LICE

OF

PUBLIC HEALTH IMPORTANCE

AND

THEIR CONTROL

Training Guide - Insect Control Series

Harry D. Pratt and Kent S. Littig

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INTRODUCTION

Lice have been intimately associated with man since time immemorial. They are most common during times of stress, such as war, famine, or disasters when people do not bathe or wash their clothing regularly. Lice inject an irritating saliva into the skin during feeding which causes considerable itching. Severe infestations may lead to scratching, secondary infections, and scarred, hardened, or pigmented skin conditions known as PEDICULOSIS. In many parts of the world, lice also transmit pathogens causing human diseases. The most important of these is LOUSE-BORNE or EPIDEMIC TYPHUS. This rickettsial disease has determined the course of many wars in Europe in recent times. Extensive campaigns against the louse and epidemic typhus were carried out during World Wars I and II and during the Korean conflict. RELAPSING FEVER caused by a spirochete is another louse-borne disease. It is most prevalent in Europe, Africa, and Asia. During World War I, lice known to the American doughboy as "cooties" transmitted rickettsiae causing TRENCH FEVER. Fortunately, this disease has not been recognized in recent years.

All three human lice: the body louse (*Pediculus humanus humanus*), the head louse '(*Pediculus humanus capitis*), and the crab louse (*Phthirus pubis*) cause dermatitis, but apparently the body louse is the important species involved in actual epidemics of epidemic typhus, relapsing fever, and trench fever.

Louse control, and hence the control of epidemic typhus, has been simplified by the development of DDT, lindane, and other chlorinated hydrocarbons. The public health importance, biology, and the control of sucking lice will be considered in some detail in this chapter.

LICE AND HISTORY

Lice have plagued the world's armies since ancient times. Some of the early epidemics which swept through the ancient civilizations cannot be identified with certainty but may have been cholera, anthrax, dysentery, plague, or typhus. Zinsser has written in his fascinating book "Rats, Lice, and History" (1935) that the outbreak of disease in a monastery in Salerno, Italy, in 1083 was probably typhus. The next trustworthy account of typhus was recorded during the Spanish civil wars in 1489 and 1490 when many Christians and Moors died of the disease. Since that time typhus has played an important role in European history. The deaths from typhus at Naples. Italy, in 1527 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 epidemic typhus became generally established in the Balkans, Poland, Hungary, and European Russia.

Historians have noted that the epidemiological history of the Thirty Years' War might be divided into two main periods: the earlier, from 1618 to 1630, when typhus was the chief scourge; and the latter, from 1630 to 1648, when plague gained ascendancy. Typhus occurred commonly not only among the armies, but also among the general populace. It played 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. Following 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 with extreme precautions to prevent the introduction of typhus into the civilian population and German armies in the West. As a result, epidemic typhus never occurred either in the German or Allied armies in France and Belgium. However, body lice or "cooties" were common in this area and another louse-borne rickettsial disease known as trench fever occurred in epidemic proportions in both German and Allied armies. It has been reported that trench fever caused more sickness than any other disease ex-

cept scabies among soldiers during World War I, there being over a million cases.

During the period 1917-1921, there were no reliable figures on typhus in present Soviet Russia, but Zinsser (1935, p. 299) 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."

In World War II, epidemic typhus occurred in North Africa, the Balkans, Russia, Italy, and in the slave labor and concentration camps in Nazi Germany. DDT was first used extensively to control a large outbreak of typhus in Naples in the winter of 1943-1944. This was the first time in history that a typhus outbreak had been broken in winter time. Later as the Allied forces captured slave labor and concentration camps in Nazi Germany, DDT dusting of all personnel was carried out before people were released to civilian life. As a result there was no generalized epidemic of typhus in Europe following the end of World War II as there had been in the Balkans and Russia following World War I.

In the Korean conflict, one of the major public health accomplishments was the delousing of 100,000 to 160,000 North Korean and Chinese Communist prisoners of war. These prisoners were infested with lice which were resistant to the standard 5 and 10% DDT louse-powders which had been so effective in Europe during and after World War II. Therefore, Hurlbut *et al* (1952) recommended the use of a 1% lindane dust. This was so successful that 1% lindane powder is now a standard insecticide used when lice are resistant to DDT.

