Xenopsylla
(insect: flea)

Overview

Arthropods are coelomate metameric invertebrate animals with a chitinous exoskeleton and jointed limbs. They undergo protostomial embryonic development and grow by cuticular moulting (ecdysis). Three main subphyla are recognized: Chelicerata, Crustacea and Hexapoda. Insects are hexapods with three pairs of uniramous legs, three tagmata (head, thorax, abdomen), ectognathous mouthparts with whole-limb mandibles, and one pair of antennae. Siphonaptera (fleas) are bilaterally-flattened wingless insects whose hindlimbs are enlarged and specially adapted for jumping (using elastic resilin pads rather than muscles). Fleas are holometabolans and undergo complete metamorphosis whereby grub-like larvae form pupae from which adult fleas emerge. The larvae are not parasitic but feed on debris associated mainly with bedding, den or nest material, whereas the adult stages are parasitic and feed on host blood. Pulicid fleas occur as ectoparasites on mammals, including humans, domestic and companion animals and wildlife, especially rodents. Adult *Xenopsylla cheopis* lack genal (oral) and pronotal (thoracic) combs and infestations have been associated with dermal irritation in humans and rats. The fleas may also transmit serious pathogens; including bubonic plague, murine typhus and tapeworms.

Classification:

Domain:	Eukaryota (membrane-bound nucleus)
Supergroup:	Amorphea (unikonts with single flagellum, or nonflagellated amoebae)
Kingdom:	Metazoa (multicellular eukaryotes, heterotrophs, notably animals)
Group:	Protostomia (triploblastic, spiral cleavage)
Subgroup:	Ecdysozoa (cuticle moulted = ecdysis)
Phylum:	Arthropoda (chitinous exoskeleton, segmented body, jointed limbs, haemocoel)
Subphylum:	Hexapoda (three tagmata, three pairs uniramous legs, whole-limb mandibles, Malpighian tubules)
Class:	Insecta (ectognathous mouthparts (bases lie outside head capsule), single pair antennae, many with wings)
Superorder:	Holometabola (Endopterygota) (young do not resemble adults, pupae, with internally developing wings)
Order:	Siphonaptera (fleas, wingless, laterally compressed, third pair of legs adapted for jumping)
Family:	Pulicidae (parasites of mammals)
Genus:	*Xenopsylla* (parasitic on skin of rats/dogs/cats/humans)
Species:	various species cause pruritus in humans and rats

Parasite biodiversity and host range: Most Metazoa are multicellular triploblastic animals with differentiated tissues, many being bilaterally symmetrical with a body cavity. Most invertebrate animals are protostomes as their embryonic development involves spiral determinate cleavage. Those that moult their external cuticles during their life-cycles (process known as ecdysis) are grouped together in the unique clade Ecdysozoa, including the nematodes (roundworms), onychophorans (velvet worms), tardigrades (water bears) and arthropods (myriapods, chelicerates, crustaceans and hexapods). Arthropods have small segmented bodies encased in chitinous exoskeletons with articulated limbs. Most species are free-living in terrestrial and aquatic habitats, although a small range are ectoparasitic on other animals, some feeding on the blood or skin of vertebrates. Five subphyla are recognized: Chelicerata, Crustacea, Hexapoda, Myriapoda and Trilobita. Insects are hexapods with six legs, three distinct body parts, two antennae and mouthparts with whole-limb mandibles. Insects are the most biodiverse group on the planet, with millions of species described in numerous taxa. Notorious ectoparasitic species belong to four orders in two superorders: the Hemipterodea (Exopterygota) containing the orders Hemiptera (bugs) and Phthiraptera (lice); and the Holometabola (Endopterygota) containing the orders Siphonaptera (fleas) and Diptera ('true' flies). Fleas are small wingless insects that undergo complete (holometabolous) metamorphosis with vermiform larvae undergoing pupation in silk cocoons. The adults are ectoparasitic and use siphon-like mouthparts to feed on blood from warm-blooded vertebrates [the name 'Siphon-aptera' literally translates as 'siphon' and 'wingless']. All adult fleas are further characterized by having laterally compressed bodies (allowing movement through hair/feathers), backward-pointing hairs and bristles (resisting grooming by host), strong tarsal claws (for grasping), and enlarged hindlegs (adapted for jumping). Around 2,200 flea species have been described in 250 genera on the basis of morphological and biological differences, and recent molecular phylogenetic studies have indicated some 18 families may occur in 4 infra-orders.

