

Pediculus
(insect: louse)

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. Lice (Phthiraptera) are small wingless dorsoventrally-flattened hemipterodeans which are permanent obligate ectoparasites on other animals. All lice undergo gradual metamorphosis and there are no free-living stages. Eggs are cemented to host hairs whereas nymphs and adults cling to hairs using enlarged tarsal claws. Lice do not survive long off their hosts so transmission is usually by direct contact. Anopluran (sucking) lice have narrow pointed heads adapted to piercing the skin and feeding on tissue fluids (solenophage mode of feeding). Sucking lice are ectoparasitic on mammals and most species are highly host specific and even site-specific, being found predominantly in areas with coarse hairs. Pediculids occur on primates, with different *Pediculus* spp. or subspecies infesting the head and body of humans causing irritation, dermatitis, pruritus and excoriation. Human body lice may also transmit bacterial pathogens, including rickettsias (causing epidemic or louse-borne typhus, and trench fever) and spirochaetes (causing relapsing or recurrent fever).

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: Hemipteroidea (Exopterygota) (young resemble adults, externally developing wings)
Order: Phthiraptera (lice, wingless, ectoparasites, dorsoventrally flattened, stout legs, claws, eggs, nymphs, adults)
Suborder: Anoplura (sucking lice, narrow pointed head, pierce skin and feed on fluids (solenophagy))
Family: Pediculidae (head/body lice of primates)
Genus: *Pediculus* (parasitic on skin/hair of primates)
Species: two species cause pruritus in humans

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 Hemipteroidea (Exopterygota) containing the orders Hemiptera (bugs) and Phthiraptera (lice); and the Holometabola (Endopterygota) containing the orders Siphonaptera (fleas) and Diptera ('true' flies). Lice are small wingless hemipterodeans that undergo gradual (hemimetabolous) metamorphosis and are permanent obligate ectoparasites on other animals. Four suborders are recognized: the Anoplura containing the haematophagous sucking lice of placental mammals; the Ischnocera and Amblycera (previously classified together as Mallophaga) comprising the chewing or biting lice of birds, marsupials and placental mammals; and the Rhynchophthirina confined to elephants and warthogs in Africa.

Major parasitic phthirapteran families	Biodiversity	Hosts	Parasitic stages	Pathogenesis	Disease transmission
Suborder: Anoplura (sucking lice of placental mammals) (narrow pointed head, pierce skin and feed on fluids (solenophagy)) [16 families, 51 genera, 694 species]					
Pediculidae (head & body lice)	1 genus, 4 spp.	mammals (hominids, New World primates)	nymphs, adults	blood-sucking	bacterial
Pthiridae (pubic lice)	1 genus, 2 spp.	mammals (hominids)	nymphs, adults	blood-sucking	-
Haematopinidae (ungulate lice, short-nosed lice)	1 genus, 21 spp.	mammals (equids, bovids, suids)	nymphs, adults	blood-sucking	viral, bacterial
Linognathidae (pale lice, long-nosed lice)	3 genera, 73 spp.	mammals (bovids, canids)	nymphs, adults	blood-sucking	-
Suborder: Rhynchophthirina (sucking lice of African wildlife) [1 family, 1 genus, 4 species]					
Haematomyzidae (elephant & warthog lice)	1 genus, 4 spp.	mammals (elephants, warthogs)	nymphs, adults	blood-sucking	-
Suborder: Ischnocera [Mallophaga p.p.] (chewing lice of mammals and birds, broad rounded head, without maxillary palps, prominent filiform antennae, keratin feeders) [2 families, 158 genera, 3,371 species]					
Trichodectidae (fur lice)	20 genera, 413 spp.	mammals (bovids, equids, carnivores)	nymphs, adults	biting	helminth
Philopteridae (bird lice)	138 genera, 2,958 spp.	birds	nymphs, adults	biting, chewing	-
Suborder: Amblycera [Mallophaga p.p.] (chewing lice of mammals and birds, large rounded head, with maxillary palps, 4-segmented antennae in antennal grooves, keratin feeders) [6 families, 96 genera, 1,550 species]					
Menoponidae (bird lice)	68 genera, 1,150 spp.	birds	nymphs, adults	biting, chewing	-
Boopiidae (marsupial chewing lice)	8 genera, 57 spp.	mammals (incl. marsupials)	nymphs, adults	biting	helminth