EPIDEMIC TYPHUS

The Typhus Organism

Typhus fevers are caused by rickettsiae. There are several distinct human diseases bearing the name "typhus." The first and most important one is "classical," "louse-borne," or "epidemic typhus" which occurs only in man, is highly fatal during epidemics, is transmitted by the body louse, and has its highest attack rate during the winter months. Another type is "murine typhus" or "flea-borne typhus" which occurs in rodents and man, is relatively mild as compared with epidemic typhus, is transmitted from rodents to man by fleas, primarily the oriental rat flea, and has its highest attack rate during the summer and early fall months.

Murine typhus has often been mistakenly called "Brill's disease" because both are mild diseases with similar symptoms. Brill's disease is a mild relapsing form of epidemic typhus which recurs in individuals who have had this disease before, usually in Eastern Europe.

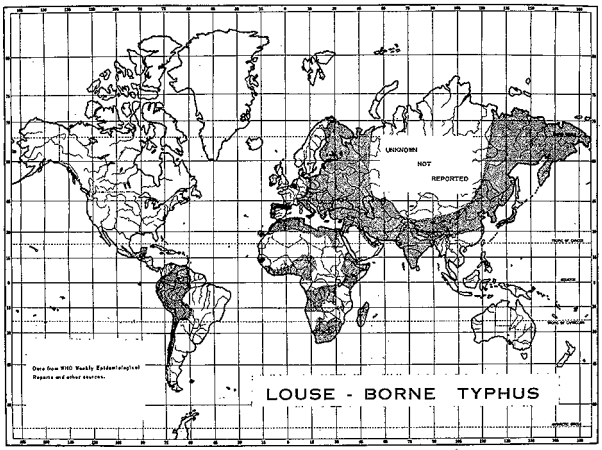
A third type, "scrub typhus" or "Japanese river fever," occurs in the Pacific Oriental regions and is transmitted by a chigger.

In many parts of the world there are a number of forms of spotted fevers known as "tick typhus."

Many authorities believe that murine typhus is the primitive form of the disease, well adapted to maintaining itself in a mild form in a rodent reservoir and seldom killing the rat flea which is one of the principal vectors from rat to rat. Epidemic typhus, on the other hand, is a more recent, highly virulent mutant which frequently kills both man and body louse. Epidemic typhus may have had its beginning when a rat flea carried the murine typhus organism to a man who was heavily infested with lice. The murine typhus organism (*Rickettsia typhi*) may have changed within the body of man or louse to the epidemic typhus organism (*Rickettsia prowazeki*).

RICKETTSIAE are very simple in structure and are intermediate in size between viruses and bacteria. When stained they appear as minute, reddish, rod-shaped organisms in the bluish cytoplasm of cells. Epidemic typhus organisms live only within the cytoplasm of living cells. They cannot be cultivated except in the presence of living cells; hence these rickettsiae must be reared in some living medium, such as fertile hen's eggs.

It is not possible to make a definite diagnosis of a single case of typhus by ordinary 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 in the laboratory, using two samples of blood taken during the acute and convalescent stages of the sickness, 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 clinical physician when rickettsial diseases are suspected.



Cycle of *Rickettsia prowazeki*

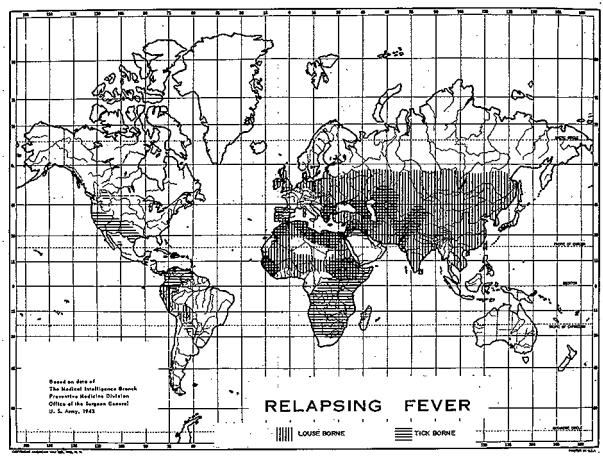
After a louse feeds upon a person infected with *R. prowazeki*, there is a rapid multiplication of the rickettsiae in the midgut (stomach) of the insect. The epithelial cells of the midgut become so full of rickettsiae that they rupture, and the disease organisms are released in tremendous numbers into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