Siphonapteran families	Biodiversity	Hosts	Characters	Biogeographical distribution
Infraorder: Pulicomorpha (compact body, small thorax, pronotum with entire undivided ventral margin)				
Pulicidae (common fleas)	22 genera 207 species	carnivores, lagomorphs, rodents, artiodactyls, birds	sensilium with at most 14 pits, coxa with spiniform setae	pan-Tropical, cosmopolitan
Tungidae (sand fleas)	5 genera 23 species	rodents, insectivores, bats, suids, humans, birds	compression of 3 thoracic segments, neosomy	Neotropical, Holarctic
Vermipsyllidae	3 genera 39 species	carnivores, pikas, ungulates	frontal tubercle, large spiracles, reduced tergites	Holarctic
Ancistropsyllidae	1 genus 3 species	artiodactyls	metanotum and abdominal tergites with spinelets	Oriental
Coptopsyllidae	1 genus 19 species	rodents	combless, 2 spermathecae, tergal spinelets absent	Southern Palaearctic
Malacopsyllidae	2 genera 2 species	insectivores	high mesonotum, metanotum without spinelets	Patagonian
Rhopalopsyllidae	14 genera 126 species	rodents, insectivores, birds	metanotum and abdominal tergites with spinelets	Neotropical, Australasian
Infraorder: Ceratophyllomorpha (elongate body, long thorax, head without intergenal process, interantennal dimorphism)				
Ceratophyllidae	47 genera 540 species	rodents, pikas, carnivores, insectivores, birds	genal combs absent, males with interantennal suture	cosmopolitan
Ischnopsyllidae (bat fleas)	20 genera 125 species	bats	genal comb with 2-4 flattened spines, interantennal furrow	cosmopolitan
Leptopsyllidae	29 genera 260 species	insectivores, lagomorphs, rodents, carnivores, birds	head with tentorial arch, males with interantennal suture	Holarctic, Australasia
Xiphlopsyllidae	1 genus 8 species	rodents, shrews	squamulum absent, simple interantennal wall	Eastern African
Infraorder: Hystrichopsyllomorpha (elongate body, long thorax, head with intergenal process, clasper without process)				
Chimaeropsyllidae	8 genera 26 species	rodents, shrews	sensilium with 14 pits, hind coxa with spiniform setae	African
Hystrichopsyllidae (nest fleas)	46 genera 582 species	rodents, insectivores, pikas, marsupials	highly variable structures, 2 spermathecae	cosmopolitan
Macropsyllidae	2 genera 2 species	rodents	single head comb, 4 abdominal combs, 2 spermathecae	Australian
Stephanocircidae (helmet fleas)	9 genera 51 species	rodents, marsupials, birds	helmet (frons) with 2 separate combs, single spermatheca	Neotropical, Australian
Infraorder: Pygiopsyllomorpha (elongate body, long thorax, head with intergenal process, metanotum without spinelets)				
Pygiopsyllidae	10 genera 48 species	rodents, marsupials, birds	unique articulation between digitoid and main part of clasper	Australasian, Neotropical
Lycopsyllidae	4 genera 8 species	marsupials	genal lobe, simple interantennal wall, single mesopleural rod	Australian
Stivaliidae	23 genera 110 species	rodents, marsupials	strongly developed basal arm of Y-sclerite	Palaearctic, Australasia

Fleas from several families are found as ectoparasites on domestic and companion animals around the world: particularly those belonging to the families Pulicidae and Tungidae on mammals, and the family Ceratophyllidae on birds. Members of the family Pulicidae (syn. Archaeopsyllidae, Xenopsyllidae, Sarcopsyllidae p.p.) are characterized by compact bodies, small rounded heads and reduced chaetotaxy (small numbers of setae, spines and/or bristles). Over 20 genera have been recognized in 5 subfamilies: namely, Archaeopsyllinae (*Aphropsylla*, *Archaeopsylla*, *Centetipsylla*, *Ctenocephalides*, *Nesolagobius*), Moeopsyllinae (*Moeopsylla*), Pulicinae (*Delopsylla*, *Echidnophaga*, *Pulex*), Spilopsyllinae (*Actenopsylla*, *Cediopsylla*, *Euchoplopsyllus*, *Hoplopsyllus*, *Ornithopsylla*, *Spilopsyllus*), and Xenopsyllinae (*Parapulex*, *Pariodontis*, *Procaviopsylla*, *Pulicella*, *Synopsyllus*, *Synosternus*, *Xenopsylla*). Various pulicid species and genera are considered to be important parasites of medical and veterinary significance either as parasites in their own right (blood-sucking behaviour causing anaemia, dermatitis and hypersensitivity reactions) or as vectors for other infectious micro-organisms (including bacteria and helminths). Pulicid genera are differentiated mainly on the basis of whether the thoracic segments are very short (*Echidnophaga*), whether both genal (head) and pronotal (thorax) ctenidia (combs) are present (*Ctenocephalides, Spilopsyllus*) or absent (*Pulex, Echidnophaga, Xenopsylla*), and whether the axis of the genal comb is horizontal (*Ctenocephalides*) or vertical (*Spilopsyllus*).

