

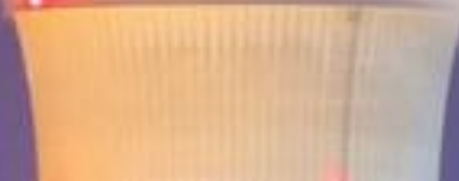


ESSENTIAL PUBLIC HEALTH

Essentials of
**Environmental
Health**

SECOND
EDITION

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Chapter 5

Zoonotic and Vector-Borne Diseases

Learning Objectives

By the end of this chapter the reader will be able to:

- Discuss the impact of human environmental change on emerging infectious diseases in animals and man
- Indicate how a disease may be transmitted from an animal reservoir to humans
- Define what is meant by a vector-borne disease and a zoonotic disease
- List three human diseases transmitted by arthropod vectors and three caused by zoonoses
- Discuss methods used to control vector-borne and zoonotic disease

Zoonosis

- Refers to “an infection or infectious disease transmissible under natural conditions from vertebrate animals to humans.”

Methods for Transmission of Zoonoses

- Contact with the skin
- A bite or scratch from an animal
- Direct inhalation or ingestion
- The bite of an arthropod vector

Vector

- Defined as “an insect or any living carrier that transports an infectious agent from an infected individual or its wastes to a susceptible individual or its food or immediate surroundings.”

Examples of Vectors

- Various species of rodents (rats and mice)
- Arthropods (mosquitoes, ticks, sand flies, biting midges)

Vector-Borne Diseases

- Malaria
- Leishmaniasis
- Plague
- Lyme disease
- Rocky Mountain spotted fever

Malaria

- A disease found in more than 100 countries, with more than 40% of the world's population at risk
- Endemic regions include Central and South America, Africa, India, Southeast Asia, the Middle East, and Oceania.
- Annual death toll for malaria is more than 1 million persons.

Infectious Agents of Malaria

- *Plasmodium falciparum*
 - Most deadly
- *Plasmodium vivax*
- *Plasmodium ovale*
- *Plasmodium malariae*

The Cost of Malaria

- Global direct economic costs incurred by malaria are estimated to be \$12 billion U.S. annually
- The direct costs include those for treatment and prevention of the disease (e.g., medicine, hospitalization, and pesticide use).
- Lost productivity, lost earnings, and negative impacts upon travel and tourism

Malaria Transmission

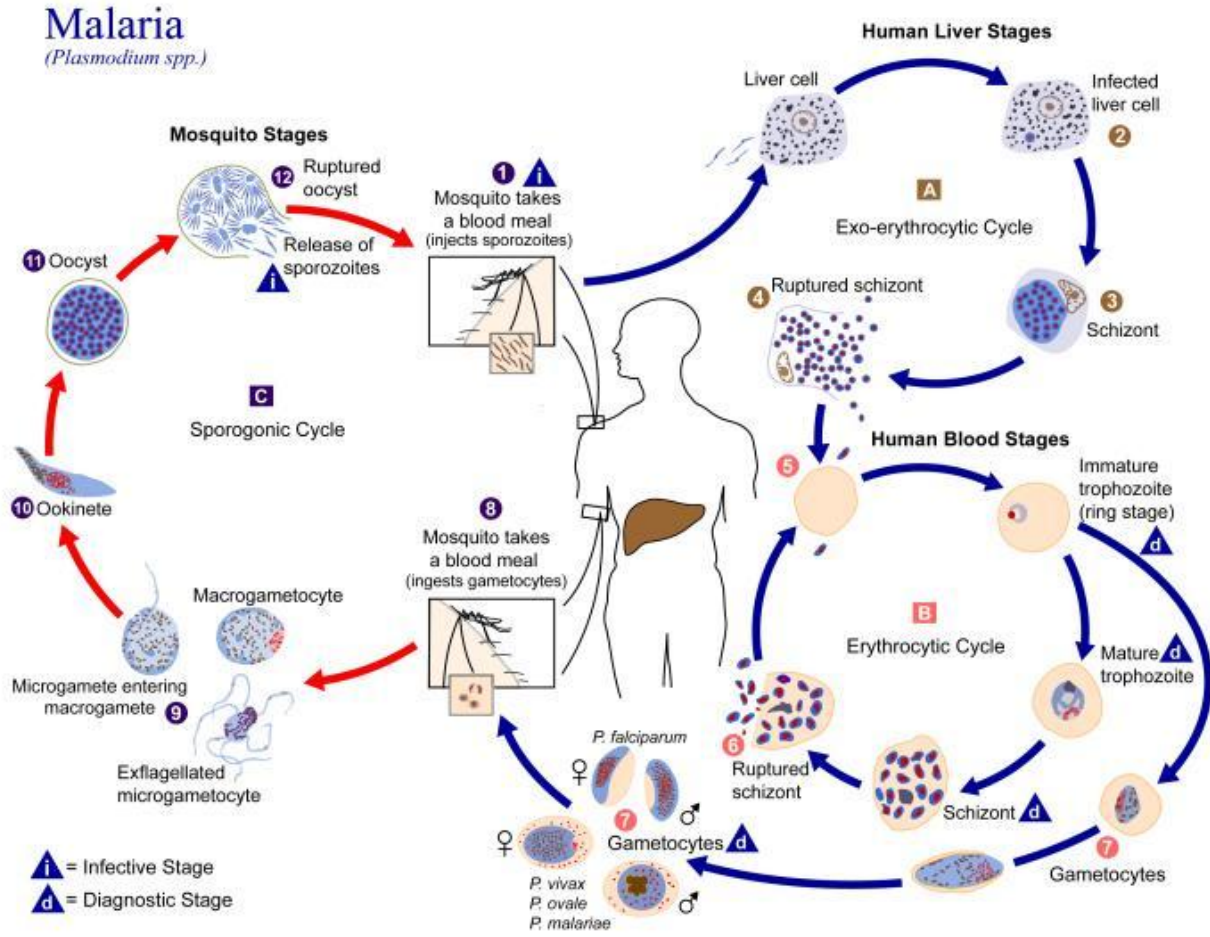
- Transmission involves the complex life cycle of mosquitoes (the vector) and human hosts (with human liver and human blood stages).
- Transmitted through the bite of an infected mosquito of the anopheles type.