The typhus patient is infectious to the louse from early in the disease to the tenth day and occasionally later. *The louse will then become infective to man in about a week when the organisms become abundant in the louse feces which are deposited on the human skin* as the insect gorges itself with blood. The typhus rickettsiae in these feces penetrate the skin through cuts and minor abrasions, perhaps caused when the person scratches the louse bite. Lice frequently leave the typhus patient when high fever develops and attack other human hosts causing a rapid spread of disease. Infected feces may remain virulent for many days, thus preserving the pathogen. Tests have not shown that typhus can be spread by the louse bite. It is possible that the disease may be acquired by accidentally crushing infected lice with the teeth, as is the custom in some countries.

Louse-borne typhus cannot be transmitted by the insect to its offspring through the egg. Therefore the louse must acquire the disease by biting an infected host.

Modern Epidemic Typhus Control

In areas where typhus is present, modern vaccines give a high degree of protection. Whayne (1951) has written that there were only 5 cases of epidemic typhus and no deaths in Army personnel during World War II, most of whom had received typhus vaccinations before entering areas where this disease was known to occur. South American countries, such as Peru, are planning wide-spread vaccination campaigns, and hoping for two or three years protection after each inoculation. Modern insecticides give strong hopes for effective louse control, either by mass delousing applying 5 or 10 percent DDT powder with compressor type machines, or by individual treatment with 2 ounce cans of 5 and 10 percent DDT. In areas where lice are resistant, other insecticides may be used such as 1 percent lindane powder, a German insecticide known as lauseto neu, fortified pyrethrum powder, or benzyl benzoate. Moreover, new drugs such as aureomycin, terramycin, or chloromycetin are now available for treatment of epidemic typhus.



TRENCH FEVER

Trench fever caused more sickness among the troops on the Western Front in World War I than any other disease except scabies, there being over a million reported cases. This disease was not known before 1915 when it broke out in epidemic form in many parts of Europe. During World War II it appeared again in the German-Russian campaign. *Rickettsia quintana* is probably the microorganism causing the disease, but conclusive evidence as to the exact agent is still wanting. Trench fever was a relatively mild disease with a negligible mortality and was believed to be transmitted from man to man by the body louse. Man probably became infected by the bite or by the inoculation of the feces of an infected louse. Control of trench fever probably could be accomplished by eradication of lice.

RELAPSING FEVERS

Relapsing fevers are a group of closely related diseases in which periods of fever occur at rather regular intervals. Louse-borne 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. Louse-borne relapsing fevers may have arisen from the more widespread tick-borne diseases. They are severe diseases that have produced very high fatalities (to 50 percent) in undernourished populations, but generally low fatalities (2 – 5 percent) in well-fed individuals.

When a louse bites a relapsing fever patient, it takes about 1 milligram of blood, enough to contain many spirochetes of the disease. 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 by the feces. *The disease 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 gains entrance through minor abrasions in the skin or membrane.

Other types of relapsing fevers are transmitted by ticks in the genus *Ornithodoros* in western United States, the Mediterranean region, Africa, and Asia. These are caused by spirochetes in the genus *Borrelia*, most of which are specific for the particular tick vector. These types of relapsing fever usually do not cause epidemics, according to Buxton (1946).

Outbreaks of relapsing fever and epidemic typhus are most frequent during wars and disasters. Both of these diseases are dependent upon poor sanitation, abundant lice, and crowded living conditions.

