LICE

of

PUBLIC HEALTH IMPORTANCE

and

Harry D. Pratt and Kent S. Littig

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CENTER FOR DISEASE CONTROL
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Chapter 1

LICE AND PUBLIC HEALTH

INTRODUCTION

Lice have been intimately associated with man for centuries. Infestations with lice occur today in the United States and many other countries despite great efforts to maintain high standards of public health. Public health agencies are often called upon if infestations include or expose large groups of people, particularly those in public institutions such as schools, jails, hospitals, or homes for the aged.

The three sucking lice that infest humans are: the body louse *(Pediculus humanus humanus)*, the head louse *(Pediculus humanus capitis)*, and the crab louse *(Pthirus pubis)*. The body louse is the species involved in epidemics of louseborne typhus, trench fever, and relapsing fever, but all three cause pediculosis. This manual covers the public health importance, biology, and control of these lice.

INFLUENCE OF LICE ON HISTORY

Lice have plagued man since ancient times. Some of the epidemics which swept through the ancient civilizations cannot be identified with certainty but may have been cholera, anthrax, dysentery, plague, or typhus. These diseases commonly occurred among the general populace, but their occurrence among armies had direct bearing on events in history. In his book Rats, Lice and History, Zinsser has written that an outbreak of disease in a monastery in Salerno, Italy, in 1083 was probably typhus. An account of typhus was recorded during the Spanish civil wars in 1489 and 1490 when many Christians and Moors died of the disease, and since then records show that typhus has played an important role in European history. At Naples, Italy, in 1528, deaths from typhus led to the defeat of a French army, the crowning of Charles V of Spain as ruler of the Holy Roman Empire, and the emergence of Spain as a dominant power in Europe for more than a century. In the late 1500's, louseborne typhus became established in the Balkans, Poland, Hungary, and European Russia.

Historians have noted that an epidemiological history of the Thirty Years' War might be divided into two main periods: from 1618 to 1630, the earlier period when typhus was the main scourge and from 1630 to 1648, the later period when plague was the main scourge. Typhus had a key role in lifting the siege of Vienna by the Turks in 1683. Epidemic disease, including dysentery and typhus, decimated Napoleon's armies, particularly in the retreat from Moscow in 1812 and during the summer of 1813.

In World War I, typhus was rampant in the Balkans and on the Eastern Front. About 100,000 cases were reported in Russia during 1914 and perhaps 150,000 in 1916. After the collapse of Russia in 1917, the German army withdrew thousands of soldiers from the Eastern Front for a final attack on the Western Front, but took extreme precautions to prevent the spread of typhus into the civilian population and German armies in the west. As a result, louseborne typhus did not occur in either the German or Allied armies in France or Belgium. However, body lice, or "cooties," were common

in this area and another louseborne rickettsial disease known as trench (Wolhynian) fever occurred in epidemic proportions in both German and Allied armies.

During the period 1917 to 1921, there were no reliable figures on typhus in what was by then Soviet Russia, but Zinsser has written that there "were no less and probably more than twenty-five million cases of typhus in the territories controlled by the Soviet Republic, with from two and one-half to three million deaths" *(49)*.

In World War II, epidemic typhus occurred in North Africa, the Balkans, Russia, and Italy, and in the slave labor and concentration camps of Nazi Germany. In the winter of 1943-1944, DDT was first used extensively to control a large outbreak of typhus in Naples, and for the first time in history a typhus outbreak was stopped in winter. Later, as the Allied forces captured slave labor and concentration camps in Germany, all inhabitants were dusted with DDT before they were released. Consequently, no general epidemic of typhus occurred in Europe after World War II as had occurred in the Balkans and Russia after World War I.

In the Korean conflict, a major public health accomplishment was the delousing of 100,000 to 160,000 North Korean and Chinese prisoners of war. They were infested with lice that were resistant to the standard 5 percent and 10 percent DDT louse dusts which had been so effective in Europe during and after World War II. Then the use of 1 percent lindane dust was recommended *(26)*. This was so successful that 1 percent lindane powder became the standard insecticide when lice were resistant to DDT.

TYPHUS FEVERS

There are several distinct human diseases bearing the name "typhus," each caused by a different species of *Rickettsia*. *Rickettsia* are simple in structure and are intermediate in size between viruses and common bacteria. When stained with Macchiavello's stain, they appear as minute, reddish, rod-shaped organisms in the bluish cytoplasm of cells. *Rickettsia prowazeki* live only within the cytoplasm of living cells. They cannot survive except in living cells; hence these rickettsiae must be cultivated in a living medium, such as fertile hen eggs.

Rickettsia prowazeki is the organism that causes louseborne (epidemic or classical) typhus. It is transmitted by the body louse *(P. humanus humanus)*, and man is the reservoir. Louseborne typhus has a high fatality rate during epidemics, and it is more prevalent in winter.

Rickettsia mooseri (typhi) causes fleaborne (endemic or murine) typhus. It is transmitted to man by fleas, primarily the oriental rat flea *(Xenopsylla cheopis)*, and rats are the reservoir. Fleaborne typhus is a milder disease than is louseborne typhus; its attack rate is highest during summer and early fall months. Fleaborne typhus is sometimes mistakenly called Brill-Zinsser disease because both are mild diseases with similar symptoms. Brill-Zinsser disease is, however, a relapsing form of louseborne typhus. It has been diagnosed in the United States in persons who had the disease earlier in eastern Europe.

Rickettsia rickettsii causes tickborne typhus fever, the name given to several forms of spotted fever such as Rocky Mountain spotted fever. Tickborne typhus is the designation used for reporting these illnesses in the "Morbidity and Mortality Weekly Report" of the Center for Disease Control. This typhus is transmitted by hard ticks in the genera *Dermacentor* and *Amblyomma*.

Rickettsia tsutsugamushi causes scrub typhus or Japanese river fever. It occurs in the Orient from Japan to India, south to Australia, and it is transmitted by chiggers (mites).

