

**Medical academy named by  
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**Structure and life cycle of fleas. The epidemiological  
importance of human fleas**

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**SVETLANA SMIRNOVA**

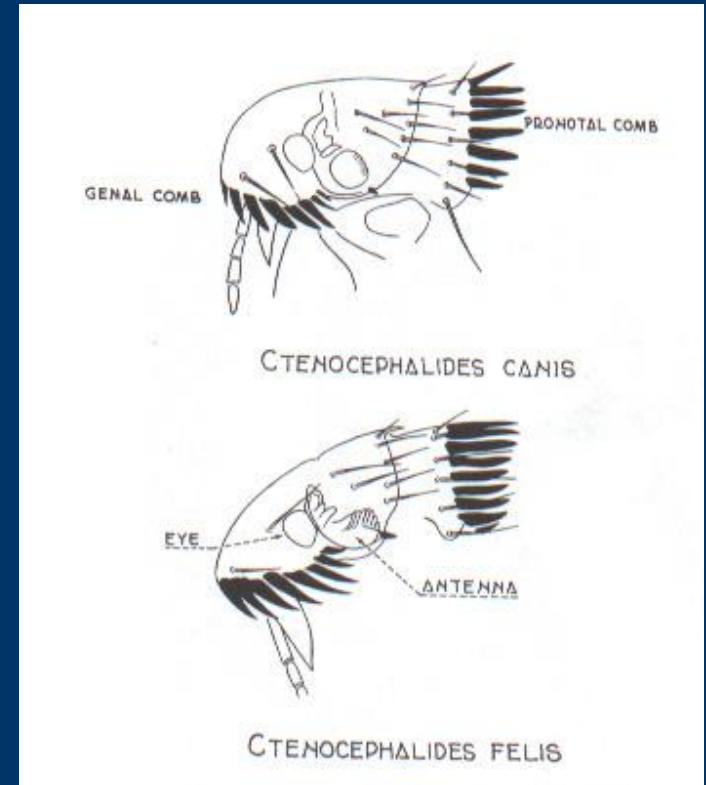
## Morphology

- The body is laterally compressed and the first segment on each leg (the coxa) is large and provides incredible power for jumping; lateral compression allows ease of movement through the hairs on the host; being a good jumper allows them to effectively move from one host to another
- The antennae of males are nearly always longer than those of females; during copulation, the male takes up a position beneath the female and holds her firmly with his antennae from below
- The male body has an upward tilt posteriorly, but the female body is evenly rounded terminally

### Morphology cont.

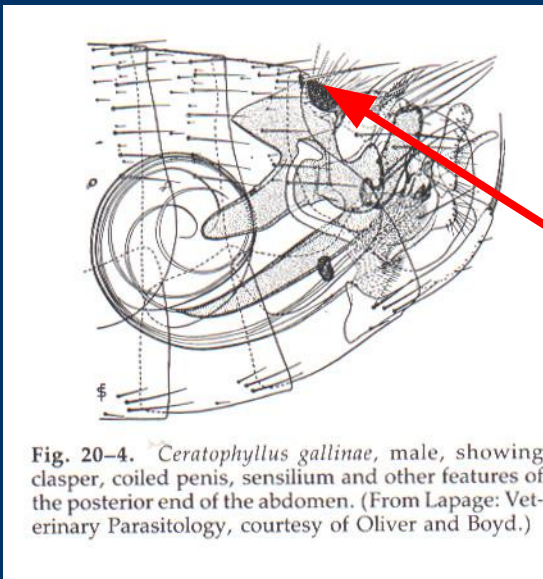
- Fleas are encased in a suit of armor; each segment of the thorax may be regarded as a membranous ring of adjoining plates
- The notum of the prothorax is often armed with a row (comb) of heavily pigmented spines (one row on each side), the **pronotal ctendium**; this structure, plus setae are important for maintaining position on host

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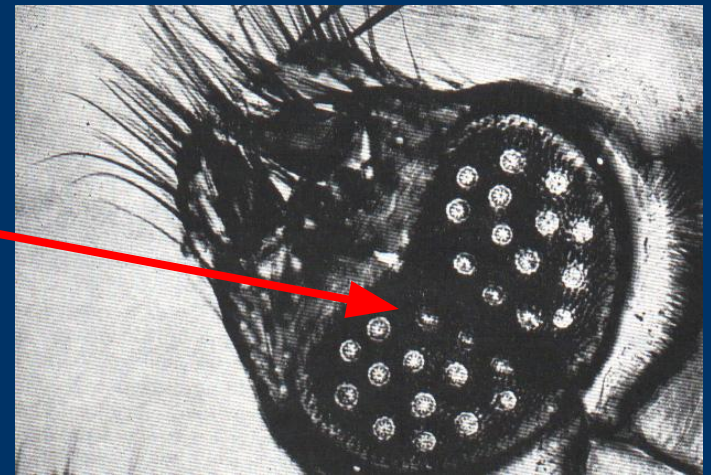