GENERAL BIOLOGY 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. Lice have mouthparts consisting of 3 stylets modified for piercing and sucking which are retracted within the head when not in use. Their legs are short and stout, with a large claw on one or more pairs of legs for grasping and holding onto hairs. The eggs of lice differ from those of most other insects in being glued to mammal hairs and in possessing a distinct cap or operculum. There are three immature stages known as nymphs, which resemble the adults considerably. Most nymphs differ from the adults in having less 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 in their life histories: *eggs, nymphs,* and *adults.* Females are usually larger than males and have the tip of the abdomen notched or bilobed. Males have the tip of the abdomen rounded with a somewhat cigar-shaped male genitalia often visible through the body wall.

Most sucking lice spend their entire life as ectoparasites on mammals. The body louse is a conspicuous and important exception since it rests on clothing except when feeding. Sucking lice occur only on mammals, never on birds, reptiles, or amphibia. These lice are parasites of most mammals with the exception of the bats, marsupials and the carnivores (exclusive of the dog family). One 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 racial forms often called distinct subspecies: the body louse (*Pediculus humanus humanus* L.) and the head louse (*Pediculus humanus capitis* DeGeer). Muesebeck (1953) and others prefer the scientific name *Pediculus humanus humanus* to *Pediculus humanus corporis* for the body louse. Morphologically these two forms differ principally in size, proportion, and color; but there is considerable overlapping of characters in the extremes of any series. Therefore, it is impossible to assign an individual specimen to either form with certainty although series usually can be determined with some certainty. In general, the body lice are 10 to 20 percent larger than the 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.

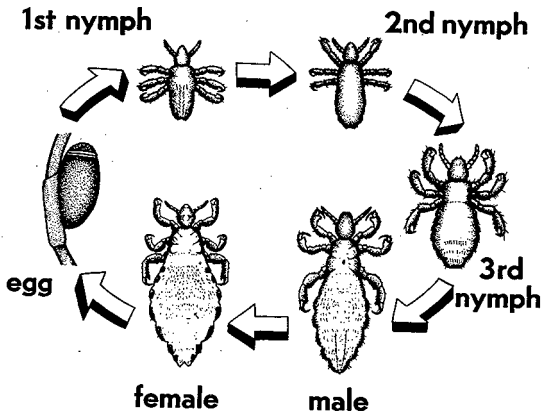
The two forms are rather similar physiologically, but laboratory experiments indicate that the body louse is more efficient since it lays more eggs, lives longer, and is more resistant to starvation. Biologically, the chief differences are in the habits, one form living on the head and neck and the other on the body. Correlated with these two habits are differences in egg-laying, i.e., the head louse cements her eggs to the hair of the scalp, while the body louse normally glues her eggs to fibers of clothing or, less commonly, to body hairs. Cross-mating will occur between head and body lice, and Nuttall (1919) has even reported that typical head lice lose their subspecific characteristics and acquire the morphological characters of body lice after four or more generations.

From the public health viewpoint, the important difference between the two forms lies in the fact that the major epidemics of typhus have all been associated with widespread infestations of body lice, not head lice. Furthermore, typhus continues to remain 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 the majority of specimens are head lice, according to Buxton (1946).

BIOLOGY AND HABITS OF THE HEAD AND BODY LOUSE – *Pediculus humanus*

The Egg

The large, yellowish egg of *P. 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 facilitate escape of the young insect. The egg of the head louse is attached to a human hair with cement, and is commonly called a "nit." The egg of the body louse is attached to fibers of the underclothing. The eggs on the human scalp or undergarment are incubated by the body heat, hatching in about a



Life Cycle of the Head Louse

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 as would be the natural course in most civilized lands. When the same clothing is worn over periods of several weeks or months, it may become heavily infested with body lice. Conversely, if clothing is stored for a month, without treatment, all eggs would hatch or die, and any young which hatch would starve to death.

The Nymph

After emerging from the egg, the louse nymph goes through 3 molts 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 therefore may be completed in about 18 days.