Genera	No. spp.	Hosts	Ctenidia (combs)		Disease	Vector
			Genal (head)	Pronotal (thorax)		
Pulicidae						
Pulex	12	humans, carnivores, marsupials, rodents, birds	absent	absent	irritation, dermatitis, anaemia	plague, typhus, spotted fevers, tapeworms
Echidnophaga	23	birds, rodents, carnivores, marsupials	absent	absent	inflammation, ulceration	rickettsioses, plague, myxomatosis
Xenopsylla	76	rodents, carnivores, marsupials, birds	absent	absent	irritation	plague, typhus, rat tapeworms
Ctenocephalides	12	carnivores, rodents, rabbits, insectivores, ungulates, birds	horizontal	present	pruritus, anaemia, hypersensitivity (flea-bite allergy)	bartonelloses, typhus, plague, dog tapeworm, filarial nematode
Spilopsyllus	1	rabbits, rodents, carnivores, birds	vertical	present	irritation	myxomatosis, tularemia
Tungidae						
Tunga	13	humans, insectivores, rodents, carnivores	absent	absent	inflammation, ulceration	*Staphylococcus, Wolbachia*, tetanus
Ceratophyllidae						
Ceratophyllus	64	birds, rodents, carnivores, ungulates	absent	present	irritation, reduced productivity	
Nosopsyllus	52	rodents, carnivores, some birds	absent	present	irritation	plague, erysipeloid, rat tapeworm

Xenopsylla spp. are primarily rat fleas, but they will readily feed opportunistically on other mammalian hosts, including humans. They are distributed throughout tropical, subtropical and temperate regions, rarely being found in cold regions as such conditions are not conducive to pupation. Studies on flea morphology and biology resulted in the differentiation of 8 species groups; *cheopis, trispinis, nilotica, eridos, brasiliensis, hirsuta, conformis* and *erilli* groups. Several flea species (particularly *X. cheopis*) are regarded to be primary vectors for the transmission of bacterial pathogens, including *Yersinia pestis* causing bubonic plague. Once the source of infection was discovered, flea and rodent control became prime concerns throughout human history in attempts to curb plague epidemics.

***Xenopsylla* species**	**Hosts**	**Clinical signs**	**Distribution**
'*cheopis'* group			
X. acomydis	Rodentia: murid (spiny mouse, Cyprus spiny mouse)		Cyprus
X. aequisetosa	Rodentia: nesomyid (Gambian pouched rat)		Africa
X. astia	Rodentia: murid (black rat, lesser bandicoot rat, greater bandicoot rat, flat-haired mouse, Indian gerbil); Strigiformes: strigid (spotted owlet)		Asia, Africa
X. australiaca	Rodentia: murid (black rat, brown rat, house mouse, spinifex hopping mouse, Mitchell's hopping mouse, ash-grey mouse)		Australia
X. bantorum	Rodentia: murid (field rats)		Africa
X. cheopis (syn. *Alaopsylla murinus, pachyruomyidids, philippinensis, tripolitanus, Pulex, cheopis, murinus*) (Oriental rat flea, tropical rat flea, black rat flea, plague flea)	Rodentia: murid (black rat, brown rat, grey spiny mouse, African grass rat, grassland melomys), sciurid (squirrel, chipmunk); Lagomorpha: leporid (European rabbit); Didelphimorphia: didelphid (Virginia opossum); Diprotodontia: macropodid (black wallaroo); Peramelemorphia: peramelid (northern brown bandicoot); Carnivora: canid (dog, fox), felid (cat), procyonid (raccoon), viverrid (common genet); Primates: hominid (human); Galliformes: phasianid (chicken)	irritation, pruritus (+ vector for plague, murine typhus, rat tapeworm, mouse tapeworm)	worldwide
X. dipodilli	Rodentia: murid (Wagner's gerbil)		Middle-East
X. guancha	Rodentia: murid (black rat, house mouse); Eulipotyphla: soricid (Canarian shrew)		Canary Islands
X. hussaini	Rodentia: murid (Indian gerbil)		India

