Chapter 7

Lice (Phthiraptera)

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Lice can be a menace to humans, pets, and livestock, not only through their blood-feeding or chewing habits but also because of their ability to transmit pathogens. The human body louse has been indirectly responsible for influencing human history through its ability to transmit the causative agents of epidemic typhus, trench fever, and louse-borne relapsing fever. However, most of the approximately 5,000 known species of lice are ectoparasites of wild birds or mammals and have little or no known medical or veterinary importance.

The Phthiraptera are divided into two main morphologically distinct groups: sucking lice and chewing lice. All sucking lice are obligate, hematophagous ectoparasites of placental mammals, whereas the more diverse chewing lice include species that are obligate associates of birds, marsupials, or placental mammals. Although certain chewing lice imbibe blood, most species ingest host feathers, fur, skin, or skin products. Because of the different feeding strategies of the two groups, the blood-feeding sucking lice are far more important than the chewing lice in transmitting pathogens to their hosts.

TAXONOMY

The Phthiraptera are divided into four suborders (Fig. 7.1, Tables 7.1, 7.2): the Anoplura (sucking lice) and the Amblycera, Ischnocera, and Rhynchophthirina (collectively known as chewing lice or biting lice). Previous classifications treated the Anoplura and Mallophaga as separate orders with the Amblycera, Ischnocera, and Rhynchophthirina all included in the Mallophaga. However, phylogenetic analyses have shown that the chewing lice do not represent a monophyletic group and that some are more closely related to members of the Anoplura than to other chewing lice. Further, sucking and chewing lice originated from a common nonparasitic ancestral group within, the Psocoptera (book lice and bark lice). Some recent molecular phylogenetic analyses embed the parasitic lice within the nonparasitic bark lice and book lice, and some authors now recognize the order Psocodea, which includes the parasitic lice as well as the book and bark lice. The parasitic lice diverged from the book and bark lice 100–150 million years ago, and the sucking lice diverged from the chewing lice approximately 77 million years ago and proliferated approximately 65 million years ago to parasitize multiple orders and families of mammals (Light et al., 2010). The fossil record for Phthiraptera is sparse with, at present, only one well-documented specimen, an amblyceran menoponid chewing louse from Germany dated at 44.3 ± 0.4 million years old (Dalgleish et al., 2006).

About 550 species of sucking lice have been described (Durden and Musser, 1994a). The sucking lice are currently assigned to 50 genera and 15 families. Price et al. (2003) recognize 4,464 valid species and subspecies of chewing lice; most of these taxa are associated with birds, but 553 of them (12.4%) parasitize mammals. The chewing lice are divided into three suborders (Table 7.1), 11 families, and 205 genera. According to Price et al. (2003), within the chewing lice, the Amblycera includes seven families, about 76 genera, and about 1,341 species; the Ischnocera includes three families, about 130 genera, and about 3,120 species, and the Rhynchophthirina includes one family, one genus, and three species.

Major taxonomic syntheses for the sucking lice include a series of eight volumes by Ferris (1919–1935) that remains the most comprehensive treatment of this group on a worldwide basis. Ferris (1951) updated much of his earlier work in a shorter overview of the group. Kim et al. (1986) compiled a manual and identification guide for the sucking lice of North America. Durden and Musser (1994a) provide a taxonomic checklist for the sucking lice of the world with host records and the known geographical distributions for each species. Beaucournu (1968) provides an identification guide to the sucking lice of rodents, insectivores, and lagomorphs of Western Europe, and Pajot (2000) provides an identification guide to sucking lice of the Afrotropical region.
Fewer authoritative identification guides are available for chewing lice. These include a synopsis of the lice associated with laboratory animals (Kim et al., 1973), guides to the lice of domestic animals (Tuff, 1977; Price and Graham, 1997), and an identification guide to the lice of sub-Saharan Africa (Ledger, 1980). These publications provide information on both sucking lice and chewing lice. Checklists of the chewing lice of the world (Price et al., 2003) and of North America (Emerson, 1972) are useful taxonomic references for this group.

Because of the relatively high degree of host specificity exhibited by both chewing and sucking lice, several host–parasite checklists have been prepared. These include a detailed list of both sucking and chewing lice associated with mammals (Hopkins, 1949), a host–parasite list for North American chewing lice (Emerson, 1972), a world host–parasite list for the chewing lice (Price et al., 2003)

and a host–parasite checklist for the Anoplura of the world (Durden and Musser, 1994b).

Sucking lice of medical importance are assigned to two families, the Pediculidae and Pthiridae, whereas sucking lice of veterinary importance are assigned to five families, the Haematopinidae, Hoplopleuridae, Linognathidae, Pedicinidae, and Polyplicidae (Table 7.2). Only one species of chewing louse, the dog biting louse, in the family Trichodectidae, has public health importance. Chewing lice of veterinary significance are typically placed in five families: the Boopiidae, Gyropodidae, Menoponidae, Philopteridae, and Trichodectidae (Table 7.1).
TABLE 7.1 Classification and Hosts of Chewing Lice of Medical and Veterinary Importance

<table>
<thead>
<tr>
<th>Lice</th>
<th>Hosts</th>
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<tbody>
<tr>
<td><strong>Suborder Amblycera</strong></td>
<td></td>
</tr>
<tr>
<td><em>Heterodoxus spiniger</em></td>
<td>Dog, other carnivores</td>
</tr>
<tr>
<td><strong>Family Gyropidae</strong></td>
<td></td>
</tr>
<tr>
<td>Slender guineapig louse, <em>Gliricola porcelli</em></td>
<td>Guinea pig</td>
</tr>
<tr>
<td>Oval guineapig louse, <em>Gyropus ovalis</em></td>
<td>Guinea pig</td>
</tr>
<tr>
<td><strong>Family Menoponidae</strong></td>
<td></td>
</tr>
<tr>
<td>Chicken body louse, <em>Menacanthus stramineus</em></td>
<td>Domestic fowl</td>
</tr>
<tr>
<td>Shaft louse, <em>Menopon gallinae</em></td>
<td>Domestic fowl</td>
</tr>
<tr>
<td>Goose body louse, <em>Trinoton anserinum</em></td>
<td>Geese</td>
</tr>
<tr>
<td>Large duck louse, <em>Trinoton querqueculae</em></td>
<td>Ducks</td>
</tr>
<tr>
<td><strong>Suborder Ischnocera</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Family Philopteridae</strong></td>
<td></td>
</tr>
<tr>
<td>Slender goose louse, <em>Anaticola anseris</em></td>
<td>Geese</td>
</tr>
<tr>
<td>Slender duck louse, <em>Anaticola crassicorns</em></td>
<td>Ducks</td>
</tr>
<tr>
<td>Large turkey louse, <em>Chelopistes meleagris</em></td>
<td>Turkey</td>
</tr>
<tr>
<td>Chicken head louse, <em>Cucilotogaster heterographus</em></td>
<td>Domestic fowl</td>
</tr>
<tr>
<td>Fluff louse, <em>Goniocotes gallinae</em></td>
<td>Domestic fowl</td>
</tr>
<tr>
<td>Brown chicken louse, <em>Goniodes dissimilis</em></td>
<td>Chicken</td>
</tr>
<tr>
<td>Large chicken louse, <em>Goniodes gigas</em></td>
<td>Domestic fowl</td>
</tr>
<tr>
<td>Wing louse, <em>Lipeurus caponis</em></td>
<td>Domestic fowl</td>
</tr>
<tr>
<td>Slender turkey louse, <em>Oxyliqueurus polytripezius</em></td>
<td>Turkey</td>
</tr>
<tr>
<td><strong>Family Trichodectidae</strong></td>
<td></td>
</tr>
<tr>
<td>Cattle biting louse, <em>Bovicola bovis</em></td>
<td>Cattle</td>
</tr>
<tr>
<td>Goat biting louse, <em>Bovicola caprae</em></td>
<td>Goat</td>
</tr>
<tr>
<td>Angora goat biting louse, <em>Bovicola crassipes</em></td>
<td>Goat</td>
</tr>
<tr>
<td>Horse biting louse, <em>Bovicola equi</em></td>
<td>Horse</td>
</tr>
<tr>
<td><em>Bovicola limbata</em></td>
<td>Goat</td>
</tr>
<tr>
<td>Donkey biting louse, <em>Bovicola ocellata</em></td>
<td>Donkey</td>
</tr>
<tr>
<td>Sheep biting louse, <em>Bovicola ovis</em></td>
<td>Sheep</td>
</tr>
</tbody>
</table>

**TABLE 7.1 cont’d**

<table>
<thead>
<tr>
<th>Lice</th>
<th>Hosts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cat biting louse, <em>Felicola subrostrata</em></td>
<td>Cats</td>
</tr>
<tr>
<td>Dog biting louse, <em>Trichodectes canis</em></td>
<td>Dog, other canids</td>
</tr>
<tr>
<td><strong>Suborder Rhynchophthirina</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Family Haematomyzidae</strong></td>
<td></td>
</tr>
<tr>
<td>Elephant louse, <em>Haematomyzus elephants</em></td>
<td>Elephants</td>
</tr>
</tbody>
</table>

possesses sclerotized dorsal, ventral, and/or lateral plates in many lice (Fig. 7.2); these provide some rigidity to the abdomen when it is distended by a bloodmeal or other food source. In adult lice the abdomen is 11-segmented and terminates in genitalia and associated sclerotized plates. In females, the genitalia are accompanied by two pairs of finger-like gonopods, which serve to guide, manipulate, and glue eggs onto host hair or feathers. The abdomen is adorned with numerous setae in most lice. Immature lice closely resemble adults (Fig. 7.4) but are smaller, have fewer setae, and lack genitalia. After each nymphal molt, the abdomen is adorned with progressively more setae, and the overall size of the louse increases (Fig. 7.4).

The male genitalia of lice are relatively large, sometimes occupying almost half the length of the abdomen and are conspicuous in cleared, slide-mounted specimens (Figs. 7.15A, 7.16). The terminal, extrusable, sclerotized pseudopenis (aeaeagus) is supported anteriorly by a basal apodeme. Laterally, it is bordered by a pair of chitinized parameres. Two or four testes are connected to the vas deferens, which coalesce posteriorly to form the vesicula seminalis. In the female, the vagina leads to a large uterus to which several ovarioles supporting eggs in various stages of development are connected by the oviducts. Two or more large accessory glands that secrete materials to attach or coat the eggs and a single spermatheca, in which sperm is stored after mating, are situated posteriorly in the abdomen. Except for the human body louse, all lice cement their eggs, called nits, onto the hair or feathers of their host. Eggs are usually subcylindrical with rounded ends and a terminal cap, the operculum (Fig. 7.3). On the top of the operculum is a patch of holes or areas with thin cuticle, called aeropyles, through which the developing embryo respires. Most of the egg is heavily chitinized, which helps to protect the embryo from mechanical damage and desiccation (and from insecticides in many cases). A suture of thin cuticle encircles the base of the operculum. At the time of hatching, the first-instar nymph emerges from the egg by cracking this suture and pushing off the operculum.
### TABLE 7.2 Classification and Hosts of Sucking Lice (Anoplura) of Medical and Veterinary Importance

