Body lice

Individual treatment

Regular washing and changing of clothes usually prevents body louse infestations. In areas where water is scarce, washing facilities are lacking and people own only a single piece of clothing, this may be impractical. Another solution is to wash clothing and bedding with soap containing 7% DDT.

Soap and cold water are not sufficient to eliminate lice from clothing. Clothing must be washed in water hotter than 60 °C and should then be ironed if possible.

Group or mass treatment for disease control

The preferred method for mass treatment is the blowing of insecticidal powder between the body and underclothes. A suitable powder consists of talcum powder mixed with permethrin (0.5%), DDT (10%), lindane (1%) or another insecticide. Alternative insecticidal dusts, as shown in Table 4.3, can be used in the case of resistance. Because the dusts come into close contact with the body, it is important that the insecticides have a low toxicity to people and do not cause irritation.

An advantage of dusting powder is that it is easily transported and stored. Application can be made by any type of dusting apparatus, such as compressed-air dusters, plunger-type dusters and puff dusters (Fig. 4.21) (see p. 250), or by hand. It is important to explain the purpose of dusting to the people to be treated because the powder leaves clearly visible traces on clothing.

For individual treatment, about 30 g of powder can be applied evenly from a sifter-top container over the surfaces of clothing that are in close contact with the body. Special attention should be given to the seams of underwear and other garments. To treat large groups of people about 50 g of powder per person is needed. The powder is blown into the clothing through the neck openings, up the sleeves and from all sides of the loosened waist (Fig. 4.22). Socks, headwear and bedding should also be treated. One treatment should be sufficient but re-treatment may be needed at intervals of 8–10 days if infestations persist.

The impregnation of clothing with a pyrethroid emulsion may provide long-lasting protection (*29*), the insecticide possibly remaining effective after 6–8 launderings.

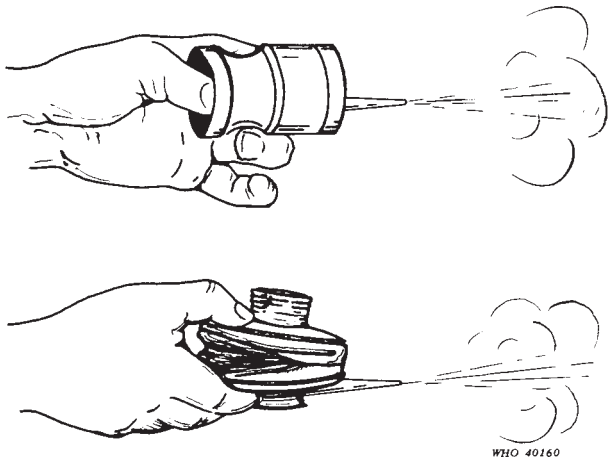

Fig. 4.21
Insecticidal dust can be applied to clothing with a hand-operated puff-duster (© WHO).

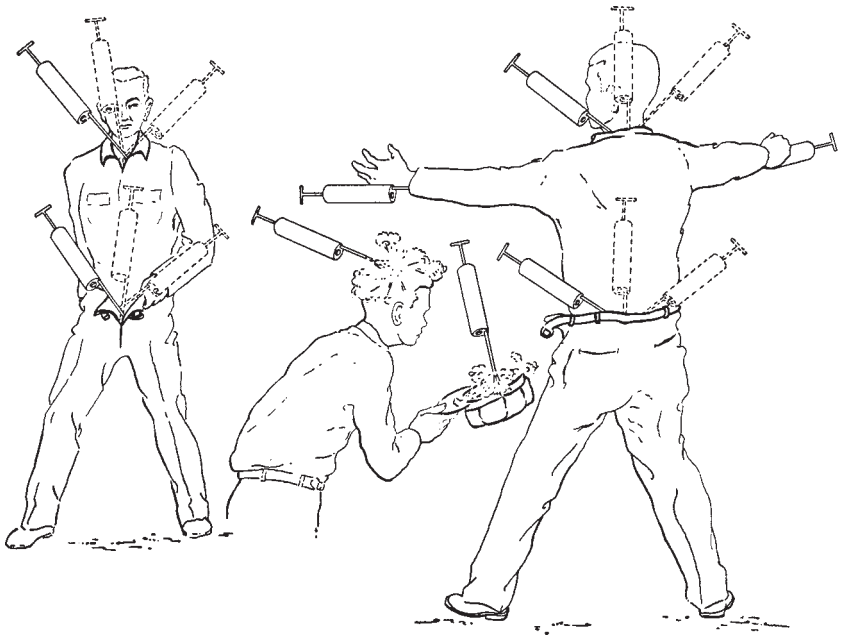

Fig. 4.22
Treating an individual with insecticidal dust using a plunger-type duster. (Reproduced from *Insect and rodent control*. Washington, DC, Departments of the Air Force, the Army and the Navy, 1956.)

TICKS

Ticks are arthropods that suck blood from animals and humans. They occur around the world and are important as vectors of a large number of diseases. Among the best-known human diseases transmitted by ticks are tick-borne relapsing fever, Rocky Mountain spotted fever, Q fever and Lyme disease. Ticks are also important as vectors of diseases of domestic animals and they can cause great economic loss. Two major families can be distinguished: the hard ticks (Ixodidae), comprising about 650 species, and the soft ticks (Argasidae), comprising about 150 species. Ticks are not insects and can easily be distinguished by the presence of four pairs of legs in the adults and the lack of clear segmentation of the body (Fig. 4.23).

Biology

Ticks have a life cycle that includes a six-legged larval stage and one or more eight-legged nymphal stages (Fig. 4.24). The immature stages resemble the adults and each of them needs a blood-meal before it can proceed to the next stage. Adult ticks live for several years, and in the absence of a blood-meal can survive several years of starvation. Both sexes feed on blood, the males less frequently than the females, and both can be vectors of disease. Disease organisms are not only passed from one host to another while blood is being taken: female ticks can also pass on certain disease agents to their offspring.

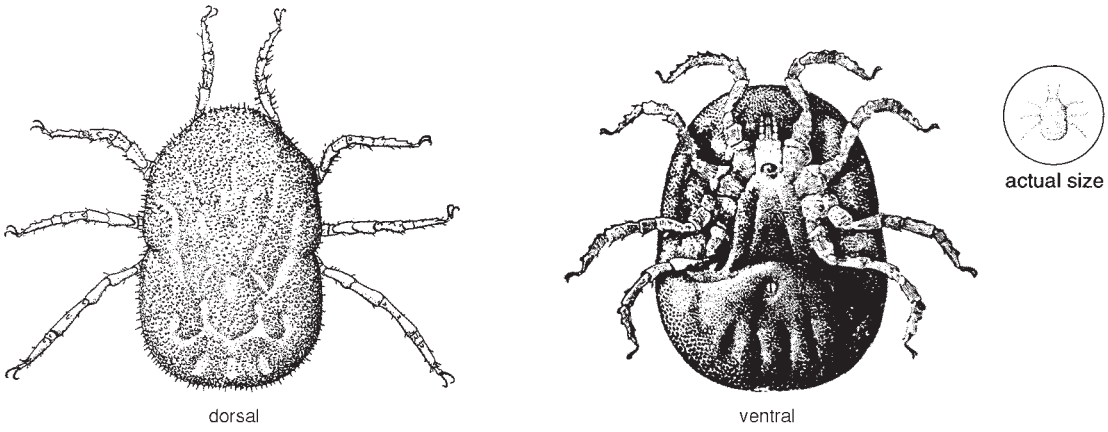

Fig. 4.23
A soft tick, *Ornithodoros moubata*, vector of relapsing fever in Africa (by courtesy of the Natural History Museum, London).

