

CHAPTER 4

Bedbugs, fleas, lice, ticks and mites

Ectoparasites that live on the body, in clothing and in beds

There are many different species of bloodsucking fleas, lice, ticks and mites. Lice live on humans or in their clothing, while fleas are frequently found taking blood-meals on people and domestic animals. Bedbugs, which can be found in beds or furniture, feed on humans to obtain blood-meals. Some mites live in people's skin, e.g. the mites that cause scabies. Other mite species and ticks may take blood-meals on humans. Fleas, bedbugs and lice are insects, whereas ticks and mites belong to another group of arthropods, the Acarina. Unlike adult insects they have only two main sections to their body, and the adults have four pairs of legs (as opposed to three pairs in insects).

Bedbugs, head lice and crab lice do not carry disease, but their biting can be a serious nuisance. However, important diseases of humans and animals are transmitted by other arthropods dealt with here, among them the following:

- epidemic typhus and epidemic relapsing fever (body lice);
- plague and murine typhus (certain fleas);
- Lyme disease, relapsing fever and many viral diseases (ticks);
- scrub typhus (biting mites).

BEDBUGS

Two species of bedbug feed on humans: the common bedbug (*Cimex lectularius*), which occurs in most parts of the world, and the tropical bedbug (*Cimex hemipterus*), which occurs mainly in tropical countries. They are a severe nuisance when they occur in large densities, being commonest in places with poor housing conditions. They are not important in the transmission of diseases, although they possibly play a role as vectors of hepatitis B virus.

Biology

Bedbugs have a flat, oval-shaped body with no wings, and are 4–7 mm long. Their colour is shiny reddish-brown but after a blood-meal they become swollen and dark brown in colour. There are three stages in the bedbug's life cycle: egg, nymph and adult (Fig. 4.1). The eggs are white and about 1 mm long. The nymphs look like adults but are smaller. Complete development from egg to adult takes from six weeks to several months, depending on temperature and the availability of food. Both male and female bedbugs feed on the blood of sleeping persons at night. In the absence of humans they feed on mice, rats, chickens and other animals. Feeding takes about 10–15 minutes for adults, less for nymphs, and is repeated about every three days. By day they hide in dark, dry places in beds, mattresses, cracks in walls and floors, and furniture; they are also found behind pictures and wallpaper; hiding places are also used for breeding. The bugs are frequently

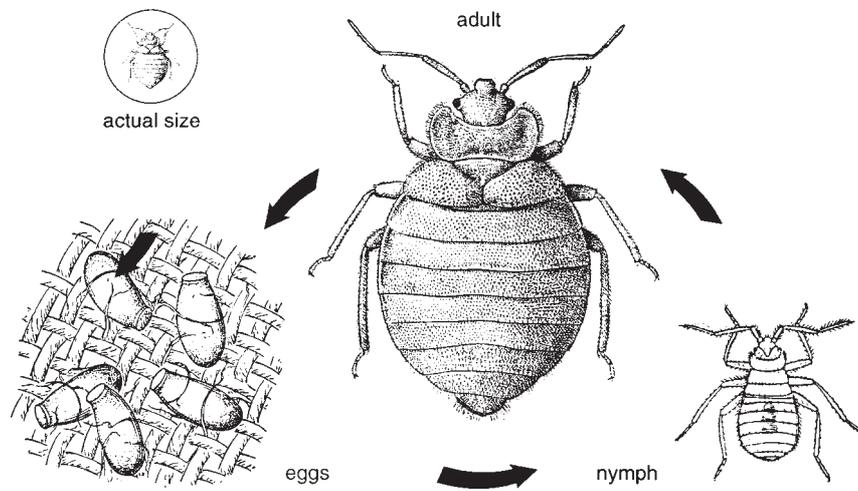


Fig. 4.1
Life cycle of the bedbug (by courtesy of the Natural History Museum, London).

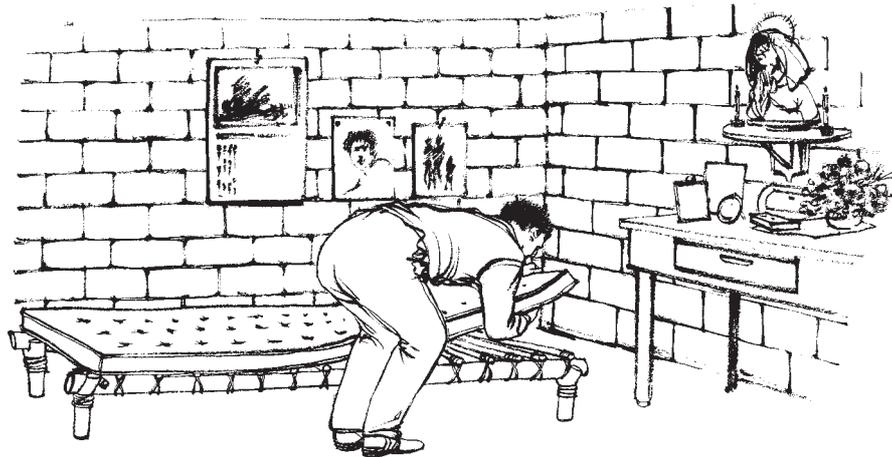


Fig. 4.2
Bedbugs are almost always found in bedrooms.

abundant in bedrooms in warm climates. Heated bedrooms in cooler climates are also favourable for the bugs, which cannot develop below 13 °C (Fig. 4.2). Adults can survive for several years without food.

Dispersal

Because they have no wings, bedbugs travel only short distances. In poorly built houses with many suitable hiding places they crawl from one bedroom to another; they spread from one house to another mainly in second-hand furniture, bedding and, sometimes, clothes.

Public health importance

Bedbugs are not considered vectors of disease. It has been suggested that they play a role as vectors of the hepatitis B virus (1, 2) but this was denied in a recent study in the Gambia (3). They are mainly important as a biting nuisance. Some people, especially those exposed for a long time, show little or no reaction to the bites, which appear as small red spots that may not even itch. People never bitten before may suffer from local inflammation, intense itching and sleepless nights. The bite produces a hard whitish swelling that often continues to bleed. Scratching may cause secondary infections.

In heavily infested houses where people may receive one hundred or more bites a night it is possible that the blood loss causes mild anaemia in infants.

Control measures

Bedbugs can move rapidly when disturbed and are not easily detected while biting. Some people may not even be aware that they are bitten each night by large numbers of bedbugs. Control measures are therefore carried out only if there is evidence of the presence of the insects.

Detection

Infestations can be detected by the examination of possible hiding places for the presence of live bugs, cast-off nymphal skins, eggs and excreta. The excreta may also be visible as small dark brown or black marks on bed sheets, walls and wallpaper (4). Houses with large numbers of bedbugs may have a characteristic unpleasant smell. Live bugs can be detected by spraying an aerosol of pyrethrum into cracks and crevices, thus irritating them and driving them out of their hiding places.

Repellents

Deet and other insect repellents are effective against bedbugs. They can be used by travellers who have to sleep in houses infested with the insects. However, repellents applied to the skin are unlikely to last the whole night. It is likely that burning mosquito coils offer some protection (see Chapter 1).

Simple household measures

Small numbers of bedbugs can occur in any household, especially when second-hand furniture or bedding is used. Light infestations can be treated by thoroughly cleaning infested articles, pouring boiling water over them and exposing them to sunlight. Aerosol spray cans can be used to spray household insecticides on to mattresses, in crevices in walls, and in other possible hiding places. Among the effective insecticides are the pyrethroids, propoxur, bendiocarb and dichlorvos. The procedure should be repeated if bugs are still found after a few weeks.