<table>
<thead>
<tr>
<th>Lice</th>
<th>Hosts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Family Echinophthiridae</strong></td>
<td></td>
</tr>
<tr>
<td>Echinophthirus horridus</td>
<td>Harbor seals</td>
</tr>
<tr>
<td><strong>Family Haematopinidae</strong></td>
<td></td>
</tr>
<tr>
<td>Horse sucking louse, Haematopus asini</td>
<td>Horse, donkey</td>
</tr>
<tr>
<td>Short nosed cattle louse, Haematopus euysternus</td>
<td>Cattle</td>
</tr>
<tr>
<td>Cattle tail louse, Haematopus quadruperosus</td>
<td>Cattle</td>
</tr>
<tr>
<td>Hog louse, Haematopus suis</td>
<td>Swine</td>
</tr>
<tr>
<td>Buffalo louse, Haematopus tuberculatus</td>
<td>Asiatic buffalo, cattle</td>
</tr>
<tr>
<td><strong>Family Hoplopleuridae</strong></td>
<td></td>
</tr>
<tr>
<td>Hoplopleura captiosa</td>
<td>House mouse</td>
</tr>
<tr>
<td>Tropical rat louse, Hoplopleura pacifica</td>
<td>Domestic rats</td>
</tr>
<tr>
<td><strong>Family Linognathidae</strong></td>
<td></td>
</tr>
<tr>
<td>African blue louse, Linognathus africanus</td>
<td>Goat, sheep, deer</td>
</tr>
<tr>
<td>Sheep face louse, Linognathus ovillus</td>
<td>Sheep</td>
</tr>
<tr>
<td>Sheep foot louse, Linognathus pedalis</td>
<td>Sheep</td>
</tr>
<tr>
<td>Dog sucking louse, Linognathus setosus</td>
<td>Dog, other canids</td>
</tr>
<tr>
<td>Goat sucking louse, Linognathus stenopsis</td>
<td>Goat</td>
</tr>
<tr>
<td>Long nosed cattle louse, Linognathus vituli</td>
<td>Cattle</td>
</tr>
<tr>
<td>Little blue cattle louse, Solenopotes capillatus</td>
<td>Cattle</td>
</tr>
<tr>
<td><strong>Family Pedicinidae</strong></td>
<td></td>
</tr>
<tr>
<td>Pedicinus spp.</td>
<td>Old World Primates</td>
</tr>
<tr>
<td><strong>Family Pediculidae</strong></td>
<td></td>
</tr>
<tr>
<td>Head louse, Pediculus humanus capitis</td>
<td>Human</td>
</tr>
<tr>
<td>Body louse, Pediculus humanus humanus</td>
<td>Human</td>
</tr>
<tr>
<td><strong>Family Polyplacidae</strong></td>
<td></td>
</tr>
<tr>
<td>Rabbit louse, Haemodipsus ventricosus</td>
<td>Domestic rabbit</td>
</tr>
<tr>
<td>Mouse louse, Polyplax serrata</td>
<td>House mouse</td>
</tr>
<tr>
<td>Spined rat louse, Polyplax spinolosa</td>
<td>Domestic rats</td>
</tr>
<tr>
<td><strong>Family Phthiridae</strong></td>
<td></td>
</tr>
<tr>
<td>Crab louse, Pthirus pubis</td>
<td>Human</td>
</tr>
</tbody>
</table>

### FIGURE 7.2 A generalized sucking louse (Anoplura), showing dorsal (left) and ventral (right) morphology. From Ignaffo (1959).

In amblyceran and ischnoceran chewing lice, the head is broader than the thorax (Figs. 7.11A, 7.12, 7.15A,B, 7.17A–F). Amblyceran chewing lice have four-segmented antennae and have retained distinct maxillary palps characteristic of their psocopteran ancestors (Fig. 7.1C). However, ischnoceran chewing lice have three to five antennal segments and lack maxillary palps (Fig. 7.1A). In the Amblycerana, the antennae are concealed in lateral grooves (Fig. 7.1C), whereas in the Ischnocera and Rhynchophthirina, the antennae are free from the head (Figs. 7.1A,D, 7.5).

There is a gradation in the specialization of the mouthparts and of the internal skeleton of the head, or tentorium, from the psocopteran ancestor of the parasitic lice through the Amblycerana, Ischnocera, Rhynchophthirina, and Anoplura. Although all chewing lice possess chewing mouthparts, the mechanics of these mouthparts differ for different groups. For example, members of the Rhynchophthirina possess tiny mandibles that are situated at the tip of an elongated rostrum (Figs. 7.1D, 7.5). Also, through extreme modifications, members of the chewing louse genus *Trochiloecetes* (parasites of humming birds) have evolved mouthparts that can function as sucking organs.
In sucking lice, the head is slender and narrower than the thorax (Figs. 7.2 and 7.6). Anoplura have three- to five-segmented antennae and lack maxillary palps. Noncompound eyes, which represent groups of ocelli, are reduced or absent in most sucking lice but are well developed in members of the medically important genera *Pediculus* (Figs. 7.6, 7.7 and 7.9) and *Pthirus* (Fig. 7.10). **Ocular points**, or eyeless projections posterior to the antennae, are characteristic of sucking lice in the genus *Haematopinus* (Figs. 7.11D, 7.13 and 7.14).

As indicated by their name, anopluran mouthparts function as sucking devices during blood feeding (Fig. 2.2F). At rest, the mouthparts are withdrawn into the head and are protected by the snoutlike haustellum, representing the highly modified labrum. The haustellum is armed with tiny recurved teeth that hook into the host skin during feeding. The stylets, consisting of a serrated labium, the hypopharynx, and two maxillae, then puncture a small blood vessel (Fig. 2.2F). The hypopharynx is a hollow tube through which saliva (containing anticoagulants and enzymes) is secreted. The maxillae oppose each other and are curved to form a food canal through which host blood is imbibed (Fig. 2.2F).

In sucking lice, all three thoracic segments are fused and appear as one segment. In most species, the legs, especially the hindlegs and midlegs, terminate in highly specialized claws for grasping the host pelage. These **thriotarsal claws** consist of a curved tarsal element that opposes a tibial spur (Fig. 2.4C,D) to enclose a space that typically corresponds to the diameter of the host hair.

The internal anatomy of lice is best known for the human body louse. As in most hematophagous insects, strong cibarial and esophageal muscles produce a sucking action during blood feeding. The esophagus leads to a spacious midgut composed primarily of the ventriculus. The posterior region of the midgut is narrow and forms a connection between the ventriculus and the hindgut. Ventrally, **mycetomes** (also called bacteriomes or stomach discs by some authors) containing symbiotic microorganisms connect to the ventriculus. These obligate symbiotes synthesize B vitamins that are lacking in the bloodmeal.

**LIFE HISTORY**

Lice are hemimetabolous insects. Following the egg stage, there are three nymphal instars, the last of which molts to an adult (Fig. 7.4). Although there is wide variation between species, the egg stage typically lasts for 4–15 days and each nymphal instar for 3–8 days, and adults live for up to 35 days. Under optimal conditions, many species of lice can complete 10–12 generations per year, but this is rarely achieved in nature. Host grooming, immune
responses, molting or feather loss, hibernation, hormonal changes, as well as predators (especially insectivorous birds on large ungulates), parasites and parasitoids, and unfavorable weather conditions can reduce the number of louse generations.

Fecundities for fertilized female lice vary from 0.2 to 10 eggs per day. Males are unknown in some parthenogenetic species such as the Damalinia sp. louse that causes hair-loss syndrome in North American deer and typically constitute less than 5% of adults in the cattle biting louse (Bovicola bovis) and less than 1% in the horse biting louse (Bovicola equi).

**BEHAVIOR AND ECOLOGY**

Blood from the host is essential for the successful development and survival of all sucking lice. Anoplura are vessel feeders, or solenophages, that imbibe blood through a hollow dorsal stylet derived from the hypopharynx (Fig. 2.2F). Contractions of powerful cibarial and pharyngeal muscles create a sucking reaction for imbibing blood.

Chewing lice feed by the biting or scraping action of the mandibles. Bird-infesting chewing lice typically use their mandibles to sever small pieces of feather, which drop onto the labrum and then are forced into the mouth. Chewing lice that infest mammals use their mandibles in a similar manner to feed on host fur. Many chewing lice that infest birds and mammals can also feed on other integumental products such as skin debris and secretions. Some species of chewing lice are obligate, or more frequently facultative, hematophages. Species of chewing lice that imbibe blood typically scrape the host integument until it bleeds. The rynchophthirinian Haematomyzus elephantis (Fig. 7.5), which parasitizes both African and Asian elephants, feeds in this manner.

Symbionts are thought to be present in all lice that imbibe blood. Symbionts in the mycetomes (also called bacteriomes or stomach discs) synthesize vitamins essential to growth and reproduction, and lice deprived of them die after a few days; female lice lacking symbionts also become sterile. Experimentally administering antibiotics to bloodmeals of human head and body lice kills symbiotic bacteria in the mycetomes and eventually results in death of the lice. In female human body lice, some symbionts migrate to the ovary, where they are transferred transovarially to the next generation of lice.

Many lice exhibit host specificity, some to such a degree that they parasitize only one species of host. The hog louse (Fig. 7.14), slender guineapig louse, large turkey louse, and several additional species listed in Tables 7.1 and 7.2 all are typical parasites of a single host species. Host specificity is less stringent in some lice. For example, some lice of veterinary importance parasitize two or more closely related hosts. Examples include the three species that parasitize domestic dogs: Trichodectes canis (Fig. 7.15A), Heterodoxus spiniger (Fig. 7.15B), and Linognathus setosus (Fig. 7.15C). These lice also parasitize...
foxes, wolves, coyotes, and occasionally other carnivores. Similarly, the horse sucking louse (*Haematopinus asini*) (Fig. 7.13) parasitizes horses, donkeys, asses, mules, and, sometimes, zebras, whereas the African blue louse, *Linognathus africanus*, parasitizes both sheep and goats. At least six species of chewing lice are commonly found on domestic fowl, most of them parasitizing chickens, but some also feeding on turkeys, guinea fowl, pea fowl, or pheasants (Fig. 7.17, Table 7.1). Lice found on atypical hosts are termed *stragglers*.

Some sucking lice, such as the three forms that parasitize humans, the sheep foot louse, and sheep face louse, not only are host specific but also infest specific body areas from which they can spread in severe infestations. Many chewing lice, particularly species that parasitize birds, also exhibit both host specificity and site specificity; examples include several species that are found on domestic fowl and species confined to turkeys, geese, and ducks (Table 7.1). Lice inhabiting different body regions on the same host typically have evolved morphological adaptations in response to specific attributes of the host site. These include characteristics such as morphological differences of the pelage, thickness of the skin, availability of blood vessels, and grooming or preening activities of the host. Site specificity in chewing lice is most prevalent in the more sedentary, specialized ischnocerans than in the mostly mobile, morphologically unspecialized amblícerans. For example, on many bird hosts, round-bodied ischnocerans with large heads and mandibles are predominately found on the head and neck. Elongate forms with narrow heads and small mandibles tend to inhabit the wing feathers, whereas morphologically intermediate forms occur on the back and other parts of the body.

Some chewing lice inhabit highly specialized host sites. These include members of the amblíceran genus *Pliacystomus spinifer*, which are found inside the oral pouches of pelicans, and members of several amblíceran genera, including *Actornithophius* and *Colpoccephalus*, which live inside feather quills. Several bird species are parasitized by five or more different species of site-specific chewing lice, and up to 15 species (belonging to three families and 12 genera) may be found on the great tinamou (*Tinamus major*), a bird native to the Neotropical region.

With the exception of the three kinds of lice that parasitize humans, site specificity is less well documented for sucking lice. However, domestic cattle may be parasitized by as many as five sucking louse species, each predominating on particular parts of the body. Similarly, some Old World squirrels and rats can support up to six species of sucking lice, often on different parts of the body.