X. nesiotes	Rodentia: murid (rat, mouse)		Christmas Island
X. nesokiae	Rodentia: murid (short-tailed bandicoot rat), cricteid (mole vole)		Central Asia
X. nubica	Rodentia: dipodid (jerboa, lesser Egyptian jerboa)		Middle-East
X. papuensis	Rodentia: murid (rat, mouse)		New Guinea
X. pestanai	Rodentia: murid (rock rat, striped grass mouse)		Africa
X. versuta	Rodentia: sciurid (African bush squirrel, African striped squirrel), glirid (African dormouse), murid (soft-furred mouse, African four-striped mouse, rock rat, vlei rat)		Africa
X. vexabilis	Rodentia: murid (greater sticknest rat, pale field rat, bush rat, plains rat, common rock rat, dusky rat, dusky field rat, long-haired rat, Cape York rat, brush-tailed rabbit rat, fawn hopping mouse); Dasyuromorphia: dasyurid (northern quoll, antechinus, kowari, crest-tailed mulgara, fat-tailed dunnart); Peramelemorphia: peramelid (northern brown bandicoot)		Australia, Hawaii
'*trispinis'* group			
X. moucheti	Passeriformes: picarthartid (grey-necked rockfowl)		Africa
X. trispinis	Passeriformes: hirundinid (South African cliff swallow)		South Africa
'*nilotica'* group			
X. coppensi	Rodentia: murid (black-tailed gerbil)		Ethiopia
X. debilis	Rodentia: murid (gerbils)		Africa
X. difficilis	Rodentia: murid (gerbils)		Africa
X. humilis	Rodentia: murid (gerbils)		Africa
X. jorgei	Rodentia: murid (four-striped mouse, gerbil)		Africa
X. mulleri	Rodentia: murid (highveld gerbil)		Africa
X. nilotica	Rodentia: murid (gerbils)		Africa
X. orientalis	Rodentia: murid (bushveld gerbil)		Africa
X. raybouldi	Rodentia: murid (gerbils)		Africa
X. silvai	Rodentia: murid (gerbils)		Africa
X. tanganyikensis	Rodentia: murid (gerbils)		Africa
X. trifaria	Rodentia: murid (hairy-footed gerbil, Cape short-eared gerbil)		Africa
'*eridos'* group			
X. eridos	Rodentia: murid (whistling rat, vlei rat, gerbil)		South Africa
X. frayi	Rodentia: murid (bushveld gerbil)		Africa
X. geldenhuysi	Rodentia: murid (highveld gerbil)		Africa
X. hipponax	Rodentia: murid (rock rat, gerbil, soft-furred mouse)		Africa
X. occidentalis	Rodentia: murid (Littledale's whistling rat)		Africa
X. philoxera	Rodentia: murid (gerbils)		South Africa
X. phyllomae	Rodentia: murid (gerbils)		Africa
X. piriei	Rodentia: murid (gerbil, hairy-footed gerbil)		South Africa
'*brasiliensis'* group			
X. angolensis	Rodentia: nesomyid (pouched mouse)		Africa
X. bechuanae	Rodentia: nesomyid (South African pouched mouse)		Africa
X. brasiliensis	Rodentia: murid (black rat, brown rat)		cosmopolitan
X. cornigera	Rodentia: murid (savanna gerbil), glirid (woodland dormouse)		Africa
X. crinita	Rodentia: nesomyid (Gambian pouched rat)		Africa
X. cuisancei	Rodentia: murid (red rock rat, savanna gerbil)		Africa
X. georychi	Rodentia: bathyergid (common mole-rat)		Africa
X. graingeri	Rodentia: murid (acacia rat)		Africa
X. hamula	Rodentia: glirid (woodland dormouse), murid (woodland thicket rat)		Africa
X. morgandaviesi	Rodentia: murid (soft-furred mouse, striped grass mouse, spiny mouse); Eulipotyphla: soricid (musk shrew)		Africa
X. sarodes	Rodentia: nesomyid (South African pouched mouse)		Africa
X. scopulifer	Rodentia: nesomyid (South African pouched mouse)		Africa
X. syngenis	Rodentia: murid (soft-furred mouse, rock rat, gerbils), nesomyid (pouched mouse)		Africa
X. robertsi	Rodentia: murid (black rat, acacia rat, typical striped grass mouse)		Africa
X. torta	Rodentia: nesomyid (Gambian pouched rat)		Africa
X. zumpti	Rodentia: murid (acacia rat, thicket rat, rock rat); sciurid (African		Africa