Total release fogger

This device is similar to the aerosol spray can but is designed to release the total contents of the can in a single shot through a special valve. The fog contains rather large droplets that do not penetrate well into crevices. Cans containing an insecticide–kerosene mixture should not be used for fogging because of the risk of explosion.

Impregnated mosquito nets

Mosquito nets impregnated with a long-lasting pyrethroid insecticide are effective in repelling and killing bedbugs (Fig. 4.3) (5, 6). Such nets are increasingly popular for the control of malaria mosquitoes. A commonly reported incidental benefit of the use of these nets is the complete disappearance of bedbug and head louse infestations, which makes the nets highly popular among people in bedbug-infested areas.

Smoke generators

Smoke generators, which are commercially available and usually contain pyrethroid insecticides, can be used to fumigate the interior of houses. They burn for 3–15 minutes and can be used only once. A smoke of very small droplets of insecticide is produced which can penetrate into cracks and crevices to kill bedbugs, fleas, flies, mosquitos and tropical rat mites. Smoke generators do not always work well, as the insecticide may settle on horizontal surfaces without penetrating into deep crevices. They have a brief effect and do not prevent reinvasion from neighbouring, untreated dwellings. They are mainly used where quick action is needed. A fumigant canister developed in South America against the triatomine bugs is described in Chapter 3, together with general instructions on how to

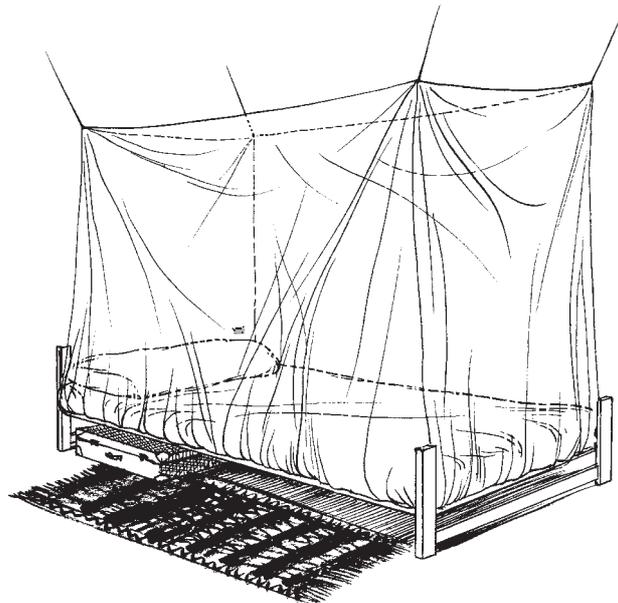


Fig. 4.3
The use of mosquito nets impregnated with a pyrethroid insecticide may result in the reduction or even eradication of bedbug and head louse infestations.

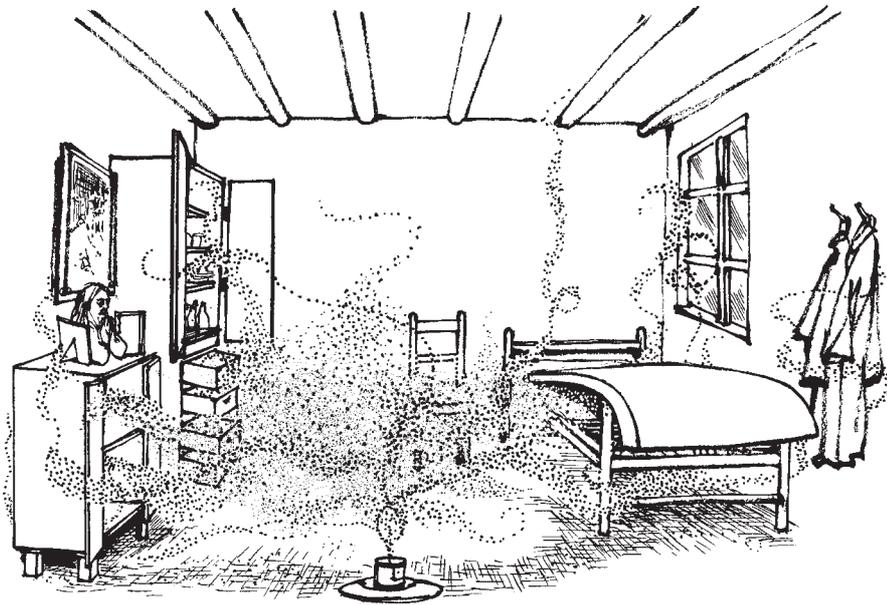


Fig. 4.4
The fumigant canister releases insecticide vapour for up to 15 minutes.

fumigate a house (Fig. 4.4). It contains an irritant insecticide that drives the bugs out of hiding.

Residual insecticides

Houses with heavy infestations need to be treated with long-lasting residual insecticide. One treatment is normally sufficient to eliminate bedbugs but, if an infestation persists, re-treatments should be carried out at intervals of not less than two weeks. In many countries, resistance of bedbugs to DDT, lindane and dieldrin is common. The insecticide selected should thus be one known to be effective against the target population (see Table 4.1). The addition of an irritant insecticide, e.g. 0.1–0.2% pyrethrin, helps to drive the bugs out of their hiding places, thus increasing exposure to the residual insecticide. Most pyrethroids are effective flushing and killing agents.

A residual spray is applied with a hand-operated compression sprayer (see Chapter 9). Special attention should be given to mattresses, furniture, and cracks and crevices in walls and floors (Fig. 4.5). In severe infestations, walls and floors should be sprayed until they are visibly wet (point of run-off). Usually this corresponds to 1 litre per 50 m² on non-absorbent surfaces and to 5 litres or more per 50 m² on absorbent surfaces such as those of mud-brick walls. Rooms in humid tropical countries must be treated in the morning so that they are dry and suitable for re-entry in the evening. Mattresses and bedding should be treated carefully to avoid staining and soaking, and should be thoroughly aired and dried before use. Hand dusters containing insecticide powder may be used to dust mattresses and bedding, to avoid wetting them. Bedding used for infants should not be treated with residual insecticide, but with a short-lasting insecticide such as may be found in most aerosol spray cans.

Table 4.1
Residual insecticides for use against bedbugs

| Insecticide | Concentration in spray (%) |
|--------------------|----------------------------|
| malathion | 2.0 |
| fenitrothion | 0.5–1.0 |
| propoxur | 2.0 |
| carbaryl | 1.0 |
| diazinon | 0.5 |
| bendiocarb | 0.2–0.3 |
| fenchlorvos | 1.0 |
| pirimiphos methyl | 1.0 |
| proprymphos | 0.5–1.0 |
| permethrin | 0.5 |
| cyfluthrin | 0.01 |
| deltamethrin | 0.005 |
| lambda-cyhalothrin | 0.005 |

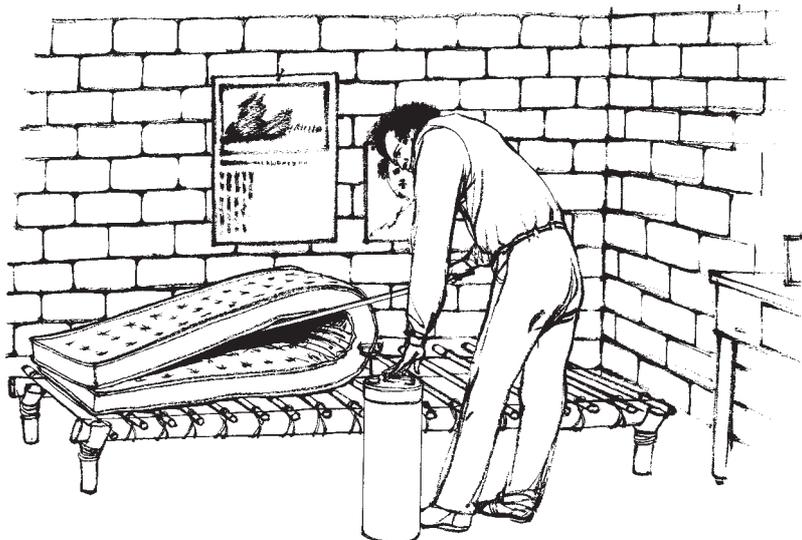


Fig. 4.5
Spray residual insecticide on to mattresses, cracks in walls, floors and other hiding places with a compression sprayer.