Because of the importance of maintaining a permanent or close association with the host, lice have evolved specialized host-attachment mechanisms to resist grooming activities of the host. The robust tibiotarsal claws of sucking lice (Fig. 2.4C,D) are very important in securing them to their hosts. Various arrangements of hooks and spines, especially on the head of lice that parasitize arboreal or flying hosts, such as squirrels and birds, also aid in host attachment. Mandibles are important attachment appendages in ischnoceran and rhynchophthirinian chewing lice. In some species of *Bovicola*, a notch in the first antennal segment encircles a host hair to facilitate attachment. A few lice even possess ctenidia ("combs") that are convergently similar in morphology to those characteristic of many fleas. They occur most notably among lice that parasitize coarse-furred, arboreal, or flying hosts. Additionally, chewing lice that parasitize arboreal or flying hosts often have larger, more robust claws than do their counterparts that parasitize terrestrial hosts.

Because of their reliance on host availability, lice are subjected to special problems with respect to their long-term survival. All sucking lice are obligate blood-feeders; even a few hours away from the host can prove fatal to some species. Some chewing lice also are hematophages and, similarly, cannot survive prolonged periods off the host. However, many chewing lice, particularly those that subsist on feathers, fur, or other skin products, can survive for several days away from the host. For example, the cattle biting louse can survive for up to 11 days (this species will feed on host skin scrapings) and *Menacanthus* spp. of poultry for up to 3 days off the host. Off-host survival is generally greater at low temperatures and high humidities. At 26°C and 65% relative humidity (RH), 4% of human body lice die within 24 h, 20% die within 40 h, and 84% die within 48 h. At 75% RH, a small proportion of the sheep foot louse survive for 17 days at 2°C, whereas most die within 7 days at 22°C. Recently fed lice generally survive longer than do unfed lice away from the host. Although most lice are morphologically adapted for host attachment and are disadvantaged when dislodged, the generalist nature of some amblíceran chewing lice better equips them for locating another host by crawling across the substrate. Amblícerans are more likely than other lice to be encountered away from the host, accounting for observations of these lice crawling on bird eggs or in unoccupied nests and roosts.

Host grooming is an important cause of louse mortality. Laboratory mice infested by the mouse louse, *Polyplax serrata*, for example, usually limit their louse populations to 10 or fewer individuals per mouse by regular grooming. Prevention of self or mutual grooming by impaired preening action of the teeth or limbs of mice can result in heavy infestations of more than 100 lice. Similarly, impaired preening due to beak injuries in birds can result in tremendous increases in louse populations (Clayton et al. 2015). Host biting, scratching, rubbing, and licking can also reduce louse populations on several domestic animals.
Whereas most species of lice on small and medium-sized mammals exhibit only minor seasonal differences in population levels, some lice associated with larger animals show clear seasonal trends. Some of these population changes have been attributed to host molting, fur density and length, hormone levels in the bloodstream, or climatological factors such as intense summer heat, sunlight, or desiccation. On domestic ungulates in temperate regions, louse populations typically peak during the winter or early spring and decline during the summer. An exception to this trend is the cattle tail louse, *Haematopinus quadripertusus*, in which populations peak during the summer.

Another important aspect of louse behavior is the mode of transfer between hosts. Direct host contact appears to be the primary mechanism for louse exchange. Transfer of lice from an infested mother to her offspring during suckling (in mammals) or during nest sharing (in birds and mammals) is an important mode of transfer. Several species of lice that parasitize livestock transfer during suckling, including the sheep face louse and the sheep biting louse, both of which move from infested ewes to their lambs at this time. Lice can also transfer during other forms of physical contact between hosts such as mating or fighting. Transfer of lice between hosts also can occur between hosts that are not in contact. The sheep foot louse, for example, can survive for several days off the host and reach a new host by crawling across pasture land. Nests of birds and mammals can act as foci for louse transfer but these are infrequent sites of transfer.

Dispersal of some lice occurs via *phoresy* in which the lice temporarily attach to other arthropods and are carried from one host to another. During phoresy, most lice attach to larger, more mobile blood-feeding arthropods, usually a fly such as a hippoboscid or muscid. Phoresy is particularly common among ischnoceran chewing lice. Once thought to represent an anecdotal association between two groups of organisms, phoresy of certain species of chewing lice on hippoboscid flies is now considered to be an important mechanism for dispersal and host location by these lice. Phoresy is relatively rare among sucking lice. This is probably because attachment to the fly is achieved by the less efficient mechanism of grasping with the tibio-tarsal claws.

Mating in lice occurs on the host. It is initiated by the male pushing his body beneath that of the female and curling the tip of his abdomen upward. In the human body louse, the male and female assume a vertical orientation along a hair shaft with the female supporting the weight of the male as he grasps her with his anterior claws. Other lice appear to exhibit similar orientation behavior during mating. Notable exceptions include the crab louse of humans in which both sexes continue to clasp with their tibio-tarsal claws a host hair, rather than each other, during mating and the hog louse in which the male strokes the head of the female during copulation. Some male ischnoceran chewing lice possess modified hooklike antennal segments with which they grasp the female during copulation.

Oviposition behavior by female lice involves crawling to the base of a host hair or feather and cementing one egg at a time close to the skin surface. Two pairs of finger-like gonopods direct the egg into a precise location and orientation as a cement substance is secreted around the egg and hair or feather base. Optimal temperature requirements for developing louse embryos inside eggs are very narrow, usually within a fraction of a degree, such as may occur on a precise area on the host body. For this reason, female lice typically oviposit preferentially on an area of the host that meets these requirements.

**LICE OF MEDICAL IMPORTANCE**

Three taxa of sucking lice parasitize humans throughout the world: the *body louse*, *head louse*, and *crab louse* (= pubic louse). All are specific ectoparasites of humans; rarely, dogs or other companion animals may have temporary, self-limiting infestations.

Human head and body lice are closely related and can interbreed to produce fertile offspring in the laboratory. For this reason, they are often treated as separate subspecies of *Pediculus humanus*, as they are in this chapter. Nevertheless, they rarely interbreed in nature, which has prompted some epidemiologists to treat them as separate species: *Pediculus humanus* (body louse) and *P. capitis* (head louse). Recent publications based on gene sequences have provided conflicting evidence for the recognition of human head and body lice as either separate species, subspecies or strains of a single species. One intriguing hypothesis suggests that body lice “emerge” from head louse populations under conditions of poor human hygiene (Li et al., 2010). In partial support of this idea, head louse populations can be assigned to three different phylotypes—A, B, and C, whereas body lice are all assigned to phylootype A.

Recent genetic analyses of human lice have produced indirect evidence for important events during human history (Reed et al., 2004). For example, analysis of two separate head louse genetic lineages suggests that *Homo sapiens* and *Homo erectus* physically interacted at some time during prehistory and that both louse lineages infested *H. sapiens* when *H. erectus* became extinct. Similarly, genetic analysis of crab lice show that humans acquired their pubic lice from gorillas about 3.3 million years ago; gorilla and human crab lice have since evolved into distinct species. Further, because human body lice infest clothing, the origin of body lice on humans might correspond with the time when humans first starting wearing clothes; one study along these lines suggests that this occurred 72,000 ± 42,000 years ago.
Human Body Louse (*Pediculus humanus humanus*)

Infestations with the human body louse are sometimes referred to as *pediculosis corporis*. The human body louse, or *cootie*, was once an almost ubiquitous companion of humans. Today it is less common, especially in developed nations. Body lice persist as a significant problem in less developed nations in parts of Africa, Asia, and Central and South America and on populations of some homeless people worldwide. This is significant because *P. h. humanus* (Figs. 7.4, 7.6 and 7.7) is the only louse of humans that is known to naturally transmit pathogens. The large-scale reduction in body louse infestations worldwide has led to a concomitant decrease in the prevalence of human louse-borne diseases. However, situations that result in human overcrowding and unsanitary conditions (e.g., wars, famines, natural disasters, homelessness) can lead to a resurgence of body louse infestations, often accompanied by one or more louse-borne diseases.

Adult human body lice are 2.3–3.6 mm long. Under optimal conditions their populations can multiply dramatically if unchecked (e.g., if clothes of infested individuals are not changed and washed in hot water at regular intervals). In unusually severe infestations, populations of more than 30,000 body lice on one person have been recorded. Body lice typically infest articles of clothing and crawl onto the body only to feed. Females lay an average of four or five eggs per day, and these typically hatch after 8 days. Unique among lice, females oviposit not on hair but on clothing (Fig. 7.8), especially along seams and creases. Each nymphal instar lasts for 3–5 days, and adults can live for up to 30 days.

Biting by body lice often causes irritation, with each bite site typically developing into a small red papule with a tiny central clot. The bites usually itch for several days but occasionally for a week or longer. Persons exposed to numerous bites over long periods often become desensitized and show little or no reaction to subsequent bites. Persons with chronic body louse infestations may develop a generalized skin thickening and discoloration called Vagabond’s disease or Hobo’s disease, names depicting a lifestyle that can promote infestation by body lice. Several additional symptoms may accompany chronic
infestations; these include lymphadenitis (swollen lymph nodes), edema, increased body temperature often accompanied by fever, a diffuse rash, headache, joint pain, and muscle stiffness.

Some people develop allergies to body lice. Occasionally, patients experience a generalized dermatitis in response to just one bite or a small number of bites. A form of asthmatic bronchitis has similarly, been recorded in response to louse infestation allergies. Secondary infections such as impetigo or (rarely) septicemia (blood poisoning) can also result from body louse infestations.

Body lice tend to leave persons with elevated body temperatures and may crawl across the substrate to infest a nearby person. This has epidemiological significance because high body temperatures of lousy persons often result from fever caused by infection with louse-borne pathogens.

**Human Head Louse (Pediculus humanus capitis)**

Infestations with head lice can be referred to as *pediculosis capitis*. The human head louse (Fig. 7.9) is virtually indistinguishable from the human body louse on the basis of morphological characters and its life cycle. Generally, adult head lice are slightly smaller (2.1–3.3 mm in length) than body lice and tend to feed more frequently.

As indicated by their name, human head lice typically infest the scalp and head region. Females attach their eggs to the base of individual hairs. As the hair grows, the eggs become more distant from the scalp. An indication of how long a patient has been infested can be gleaned by measuring the farthest distance of eggs from the scalp and comparing this with the growth rate of hair—about 0.5 inch (1.27 cm) per month.

Today, head lice are far more frequently encountered than are body lice, especially in developed countries. Transmission occurs by person-to-person contact and via shared objects such as combs, brushes, headphones, and caps. School-aged children are at high risk because they are more likely to share these items. About 8% of all children 3–12 years old in the United States are infested with head lice, but in some school districts in the United States, Britain, and France, for example, infestation prevalence approaches 50%. It has been estimated that 6–12 million people, principally children, are infested with head lice annually in the United States. Some ethnic groups, such as persons of recent African origin, have coarser head hairs and are less prone to head louse infestations. The reason for this is that the tibiotarsal claws of these lice cannot efficiently grip the thicker hairs.

Although head lice are not typically important in transmitting pathogens, they can mechanically transmit the bacteria *Staphylococcus aureus* and *Streptococcus pyogenes*, both of which can cause skin/tissue infections. Under optimal laboratory conditions, head lice can transmit the causative agent of epidemic typhus, *Rickettsia prowazekii*, but only human body lice are implicated as vectors of this agent in nature. Although *Bartonella quintana*, the causative agent of trench fever, has been detected in head lice from various parts of the world, there is no current evidence of transmission of this pathogen by this louse in nature. The same is true for the emerging pathogenic bacteria *Acinetobacter baumannii*, which has been detected in head lice. Heavy infestations of head lice can cause severe irritation. As is the case with human body lice, the resultant scratching often leads to secondary infections such as impetigo, pyoderma, or (rarely) septicemia. Severe head louse infestations occasionally result in the formation of scabby crusts beneath which the lice tend to aggregate. Enlarged lymph nodes in the neck region may accompany large infestations.

