the splashing or aerosolization of blood.
- If a needle stick, bite, or other injury occurs which breaks the skin, stop work and cleanse the injury site with disinfectant. Leave the processing area, remove the glove or other skin covering, wash hands with soap and water while trying to express blood or fluid from the wound, and clean the site of injury thoroughly with disinfectant. Report the injury immediately to your supervisor. If swelling, pain, or discharge from the injury site occurs within 7-10 days, or fever, muscle aches, or other influenza-like symptoms appear within 45 days, seek medical attention and alert the attending physician to the possibility of infection.



# Clean-up and Disinfection

- Site clean-up

- After the processing of rodents has been completed, the processing area and all work surfaces, equipment, and remaining supplies should be sprayed and wiped down with disinfectant. All equipment should be allowed to air dry before handling and storage. All soiled paper towels, trap bedding, disposable gloves and clothing, and any remaining bait or feces should be placed in a plastic bag, sealed, and disposed of in accordance with state and local requirements. If processing was done indoors, the floor should be sprayed with disinfectant and the area well-ventilated before permitting access to persons without respirators.



- Trap clean-up

- Traps previously occupied by rodents should be disinfected and cleaned before reuse. With Sherman traps, this process is best done with 5-gallon buckets, one with disinfectant and another with rinse-water. A brush will aid in removing fecal material. After traps have been cleaned, disinfected, and rinsed, they should be allowed to air dry, preferably in the sun, before reuse or packing them away. When cleaning traps, wear heavy rubber gloves over disposable gloves to avoid sharp edges and any potential tears or punctures. Safety glasses or goggles should be worn to prevent splash-back of disinfectant into the eyes. Larger Tomahawk-type traps can be sprayed with disinfectant, cleaned, rinsed, and air-dried.





# Disinfectants

- The use of appropriate disinfectants is one of the easiest and most effective ways of reducing the risk of the spread of hantaviruses. Hantaviruses are sensitive to household bleach (dilute hypochlorite solutions), ammonium solutions, phenolics, detergents, and most all-purpose household disinfectants.
- An appropriate disinfectant should be used for:
  - Decontaminating traps that contained or were soiled by rodents.
  - Clean gloved hands before removal and disposal of gloves.
  - Disinfect any instruments used while processing rodents.
  - Disinfect or wipe down any work surfaces or other items which may have been contaminated.



# Transport and Disposal of Hazardous Waste

- All bagged waste material should be disposed of in accordance with state and local requirements.
- Full sharps containers should be turned over to a local hospital or laboratory for disposal in accordance with regulations for infectious materials.



# Packing and Shipping Specimens

- Packing and shipping of biologic specimens are strictly regulated and should be done in accordance with the latest regulations.
- All persons who transport infectious or potentially infectious materials must carry a current hauling permit from the California Department of Public Health, Medical Waste Management Program.



# Other Infectious Disease Concerns

- People conducting field work, collecting and handling of small mammals are at increased risk for many zoonotic infections. Precautions to prevent infection with hantavirus should also be effective in preventing other infections spread by aerosol or direct contact.
- Efforts to prevent flea and tick bites are very important. Ectoparasites can vector several infections from animals to humans including plague, Colorado tick fever, Lyme disease, babesiosis, anaplasmosis, Rocky Mountain spotted fever, and tularemia. When processing animals disposable gloves should be pulled over the cuffs of clothing and taped to deny fleas access to arms.



# Zoonotic Diseases Associated With California Vertebrates

Chapter 8



# Viral Diseases

- **Rabies**

- Agent: Rabies virus (*Lyssavirus*)
- Reservoir: Principally bats and skunks in California, though any mammal can become infected and transmit the virus.
- Transmission: Contamination of bite or scratch with virus-laden saliva of an infected animal.
- Symptoms/signs: Incubation 3-6 weeks, but can be several months. Symptoms are initially headache, fever, malaise. Continuing to weakness, paralysis, convulsions, delirium, Regularly fatal 2-7 days after onset.
- Diagnosis: Characteristic staining of brain tissue.
- Treatment: There is no treatment once symptoms arise. Prophylaxis is, vaccination prior or immediately following exposure to an infected animal.
- Significance: 1975-2014: 16 human rabies deaths, one survivor. In between 300-500 cases of rabies in terrestrial mammals are reported each year in California. Skunk and bat strains are endemic in California with these mammals representing 80% and 14% of positive animals.