Bedbugs and malaria control

House spraying against malaria was very popular in many tropical countries, partly because it killed bedbugs. Unfortunately, the bugs quickly developed resistance to the insecticides, resulting in numerous complaints that spraying no longer controlled bedbugs, even though it still killed mosquitos.

Another possible explanation for the increase in the numbers of bedbugs observed is that the insecticide spray irritated the bugs, causing them to leave their hiding places. Seeing many more bedbugs than before, people believed that spraying caused an increase in the bug population (7, 8).

As a result, many householders refused malaria spraying teams access to their homes. It is possible that in some areas the occurrence of bedbugs contributed indirectly to the ineffectiveness of malaria control programmes.

FLEAS

Fleas are small, wingless bloodsucking insects (order Siphonaptera) with a characteristic jumping movement. They feed mainly on mammals but also on birds. Of the 3000 species only a dozen commonly attack humans. The most important species are the rat flea, the human flea and the cat flea (Fig. 4.6). Their bites can cause irritation, serious discomfort and loss of blood. The rat flea is important as a vector of bubonic plague and flea-borne typhus. Cat fleas incidentally transmit tapeworms. The sand flea or jigger burrows into the skin of humans and may cause infections. Fleas that bite people occur in most parts of the world.

Biology

The life cycle of fleas has four stages: egg, larva, pupa and adult (Fig. 4.7). Adult fleas are 1–4 mm long and have a flat narrow body. They are wingless with well developed legs adapted for jumping. They vary in colour from light to dark brown. The larvae are 4–10 mm long and white; they have no legs but are very mobile. The cocoon (pupal stage) is well camouflaged because it is sticky and soon becomes covered with dust, sand and other fine particles.

Both female and male fleas take blood-meals. Fleas breed close to the resting and sleeping places of the host, in dust, dirt, rubbish, cracks in floors or walls, carpets, animal burrows and birds' nests. High humidity is required for development. The larvae feed on organic matter such as the faeces of the host, small dead

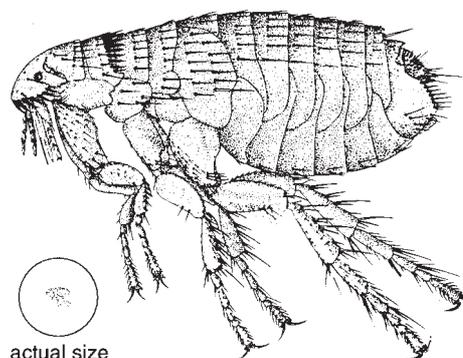


Fig. 4.6

A cat flea (*Ctenocephalides felis felis*) (by courtesy of the Natural History Museum, London).

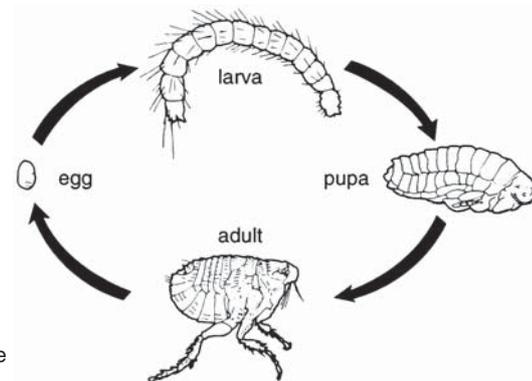


Fig. 4.7
The life cycle of the flea (by courtesy of the Natural History Museum, London).



Fig. 4.8
A scratching cat is an indication of a flea infestation.

insects and undigested blood expelled by adult fleas. At the end of the larval period the larva spins a loose whitish cocoon within which it develops into a pupa.

The adult fleas are fully developed within 1–2 weeks but only emerge from the cocoons after receiving a stimulus, such as the vibrations caused by movement of the host. In vacant houses they may survive in the cocoons for up to a year. People moving into a vacant house can cause many fleas to emerge simultaneously from the cocoons and attack people or animals in large numbers. Under optimal conditions the development from egg to adult takes 2–3 weeks.

Behaviour

Fleas avoid light and are mostly found among the hairs (Fig. 4.8) or feathers of animals or in beds and in people's clothing. If possible, a flea will feed several times during the day or night. Heavy infestations with fleas are recognized by

marks on clothing and bedding of undigested blood ejected by the fleas. Most flea species feed on one or two host species, but in the absence of their normal host they feed on humans or other animals. Adult fleas can survive several months without food. Fleas move around by jumping; some species can jump as high as 30 cm.

Public health importance

Nuisance

Humans are most commonly bitten by the cat flea, *Ctenocephalides felis* and, less commonly, the dog flea, *C. canis*. The so-called human flea (*Pulex irritans*) is, in spite of its name, less important. Fleas jump up from the ground and most frequently attack people on the ankles and legs, the easiest parts to reach, although sleeping people can be attacked anywhere on the body. Flea bites cause irritation and sometimes extreme discomfort. Heavy infestations may cause allergic reactions and dermatitis.

Plague

Plague is a disease caused by the bacterium *Yersinia pestis*. It occurs primarily in wild animals, such as rats and other rodents. Plague bacteria are transmitted by fleas, and humans may be infected by fleas that have fed on infected animals. In the past, plague was called the black death and caused disastrous epidemics.

Plague is still dangerous because it occurs widely in rodent populations. Rural or sylvatic plague may be contracted in the western USA, South America, Africa, the former USSR, parts of the eastern Mediterranean area, and central and south-east Asia. Human plague frequently occurs in several countries in Africa, Bolivia/north-eastern Brazil, Ecuador, Myanmar, Peru and Viet Nam (9).

Rural plague is acquired by people entering rural areas and handling wild animals. Most at risk are hunters who may be bitten by infected fleas while handling recently killed animals.

Urban plague may occur when rats living in and around human dwellings are infected. Rat fleas (*Xenopsylla* species) that normally feed on rats may occasionally feed on humans and thus spread the disease to them. When rodents infected with plague die the fleas leave their hosts and are then likely to attack and infect people. Other fleas, such as the human flea, may subsequently transmit the disease from person to person.

There are three clinical types of plague:

- *Bubonic plague*. Swellings (buboes) filled with bacteria develop in the lymph nodes, especially in the armpits and groin. This form is normally transmitted to humans by infected fleas. If left untreated, it causes death in about 50% of cases.
- *Pneumonic plague*. This is a secondary form in which the lungs become affected. It is highly contagious, the plague bacillus easily spreading from person to person in sputum or droplets coughed up or sneezed by sick people. Pneumonic plague occurred in epidemics in past centuries, killing millions of people. If left untreated it very often results in death.

- *Septicaemic plague*. The bloodstream is invaded by the plague bacillus, resulting in death before one of the above two forms can develop.