The Adult

The adult body or head louse differs little from the nymph save 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 characteristics of human lice.

The head bears a pair of eyes, a pair of short, 5-jointed antennae, and the mouthparts. The mouth, or buccal opening, is encircled by 6 pairs of hooks that serve to attach the louse to the skin during feeding. There is also a retractable proboscis 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 with the pumping pharynx.

The three thoracic segments are fused together. They bear 3 pairs of strong, five-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. Egg

TABLE 8.1

CHARACTERISTICS 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 and 3rd pairs
Color	Grayish-white	Grayish-white with dark margins	Grayish-white
Length of eggs	0.8 mm.	0.8 mm.	0.6 mm.

laying takes place 24 to 48 hours later, depending upon temperature conditions. Eggs are glued on head hairs by the head louse 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.

Human lice are completely dependent 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 passed on the human skin. Infected louse feces, deposited on human skin, transfer the rickettsiae from louse to human.

Adults and nymphs of head lice are found in the hair and on the scalp. They are not known to occur on eyebrows or eyelashes, but the crab louse, *Phthirus pubis*, may be present. Head lice tend to be most prevalent on the back of the neck and behind the ears.

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.

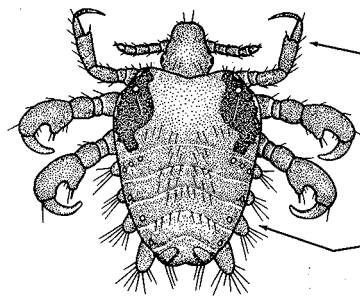
It is difficult to find human lice and crab lice away from man. Beds occupied every night by insanitary individuals tend to be lousy. If unoccupied for several nights, they tend to be free of lice. Head and body lice may be acquired by personal contact and by putting on infested garments. Head lice may 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.

LICE COMMONLY FOUND ON MAN

BODY LOUSE AND HEAD LOUSE

PEDICULUS HUMANUS

CRAB LOUSE



PHTHIRUS PUBIS

BIOLOGY AND HABITS OF THE CRAB LOUSE

Crab lice (*Phthirus pubis* L.) are small whitish insects with a definitely short abdomen and large second and third pair of legs which give them a crab-like appearance. Relatively little is known about the detailed biology of the crab louse because they are difficult and unpleasant to rear in captivity. These insects are most commonly found on the hairs in the pubic region,, but they may be found on the hairy regions of the chest or arm pits. Infestations of the eyebrows and eyelashes have been reported frequently. Crab lice on the eyebrows apparently feed in a very localized area with the deposition of a bluish pigment in the skin directly above the eyebrows. Quarantine doctors often note this bluish pigment as one of the first signs of louse infestations in their patients.

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 in *Pediculus*. It is not known definitely how many eggs are laid in nature, but one female confined under a stocking laid 26 eggs with an average of three per day. There are three nymphal stages which required 13 – 17 days to become adults in the few specimens carefully studied. Adult life apparently lasts less than a month. All stages are very much more sedentary than 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 peri-anal regions. This insect survives only a short time away from the host. Nuttall records that he removed 200 from a man and only one was alive less than 24 hours later, although the insects were kept in moist air.

Crab lice are spread chiefly by sexual contact, but are often acquired by other means such as by infested toilet seats, beds, and by close personal contact. Small children may become infested with crab lice on their eyebrows or eyelashes from their mothers or nurses, or through normal play activities.

CONTROL OF HEAD, BODY AND CRAB LICE

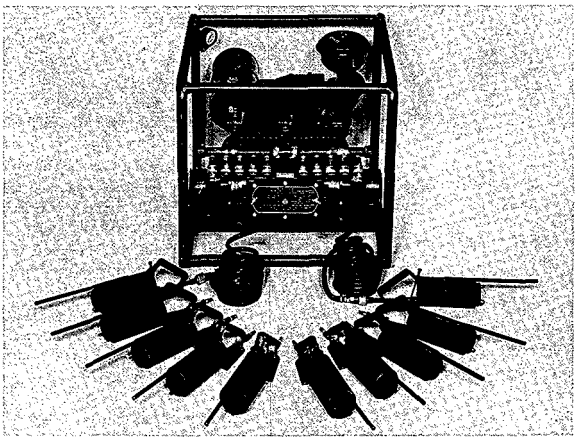
Three kinds of lice infest man – the body louse, the head louse, and the crab louse. They differ considerably in habits and therefore require different methods of control. Since the body louse is the vector of epidemic typhus and other diseases, emphasis has been placed on development of measures for its control.

