

Solenopotes
(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. Linognathids are long-nosed lice whose tarsal claws are smaller on the first legs than on other legs. *Solenopotes* spp. are commonly found on the skin/hair of cattle/deer and infestations have been associated with irritation, dermatitis, pruritus, alopecia, excoriation and self-wounding.

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: Linognathidae (long-nosed lice, claws on first leg smaller than those on other legs)
Genus: *Solenopotes* (parasitic on skin/hair of cattle)
Species: various species cause skin lesions on cattle

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]					
Linognathidae (pale lice, long-nosed lice)	3 genera, 73 spp.	mammals (bovids, canids)	nymphs, adults	blood-sucking	-
Haematopinidae (ungulate lice, short-nosed lice)	1 genus, 21 spp.	mammals (equids, bovids, suids)	nymphs, adults	blood-sucking	viral, bacterial
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	-
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*, *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*, *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). Linognathids are commonly known as pale lice or long-nosed lice. The tarsal claws on the first pair of legs are smaller than those on the second and third pairs of legs. Two genera are of particular veterinary importance: several *Linognathus* spp. cause disease in domestic ruminants and companion animals; and several *Solenopotes* spp. cause disease in cattle and deer. Nine *Solenopotes* spp. have been described from artiodactyls, including domesticated and wild animals. Most species are host-specific and occur only within the geographic ranges of their hosts, although species on domestic livestock may be found worldwide due to large scale translocations.

<i>Solenopotes</i> species	Hosts	Location	Clinical signs	Distribution
<i>S. binipilosus</i> (syn. <i>S. coassus</i>)	Artiodactyla: cervid (white-tailed deer, brown brocket)	skin	irritation, dermatitis, pruritus	Americas
<i>S. burmeisteri</i> (syn. <i>S. crassicornis</i>)	Artiodactyla: cervid (red deer, sika deer)	skin	irritation, dermatitis, pruritus	Eurasia
<i>S. capillatus</i> (little blue cattle louse, tubercle-bearing louse)	Artiodactyla: bovid (cattle)	skin (head, neck, shoulders, back, tail)	irritation, dermatitis, pruritus	worldwide
<i>S. capreoli</i>	Artiodactyla: cervid (roe deer)	skin	irritation, dermatitis, pruritus	Eurasia
<i>S. ferrisi</i>	Artiodactyla: cervid (red deer, white-tailed deer, mule deer)	skin	irritation, dermatitis, pruritus	North America

<i>S. holoastrus</i>	Artiodactyla: bovid (wildebeest); Rodentia: sciurid (red-legged sun squirrel)	skin		Africa
<i>S. muntiacus</i> (syn. <i>S. sinensis</i>)	Artiodactyla: cervid (Indian muntjac, Reeve's muntjac)	skin	irritation, dermatitis, pruritus	Southern Asia
<i>S. natalensis</i>	Artiodactyla: bovid (steenbok, Cape grysbok, Sharpe's grysbok)	skin		Africa
<i>S. tarandi</i>	Artiodactyla: cervid (reindeer, caribou)	skin	irritation, dermatitis, pruritus	Eurasia, North America