	bush squirrel)		
'*hirsuta'* group			
X. demeilloni	Rodentia: murid (hairy-footed gerbil, pygmy gerbil)		Africa
X. davisi	Rodentia: murid (hairy-footed gerbil, Cape gerbil)		Africa
X. hirsuta	Rodentia: murid (striped mouse, vlei rat, gerbils)		South Africa
X. lobengulai	Rodentia: murid (Cape gerbil)		South Africa
X. petteri	Rodentia: nesomyid (Malagasy giant rat)		Madagascar
X. sulcata	Rodentia: murid (Cape gerbil)		Africa
'*conformis'* group			
X. blanci	Rodentia: murid (house mouse)		North Africa
X. buxtoni	Rodentia: murid (gerbils)		Iran
X. conformis	Rodentia: murid (gerbil), dipodid (jerboa)		North Africa
X. cunicularis	Lagomorpha: leporid (European rabbit)		North Africa
X. gerbilli	Rodentia: murid (jird, great gerbil)		Central Asia
X. gratiosa	Procellariiformes: procellariid (streaked shearwater)		Atlantic
X. hirtipes	Rodentia: murid (great gerbil, jird)		Central Asia
X. magdalinae	Rodentia: murid (bandicoot rat), cricetid (mole vole)		Central Asia
X. minax [former subsp. of *X. gerbilli*]	Rodentia: murid (great gerbil, jird)		Central Asia
X. nuttalli	Rodentia: murid (gerbils), dipodid (jerboa)		Central Asia
X. persica	Rodentia: murid (Persian jird)		Central Asia
X. ramesis	Rodentia: murid (great gerbil, jird)		
X. skrjabini	Rodentia: murid (great gerbil, jird)		Central Asia
X. regis	Rodentia: murid (great gerbil, king jird)		Middle-East
X. taractes	Rodentia: murid (great gerbil, jird)		North Africa
X. tarimensis	Rodentia: dipodid (northern three-toed jerboa)		China
'*erilli'* group			
X. cryptonella	Rodentia: sciurid (Cape ground squirrel)		Africa
X. erilli	Rodentia: sciurid (Cape ground squirrel)		Africa

Parasite morphology: *Xenopsylla* spp. form 4 different types of developmental stages in their life-cycles; eggs; larvae (3 instars); pupae (cocoons); and adults (males and females). The eggs are white, ovoid (0.4-0.5 x 0.3-0.35 mm) and have small cephalic and caudal pores (aeropyles and micropyles, respectively). The larvae have elongated cylindrical vermiform (worm-like) bodies that are white-cream coloured with darker sclerotized heads possessing powerful mandibles and mandibular teeth well-adapted for biting and chewing. There are 3 larval instars growing in length from 0.5-4.5 mm and each possessing 14 bristly segments. Mature larvae form silken cocoons 2-4 mm long which become adorned with debris (small sand grains and dirt) from the surrounding environment. The enclosed stages transform into pupae by losing the larval head and last 3 segments while the rest of the body becomes compressed (shorter and wider). They are exarate pupae with free appendages (in contrast to many other insects which form obtect pupae whose appendages are fused to the body wall). The emergent adult fleas are laterally compressed, measure from 1.5-4.0 mm in length and have shiny light-dark brown bodies with sclerotized plates (sclerites). They are moderately setate with strong setae, spines and/or bristles, usually facing backwards so as to not impede forward movement through pelage, but catching on hairs when dragged backwards by host grooming. However, *Xenopsylla* spp. do not possess genal (cheek) or pronotal (thoracic) ctenidia (combs of bristles). Adult fleas have small rounded heads, small compact thoracic segments and broad ovoid abdominal segments. The head is helmet-like, smoothly rounded and lacking a frontal tubercle (brow). The frons (forehead) is not heavily sclerotized and integricipit (without an interantennal suture). The head has a pair of small simple noncompound eyes (clusters of ocelli) located laterally with a stout ocular bristle present just in front but below each eye (whereas the ocular bristle in *Pulex* spp. is located beneath each eye). A pair of short compact club-like antennae (each comprising 3 segments) are held flat against the head behind the eyes. There are 6-8 large setae located on each side of the head behind the antennae, many conspicuous in a row along the posterior margin. All adults have conspicuous ventral piercing-sucking mouthparts (lacking mandibles and teeth) located between sensory palps consisting of a pair of long 4-segmented maxillary palps mounted on short blade-like maxillary lobes (stipes) as well as a pair of long 5-segmented labial palps arising from a short basal labium. The actual mouthparts (fascicle) consist of 3 long slender stylets: the 2 outer stylets (maxillary laciniae) being blade-like and serrated; and the third central stylet (labrum-epipharynx) being an outgrowth of the body wall (unique to fleas). All 3 stylets join to form a tube-like canal to inject saliva (via salivary pumps) and ingest blood (via cibarial and pharyngeal pumps). The alimentary tract consists of a tubular foregut (anterior pharynx with salivary glands inserted apically, elongate oesophagus, and small globular proventriculus), a large expandable digestive midgut (simple undivided organ lacking diverticula and caeca, unlike the elaborate divided midguts of other haematophagous arthropods), a tubular hindgut (with excretory Malpighian tubules) and rectum. The thorax has 3 conspicuous segments with a vertical thickening (meral rod) in the ventral mesopleuron. The ventral thorax gives rise to 3 pairs of strong legs, each composed of 5 segments (coxa, trochanter, femur, tibia, and tarsus) and all terminating in a pair of tarsal claws. The hindmost pair of legs are larger and well-adapted for jumping (using unique elastic resilin pads to store energy under compression, rather than