Some 700 species of anopluran sucking lice have been described in 51 genera in 16 families, namely: Echinophthiriidae (*Antarctophthirus*, *Echinophthirus*, *Latagophthirus*, *Lepidophthirus*, *Proechinophthirus*); Enderleinellidae (*Atopophthirus*, *Enderleinellus*, *Microphthirus*, *Phthirunculus*, *Werneckia*); Haematopinidae (*Haematopinus*); Hamophthiriidae (*Hamophthirus*); Hoplopleuridae (*Ancistroplox*, *Ferrisella*, *Haematopinoidea*, *Hoplopleura*, *Paradoxophthirus*, *Pterophthirus*, *Schizophthirus*, *Typhlomyophthirus*); Hybophthiridae (*Hybophthirus*); Linognathidae (*Linognathus*, *Prolinognathus*, *Solenopotes*); Microthoraciidae (*Microthoracius*); Mirophthiridae (*Mirophthirus*); Neolinognathidae (*Neolinognathus*); Pecaroecidae (*Pecaroecus*); Pedicinidae (*Pedicinus*); Pediculidae (*Pediculus*); Polyplacidae (*Abrocomaphthirus*, *Ctenophthirus*, *Cuyana*, *Docophthirus*, *Eulinognathus*, *Fahrenholzia*, *Galeophthirus*, *Haemodipsus*, *Johnsonphthirus*, *Lagidiophthirus*, *Lemurpediculus*, *Lemurphthirus*, *Linognathoides*, *Neohaematopinus*, *Phthirpediculus*, *Polyplax*, *Proenderleinellus*, *Sathrax*, *Scipio*); Pthiridae (*Pthirus*); and Ratemiidae (*Ratemia*). Those of medical significance are found in the families Pediculidae (hominids, New World primates) and Pthiridae (hominids), while those of particular veterinary significance occur in the families Haematopinidae (equids, bovids, suids), Linognathidae (bovids, canids), Hoplopleuridae (rodents), Pedicinidae (Old World primates) and Polyplacidae (rabbits, rodents). Pediculids have pointed heads with eyes, elongate bodies, 6 similar legs, and conspicuous abdominal paratergites. The family comprises a single genus, *Pediculus*, containing four recognized species, although over 40 names had been proposed for different isolates but are now considered to be junior synonyms or invalid. Humans are infested by head and body lice which are highly host-specific and will not infest other animals, although body lice colonies can be bred in the laboratory after their adaptation to feeding on rabbits. Head and body lice are remarkably similar morphologically and genetically but they normally do not interbreed, although they have been shown to do so with partial success under experimental conditions. Some authors regard them to be separate species (*P. capitis* and *P. humanus*), while others consider them to be subspecies or ecotypes of *P. humanus*. There is no doubt that they exhibit significant differences in biology; particularly in tropism, development, ecology, pathogenicity and vectorial capacity. Two additional species have also been recorded from non-human primates; *P. schaeffi* from chimpanzees and bonobos and *P. mjobergi* (or *P. humanus mjobergi*) from South American monkeys.