- **Hantavirus pulmonary syndrome (HPS)**

- Agent: Sin Nombre virus (SNV) in western United States.
- Reservoir: Deer mice ( *Peromyscus maniculatus*). Maybe to a lesser amount other *Peromyscus* spp.
- Transmission: Inhalation of aerosolized virus-laden urine or feces of deer mice.
- Symptoms/signs: Incubation 1-2 weeks, rarely up to 6 weeks. Symptoms are initially flu-like: It progresses to a rapid onset of severe respiratory distress. Case-fatality is around 40%.
- Diagnosis: Serology or identification of SNV in lung tissue of fatal cases.
- Treatment: None specific. Support of cardiopulmonary function.
- Significance: There had been 69 cases of HPS in California residents (2014); approximately half with exposure likely in eastern Sierra Nevada. Deer mice prevalent throughout the state have an infection rate of about 11%.



- **Lymphocytic choriomeningitis (LCM)**

- Agent LCM arenavirus.
- Reservoir: House mouse (*Mus musculus*).
- Transmission: Virus is shed in rodent's urine and feces. Humans infected by consumption or inhalation of virus-contaminated excreta or contact with infected rodents.
- Symptoms/signs: Diverse symptoms include fever, headache, and muscle pain. Rash, neurologic symptoms, and arthritis may occur in some patients. Death rarely occurs.
- Diagnosis: Isolation of virus from blood or spinal fluid; serology.
- Treatment: None.
- Significance: No cases of LCM have been reported in California since it was made a reportable disease in 1996.

- **Arboviral encephalitides**

- Agent : West Nile virus (WNV), Western equine encephalomyelitis virus (WEE), St. Louis encephalitis virus (SLE).
- Reservoir: Wild birds.
- Transmission: Bite of infected mosquito, mainly (*Culex tarsalis*).
- Symptoms/signs: Most infected persons are without symptoms or with mild, flu-like illness. Some people, especially children and the elderly, develop fever, headache, neck pain and stiffness that may lead to severe neurological symptoms and possibly coma and death.
- Diagnosis: Serology.
- Treatment: None.
- Significance: WEE, WNV, SLE are enzootic in birds in California. Surveillance of mosquitoes and sentinel chicken flocks between late spring and autumn detect transmission of these viruses. Clinical cases of WEE/SLE are currently rare, but there are between 300-400 cases if WNV yearly in California.



# Rickettsial Disease

- **Anaplasmosis**

- Agent: *Anaplasma phagocytophilum*.
- Reservoir: wild rodents.
- Transmission: Bite of infected *Ixodes pacificus*.
- Symptoms/signs: Ranges from no symptoms to fatal fever, headache, muscle ache, and chills are common. Severe complications include neurologic symptoms and organ failure. Case fatality is 2% to 10%.
- Diagnosis: Observation of inclusion bodies on blood smear; serology.
- Treatment: Antibiotics (tetracyclines).
- Significance: Approximately 1-2 cases of anaplasmosis occur each year in California. Most cases have occurred in northern coastal counties. Illness in horses due to infection with *A. phagocytophilum* (formerly *Ehrlichia equi*) has been recognized in California since the 1960's.