**Human Crab Louse (Pthirus pubis)**

Infestations with crab lice can be referred to as *pediculosis inguinalis* or *phtiriasis*. The crab louse, or pubic louse (Fig. 7.10), is a medium-sized (1.1–1.8 mm long), squat louse, with robust tibiotarsal claws used for grasping thin hairs, especially those in the pubic region. It also may infest coarse hairs on other parts of the body, such as the eyebrows, eyelashes, chest hairs, beards, moustaches, and armpits. This louse typically transfers between human partners during sexual intercourse and other intimate contact; in France, crab lice are sometimes described as “papillons d’amour” (butterflies of love). Transfer via infested bed linen, sofas, or toilet seats can also occur. This is uncommon, however, because crab lice can survive for only a few hours off the host.

Female crab lice lay an average of three eggs per day. Eggs hatch after 7–8 days; the three nymphal instars combined last for 13–17 days. Under optimal conditions,
the generation time is 20–25 days. The intense itching caused by these lice is often accompanied by purplish lesions at bite sites and by small blood spots from squashed lice or louse feces on underwear. Crab lice are widely distributed throughout the world. They are not known to transmit any pathogens.

The generic name *Phthirus* is the taxonomically correct spelling as placed on the “Official List of Generic Names in Zoology” (1958, Opinion 104) with both *Phthirus* and *Phthirius* officially treated as invalid emendations of the original spelling *Phthis* (see Kim et al., 1986). The correct family name is Phthiridae (not Phthiridae), following the valid generic spelling.

**LICE OF VETERINARY IMPORTANCE**

A variety of lice infests domestic livestock, poultry, pets, and laboratory animals (Tables 7.1, 7.2). Small rodents usually support few, if any, lice, whereas larger hosts such as livestock animals, including poultry, may be parasitized by extremely large numbers of lice. For example, fewer than 10 mouse lice (*Polyplax serrata*) on a house mouse is a typical burden, but 0.5–1.0 million sheep biting lice (*Bovicola ovis*) may be present on one heavily infested sheep. Although many species of wildlife have their own species of lice, seldom are they a problem. Relatively few lice species of veterinary concern are vectors of pathogens.

**Lice of Cattle**

Cattle lice cause economic problems worldwide. Both dairy and beef breeds are affected. Domestic cattle are typically parasitized by one species each of *Haematopinus*, *Linognathus*, *Solenopotes*, and *Bovicola*. Domestic Asiatic buffalo are typically parasitized by *Haematopinus tuberculatus* (Table 7.2), which has also successfully transferred to cattle in tropical climates.

The cosmopolitan cattle biting louse (*Bovicola bosis*) (Fig. 7.11A) is the only species of chewing louse that infests cattle. This species is primarily parthenogenetic, but males are occasionally seen. The adult female is about 1.7 mm in length. Females lay an average of 0.7 egg per day, which hatch 7–10 days later. Nymphal instars last 5–7 days each, and adult longevity can be as long as 10 weeks. The preferred host site for this louse is the top line of the back, especially the withers area from which it spreads to the rump and poll area (Watson et al., 1997). In heavy infestations, these lice spread to other body regions. In the most severe infestations, lice may be found beneath heavily encrusted scurf.

The longnosed cattle louse (*Linognathus vituli*) (Fig. 7.11B) is also a worldwide pest. Adult females and males are about 2.4 and 1.8 mm in length, respectively. Females deposit one egg per day, and the life cycle is completed in approximately 21 days. This louse occurs in greater numbers on calves than on mature cattle. The species is widely distributed over the body of the host, but preferred infestation sites are the shoulder, back, neck, and dewlap.

The little blue cattle louse (*Solenopotes capillatus*) (Fig. 7.11C) is also worldwide in distribution. It is a common species on cattle but, because of its small size (adult female 1.5 mm; adult male 1.1 mm) it is commonly mistaken for nymphs of the longnosed cattle louse, which are also blueish in color. Females lay one or two eggs per day. Eggs hatch after about 12 days, and the time from egg to egg is about 28 days. Infestation by *S. capillatus* is usually noticed when dark blue patches, representing aggregations of this louse, appear on the face of the host (i.e., muzzle, cheeks, and around the eyes). Occasionally, the longnosed cattle louse may also be seen within these
clusters. As spring approaches, heavier infestations of the little blue cattle louse may extend to the neck and dewlap.

The cosmopolitan shortnosed cattle louse (*Haematopinus eurysternus*) (Fig. 7.11D) is the largest louse found on cattle in northern states of the U.S. Adult females and males measure 2.9 and 2.3 mm in length, respectively. The female lays an average of 1.4 eggs per day for about 2 weeks, nymphs reach adulthood in about 14 days, and average adult longevity is 10 days for males and 15 days for females. The life cycle from egg to egg normally requires 28 days. Preferred infestation sites are the top of the neck, the dewlap, and the brisket. In severe infestations, the entire region from the base of the horns to the base of the tail can be infested. In warmer weather, this species can also be found abundantly inside and on the tips of the ears. Although heavy infestations are occasionally encountered, the shortnosed cattle louse is the least common species on cattle in Wyoming, Nebraska, and, probably, the neighboring Rocky Mountain and Great Plains states.

The cattle tail louse (*Haematopinus quadripertusus*) is a tropical sucking louse that was inadvertently introduced into Florida in 1945. It has since spread to warmer regions of the United States, including Florida, the Gulf Coast states, and southern California. The cattle tail louse is larger than the closely related short nosed cattle louse. Adult females are 4.0 mm and adult males are 3.2 mm, respectively. Unlike other cattle lice in North America, *H. quadripertusus* is most abundant during the summer. Adult females of this louse, which are normally found on the distal area of the tail, oviposit on the tail hairs. Hatching may be delayed 40+ days in January and February due to cool weather. Consequently the tail brush becomes matted with eggs that hatch when temperatures begin to rise in the spring. In severe infestations, hair may be shed. Eggs hatch after 9 days under optimal conditions, and the entire life cycle can be as short as 25 days. Nymphs migrate over the host body surface, but adults are typically confined to the tail. Although the cattle tail louse is spread via direct contact or contaminated facilities and equipment, phoresy appears to be common. Third-instar nymphs may migrate to the backs and shoulders of the host, where they attach to flies and are carried to a new host. In a sample of 5,000 horn flies collected in Florida, 100 were carrying *H. quadripertusus* nymphs (Kauffman et al., 2005).

Except for *H. quadripertusus*, cattle lice increase in numbers during the winter and early spring in temperate regions. Chronically infested cattle, often referred to as carriers, may have heavy burdens of lice, even in the summer. Cattle producers customarily cull these animals from a herd as they are considered a source of lice for the other animals. Thorough examination of cattle with no clinical signs of lice infestation in the summer, however, has shown that these animals also may harbor all four species of cattle lice (Hanlin, 1994).

### Lice of Other Livestock Animals

Horses, donkeys, hogs, goats, and sheep are all parasitized by one or more species of louse (Tables 7.1, 7.2). Except for hogs, all of these animals are parasitized by at least one species of sucking lice and one species of chewing lice. The horse biting louse (*Bovicola equi*) (Fig. 7.12) is the most important louse of equids worldwide. Adult females and males average approximately 1.9 and 1.3 mm, respectively.
Females of this louse oviposit on fine hairs near the skin, usually singly, avoiding the coarse hairs of the mane and tail. This louse typically infests the side of the neck, the flanks, and tail base but can spread to most of the body with the exception of the mane, tail, ears, and lower legs. Long-haired horse breeds are more prone to infestation by *B. equi*. *Haematopinus asini*, the horse sucking louse (Fig. 7.13), is worldwide in distribution but more common in areas with cooler climates. It commonly parasitizes horses, donkeys, and mules. Adult females and males are 3.0 and 2.3 mm in length, respectively. Generally, this louse is found in areas of coarse hair avoided by the horse biting louse: the forelock, mane, base of the tail, and above the hooves.

Infestations by both species of horse lice are heavier during the winter months. As with other species of lice, advanced infestations can spread to additional regions of the body. While these lice normally transfer via direct contact, the use of contaminated grooming equipment and blankets can contribute to their spread.

Domestic swine are parasitized by one louse species, the hog louse (*Haematopinus suis*) (Fig. 7.14). This is a large species of sucking louse in which adult females measure
5—6 mm in length and males measure over 4.1 mm. Geographically, the hog louse is found wherever hogs are raised, but it is more common in cooler climates. Hog lice normally frequent skin folds of the neck, the ears (often deep within the canal), the tender skin behind the ears, inside the legs, and the inner flanks of swine. Hog lice tend to favor upper regions of their predilection sites in summer and lower regions in winter. The heaviest infestations of hog lice occur in winter, usually December to March in North America, Europe, and northern Asia. Eggs are deposited singly on hairs (except when infestations become very heavy) along the lower parts of the body, in skin folds on the neck, and on and in the ears. Under optimal conditions, females deposit three to six eggs per day. The egg and nymphal stages last approximately 2 weeks each. Adults are thought to live about 1 month, and there can be 6–12 generations per year.

Domestic sheep and goats are parasitized by several species of sucking lice and chewing lice (Tables 7.1, 7.2). Worldwide, the sheep biting louse, *Bovicola ovis*, is the principal louse parasitizing domestic sheep. It is also one of the most studied. In Australia, a major sheep producing country, Roberts (1952) noted that the sheep biting louse occurred throughout the country in sheep-raising areas but was less frequent in, and sometimes absent from, the drier inland districts. This is probably true in the United States as well, where its distribution has not been documented. In 40 years, it has not been seen in Wyoming, one of the major U.S. sheep-producing states, and veterinary entomologists in neighboring states of Montana and Nebraska report that the species is uncommon, if not absent, in those states as well.

Females of the sheep biting louse are about 1.8 mm long, and males are around 1.0 mm. Females attach eggs primarily to wool fibers close to the skin. The incubation period is about 10 days, and the three nymphal stages together last about 3 weeks. The female lays eggs at the relatively slow rate of one egg every 2–4 days and can live for up to 30 days. Despite the low reproductive rate, infestations may reach hundreds of thousands and even a million on a single sheep. *Bovicola ovis* mainly feeds on epidermal scales, scurf, and dermal secretions. In the winter, when louse populations are high, most *B. ovis* are found on the back and mid-sides of the sheep. Lighter summer populations are along the ribs, lower flank, and abdomen.

The African blue louse, *Linognathus africanus*, is a parasite of both sheep and goats. Originally described from sheep in Africa, as its name implies, the species now appears to be distributed worldwide. In the United States, it has been reported from the southern and southwestern United States. Recently, it appears to have established in sheep-producing areas of several Western states, where it has become a major pest of sheep. The species has also been reported from mule deer, Columbian black-tailed deer, and white-tailed deer. Females are 2.2 mm long and males are 1.7 mm. In the winter, when infestations are heaviest, *L. africanus* is found most abundantly on the loin, back, rib, and shoulder areas of sheep. Populations may reach several thousand per sheep. On goats, the distribution is different, with lice occurring on the upper neck, base of the ears, poll, and ventral surface of the jaw.

**Lice of Cats and Dogs**

Domestic cats are parasitized by one species of chewing louse, whereas dogs are parasitized by two species of chewing lice and one species of sucking louse. All four species appear to be distributed worldwide, but none of them are common associates of healthy cats or dogs in North America or Europe.

The cat biting louse (*Felicola subrostrata*) parasitizes both domestic and feral cats. It may occur almost anywhere on the body.