<i>Pediculus</i> species	Hosts	Location	Clinical signs	Distribution
<i>P. humanus</i> (syn. <i>P. h. humanus</i> , <i>P. h. corporis</i> , <i>P. corporis</i> , <i>P. vestimentis</i>) (human body louse, clothing louse)	Primates: hominid (human)	skin (body), clothing	irritation, dermatitis, pruritus [plus vector for bacterial pathogens causing epidemic (louse-borne) typhus, trench fever, relapsing (recurrent) fever]	Africa, Asia, Americas
<i>P. capitis</i> (syn. <i>P. h. capitis</i>) (human head louse)	Primates: hominid (human)	skin (head)	irritation, dermatitis, pruritus	worldwide
<i>P. mjobergi</i> (syn. <i>P. h. mjobergi</i> , <i>atelophilus</i> , <i>chapini</i> , <i>lobatus</i>)	Primates: cebid (Columbian white-faced capuchin, tufted capuchin), atelid (black-headed spider monkey, black-handed spider monkey, red-faced spider monkey, white-bellied spider monkey, red-handed howler, black howler, mantled howler, Guatemalan howler)	skin (head, body)	irritation, dermatitis, pruritus	zoos, South America
<i>P. schaeffi</i>	Primates: hominid (chimpanzee, bonobo)	skin (head, body)	irritation, dermatitis, pruritus	zoos, Africa

Parasite morphology: Lice form three developmental stages: eggs, nymphs (3 instars) and adults. Eggs appear as white-tan ellipsoidal operculate bodies (0.8 x 0.3 mm) glued along half of one side to hair shafts (head lice) or clothing fibres (body lice). Eggs are colloquially called nits by some authorities, whereas others reserve the term for empty eggshells. There are three nymphal instars which are similar in appearance to adults (or imagoes). All have three body parts (head, thorax and abdomen), but the nymphs are smaller measuring 1.0-2.5 mm in length, are less sclerotized, possess fewer body setae, and lack genitalia. Adult lice have elongated dorsoventrally flattened bodies (1.0-4.5 mm long) which appear opaque although darker internal organs can be seen mainly in the abdomen. Head lice are slightly smaller than body lice, with females being 1.8-3.3 mm and males 1.0-2.6 mm long, compared to 2.0-4.5 mm and 2.0-3.0 mm respectively. They are sucking lice and have small pointed rhomboidal heads (as wide as long) with long thin terminal mouthparts modified for piercing and sucking. The mouthparts are located in a snout-like proboscis (labrum) containing an eversible tubular haustellum armed with teeth and supporting four retractable stylets (two supported by maxillae to form a food channel, one derived from the hypopharynx and connected to the salivary gland, and one derived from the flattened labium and serving to guide the other stylets). The mouthparts are retracted into a pocket in the head when not used for feeding. The mouthparts lack sensory maxillary palps (present in amblyceran chewing lice), and they lack mandibles and pulvinus pads (present in other chewing/biting lice). The head has two prominent noncompound eyes (lateral ocelli) and a pair of short antennae (each with 5 segments). The alimentary tract consists of a foregut (with buccal funnel, cibarial pump, pharynx and oesophagus), a large midgut (with ventriculus, anterior caeca and round mycetome (special organ, sometimes called bacteriome or stomach disc, harbouring bacterial/fungal symbionts)), and a hindgut (with pylorus, papillae and rectum). The thorax appears as a truncated cone possessing a reduced tergum with a small notal pit, and three pairs of stout jointed legs of similar size, each with five sections (coxa, trochanter, femur, tibia, and tarsus). The legs terminate in large tarsal claw closing onto a small tibial spur (thumb) with small bristles. The diameter enclosed by the modified tibiotarsal claws conforms to the diameter of the host hair shafts at the predilection sites of infection. The elongate abdomen is membranous with seven segments having prominent sclerotized paratergal plates (the first six segments each have a pair of spiracles for breathing and the last segment contains the genitalia and anus). The terminal abdominal segment in males is pointed and contains a well-developed genital apparatus visible through the cuticle. Male genitalia comprise compact lobular testes, tubular vas deferens, saccular seminal vesicle, and an elaborate genital sac with an aedeagus (penis-like tube with dorsal gonopore and terminal V-shaped pseudopenis) supported by large basal apodeme (plate-like sclerite) and short lateral parameres (rod-like sclerites). The terminal abdominal segment in females is W-shaped with two well-developed gonopods used to assist oviposition. Female genitalia comprise ovaries with polytrophic ovarioles, tubular oviducts, an ovoid uterus with accessory glands (for eggshell and cement/glue production), and a vagina supported by a large transverse genital plate, valvula and setae (spermatheca indistinct or absent).