Body Louse Control

Inspection – The body louse spends its life in the clothing except for a short time on the skin while feeding. The eggs are laid on the cloth, attached to the fibers. Woolen 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.

Control Measures – Ordinary laundering, using hot water, will destroy all stages of lice on infested clothing. Dry cleaning may be used to destroy lice on woolen garments. The Stoddard 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. Special attention must be given to seams.

Three louse powders have been tested extensively and carried as stock items by the U. S. Government: 10 percent DDT in pyrophyllite, 1 percent lindane in pyrophyllite and MYL-type powder containing pyrethrins with or without allethrin, a pyrethrum synergist, and a louse ovicide. In most parts of United States thorough dusting of the clothing with 10 percent DDT dust has given effective control of body lice. It is frequently dispensed in two ounce sifter-top cans for individual use. The powder should be applied over the inner surface of the underwear with special emphasis to the seams and evenly distributed by hand. The seams inside the shirt and trousers should be similarly treated. About one ounce of powder is necessary for one



Power Dustings Machine used in delousing people during the Korean conflict (Courtesy, U. S. Army).

treatment. In addition, ten percent DDT powder is available in 5- and 25-pound containers for mass use. Mass treatment of civilian populations, troops and prisoners of war with 10 percent DDT dust for the control of epidemic typhus has been accomplished by hand-operated plunger dusters and a gasoline-powered unit with many duster heads. These methods were used during the 1943 Naples typhus epidemic and in Korea during 1951 and 1952. In Korea body lice were resistant to the standard 10 percent DDT dust issued to troops so 1 percent lindane dust was used effectively for delousing purposes. DDT is rather slow in action, but the lice are usually immobilized in less than six hours. It is not effective against the eggs, but owing to its long lasting effect, a single application can eradicate any infestation since the eggs normally hatch in less than two weeks. Lindane dust is not so long lasting, therefore, a second application is recommended 7 to 10 days after the first.

The MYL powder was developed before DDT became available. It was used in North Africa during World War II and in Korea against DDT-resistant body lice. This type of louse powder contained 0.2 percent of pyrethrins, sulfoxide as the synergist, and 2,4-dinitroanisole as an ovicide. The residual action of the MYL powder was much shorter than that of DDT, but it did give complete control of lice for one week and a high degree for three or four days longer.

DDT is very effective and long lasting when used to impregnate clothing. If the clothing is treated in mass before issuance or during laundering, this method largely eliminates the personal factor and provides more permanent louse control than powders. Properly impregnated garments remain effective through 6 to 8 launderings. Garments may be impregnated with DDT in a volatile solvent or in an emulsion according to directions in the U.S.D.A. Circular 997 issued in 1955.

A spray formula has been developed for the treatment of all three species of lice. The formula is an emulsifiable concentrate 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. It is diluted with 5 volumes of water before application. Each person is required to take a soap and water bath and is then sprayed with the NBIN emulsion.

The spray should be kept out of the eyes by covering them with the fingers. Treated people should not bathe again for at least 24 hours. Benzocaine is a very effective ovicide, so that the eggs as well as the active stages are killed. About 20 ml. of the finished emulsion is required per individual, or about 5 gallons per 1,000 men.

Rotenone and sabadilla have been recommended for louse control. However, Cole and co-workers (1960) reported that these vegetable insecticides were inferior to pyrethrum or allethrin formulations in laboratory investigations conducted by the U. S. Department of Agriculture.