- **Murine typhus (flea-borne typhus, endemic typhus)**

- Agent: *Rickettsia typhi*.
- Reservoir: Commensal rodents (*Rattus* spp.); in southern California, the opossum (*Didelphis virginianus*).
- Transmission: Contamination of bite from infected flea (*Ctenocephalides felis*) with flea feces.
- Symptoms/signs: Fever headache, chills, muscle ache, macular rash on trunk that spreads to most of the body. Case-fatality < 1%.
- Diagnosis: Serology.
- Treatment: Antibiotics (tetracycline).
- Significance: Typhus is enzootic in the opossum population of some regions of greater Los Angeles Basin.



- **Rickettsialpox**

- Agent: *Rickettsia akari*.
- Reservoir: House mouse (*Mus musculus*).
- Transmission: Bite of infected mite, *Liponyssoides sanguineus*.
- Symptoms/signs: Rash begins at mite bite site and spreads over the body, except palms and soles. Lymph nodes are often swollen.
- Diagnosis: Serology or immunostaining of skin lesions.
- Treatment: Antibiotics(tetracyclines).
- Significance: Incidence in California is unknown but is believed to be low. Risk would be greatest in areas where plentiful food stores or poor sanitary conditions support extensive *M. musculus* populations.

- **Rocky Mountain Spotted Fever**

- Agent: *Rickettsia rickettsii*.
- Reservoir: Wild rodents, occasionally domestic dogs, and ticks (*Dermacentor* and *Rhipicephalus sanguineus*).
- Transmission: Bite of infected *Dermacentor* spp. or *Rhipicephalus sanguineus*.
- Symptoms/signs: Serious disease can be fatal; fever headache, muscle ache, and chills are common. Rash on extremities spreading to the trunk 2-5 days after fever. Case fatality 20-80%.
- Diagnosis: Serology, PCR, immunohistochemistry of tissues.
- Treatment: Antibiotics ( tetracyclines).
- Significance: 1-3 confirmed cases each year are reported in CA.



# Bacterial Diseases

- **Salmonellosis**

- Agent: Numerous serovars of *Salmonella enterica*.
- Reservoir: Various wild and domestic animals. Pet reptiles are a frequent source of infection.
- Transmission: Consumption of fecal-contaminated water or food. Hand to mouth contact with infected animals.
- Symptoms/signs: Sudden onset of diarrhea, abdominal pain, nausea, headache, and fever. Symptoms usually subside in a few days. Rarely, may infect other organ systems.
- Diagnosis: Isolation of *Salmonella* organisms from feces.
- Treatment: None, usually from uncomplicated cases.
- Significance: 4000-6000 cases of salmonellosis are reported in California per year. This represents an underestimate of true incidence. The animal source of the infection is rarely definitively identified.

- **Plague**

- Agent: *Yersinia pestis*
- Reservoir: Wild rodents, primarily chipmunks, ground squirrels, and mice.
- Transmission: Saliva from bite of infected flea; contact with tissues, secretions, or respiratory particles from infected animals, especially domestic cats.
- Symptoms/signs: Most commonly fever, malaise, swollen painful lymph nodes. If untreated may progress to infection of blood and lungs. Case-fatality of plague pneumonia is >90%.
- Diagnosis: Serology, identification/culture of organism from lymph tissue, blood, sputum.
- Treatment: Antibiotics (Streptomycin, tetracyclines)
- Significance: Plague is enzootic in wild rodent populations in much of California. When epizootics occur, the risk for human infection increases. On average there are 1-2 cases of plague per year in California. Plague acquired through contact with an infected cat is more likely to be pneumonic and more likely to be fatal. It is also listed by the CDC as a Category A (top priority) bioterrorism threat agent.



- **Tularemia**

- Agent: *Francisella tularensis*.
- Reservoir: Rabbits and some rodents.
- Transmission: Handling of tissues of infected animals (esp. rabbits, beaver); ingestion of undercooked tissues of infected animals; consumption of contaminated water; arthropod bite (ticks, deerflies); rarely, inhalation of dust from contaminated soil or dried vegetable matter.
- Symptoms/signs: Variable by route of infection and biovar of organism. Most commonly, ulceration of skin and swollen lymph nodes. Pneumonia, pharyngitis, and gastrointestinal manifestations also possible. Can often resemble plague.
- Diagnosis: Serology, identification/culture of organism from ulcer/lymph node.
- Treatment: Antibiotics (streptomycin, also tetracyclines, gentamicin).
- Significance: Zero to 10 cases of tularemia are reported in California each year. Listed by CDC as Category A (top priority) bioterrorism threat agent.