Prevention and control

Partial immunity is acquired after an infection. A vaccine is available which provides protection for a period of only a few months. Treatment with streptomycin, tetracycline or its derivatives or chloramphenicol is highly effective if used within a day after the onset of symptoms.

Urban plague is controlled by rapidly applying insecticide dusts in rodent burrows and on to rodent runways where it will be taken up by the animals on their fur, thus killing the vector fleas. Dusting against fleas should be followed by measures to control rodents.

People working in the field may protect themselves by dusting their clothing with insecticidal powder, using impregnated clothing, and using repellents on a daily basis.

Flea-borne typhus

Flea-borne typhus, also called murine typhus fever, is caused by *Rickettsia typhi* and occurs sporadically in populations of rats and mice. It is transmitted mainly by rat fleas and cat fleas, and humans can become infected as a result of contamination from the dried faeces and crushed bodies of the fleas. The disease occurs worldwide and is found in areas where people and rats live in the same building. Its symptoms are similar to those of louse-borne typhus (see p. 257) but milder.

Prevention and control

Immunity is acquired after the first infection. The treatment of sick people is similar to that for louse-borne typhus (see p. 257). Control is carried out by applying residual insecticides to the runs, burrows and hiding places of rats. If these measures are successful in killing fleas, rodent control measures can be taken (see p. 250, box).

Other diseases

Fleas occasionally transmit other diseases and parasites from animals to humans, for instance tularaemia caused by the bacillus *Francisella tularensis*, and the parasitic tapeworms that occur in dogs and cats. Children playing with domestic pets may become infected by swallowing fleas that carry the infective stage of the worms.

Control measures

The recommended control methods depend on whether the intention is to deal with fleas as a biting nuisance or as vectors of disease.

Fleas as a nuisance

Individual self-protection

An effective repellent, such as deet, applied to skin and clothing, prevents fleas from attacking. A disadvantage is that repellents applied to the skin last only a few hours (see Chapter 1). Longer-lasting protection is obtained by dusting clothing with insecticide powder (see p. 262) or by using insecticide-impregnated clothing (see Chapter 1).

Simple hygienic measures

Fleas and their eggs, larvae and cocoons can be effectively removed by keeping houses well swept and floors washed. Removal with a vacuum cleaner is also effective. When people enter an infested house that has been vacant for some time, large numbers of newly emerged fleas may attack. The treatment of floors with detergents, insecticides or a solution of naphthalene in benzene is recommended; care should be taken to avoid inhaling benzene fumes.

Application of insecticides

Heavy infestations can be controlled by spraying or dusting insecticides into cracks and crevices, corners of rooms and areas where fleas and their larvae are likely to occur. Insecticides can also be applied to clothing and the fur of animals. Fumigant canisters that produce aerosols of quick-acting insecticides (e.g. the pyrethroids, propoxur and bendiocarb) kill fleas directly and are convenient to use (see p. 240 and Chapter 3). However, the insecticidal effect is brief and reinfestations may appear quickly.

Cat and dog fleas

Fleas can be detected in the hair around the neck or on the belly of cats and dogs. Treatment involves applying insecticidal dusts, sprays, dips or shampoos to the fur. Dusts are safer to use than sprays because the insecticides are less likely to be absorbed through the skin in the dry form. Dusts also produce less odour and do not affect the skin as much as sprays. Carbaryl and malathion should not be used on kittens and puppies under four weeks of age. Pets can be provided with plastic flea collars impregnated with an insecticide. Flea collars are effective for 3–5 months, whereas other treatments give only short-term control.

Recently, lufenuron tablets have been used to control fleas in cats and dogs. The tablets are administered once monthly at a dose of 30 mg per kg of body weight to cats and 10 mg per kg of body weight to dogs and are safe for use in pregnant and nursing animals. Lufenuron is taken up by the female flea during feeding and acts by inhibiting egg development (10).

Dusts must be rubbed thoroughly into the hair and can be applied by means of a shaker (Fig. 4.9). They must not be allowed to get into the eyes, nostrils and mouths of animals. Heavy applications should not be made to the abdomen as the material will be licked off. Application should begin above the eyes and all the areas backward to the tail and haunches should be covered, ensuring thorough treatment around the ears and underneath the forelegs. A small animal can be



Fig. 4.9
Dusting a dog with insecticide powder to control fleas.

treated with one tablespoonful of dust, while 30 g may be required for a large dog. Sprays must wet the hair completely and can be applied with a hand-compression sprayer. It is also possible to spray with an insecticide aerosol from a pressurized spray can.

Re-treatment may be necessary if reinfestation occurs. Important sources of reinfestation are the places where animals or humans sleep or spend much time, such as beds, bedding and kennels. Where possible, animal bedding should be burned or laundered in hot soapy water. A vacuum cleaner may be used to remove accumulations of dust that contain flea larvae and pupae, and infested premises can then be treated with a residual insecticide. Treatment with insecticidal powders or solutions is possible (11). Because flea cocoons are much less susceptible to insecticides than the larvae and adults, treatments should be repeated every two weeks over a period of six weeks to ensure that all emerging fleas are killed (12).

Human flea

This flea species does not usually remain on the person after feeding and by day it rests in cracks, crevices, carpets and bedding. Regular cleaning of houses, and of bedrooms in particular, should prevent large infestations.

More effective control is achieved by dusting or spraying insecticides on to mattresses and cracks and crevices in floors and beds. Bedding left untreated should be washed and cleaned during insecticide application. Fleas in many parts of the world have developed resistance to DDT, lindane and dieldrin (13–15). Suitable insecticides for spraying or dusting are indicated in Table 4.2.

Table 4.2
Insecticides and application methods effective against fleas

| Type of application | Pesticide and formulation |
|----------------------------|---|
| Residual spray | malathion (2%), diazinon (0.5%), propoxur (1.0%), dichlorvos (0.5–1.0%), fenchlorvos (2%), bendiocarb (0.24%), natural pyrethrins (0.2%), permethrin (0.125%), deltamethrin (0.025%), cyfluthrin (0.04%), pirimiphos methyl (1%) |
| Pesticide power (dust) | malathion (2–5%), carbaryl (2–5%), propoxur (1%), bendiocarb (1%), permethrin (0.5–1.0%), cyfluthrin (0.1%), deltamethrin (0.05%), temephos (2%), pirimiphos methyl (2%), diazinon (2%), fenthion (2%), fenitrothion (2%), jodfenphos (5%), (+)-phenothrin (0.3–0.4%) |
| Shampoo | propoxur (0.1%), (+)-phenothrin (0.4%) |
| Fumigant canister | propoxur, dichlorvos, cyfluthrin, permethrin, deltamethrin, (+)-phenothrin |
| Flea collar for dog or cat | dichlorvos (20%), propoxur (10%), propetamphos, diazinon |
| Repellent | diethyl-toluamide (deet), dimethyl phthalate, benzyl benzoate |

Retreatment is probably not needed if all infested places in a house are treated or cleaned. Infants' bedding should not be treated but should be thoroughly washed.

Fleas that transmit diseases

Control measures during epidemics of plague or typhus must be effected in two stages:

- (1) insecticidal dusting of rat habitats to kill rat fleas;
- (2) rat control.

A control campaign with the sole aim of killing rodents could result in increased disease transmission to humans: the deaths of many rodents could cause large numbers of fleas to leave the dead hosts and seek alternative sources of blood.

Insecticidal powder

The most common and effective method of controlling rodent fleas has been to use DDT in a 10% dust formulation. Alternative insecticides in dust formulation are increasingly used (see Table 4.2) because of the resistance of fleas in many areas to DDT and also because of environmental concerns.