## Morphology cont.

- The abdomen consists of ten segments, and each segment has a dorsal and ventral sclerite; these plates overlap on the abdomen, permitting considerable flexibility of the abdomen
- Dorsal sclerite 9 of the male is modified to form a clasping apparatus used during copulation with the female
- The 9<sup>th</sup> segment of both males and females has on its dorsal sclerite a dorsal sensory plate called the **sensilium (pygidium)**; this structure is believed to function in the detection of air currents and thus may assist the flea in finding a host that may be moving about



pygidium



## Morphology cont.

- The **spermatheca** is taxonomically the most important genital structure of the female flea

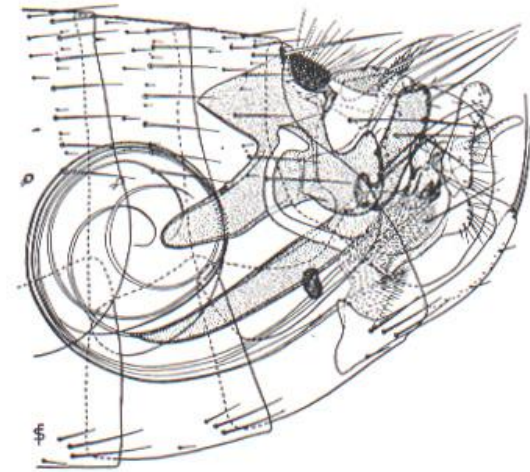


Fig. 20-4. *Ceratophyllus gallinae*, male, showing clasper, coiled penis, sensillum and other features of the posterior end of the abdomen. (From Lapage: *Veterinary Parasitology*, courtesy of Oliver and Boyd.)

- Possess cutting-piercing mouthparts; the mouth leads to a thick-walled pharynx equipped with pumping muscles, then to a narrow esophagus, which enters a pear shaped proventriculus, which is provided internally with a series of spines that project backward in front of the entrance of the stomach
- These spines presumably help to crush the blood cells of the host

## Morphology cont.

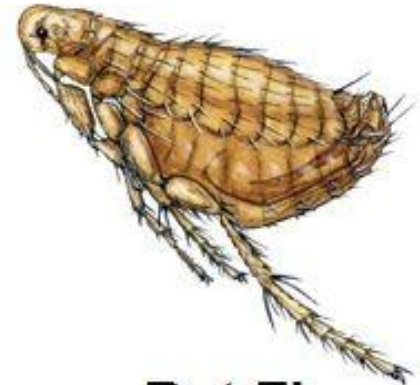
- Between the proventriculus and the stomach is a valve that prevents the food in the stomach from being regurgitated during the process of digestion
- A salivary gland lies on each side of the stomach and a duct leads from these glands to the pharynx
- During the process of biting and feeding, the piercing mouthparts enter the host skin, and the flea thrusts its head downward, elevating the abdomen and the hind legs; after feeding the mouthparts are withdrawn with a sudden jerk
- When a flea bites, the salivary pump pours out a stream of saliva that eventually reaches the host blood vessels; at the same time, the pharyngeal pumps works to draw up the host blood, mixed with saliva and forces it into the esophagus and stomach where it is digested