- **Leptospirosis**

- Agent: Over 200 serovars of *Leptospira interrogans* (esp. *canicola*, *pomona*, *icterohemorrhagiae*).
- Reservoir: Numerous wild and domestic mammals.
- Transmission: Contact of abraded skin or mucus membranes with animal urine or consumption of water contaminated with animal urine (esp. rats, cattle, swine, dogs).
- Symptoms/signs: Varies with infecting serovar. Fever, headache, chills, muscle pain common initially. Later may resemble encephalitis/meningitis.
- Diagnosis: Serology.
- Treatment: Any of several antibiotics can be effective.
- Significance: One to 15 cases of leptospirosis are reported in California each year. Clusters of cases among persons with common exposure to a contaminated water source occasionally occur.



- **Lyme disease**

- Agent: *Borrelia burgdorferi*.
- Reservoir: Wild rodents, principally woodrats, gray squirrels in California.
- Transmission: Bite of infected Ixodid (hard) tick; in California, the western black-legged tick (*Ixodes pacificus*).
- Symptoms/signs: Red, expanding rash and flu-like symptoms early; if untreated can progress to arthritis and neurologic symptoms.
- Diagnosis: Based on clinical symptoms, especially characteristic rash; supported by serology.
- Treatment: Oral antibiotics (e.g., tetracyclines) for early symptoms; intravenous antibiotics (e.g., ceftriaxone) for later neurologic disease.
- Significance: About 100 cases are reported in California each year. Highest incidence is in coastal counties north of the Bay Area - Sonoma, Mendocino, Humboldt, Trinity. Lower percentage of ticks infected in California compared to East Coast due to *I. pacificus* feeding on lizards which eliminate the spirochetes.

- **Tick-borne relapsing fever**

- Agent: *Borrelia hermsii*
- Reservoir: Wild rodents, particularly chipmunks.
- Transmission: Bite of infected argasid (soft) tick, usually *Ornithodoros hermsi*. Ticks will feed on humans when their preferred rodent hosts are not available.
- Symptoms/signs: Cyclical fever (up to 106°) that lasts for a few days, disappears for a few days then will reappear. If not treated several (up to 20) relapses can occur.
- Diagnosis: Observation of *Borrelia* spirochetes on blood smear, serology.
- Treatment: Antibiotics (tetracyclines) usually will relieve the fever within 24 hours.
- Significance: Five to 20 cases per year in California. Most cases are acquired while occupying and sleeping in buildings located in underdeveloped areas between 1200-2700m., elevation. Clusters of cases among people sharing sleeping quarters are not uncommon.



- **Psittacosis (ornithosis, parrot fever)**

- Agent: *Chlamydophila psittaci*.
- Reservoir: Psittacine birds (e.g., parrots parakeets), occasionally other wild and domestic fowl and wild mammals.
- Transmission: Inhalation of organism from feces or other secretions of infected birds, generally within an enclosed space. Also, handling of contaminated birds or tissues.
- Symptoms/signs: Fever, headache, chills, cough, chest pain. Can be severe, rarely fatal.
- Diagnosis: Serology, recovery of the organism from sputum.
- Treatment: Tetracycline for 10-14 days.
- Significance: Fewer than 10 cases are reported annually in California, but this is likely under-diagnosed. Pet store staff and exotic bird fanciers are at particular risk of exposure.