Dust is applied to burrows, runways and other sites where rodents are likely to pick it up. When the rodents groom themselves they spread the dust on their fur, thus killing the fleas.

Before control is begun, it is important to know where rodent burrows and runways are. To save insecticide, the burrows should first be closed off; only those

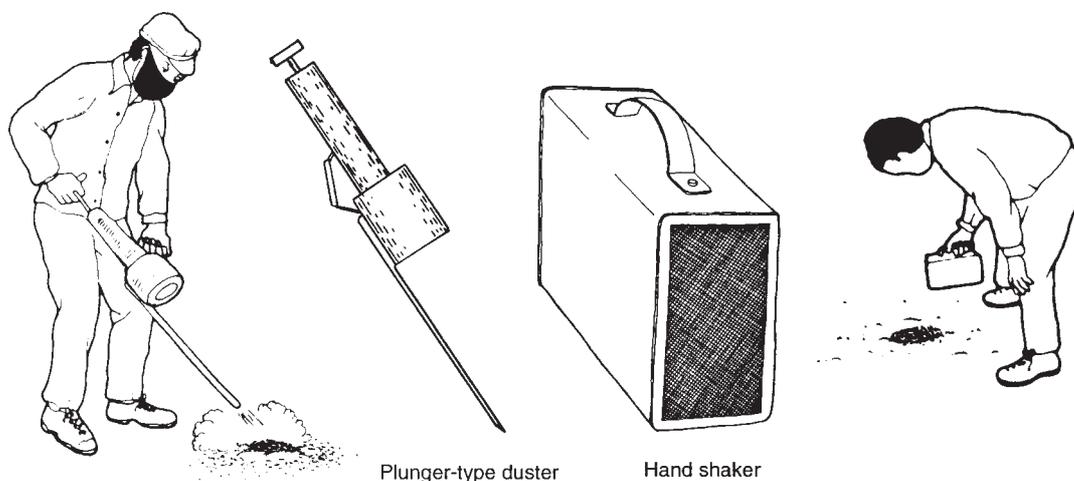


Fig. 4.10
Equipment for applying anti-flea dusts (© WHO).

that are subsequently reopened should be treated. Insecticidal dust should be blown into each burrow with a duster. A patch of dusting powder, 1 cm in depth, should be left around the opening. Patches of dust 15–30 cm wide should be placed along runways. Dust should be applied only where it will remain undisturbed by humans and the wind. Care must be taken not to apply insecticides to areas where they can contaminate food. Many insecticidal dusts remain effective for 2–4 months if used indoors in undisturbed places.

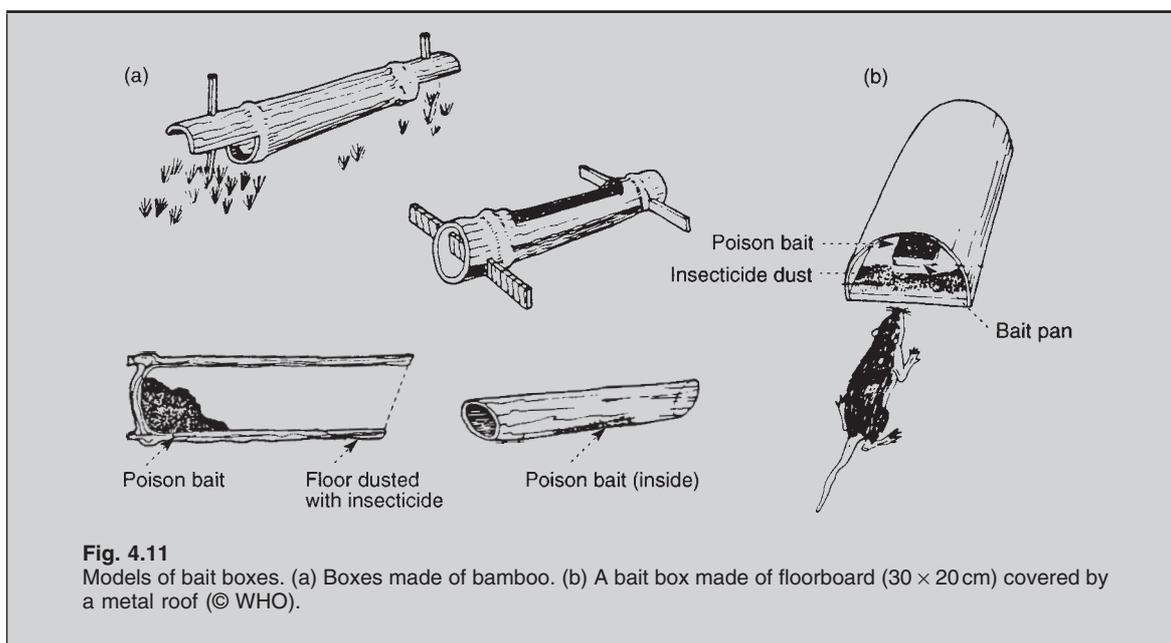
A plunger-type duster is suitable for fast applications of dust to rodent burrows and runways, in attics and spaces under buildings. It consists of an air pump like a bicycle pump to which a container for the dust is attached. The air from the pump is led into this container, agitating the contents and expelling them from an orifice (Fig. 4.10).

Alternatively, a hand shaker can easily be made from a can by fitting a 16-mesh screen at one end. A can with nail-holes punched in the top can also be used. Insecticidal dust of low toxicity can be applied to human clothing or the fur of animals with such equipment.

Integrated rat and flea control

To control urban outbreaks of plague or typhus, insecticides to kill rat fleas are applied at the same time as or a few days earlier than rat poisons. Suitable rat poisons are warfarin, coumafuryl, difenacoum, brodifacoum, coumatetralyl, bromadiolone, chlorophacinone and zinc phosphide (16, 17).

In places where food for human consumption is stored and in crowded areas, such as markets, it is safer to use bait boxes (Fig. 4.11) in which the rodents contaminate themselves with the anti-flea dust before they die from eating the toxic bait. Bait boxes can be placed along rodent runs at intervals of 60 metres. A suitable bait consists of 100 g of rolled oats mixed with rat poison.



Sand fleas or jigger fleas

The sand flea, chigoe or jigger flea (*Tunga penetrans*) is not known to transmit disease to humans but, unique among the fleas, it is a nuisance because the females burrow into the skin. Sand fleas occur in the tropics and subtropics in Central and South America, the West Indies and Africa.

Biology

The larvae of sand fleas are free-living and develop in dusty or sandy soil. The adults are initially also free-living but, after copulation, the fertilized females attach themselves under the skin of humans, pigs, dogs, poultry and other animals, penetrating soft areas of skin, for instance cracks in the soles of the feet, between the toes, and under the toenails. Other parts of the body may also be affected.

Public health importance

Usually a person is infested by only one or two jiggers at a time but infestation with hundreds is possible. People who do not wear shoes, such as children, are most commonly affected. The flea burrows entirely into the skin with the exception of the tip of the abdomen. It feeds on body fluids and swells up to the size and shape of a small pea in 8–12 days (Fig. 4.12). The body of the female flea is completely filled with thousands of eggs which are expelled in the next weeks (Fig. 4.13). Most of the eggs fall to the ground where they hatch after a few days.