Many authorities believe that fleaborne typhus is the primitive form of the disease, well adapted to maintaining itself in a mild form in a rat reservoir and seldom killing the rat flea. Louseborne typhus, on the other hand, is caused by a more recent, highly virulent mutant form of the organism; it frequently kills both man and body louse. Louseborne typhus may have had its beginning when a rat flea carried the typhus organism to a man who was heavily infested by lice. The fleaborne typhus organism *Rickettsia mooseri* may have changed within the body of man or louse to the louseborne typhus organism *Rickettsia prowazeki*.

It is not possible to diagnose a single case of typhus by clinical observation alone because the symptoms, especially in the early stages, resemble a number of other diseases--particularly Rocky Mountain spotted fever, Q fever, and rickettsialpox. Serological examinations, using a sample of blood taken during the acute stage, and another taken during the convalescent stage of the illness, are necessary for a confirmed diagnosis of most rickettsial diseases. The Weil-Felix and complement fixation tests are two of the most useful diagnostic tools available to the physician when rickettsial diseases are suspected.

Epidemiology of Louseborne Typhus

Outbreaks of louseborne typhus are most frequent during wars and natural disasters; its spread is dependent on poor sanitation, abundant lice, and crowded living conditions. Louseborne typhus has not been reported in the United States since the 1930's; it does occur in parts of Central and South America, Europe, Asia, and Africa. The disease has a cycle of man to body louse and body louse to man.

After a louse feeds on a person infected with *R. prowazeki,* the rickettsiae multiply rapidly in the midgut (stomach) of the insect. The epithelial cells of the midgut become so full of rickettsiae that the cells rupture, and the disease organisms are released in tremendous numbers into the contents of the gut and the feces of the insect. The louse dies within a week or ten days ordinarily, although it may live longer in exceptional cases.

A typhus patient is infective to the louse from early in the course of disease to the tenth day after onset and occasionally later. The louse then becomes infective to man in about a week when the organisms are abundant in the louse feces; feces are deposited on the human skin as the insect gorges itself with blood. The typhus rickettsiae penetrate the skin through cuts and minor abrasions, perhaps caused when the person scratches the louse bite. Tests have not shown that typhus can be spread by the louse bite itself. It is possible that the disease may be acquired by crushing infected lice with the teeth, as is the custom in some countries. Lice frequently leave the typhus patient when high fever develops and attach to other human hosts; thus, a rapid spread of disease may occur. Organisms may remain viable in a dead louse or in louse feces for many days.

Rickettsia prowazeki cannot be transmitted by the insect through the egg to its offspring. Therefore, the louse can acquire the organism only by biting an infected host.

In recent years many investigations have been made to determine the existence, importance, and epidemiology of louseborne typhus in sheep, goats, cattle, and other domestic animals and their ectoparasites, particularly ticks. At present, these animals and their ectoparasites are not considered to be an important source of human louseborne typhus *(34)*.

TRENCH FEVER

Trench fever, also known as Wolhynian fever, caused more sickness among the troops on the Western Front in World War I than any other diseases except scabies and influenza. Over a million cases were reported. Trench fever broke out in epidemic form in many parts of Europe in 1915; it had not been recognized earlier. During World War II it appeared again in the German-Russian campaign. *Rickettsia quintana* is probably the microorganism causing the disease, but conclusive evidence has not been established. Trench fever is a relatively mild disease with a negligible mortality and is believed to be transmitted from man to man by the body louse. Man probably becomes infected by the bite or by inoculation with the feces of an infected louse. Trench fever could probably be controlled by controlling body lice.

RELAPSING FEVER

Relapsing fevers are a group of closely related diseases in which periods of fever occur at rather regular intervals. Louseborne relapsing fevers have occurred in epidemic proportions in parts of Europe, Africa, and the Orient. The causative agents are spirochetes *(Borrelia recurrentis* and related species*)*. Louseborne relapsing fevers may have arisen from the more widespread tickborne diseases. Relapsing fevers are severe diseases that can produce a high fatality rate (as great as 50 percent) in undernourished people, but generally produce a low fatality rate (2 to 5 percent) in well-nourished people.

When a louse bites a relapsing fever patient, it takes about 1 milligram of blood, enough to contain many spirochetes. By the end of the first day, all live spirochetes have disappeared from the gut of the insect. About 6 days later they reappear in great numbers in the blood of the louse, circulating to all parts of the body cavity. The louse remains infective for life. The disease is not transmitted to humans by bite or through the feces; it is acquired only by crushing a louse or damaging it in some way to allow its blood to contaminate skin or mucus membrane of a human being. The mobile spirochete then enters the body through minor abrasions in the skin or membrane *(43)*.

Other types of relapsing fevers are transmitted by ticks of the genus *Ornithodoros* in western United States, the Mediteranean region, Africa, and Asia. They are caused by *Borrelia sp.* most of which are specific for the particular tick vector. These tickborne relapsing fevers usually do not occur in epidemics *(12)*.

Outbreaks of relapsing fever, like those of louseborne typhus, are most frequent during wars and natural disasters. It, too, is dependent on poor sanitation, abundant lice, and crowded living conditions.

PEDICULOSIS

Pediculosis (from the generic name of the louse, *Pediculus*) or infestation with lice is generally associated with people living crowded together and having limited facilities for regular bathing and laundering. The condition is most common during times of stress, such as war, and in concentration camps, evacuation centers, labor camps, schools, and institutions. In many countries pediculosis is associated with tramps and migrants and is known as "hobo's disease." Severe infestations lead to scratching, secondary infections, and scarred, hardened, or pigmented skin--the classic signs of pediculosis. After the widespread use of DDT following World War II, there were relatively few reports of pediculosis in the United States. However, as the use of DDT has become restricted, the number of cases of head lice in school children and in people in institutions has been increasing in recent years. Moreover, the growing number of people of both sexes with unkempt long hair and the tendencies in some population groups to live communally, to wear the same clothing for long periods of time, and to bathe irregularly have apparently led to an increase in all three kinds of lice that infest man *(1, 29)*.