- **Rat bite fever**

- Agent: Streptobacillus, *Spirillum minus*.
- Reservoir: Any rodent, but most commonly associated with *Rattus* spp.
- Transmission: Bacteria shed in saliva and urine. Transmission usually through rodent bite. Rarely, infection occurs through contact of broken skin with contaminated surfaces (e.g. rodent cage) or consumption of contaminated water.
- Symptoms/signs: Abrupt onset of fever, chills, headache, muscle pain 3-10 days after exposure. A rash on the arms and joint swelling may follow in 1-3 days. Infection of heart tissue and brain may occur in severe, untreated cases. Case-fatality is about 10%.
- Diagnosis: Isolation of the organism from blood or other infected tissues.
- Treatment: Antibiotics (e.g., penicillin) for 7-10 days.
- Significance: Cases are rarely reported, so the true incidence is unknown. There is an ever present risk to anyone who handles rodents since the infectious agent can be found in the saliva of up to 100% of laboratory rats and up to 100% of wild rodents.



# Fungal Diseases

- **Cryptococcosis**

- Agent: *Cryptococcus neoformans*
- Reservoir: Ever-present environmental saprophyte that grows in bird feces, especially pigeon droppings.
- Transmission: Inhalation of contaminated soil or pigeon droppings.
- Symptoms/signs: Organism localized in the lungs, then spreads to other parts of the body. Symptoms are commonly pneumonia and meningitis. The skin, bones and kidneys can be infected as well. If untreated cryptococcal meningoencephalitis is 100% fatal.
- Diagnosis: Observation of fungal bodies in the spinal fluid; serology; culture of fungi from skin lesions.
- Treatment: Antifungal drugs (Amphotericin B, 5-fluorocytosine).
- Significance: The most common fungal disease in immunocompromised individuals (e.g., AIDS, cancer patients), in whom cryptococcosis is more severe and 10-25% fatal.

- **Histoplasmosis**

- Agent: *Histoplasma capsulatum*.
- Reservoir: Fungus frequently found in soil with high organic content. Grows in buildups of bat guano easily.
- Transmission: Inhalation of airborne fungus.
- Symptoms/signs: Several clinical forms recognized: asymptomatic, acute respiratory disease (fever, headache, cough), diseases involving other organ systems like the liver, kidney and spleen. Chronic disease like chronic respiratory disease similar to tuberculosis.
- Diagnosis: Culture or fungus seen in the sputum, blood or other tissues, serology.
- Treatment: Antifungal drugs (e.g., ketoconazole, itraconazole).
- Significance: One to 15 cases reported in California each year. Less common cause of fungal respiratory disease in California than *Coccidioides immitis*, “Valley fever”, with 700-1000 cases annually.



# Protozoal Disease

- **Babesiosis**

- Agent: *Babesia ducani*.
- Reservoir: Unknown.
- Transmission: Bite of infected tick and also through transfusion of blood products from an infected person.
- Symptoms/signs: Infection can be asymptomatic to mild having fever, chills and muscle ache. Some cases progress to anemia, blood clotting problems and respiratory difficulty. Rarely, babesiosis is fatal.
- Diagnosis: Observation of organisms on blood smear; serology.
- Treatment: Atovaquone and Azithromycin; Clindamycin.
- Significance: Babesiosis due to *B. ducani* is rarely reported (< 1 case per year). Babesiosis caused by *B. microti* reported in Californians (~1 per year), with exposure in eastern or upper midwestern U.S.

- **Chagas' disease**

- Agent: *Trypanosoma cruzi*.
- Reservoir: Opossum (*D. virginianus*) and woodrats (*Neotoma fuscipes*).
- Transmission: Reduviid bugs (e.g., *Triatoma* spp.) shed organism in feces while feeding. Contaminated feces are rubbed into the bite wound, mucus membranes or eyes.
- Symptoms/signs: The disease can be asymptomatic to acute illness with fever, malaise, enlarged lymph nodes, edema of the eyelids. Rarely chronic infection may result in cardiac and gastrointestinal dysfunction.
- Diagnosis: Observation of organism in blood.
- Treatment: Nifurtimox, benznidazole.
- Significance: Occurs primarily in Mexico and Central and South America. Cases have been rarely reported in California. *T. cruzi* has been isolated from two species of Reduviidae native to California, *Triatoma protracta* and *T. rubida*.