Figure 5-3 Female *Anopheles gambiae* mosquito feeding.



Source: Reprinted courtesy of the CDC Public Health Image Library. ID# 1662. Jim Gathany Content Provider. Available at: <http://phil.cdc.gov/phil/details.asp>. Accessed March 1, 2010.

Figure 5-4 The life cycle of the parasites of the genus *Plasmodium*, causal agents of malaria.



Source: Reprinted courtesy of the CDC Public Health Image Library. ID# 3405. Alexander J. da Silva, PhD, and Melanie Moser Content Providers. Available at: <http://phil.cdc.gov/phil/details.asp>. Accessed March 1, 2010.

What Can Be Done to Control Malaria?

- During mid-20th century, efforts to control malaria by spraying with DDT and administering synthetic antimalaria drugs were found to be efficacious.
- Thought to be harmful to wildlife; use of DDT was opposed by many developed nations, especially the U.S.
- South Africa has used annual spraying of DDT inside of homes.

Figure 5-9 Skin ulcer due to leishmaniasis; hand of Central American adult.

- Cutaneous leishmaniasis is transmitted by the bite of an infected sand fly.



Source: Reprinted from CDC
Public Health Image Library, ID#
352. Available at:
<http://phil.cdc.gov/phil/details.asp>.

Accessed March 14, 2010.

Leishmaniasis (continued)

- The reservoir for the cutaneous form of leishmaniasis includes wild rodents, human beings, and carnivores (e.g., domestic dogs).
- The disease is transmitted from the reservoir to the human host by a sand fly known as the phlebotomus fly.
- Endemic in a total of 82 countries

