Pthirus
(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. Pthirids occur on primates, with different species found on humans and gorillas. Infestations by human pubic lice (*Pthirus pubis*) are transmitted mainly by sexual contact and may cause irritation, dermatitis and intense pruritus.

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:	Hemipterodea (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:	Pthiridae (pubic lice of primates)
Genus:	*Pthirus* (parasitic on skin/hair of humans)
Species:	*P. pubis* causes irritation/dermatitis 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 Hemipterodea (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	Patho-genesis	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]					
Pthiridae (pubic lice)	1 genus, 2 spp.	mammals (hominids)	nymphs, adults	blood-sucking	-
Pediculidae (head & body lice)	1 genus, 4 spp.	mammals (hominids, New World primates)	nymphs, adults	blood-sucking	bacterial
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*, *Echinophthirius*, *Latagophthirus*, *Lepidophthirus*, *Proechinophthirus*); Enderleinellidae (*Atopophthirus*, *Enderleinellus*, *Microphthirus*, *Phthirunculus*, *Werneckia*); Haematopinidae (*Haematopinus*); Hamophthiriidae (*Hamophthirius*); Hoplopleuridae (*Ancistroplax*, *Ferrisella*, *Haematopinoides*, *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*, *Johnsonpthirus*, *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). Pthirids have short heads with eyes, compact ovoid bodies, mid- and hind-legs and claws stouter than the fore-legs, and 4 pairs of lateral abdominal tubercles. The family contains a single genus, *Pthirus*, with two species: human pubic lice *P. pubis* (commonly called 'crabs' because they have grasping tarsi reminiscent of crab pincers); and gorilla lice *P. gorillae*. [Note that the correct spelling for the genus is *Pthirus* according to the International Code of Zoological Nomenclature (ICZN), with the names *Phthirus* and *Phthirius* designated as invalid emendations of the original.] *P. pubis* is host-specific for humans and infestations have been found worldwide in all races and ethnic groups.

***Pthirus* species**	**Hosts**	**Location**	**Clinical signs**	**Distribution**
P. pubis (syn. *P. inguinalis, chavesi, Pediculus ferus, pubis*) (human pubic louse, crab louse)	Primates: hominid (humans)	skin (pubis, occasionally eyebrows, eyelashes, beard, moustache)	irritation, dermatitis, pruritus	worldwide
P. gorillae (gorilla louse)	Primates: hominid (gorillas)	skin (groin, armpits, legs, arms)	irritation, pruritus	Rwanda, DR Congo