muscular contraction). The legs are setate with prominent posterior tibial bristles and smaller tarsal bristles. The ovate abdomen has 8 visible segments consisting of dorsal tergites and ventral sternites with lateral respiratory spiracles. Most tergites have a single row of setae and the last segment bears a flat dorsal plate-like sensory organ (pygidium or sensilium). Male fleas are smaller than females and have highly elaborate genitals consisting of an aedeagal apodeme (penis plate) with long extendable penis rods held coiled and retracted within an endophallic sac. Female fleas are often recognizable by the presence of dark saccular spermatheca (sperm storage organs) located ventro-posteriorly. Females have 2 ovaries with tubular oviducts connected to the uterus and bursa copulatrix (depression to receive male organ).

Site of infection: Adult fleas are obligate ectoparasites of vertebrates, predominantly mammals (especially rodents but also some small marsupials, carnivores, lagomorphs and occasionally humans) as well as a few birds. Adults move through the pelage/plumage next to the skin and stop intermittently to feed on host blood. Between meals, adult fleas may remain on hosts or may drop off into burrows and nests (they are thought to dislike constant exposure to mammalian body temperatures). All other life stages (eggs, larvae and pupae) occur in the external environment, most being nidicolous and associated with host nests.

Pathogenesis: *Xenopsylla* spp. use their mouthparts to pierce the skin and then ingest blood by sucking from pools forming in the dermis (process known as telmophagy, as opposed to solenophagy where blood is sucked directly from blood vessels). Adults of both sexes feed on blood and some species are able to ingest up to 0.5 ml blood per meal. During feeding, they inject saliva containing numerous chemicals with anticoagulant, vasodilatory and anti-inflammatory properties. Nonetheless, bite sites often become irritated, inflamed and itchy, provoking hosts to scratch with the propensity to exacerbate wounds through self-trauma. Some individual hosts may also exhibit allergic and hypersensitivity responses to persistent infestations. In addition to being annoying pests causing transient skin lesions and anaemia, these rat fleas have gained notoriety as efficient vectors for the transmission of infectious diseases. In particular, the Oriental rat flea (*X. cheopis*) has been shown to transmit *Yersinia pestis* causing bubonic plague (lymph nodes), pneumonic plague (lungs) and septicaemia plague (skin, viscera) in humans. The bacteria multiply rapidly in the guts of the fleas often blocking the proventriculus and causing the hungry fleas to search for new hosts which become infected by regurgitative feeding. Adult fleas have also been shown to transmit other bacterial infections to humans, including *Rickettsia typhi* (the causative agent of murine or endemic typhus) and several *Bartonella* spp. (causing bartonellosis characterized by prolonged intraerythrocytic bacteraemia). Several flea species have also been found to act as vectors for the transmission of the nonpathogenic trypanosome (*T. lewisi*) in rats, and as intermediate hosts for *Hymenolepis diminuta* (rat tapeworm) and *H. nana* (mouse tapeworm).

