# Yersinia pestis (Infection with)



## AETIOLOGY

### Classification of the causative agent

*Yersinia pestis* (also known as the Plague, Sylvatic Plague, and the Black Death) is a Gram-negative coccobacillus and zoonotic bacterium found in small mammals and their fleas. *Y. pestis* forms small (1-2 mm), grey-white to yellow, "hammered copper" colony formations when cultured. Plague manifests in symptomatic hosts in bubonic, pneumonic, or septicaemic forms, determined by the route of infection. It is 1 of 6 original communicable diseases that are reportable to the World Health Organisation by member states.

### Resistance to physical and chemical action

Temperature: Optimum growth is at 28°C (82°F); sensitive to moist heat (121°C for 15-20 minutes minimum) or dry heat (160-170°C for 60 minutes minimum)

pH: Not well determined

Chemicals/Disinfectants: 1% sodium hypochlorite, 70% ethanol, 2% glutaraldehyde, formaldehyde, and iodine-based and phenolic disinfectants, diatomaceous earth

Survival: Does not survive long at high temperatures or in dry environments

## EPIDEMIOLOGY

### Definitive Hosts

Over 200 species can serve as definitive hosts for *Y. pestis*. Common hosts include:

- Rodents
  - Prairie dogs (*Cynomys* spp.), particularly the black-tailed prairie dog (*C. ludovicianus*)
  - Great gerbils (*Rhombomys opimus*)
  - Mongolian gerbils (*Meriones unguiculatus*)
  - Ground squirrels (*Spermophilus* spp.)
  - Rats (*Neotoma* spp., *Rattus* spp.)
  - Mice (*Peromyscus* spp.)
  - Chipmunks (*Tamias* spp.)
- Humans (*Homo sapiens*)
- Non-human primates
- Wild and domestic felids
  - Bobcats (*Lynx rufus*)
  - Mountain lions (*Puma concolor*)
  - Domestic cats (*Felis catus domesticus*)
- Wild and domestic canids
  - Coyotes (*Canis latrans*)
  - Domestic dogs (*Canis familiaris*)
- Wild and domestic lagomorphs
- Black-footed ferrets (*Mustela nigripes*)
- American badgers (*Taxidea taxus*)
- Goats (*Capra* spp.)

- Camels (*Camelus* spp.)
- Sheep (*Ovis* spp.)
- Cervids
    - Mule deer (*Odocoileus hemionus*)
- Pronghorn Antelope (*Antilocapra americana*)

### *Vectors*

- Fleas
    - *Ctenocephalides* spp.
    - Oriental rat flea (*Xenopsylla cheopis*)
    - Gerbil fleas (*Xenopsylla gerbilli minax*)
    - Uncommonly, human fleas (*Pulex irritans*)

### *Transmission*

- Vector-mediated
    - Fleas acquire and transmit *Y. pestis* by feeding on animals
- Direct contact with an infected animal, namely consumption of undercooked game meat and handling infectious tissues (e.g., skinning infected animals)
- Inhalation of aerosolized bacteria

### *Sources*

- Infected fleas
- Infected animals (tissues, respiratory secretions)
- Aerosols

### *Occurrence*

*Y. pestis* has a global distribution, but is more prominent in the western United States and parts of Asia.

Plague is non-native but enzootic to the western United States and is a prominent cause of morbidity and mortality in prairie dog species due to a lack of natural immunity. These species are prey to many, including the endangered black-footed ferret, which is dependent upon prairie dogs for food. Therefore, plague management has become a significant focus in conservation strategies.

In Southeast and Central Asia (especially Kazakhstan), gerbil species are the primary carriers of *Y. pestis*. Transmission is believed to be significantly impacted by the social behaviors exhibited by great gerbils; they are known to frequently visit occupied burrows beyond their own, especially when foraging. This significantly facilitates the movement of fleas across a landscape. Unlike the North American plague system, flea burden and burrow density are significant contributors to the rate of disease spread.

## *DIAGNOSIS*

*Y. pestis* must be differentiated from other bacterial infections, such as Tularaemia, Staphylococcal or Streptococcal infections, and any abscessations due to wounds. Early clinical signs may be nonspecific, and acute death is common.

## *Clinical diagnosis*

The incubation period of *Y. pestis* is between 2-6 days. For clinical diagnosis, antemortem and postmortem samples can be taken (see **Laboratory Diagnosis**). Samples taken antemortem during acute illness should be collected prior to antibiotic administration. Infected wildlife and rodents are often found acutely dead, but may present with fever, anorexia, and enlarged lymph nodes that may be draining or abscessed. Oral and lingual ulcers may also be present. Livestock are not known to develop clinical signs beyond decreased thriftiness and sudden mortality.