Each of the three human lice cause pediculosis. Head lice are confined to the head hair and scalp where the adult and immature lice, and particularly the eggs, are found fastened to the hairs. Body lice are found on hairy parts of the body below the neck, with adult and immature lice and eggs frequently on clothing, especially along the seams of the inner surfaces. Crab lice are found in the pubic and anal regions and occasionally in the armpits, on the hairy areas of the chest, and on the eyebrows and eyelashes. Lice are transmitted from an infested person to another by direct contact and indirectly by contact with personal belongings, especially combs, clothing, headgear, and bedding. Animal lice normally do not infest man.

Head lice are often the cause of pediculosis outbreaks among persons in schools, jails, hospitals, nursing homes, and summer camps. Adult and immature head lice are seen less frequently than the eggs (commonly called "nits") which are fastened to the hairs, particularly those behind the ears. Public health workers should be aware that foreign material in the hair and hair casts have been mistaken for eggs. (A hair cast is the inner hair root sheath which has slid along the hair shaft, Figure 1c.) A number of cases of pseudo-pediculosis have been reported in which solidified globules of hair spray were confused with eggs, as shown in Figure 1b *(2, 29)*.

In Oregon, several thousand children and adults were sent home from school because many had small, whitish objects attached to their hair. An amorphous cellular mass was found in some cases and hair follicle mites *(Demodex sp.)* in others. However, only a very few of these persons were found with head infestations of lice *(35)*. The louse egg seen through a microscope is easily distinguished from other objects by distinct characteristics: the ring at the base of the egg by which it is fastened securely to the hair; the egg itself, frequently with an embryo visible inside; and the cap (operculum) with definite pores (Figure 1a).

When outbreaks occur in schools, the school child must be treated daily upon returning home. Otherwise the child is likely to become reinfested and the condition may spread to his classmates. In many instances other family members and close associates may require treatment.

Public institutions, such as hospitals, jails, and nursing homes, sometimes find incoming people infested with lice. If the incidence is high, it may be necessary to use experienced inspectors or public health nurses to inspect all people entering such institutions and to treat infested persons. Cases of infestation must be handled as a medical problem and considerable effort must be made to avoid exposure of patients to ridicule.

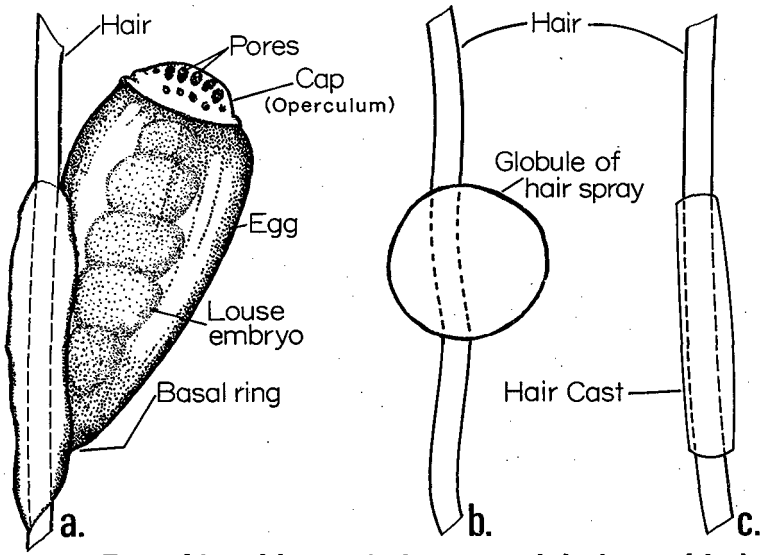

Figure 1. Egg of head louse, hair spray globule, and hair cast. (1a, after Ferris, 1951; 1b, 1c after Keh and Poorbaugh, 1971.)
50X MAGNIFIED

Chapter 2

BIOLOGICAL ASPECTS OF LICE

CHARACTERISTICS OF SUCKING LICE

Sucking lice belong to the order Anoplura. These wingless insects are flattened dorsoventrally, i.e., from top to bottom like a pancake. Adult lice have mouthparts consisting of 3 stylets modified for piercing and sucking; the stylets are retracted within the head when not in use. Their legs are short and stout, with a large claw on one or more of the three pairs of legs for grasping and holding onto hairs. The eggs of lice differ from those of most other insects because they are attached by cement and possess a distinct cap or operculum. Lice have three immature (nymphal) stages which resemble the adult stage. Most nymphs differ from adults in having fewer hairs on their bodies, fewer sclerotized plates, and in being sexually undifferentiated. Lice are, therefore, good examples of insects with incomplete or gradual metamorphosis, that is, insects with three stages of life: eggs, nymphs, and adults (Figure 2). Females are usually larger than males and the tip of their abdomen is notched or bi-lobed. Males have the tip of the abdomen rounded with the somewhat cigar-shaped genitalia often visible through the body wall.

Most sucking lice spend their entire life as ectoparasites on mammals (exceptions are bats, marsupials, certain aquatic mammals, and carnivores exclusive of the dog family). The body louse is a conspicuous and important exception because it rests on clothing except when feeding. Sucking lice occur only on mammals, never on birds, reptiles, or amphibia. Each species of louse generally feeds upon only one species of host animal, one genus or, more rarely, one group of mammals. In general, closely related groups of mammals appear to be infested by closely related species of lice.

Pediculus humanus occurs in two different forms often designated as distinct subspecies: *Pediculus humanus humanus* (the body louse) and *Pediculus humanus capitis* (the head louse). *P. humanus humanus* is called *P. humanus corporis* or *P. humanus vestimenti* by some taxonomists *(31)*. These two forms differ morphologically in size, proportion, and color, but there is an overlapping of characteristics in the extremes of any series. Therefore, it is impossible to assign an individual specimen to either racial form with certainty, although series usually can be determined with some certainty. In general, body lice are 10 to 20 percent larger than head lice and are often lighter colored, particularly those body lice from dark-haired Caucasians or Orientals. In addition, body lice tend to have more slender antennae, less pronounced constrictions between the abdominal segments, and more developed musculature of the abdomen.