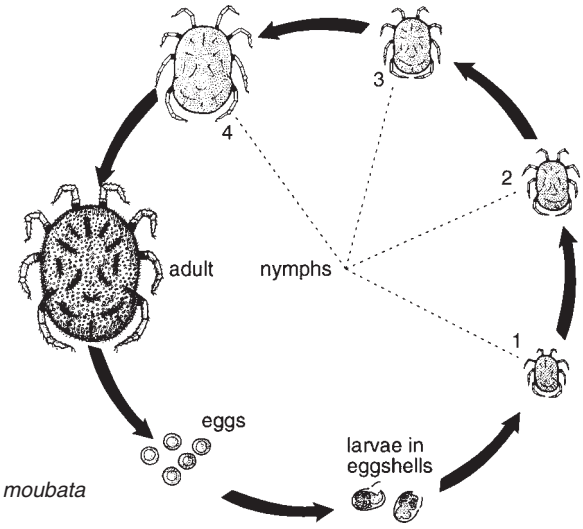

Fig. 4.24
Life cycle of the soft tick, *Ornithodoros moubata* (*30*).

Soft ticks

The adults are flat and oval in outline and have tough, leathery, wrinkled bodies. The mouthparts are situated underneath the body and are not visible from above. The eggs are laid in the places where the adults rest, such as cracks and crevices in the walls and floors of houses and in furniture. The larva, the five nymphal stages and the adults all actively search for hosts from which to take blood-meals. After feeding, which lasts about 30 minutes, they drop to the ground. Most species can survive for more than a year between blood-meals, and some for more than 10 years.

The soft ticks live apart from their hosts and are most common in the nests and resting places of the animals on which they feed. Some species, such as the chicken tick and the pigeon tick (*Argas* species) may feed on humans when the preferred hosts are not available.

Species that commonly feed on humans are found around villages and inside houses (Fig. 4.25). Their habits are comparable to those of bedbugs: ticks often emerge from hiding places at night to suck the blood of humans and animals. Some species are common on travel routes, in rest houses and camping sites, and in caves and crevices.

Hard ticks

The adult hard ticks are flat and oval in shape and between 3 and 23 mm long, depending on the species (Fig. 4.26). The mouthparts are visible at the front of the body, differentiating them from the soft ticks. In contrast to the soft ticks they have a shield-like plate or scutum behind the head on the back of the body, and there is only one nymphal stage (Fig. 4.27).

The eggs are deposited on the ground in large numbers. The larvae are very small, between 0.5 and 1.5 mm in length; they climb up vegetation, wait until a suitable host passes by, then climb on to it and attach themselves at a preferred feeding site, such as in the ears or on the eyelids.

After several days, when fully engorged, they drop to the ground, seek shelter and moult to the nymphal stage, which in turn seeks a blood-meal (Fig. 4.28), engorges, detaches itself and moults into an adult. The adult females climb up vegetation to wait for a suitable host, remaining on it for one to four weeks, then

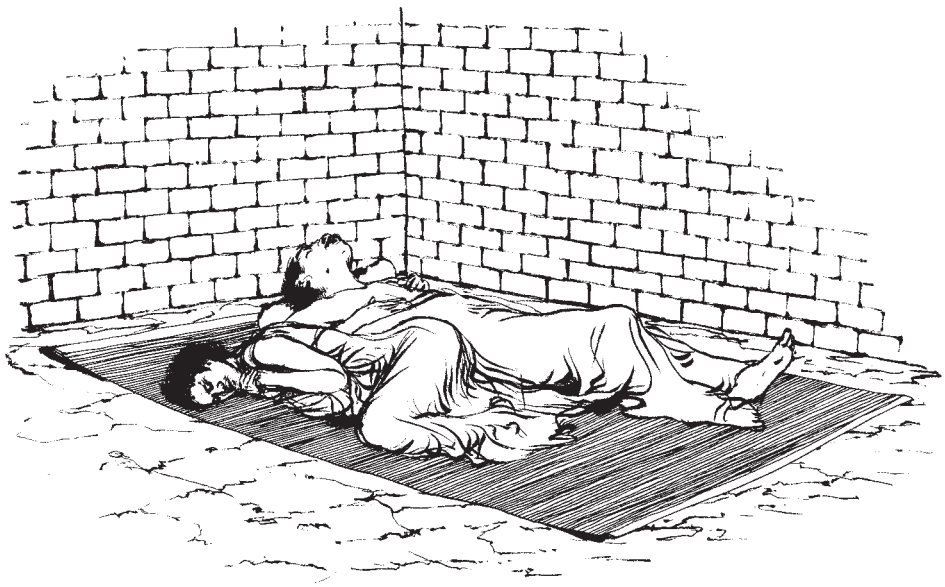

Fig. 4.25
Ornithodoros soft ticks are common in traditional-style mud-built houses with mud floors in some parts of Africa.