## *Lesions*

- Mucohaemorrhagic diarrhoea
- Multifocal hepatic and splenic necrosis
- Mesenteric lymphadenopathy
- Ulcerative gastroenterocolitis
- Vascular oedema

## *Differential diagnoses*

- Tularaemia
- Streptococcal or staphylococcal lymphadenitis
- Infectious mononucleosis

## *Laboratory diagnosis*

**Samples**

*For isolation of agent*

- Antemortem: whole blood, lymph node aspirates, swabs from draining lesions, oropharyngeal swabs
- Post-mortem: spleen, lung, liver, affected lymph nodes
- Air-dried glass slide smears of bubo aspirates

*Serological tests*

- Nasal mucosa
- Serum sample
- Whole blood

**Procedures**

*Identification of the agent*

- Immunofluorescent antibody test for the F1 antigen (IFA)
- Polymerase chain reaction (PCR)

*Serological tests*

- Serologic antibody tests can be considered diagnostic if samples collected 2-3 weeks apart (acute and convalescent) yield a 4-fold rise in antibody titre

## PREVENTION AND CONTROL

### Sanitary prophylaxis

- In captive settings, utilise commercial products to kill fleas in conjunction with rodent control measures around enclosures

### Medical prophylaxis

- Captive wildlife can be treated with a flea control product on a regular basis, determined by the product used.
- A successful oral recombinant raccoon pox-vectored vaccine for prairie dogs has been developed in the United States, and projects to increase the scale of delivery are ongoing. Current data suggests a ~70% ingestion rate which is variable by vegetation density as well as prairie dog size and species.
    - There have been no observed adverse effects to other rodent species that incidentally ingest the vaccine bait

## POTENTIAL IMPACTS OF DISEASE AGENT BEYOND CLINICAL ILLNESS

### Risks to public health

- *Y. pestis* is a zoonotic disease known to infect humans, with the bubonic plague as the most common form of illness. There are three classic modes of transmission that include: vector-mediated, direct contact with infectious animals/tissues, or inhalation of the bacterium
- The aerosolized bacterium is listed as a potential agent of bioterrorism
- Local or regional public health officials should be notified immediately when plague is suspected

### Risks to agriculture

- If livestock facilities are infected, *Y. pestis* can cause severe economic loss due to decreased thriftiness (meat production, milk production) and mortality. Developing countries are particularly at risk of economic consequences.

## REFERENCES AND OTHER INFORMATION


- Anisimov, A.P., Lindler, L.E., & Pier, G.B. (2004). Intraspecific diversity of *Yersinia pestis*. *Clinical Microbiology Reviews, 17*, 434–64.
- Artois, M., Caron, A., Leighton, F.A., et al. (2006). Wildlife and emerging diseases. *Revue Scientifique et Technique-Office International des Epizooties, 25*, 897– 912.
- Centers for Disease Control (2018). Plague - Resources for clinicians. Accessed 2020: https://www.cdc.gov/plague/healthcare/clinicians.html
- Eisen, R.J., Petersen, J.M., & Higgins, C.L. (2008). Persistence of *Yersinia pestis* in soil under natural conditions. *Emerging Infectious Diseases, 14*, 941–3.
- Ettestad, P. (2005). *Yersinia pestis. Merck Veterinary Manual.* Accessed 2019: https://www.merckvetmanual.com/generalized-conditions/plague/overview-of-plague
- Orloski, K. A., & Lathrop, S. L. (2003). Plague: a veterinary perspective. *Journal of the American Veterinary Medical Association*, *222*(4), 444–448.
- Reijniers, J., Davis, S., Begon, M., Heesterbeek, J. A. P., Ageyev, V. S., & Leirs, H. (2012). A curve of thresholds governs plague epizootics in Central Asia. *Ecology Letters, 15*, 554-560.
- Rhyan, J.C., & Spraker, T.R. (2010). Emergence of diseases from wildlife reservoirs. *Veterinary Pathology Online, 47*, 34–9.
- US Fish and Wildlife (n.d.) Black-footed ferret sylvatic plague vaccine trials: frequently asked questions. Accessed 2020: https://www.fws.gov › pressrel › BlackFootedFerret_FAQs_final
- USGS National Wildlife Health Center (n.d.) Sylvatic Plague. Accessed 2020: https://www.usgs.gov/centers/nwhc/science/sylvatic-plague?qt-science_center_objects=0#qt-science_center_objects

- The World Organisation for Animal Health (2016). *Yersinia Pestis*.


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The OIE will periodically update the OIE Technical Disease Cards. Please send relevant new references and proposed modifications to the OIE Science Department (scientific.dept@oie.int). Last updated 2020. Written by Marie Bucko and Samantha Gieger with assistance from the USGS National Wildlife Health Center.