Both the dog biting louse (*Trichodectes canis*) (Fig. 7.15A) and the dog sucking louse (*Linognathus setosus*) (Fig. 7.15C) parasitize dogs and closely related wild canids. For example, *T. canis* also parasitizes coyotes, foxes, and wolves. A second species of chewing louse of dogs is *Heterodoxus spiniger* (Fig. 7.15B), which evolved in Australasia from marsupial-infesting lice and apparently switched to dingo hosts. It now parasitizes various canids and other carnivores throughout the world. *Trichodectes canis* usually infests the head, neck, and tail region of dogs, where it attaches to the bases of individual hairs. *Linognathus setosus* occurs primarily on the head and neck and may be especially common beneath collars. *Heterodoxus spiniger* can typically be found anywhere on its host.

**Lice of Laboratory Animals**

The principal species of lice that parasitize laboratory mammals have been discussed by Kim et al. (1973). These lice also parasitize feral populations of their respective hosts.

The house mouse (*Mus musculus*) is often parasitized by the mouse louse (*Polyplax serrata*). Populations of this louse are typically low, with 10 or fewer lice per infested mouse, unless self or mutual host grooming is compromised. Eggs of this louse typically hatch 7 days after oviposition. Together, the three nymphal instars last only 6 days under optimal conditions, which can result in a generation time as short as 13 days.

Domestic rats are often parasitized by the spined rat louse (*Polyplax spinulosa*) (Fig. 7.16) and the tropical rat louse (*Hoplopleura pacifica*). Common hosts include the black rat (*Rattus rattus*) and the Norway rat
Europe but has accompanied its host wherever it has been introduced throughout the world.

**Lice of Poultry and Other Birds**

At least nine species of chewing lice infest poultry (Table 7.1, Fig. 7.17) in various parts of the world. Individual birds can be parasitized by multiple species, each of which often occupies a preferred host site.

The chicken body louse (*Menacanthus stramineus*) (Figs. 7.17B, 7.22) is the most common and destructive louse of domestic chickens. It is thought to have originally been a pest of wild turkeys that transferred to domestic poultry and is now common on both chickens and turkeys. The chicken body louse has a worldwide distribution and often reaches pest proportions. Unlike other chicken lice, it is found on the host’s skin rather than on the feathers. It may be detected by parting the feathers, especially in the vent area of the bird. This louse is most abundant on the sparsely feathered vent, breast, and thigh regions. However, in heavily infested poultry, it may be found on any part of the body. Adults measure 3–3.5 mm in length. Females lay one or two eggs per day, cementing them in clusters at the bases of feathers, especially around the vent (Fig. 7.22). Eggs typically hatch after 4–5 days. Each nymphal instar lasts about 3 days, and the generation time typically is 13–14 days.

Several other chewing lice are pests of poultry more or less throughout the world (Table 7.1). Adults of the shaft louse (*Menopon gallinae*) (Fig. 7.17F) measure about 2 mm in length and may be seen in a line along the shaft of

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**FIGURE 7.16** Spined rat louse (*Pthirius spinulosus*), male. Stacked image of cleared specimen. Photograph by Lorenza Beati and Lance A. Durden.

(*R. norvegicus*). The spined rat louse parasitizes these hosts throughout the world, whereas the tropical rat louse is confined to tropical, subtropical, or warm temperate regions, including the southern United States.

Laboratory rabbits are parasitized by the rabbit louse (*Haemodipsus ventricosus*). This louse originated in
a feather. Although these lice do not normally rest on the skin, they quickly disperse to the skin if disturbed. Females deposit eggs singly at the base of the shaft on thigh and breast feathers. Eggs of the wing louse (*Lipeurus caponis*) (Fig. 7.17E) hatch 4–7 days after the female has cemented them to the base of a feather. Nymphal stages of this species each last 5–18 days, generation time typically is 18–27 days, and females can live up to 36 days. Females of the chicken head louse (*Cuclutogaster heterographus*) (Fig. 7.17D) attach their eggs to the bases of downy feathers. Eggs hatch after 5–7 days, each nymphal instar lasts 6–14 days, and average generation time is 35 days. The fluff louse (*Goniocotes gallinae*) (Fig. 7.17A) is a small louse that often infests the entire body of chickens, especially in the fluffy areas at the feather bases. *Menacanthus cornatus* (Fig. 7.17C) is a fairly large poultry louse and can occur in large numbers, especially on backyard chicken flocks (Murillo and Mullens, 2016).

Poultry lice typically transfer to new birds via direct host contact. However, because most species can survive for several hours or days off the host, they also can infest new hosts during transportation in inadequately disinfected cages or vehicles.

**PUBLIC HEALTH IMPORTANCE**

Three important pathogens are transmitted to humans by body lice: these are agents of epidemic typhus, trench fever, and louse-borne relapsing fever. Today, the prevalence and importance of all three of these louse-borne diseases are
low compared with times when human body lice were an integral part of human lives and before the widespread use of antibiotics starting in the 1940s. However, trench fever has reemerged as an opportunistic disease of immuno-compromised individuals, including persons who are positive for human immunodeficiency virus (HIV). Although these three pathogens are only known to be transmitted by body lice in nature, they have also been sporadically detected in head lice. Further, Acinetobacter baumannii, an opportunistic emerging bacterium that can infect humans via other transmission routes, has been found in both body and head lice.

Epidemic Typhus

Epidemic typhus is caused by infection with the rickettsial bacterium Rickettsia prowazekii. The entire genome sequence of R. prowazekii was reported by Andersson et al. (1998). The disease is also known as louse-borne typhus, louse-borne fever, jail fever, and exanthematic typhus. Some earlier reports of this disease simply referred to it as “typhus.” Epidemic typhus persists in several parts of the world, most notably in Burundi, Democratic Republic of Congo, Ethiopia, Nigeria, Rwanda, areas of northeastern and central Africa, parts of Russia, Central and South America, and northern China. Epidemic typhus is largely a disease of cool climates, including higher elevations in the tropics. It thrives in conditions of widespread body louse infestations, overcrowding, and poor sanitary conditions. This disease apparently was absent from the New World until the 1500s, when the colonizing Spanish inadvertently introduced it. One resulting epidemic in 1576–1577 killed 2 million indigenous peoples in the Mexican highlands alone.

The principal vector of R. prowazekii is the human body louse. Lice become infected when they feed on a person with circulating R. prowazekii in their blood. Infective rickettsiae invade cells that line the louse gut, and multiply there, eventually causing the cells to rupture. Liberated rickettsiae either rein invade gut cells or are voided in louse feces. Other louse tissues typically do not become infected. Because salivary glands and ovaries are not invaded, anterior-station and transovarial transmission do not occur. Infection of susceptible humans occurs via louse feces (posterior-station) when infectious rickettsiae are scratched into the skin in response to louse bites. Rickettsia prowazekii can remain infectious in dried louse feces for 60 days. Infection via inhalation of dried louse feces or by crushed lice is an infrequent transmission route.

Transmission of R. prowazekii by body lice was first demonstrated by Charles Nicolle when he was working at the Institut Pasteur in Tunis in 1909. During these studies, Nicolle accidentally became infected with epidemic typhus, from which he eventually recovered. He was awarded the Nobel prize in 1928 for his groundbreaking work on typhus. Several other typhus workers also were infected with R. prowazekii during laboratory experiments. The American researcher Howard T. Ricketts, working in Mexico, and Czech scientist Stanislav von Prowazek, working in Europe, both died from their infections and were recognized posthumously when the etiologic agent was named.

Infection with R. prowazekii is ultimately fatal to body lice as progressively more and more infected gut cells are ruptured. Infective rickettsiae are first excreted in louse feces 3–5 days after the infectious bloodmeal. Lice usually succumb to infection 7–14 days after the infectious bloodmeal, although some may survive for 20 days.

The disease caused by infection with R. prowazekii and transmitted by body lice is called classic epidemic typhus because it was the first form of the disease to be recognized. Disease onset occurs 10–14 days after infection by a body louse in classic epidemic typhus. Abrupt onset of fever accompanied by malaise, muscle and head aches, cough, and general weakness usually occur at this time. A blotchy, often reddish-blue rash spreads from the abdomen to the chest and then often across most of the body (Fig. 7.18), typically within 4–7 days after the initial symptoms. The rash rarely spreads to the face, palms, and soles and then only in severe cases. Headache, rash, prostration, and delirium intensify as the infection progresses. Coma and very low blood pressure often signal fatal cases. A case-fatality rate of 10%–20% is characteristic of most untreated outbreaks, although figures approaching 50% have been recorded.

Diagnosis of epidemic typhus involves positive serology, usually by microimmunofluorescence. Primers to R. prowazekii can also amplify DNA from infected persons or lice using polymerase chain reaction techniques. Antibiotic treatment, especially with doxycycline or tetracycline, usually results in rapid and complete recovery. Vaccines are available but are not considered to be sufficiently effective for widespread use.

**FIGURE 7.18** Patient infected with epidemic (louse-borne) typhus showing characteristic maculopapular cutaneous rash. Courtesy, Public Health Image Library, Centers for Disease Control and Prevention, Atlanta, Georgia, USA.
Persons who recover from epidemic typhus typically harbor *R. prowazekii* in lymph nodes or other tissues for months or years. This enables the pathogen to later reinfect other body tissues to cause disease. This form of the disease is called **recrudescent typhus** or **Brill–Zinsser disease**. The latter name recognizes two pioneers in the study of epidemic typhus, **Nathan Brill**, who first recognized and described recrudescent typhus in 1910, and **Hans Zinsser**, who demonstrated in 1934 that it is a form of epidemic typhus. Zinsser's (1935) book *Rats, Lice and History* is a pioneering account of the study of epidemic typhus in general.

Recrudescent epidemic typhus was widespread during the nineteenth and early twentieth centuries in some of the larger cities along the east coast of the United States (e.g., Boston, New York, and Philadelphia). At that time, immigrants from regions that were rampant with epidemic typhus, such as eastern Europe or Ireland, presented with Brill–Zinsser disease after being infected initially in their country of origin. Some of these patients experienced relapses more than 30 years after their initial exposure, with no overt signs of infection with *R. prowazekii* between the two disease episodes. Because infestation with body lice was still a relatively common occurrence during that period, lice further disseminated the infection to other humans, causing regional outbreaks. The last outbreak of epidemic typhus in North America occurred in Philadelphia in 1877. Today, even recrudescent typhus is a rare occurrence in North America. However, this form of typhus is still common in parts of Africa, Asia, South America, and occasionally eastern Europe. Some travelers returning to Europe or North America from endemic areas have presented with classic epidemic typhus.

The *southern flying squirrel* (*Glaucomys volans*) has been identified as a reservoir of a less virulent strain of *R. prowazekii* in the United States, where it was first found to be infected in Virginia during vertebrate serosurveys for Rocky Mountain spotted fever. Since the initial isolations from flying squirrels in 1963, *R. prowazekii* has been recorded in flying squirrels and their ectoparasites in several states, especially eastern and southern states. Peak seroprevalence (about 90%) in flying squirrels occurs during late autumn and winter when fleas and sucking lice are also most abundant on these hosts. Although several ectoparasites can imbibe *R. prowazekii* when feeding on infected flying squirrels, only the sucking louse *Neohaeamatorpinus sciuopteri* is known to maintain the infection and to transmit the pathogen to uninfected squirrels; nevertheless, a squirrel flea, *Orchopeas howardi*, is also a likely vector. Several North American cases of human infection have been documented in which the patients recalled having contact with flying squirrels, especially during the winter months when these rodents commonly occupy attics of houses or cabins. To distinguish this form of the disease from classic and recrudescent typhus, it is called **sporadic epidemic typhus** or sylvatic epidemic typhus. Some details such as the mode of human infection remain unresolved. Because the flying squirrel–associated louse *N. sciuopteri* does not feed on humans, it has been speculated that human disease may occur when infectious, aerosolized rickettsiae from louse feces are inhaled from attics or other sites occupied by infected flying squirrels.