Malathion has been investigated as a replacement for DDT in the control of lice because of the increasing number of reports that lice were becoming resistant to the chlorinated hydrocarbon insecticides (see Barnett and Knoblock, 1952, or Eddy *et al.* 1955). Cole and co-workers (1960) reported that 1 percent malathion powder was effective against eggs and that 0.1 percent powder gave 14-days kill of adult lice in patch tests. These workers reported that the 1 percent malathion powder was cheaper than the pyrethrum or allethrin powders, or the DDT formulations, issued as standard government insecticides. Toxicological studies by Hayes and co-workers (1960) indicated that 1 percent malathion may be used as safely as standard 10 percent DDT powders.

Head Louse Control

Inspection – Lice spread rapidly through a family and may be transmitted to people throughout a community. They are the most abundant in children. Girls tend to be more heavily infested by both head and body lice than boys in some countries.

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.

Control Measures – With school boys, men, or prisoners of war, a very close hair cut, or even shaving the scalp, to remove eggs and all later stages is a simple, inexpensive method of controlling head lice. With women or girls other methods are often used. Both the lice and the eggs (nits) must be destroyed. Vinegar *will not destroy* the glue which holds eggs to hairs, as was once commonly supposed. The safest and best materials for head louse control are benzyl benzoate emulsion and DDT dust. The following procedure with NBIN emulsion or 25 percent benzyl benzoate emulsion 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 toweling.
3. Apply 25 percent benzyl benzoate emulsion liberally to hair and scalp with brush or 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 24 hours, shampoo the hair.
6. Dry, comb, and brush hair to remove dead lice and loosened eggs.

A 10 percent DDT dust in pyrophyllite or talc is another effective remedy for head louse infestation, although it is unsightly. One thorough application of 10 percent dust to the hair and scalp will kill all louse nymphs and adults, but will not affect the eggs. 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. Some people will prefer only one treatment leaving the dust on the hair for 10 days. If these insects are resistant to DDT powders, 1 percent lindane dust may be substituted to control head lice.

Where these modern insecticides are not available, as following a civil disaster or the mass evacuation of a large city after an atomic explosion, it may be necessary to revert to 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 are applied thoroughly to wet the hair and the head is then bound up in a towel for at least an hour.

Crab Louse Control

Crab lice do not represent a school health problem, though they are important in the general health program. The crab louse has recently (Weyer, 1952) been found capable of carrying the rickettsiae of typhus. This is a rare case and does not indicate that this louse is an important disease vector.

As with head lice, the early treatments involve shaving or cutting of the infested hair but this should not be necessary. The centuries old use of mercuric ointment for crab lice cannot be recommended. Its insecticidal value is low, and there is some risk of mercurial poisoning. Crab lice may be destroyed completely by application of 10 percent DDT dust in the pubic region and around the

anus. The dust must not be washed off for 24 hours or more after treatment. A second treatment should be made in 7 to 10 days to kill the lice hatched since the first treatment. The NBIN formula mentioned previously in the section dealing with body lice may also be used for the control of crab lice. In recent years a number of pediatricians have requested information regarding the control of crab lice on the eye lashes of young children. Two methods have been recommended: the application of 10 percent DDT dust (DDT is almost completely insoluble in water and presents no toxic hazard in minute quantities) to the eye lashes with a camel's hair brush, or a vaseline ointment containing pyrethrins. The insects are removed with fine forceps, cocaine having been applied to the conjunctiva if necessary.

People are very sensitive about infestations of crab lice. A rumor of an infestation in a large building can do much to disrupt the normal operations and cause a case of panic. These problems must be dealt with quickly and firmly, and they will soon be forgotten. The following procedure will bring results:

1. Close all rest rooms one floor at a time. This makes other facilities in the building available during the treatment period.
2. Wash all water closets with a hot solution containing pine oil, creolin, or other odoriferous chemical.
3. Leave small 2-ounce cans or bags containing 10 percent DDT dust on window sill or table with mimeographed directions for treatment.
4. Open rest rooms, one floor at a time, and announce to person in charge that treatment is complete.