- **Giardiasis**

- Agent: *Giardia lamblia*, *G. intestinalis*, *G. duodenalis*
- Reservoir: Humans, many species of domestic and wild mammals. Beavers are often cited as the source of infection.
- Transmission: Ingestion of cysts present in water contaminated with feces from an infected human or animal.
- Symptoms/signs: Chronic diarrhea, abdominal cramps, weight loss. People can be asymptomatic as well.
- Diagnosis: Observation of cysts in feces.
- Treatment: Metronidazole.
- Significance: About 2000 cases of giardiasis are reported each year in California. Hikers, campers, and others who consume unfiltered water from natural sources in mountainous areas are most at risk.



# Parasitic Diseases

## • Visceral/ocular larval migrans

- Agent: Roundworm larvae of *Toxocara canis*. *Baylisascaris procyonis*.
- Reservoir: Wild and domestic dogs for *Toxocara*; raccoons for *Baylisascaris*.
- Transmission: Consumption of embryonated eggs shed in feces of canids and raccoons.
- Symptoms/signs: Usually asymptomatic in adults. In children, symptoms referable to tissues and organs to and through which the roundworm larvae migrate: commonly the eye and central nervous system. Occasionally fatal; long-term sequelae possible in children with heavy infection.
- Diagnosis: Serology, identification of larvae on tissue biopsy.
- Treatment: Anthelminthics (e.g., thiabendazole) are variably effective.
- Significance: Clinical cases of larval migrans are rarely diagnosed in California, though exposure to the infection ova is likely high.

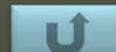
## • Trichinosis (Trichinellosis)

- Agent: *Trichinella spiralis*.
- Reservoir: Bear, wild and domestic swine.
- Transmission: Consumption of raw or undercooked meat that contains the encysted larvae.
- Symptoms/signs: Initially muscle pain, edema of the eyelids, ocular pain, photophobia. Progressing to fever, chills, prostration, profuse sweating, weakness. Late symptoms the larvae migrate and encyst, often causing myocardial failure.
- Diagnosis: Biopsy of affected tissue.
- Treatment: Anthelminthics ( mebendazole, thiabendazole).
- Significance: 1-3 cases in California are reported yearly.



- **Mite dermatitis**

- Agent: *Ornithonyssus bacoti*, *O. bursa*, *O. sylvarium*.
- Reservoir: *Rattus* spp. for *O. bacoti*, birds for *O. bursa* and *O. sylvarium*
- Transmission: Humans become accidental hosts for these mites following contact with infested animals or when the mites' preferred hosts are unavailable (e.g., following rodenticide population control).
- Symptoms/signs: Mite bites produce a painful, itchy rash. Some persons may experience an allergic reaction to mite bites.
- Diagnosis: Human infestations typically involve only a few mites, so detection is difficult. Diagnosis usually based on rash and history of contact with rodents or birds.
- Treatment: Treatment is symptomatic to relieve pain and itching. Control measures in the environment should be taken to prevent re-infestation.
- Significance: A few cases of rat mite dermatitis are informally reported to public health officials each year. The true incidence and risk of infestation with these mites in California is unknown.



# GLOSSARY

## Chapter 9



**Acute**: Referring to a health effect that is brief; sometimes also used to indicate severe. (cf. Chronic)

**Anthelmintic**: An agent or substance that destroys or expels parasitic worms, esp. intestinal worms.

**Arboreal**: Inhabiting or frequenting trees.

**Arbovirus**: ("Arbo" = "arthropod-borne"). General term for viruses which are transmitted from individual to individual by way of biting arthropods (e.g., mosquitoes).