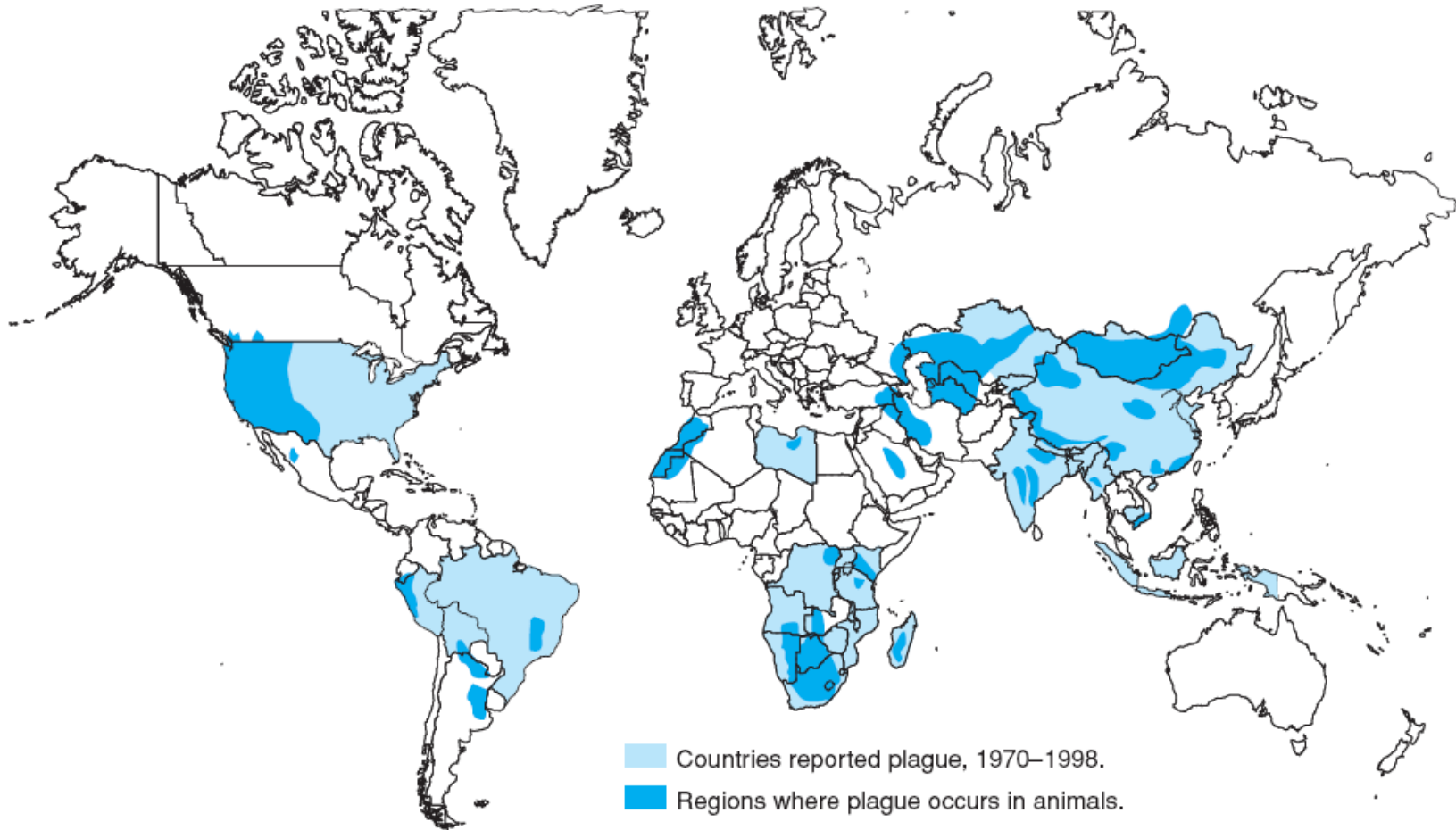
Environmental Factors Associated with Observed Increases in Leishmaniasis

- Movement of the human population into endemic areas
- Increasing urbanization
- Extension of agricultural projects into endemic areas
- Climate change due to global warming

Plague

- The bacterium *Yersinia pestis* is the infectious agent for plague, a condition that infects both animals and humans.
- Transmitted by the bite of a flea harbored by rodents.
- Historians believe that the plague epidemic during the Middle Ages (the “black death”) was caused by fleas from infested rats.

Figure 5-14 World distribution of plague, 1998.



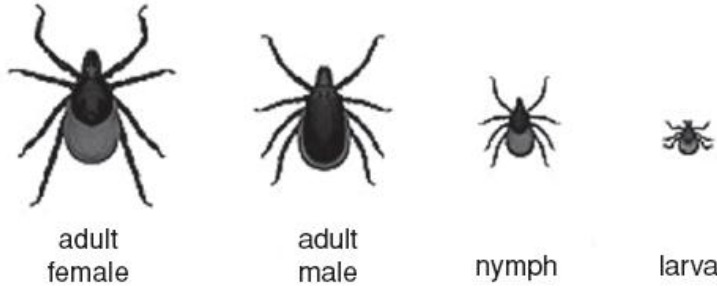
Source: Adapted and reprinted from the Centers for Disease Control and Prevention. Plague: CDC Plague Home Page. Available at: <http://www.cdc.gov/ncidod/dvbid/plague/index.htm>. Accessed February 28, 2010.

Lyme Disease

- A condition identified in 1977 when a cluster of arthritis cases occurred among children around the area of Lyme, Connecticut.
- The causative agent for the disease is a bacterium known as *Borrelia burgdorferi*.
- Transmission of Lyme disease to humans is associated with infected black-legged ticks (*Ixodes scapularis*) that ingest blood by puncturing the skin of the host

1 inch

Black-legged Tick (*Ixodes scapularis*)



Lone Star Tick (*Amblyomma americanum*)



Dog Tick (*Dermacentor variabilis*)



Figure 5-16
(Top) From left to right:
The black-legged tick (*Ixodes scapularis*) adult female, adult male, nymph, and larva.

Source: Adapted and reprinted from the Centers for Disease Control and Prevention. Lyme Disease. Available at: http://www.cdc.gov/ncidod/dvbid/lyme/ld_transmission.htm. Accessed March 14, 2010.