The two forms are similar physiologically, but laboratory experiments indicate that the body louse is more efficient because it lays more eggs, lives longer, and is more resistant to starvation. Biologically, the chief differences are in the habits, one form living on the head and neck and the other on the body. Correlated with these two habits are differences in egg laying, i.e., the head louse cements her eggs to the hairs of the scalp, while the body louse normally glues her eggs to fibers of clothing, or, less commonly, to body hairs. Mating will occur between head and body lice; it

has even been reported that typical head lice confined on the body lose their subspecific characteristics and acquire the morphological characters of body lice after four or more generations *(33)*.

From the public health viewpoint, the important difference between the two forms is that the major epidemics of typhus have all been associated with widespread infestations with body lice, not head lice. Furthermore, typhus remains endemic in cool areas where people wear several layers of clothing and body louse infestations are common. Typhus is rare in tropical areas such as Malaya or tropical Africa where little clothing is worn, and most specimens found are head lice *(12)*.

HEAD AND BODY LICE

The Egg

The large, yellowish egg of *Pediculus humanus* is about 0.8 mm. long by 0.3 mm. broad. It is provided with a cap at one end to admit air during development of the embryo and to facilitate escape of the young insect. The egg of the head louse is attached to a human hair with cement (Figure 2). The egg of the body louse is cemented to fibers of the underclothing. The eggs on the human scalp or undergarment are incubated by heat from the body and hatch in about a week. Hatching of eggs is greatly reduced or completely prevented by exposure to temperatures above 100°F. or lower than 75°F. Thus, the body louse is readily controlled when the same articles of apparel are worn intermittently. When the same clothing is worn for several weeks or months, it may become heavily infested with body lice. Conversely, if clothing were stored for a month, even without treatment, all eggs would hatch or die, and any young which hatch would die.

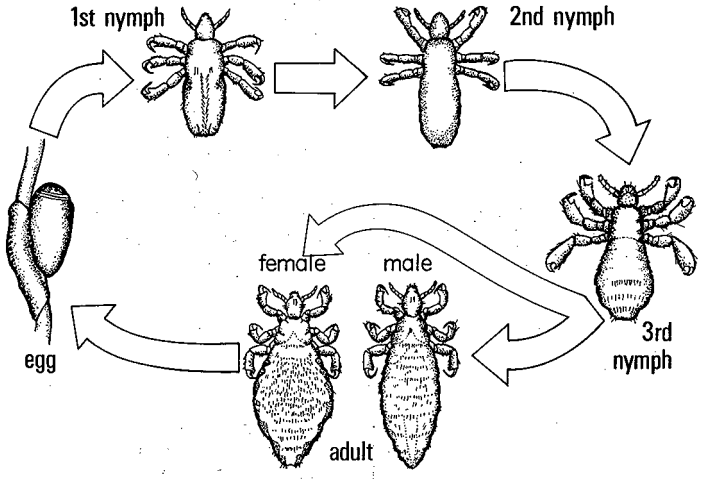

Figure 2. Life Cycle of the Head Louse

The Nymph

After emerging from the egg, the louse nymph molts three times before becoming a sexually mature adult. Therefore, there are three nymphal instars, differing from each other by the increased length of the abdomen as development progresses. The nymphal stages require 8 to 9 days for lice remaining in contact with the human body, but may require 2 to 4 weeks when the clothing is removed at night. If the clothes are not worn for several days, all of the lice will usually succumb. The total life cycle of head and body lice may be completed in about 18 days.

The Adult

The adult body or head louse differs little from the nymph except in size and sexual maturity. The elongate body has 3 parts: a head, a fused thorax, and a segmented abdomen over three-fifths the body length. The male is smaller than the female. Table 1 lists some of the morphological characteristics of human lice.

TABLE 1

MORPHOLOGY OF LICE PARASITIC ON MAN

	Body Louse	Head Louse	Crab Louse
Size of Adults			
male	2.0 - 3.0 mm.	1.0 - 1.5 mm.	0.8 - 1.0 mm.
female	2.0 - 4.0 mm.	1.8 - 2.0 mm	1.0 - 1.2 mm.
Abdomen	Elongate, without hairy lateral processes	Elongate, without hairy lateral processes	Short, with hairy lateral processes
Legs	Approximately equal	Approximately equal	First pair smaller, more slender than 2nd or 3rd pairs
Color	Grayish-white	Grayish-white with dark margins	Grayish-white
Average length of eggs	0.8 mm.	0.8 mm.	0.6 mm.

The head bears a pair of eyes, mouthparts, and a pair of short, 5-segmented antennae. The mouth is encircled by 6 pairs of hooks by which the louse attaches to the skin during feeding. There is also a retractable, soft, haustellum with piercing stylets to open the wound and provide a salivary duct.

When ready to feed, the louse anchors its mouth to the skin, stabs an opening through the skin, pours saliva into the wound, and pumps blood from the injury into the digestive system by means of the pharyngeal pump.

The three thoracic segments each bear a pair of strong, 5-segmented legs. Each leg terminates in a hook-like claw which by opposing a thumb-like tibial process enables the louse to maintain its hold on hairs and fibers. The abdomen is elliptical and has 9 segments. Mating occurs frequently and at any time in the adult's life, from the first 10 hours to senescence. Eggs are laid 24 to 48 hours later, depending upon temperature conditions. Eggs are cemented on head hairs by head lice or on the underclothing by body lice. If the human is relatively nude, as in some tropical areas, lice may infest beads and necklaces. Body lice may deposit 9 or 10 eggs per day and a total of 270 to 300 eggs in a lifetime. Head lice are less prolific, depositing about 4 eggs per day for a total of about 88 in a lifetime.

Human lice depend upon human blood for sustenance. They suck blood for long periods of time, but do not ordinarily become engorged. Some individual lice feed too avidly, causing rupture of their digestive system, and succumb because of their greed. During feeding, dark red feces may be deposited on the skin.

Adults and nymphs of head lice are found in the hair and on the scalp; they tend to be most prevalent on the back of the neck and behind the ears. They are not known to infest eyebrows or eyelashes, but the crab louse may.