**Arthropod**: Member of the Phylum Arthropoda, characterized by possession of a chitin exoskeleton and jointed appendages. (e.g., insects, crustaceans, arachnids)

**Asymptomatic**: Without, or producing no, symptoms.

**Bacillus**: Strictly, a bacterium that is a member of the genus Bacillus, any rod-shaped bacterium.

**Bacteria**: A single-celled organism that possesses a cell wall, lacks a nucleus, and typically reproduces by cell division.

**Biopsy**: Process of removing a tissue sample from a living patient for diagnostic purposes.

**Biovar**: A group of bacterial strains distinguishable from other groups within the same species based on physiological characteristics.

**Black Death**: Common name given to the pandemic of plague that occurred throughout Europe in the 14th Century.

**Cardiac**: Relating to the heart.

**Cardiopulmonary**: Relating to the heart and lungs.

**Case-fatality**: The proportion of patients with a particular illness who die.

**Chronic**: Referring to a health effect that is long-lasting.



**Commensal**: Living with or deriving benefit from another species. Specifically where one species benefits and the other species is neither benefitted nor harmed.

**Conjunctiva**: The mucous membrane surrounding the anterior surface of the eyeball and posterior surface of the eyelids.

**CSF**: Cerebrospinal fluid.

**Dermatitis**: Inflammation of the skin.

**Diurnal**: Active or occurring during the day.

**Dysfunction**: Impaired or abnormal function.

**Edema**: Swelling of a tissue or organ due to retention or infiltration of excessive fluid.

**Encephalitis**: Inflammation of the brain.

**Encephalopathy**: Any disorder of the brain.

**Encyst**: Formation of a membranous wall around an organism or other foreign substance within living tissue.

**Endemic**: A condition, typically a disease, that persists within a population of humans at a constant level (cf. Enzootic, Epidemic).

**Endophthalmitis**: Inflammation of the tissues within the eyeball.

**Enteric**: Relating to the intestine.

**Enzootic**: A condition, typically a disease, that persists within a population of animals at a constant level.

**Epidemic**: The occurrence of a disease within a population of humans at a level in excess of normal (cf. Endemic, Epizootic).



**Epizootic**: The occurrence of a disease within a population of animals at a level in excess of normal (cf. Epidemic, Enzootic).

**Estivation**: To pass the summer months in a state of torpor-a condition of physical inactivity.

**Etiologic**: Relating to the cause of a disease.

**Excreta**: The product of a tissue or organ that is expelled from the body. Commonly used to refer specifically to urine and feces.

**Fecundity**: The production of live offspring. Fertility. The ability to conceive offspring. Gastrointestinal. Relating to the stomach and intestines.

**Gestation**: The process or period of conception and development of offspring.

**Gregarious**: Tending to reside or function in a group.

**Guano**: Excrement, usually of birds or bats, which accumulates in the environment.

**Hard tick**: Ticks belonging to the Family Ixodidae and possessing a dorsal scutum (e.g., *Ixodes pacificus*, the Western black-legged tick, vector of Lyme disease in California).

**Hemorrhage**: An escape of blood from a ruptured vessel.

**Hibernation**: To pass the winter months in a state of torpor-a condition of physical inactivity.

**Homeothermic**: Capable of maintaining a constant body temperature - "warm-blooded".

**Incidence**: The number of new cases of a disease that occur in a defined population over a specified period of time.

**Inclusion bodies**: Visual evidence of a foreign substance or organism within a cell or tissue, usually as observed under microscopy.



**Incubation**: The period of time between exposure to a disease agent and onset of symptoms.

**Larval migrans**: Migration of a larval worm, typically a nematode, through tissues of an abnormal host without maturation to an adult worm.

**Lymph**: A clear, faintly yellow fluid that is collected from the tissues of the body and transports proteins and other wastes by vessels through nodes and eventually into the blood.

**Lymph node**: One of numerous round or bean-shaped bodies located throughout the body and connected to the lymphatic vessels which process wastes collected from cells.