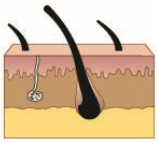
Developmental cycle and mode of transmission: These rat fleas, like all fleas, exhibit holometabolous development where vermiform larvae undergo complete metamorphosis in pupal cocoons to form adult fleas. Gravid female fleas residing on hosts lay 15-20 eggs each day (sometimes up to 50 eggs per day). The eggs are not sticky and invariably drop off the host into the surrounding environment, particularly into dirt and crevices in nesting materials. Depending on prevailing environmental conditions, the eggs hatch in 2-12 days (or longer in colder conditions). The emergent larvae use their biting/chewing mandibles to feed on organic material in the environment (including plant detritus, cereal grains, and other micro-organisms), but rarely on ‘flea dirt’ (pellets of dried blood excreted by adults into the environment) like many other flea taxa. The larvae moult twice over 9-15 days, although it may take up to 200 days in unfavourable cold conditions. Mature third-stage larvae then weave silken cocoons around themselves and pupate into adult fleas over 5-14 days. The adult fleas usually remain in their pupal cases until they sense the presence of a nearby host by a combination of mechanical, chemical and thermal receptors (detecting vibration, pressure, noise, heat and increased carbon dioxide concentrations). Emergent fleas seek hosts and are able to jump up to 30-50 cm to engage hosts. Unfed fleas have been shown to survive for 6-10 weeks without feeding, but both sexes require bloodmeals to mature sexually. Fertilized females lay eggs regularly and may produce up to 600 eggs in their life-times. Adults have relatively long life-spans, and may survive for up to one year with regular access to bloodmeals. They are distributed throughout tropical, subtropical and temperate regions, and epidemiological and experimental studies have shown they flourish best when able to pupate in warm climatic conditions (temperatures of 20-25°C).

Differential diagnosis: Infestations are usually diagnosed by the direct detection of adult fleas on hosts, although they can be difficult to catch for microscopic examination. Fleas can be recovered from dead animals by roughly swabbing them with alcohol in plastic bags and then examining the washings. Adults can be identified by their morphological characteristics, particularly their rounded heads, setate bodies and the absence of genal and pronotal combs. Molecular biological techniques have been used to characterize species by polymerase chain reaction (PCR) amplification of nuclear (ribosomal RNA and internal transcribed spacer regions) and mitochondrial (16S ribosomal RNA) gene sequences.

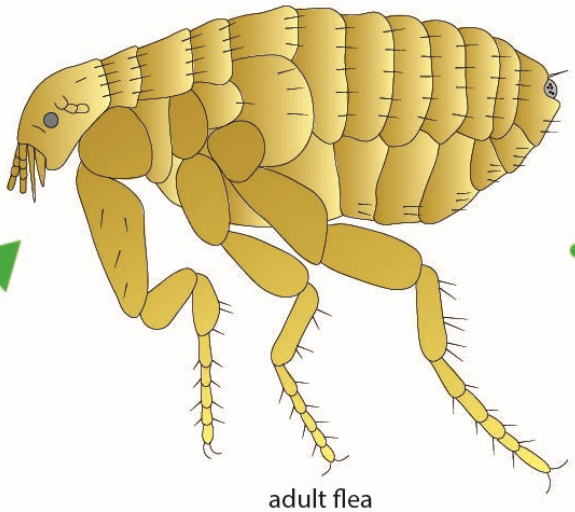
Treatment and control: Many studies have been conducted on flea and vermin control in peri-urban environments due to the potential for rat fleas to transmit deadly infectious diseases to humans (such as plague). Considerable efforts have been made to eradicate rodents from communities by trapping, baiting or poisoning them. However, some initial caution is advised as starving fleas may seek alternative hosts on which to feed, including humans. Flea bites are generally treated with anti-inflammatory agents

such as topical steroids (glucocorticoids, prednisolone), cooling preparations (propylene glycol, menthol, camphor, pramoxine, calamine, and ice compresses) together with antibiotics for secondary pyoderma. Animals may be treated with insecticidal chemicals, including organophosphates (coumaphos, chlorfenvinphos, diazinon, malathion, trichlorfon), pyrethroids (permethrin, cypermethrin), chloronictinyles (imidacloprid, nitenpyram), carbamates (carbaryl), arylpyrazoles (fipronil), macrocyclic lactones (selamectin) and some insect growth regulators (lufenuron, pyriproxyfen). Attempts should be made to decontaminate the surrounding environment (bedding, nests, burrows) with environmental insecticides (such as flea bombs and sprays containing organophosphates or pyrethroids) or desiccants (diatomaceous earth, sodium polyborate). Infested houses should be thoroughly cleaned by washing hard substrates and crevices with disinfectants, shampooing and vacuuming carpets, and fogging or spraying rooms with residual pyrethroid insecticides (cyfluthrin, fenvalerate).