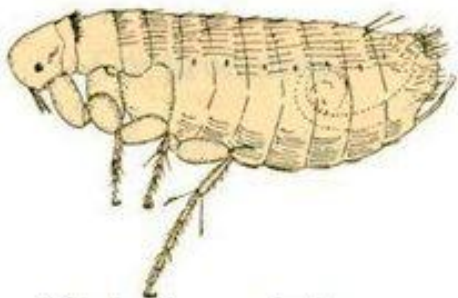
**Sticktight Fleas**



**Human Fleas**



**Rat Fleas**



**Chicken Fleas**



**Cat Fleas**

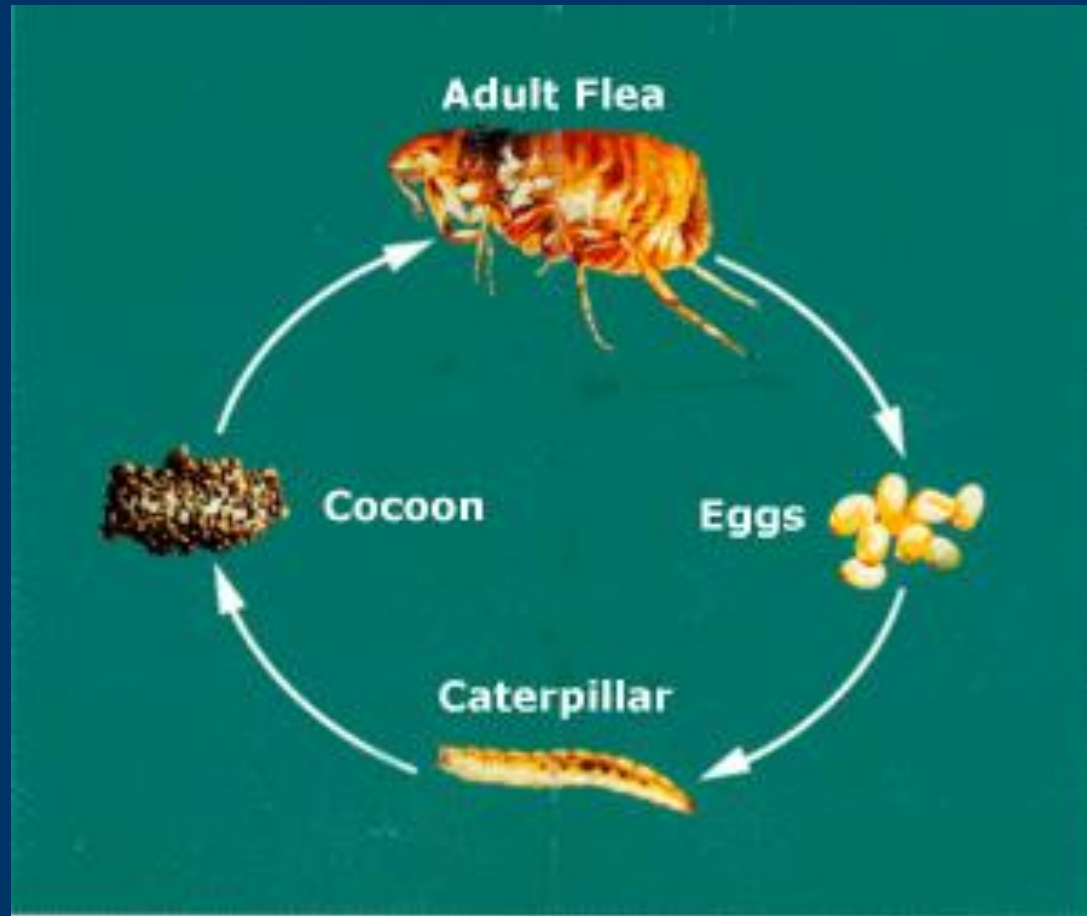


**Sand Fleas**



# Life History and Habits

- During their life cycles, fleas pass through a complete metamorphosis from egg to larva to pupa to adult



## Life History and Habits cont.

- Eggs are large, smooth and oval and translucent
- In 2-10 days the eggs hatch into eyeless, legless active larvae; the heads are strongly sclerotized
- Under favorable conditions, the larvae may reach their 3<sup>rd</sup> stage in about 2 weeks, but development may be delayed for 6 months or more
- Larvae feed on organic debris in the host's nest, in crevices on the floor or under rugs; larvae of bird fleas thrive on broken-down sheaths of feathers on the epidermal scales of young birds
- Most fleas have 3 larval stages; each 3<sup>rd</sup> instar larva spins a cocoon within which it pupates
- Pupae may live for a week up to a year depending on the species and the environmental conditions related to temperature and moisture
- The fully formed adult may lie quiescent for an indefinite period of time before it becomes active and attempt to infect a host