Parasite morphology: *Solenopotes* spp. form three different types of morphological stages during their developmental cycles: eggs (nits); nymphs (three instars); and adult lice (male and female). The eggs of these sucking lice are small measuring around 0.7 mm in length, elongate and asymmetrical in shape and dark brown-blue in colour. They are glued by their bases to hair shafts and often lay along the hair which is sometime bent at the point of attachment. Eggs contain a developing embryo with darkened internal elements. They hatch to release first-stage nymphs (N1) which moult by gradual (incomplete) metamorphosis through another two nymphal stages (N2, N3) before forming adults. All nymphs are similar in appearance to adult lice but are less sclerotized, lack genitalia, have fewer setae, and are smaller in size (N1 measure on average 0.7 mm in length, N2 0.8 mm, N3 1.0 mm, and adults range from 1.0-1.8 mm). Adult lice are dorso-ventrally flattened (dorsal tergum, ventral sternum) and have three distinct body parts (head, thorax, abdomen) which range from brown to blue/gray in colour (abdomen darkest). The head is short, blunt and rhomboidal in shape (compared to long thin heads in the sister genus *Linognathus*), lacks eyes and ocular points, but has two lateral antennae, each composed of 5 segments with terminal sensoria. The piercing/sucking mouthparts are located in an anterior snout-like proboscis (labrum) and are retracted into a pocket in the head when not used for feeding. The mouthparts comprise an eversible tubular haustellum armed with teeth and 4 retractable stylets (2 flanked by maxillae to form a food channel, one arising from the hypopharynx and forming a salivary channel, and one originating from the flattened labium to guide the other stylets). *Solenopotes* lack maxillary palps (present in amblyceran lice), and they lack mandibles and pulvinus pads (present in chewing/biting lice). Lice have an elongate alimentary tract divided into 3 sections: a tubular foregut (with cibarial pump, pharynx and oesophagus), an expansive midgut (with anterior caeca, ventriculus and globular mycetome (special organ, sometimes called bacteriome or stomach disc, harbouring bacterial/fungal symbionts)), and a short hindgut (with pylorus, papillae and rectum). The thorax consists of three segments fused together without obvious divisions, but contains a distinctive dark hexagonal sternal plate (absent in *Linognathus* spp.). The ventral thorax gives rise to 3 pairs of stout legs which are dissimilar in that the fore-legs are shorter and thinner than the mid- and hind-legs. Each leg consists of 5 segments (coxa, trochanter, femur, tibia, tarsus) terminating in specialized tarsal claws closing on tibial spurs (spurs absent on fore-legs). The abdomen is large, dark, elliptical, and consists of 9 membranous segments without paratergal plates but with rows of ventral setae and spiracles (respiratory pores) located on conspicuous protruding lateral tubercles (absent in *Linognathus* spp.). Female lice are slightly larger than males (average 1.5 cf. 1.1 mm in length) and their posterior abdominal segments have two distinctive pointed lobes (called gonopods or gonapophyses) which aid in oviposition. Mature females have globular ovaries with polytrophic ovarioles, tubular oviducts leading to the uterus together with accessory glands (produce glue), saccular spermatheca (store sperm after mating) and a rounded vagina with a sclerotized genital plate, valvula and genital setae. Males have compact bilobed testes, tubular vas deferens which join to form the seminal vesicle, and a distinct genital sac containing the copulatory aedeagus (penis-like tube with dorsal gonopore and terminal pseudopenis) supported by a basal plate-like sclerite (apodeme) and lateral rod-like sclerites (parameres).

Site of infection: These sucking lice are ectoparasitic on artiodactyls (bovids and cervids), moving amongst the hair and feeding on blood through the skin. Most louse species are host specific and are found only on one or a few closely-related host species. They are also highly site specific and prefer particular body parts of their hosts, although they may move to surrounding areas in heavy infestations. For example, the little blue cattle louse *S. capillatus* is usually found clustered on the face of cattle (on the cheeks, ears and around the muzzle and eyes), sometimes extending to the neck and dewlap, but they may invade the shoulders, back and tail in heavier infestations developing over winter.

Pathogenesis: Most infestations are light and often remain asymptomatic going unnoticed by their hosts. Heavier louse burdens are not highly pathogenic, although they may occasionally cause mild disease involving dermatitis and secondary self-trauma. Adults and nymphs feed on host blood but rarely do infestations cause anaemia although persistent blood loss must contribute to deteriorating health. More often, sucking lice cause discomfort and annoyance when feeding by piercing the skin, injecting saliva and sucking blood. Bites sites may become inflamed (local dermatitis) and pruritic (itchy), responses which appear to be exacerbated by hypersensitivity responses to allergens in louse saliva or faeces. Infested animals become restless and try to relieve the irritation by grooming (biting, licking, scratching or rubbing) afflicted body parts which may appear as dark blue patches due to aggregations of lice. Manic grooming can result in self- trauma with skin lesions, excoriations, scales, crusts, alopecia and secondary infections. Infested animals may be distracted and eat less exhibiting reduced productivity (poor growth and development) and their hides may be damaged by superficial erosive spots at slaughter. Heavier infestations develop on young, old, sick or stressed animals due to their compromised physiological and immunological states. Indeed, secondary increases in louse

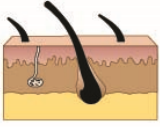
burdens often occur on animals with concomitant diseases as well as on individuals unable to groom effectively. Well-nourished animals in good health are generally able to tolerate infestations and keep louse populations low.