Historically, epidemic typhus has been the most widespread and devastating of the louse-borne diseases. Zinsser (1935), Snyder (1966), and Allen (2014) have documented the history of this disease and highlighted how major epidemics influenced human history. For example, Napoleon's vast army of 1812 was arguably defeated more by epidemic typhus than by opposing Russian forces. Soon thereafter (c. 1816–1819), 700,000 cases of epidemic typhus occurred in Ireland. Combined with the potato famine of that period, this encouraged many people to emigrate to North America; some of these people carried infected lice or latent infections with them. During World War II, several military operations in North Africa and the Mediterranean region were hampered by outbreaks of epidemic typhus. One epidemic in Naples, Italy, in 1943 resulted in more than 1,400 cases and 200 deaths. This outbreak is particularly noteworthy because it was the first epidemic of the disease to be interrupted by human intervention through widespread application of the insecticide DDT to louse-infested persons.

Today, epidemic typhus is much less of a health threat than it once was. This is largely because few people, especially in developed countries, are currently infested by body lice. Higher sanitary standards, less overcrowding, regular laundering, frequent changes of clothes, effective pesticides, and effective antibiotics have all contributed to the demise of this disease. Nevertheless, epidemic typhus has the potential to reemerge. This is evidenced by the largest outbreak of epidemic typhus since World War II that affected about 50,000 people living in refugee camps in Burundi in 1997 and 1998. Further, more than 5,600 cases were recorded in China during 1999, and recent cases have been recorded in parts of Russia. Some people in Mexico and Texas have antibodies to *R. prowazekii*. *Rickettsia prowazekii* is currently listed as a select agent by the U.S. Centers for Disease Control and Prevention because of its ability to cause epidemics with high mortality and its bioweapon potential. Additional information about epidemic typhus is provided by Andersson et al. (1998), Anderson and Andersson (2000), and Allen (2014).

### Louse-Borne Relapsing Fever

Also known as epidemic relapsing fever, this disease is caused by the spirochete bacterium *Borreia recurrentis*. This pathogen is transmitted to humans by the body
louse, as first demonstrated by Sergent and Foley in 1910. Clinical symptoms include the sudden onset of fever, headache, muscle ache, anorexia, dizziness, nausea, coughing, and vomiting. Thrombocytopenia (a decrease in blood platelets) also can occur which can result in bleeding, a symptom that may initially be confused with a hemorrhagic fever. Episodes of fever last 2–12 days, typically followed by periods of 2–8 days without fever, with two to five relapses being most common. As the disease progresses, the liver and spleen enlarge, leading to abdominal discomfort and labored, painful breathing as the lungs and diaphragm are compressed. At this stage, most patients remain prostrate, often shivering and taking shallow breaths. Case-fatality rates for untreated outbreaks range from 5% to 40%. Antibiotic treatment is with penicillin or tetracycline. Humans are the sole known reservoir of B. recurrentis.

Body lice become infected when they feed on an infected person with circulating spirochetes. Most of the spirochetes perish when they reach the louse gut, but a few survive to penetrate the gut wall, where they multiply to massive populations in the louse hemolymph, nerves, and muscle tissue. Spirochetes do not invade the salivary glands or ovarian tissues and are not voided in louse feces. Therefore, transmission to humans typically occurs when infected lice are crushed during scratching, which allows the spirochetes in infectious hemolymph to invade the body through abrasions and other skin lesions. However, B. recurrentis is also capable of penetrating intact skin. As with R. prowazekii infections, body lice are eventually killed as a result of infection with B. recurrentis.

An intriguing history of human epidemics of louse-borne relapsing fever is provided by Bryceason et al. (1970). Hippocrates described an epidemic of “caucus” or “ardent fever” in Thasos, Greece, which can clearly be identified by its clinical symptoms as this malady. From 1727 to 1729, an outbreak in England killed all inhabitants of many villages. An epidemic that spread from eastern Europe into Russia during 1919–1923 resulted in 13 million cases and 5 million deaths. Millions also were infected during an epidemic that swept across North Africa in the 1920s. Several major epidemics subsequently have occurred in Africa, with up to 100,000 fatalities being recorded for some of them. During and immediately after World War II, more than 1 million persons were infected in Europe alone.

An ongoing outbreak of louse-borne relapsing fever is occurring in Ethiopia, where 1,000–5,000 cases are typically reported annually accounting for about 95% of the world’s recorded infections. Other smaller foci occur intermittently in other regions such as Burundi, Rwanda, Sudan, Uganda, China, Russia, Central America, and the Peruvian Andes. Localized resurgence of this disease under conditions of warfare or famine is a possibility.

Trench Fever

Also known as 5-day fever and wolhynia, trench fever is caused by infection with the bacterium Bartonella (formerly Rochalimaea) quintana. Like the two preceding diseases, the agent is transmitted by the human body louse. Human infections range from asymptomatic through mild to severe, although fatal cases are rare. Clinical symptoms can be nonspecific and include headache, muscle aches, fever, and nausea. The disease can be cyclic with several relapses often occurring. Previously infected persons often maintain a cryptic infection that can cause relapses years later with the potential for spread to other persons if they are infested with body lice. Effective antibiotic treatment of patients involves administering drugs such as doxycycline or tetracycline. Bartonella quintana DNA has been molecularly detected in a 4,000-year-old human tooth (Drancourt et al., 2005).

Lice become infected with B. quintana after feeding on the blood of an infected person. The pathogen multiplies in the lumen of the louse midgut and in the midgut epithelial cells. Infectious bacteria are voided in louse feces, and transmission to humans occurs via the posterior-station route when louse bites are scratched. Bartonella quintana can remain infectious in louse feces for several months, contributing to aerosol transmission as a rare but alternative route of transmission. Transovarial transmission does not occur in the louse vector. Infection is not detrimental to lice and does not affect their longevity.

Trench fever was first recognized as a clinical entity in 1916 as an infection of European troops engaging in trench warfare during World War I. At that time, more than 200,000 cases were recorded in British troops alone. Between the two world wars, trench fever declined in importance but reemerged in epidemic proportions in troops stationed in Europe during World War II. Because of the presence of asymptomatic human infections, the current distribution of trench fever is difficult to determine. However, since World War II, infections have been recorded in several European and African nations, Japan, China, Mexico, Bolivia, and Canada.

Until the 1990s, B. quintana was considered to be a rare disease of humans. However, several inner-city homeless and/or immunocompromised people, including HIV-positive individuals, particularly in North America, Europe, and Asia, have presented with B. quintana infections. This is manifested not as trench fever but as vascular tissue lesions (bacillary angiomatosis), liver pathology, chronically swollen lymph nodes, and/or inflammation of the heart valves (endocarditis). Because this disease typically occurs in inner cities, it has been given the name urban trench fever. The disease is probably widespread worldwide having been recorded, for example, in the cities of New York, Seattle, San Francisco, Marseille, Tokyo, and Moscow.
Long thought to be only a human disease (an anthroponosis), *B. quintana* has recently been reported to infect at least three species of macaques in southeast Asia and a macaque-associated sucking louse, *Pediculus obtusus*, suggesting the possibility of an animal (zoonotic) origin for this disease (Li et al., 2013).

**Other Pathogens Transmitted by Human Body Lice**

Some additional bacterial pathogens can be transmitted by body lice under certain conditions. For example, *Salmonella typhi*, the agent of typhoid (salmonellosis), can be louse-borne during outbreaks of this disease. However, other modes of transmission, such as through contaminated food, account for most human cases. Another emerging, widespread bacterium, *Acinetobacter baumannii*, which can cause infections of human skin, wounds, the urinary tract, lungs, and meningitis (and is often drug resistant), has been molecularly detected in both body and head lice removed from humans. In laboratory trials, body lice can successfully imbibe *A. baumannii* while feeding on experimentally infected rabbits. These lice cannot transmit *A. baumannii* via a bite, but they excrete viable bacteria in their feces, which could represent a source of human infection. Human body lice can also transmit *R. rickettsii* and *Rickettsia conorii* to rabbits under laboratory conditions; these pathogens cause Rocky Mountain spotted fever and Boutonneuse fever, respectively, and are typically transmitted by ticks. Human body lice can transmit *Yersinia pestis*, the causative agent of plague, under laboratory conditions, and it has been hypothesized that transmission of this pathogen by body lice could have been widespread during the historical plague outbreaks (Ayyadurai et al., 2010).

**Lice as Intermediate Hosts of Tapeworms**

Occasionally, humans become infested with the double-pored tapeworm (*Dipylidium caninum*). Although carnivores are the normal definitive hosts for this parasite, humans can be infested if they accidentally ingest infested dog biting lice (*Trichodectes canis*), which serve as intermediate hosts. Although this would appear to be an unlikely event, infants, especially children playing on carpets or other areas frequented by a family dog, may touch an infested louse with sticky fingers, which may then be put into their mouth to initiate an infestation.

**VETERINARY IMPORTANCE**

A variety of chewing lice and sucking lice parasitize domestic animals (Tables 7.1, 7.2). The potential effects of the various species of lice on livestock production are many. Even infestations that are considered relatively light may, in some way, have a measurable negative impact. Infestation by lice, presumably because of both their feeding and movement on the host, may be extremely annoying. Host animals often become restless. The host may develop dermatitis, allergic reactions, or secondary infection contributing to the pruritus. Host responses to the irritation include licking and rubbing the affected body parts, which may produce negative consequences. Hair, wool, mohair, or feather loss might hinder thermoregulation and result in unsightly animals with a lower market value. Scratches reduce the value of hides from slaughtered animals because defects must be trimmed away. Licking can lead to the formation of hair balls in the stomach, as seen especially in cats and calves. Large animals, in particular, can damage gates, fences, and other livestock equipment against which they rub to relieve irritation. Feeding by lice may directly, or through an immunological response by the host, result in blemishes in the hide.

The effect of blood-feeding parasites such as lice is more than merely robbing nutrients necessary for normal growth of the host. Feeding and salivary secretions of ectoparasites can stimulate immunologic and nonspecific defense mechanisms, ultimately influencing behavior and physiology of a host and preventing the host from reaching its full growth potential. This effect may reduce not only weight gains but also production of byproducts such as milk and eggs. Although lice may be barely detectable, they can multiply to extremely high numbers, particularly on young, old, sick, or stressed animals. Often this is because these hosts are unable to effectively groom themselves or they are immunocompromised. Sucking lice infestations, especially when they become severe, may affect the vitality of the host, promoting anemia, toxic anemia, abortion, and death and likely, as suggested by Campbell (1988), increasing susceptibility to pathogens.

Few pathogens are known to be transmitted to domestic animals by lice (Table 7.3). The most important of these are the viral agent of swinepox and the bacterial agents of murine mycoplasma infection of rats and mice, caused by *Mycoplasma muris* and *Mycoplasma cocceoides*, respectively (Table 7.3). Additionally, *Mycoplasma suis*, which causes an acute febrile disease in feeder pigs, has been reported to be transmitted by the hog louse by some researchers. Other pathogens have been detected in various species of lice, but there is no current evidence that lice are vectors of these organisms.