As many as 1,000 body lice have been removed from the undergarments of one person. It is more typical to find less than 10 lice per person. Most of the lice are on the inner surface of the clothing, next to the skin. Females tend to congregate along seams for egg laying. Some of the adults tend to migrate away from the skin to the outer garments, hence to other persons. Head and body lice can move fairly rapidly and will pass from host to host, or from one host to bedding, by simple contact.

It is difficult to find human lice and crab lice away from man. Beds occupied every night by insanitary individuals have more chance of being lousy. If unoccupied for several nights, they tend to be free of lice. Head and body lice may be acquired by personal contact and by putting on infested garments. Head lice may be acquired by contact with upholstered chairs and by using infested brushes and combs. Hairs with eggs attached may be blown about. Lice tend to leave a feverish patient and seek other hosts.

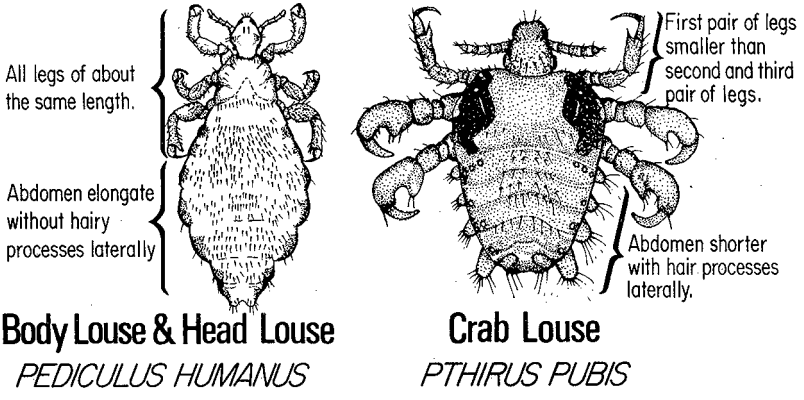

Figure 3. Lice commonly found on man.

CRAB LICE

Crab lice *(Pthirus pubis)* are small grayish-white insects with a short abdomen bearing hairy lateral tufts and large second and third pairs of legs which gives them a crab-like appearance (Figure 3). The scientific name of this insect is often incorrectly spelled *Phthirus pubis* or *Phthirius pubis*.

Relatively few details of the biology of the crab louse are known because they are difficult and unpleasant to rear in captivity. These insects are most commonly found on hairs in the pubic areas, but they may be found on hairy areas of the chest or armpits. Infestations of the eyebrows and eyelashes have been reported frequently. Crab lice on the eyebrows feed in a very localized area and cause hemorrhages into the skin which result in a bluish pigment directly above the eyebrows. Quarantine doctors often note this bluish coloration as one of the first signs of louse infestations.

The life cycle of the crab louse is similar to that of the head and body lice. The eggs are glued to hairs but are smaller and have a more convex cap than do *Pediculus*. It is not known definitely how many eggs are laid in nature, but one female confined under a stocking laid 26 eggs, averaging three per day. There are three nymphal stages. In a few specimens that were carefully studied, it took 13 to 17 days for them to become adults. Adult life apparently lasts less than a month. All stages are more sedentary than those of head or body lice. They tend to settle down at one spot, grasping hairs with the legs of both sides of the body, inserting the mouthparts, and taking blood intermittently for many hours at a time. The legs are adapted for grasping rather large hairs and, in the

position adopted, the adult prefers hairs rather widely spaced (compared with the dense hairs of the head). This may partly explain the distribution of the crab louse which is found most commonly on the hair in the pubic and anal areas. This insect survives only a short time away from the host; 200 crab lice were removed from a man and only one was alive less than 24 hours later, although the insects were kept in moist air *(33)*.

Crab lice are spread chiefly by sexual contact, but may be acquired by other means such as infested toilet seats and beds, and by close personal contact. Many authorities believe that there has been a genuine resurgence in the number of cases of crab louse infestations, related to the present worldwide climate of cultural permissiveness. "It is not surprising that the incidence of *P. pubis* like that of other venereal diseases, has risen significantly as the boundaries of sexual freedom have blurred" *(1)*. Small children may become infested with crab lice on their eyebrows or eyelashes from their mothers or nurses or through normal play activities. "As many as 100 have been counted on the eyelashes of a single person; in this site they may induce blepharitis" *(1)*, an inflammation of the eyelid.

OTHER SUCKING LICE

Good discussions and illustrations of other species of sucking lice are found in certain references *(22, 27)*. An illustrated key to the important species in the United States has been published *(41)*, and extensive data on the host-parasite relationships of Anoplura throughout the world have been assembled *(24)*.

Sucking lice are often collected by public health workers during rat ectoparasite surveys. Sometimes lice are more abundant on rats than fleas or mites. Rat lice are similar in structure, life history, and habits, to those lice which infest man. The two most common species are less than 1/16 inch long, feed exclusively on the blood of mammals, attach their eggs to the hairs, and undergo three molts on the host.

The rat louse *(Polyplax spinulosa)* is found almost worldwide. It often occurs in great numbers on domestic rats throughout the United States *(36)*. This species is readily infected with fleaborne typhus rickettsiae *(25)* and is capable of transmitting the disease from rat to rat in nature. It may help to maintain the reservoir of this malady in rats, but not in man since the rat louse is not known to feed on humans.

The tropical rat louse *(Hoplopleura pacifica)* has been incorrectly identified and reported as *(Hoplopleura oenomydis) (28)*. It is common on rats in the southern United States. Nothing is known about the possible relationship of this species to fleaborne typhus.

Both species of rat lice have been well illustrated, including male and female, the three immature stages, and the eggs *(37)*. Two other species of sucking lice, *(Hoplopleura acanthopus* and *Hoplopleura hirsuta)*, are occasionally found on rats and are included in the pictorial key of rat lice in the appendix.

IDENTIFICATION OF LICE

Pictorial keys for identifying common sucking lice and rat lice are found in the appendix.

Chapter 3

CONTROL OF LICE

The three kinds of lice that infest man differ considerably in habits and, therefore, require different methods of control. Because the body louse is the vector of epidemic typhus and other diseases, emphasis has been placed on development of measures for its control.