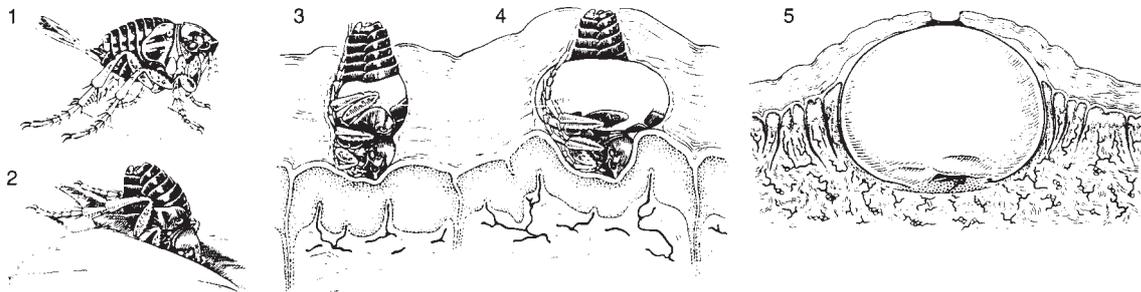


Fig. 4.12
The female sand flea attacks bare-footed persons by burrowing into soft skin on the feet (18).

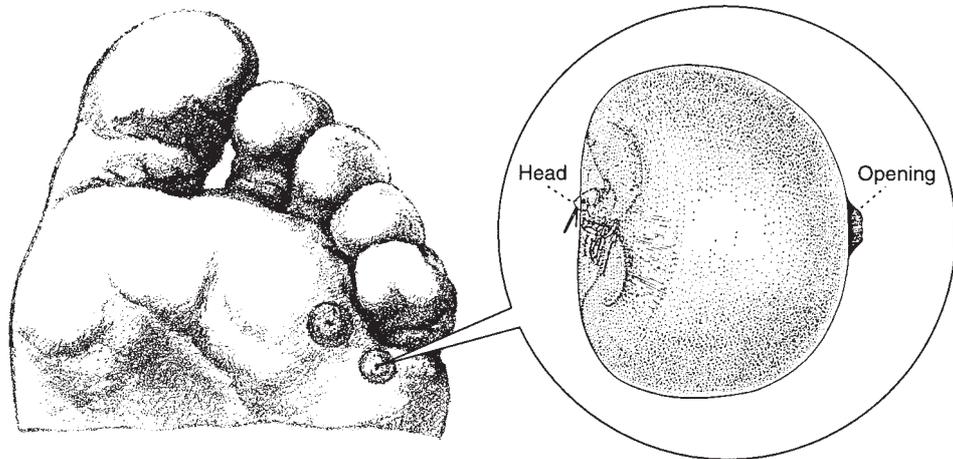


Fig. 4.13
Detail of foot with jigger infections. Eggs are expelled through the dark opening in the centre (by courtesy of the Natural History Museum, London).

Symptoms

An infestation begins to irritate and itch when the female is almost fully developed. Sometimes it causes severe inflammation and ulceration. If the female flea dies in the skin it may cause a secondary infection which, if ignored, could lead to tetanus, gangrene and even the loss of a toe.

Natural extrusion of the egg sac or removal of the jigger with a dirty pin or needle leaves a tiny pit in the skin which may develop into a sore. The sore may extend and develop into a septic ulcer. An infection under a toenail may cause pus to form.

Prevention, control and treatment

Jigger populations often maintain themselves in the domestic environment by breeding on livestock and domestic animals. Efforts should be made to remove the jiggers from these animals. Infections in dogs can be controlled by the administration of ivermectin (0.2 mg/kg of body weight) or by bathing the feet with dichlorvos

(0.2%) (19). The former treatment may kill other parasites, such as *Dermatobia* larvae, which cause skin infections. In infested areas, people should inspect their feet daily for freshly burrowing jiggers, which are visible as minute black spots and cause an itchy sensation.

Wearing shoes prevents attacks. The fleas may also be deterred by a repellent applied to the skin, although walking bare-footed in dirt quickly removes it. If it is possible to locate the area of soil where the jiggers originate it could be burnt off or sprayed with a suitable insecticide in an effort to kill the fleas.

Treatment

With some skill it is possible to remove the jigger with forceps or with a sharp object, such as a needle, a thorn or the tip of a knife (Fig. 4.14). The object and the site of infection should be cleaned, if possible with alcohol, to reduce the risk of infection. Removal can be done in a painless way but care should be taken not to rupture the egg sac. Infection may result if eggs or parts of the flea's body are left in the wound. After removal, the wound should be dressed antiseptically (with alcohol or iodine) and protected until healed.

LICE

Lice are small bloodsucking insects that live on the skin of mammals and birds. Three species of lice have adapted themselves to humans: the head louse (*Pediculus humanus capitis*), the body louse (*Pediculus humanus*) and the crab or pubic louse (*Phthirus pubis*) (Fig. 4.15). All three species occur worldwide. Lice infestations can cause severe irritation and itching. In addition the body louse can transmit typhus

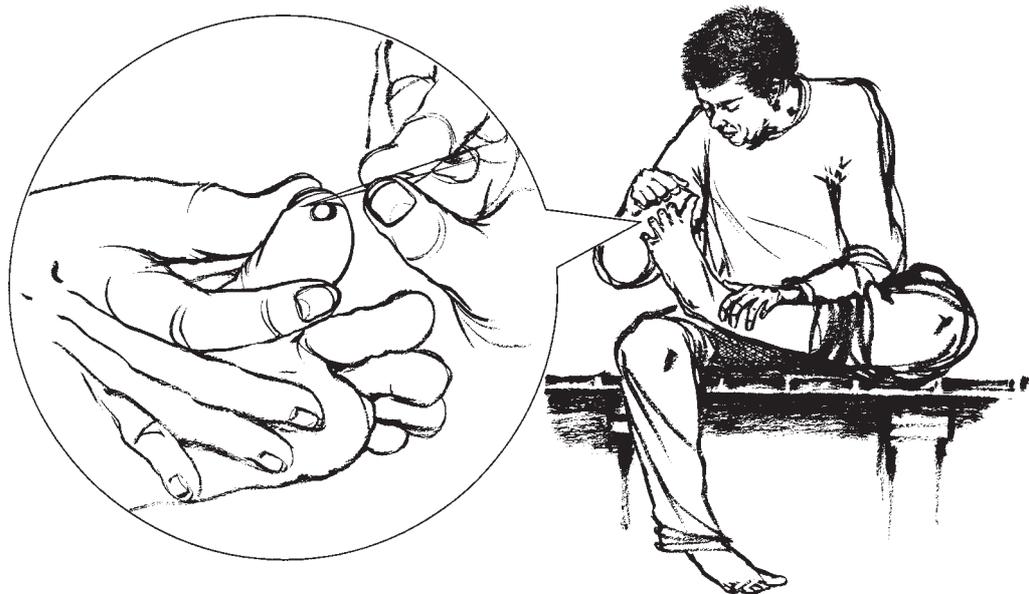


Fig. 4.14
The egg sac of the sand flea can be removed with a sharp object.