Developmental cycle and mode of transmission: The entire life-cycle of *Solenopotes* spp. may be completed in the pelage of individual hosts, and transmission between hosts occurs by close contact. Adult female lice glue their eggs to hair shafts close to the skin where they hatch in around 12 days to release first-stage nymphs which commence to feed. They undergo gradual (incomplete) metamorphosis (hemimetabolous) and moult through another two nymphal stages before moulting to adults. After mating, female lice lay 1-2 eggs per day during the first half of their 6-10 week lifespans. The whole life-cycle may be completed in as little as 4 weeks. Transmission occurs when motile stages (nymphs, adults) crawl onto new hosts in close contact or via contaminated fomites (bedding, equipment). Lice only survive off hosts for a short period (3-4 days) so most transmission occurs when animals are crowded in confined surroundings for protracted periods, either naturally (during mating, nursing, feeding or sheltering in herds) or artificially (when brought into yards, pens, barns or feedlots). Most clinical infestations occur over winter when environmental conditions favour louse development (cooler temperatures, available moisture, short daylight) and hosts become more susceptible (poorer nutrition, greater thermoregulatory stress, increased gregarious behaviours).

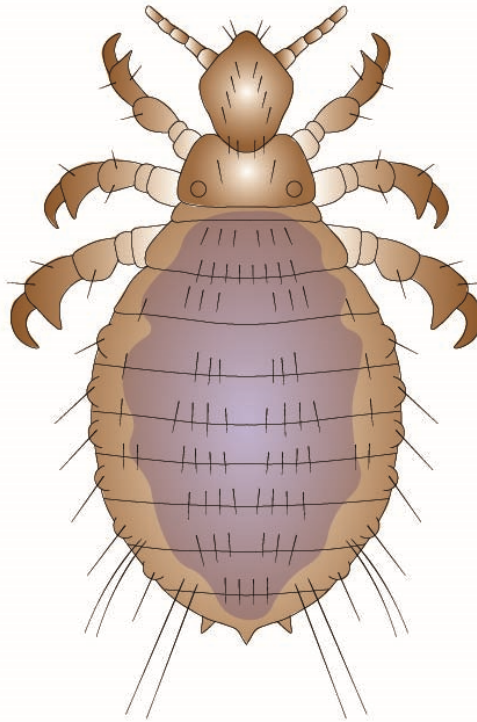
Differential diagnosis: Infestations may be suspected on the basis of clinical symptomatology (focal dermatitis, pruritus and increased grooming/rubbing in cooler months). Aggregations of the little blue cattle louse *S. capillatus* may even appear as dark blue patches on the faces of infested cattle. Definitive diagnosis is made by the direct detection of lice and sometimes their eggs in the host coat. The lice move slowly and tend not to avoid light when the coat is parted (unlike the rapid motility and photo-avoidance behaviours of chewing/biting lice). Lice may be readily collected and identified by microscopic examination of their unique morphological features. Modern molecular biological techniques have been used to examine phylogenetic relationships following the polymerase chain reaction (PCR) amplification of nuclear genes sequences (18S ribosomal RNA).