CONTROL OF BODY LICE

The body louse spends its life on the clothing except for a short time on the skin while feeding. The eggs are laid on the cloth, attached to the fibers; wool cloth is much preferred to other kinds. In looking for infestations, one should examine the clothing along the seams and folds, especially on the inside of the underwear.

Ordinary laundering with hot water will destroy all stages of lice on infested clothing and bedding. Dry cleaning may be used to destroy lice on wool garments. The solvent used in cleaning is toxic to lice, and the steam used in pressing makes certain that control is complete. Pressing woolens at home is also satisfactory, but special attention must be given to the seams.

Three insecticide powders, 10 percent DDT, 1 percent lindane, and 1 percent malathion, have been extensively used to control body lice. During epidemics of typhus, 10 percent DDT has been the insecticide of choice in many parts of the world *(47)*. In the United States where DDT is difficult to obtain and where its use has been largely banned since January 1, 1973, or in areas where body lice are resistant to DDT, these insects may be controlled with dusts containing 1 percent lindane, 1 percent malathion, or 0.2 percent pyrethrin or 0.3 percent allethrin synergized with piperonyl butoxide *(14)*.

Frequently, liquid preparations are more acceptable than dusts because the powders are unsightly and suggest that the person is infested with lice. Moreover, it is reported that louse powders are not registered for use in California. Three shampoos or lotions are listed as being available commercially: the first (A-200 Pyrinate*) containing 0.2 percent synergized pyrethrins; a second (Cuprex*) with 31 percent tetrahydronaphthalene and 0.03 percent copper oleate; and a third (Bornate*) with 5 percent isobornyl thiocyanoacetate and 0.6 percent dioctyl sodium sulfosuccinate *(29)*.

Two emulsifiable concentrates for controlling all three species of human lice are available by physician's prescription. One contains 1 percent lindane (Kwell*). The second (Topocide*) is also known as NBIN and contains the following materials by weight: benzyl benzoate--68 percent, DDT--6 percent, benzocaine--12 percent, and Tween 80--14 percent. The present formula may not contain DDT *(14)*. NBIN is diluted with 6 volumes of water before application. Each person is required to take a soap and water bath before treatment. The mixture should be kept out of the eyes. People treated with Kwell* should not bathe again for at least 24 hours; those treated with Topocide* should wait 48 hours *(29)*. Benzocaine is a very

effective ovicide so the eggs, as well as the active stages, are killed. About 20 ml. of the finished emulsion is required per person, or approximately 5 gallons per 1,000 men.

One percent malathion dust usually provides 3 to 4 weeks protection, killing adults and immature stages, and any young which hatch from the eggs. One study reported that this dust was effective against eggs *(16)*. Toxicological studies indicated that 1 percent malathion may be used as safely as the standard 10 percent DDT powder which has been used to control lice on millions of people with no ill effects. DDT is rather slow in action, but the lice are usually immobilized in less than six hours. It is not effective against the eggs. Treatments with 1 percent lindane, 0.2 percent pyrethrin, or 0.3 percent allethrin plus synergist have a short residual action and require a second application 7 to 10 days later to kill newly hatched lice.

These powders are frequently dispensed in 2-ounce sifter-top cans or plastic bags for individual use. The powder should be applied over the inner surface of the underwear and evenly distributed by hand, with special emphasis on the seams and folds. The seams inside the shirt and trousers and socks or stockings should be similarly treated. About one ounce of powder is necessary for one treatment.

Hand-operated dust blowers or motor-driven air compressors with as many as 10 dusting heads have been used for mass treatment of civilian populations, troops, and prisoners of war. The clothing need not be removed. About two ounces of the powder is shaken or blown into the clothing through neck openings, up the sleeves, and all around the loosened waist of trousers. In delousing women, an extra amount of the insecticide may be introduced around the neck and the application at the waistline omitted. These methods were used during the 1943 Naples typhus epidemic, in delousing prisoners of war in concentration camps toward the end of World War II, and in Korea during 1951 and 1952. In Korea, lice were resistant to the standard 10 percent DDT dust issued to troops, so 1 percent lindane powder was used effectively for mass delousing. DDT is very effective and long lasting when used to impregnate clothing. The personal factor is largely eliminated if the clothing is bulk treated with liquid insecticide before issuance or during laundering; this treatment also provides more permanent louse control than powders. Garments may be impregnated with DDT in a volatile solvent or by soaking them in a 1 percent DDT emulsion four times their weight, according to directions of the World Health Organization *(47)*. For example, if 100 pounds of clothing were to be treated, 400 pounds of 1 percent DDT emulsion would be required. (100 pounds of clothing x 4 = 400 pounds of 1 percent DDT emulsion.) Converting the 400 pounds of emulsion into gallons approximately 48 gallons would be required. (400 pounds of emulsion ÷ 8.34 pounds per gallon = 48 gallons.) Insecticide properly impregnated in garments remains effective through 6 to 8 launderings.

In the past, fumigation of clothing with hydrogen cyanide or methyl bromide has been used. However, these gases are very dangerous and such fumigation should be done only by well-trained personnel. In recent years, ethyl formate applied at a rate of 2 ml. per liter for 1 hour to clothing in metal bins or plastic bags has proven more satisfactory. Care should be taken with such fumigation because ethyl formate is flammable *(47)*.

CONTROL OF HEAD LICE

Head lice spread rapidly through a family and may be transmitted to people throughout a community. They are most abundant in children. In some countries, girls tend to be more heavily infested by both head and body lice than do boys.

The eggs, often called "nits," are the easiest stage to discover when inspecting for head lice. They are most commonly attached to the hair, close to the scalp behind the ear.

With school boys, men, or prisoners of war, a very close hair cut or even shaving the head to remove the eggs and all later stages is a simple, inexpensive method of controlling head lice. With women and girls, other methods are often used. Both the lice and the eggs must be destroyed. Vinegar will not destroy the glue which holds the eggs to hairs, as was once commonly supposed. The safest and best materials for head louse control are emulsions containing 0.2 percent pyrethrins, 1 percent lindane (Kwell*), or 12 percent benzyl benzoate, or insecticide dusts containing 1 percent lindane or 1 percent malathion *(14)*. The following procedure for using emulsions is safe and easy to follow.