**Lice of Livestock**

Lice cause major economic losses through reduced livestock productivity and diminished health. These losses include the cost of treatment, which can be considerable. Louse infestation may lead to pruritus and its side effects,
TABLE 7.3 Pathogens and Parasites Transmitted by Lice

<table>
<thead>
<tr>
<th>Disease</th>
<th>Disease Agent</th>
<th>Vector(s)</th>
<th>Host(s)</th>
<th>Geographic Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VIRAL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swinepox</td>
<td>Swinepox virus</td>
<td><em>Haematopinus suis</em></td>
<td>Hogs</td>
<td>Widespread</td>
</tr>
<tr>
<td><strong>BACTERIAL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Epidemic typhus</td>
<td><em>Rickettsia prowazekii</em></td>
<td><em>Pediculus humanus</em></td>
<td>Humans</td>
<td>Global (focal)</td>
</tr>
<tr>
<td>Sporadic epidemic typhus</td>
<td><em>Rickettsia prowazekii</em></td>
<td>Flying squirrel lice</td>
<td>Flying squirrels, humans</td>
<td>North America</td>
</tr>
<tr>
<td>Louse-borne relapsing</td>
<td><em>Borrelia recurrentis</em></td>
<td><em>Pediculus humanus</em></td>
<td>Humans</td>
<td>Global (focal)</td>
</tr>
<tr>
<td>fever</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Trench fever</td>
<td><em>Bartonella quintana</em></td>
<td><em>Pediculus humanus</em></td>
<td>Humans</td>
<td>Global</td>
</tr>
<tr>
<td>Tularemia</td>
<td><em>Francisella tularensis</em></td>
<td>Rodent &amp; lagomorph lice</td>
<td>Rodents, rabbits</td>
<td>Global</td>
</tr>
<tr>
<td>Murine Mycoplasma</td>
<td><em>Mycoplasma muri</em></td>
<td><em>Polyplax spinulosa</em></td>
<td>Domestic rats</td>
<td>Global</td>
</tr>
<tr>
<td>Infection</td>
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<tr>
<td>Murine Mycoplasma</td>
<td><em>Mycoplasma coccoides</em></td>
<td><em>Polyplax serrata</em></td>
<td>Domestic mice</td>
<td>Global</td>
</tr>
<tr>
<td>Infection</td>
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<tr>
<td><strong>HELMINTHIC</strong></td>
<td></td>
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</tr>
<tr>
<td>Seal heartworm</td>
<td><em>Dipetalonema spirocauda</em></td>
<td><em>Echinophthirus horridus</em></td>
<td>Harbor seal</td>
<td>Northern Hemisphere</td>
</tr>
<tr>
<td>Avian filariasis</td>
<td><em>Eulindana spp.</em></td>
<td>Bird chewing lice</td>
<td>Charadriiform birds</td>
<td>Widespread</td>
</tr>
<tr>
<td>Avian filariasis</td>
<td><em>Pelecitus fulicaeae</em></td>
<td>Bird chewing lice</td>
<td>Aquatic birds</td>
<td>Holarctic region</td>
</tr>
<tr>
<td>Avian filariasis</td>
<td><em>Sarconema eurycerca</em></td>
<td><em>Trichomon asserinum</em></td>
<td>Geese, swans</td>
<td>Holarctic region</td>
</tr>
<tr>
<td>Double-pored tapeworm*</td>
<td><em>Dipylidium caninum</em></td>
<td><em>Trichodectes canis</em></td>
<td>Dogs, humans</td>
<td>Global</td>
</tr>
</tbody>
</table>

*lice are intermediate hosts, not vectors, of this tapeworm.

reduced productivity, and diminished general health. During colder months of the year, louse infestations can reach into the thousands, hundreds of thousands, or even a million per animal. Under these conditions, the most serious detrimental effects to the host occur, including death. Animals most heavily infested are often the young, ill, nutritionally deprived, and immunocompromised.

Cattle sucking lice can decrease cattle weight gains and milk production, in addition to necessitating additional feed to maintain louse populations and additional time to feed. The shortnosed cattle louse (Fig. 7.11D) in North America can be a cause of severe, and terminal, anemia in range cattle. The cattle tail louse is considered to be the most damaging cattle louse in Florida. Results of studies on the impact of the longnosed cattle louse (Fig. 7.11B), little blue cattle louse (Fig. 7.11C), and cattle biting louse (Fig. 7.11A) on weight gains have been mixed. However, Gibney et al. (1985) found significant differences between weight gains of cattle heavily infested with this complex of lice and weight gains of noninfested cattle. This complex of lice is typical on yearling cattle throughout the Great Basin and Rocky Mountain region of the United States. Weight gains are typically lower in stressed cattle and those receiving inadequate nutrition. Nelson (1984) identified a "synergistic relationship," whereby a coexisting malnutrition and parasitic infestation are more deleterious to the host than either one is alone. Campbell (1988) further suggested a synergistic relationship between louse infestation and cold winter weather.

Damage to leather caused by cattle lice is costly. Irritation, leading to rubbing and subsequent hide damage (Fig. 7.19), may be caused by small numbers of lice in sensitive cattle. The cattle biting louse not only is responsible for increased scratches in cattle hide due to irritation (Fig. 7.19) but also is the major cause of the defect known as light spot, manifesting as 1- to 3-mm lesions that result from erosion of grain enamel of the hide. Light spot has been responsible for annual losses in the United Kingdom of £15 to £20 million (Coles et al., 2003). Rubbing also damages livestock facilities, a major concern in cattle feed
lots. Under laboratory or confined conditions, at least three pathogens can be transmitted by cattle sucking lice: the causative agents of bovine anaplasmosis, dermatomycosis (=ringworm), and, rarely, theileriosis. The importance of cattle lice in transmitting any of these pathogens in nature is unknown but presumed to be low.

Lice of horses and other equids typically do not greatly debilitate their hosts except when they are present in large numbers. As with other host species, horses that are malnourished or in poor health can become heavily infested. Horses in poor health may be infested by several thousand individuals of the horse biting louse (Fig. 7.12). Pruritus, hair loss, and coat deterioration may occur in severely infested animals. Horses with severe louse infestations, or horses that are extremely sensitive to infestation, are nervous and irritable. They stamp their hooves, lick, and rub in response to lice. They bruise and scratch themselves. Hair can be rubbed from the neck, shoulders, flanks, and tail base, resulting in an unthrifty appearance that may affect the market value of the horse. No pathogens are known to be transmitted by equid lice.

Hog lice, *Haematopinus suis* (Fig. 7.14), are extremely irritating to the host, and frequent feeding by the lice causes hogs to rub on objects to the point of bleeding. Hair is lost and the skin becomes rough and scaly with lesions. Heavily infested hogs are restless and eat less, which interferes with their growth. Hog lice can imbibe significant volumes of blood, especially from piglets, which often have larger infestations than adult pigs. Anemia may occur. Hog lice are potential vectors of several disease agents of swine. *Haematopinus suis* is a mechanical vector of the virus that causes swinepox (Table 7.3), a serious and potentially fatal disease characterized by large pockmark lesions mainly on the belly of infected animals. Swinepox is more commonly transmitted via direct contact between pigs. Some studies have also implicated this louse as a vector of *Mycoplasma* (formerly *Eperythrozoon*) *suis* and *Mycoplasma* (formerly *Eperythrozoon*) *parvum*, causative agents of swine mycoplasma infection, and of African swine fever virus. However, transmission of these pathogens by lice appears to be rare in nature.

Lice that parasitize sheep and goats (Tables 7.1, 7.2) can cause serious losses, even when present in relatively small numbers, because of damage to wool and mohair (Figs. 7.20, 7.21). Biting and rubbing in response to irritation damage the skin and devalue wool and mohair. The fleece becomes ragged with broken fibers, and it may slip from, or be pulled from, the skin, creating bare areas (Fig. 7.21). The fleece becomes contaminated with lice, cast exoskeletons, ova, and feces. Sucking lice can stain the wool with blood (Fig. 7.20), presumably due to undigested blood in their feces; this wool will not scour.

Significant losses due to the sheep biting louse, *Bovicola ovis*, are incurred in the major sheep-producing countries, such as Australia, New Zealand, South Africa, [African blue louse](https://en.wikipedia.org/wiki/Linognathus_africana)
and others. In Western Australia, louse infestation reduces production of clean wool by 0.3—0.8 kg/animal. In addition to causing fleece devaluation worldwide, the sheep biting louse is the major cause of cockle in pelts. Some sheep develop hypersensitivity to the sheep biting louse. Cockle, a nodular condition of the skin, arises in response to infestation by B. ovis and a hypersensitivity to louse antigens (Heath et al., 1996). The term scatter cockle has been used to describe the distribution of this defect and to distinguish it from rib cockle, a pelt blemish caused by sheep keds (Melophagus ovinus).

Sheep heavily infested with the African blue louse, Linognathus africanus, develop bare spots along the sides of the body (Fig. 7.21). Wool slips from the infested areas, leaving a bare area surrounded by a circle of densely infested fleece. Additional effects can include anemia and death in goats, especially kids, and skin irritation and fleece damage in Angora goats.

Wild and working elephants (Indian and African) can be infested by the elephant louse (H. elephantis) (Figure 7.1D, 7.5). In large infestations, this louse can cause intense irritation in its hosts, which can result in rubbing and skin lesions.

Lice of livestock, especially cattle, can also transmit fungi that cause ringworm (dermatomycosis), including Trichophyton verrucosum. Presumably, this involves mechanical transmission of fungal spores on louse bodies, including mouthparts. However, these fungi are more commonly transmitted via direct contact between infected animals.

Lice of Wildlife

Typically, lice of wildlife cause little or no apparent health problems unless their hosts are immunosuppressed, stressed, or unable to groom efficiently, sometimes because of injury. However, a chewing louse of North American wild deer (Odocoileus spp.) can multiply to huge numbers and cause severe hair loss (hair loss syndrome) and sometimes death from hypothermia in winter. Although the louse appears to be widespread on deer in the United States, most pathological cases have been reported from the Pacific Northwestern states of Oregon and Washington from Columbian black-tailed deer (Odocoileus hemionus columbianus) (Bildfell et al., 2004). The causative chewing louse has been identified as an undescribed species of Damalinia, a louse genus that is not thought to be native to North America. Similarly, massive infestations of the African blue louse, Linognathus africanus, have been associated with mule deer deaths in California due to exsanguination, anemia, and winter stress.

Lice of Cats and Dogs

Louse infestations of cats and dogs are most noticeable on sick, malnourished hosts, which are often unable to groom themselves, or on very young or old animals. Under these conditions, louse populations can increase dramatically. Apparently healthy pets will readily pick up lice when exposed to infested animals. Severe infestations by any of the four species of lice cause host restlessness, scratching, skin inflammation, a ruffled or matted coat, and hair loss. Heavy infestations of sucking lice may produce anemia. The dog biting louse (Trichodectes canis) (Fig. 7.15A) is distributed worldwide but apparently is becoming less common in the United States (Kim et al., 1973). This species often occurs on the head, neck, and tail of the host and will aggregate around wounds and body openings. Infestations are typically most severe on puppies and older dogs in poor condition. The dog biting louse is an intermediate host of the double-pored tapeworm (Dipylidium caninum) (Table 7.3). Lice become infected when they ingest viable D. caninum eggs from dried host feces. The tapeworm develops into a cysticercoid stage in the louse where it remains quiescent unless the louse is ingested by a dog, usually during grooming. In the dog gut, the cysticercoid is liberated and metamorphoses into an adult tapeworm.

The dog sucking louse (Linognathus setosus) (Fig. 7.15C) occurs worldwide but is infrequently encountered. This louse occurs primarily on the neck, shoulders, and under the collar and mainly on long-haired dog breeds. The dog sucking louse may cause anemia due to blood loss. The lice may cause irritation, resulting in sleeplessness, nervousness, biting, and scratching, often leading to secondary bacterial infection and hair loss. This species has been shown to harbor immatures of the filarial nematode Acanthocheilonema reconditum, which parasitizes dogs, and these lice appear to be vectors.

The cat biting louse, Felicola subrostrata, is worldwide in distribution but relatively uncommon. Infestations occur
mainly on unhealthy, older or long-haired cats, or on cats unable to groom. The intense irritation caused by this species may cause severe scratching, dermatitis, and hair loss on the back of infested cats. Secondary bacterial infections may develop as a result of the scratching.