## Life History and Habits cont.

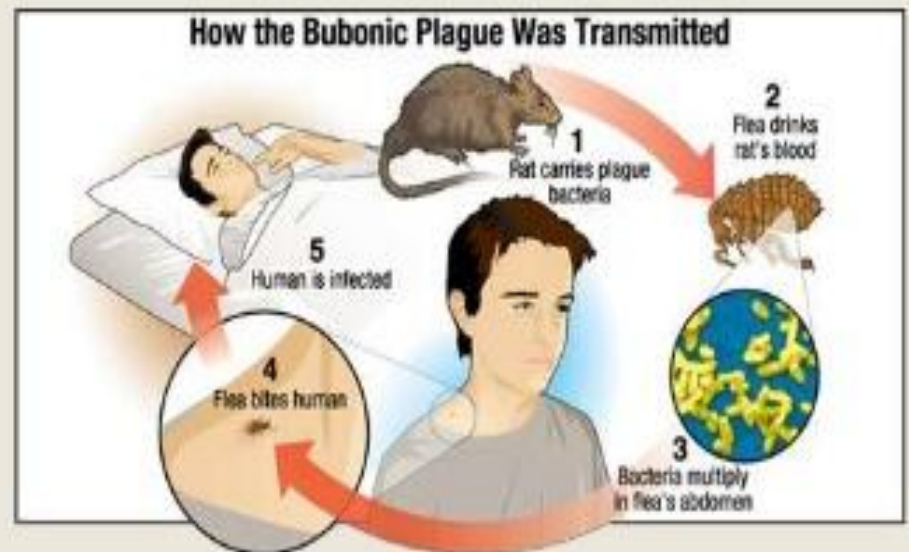
- Fleas are usually equally common on hosts of either sex; however, there are some exceptions
- Bat fleas tend to crowd onto female bats before they migrate to summer colonies
- Fleas of small mammals may be found more commonly on male hosts
- It is not clear why this is the case: larger male size, larger home ranges, mutually groom females
- Females usually require a blood meal before they copulate; males typically die after mating while females live long enough to lay large quantities of eggs

# Fleas and Human Diseases

- The bacterial causative agent of plague, *Yersinia pestis*, is transmitted by fleas (*Xenopsylla cheopis* and *Nosopsyllus fasciatus*) from rodents to man
- Bacilli in an infected flea so congest its proventriculus and stomach that blood sucked from a mammalian host fails to pass into the stomach
- A “blocked” flea continues its attempt to feed and bits of bacillary mass break off and are injected into the host
- *Xenopsylla cheopis* and *Nosopsyllus fasciatus* are also vectors of a nonepidemic typhus of man, “murine typhus”
- This flea-borne disease is caused by *Rickettsia typhi*, which normally occurs in rats
- Other diseases that can be transmitted by fleas include tularemia in man caused by the bacterium *Francisella tularensis*
- Cysticercoid stages of several tapeworms (e.g., *Dipylidium caninum*) develop in larva of several species of fleas

# Human plague

- Most frequently contracted from
  - A. bite of infected flea
  - B. direct contact with tissues of infected animal
  - C. droplet infection from cases of pneumonic plague
- 3 types of human plague
  - A. bubonic plague
  - B. pneumonic plague
  - C. Septicemic plague



# History & Significance

- 14<sup>th</sup> Century: “Black Death” responsible for >20 million deaths in Europe
- Used as a BW agent by Japan in WW II
- Studied by Soviet and, to a smaller extent, U.S. BW programs
- 1995: Larry Wayne Harris arrested for illicit procurement of culture via mail



# Epidemiology



- Caused by *Yersinia pestis*
- Gram negative, non-motile, non-spore-forming bacillus
- Resistant to freezing temperature and drying, killed by heat and sunlight
- Zoonotic infection; Humans are accidental hosts
- Human plague occurs from bite of an infected flea (bubonic)
- Outbreaks are cyclical corresponding to rodent reservoir and arthropod vector populations
- Only pneumonic form of plague is spread person-to-person
  - Last case of person-to-person transmission in U.S. occurred in 1924

# Epidemiology

- Transmission
  - Historically, rat-borne urban epidemics
  - Now mostly endemic sylvatic plague with sporadic outbreaks
  - Pneumonic is only form capable of person to person spread
  - Higher risk in overcrowding, indoor contacts, cold/wet weather