1. Shampoo and dry the hair thoroughly.
2. Seat person in chair with head tilted backward and eyes covered with towel.
3. Apply the emulsion liberally to the hair and scalp with brush and swab. Work against the nap of the hair and touch all hair and the whole scalp.
4. Comb the hair in the usual manner.
5. After 10 minutes with the pyrethrin emulsion, or after 24 hours with the lindane or benzyl benzoate emulsion, shampoo the hair.
6. Dry, comb, and brush hair to remove dead lice and loosened eggs.

The application of 1 percent lindane or 1 percent malathion dust in pyrophyllite or talc is effective, although it is unsightly. The dust should remain on the scalp 24 hours in order to produce a complete kill. A second treatment 7 to 10 days later will kill all lice that have hatched out since the first treatment.

When these insecticides are not available, as may be the case following a civil disaster or in some rural areas, it may be necessary to use older treatments. In such cases, 2 percent Lysol or a mixture of 50 percent kerosene and 50 percent of any bland vegetable oil may be used. These substances should be applied thoroughly to wet the hair, and the head is then bound up in a towel for at least an hour. The hair may then be shampooed, thoroughly dried, and combed to remove any dead lice or eggs which have been loosened.

CONTROL OF CRAB LICE

As with head and body lice, a simple treatment for crab louse control is shaving or cutting the infested hair to remove adults, immature stages, and eggs glued to hairs. The centuries-old use of mercuric ointment for crab lice cannot be recommended; its insecticidal value is low, and there is

risk of mercurial poisoning. Crab lice have been controlled effectively by the application of 10 percent DDT dust to the pubic and anal areas. However, this dust is difficult to obtain in the United States, and its use has been largely banned since January 1, 1973. Therefore, alternate insecticides should be used: 1 percent lindane or 1 percent malathion powder, or emulsions of 1 percent lindane, 0.2 percent pyrethrins plus a synergist, or 12 percent benzyl benzoate. In recent years, crab lice have been reported on the eyelashes of people, particularly young children. An ophthalmic ointment containing 0.25 percent physostigmine has been recommended *(1, 47)*.

People are very sensitive about infestations of crab lice. A rumor of an infestation in a large office building can do much to disrupt normal operations and cause distress. If these problems are dealt with quickly and firmly, they will soon be forgotten. The following procedure is effective:

1. Close all rest rooms, one floor at a time. Make other facilities in the building available during the treatment period.
2. Wash all water closets and seats with a hot solution of Lysol* or a similar chemical used for cleaning rest rooms.
3. In order for those infested to treat themselves, leave 2-ounce containers of 1 percent lindane or 1 percent malathion powder with directions for treatment in the washroom in a conspicuous place.
4. Open rest rooms, one floor at a time, and announce to the person in charge that treatment is complete.

CONTROL OF RAT LICE

During the Murine Typhus Control Program of CDC and the State Health Departments in the United States from 1945 to 1952, 10 percent DDT dust was applied to rat nests, burrows, and runways for ectoparasite control. This chemical produced very effective control of rodent fleas, but was less efficient against rat lice. Complete control of rat lice has not been necessary in fleaborne typhus control programs, indicating that the louse is not able to keep the disease active in rats after flea populations have been reduced. Since the use of DDT has been restricted in recent years and has been banned in the United States since January 1, 1973, alternate insecticides should be considered. The most promising alternates (malathion, lindane, and carbaryl) have not had extensive field trials for rat louse control so it is difficult to evaluate the effectiveness of these toxicants.

MODERN LOUSEBORNE DISEASE CONTROL

For many years, louseborne typhus and relapsing fever were two of six internationally quarantinable diseases, the other four being cholera, smallpox, plague, and yellow fever. Only the last three diseases remain as Class 1 diseases, those diseases which international health regulations require case reports through official channels to the World Health Organization. As of January 1, 1971, epidemic typhus and relapsing fever became Diseases under Surveillance by WHO, together with poliomyelitis, malaria, and influenza *(8)*. In September 1971, cholera was also placed in this category.

Modern louseborne disease control has been revolutionized by the development of effective vaccines, drugs, and residual insecticides. Louseborne

typhus still occurs in parts of Central and South America, Europe, Asia, and Africa. In 1969, 22,116 cases were reported, of which 21,824 (99 percent) occurred in Burundi and Ethiopia *(45)*. Vaccines give a high degree of protection. The usual vaccine, containing rickettsiae grown in chick embryos, inactivated by formalin, and extracted with ether, is administered in 2 doses at an interval of not less than 7 days. A booster dose repeated at yearly intervals is indicated where typhus is a hazard. There were only 104 mild cases of louseborne typhus and no deaths among the U.S. Army personnel during World War II. Most of the patients had received typhus vaccinations before entering areas where this disease was known to occur *(48)*. The tetracycline antibiotic drugs and chloramphenicol provide effective treatment for clinical cases of louseborne typhus and the tetracyclines for relapsing fever *(8)*.

In recent years, wherever outbreaks of these diseases have occurred, insecticides have been used to kill the body lice which transmit typhus and relapsing fever. Ten percent DDT dust has been the chemical of choice. However, body lice have become resistant to DDT in many countries *(9)*, but alternate insecticides such as 1 percent lindane, malathion or carbaryl dusts, fortified pyrethrum powder, or benzyl benzoate, have been used. The body and head hair of all patients and contacts and their clothing and bedding should be thoroughly dusted with an appropriate residual insecticide for all lice or any which might hatch from eggs.

In summary, quarantine or isolation of clinical cases and/or contacts of louseborne typhus and relapsing fever is not required if the following steps have been taken *(8, 46)*:

1. Laboratory confirmation of the case of louseborne typhus or relapsing fever.
2. Treatment of clinical cases with tetracyclines or chloramphenicol.
3. Collection and identification of body lice from case or contacts, if possible.
4. Testing insecticide susceptibility of lice, if possible.
5. Reporting of cases and vector information to appropriate health department.
6. Immunization of immediate contacts in case of louseborne typhus.
7. Systematic delousing of all patients, contacts, and their clothing and bedding with appropriate insecticide dusts or liquids.