Site of infection: Head lice are known colloquially as cooties, greybacks, or mechanized dandruff. All developmental stages are found attached to, or grasping, hairs on the head, especially at the back of the neck and behind the ears. They are highly site-specific and head lice transplanted to other body regions attempt to migrate back to the head. Body lice spend most of their time in host clothing, especially around the waist and beneath armpits. Nymphs and adults visit the host skin to feed and then return to clothing where mature female lay eggs (hence their colloquial name of seam squirrels in some countries).

Pathogenesis: Louse infestation causes a condition known as pediculosis. In humans, the variant pediculosis capitis is caused by head lice and that of pediculosis corporis (also known as pediculosis vestimenti, vagabond's or hobo's disease) is caused by body lice. Nymphs and adults of both species feed by piercing the skin with their elongate mouthparts and sucking blood (solenophage mode of feeding) about every 2-3 hours. Light infestations by head lice may only cause moderate itching of the scalp exacerbated by sensitization to louse saliva. Heavy infestations, however, may cause considerable discomfort as the bites produce red papules and intense pruritus (itching) which induces scratching leading to dermatitis and secondary infections with impetigo and pyoderma and occasional swelling of local lymph nodes and fever. Head lice infestations are endemic worldwide, with children aged from 3-13 years being frequently infested (particularly girls with long hair), and outbreaks occurring during winter months (possibly due to host crowding). Persistent head lice infestations may cause matting of the hair with concomitant fungal growth contributing to a fetid odour (condition known as plica polonica). Body lice also cause considerable discomfort and skin irritation due to their feeding activities, resulting in intense pruritus, red papules, aches and fever. Infestations persisting over years may cause thickened darkened skin (vagabond's disease). While significant outbreaks have been described in many countries throughout human history, notably in times of great deprivation and war (esp. World War I), the current geographic distribution of body lice is restricted to temperate regions and high elevations of Africa, Asia and the Americas. Heavy infestations have often been associated with crowded and unsanitary conditions, often occurring after population displacements (translocations) associated with civil unrest, war, famine or natural disasters. Infestations of monkeys by other *Pediculus* spp. have been associated with irritation, papulocrustous dermatitis, self-excoriation, alopecia, anaemia, illthrift and poor weight gain.

Body lice have been shown to act as vectors for the transmission of several bacterial pathogens to humans, including *Rickettsia prowazekii* causing epidemic or louse-borne typhus, *Bartonella* (formerly *Rochalimaea*) *quintana* causing trench fever, bacillary angiomatosis bacteraemia, endocarditis and chronic lymphadenopathy, and the spirochaete *Borrelia recurrentis* causing relapsing or recurrent fever. Microbial transmission usually occurs when lice or their wastes are crushed or smeared into feeding sites or contaminate wounds. Experimental studies have implicated body lice as potential vectors for other bacteria (*Acinetobacter baumannii*, *A. Iwoffii*, *Rickettsia akari*, *R. conorii*, *R. rickettsia*, *R. typhi* and *Yersinia pestis*), and recent molecular biological studies have detected bacterial DNA from *Anaplasma phagocytophilum* and *Coxiella burnetii* in body lice and from *Acinetobacter* spp., *Anaplasma* sp., *Borrelia theileri*, *Coxiella burnetii*, *Ehrlichia* spp., *Rickettsia aeschlimannii*, *Yersinia pestis* and Moraxellaceae in head lice, but their significance in disease transmission is unknown.