**Macular**: Different in color than surrounding tissue; often used in reference to discoloration of skin rashes.

**Meningitis**: Inflammation of the membranous covering of the brain and spinal cord.

**Meningoencephalitis**: Inflammation of the brain and its membranous covering.

**Mite**: Small, eight-legged, parasitic arthropods that bite or burrow into the skin of humans and other animals; occasionally serve as vectors of disease.

**Mucous membrane**: Cells lining various passages and cavities of the body which communicate with the exterior.

**Myocardial**: Relating to the muscles of the heart.

**Neophobic**: Fearful of the new or unfamiliar.

**Niche**: The ecologic role and position of a species in a community.

**Nocturnal**: Active or occurring at night.

**Ocular**: Relating to the eye.

**Omnivorous**: Tending to include both animal and vegetable matter as part of its normal diet.

**Oviparous**: Young develop in eggs outside the maternal body - "egg-laying".



**Ovoviviparous:** Young develop in eggs retained within the maternal body.

**Pandemic:** Denoting an outbreak of a disease that occurs over an extensive region, country, or continent (cf. Epidemic).

**Parasite:** An organism that lives in or on another and derives its sustenance therefrom.

**Pathogen:** A substance or organism capable of causing disease.

**Pathogenic:** Capable of causing disease.

**Peridomestic:** In and around site of human habitation.

**Pharyngitis:** Inflammation of the pharynx, the junction between the mouth and nasal passages.

**Photophobia:** Sensitivity to or avoidance of light.

**Phylogeny:** The evolutionary development of a species.

**Placental mammals:** Group of mammals that support the metabolic needs of the developing offspring in the uterus through a direct connection between the maternal and fetal blood circulation.

**Pneumonia:** Inflammation of the lung tissue and filling of the air spaces with fluid.

**Poikilothermic:** Varying in body temperature according to the temperature of the surrounding environment - Cold-blooded.

**Prophylaxis:** Prevention of a disease, before or after exposure to the agent.

**Prostration:** Marked loss of strength, exhaustion.

**Raptor:** Bird of prey.

**Reservoir:** Living or nonliving source capable of supporting growth and multiplication of a disease agent and serving as a source of transmission, directly or indirectly, to susceptible animal



**Rickettsia**: Genus of small bacteria that are obligate intracellular organisms and are often transmitted by biting arthropods.

**Roundworm**: A member of the Phylum Nematoda, characterized by elongated shape, complete digestive tract, and an outer cuticle.

**Saprophyte**: An organism that grows on dead organic matter.

**Sequelae**: Conditions which follow as a consequence of disease.

**Serology**: General class of laboratory tests in which serum is used to measure the presence of antibodies to disease agents.

**Serovar**: A group of bacterial strains distinguishable from other groups within the same species based on antigenic characteristics.

**Soft tick**: Ticks belonging to the Family Argasidae and lacking a dorsal scutum (e.g., *Ornithodoros hermsi*, vector of relapsing fever in California).

**sp**: Abbreviation referring to any single species within a genus.

**spp**: Abbreviation referring to multiple species within a genus.

**Spirochete**: Spiral-shaped bacteria; specifically members of the genus Spirochaeta.

**Sputum**: Thick fluid produced in the respiratory passages during disease.

**Symptomatic**: Relating to dysfunctions or departures from normal health associated with disease.

**Systemic infection**: Presence and distribution of a disease agent throughout an organ system or the whole body.

**Thigmotaxis**: Movement oriented by contact with surfaces or objects.

**Vector**: An animal (esp. arthropod) that is capable of transmitting an infectious disease agent, generally from a reservoir species to a susceptible species.

**Vertebrate**: Group of animals within the Phylum Chordata that have a hollow nerve cord enclosed within a bony or cartilaginous spinal column.

**Viremia**: Presence of viruses in the blood.

**Viviparous**: Relating to organisms that bear live young.