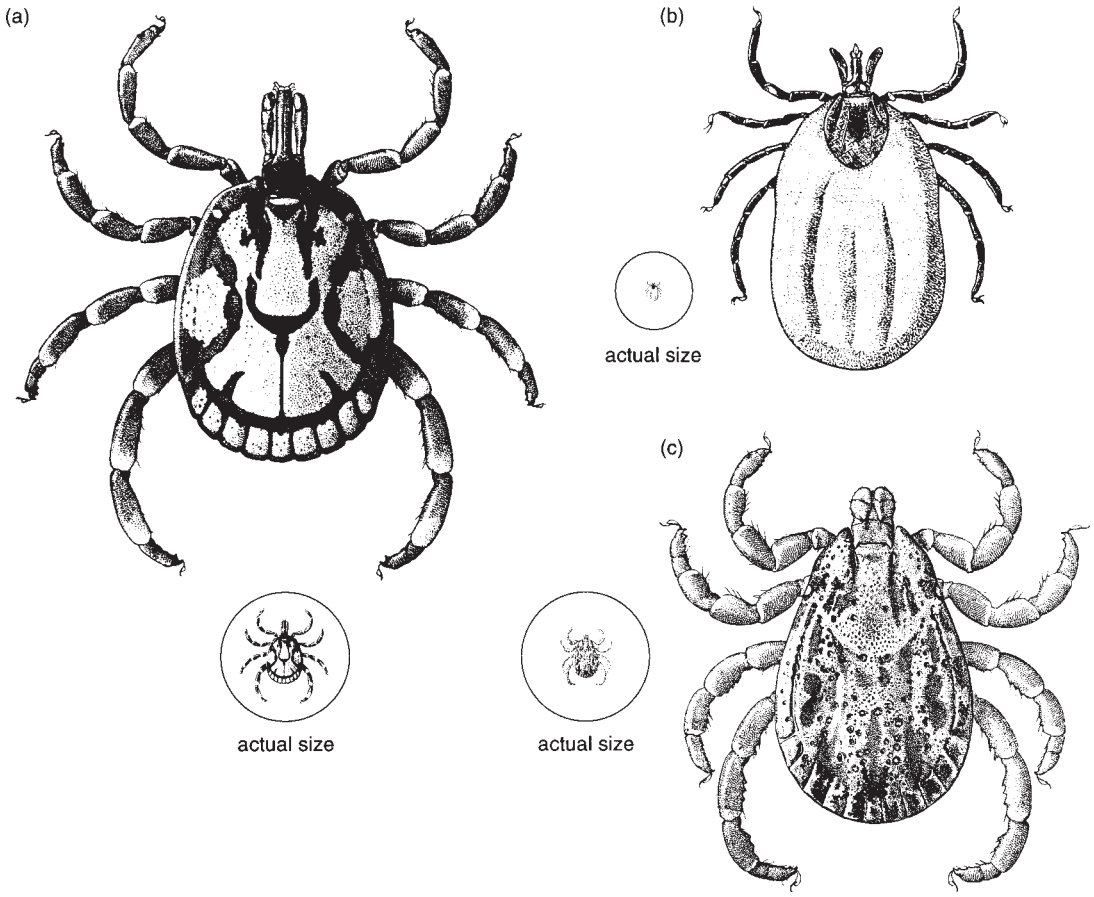

Fig. 4.26
Hard ticks. (a) The bont tick, *Amblyomma hebraeum*, vector of spotted fever due to *Rickettsia conori* in southern Africa. (b) The sheep tick, *Ixodes ricinus*, vector of tick-borne (Central European) encephalitis. (c) The Rocky Mountain wood tick, *Dermacentor andersoni*, vector of spotted fever due to *Rickettsia rickettsii* in North, Central and South America (by courtesy of the Natural History Museum, London).

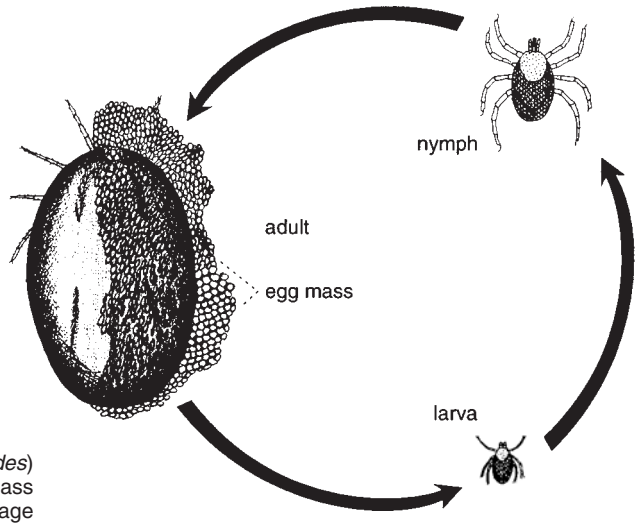

Fig 4.27
Life cycle of a hard tick (*Ixodes*) showing a female with a large mass of eggs, and a single nymphal stage (*30*).

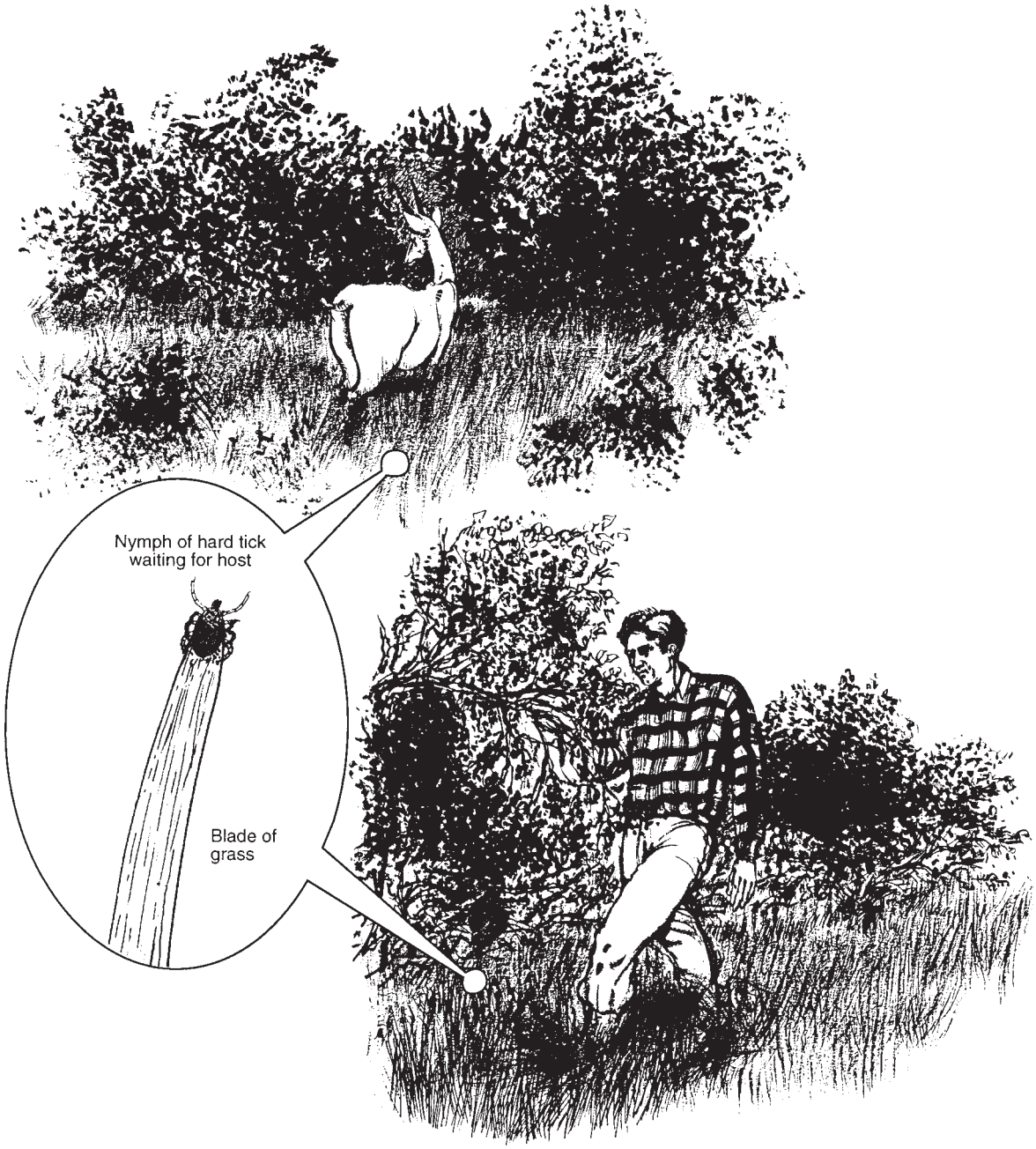

Fig. 4.28
A typical habitat of hard ticks, which normally feed on wild animals.

drop to the ground and seek shelter in cool places under stones and leaf litter, where they lay their eggs.

Most species of hard tick feed on three different hosts: one each for the larva, nymph and adult. However, some species feed on only one or two hosts. Because they remain attached to their hosts for several days, the hard ticks may be carried over large distances. The combination of feeding on different hosts and travelling considerable distances partly explains their importance as disease vectors.

Public health importance

Nuisance

Ticks can cause painful bites; heavy infestations, not uncommon in animals, can cause serious loss of blood.

Tick-borne relapsing fever

This disease is caused by a microorganism of the genus *Borrelia*. It is transmitted by biting soft ticks of the genus *Ornithodoros* in many countries in the tropics and subtropics and also in Europe and North America. The ticks usually feed quickly at night in or near houses, and then leave the host (*31*).