Parasite morphology: *Pthirus* spp. form three different types of morphological stages during their life-cycles: eggs (nits); nymphs (3 instars); and adult lice. The eggs are oval shaped (0.5-1.0 x 0.3 mm), brown to opalescent white in colour, operculate (with convex caps perforated by air holes), and glued by their bases (rather than their sides) to hair shafts. Nymphs are similar in morphology to adult lice but are smaller (measuring 1.1-1.3 mm long), less sclerotized (slightly transparent and whitish-grey in colour), have fewer body setae, and lack genitalia. Adult lice are yellow-green in colour but turn red-brown after blood meals. They have small oval dorso-ventrally flattened bodies (dorsal tergum, ventral sternum) measuring 1.1-2.2 mm in length (smaller than head and body lice). They superficially resemble crabs (hence their common name of crab lice) and have three body segments comprising a short blunt head, broad rectangular thorax and short conical abdomen. The head has a pair of short five-segmented antennae in front of a pair of simple noncompound eyes (ocelli) laterally positioned (on protuberances in gorilla lice). The ventral mouthparts are long and thin and modified for piercing and sucking. They are located in a snout-like proboscis (labrum) containing an eversible tubular haustellum armed with teeth and supporting 4 retractable stylets (2 stylets supported by lateral maxillae to form a food channel, one derived from the hypophyarnx and connected to the salivary gland, and one derived from a flattened labium with a serrated tip). When not used for feeding, the mouthparts are retracted into a pocket in the head. Pthirid lice lack maxillary palps (present in amblyceran lice) and do not have mandibles or pulvinus pads (present in most chewing/biting lice). Internally, 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 small head fits into an anterior notch in the wide thorax which lacks a sternal plate and notal pit. The thorax gives rise to three pairs of legs, each with 5 segments (coxa, trochanter, femur, tibia, tarsus). The fore-legs are slim and adapted for holding onto the skin during feeding, while the mid- and hind-legs are stouter and terminate in robust tarsal claws that close onto tibial spurs (thumbs) to grasp the coarse hairs of the pubis (and sometimes those of the armpits, eyebrows or eyelashes). The abdomen is unique for the genus *Pthirus* in that the first 5 segments are combined while the posterior 4 segments are membranous and bear dorsal spiracles located on conspicuous lateral hump-shaped tubercles (body wall protrusions) with conspicuous setae. Male lice are slightly smaller than female lice and have rounded posterior ends while those of females appear bifurcated with 2 small lateral gonopods (lobes that assist in oviposition). The male reproductive system consists of compact bilobed testes connected to tubular vas deferens which coalesce to form a seminal vesicle opening into the genital sac equipped with an aedeagus (copulatory or intromittent organ with dorsal gonopore and terminal pseudopenis) supported by a large basal plate (apodeme) and flanked by thick lateral plates (parameres). The female reproductive system comprises elongate ovaries with polytrophic ovarioles connected to tubular oviducts joined to a globular uterus with accessory glands (secrete glue/cement), a large spermatheca (for sperm storage after mating), and a genital opening (vagina) with a broad genital plate, valvula and lateral gonopods with setae.

Site of infection: The enlarged tarsi of pubic lice are adapted to gripping coarse hairs and most infestations are confined to the pubic region, but can involve the peri-anal region, upper thighs, genitals and lower abdomen. Occasionally, pubic lice may be found in other coarse-hair locations, including the armpits, beard, moustache, eyebrows and eyelashes.

Pathogenesis: Infestations by pubic (crab) lice generally cause discomfort and local inflammation, with symptoms becoming more severe in heavier infestations. The disease is known as pthiriasis pubis (earlier called pediculosis pubis or pediculosis inguinalis). Nymphs and adult lice feed by piercing the skin with their mouthparts, injecting saliva containing anticoagulants and sucking blood. They may remain attached for hours or even days feeding intermittently (4-5 times daily). Bite sites appear as small red papules or light-blue macules (maculae caerulae) blue-grey in colour due to haemosiderin deposits, especially in chronic infestations. Inflammatory responses (erythema, dermatitis) often cause irritation with intense pruritus in infested areas, particularly the groin but sometimes the armpits, eyebrows or eyelashes. Some individuals may exhibit allergic (hypersensitive) reactions to bites with pruritus intensifying nocturnally. Hosts attempt to relieve the itching by scratching, often causing minor lesions (abrasions/ulcerations with crusting) which are susceptible to secondary bacterial or fungal infections leading to pus formation, lymphadenopathy and sometimes fever. Infestation of the eyelashes may cause inflammation of the eyelids (condition known as pthiriasis palpebrarum) which may be seborrheic or eczematous, with bilateral ocular itching, irritation, erythematous lesions, secondary blepharitis, marginal keratitis and follicular conjunctivitis. Unlike body lice, pubic lice do act as a mechanical or biological vectors for other infectious microbial diseases.

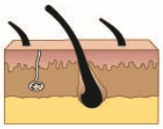
Developmental cycle and mode of transmission: Pubic lice are obligatory ectoparasites with all developmental stages occurring on hosts. Direct transmission occurs when nymphs/adults crawl from one host to another during periods of intimate contact (sexual contact or close body contact) or via recently-contaminated fomites (bedding, towels, clothing). Mature female lice lay eggs which are glued to host hairs and hatch after a 7-8 day incubation period releasing first stage nymphs (N1). The nymphs grasp hairs near their bases and feed on blood by piercing the skin with their sucking mouthparts. Unfed nymphs die within a day, and all subsequent stages require bloodmeals for further development, feeding regularly but intermittently. They undergo gradual (incomplete) metamorphosis (hemimetabolous development) moulting through another 2 nymphal stages before moulting to immature adults after 13-17 days. Pubic lice are not highly mobile and they do not move far (several millimetres-centimetres per day). Male lice are more active than females and seek mates. Female lice have a spermatheca (sperm storage organ) and only need to be fertilized once to become fertile. Gravid females begin laying eggs 1-2 days after mating and lay on average a total of 30 eggs (up to 3 eggs daily for up to 15-17 days). The entire life-cycle may be completed on a single host in 20-25 days. Transmission between hosts occurs