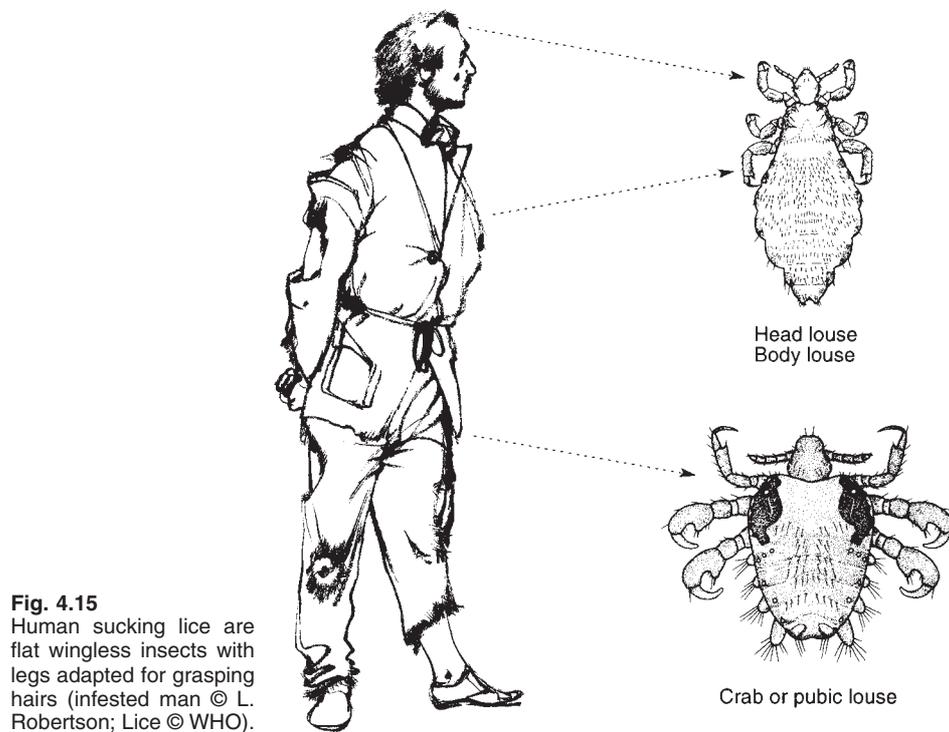


Fig. 4.15
Human sucking lice are flat wingless insects with legs adapted for grasping hairs (infested man © L. Robertson; Lice © WHO).

fever, relapsing fever and trench fever. Outbreaks of louse-borne typhus fever, sometimes claiming thousands of lives, have occurred in colder areas where people live in poor, crowded conditions, especially in some highland areas of Africa, Asia and Latin America.

Biology

The three species live only on humans (not normally on animals) and feed on human blood; the life cycle has three stages: egg, nymph and adult (Fig. 4.16). Development from egg to adult takes about two weeks. The white eggs (called nits) are glued to a hair or, in the case of the body louse, to fine threads on clothes. The nymphs are similar to the adults but much smaller. Fully grown lice are up to 4.5 mm long and feed by sucking blood. Feeding occurs several times a day. Lice can only develop in a warm environment close to human skin, and die within a few days if they lose contact with the human body. They are normally spread by contact, e.g. in overcrowded sleeping quarters and other crowded living conditions.

The three species of human lice are found on different parts of the body:

- the head louse occurs on the scalp and is most common in children on the back of the head and behind the ears;
- the pubic louse or crab louse is mainly found on hair in the pubic region but it may spread to other hairy areas of the body and, rarely, the head;
- the body louse occurs in clothing where it makes direct contact with the body; it is similar to the head louse but slightly bigger.

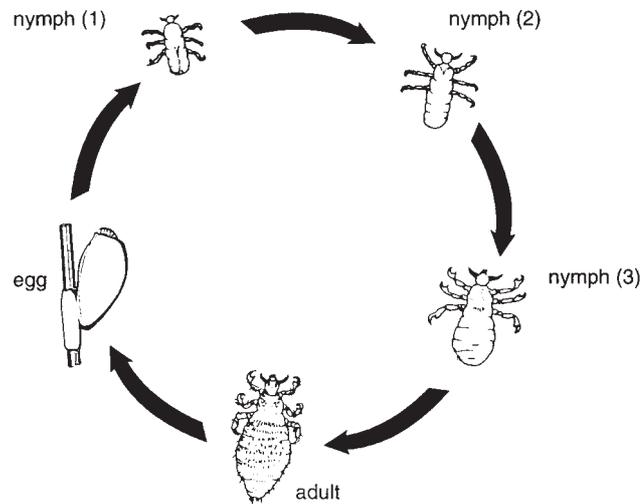


Fig. 4.16
Life cycle of the louse (© WHO).

Body lice

Body lice are most commonly found in clothing, especially where it is in direct contact with the body, as in underwear, the crotch or fork of trousers, armpits, waistline, collar and shoulders. They attach themselves to body hair only when feeding. The eggs are attached to thin threads of clothing. Body lice are most common in colder areas where people do not frequently wash or change clothes.

Body lice are spread by close contact between people. They are most commonly found, therefore, on people living in overcrowded, unhygienic conditions, as in poorly maintained jails, refugee camps and in trenches during war. They also spread by direct contact between people in crowded transport vehicles and markets. Body louse infestations may also be acquired through sharing bedding, towels and clothing or by sitting on infested seats, chair covers or cushions.

Head lice

The head louse is the most common louse species in humans. It lives only in the hair on the head and is most often found on children. The eggs (or nits) are firmly glued to the base of hairs of the head, especially on the back of the head and behind the ears (Figs. 4.17 and 4.18). Because the hairs grow about a centimetre a month it is possible to estimate the duration of an infestation by taking the distance between the scalp and the furthest egg on a hair. Infested persons usually harbour 10–20 adult head lice. The females lay 6–8 eggs per day. Head lice are spread by close contact between people, such as children at play or sleeping in the same bed. Head lice are also spread by the use of other people's combs that carry hairs with eggs or lice attached.

Crab or pubic lice

Crab lice, also called pubic lice, are greyish-white and crab-like in appearance. They are most often found on hair in the pubic region, and eggs are laid at the base



Fig. 4.17
Inspection of the hair for head lice. Girls tend to have heavier infestations than boys.

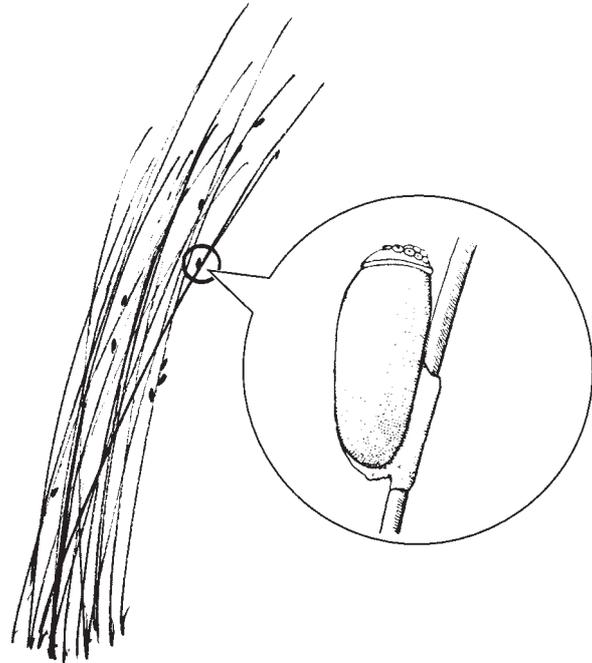


Fig. 4.18
Close-up of hair infested with lice and eggs (by courtesy of the Natural History Museum, London).

of the pubic hair. Heavy infestations may spread to other hairy areas of the body, such as the chest, thighs, armpits, eyelashes, eyebrows and beard. Crab lice are mainly spread through sexual or other close personal contact, and are most common in young, sexually active adults.

Public health importance

Only the body louse is a vector of human diseases. It transmits typhus fever, relapsing fever and trench fever.

Nuisance

Lice feed several times a day and heavy infestations can cause intense irritation and severe itching. Toxic reactions to the saliva injected into the skin may lead to weariness and a general feeling of illness.