The disease causes bouts of fever alternating with periods without fever. Death occurs in about 2–10% of persons who are untreated.

Treatment

Treatment is possible with tetracycline or its derivatives.

Prevention

Prevention requires measures to control soft ticks and to avoid their bites.

Tick paralysis

Hard ticks inject into the body with their saliva certain toxins that can cause a condition in people and animals called tick paralysis. It appears 5–7 days after a tick begins feeding, paralysing the legs and affecting speaking ability, swallowing and breathing. It occurs worldwide and is most common and severe in children aged up to two years. Treatment involves removing the tick.

Tick-borne rickettsial fevers

This group of diseases is caused by closely related *Rickettsia* microorganisms transmitted by tick bites or contamination of the skin with crushed tissues or faeces of the tick.

- Spotted fever due to *Rickettsia rickettsii* occurs in Brazil, Canada, Colombia, Mexico, Panama and the USA.
- Spotted fever due to *R. sibirica* occurs in Japan, the Russian Federation and the Pacific.
- Spotted fever due to *R. conori* is found in the Mediterranean region, Africa and southern Asia.
- Spotted fever due to *R. australis* occurs in Queensland, Australia.
- Q fever, caused by *Coxiella burnetii*, has a worldwide distribution and is commonly present in abattoirs, meat-packing and meat-rendering plants, diagnostic laboratories, stockyards and poultry farms. It is transmitted to humans mainly by the consumption of milk and meat from contaminated

cattle or the inhalation of dried infected tick faeces by people working with cattle.

Symptoms in humans are sudden fever persisting for several weeks, malaise, muscle and joint pains, severe headache and chills. A rash sometimes spreads over the entire body. Death may result in about 15–20% of persons if the disease is misdiagnosed or left untreated.

Treatment

Antibiotics such as tetracycline or chloramphenicol can be used.

Prevention

Tick bites should be avoided and attached ticks should be removed rapidly and carefully. Several hours of attachment are needed before the *Rickettsia* organisms can infect humans.

Lyme disease

Lyme disease (erythema chronicum migrans) is a severe and often debilitating condition caused by a spirochaete, *Borrelia burgdorferi*. Acute Lyme disease is a flu-like illness, characterized by an expanding red rash in about 50% of patients, accompanied by fever, fatigue, and muscle and joint pain. Weeks or even months after the infecting tick bite, patients may experience swelling and pain in large joints (knee, elbow), encephalitis, facial palsy, ocular lesions and carditis, irrespective of whether a rash occurred in the acute phase. Later, perhaps years after the bite, there may be cartilage erosion (arthritis) and neuromuscular dysfunction (Fig. 4.29). Lyme disease occurs principally in northern temperate regions of the world, including China, Europe, the USA and the former USSR.

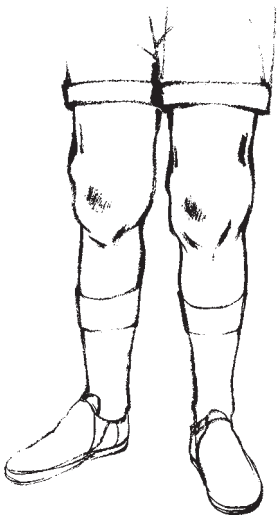

Fig. 4.29
A typical symptom of Lyme disease is swelling and pain in the large joints, such as the knees, and chronic arthritis.

Transmission

The disease is transmitted mostly by *Ixodes* ticks, commonly in the summer when the nymphs are abundant. Small rodents, especially mice, serve as reservoirs of infection while large mammals serve principally as hosts maintaining tick populations. The larvae acquire infection while feeding on mice, and nymphs or adults can transmit spirochaetes during subsequent blood-meals. In the northern temperate zone, where it occurs most intensely, Lyme disease has become more common as deer populations have increased and as this critical host has adapted to living in closer proximity to people. In many areas, Lyme disease is acquired in the suburban residential environment (*32*).

Treatment

Further development of the disease in adults may be reduced or prevented by treatment with tetracycline or its derivatives for 2–4 weeks, and in children by treatment with penicillin.

Prevention

Prevention requires avoidance of tick habitats and bites, and vector control. Personal protection may be possible by the use of repellents on the skin and clothing in tick-infested areas. The removal of attached ticks within 24 hours may prevent spirochaete transmission. Prophylactic antibiotic therapy may be desirable following the bite of an infected tick. New molecular assays are commercially available for detecting the spirochaetes in tick samples.

Tularaemia

Tularaemia, also known as rabbit fever, deerfly fever and Ohara disease, is caused by the infectious agent *Francisella tularensis*. The symptoms, which vary according to how the agent enters the body, include headache, chills, fever and the swelling of lymph nodes. The disease occurs in Europe, Japan, North America and the former USSR.

Transmission

Transmission takes place through the bites of ticks and deerflies (see Chapter 1) or as a result of handling infected animals such as rabbits and other game. Hunters and forest workers are at the highest risk of infection.

Treatment

Antibiotics such as streptomycin can be used to treat the disease.

Prevention

Tick bites and tick habitats should be avoided, impermeable gloves should be worn when skinning and dressing game animals, wild game meat should be thoroughly

cooked, and untreated drinking-water should be avoided in areas where the disease occurs.

Tick-borne viral encephalitides

This is a group of viral diseases causing acute inflammation of the brain, spinal cord and meninges. The symptoms vary in severity with the type of disease. Many infections do not result in disease. Severe infections may cause violent headaches, high fever, nausea, coma and death.

- Far Eastern tick-borne encephalitis is found in the far east of the former USSR.
- Central European tick-borne encephalitis occurs in Europe from the Urals to France.
- Louping ill is a disease of sheep in the United Kingdom which sometimes affects people.

Transmission and prevention

These diseases are transmitted by biting ticks and by the consumption of milk from infected animals. No specific treatment is available but vaccines have been developed against some of the diseases. Prevention requires avoidance or rapid removal of ticks.

Principal hard tick vectors

Usually various tick species act as vectors for any one disease and their importance varies from region to region.

Disease	Vector
Lyme disease	Deer tick, *Ixodes dammini*
Spotted fever due to:	
Rickettsia rickettsii	American dog tick, *Dermacentor variabilis*
R. sibirica	Asiatic wood tick, *Dermacentor silvarum*
R. conori	Brown dog tick, *Rhipicephalus sanguineus*
R. australis	Wattle tick, *Ixodes holocyclus*
Q fever	Lone star tick, *Amblyomma americanum*
Tularaemia	American rabbit tick, *Haemaphysalis leporis-palustris*
Far Eastern tick-borne encephalitis	Taiga tick, *Ixodes persulcatus*
Central European tick-borne encephalitis	Castor bean tick, *Ixodes ricinus*
Kyasanur Forest disease	A tick of birds and monkeys, *Haemaphysalis spinigera*
Colorado tick fever	American wood tick, *Dermacentor andersoni*
Crimean–Congo haemorrhagic fever	A tick of birds and mammals, *Hyalomma marginatum*

Other viral diseases

Kyasanur Forest disease occurs in parts of India.

Omsk haemorrhagic fever is found in south-western Siberia; it causes severe disease and death in muskrat handlers; it is mainly waterborne, although it is found in hard ticks.

Colorado tick fever is a moderately severe disease that occurs in western North America.

Crimean–Congo haemorrhagic fever is an acute, often severe and fatal disease found in parts of Africa, Asia and Europe.