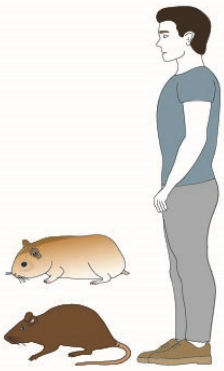
Xenopsylla



skin/pelage
(irritation, pruritus, dermatitis, allergy)
(vector for infectious microbial diseases)



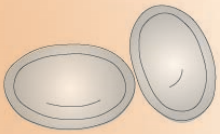
adult flea
(~ 3.5 mm)



Definitive Hosts
(mammals, mainly rodents, some birds)

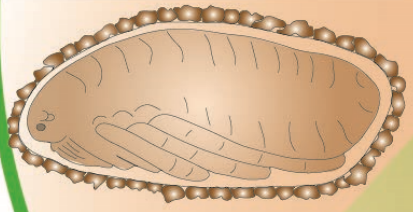
adult ectoparasitic on host
(feed on blood)

eggs drop off host

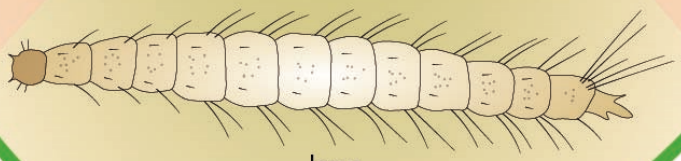


eggs
(~ 0.4 mm)

eclosion



pupa
(~ 1 mm)

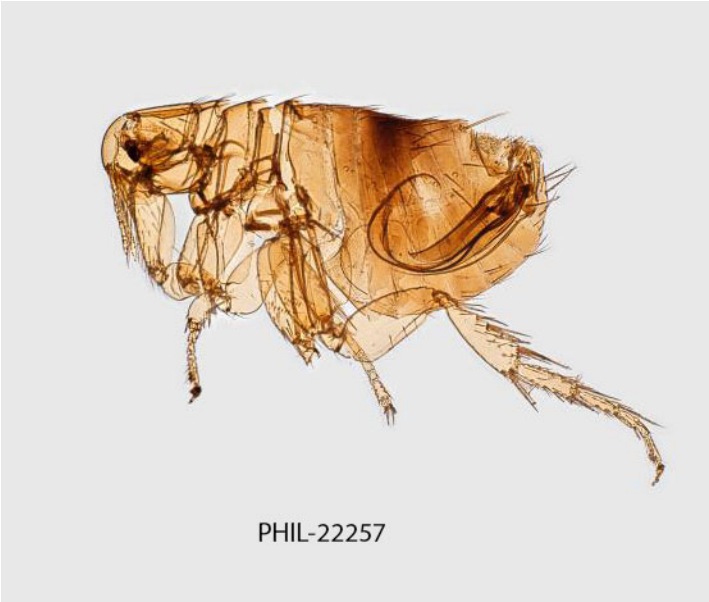


larva
(~ 4 mm)

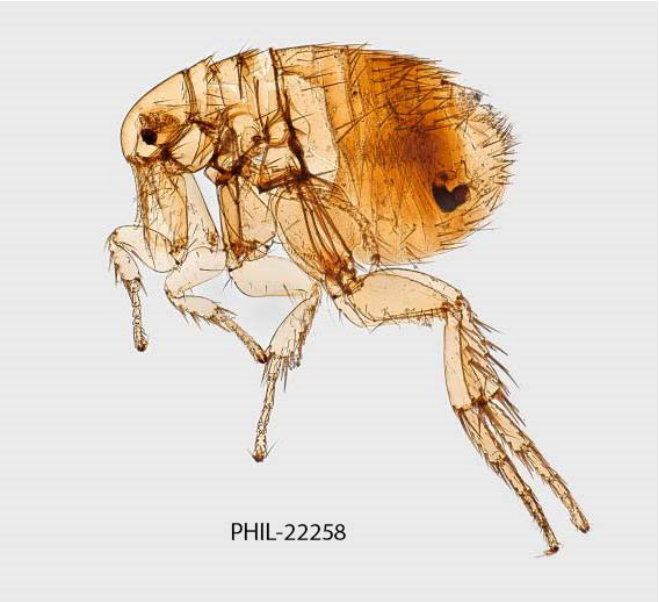
encasement

hatch

free-living in external environment
(esp. bedding, nests, hides)



Xenopsylla adult male



Xenopsylla adult female

Xenopsylla larva