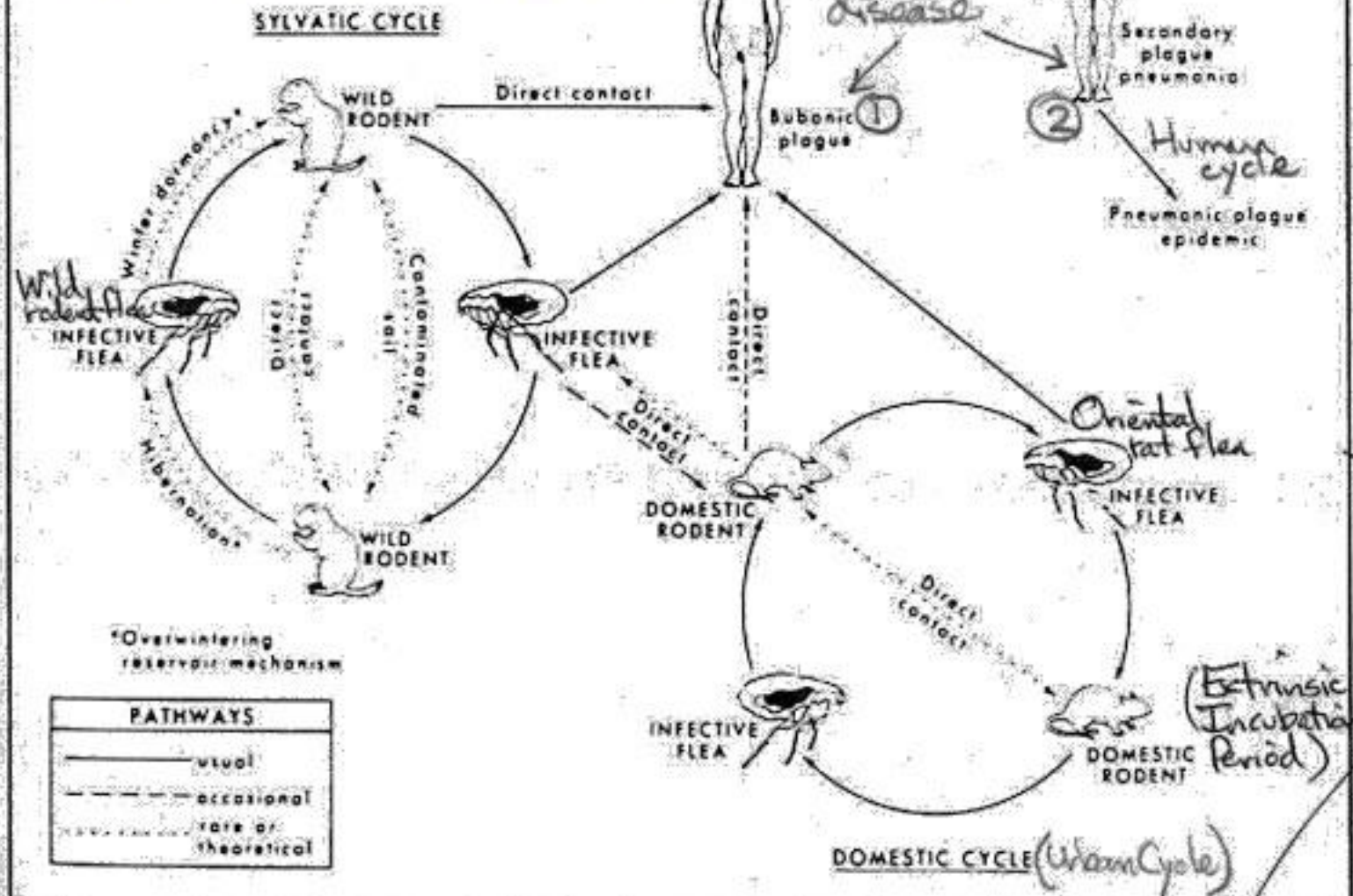
# History of Plague

- Plague recorded more than 2000 years ago
- Three pandemics
  - 1<sup>st</sup> 542AD; 100million dead in 60 years; from N.Africa
  - 2<sup>nd</sup> 14<sup>th</sup> century; Black Death; 25million dead in Europe alone (>1/4 of entire population); from central Asia; disease became endemic in urban rat population and smaller epidemics occurred through 17<sup>th</sup> century
  - 3<sup>rd</sup> ended in 1990s; Burma to China (1894) & Hong Kong to other continents including N. America via rat-infected ships; 20million dead in India alone; foci of infection firmly established in wild rodents in rural areas
- About 10-15 cases/year U.S.

# Epidemiology cycles

- **Sylvatic (wild) Cycle of Plague**
  - Reservoir (foci) = wild rodents (prairie dogs, rabbits, mice, dogs)
  - Vector = wild rodent flea
- **Urban (domestic) Cycle of Plague**
  - Reservoir = domestic (urban) black rat
    - √ Over 8 million in NYC = human population
  - Vector = oriental rat flea (*Xenopsylla cheopis*)
- **Human Cycle of Plague**
  - Bubonic plague acquired from contact with either sylvatic or urban reservoirs or arthropod vector bite and further transmitted in human population by spread of pneumonic plague

# Epidemiological Cycles of Plague



# Video Links

<https://youtu.be/ptHESS4xOkY>

<https://youtu.be/o0W5eeUqcQQ>

<https://youtu.be/ynEMFFj-PSM>

THANK YOU