Control measures

Self-protection

Avoidance

Fields and forests infested with ticks should be avoided if possible. In Africa, bites by the soft tick *Ornithodoros moubata*, the vector of relapsing fever, can be prevented by avoiding old camp sites and by not sleeping on floors of mud houses. Beds, especially metal ones, may provide some protection because the ticks have difficulty in climbing the legs. However, they may still be able to reach hosts by climbing up the walls.

Repellents

Effective repellents that prevent ticks from attaching to the body include deet, dimethyl phthalate, benzyl benzoate, dimethyl carbamate and indalone (*33*). These substances can be applied to the skin or clothing. On the skin, repellents often do not last more than a few hours because of absorption and removal by abrasion. On clothing they last much longer, sometimes for several days (*34*). For more information on repellents, see Chapter 1.

Clothing

Clothing can provide some protection if, for example, trousers are tucked into boots or socks and if shirts are tucked into trousers. Clothing should be removed and examined for the presence of ticks after a tick-infested area has been visited.

Impregnated clothing

People who frequently enter tick-infested areas should consider impregnating their clothing by spraying (*35*, *36*) or soaking with a pyrethroid insecticide such as permethrin or cyfluthrin. Ticks crawling up trousers or shirts are quickly knocked down. Thus, not only is biting prevented but the ticks are also killed. Pyrethroid treatment of clothing is additionally effective against mosquitos for a month or longer (*34*). Information on how to treat clothing with a pyrethroid insecticide is given in Chapter 1.

Removal of attached ticks

During and after visits to tick-infested areas it is important to examine the body frequently for ticks. They should be removed as soon as possible because the risk of disease transmission increases with the duration of attachment.

A tick should be removed by pulling slowly but steadily, preferably with forceps to avoid contact between the fingers and the tick's infective body fluids. The tick should be grasped as close as possible to where the head enters the skin, so as not to crush it, and care should be taken not to break off the embedded mouthparts, as they may cause irritation and secondary infection. Some veterinarians may have a special tool for quick removal of ticks from dogs.

The following methods may induce soft ticks to withdraw their mouthparts: touching with a hot object such as a heated needle tip; dabbing with chloroform, ether or some other anaesthetic. With hard ticks these methods only work immediately after biting because they are attached with a saliva cement that prevents them from quickly withdrawing their mouthparts. In areas where ticks are only a nuisance they can be coated with oil, paraffin, vaseline or nail varnish to prevent them from obtaining oxygen. Hard ticks then dissolve the cement so that they can withdraw their mouthparts, but this may take several hours. However, these methods are not recommended in areas where ticks are vectors of disease, as they work too slowly and may cause ticks to regurgitate into wounds, injecting disease organisms. In such circumstances it is recommended to pull the ticks out immediately, even if the head is left in the wound.

Application of insecticides to animals

Domestic animals are often hosts to ticks that can feed on humans and transmit disease to people and animals. Insecticides applied directly to the bodies of these animals in the form of dusts, sprays, dips or washes can be very effective. Pour-on formulations are applied over the animals' backs. The insecticide (a pyrethroid) is distributed over the whole body by tail and other movements.

Insecticidal powders or dusts can be applied by means of a shaker, puff-duster or plunger-type duster. Insecticidal sprays are applied with hand-compression sprayers. The same insecticides and dosages can be used as for the control of fleas (see Table 4.2). It is particularly important to treat the back, neck, belly and the back of the head.

Plastic collars impregnated with an insecticide for the control of fleas in dogs and cats (see Table 4.2) are only partially effective against most species of tick.

Spraying insecticides in houses and resting places for animals

Ticks can be killed by insecticides sprayed on floors in houses, porches, verandas, dog kennels and other places where domestic animals sleep. Suitable residual sprays are indicated in Table 4.4 (see also p. 246).

Houses infested with soft ticks (*Ornithodoros*) can be sprayed with lindane (0.2 g/m^2) or another insecticide formulation. Special care must be taken to treat the hiding and resting places of ticks in cracks and crevices in walls, floors and

Table 4.4
Insecticidal formulations used against ticks

Application method	Insecticide formulation
Dipping, washing or spray-on	malathion (5%), dichlorvos (0.1%), carbaryl (1%), dioxathion (0.1%), naled (0.2%), coumaphos (1%)
Insecticidal powder (dust)	carbaryl (5%), coumaphos (0.5%), malathion (3–5%), trichlorphon (1%)
Residual spray on floors, etc.	oil solutions or emulsions of DDT (5%), lindane (0.5%), propoxur (1%), bendiocarb (0.25–0.48%), pirimiphos methyl (1%), diazinon (0.5%), malathion (2%), carbaryl (5%), chlorpyrifos (0.5%)
Ultra-low-volume fogging (area spraying)	organophosphorus insecticides, carbamate compounds and pyrethroids
Flea and tick collars for dogs and cats	dichlorvos (20%), propoxur (10%), propetamphos (10%), permethrin (11%)

furniture. Residual house-spraying against malaria mosquitos has often resulted in a reduction in the numbers of ticks (see also p. 241).

Impregnated mosquito nets

Soft ticks that habitually feed indoors on sleeping persons can be controlled with impregnated bednets (*5*) (see also p. 240 and Chapter 1).

Community protection

Large-scale control activities are sometimes carried out in recreational areas or in areas where ticks transmit tick-borne diseases. It is often economical and effective to integrate several methods into a comprehensive control strategy (*37*). Possible components of an integrated strategy are as follows:

- *Surveillance*: sampling to identify tick habitats where control is needed.
- *Vegetation management*: physical or chemical measures to reduce and isolate tick habitats.
- *Host management*: removal or exclusion of host animals.
- *Targeted chemical control*: pesticide applications against ticks, targeted at the tick host or habitat.
- *Cultural practices*: lifestyle changes to limit exposure to ticks.
- *Personal protection*: protective clothing; repellents; checking for and removing of ticks.

Area spraying with insecticides

Spraying ticks directly in their natural habitats in forests and fields may control outbreaks of certain tick-borne diseases (e.g. Lyme disease (*38*) and tick-borne

encephalitides). Large areas may be treated by ultra-low-volume spraying of liquid acaricide concentrates from fixed-wing aircraft or helicopters. Small areas may be sprayed by means of motorized knapsack sprayers or mist-blowers, applying either ultra-low-volume formulations or formulations of water-based emulsions or wettable powders. Control lasts for a month or longer, depending on conditions and the size of the treated area. Suitable biodegradable insecticides are shown in Table 4.4 (*39–44*).

Vegetation management

In, for example, parks and camp sites, ticks can be controlled by removal of the vegetation serving as their habitat (*37*, *45*). This can be done by cutting, mowing or applying herbicides.

Host management

Tick populations can be reduced by removing the animals on which they usually feed. Fences can be used to exclude larger animals such as deer (*37*).

Insecticide-treated nesting material

Nest-building rodents serve as natural reservoirs or critical hosts for many vector-borne infections, including Lyme disease, several of the tick-borne encephalitides, and others. One host-targeted vector control strategy uses insecticide-impregnated nesting material directed at the rodent reservoirs of Lyme disease spirochaetes. In the USA, white-footed mice serve as the principal reservoirs. Larval deer ticks become infected while feeding on these mice, and nymphs derived from mouse-fed larvae become infected vectors. Mice actively harvest soft material for their nests; when they incorporate cotton nesting material treated with 7–8% permethrin, their tick infestations are virtually eliminated.