when lice (nymphs or adults) are dislodged and crawl to infest new hosts (transmission may involve a single fertilized female). Dislodged stages cannot live long without feeding and will die within 20-24 hours if they do not find a host. Most transmission occurs directly between humans during interludes of close physical contact (predominantly sexual intercourse but also foreplay and other intimate activities). Lice may be transferred from genital areas to facial hairs (eyelashes, eyebrows, beard, moustache) by hand or oral sexual contact. Pubic lice are most prevalent in patients that are sexually active aged between 15 and 40 years (more common in females aged 15-19 and males aged 20 years and older). Infestations are rare in countries or communities where genital hair is removed for social or cosmetic reasons. Transmission may occasionally occur via the contamination of shared items (such as clothing, bedding, towels and sometimes upholstered seating). There have been well-documented instances of infestations in young children sharing beds with parents, amongst soldiers sharing barrack facilities, and sometimes between patrons of cinemas with recurring sessions. Epidemiological studies have shown pubic lice infestations to be generally associated with poor hygiene, overcrowding, slum dwellings and rural-to-urban translocations. Infestations by gorilla lice are transmitted between animals during close contact (including rest, play, fighting, embracing as well as coitus) and lice populations are usually well regulated by communal grooming (especially mothers grooming infants).

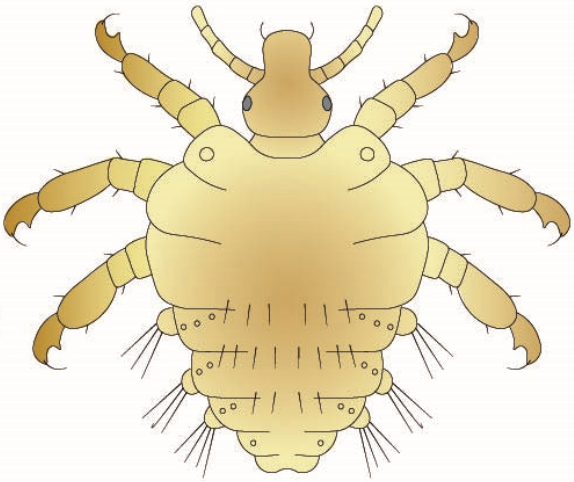
Differential diagnosis: Infestations may be suspected by developing pruritus in the groin region and discovering small spot-stains on underwear (due to blood, crusts or flecks of louse faeces). Confirmation is then made by direct detection of lice (nymphs, adults) and/or eggs (nits) by close visual inspection of infested areas, often assisted by using magnification devices (hand lenses or dermoscopic micro-cameras) and incident illumination sources (torches, lanterns or slit lamps). Nits glued to hair shafts and lice grasping hairs may be collected using forceps, fine-toothed combs, adhesive (sticky) tape or cutting infested hairs with scissors. Samples may be examined microscopically for characteristic morphological features. Molecular characterization techniques have been used to examine the phylogenetic relationships between various *Pthirus* isolates following polymerase chain reaction (PCR) amplification of nuclear (18S ribosomal RNA) and mitochondrial (cytochrome b, cytochrome c oxidase subunit I) gene sequences.