HOW LICE MAY BE AVOIDED

Louse control is not difficult, provided that people will practice the necessary measures. It is of little value to delouse a person and then permit him to return to a home to become reinfested immediately. Certain measures, such as delousing the entire family, laundering bedding and clothes, and dry cleaning are necessary to the job. This work must be thorough.

Louse control requires public education if any program is to be successful. A thorough scrubbing at least once a week will do much toward eliminating lice. The hair must be washed as often as necessary. Clean clothing is very important. People should know how to recognize louse infestations in their families. They should realize the importance of using the proper control measures, followed up by a way of life that discourages the louse.

SUCKING LICE INFESTING DOMESTIC RATS

Important Species

Rat lice are similar in structure, life history, and habits to the lice infesting man. All rat lice are less than 1/16 inch long. They feed exclusively on the blood of mammals, attach their eggs to the hairs, and undergo 3 molts on the host.

The rat louse, *Polyplax spinulosa* (Burmeister) (fig. 2), is of almost world-wide distribution. It often occurs in great numbers on domestic rats throughout United States (Pratt and Good, 1954). This louse is readily infested with murine typhus rickettsiae (Mooser *et al.* 1931) and is capable of transmitting the disease from rat to rat in nature. This louse may be a vector of disease in rats but not in man, as it is not known to feed upon human beings.

Hoplopleura oenomydis Ferris is common on domestic rats in the South. Nothing is known regarding this species' possible relation to murine typhus. Two other species of lice, *H. acanthopus* and *H. hirsuta* are occasionally found on rats.

Rat Louse Control

Ten percent DDT dust applied to rat nests, burrows, and runways is the material used for rodent ectoparasite control. This chemical produces a very effective control of rodent fleas, but is less effective against the rat lice. Complete control of rat lice has not been necessary in murine typhus control programs, indicating that the louse is not able to keep the disease active in rats after flea populations have been reduced. It would not be practical to use 1 percent lindane dust for ectoparasite control in order to kill lice. This expensive material would have to be applied several times per season because of its short residual action.

PICTORIAL KEY TO LICE OF DOMESTIC RATS IN SOUTHERN UNITED STATES

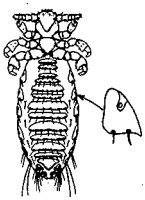
Abdomen with well defined ventral, lateral and dorsal plates

Abdomen with plates poorly defined or absent

ADULTS

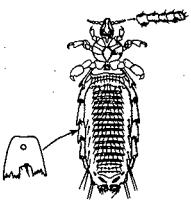
NYMPHS

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

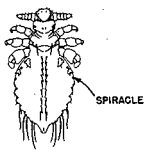


Polyplax spinulosa

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

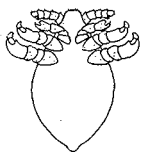


Abdomen with spiracles and two parallel rows of setae



Polyplax spinulosa

Abdomen without spiracles or parallel rows of setae



Hoplopleura spp.

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

Hoplopleura oenomydis

Lateral plates 4-6 with two large setae

Lateral plates broadly emarginate; Apical processes thorn-like

Hoplopleura hirsuta

Lateral plates narrowly emarginate; Apical processes broad

Hoplopleura acanthopus

FILMS DEALING WITH LICE AND THEIR CONTROL

Identification of some common sucking lice. Filmstrip, USPHS, CDC, 1948, 60 frames, black and white with 16-inch disc, 33-1/3 rpm. 9 minutes. Available from Communicable Disease Center Film Library, Atlanta 22, Georgia.

Typhus in Naples. Motion picture. U. S. Navy, 1944, Color, sound, 11 minutes (Medicine in action series, No. 2) Order No. MN 3726-b. One copy available on short term loan from Training Branch, Communicable Disease Center, Atlanta 22, Georgia.

Kill the louse. Motion picture. U. S. Institute of Inter-American Affairs. 1947. 8 minutes. Sound, color.

Control of louse-borne diseases. Motion picture, U. S. Army, 1946, 15 minutes, black and white. Order No. TF8 - 1467.

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