This method has been used in residential areas bordering woodlands and parklands in the northern USA to reduce the abundance of infected nymphal ticks (*46*, *47*). The treated nesting material is protected in dispensing tubes (4 cm in diameter by 20 cm in length) and is placed about every 10 m in mouse habitats. The impregnated material is made using a patented method of soaking cotton in a permethrin emulsion and then drying it.

Clearly, mice must find and use the nesting material if this method is to work, and failures have been reported (*48*). However, when used properly, such a host-targeted treatment can significantly reduce the abundance of infected ticks, using up to 20 times less active ingredient and at less cost than insecticidal spray treatments. Community-wide programmes, where all properties in a neighbourhood receive treatment, have proved most effective.

MITES

Mites are very small, ranging from 0.5 to 2.0 mm in length; there are thousands of species, of which many live on animals. Like ticks, they have eight legs and a body with little or no segmentation. In most species there are egg, larval, nymphal and adult stages. The immature stages are similar to the adults but smaller.

Some mites are important vectors of rickettsial diseases, such as typhus fever due to *Rickettsia tsutsugamushi* (scrub typhus) and several viral diseases. Mites can present a serious biting nuisance to humans and animals. Many people show allergic reactions to mites or their bites. Certain mites cause a condition known as scabies. The major mite pests discussed here are:

— biting mites (vectors of scrub typhus);
— scabies mites;
— house dust mites.

Biting mites

Numerous species of mite are parasitic on mammals and birds and occasionally attack humans. Their bites can cause irritation and inflammation of the skin. One group, the trombiculid mites, transmits typhus fever due to *R. tsutsugamushi* in Asia and the Pacific. Only the trombiculid mites are described here, the biology and life cycle of other biting mites being similar.

Biology

Adult trombiculid mites are about 1–2 mm in length, bright red or reddish-brown in colour, and of velvety appearance. The nymph is similar but smaller. The larvae, also called chiggers, are very small, being only 0.15–0.3 mm in length (Fig. 4.30). Neither the adults nor the nymphs bite animals or humans; they live in the soil and feed on other mites, small insects and their eggs. The larvae, however, feed on skin tissue.

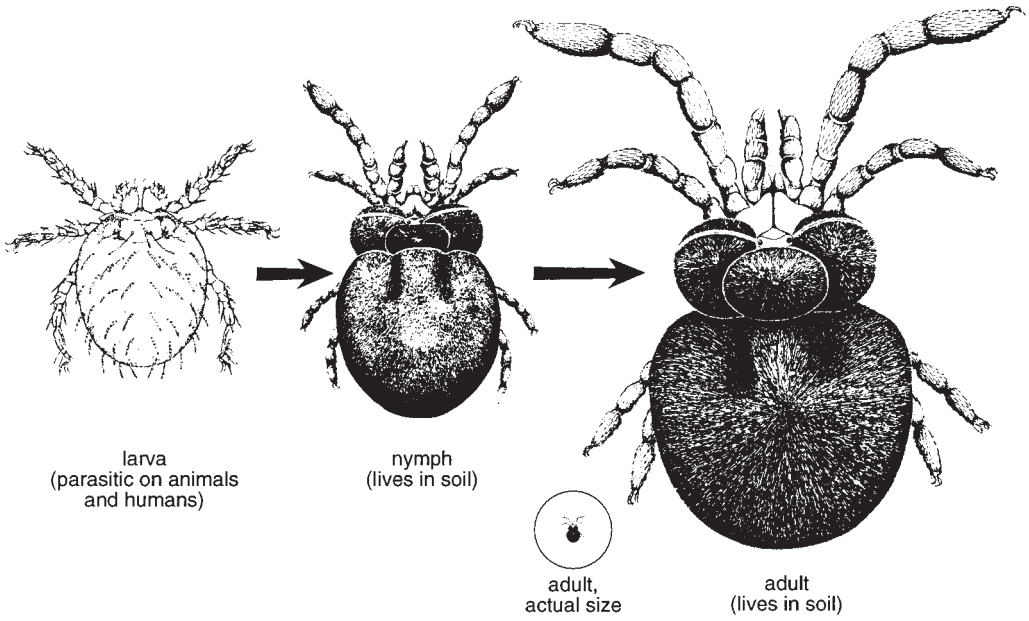

Fig. 4.30
The biting mite (*Trombicula* species). Reproduced from reference *49* with the permission of the publisher. Copyright Macmillan Publishing Company.

After emerging from the eggs the larvae crawl onto grasses or low-lying vegetation and leaf litter to wait for an animal or human host. They attach themselves to the skin of reptiles, birds, mammals and humans walking or resting in the habitat. On humans they seek out areas where clothing is tight against the skin, the waist and ankles being the parts most commonly attacked.

The larvae remain attached to the skin of the host for between two days and a month, depending on the species. They then drop to the ground and enter the soil to develop into the harmless nymphal and adult stages.

Distribution

Mites have a very patchy distribution over small areas because of their special requirements. The nymphs and adults need certain soil conditions for their survival and development while the larvae require host animals, such as wild rats, other small rodents and birds. Suitable habitats are found in grassy fields, shrubby areas, forests, abandoned rice fields and cleared forests. The mites are also found in parks, gardens, lawns and moist areas alongside lakes and streams.

The larvae wait on leaves or dry grass stems until an animal or human passes by. People usually become infested after walking or standing in mite-infested areas. Bamboo bushes are favoured by the mites in the tropics and subtropics.

Public health importance

Nuisance

The bites can cause severe itching, irritation and inflammation of the skin (scrub itch). They usually occur on the legs. At the site of a bite the skin swells slightly and turns red. In the centre a red point indicates the location of the chigger. Because chiggers are invisible to the naked eye, most people are not aware of their presence until bites appear.

Scrub typhus

Biting mites can transmit a number of rickettsial and viral diseases to humans but only the most important one, scrub typhus, is discussed here. It is caused by *Rickettsia tsutsugamushi* and causes an acute fever, severe headache and lymphadenopathy.

At the site of attachment of the infected mite a primary skin lesion consisting of a punched-out ulcer covered by an eschar commonly develops before the onset of the fever attack. Depending on a number of factors the mortality rate is in the range 1–60%.

Distribution and transmission

Scrub typhus occurs mostly in low-lying rural areas of Asia and Australia (Fig. 4.31). It was very common in troops during the Second World War. The disease occurs most frequently in people visiting or working in mite-infested areas in scrub, overgrown terrain, forest clearings, reforested areas, new settlements and newly irrigated desert regions.