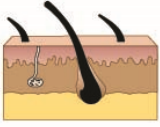
Developmental cycle and mode of transmission: Once hatched, lice undergo gradual metamorphosis whereby nymphs moult several times before forming adults. Eggs hatch within seven days and there are three nymphal moults taking 8-9 days. Adult lice then mate and fertilized female lice begin laying eggs shortly thereafter (laying from 50-150 eggs at a rate of around 10 per day). The whole life-cycle may be completed in 2-3 weeks. Head lice attach to hairs and do not survive long off their hosts. Infestations are therefore transmitted between hosts by direct physical contact when nymphs or adults crawl from one host to another, however, some transmission may occur via contaminated fomites (headwear, clothing or bedding). Head louse populations often exhibit pronounced seasonal fluctuations, apparently linked to crowding during winter housing, particularly in temperate regions. Body lice spend most of the time in host clothing and their eggs are attached to fibres in clothes, usually along seams. The whole life-cycle of body lice can take longer at lower temperatures (2-4 weeks), such as when clothing is removed at night or worn intermittently, but the lice will die if clothing is not worn for several days. Infestations can be transmitted by physical contact with infested people or with articles (clothing, bedding and towels) shared with infested persons. Transmission is highest between people living in impoverished conditions in institutions (orphanages, psychiatric hospitals), prisons (penal, political), camps (concentration, refugee, disaster-relief) and shelters (transients, homeless), particularly where clothing cannot be laundered and/or changed frequently. Body lice were more common in cooler parts of the world; in tropical areas people who wear less clothing usually have only head lice.

Differential diagnosis: Infestations are diagnosed by the direct detection of live lice in hair or clothing or their egg cases (nits) attached to hairs or clothing fibres. Fine-toothed combs have been used for millennia to remove head lice and nits, often in conjunction with hair conditioner to untangle hairs and trap lice. Close visual inspection of clothing along the seams may reveal body lice and nits, which can subsequently be removed (nit-picking). Molecular characterization techniques have been used to examine the phylogenetic relationships between various *Pediculus* species and isolates using polymerase chain reaction (PCR) amplification of nuclear (18S ribosomal RNA, elongation factor 1- α , RNA polymerase II) and mitochondrial (cytochrome b, cytochrome c oxidase subunit I, and NADH-ubiquinone oxidoreductase chain 4) gene sequences.

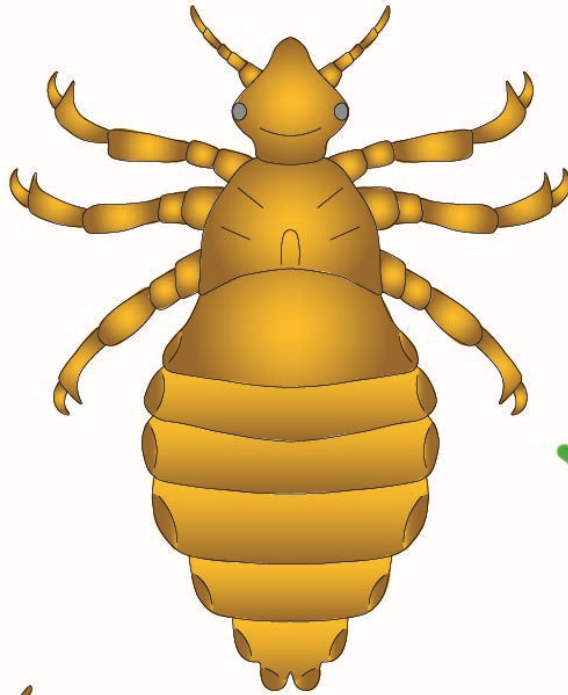
Treatment and control: Various insecticides have been used to control louse infestations on humans and other primates. Most conventional insecticides are available as topical formulations (medicated shampoos, lotions or creams) but some newer drugs are systemic (pour-on, oral or injectable formulations). Conventional organophosphates (malathion, chlorpyrifos, diazinon), organochlorides (dichloro-diphenyl trichloroethane (DDT), lindane), pyrethrins, synthetic pyrethroids (permethrin), carbamates (carbaryl, carbaryl), formamidine (amitraz), chloronicotinyl (imidacloprid), spinosyns (spinosad), arylpyrazole (fipronil), and macrocyclic lactones (ivermectin, selamectin) have shown good efficacy, particularly against nymphs and adult lice. Repeat treatments are required within 10 days as most insecticides have limited activity against eggs. Careful attention should also be paid