**Lice of Laboratory Animals**

Some lice that parasitize laboratory animals initiate serious health problems by causing pruritus, skin lesions, scab formation, anemia, and hair loss. Others are vectors of pathogens that can cause severe problems in animal colonies (Table 7.3). The mouse louse, *Polyplax serrata*, is a vector of the bacterium *Mycoplasma coccoides*, which causes **murine mycoplasma infection**, a potentially lethal infection of mice that occurs worldwide. Infection of this blood parasite in mice can either be inapparent or result in severe anemia. Transmission of this pathogen in house-infested mouse colonies is usually rapid. The spined rat louse, *Polyplax spinulosa* (Fig. 7.16), is a vector of *Mycoplasma muris*, which causes another form of **murine mycoplasma infection** (Table 7.3), a potentially fatal blood infection that can cause severe anemia in laboratory rats.

Laboratory and wild guinea pigs are parasitized by two species of chewing lice: the slender guineapig louse, *Gliricola porcelli*, and the oval guineapig louse, *Gyropus ovalis*. Small numbers of these lice cause no noticeable harm, whereas large populations can cause host unthriftness, scratching (especially behind the ears), hair loss, and a ruffled coat.

Large infestations of the rabbit louse, *Haemodipsus ventricosus*, can cause severe itching and scratching, which result in the host rubbing against its cage, often causing hair loss. Young rabbits are more adversely affected than adults and may experience retarded growth as a consequence of infestation by *H. ventricosus*. The rabbit louse is also a vector of the causative agent of tularemia among wild rabbit populations (Table 7.3).

**Lice of Poultry and Other Birds**

Although louse populations may be very large on domestic fowl, including domestic chickens, turkeys, guinea fowl, pea fowl, and pheasants, no pathogens are known to be transmitted by these lice. The chicken body louse (Menacanthus stramineus) (Fig. 7.17B) often causes significant skin irritation and reddening through its persistent feeding (Fig. 7.22). Occasionally the skin or soft quilts pushing through the skin bleed from the gnawing and scraping action of the lice, with the lice readily imbibing the resultant blood. Populations of the chicken body louse are influenced by the host’s ability to groom. Debeaked birds tend to become more heavily infested. In general, louse-infested chickens do not gain as much weight or produce as many eggs as do louse-free chickens, and heavily infested young chicks may die.

The shaft louse (Menopon gallinae) (Fig. 7.17F) also causes significant losses to the poultry industry, including deaths of young birds with heavy infestations. Large infestations of chicken body lice, shaft lice, and other poultry lice may be injurious to the host by causing feather loss, lameness, low weight gains, inferior laying capacity, and even death. Lice and other ectoparasites infest peridomestic and backyard chicken flocks more commonly than they do caged layer and other confined flocks (Murillo and Mullens, 2016).

The vast majority of chewing lice are parasites of wild or peridomestic birds. Several of these lice are suspected vectors of avian pathogens. Some chewing lice of aquatic and other birds, including geese and swans, coots, grebes, and whimbrels, are vectors of flarial nematodes, including *Pelecitus fulicaeae*, *Sarcocena euryerca*, and species of *Eulimdana* (Bartlett and Anderson, 1989; Clayton et al., 2015) (Table 7.3). Pet parrots, parakeets, budgerigars, and other birds also are subject to infestation by chewing lice, which is usually noticed mainly by host scratching and ruffled or lost feathers. Large populations of these lice can debilitate their hosts. Ranch birds such as ostriches, emus, and rheas are also prone to similar adverse effects caused by their associated chewing lice.

**PREVENTION AND CONTROL**

Several techniques have been used in attempts to rid humans and animals of lice and louse-borne diseases. Preventing physical contact between lousy persons or animals and the items they contact, as well as various chemical, hormonal, and biological control mechanisms, compose the current arsenal of techniques. Chemicals used to kill lice are called **pediculicides**.
Clothes of persons with body lice should be changed frequently, preferably daily, and washed in very hot, soapy water to kill lice and nits. Washing associated bed linen in this manner is also advisable. Infested people should also receive a concurrent whole-body treatment with a pediculicide. Overcrowded and unsanitary conditions should be avoided whenever possible during outbreaks of human body lice and louse-borne diseases because it is under these situations that both can thrive.

Crab lice can often be avoided by refraining from having multiple sexual partners and changing or laundering bed linen slept on by such persons. Pediculicides should be applied to the pubic area and to any other infested body regions.

To reduce the spread of head lice, the sharing of combs, hats, earphones, and blankets, especially by children, should be discouraged. Often, parents of children with head lice are notified to keep youngsters away from school or other gatherings until the infestation has been eliminated. If the parents are also infested, this can further involve ridding lice from the entire family to prevent reinfections. Various pediculicidal shampoos, lotions, and gels are widely available for controlling head lice. In the United States, topically applied 1% permethrin or 0.33% pyrethrins are typically used to kill human lice, and 0.5% malathion lotions are often used in cases of initial treatment failures. However, topically applied pediculicides are not very effective against body lice, which spend most of their lives in the clothing. These treatments typically kill all nymphal and adult lice but only a proportion of viable louse eggs. Therefore, treatments should be repeated at weekly intervals for up to 4 weeks to kill any recently hatched lice. Hatched or dead nits that remain glued to hair may be unsightly or embarrassing and can be removed with a fine-toothed louse comb.

Louse combs have been used, in various forms, since antiquity to remove head lice (Mumcuoglu, 1996) and remain in widespread use today. Because lice are highly susceptible to desiccation, one technique for killing head lice and their eggs is to expose infested human scalps to a stream of hot air (Goates et al., 2006). An increasingly popular method for avoiding louse infestations is to impregnate clothing with permethrin; this action prevents, for example, health care workers or soldiers who are interacting with louse-infested refugees from becoming infested.

A wide range of pediculicides are commercially available. Although its use is now banned in many developed countries, the organochlorine DDT is widely used, especially in less developed countries, for controlling human and animal lice. Several alternative pediculicides, such as lindane, chlorpyrifos, diazinon, malathion, permethrin, or pyrethrins, are currently used in different parts of the world. Pediculicides can be used in powders, fogs, or sprays to treat furniture or premises for lice. Several general parasiticides show promise as pediculicides. Avermectins such as abamectin, doramectin, and ivermectin can kill human body lice and livestock lice. Prescribed doses of these compounds can be administered orally, via injection, or as topical applications of powders, dusts, and pour-ons. Some of these compounds have not been approved for use on humans. The development of novel control agents for lice is a constant process because resistance to various pediculicides has developed in lice in many parts of the world (Mumcuoglu, 1996; Burgess, 2004, 2008; Eremeeva et al., 2017).

Healthy, well-groomed, and well-nourished animals are less likely to develop infestations of lice requiring treatment. Because lice are spread mainly via contact, introduction of infested animals should be avoided. Exposure of noninfested animals to facilities shortly after removal of infested animals and exposure to contaminated equipment are also common routes of infestation. Nevertheless, infestations occur despite best efforts. For this reason, an almost bewildering variety of insecticide products and treatment methods are available. The following classes of insecticides have at least one compound registered for use against lice of pets and livestock: organochlorines, organophosphates, carbamates, pyrethrins, synthetic pyrethrroids, macrocyclic lactones ( avermectins and milbemycins); fumigants, chloronicotinyls and spinosyns, insect growth regulators, and synergists. For a more complete review of current animal pediculicides, the reader is referred to the Merck Veterinary Manual, 11th edition (2016) and the Merck/Merial Manual for Pet Health (2007).

Small animals like dogs and cats may be treated topically with shampoos, powders, aerosols, rinses, spot-ons, etc. of low mammalian toxicity. Cure must be taken to follow the label directions to ensure that a product is indicated for cats as they tend to lick themselves. Lice may be controlled by clipping away matted hair and then bathing the host, followed by the use of a mild insecticidal shampoo, powder, spray, or other treatment according to label directions. A second treatment in 2 weeks may be indicated on the product label to control lice that were present as eggs at the time of initial treatment.

Because of the importance of lice control to the livestock industry, a large number of insecticidal products and treatment methods are available. Withdrawal times after treatment must be observed to avoid objectionable residues in meat or milk. A number of products are approved only for nonlactating cattle or goats. Caution must be taken in treating young, very old, or debilitated animals, as these may be more susceptible to toxicity. Some products may be labeled for several species of livestock; however, in the United States, the specific use must be approved by the Environmental Protection Agency or Food and Drug Administration and indicated on the product label. The label should always be read and understood before
treatment. As with pets, treatment of livestock may require a follow-up treatment to control lice that were present as eggs at the time of the initial treatment.

Beef cattle, dairy cattle, sheep, goats, swine, and equines may be effectively treated with a whole body mist or spray for louse control, although easier and less stressful methods may be available. Animal systemic insecticides, which have gained wide acceptance among livestock producers, are those that enter the circulatory system and eventually reach and control blood-feeding parasites like sucking lice. These insecticides may be administered topically/dermally, orally, or as a subcutaneous injection. The most popular method of application is the pour-on, a single line of liquid along the midline of the back (a variation is a single spot on the midline). Pour-on formulations of systemic pediculicides also control chewing lice, mainly through absorption and spread through the skin and hair coat of the treated animal. Several nonsystemic insecticides control lice in a similar manner (i.e., they spread through the skin and the hair coat from the site of application).

In the United States, more cattle are treated for lice than are any other species of livestock. While cattle may be sprayed, most commonly they are treated with the various pour-on formulations, both systemic and nonsystemic. A preventive fall treatment with a systemic insecticide is a common practice among cattle producers for control of both cattle lice and cattle grubs (*Hypoderma bovis* and *H. lineatum*). Fall treatment for lice control prevents an increase in louse infestations to potentially damaging levels over the winter.

Even when cattle are treated in the fall, it may be difficult for the cattle producer to keep his or her animals lice free. The producer will not usually see clinical manifestations of a louse infestation until winter. At this time, infested animals lick and rub in response to the lice. Bare patches may be noted (Fig. 7.19), and if the hair is parted, lice may be visible. When clinical infestations are observed, cattle may be treated with most of the products approved for louse control. Most methods can be used in cold weather; however, some, like the pour-ons, have an advantage in that they do not require elaborate equipment for spraying and the animals do not become completely wet and prone to chilling. Caution must be taken to avoid treatment of grub-infested cattle with a systemic in the winter because of the possibility of the “host–parasite reaction” occasionally seen in cattle when grubs are killed in the esophageal area or in the area of the spinal canal. Various treatment methods can be used during the winter to treat an entire herd or to treat only the animals that exhibit signs of infestation. Animals restrained in a stanchion may be individually dusted by hand. Because louse-infested animals are prone to rub, self-treatment devices like pediculicide-impregnated dust bags, oils, and back rubbers can aid in the control of lice. Insecticidal ear tags, applied in the summer for fly control, may aid in the control of lice because they are also present on cattle in the summer.

Louse infestations of sheep, goats, and swine may be treated with whole body or pour-on treatments of insecticide. Horses may be treated with a whole-body spray, but because horses may react to sprayer noise, liquid insecticide is often applied as a wipe. For control of severe infestations of swine, an insecticidal dust may be applied to the bedding.

Contact of domestic poultry with potentially infested wild birds should be avoided. When poultry houses are vacated for a new group of birds, it is important to remove all feathers that may be infested with nits. Poultry can be treated with whole body pediculicidal sprays or dusts, which should be repeated in 7–10 days. Although host treatment is most efficacious, bedding materials and cages can also be treated to aid in louse control.

With respect to louse-borne diseases, vaccines have been developed only against epidemic typhus, and none are completely safe or currently approved for widespread use. Live attenuated vaccines have been administered to humans, particularly in certain African nations, in attempts to quell epidemic typhus outbreaks but have not been highly effective.

**REFERENCES AND FURTHER READING**