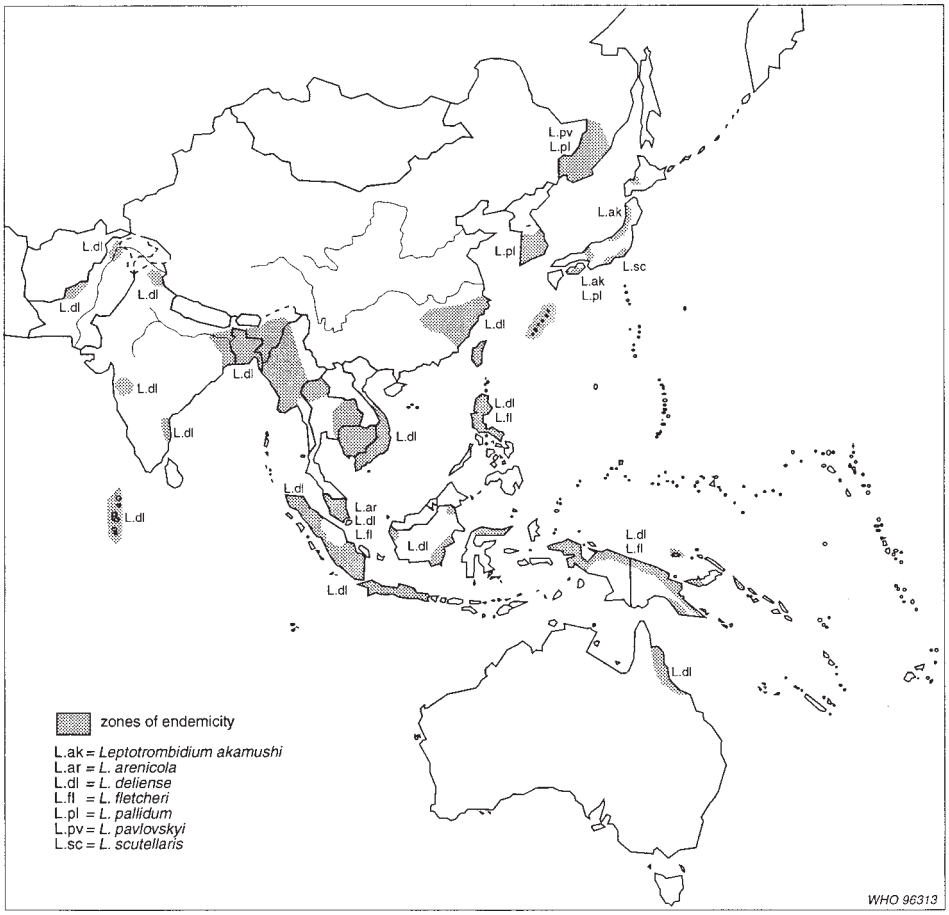

Fig. 4.31
Areas in south-east Asia and the western Pacific where scrub typhus occurs, 1996 (© WHO).

Treatment, prevention and control

Infected persons can be treated with tetracycline or its derivatives. Prevention is possible by avoiding contact with mites. The chiggers can be controlled by spraying of residual insecticides in woodland or bush areas, although this is expensive.

Control measures

Prevention of bites

Biting can be prevented by avoiding infested terrain and applying repellents to skin and clothing. Openings in clothing can be treated by hand or spray. A band of 1–3 cm is normally sufficient. Benzyl benzoate, dimethyl phthalate, deet, dimethyl carbamate and ethyl hexanediol are effective repellents. Under conditions of frequent exposure the best protection is given by impregnated clothing and by tucking trousers inside socks. Where vegetation is low it is sufficient to treat socks and the bottoms of trouser legs. The clothing can be treated with one or a combination of the above repellents or with a pyrethroid insecticide (see Chapter 2) providing more long-lasting protection, even after one or two washes. Deet and dimethyl phthalate have been shown to be the most effective repellent compounds against some mite species (*50*, *51*).

Removal of vegetation

The control of mites by killing them in their habitats is very difficult because of the patchy distribution of their populations. If it is possible to identify the patches of vegetation that harbour large numbers of larval mites (mite islands), it may be advantageous to remove them by burning or cutting and then to scrape or plough the top-soil. Mowing grass or weeds in these areas also helps. Such measures are recommended in the vicinity of camp sites and buildings.

Residual spraying of vegetation

Where the removal of vegetation is not possible, mite islands can be sprayed with residual insecticide. The spraying of vegetation up to a height of 20 cm around houses, hospitals and camp sites is effective against grass mites in Europe. The insecticides can be applied as fogs with ultra-low-volume spray equipment. Some suitable compounds are diazinon, fenthion, malathion, propoxur and permethrin (*52*).

Scabies mite

The scabies mite, *Sarcoptes scabiei*, causes an itching condition of the skin known as scabies. Infestations with scabies are common worldwide.

Biology

The mites are between 0.2 and 0.4 mm long and virtually invisible to the naked eye (Fig. 4.32). Practically the whole life cycle is spent on and in the skin of humans. In order to feed and lay eggs, fertilized females burrow winding tunnels in the surface of the skin. The tunnels are extended by 1–5 mm a day and can be seen on the skin as very thin twisting lines a few millimetres to several centimetres long.

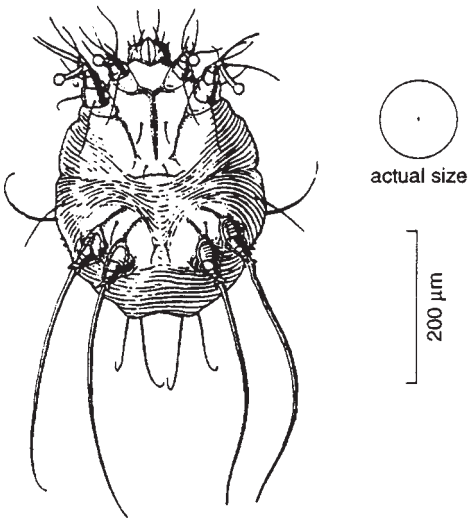

Fig. 4.32
The scabies mite. With a length of 0.2–0.4 mm it is hardly visible to the naked eye (by courtesy of the Natural History Museum, London).

Development from egg to adult may take as little as two weeks. The females may live on people for 1–2 months. Away from the host they survive for only a few days.

Scabies mites are commonly found where the skin is thin and wrinkled, for instance between the fingers, on the sides of the feet and hands (Fig. 4.33), the bends of the knee and elbow, the penis, the breasts and the shoulder blades. In young children they may also be found on the face and other areas.

Public health importance

Transmission

Scabies is usually transmitted by close personal contact, as between people sleeping together, and during sexual intercourse. Dispersal mostly takes place within families and if one family member becomes infested it is likely that all the others will follow suit. The mites are unlikely to be acquired by someone sleeping in a bed previously used by an infested person, but may be passed on in underclothes.

Distribution

Scabies occurs throughout the world in persons of all ages and social groups. In some developing countries up to a quarter of the population may be affected. It is

Fig. 4.33
A heavy infestation of scabies mites in the skin of the wrist (*53*).

most common in young children. Outbreaks of scabies are frequently reported from places where people live in overcrowded, unhygienic conditions (e.g. refugee camps) and where there is poor hygiene, such as in poorly maintained prisons and nurseries.

Symptoms

Initially a small, slightly elevated, reddish track appears, which itches intensely. This is followed by the formation and eventual rupture of papulae and tiny vesicles on the surfaces of the skin. Scratching causes bleeding and leads to the spread of the infestation. Vigorous and constant scratching often results in secondary infections, giving rise to boils, pustules and eczema.

A typical scabies rash can develop in areas of the body not infested with mites. This occurs mainly on the buttocks, around the waist and on the shoulders, and is an allergic reaction.

In newly infested persons the itching and rash do not appear until about 4–6 weeks after infestation but in previously infested individuals the rash develops in a few days.

A rare form of the disease is Norwegian scabies, which is associated with an immense number of mites and with marked scales and crusts, particularly on the palms and soles. It appears to occur more frequently among people with immunodeficiency disorders (especially HIV infection) than among immunocompetent patients (*54–56*).