Treatment and control: A range of insecticidal chemicals available as topical creams, lotions or shampoos have been used to treat infestations by pubic lice: including pyrethrins and pyrethroids (permethrin, phenothrin, some with synergists such as piperonyl butoxide); organochlorides (lindane); organophosphates (malathion); carbamates (carbamyl); RID (containing insecticides DEET (N,N-diethyl-m-toluamide) and di-n-propyl isocinchomeronate, with synergist N-octyl bicycloheptene dicarboximide and antimicrobial agent triclosan) and in some countries, macrocyclic lactones (ivermectin) for stubborn or severe cases. Most treatments were effective against nymphal and adult stages but less so against eggs, so repeat treatments after 10 days may be required. Most treatments are considered safe over-the-counter formulations (prescriptions not required), but careful attention should be paid to contra-indications as some drugs may exhibit toxicity or cause adverse side-effects such as allergic responses (e.g. lindane). Louse populations have also demonstrated some drug resistance to certain formulations, notably pyrethroids. Treatment is assisted by the mechanical removal of lice from infested areas using grooming devices (tweezers, fine-toothed combs, even fingernails) and solvents (to facilitate nit removal). When such methods prove ineffective (due to drug resistance or heavy infestations), recourse may be made to partial or complete hair removal from affected areas (by trimming, clipping or shaving). Infestations of eyelashes have been successfully treated by coating with petroleum jelly or permethrin lotion, washing with pilocarpine or povidone iodine solutions, applying sulphur or yellow mercuric oxide ointments, using fluorescein or physostigmine eyedrops, cryotherapy, argon laser photocoagulation, or even giving oral ivermectin. Preventive measures are based on breaking transmission cycles by educating patients to increase personal hygiene and restrict social contacts while infested and undertaking environmental decontamination. Education campaigns should enable sensible behavioural modifications to be implemented minimizing social stigmas and taboos so patients undertake voluntary abstinence, permit contact tracing of sexual partners and avoid sharing clothing, bedding or towels. In some countries, pubic lice infestations are considered to be sexually-transmitted diseases and government intervention is mandated. It should be noted, however, that safe-sex via condom use is ineffective in preventing infestations. Surfaces in contaminated areas should be cleaned with chemicals (bleach) or heat (steam) and floor coverings should be similarly cleaned or vacuumed. Clothing, bedding and towelling should be washed in hot water (> 55°C) for at least 20 minutes and then thoroughly dried. Items that cannot be washed or dry-cleaned may be sealed in plastic bags for 2 weeks so any lice present will starve and die.

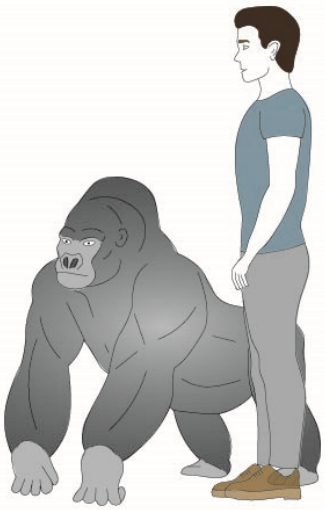
Pthirus



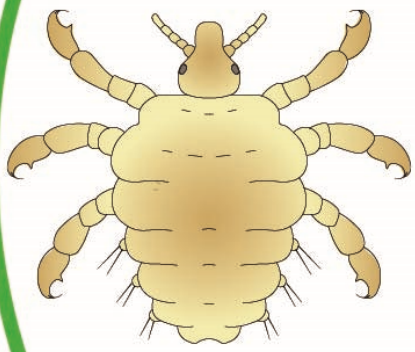
skin/pelage
(irritation, pruritus,
erythema, dermatitis)



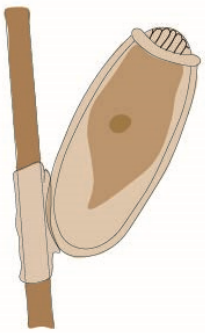
adult (dorsal)
(~ 2 mm)



Definitive Hosts
(primates)



nymph (dorsal)
(~ 1.2 mm)



egg
(~ 1 mm)

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

transmission between hosts
through transfer of motile stages
by direct contact (often sexual)
or via freshly-contaminated fomites

Pthirus adult

Pthirus adult