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APPENDIX

Key to Genera of Pediculidae

1. Abdomen much longer than basal width; without hairy tubercles (Fig. 1 A). Head and body louse.....*Pediculus humanus* Linnaeus

   Abdomen about as long as basal width; with hairy tubercles (Fig. 1 B). Crab louse.... .....*Pthirus pubis* (Linnaeus)

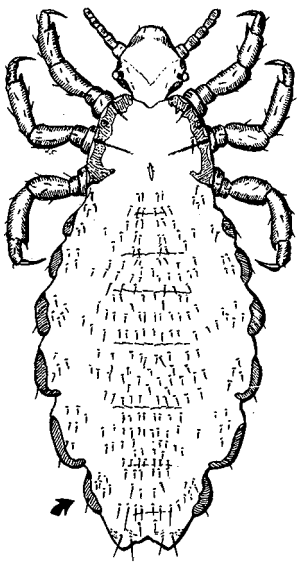


Fig. 1 A

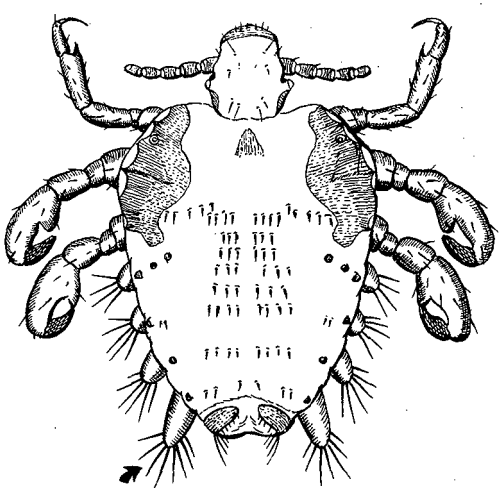
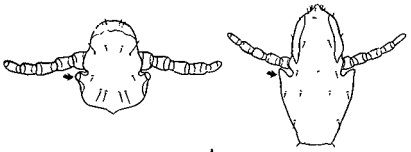


Fig. 1 B

PICTORIAL KEY TO SOME COMMON GENERA OF SUCKING LICE

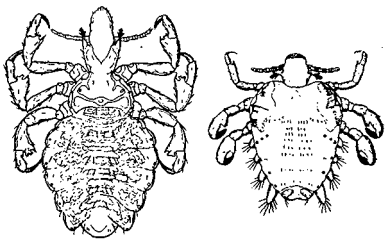
with eyes or ocular points

without eyes or ocular points



ocular points present, eyes absent

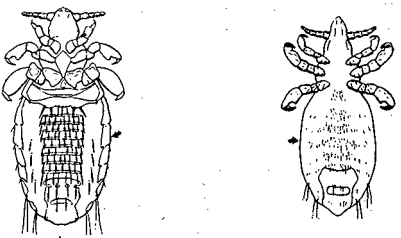
eyes present, ocular points absent



Haematopinus

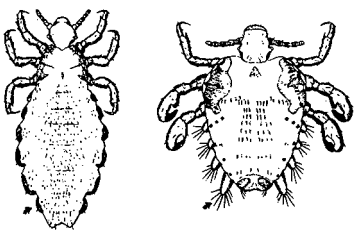
abdomen with lateral plates

abdomen without lateral plates



without hairy tubercles

with hairy tubercles

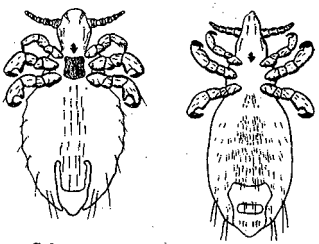


Pediculus

Pthirus

sternal plate well-developed

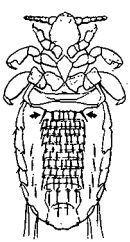
sternal plate narrow or absent



Solenopotes

Linognathus

2 groups of 2 or 3 stout spines present at base of abdomen

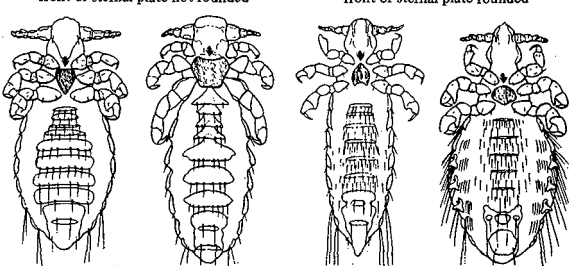


Hoplopleura

2 groups of 2 or 3 stout spines absent at base of abdomen

front of sternal plate not rounded

front of sternal plate rounded



Polyplax

Neohaematopinus

ANOPLURA: PICTORIAL KEY TO SPECIES ON DOMESTIC RATS IN SOUTHERN UNITED STATES

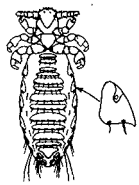
Abdomen with well defined ventral, lateral and dorsal plates

Abdomen with plates poorly defined or absent

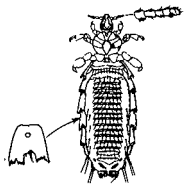
ADULTS

NYMPHS

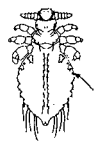
Lateral plates small, subtriangular. Segment II of antenna as long as wide



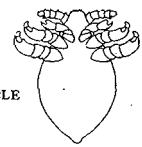
Lateral plates large, emarginate posteriorly. Segment II of antenna longer than wide



Abdomen with spiracles and two parallel rows of setae



Abdomen without spiracles or parallel rows of setae



Polyplax spinulosa

Hoplopleura spp.

Polyplax spinulosa

Lateral plates 4-6 with one large and one minute seta

Lateral plates 4-6 with two large setae

Hoplopleura pacifica

Lateral plates broadly emarginate; Apical processes thorn-like

Lateral plates narrowly emarginate; Apical processes broad

Hoplopleura hirsuta

Hoplopleura acanthopus