to drug contra-indications as some formulations exhibit toxicity or produce adverse side-effects. Unfortunately, varying degrees of resistance have been detected in louse populations to most insecticides (except spinosad), so researchers have begun to explore a range of alternative or herbal remedies. Other chemicals have also been used to occlude respiratory function or disrupt the structural integrity of lice, including synthetic silicone oils (dimeticone), esters (isopropyl myristate), detergents (octanediol) and aromatic alcohols (benzyl alcohol). During infestations, daily grooming with nit combs is recommended to remove head lice and their eggs, usually using conditioners or lubricants to ease tangles and help dislodge nits. A medieval remedy of last resort is to shave the hair from the head and impose strict hygiene. Some countries still enforce home quarantine of infested school-children to curtail outbreaks. Mass treatments for body lice infestations have involved blowing talcum powder mixed with permethrin, lindane or even DDT between the body and underclothes, regularly changing clothes, washing soiled clothing and bedding in warm water (heated to at least 60°C) with soap containing DDT, and ironing clothes, particularly over seams. Inter-personnel hygiene must be improved and shared clothing, bedding and grooming implements (brushes, combs) should be avoided. Continuous surveillance programs should be maintained because the potential exists for the wider dissemination of lice in our modern world of international travel, refugee translocations and globalization.

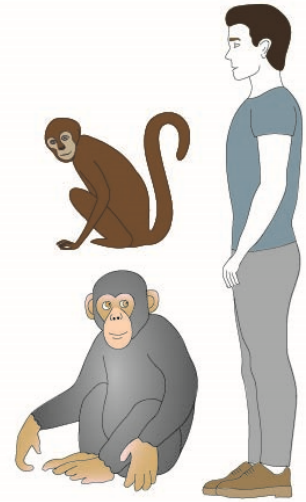
Pediculus



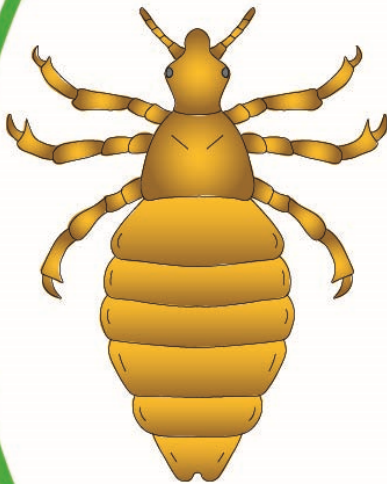
skin/pelage
(irritation, pruritus,
dermatitis, excoriation)
(some vector infectious
microbial diseases)



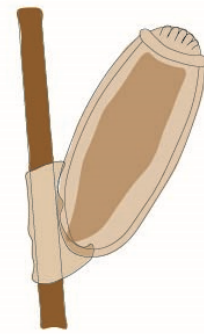
adult (dorsal)
(~ 3 mm)



Definitive Hosts
(primates)



nymph (dorsal)
(~ 2 mm)



egg
(~ 0.8 mm)

all stages ectozoic on host
(motile stages feed on blood)

transmission between hosts
through transfer of motile stages
by direct contact or via fomites



Pediculus adult female



Pediculus adult male



Pediculus adult



Pediculus nymph