Treatment and control: A range of insecticidal chemicals have proven effective against immature and mature lice: including organochlorines (dichloro-diphenyl-trichloroethane (DDT), lindane), organophosphates (chlorpyrifos, diazinon, malathion), pyrethroids (permethrin, deltamethrin, flumethrin, cypermethrin), macrocyclic lactones (ivermectin, eprinomectin, moxidectin, abamectin, doramectin, milbemycin), formamidine (amitraz), chloronicotinyl (imidacloprid), spinosyns (spinosad), and insect growth regulators (diflubenzuron). Chemicals are available as topical applications (shampoos/rinses, sprays/aerosols, powders/fogs) or as systemic formulations (oral, injectable, spot-on, impregnated tags), and some may also be used in self-treatment devices (dust bags, back rubbers/oilers). Most chemicals are not very effective against louse eggs (nits) so treatment may need to be repeated after 1-2 weeks to kill newly-emergent nymphs, although products with long residual activity may only require a single application. It is advisable to treat all animals in the cohort at the same time, and treatment is best conducted in autumn to prevent louse populations from escalating over winter. Treatments should also comply with government regulations concerning contra-indications, withholding periods, residues and environmental toxicity. Various grooming devices (brushes, combs) may be used to assist in louse removal and matted coats may need to be trimmed/clipped beforehand. Preventive control strategies should be implemented to decontaminate shared equipment and facilities (through heat or chemical treatment) and to reduce contact with infested animals (through isolation or quarantine). Livestock management should avoid over-crowded unsanitary conditions and hosts should be kept healthy, well-nourished and well-groomed.

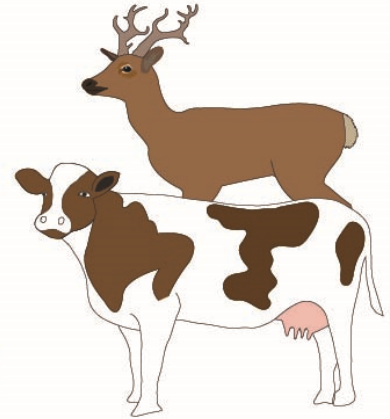
Solenopotes



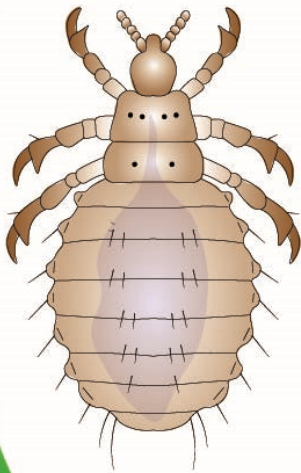
skin/pelage
(dermatitis, anaemia,
alopecia, excoriation)



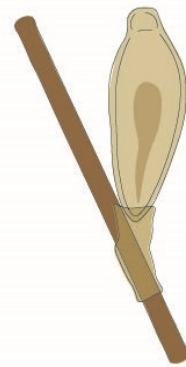
adult (dorsal)
(~ 1.8 mm)



Definitive Hosts
(ruminants)



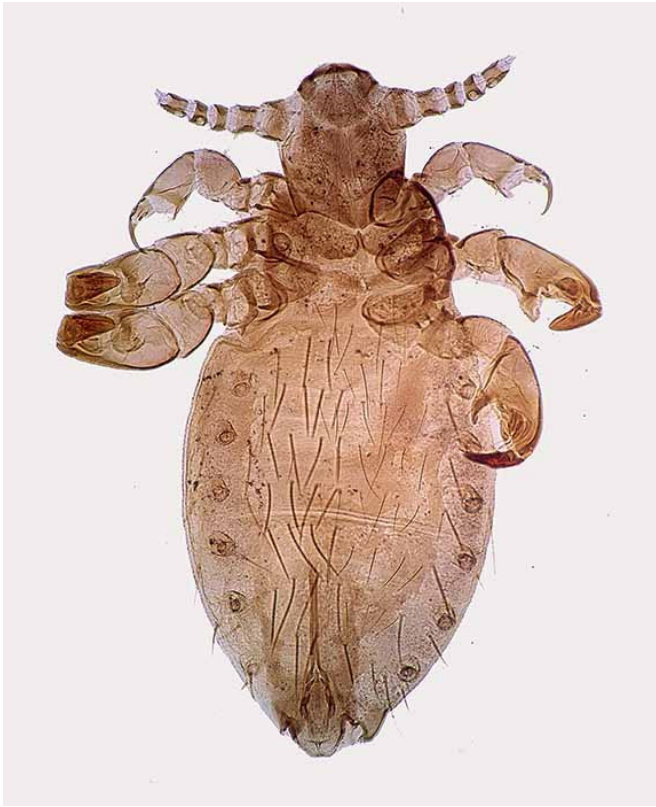
nymph (dorsal)
(~ 1 mm)



egg
(~ 0.7 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



Solenopotes adult



Solenopotes egg