Louse-borne typhus fever

This disease is caused by a microorganism, *Rickettsia prowazekii*, and is an acute, highly infectious disease with headache, chills, fever and general pains as symptoms. It may be fatal in 10–40% of untreated cases.

The disease has occurred on all continents except Australia. It is prevalent in cool areas where heavy clothing is worn and where the vector is most common. In the past the disease was most common during war and famine. Today, foci of transmission are found in mountainous regions of South America, in Central and East Africa and in the Himalayas.

Transmission

Body lice take the disease organisms up with the blood of an infected person and then expel it with their faeces. Since louse faeces dry to form a fine black powder they are easily blown about. The powder can infect small wounds, such as those caused by scratching, or the mucous membranes of the nose and mouth. Because the disease organism can remain alive for at least two months in dried louse faeces, it is dangerous to handle the clothing or bedding of patients with typhus.

Treatment

Effective treatment is possible with tetracycline, doxycycline or chloramphenicol.

Prevention and control

A vaccine has been prepared but is not yet commercially available. Infection can be prevented by controlling the body lice. Epidemic outbreaks are controlled by the application of a residual insecticide to the clothing of all persons in affected areas.

Louse-borne relapsing fever

This disease is caused by a microorganism, *Borrelia recurrentis*. Infected people suffer periods of fever lasting 2–9 days which alternate with periods of 2–4 days without fever. Usually, about 2–10% of untreated persons die but the mortality rate may be as high as 50% during epidemics. The disease occurs in limited areas of Africa, Asia and South America.

Transmission

Louse-borne relapsing fever occurs under similar conditions to those of typhus fever and the two diseases may appear together. Humans become infected by crushing infected body lice between the fingernails or the teeth. The disease organisms are thus released and can enter the body through abrasions, wounds or the mucous membranes of the mouth.

Treatment

Treatment is possible with tetracycline.

Prevention and control

Prevention and control are as described for typhus fever; no vaccine is available.

Trench fever

This bacterial disease, caused by *Rochalimaea quintana*, involves intermittent fever, aches and pains all over the body, and many relapses. Infection rarely results in death.

The disease can probably be found wherever the human body louse exists. Cases have been detected in Bolivia, Burundi, Ethiopia, Mexico, Poland, the former USSR and North Africa. Epidemics occurred during the First and Second World Wars among troops and prisoners living in crowded and dirty conditions, hence the name “trench fever”.

Transmission

Transmission occurs through contact with infected louse faeces, as for typhus fever.

Treatment

Tetracycline, chloramphenicol and doxycycline are probably effective but, as the disease is rather mild, they have not been adequately tested.

Prevention and control

Prevention and control are as for typhus fever; no vaccine is available.

Control measures

The control methods used depend on the importance of the health problem. Individual or group treatment may be carried out where lice are merely a nuisance. Large-scale campaigns are recommended for the control of epidemic outbreaks of disease.

Head lice

Hygienic measures

Regular washing with soap and warm water and regular combing may reduce the numbers of nymphs and adults. However, washing will not remove the eggs, which are firmly attached to the hair. A special louse comb with very closely set fine teeth is effective in removing both adults and eggs (Fig. 4.19). Shaving the head is effective and this measure is sometimes adopted with young boys; however, it is often objected to and should not be insisted on.

Insecticides

Insecticide applications to the hair give the most effective control (20–26). They can be in the form of shampoos, lotions, emulsions or powders (Fig. 4.20; see also Table 4.3). Some pyrethroids are the most recommended products, since they do not cause the burning sensation of the scalp or other side-effects sometimes associated with other insecticides, such as lindane (27, 28). Powder or dust formulations are usually less effective and less acceptable for use than lotions or emulsions. A soap formulation containing 1% permethrin can be applied as a shampoo (see box, p. 261).

How to make insecticidal dusts, shampoos and lotions

An insecticidal dust can be made by adding insecticide powder (wettable powder) to talcum powder to obtain the recommended dosage of active ingredient (in grams). An insecticidal shampoo is made similarly by adding insecticide powder or emulsifiable concentrate to hair shampoo with a neutral pH. An insecticidal lotion is made by mixing an emulsifiable concentrate with water or alcohol.

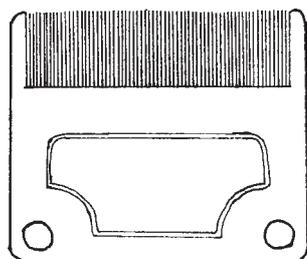


Fig. 4.19
A louse comb has very closely set fine teeth and is effective in removing head lice and their eggs.



Fig. 4.20
Hair can be treated with an anti-lice shampoo or lotion.

Table 4.3
Insecticides and formulations commonly used to control lice

| Insecticide | Formulation and concentration (%) | |
|----------------|-----------------------------------|---------|
| bioallethrin | lotion | 0.3–0.4 |
| | shampoo | 0.3–0.4 |
| | aerosol | 0.6 |
| carbaryl | dust | 5.0 |
| DDT | dust | 10.0 |
| | lotion | 2.0 |
| deltamethrin | lotion | 0.03 |
| | shampoo | 0.03 |
| jodfenphos | dust | 5.0 |
| lindane | dust | 1.0 |
| | lotion | 1.0 |
| malathion | dust | 1.0 |
| | lotion | 0.5 |
| permethrin | dust | 0.5 |
| | lotion | 1.0 |
| | shampoo | 1.0 |
| (+)–phenothrin | shampoo | 0.2–0.4 |
| | dust | 0.3–0.4 |
| propoxur | dust | 1.0 |
| temephos | dust | 2.0 |

Insecticidal soap

The insecticidal soap bar is a recently developed inexpensive formulation of permethrin (1%) which is effective in killing head lice. It can also be used against the scabies mite (see p. 282).

How to use

The bar can be used as a shampoo. Apply to wet hair, work it into a lather and thoroughly massage into the scalp. Allow to remain on the head for 10 minutes, then rinse and dry the hair. Dead lice can be combed out over a towel. Repeat the procedure after three days. The hair will remain free of reinfestation for at least several weeks.

How to make

The bar, which is commercially available, can be produced locally for non-commercial purposes.

| <i>Ingredients</i> | <i>%</i> |
|-----------------------|----------|
| Crude raw coconut oil | 57.0 |
| Antioxidant | 0.14 |
| Permethrin | 1.00 |
| Mineral oil | 8.86 |
| Caustic soda solution | 32.0 |
| Natural clay | 1.00 |

Premix the permethrin with the mineral oil at room temperature and add the mixture to the coconut oil in which the antioxidant has been dissolved. To this blend, add the caustic soda solution at ambient temperature, with rapid stirring. When all the caustic soda has been added, sprinkle the clay in and pour the emulsion into moulds, where the reaction continues for 12 hours.

The following day, cut the blocks into 40-g bars. If the bars are wrapped in polypropylene film and placed in an airtight box, the product will retain its effectiveness for more than two years. If they are packaged in a small plastic sandwich bag, or placed unwrapped in an airtight box, the shelf life is one year. If the product will be used up within a few weeks of manufacture, the lower-cost packaging is sufficient.

Impregnated mosquito nets

Head louse infestations disappear from people sleeping under mosquito nets impregnated with a long-lasting pyrethroid insecticide (5) (see Chapter 1 and p. 240).

Crab or pubic lice

Shaving the infested pubic hairs from the body has been replaced by the application of insecticidal formulations, as described for head louse control. In heavy infestations all hairy areas of the body below the neck should be treated.