Rocky Mountain Spotted Fever

- Causal agent is *Rickettsia rickettsii*, a rickettsial agent.
- A febrile disease
- Case fatality rate up to 25% among untreated patients
- Transmitted by the bite of an infected tick

Viral Hemorrhagic Fevers (VHF)

- Viruses that cause VHFs require an animal host or insect host (arthropod vector) as a natural reservoir.
- Examples of animal host reservoirs include rodents such as the cotton rat, deer mouse, and house mouse.
- The viruses are limited to those geographic areas in which the host species reside.

Arthropod-Borne Viral Diseases

- Also known as arboviral diseases.
- A group of viral diseases that can be acquired when blood-feeding arthropod vectors infect a human host.
- Vectors that transmit arboviruses include ticks, sand flies, biting midges, and mosquitoes.

Four Main Clinical Symptoms of Arboviral Disease

1. Acute CNS [central nervous system] illness
2. Acute self-limited fevers, with and without exanthum [rash]
3. Hemorrhagic fevers
4. Polyarthrititis and rash, with or without fever and of variable duration

Arboviral Encephalitides

- Caused by a virus that produces an acute inflammation of:
 - Sections of the brain
 - Spinal cord
 - Meninges
- Among the etiologic agents are viruses associated with many forms of encephalitis, including:
 - St. Louis encephalitis
 - Western equine encephalitis

Arboviral Encephalitides (continued)

- Transmitted by the bite of an arthropod vector (primarily mosquitoes)
- The reservoir hosts for some forms of encephalitis viruses consist of nonhuman vertebrate hosts (e.g., wild birds and small animals).
- Cost of arboviral encephalitides is approximately \$150 million per year, including vector control and surveillance activities.

West Nile Virus

- Classified as a mosquito-borne arboviral fever, the etiologic agent is a *Flavivirus*.
- Mosquitoes are the carriers that become infected when they feed on infected birds.
- Health effects vary from no symptoms to very severe symptomatology.

Emerging Zoonoses

- Refers to zoonotic diseases that are caused by either apparently new agents or by known agents that occur in locales or species that previously did not appear to be affected by these known agents.

Factors Associated with the Rise of Emerging Zoonoses

- Ecological changes that result from agricultural practices (e.g., deforestation, conversion of grasslands, and irrigation)
- Other factors include changes in the human population and human behavior (e.g., wars, migration, and urbanization).

Examples of Emerging Zoonoses and Their Contributing Factors

- Non-conventional agent:
 - Bovine spongiform encephalopathy
 - Changes in rendering process
- Viral:
 - Hantaviruses
 - Ecological/environmental changes
 - Increasing rodent contacts

Examples of Emerging Zoonoses and Their Contributing Factors (continued)

- Bacterial:
 - *Escherichia coli* O157:H7 (hemolytic-uremic syndrome)
 - Mass food processing technology allowing contamination of meat
- Parasitic:
 - *Cryptosporidium* and other pathogens
 - Contaminated surface water, faulty water purification

Hantavirus Pulmonary Syndrome (HPS)

- The causative agent is the hantavirus, part of the viral family known as Bunyaviridae.
- May be transmitted when aerosolized (airborne) urine and droppings from infected rodents are inhaled.
- Primary vectors are four species of rodents: cotton rat, rice rat, white-footed mouse, and deer mouse.

Figure 5-21 This is a deer mouse, *Peromyscus maniculatus*, a hantavirus carrier that becomes a threat when it enters human habitation in rural and suburban areas.

- The main host for the hantavirus is the deer mouse-- *Peromyscus maniculatus*, which is found throughout North America.



Source: Reprinted from the CDC Public Health Image Library, ID# 1183. Photo credit: James Gathany. Available at: <http://phil.cdc.gov/Phil/details.asp>. Accessed March 18, 2010.

Dengue Fever

- Caused by flaviviruses
- The proportion of deaths can be as high as 40% to 50% when the disease is untreated.
- Occurs primarily in tropical subtropical areas of the world, for example, Southeast Asia, tropical Africa, and South America.
- The vector for transmission of the disease is the *Aedes aegypti* mosquito.

Dengue Fever in the U.S.

- In the U.S., most cases of dengue are imported by travelers who are returning from endemic areas or by immigrants.
- Occurrence of dengue fever that originated in the continental U.S. has been documented.
- Southern Texas and the southeastern states are at theoretical risk for transmission of dengue and for sporadic outbreaks.

Other Zoonotic Diseases (Examples)

- Monkeypox
- Tularemia
- Rabies
- Anthrax
- Psittacosis

Control of Mosquito-Borne Diseases

- Use sentinel chickens to monitor for presence of viruses.
- Drain standing water.
- Introduce mosquito-eating fish into ponds.
- Wear repellents and protective clothing.
- Repair window screens.