Confirmation

Scabies infection can be confirmed by scraping the affected skin with a knife, transferring the material to a glass slide, and examining it for mites under a microscope. The application of mineral oil facilitates the collection and examination of scrapings. Another method involves applying ink to infested skin areas and then washing it off, thus revealing the burrows.

Treatment

It has recently been discovered that ivermectin, which is used in the treatment of onchocerciasis and lymphatic filariasis, is also suitable for the treatment of scabies infections. It is administered in a single oral dose of 100–200 µg per kg of body weight (*57–59*).

Conventional treatment methods aim to kill the mites with insecticide (see Table 4.5). Information on how to make and apply the formulations is provided on pp. 259–261. After successful treatment, itching continues for some time but eventually it disappears completely. Treatment of all family members is necessary to prevent reinfestation.

Most treatments provide a complete cure but sometimes a second application within 2–7 days is needed. Overtreatment should be avoided because of the toxicity of some of the compounds.

Commonly used insecticides are lindane (10% lotion), benzyl benzoate (10% lotion), crotamiton (10% cream) and permethrin (5% cream). The latter is now considered the treatment of choice because of its high efficacy and the low risk of associated side-effects (*55*, *60–62*).

Table 4.5
Formulations of insecticides which can be applied as creams, lotions or aqueous emulsions for use against scabies

Insecticide	Formulation
benzyl benzoate	20–25% emulsion
sulfur	in oily liquid
lindane	1% cream or lotion
malathion	1% aqueous emulsion
permethrin	1% soap bar or 5% cream

Application method

The formulation must be applied to all parts of the body below the neck, not only to the places where itching is felt. It should not be washed off until the next day. Treated persons can dress after the application has been allowed to dry for about 15 minutes.

House dust mite

House dust mites (*Dermatophagoides* complex) have a worldwide distribution (Fig. 4.34). They are very small (0.3 mm) and live in furniture, beds, pillows and carpets where they feed on organic debris, such as discarded skin scales and scurf. The inhalation of house dust laden with mites, mite faeces, and other debris and fungi associated with them produces allergic reactions in many people, such as asthma and inflammation of the nasal mucous membrane. Large numbers of allergens produced by house dust mites may be in the air after bed-making.

In temperate climates, mites occur throughout the year mainly in beds and carpets. Mites living on living room floors show a seasonal peak in density in late summer and early autumn.

Some other mites causing similar reactions in humans live among stored products, grains and animal feeds.

Prevention and control

The density of house dust mite allergens can be assessed by a test which measures the concentration of mite excreta (guanine) in dust (*63*).

Mites and associated fungi can be controlled by decreasing the humidity in rooms, improving ventilation and removing dust. Bedrooms and living rooms should be aired regularly, or other measures should be taken to reduce dampness. The shaking of bedclothes and frequent washing of sheets and blankets reduces the availability of food and therefore the number of mites. Vacuum cleaning of beds, carpets and furniture is also effective. General insecticides used for pest control are

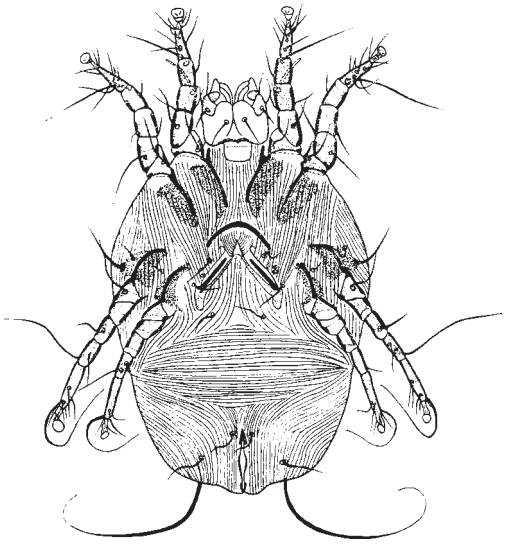

Fig. 4.34
The house dust mite (*Dermatophagoides pteronyssinus*) (by courtesy of the Natural History Museum, London).

not effective but a special product containing benzyl benzoate is available, which destroys mites when applied to mattresses, carpets and upholstery (*63*, *64*).

References

1. Jupp PG, McElligott SE, Lecatsas G. The mechanical transmission of hepatitis B virus by the common bedbug (*Cimex lectularis*) in South Africa. *South African medical journal*, 1983, 63: 77–81.

2. Maymans MV et al. Risk factors for transmission of hepatitis B virus to Gambian children. *Lancet*, 1990, 336: 1107–1109.

3. Maymans MV et al. Do bedbugs transmit hepatitis B? *Lancet*, 1994, 343: 761–763.

4. Schofield CJ et al. A key for identifying faecal smears to detect domestic infestations of triatomine bugs. *Revista da Sociedade brasileira de Medicina Tropical*, 1986, 1: 5–8.

5. Lindsay SW et al. Permethrin-impregnated bednets reduce nuisance arthropods in Gambian houses. *Medical and veterinary entomology*, 1989, 3: 377–383.

6. Charlwood JD, Dagoro H. Collateral effects of bednets impregnated with permethrin against bedbugs (Cimicidae) in Papua New Guinea. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 1989, 83: 261.

7. Newberry K, Jansen EJ, Quann AG. Bedbug infestation and intradomiciliary spraying of residual insecticide in Kwazulu, South Africa. *South African journal of science*, 1984, 80: 377.

8. Newberry K, Jansen EJ. The common bedbug *Cimex lectularis* in African huts. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 1986, 80: 653–658.

9. Butler T. The black death past and present. 1. Plague in the 1980s. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 1989, 83: 458–460.

10. Schein E, Hauschild S. Bekämpfung des Flohbefalls bei Hunden und Katzen mit dem Insekten-Entwicklungshemmer Lufenuron (Program®). Ergebnisse einer Feldstudie. [Combating flea infestations in dogs and cats with the insect development inhibitor lufenuron (Program®). Results of a field study.] *Kleintierpraxis*, 1995, 40: 277–284.

11. Osbrink WLA, Rust MK, Reierson DA. Distribution and control of cat fleas in homes in southern California (Siphonaptera: Pulicidae). *Journal of economic entomology*, 1986, 79: 135–140.

12. Rust MK, Reierson DA. Activity of insecticides against the pre-emerged adult cat flea in the cocoon (Siphonaptera: Pulicidae). *Journal of medical entomology*, 1989, 26: 301–305.

13. Lemke LA, Koehler PG, Patterson RS. Susceptibility of the cat flea (Siphonaptera: Pulicidae) to pyrethroids. *Journal of economic entomology*, 1989, 82: 839–841.

14. Miller BE et al. Field studies of systematic insecticides: V. Evaluation of seven organophosphate compounds for flea control on native rodents and rabbits in south-eastern New Mexico. *Journal of medical entomology*, 1978, 14: 651–661.

15. Schinghammer KA, Ballard EM, Knapp FW. Comparative toxicity of ten insecticides against the cat flea, *Ctenocephalides felis* (Siphonaptera: Pulicidae). *Journal of medical entomology*, 1985, 22: 512–514.

16. *Fleas. Training and information guide*. Geneva, World Health Organization, 1985 (unpublished document WHO/VBC/TS/85.1; available on request from Division of Control of Tropical Diseases, World Health Organization, 1211 Geneva 27, Switzerland).

17. Gratz NG, Brown AWA. *Fleas—biology and control*. Geneva, World Health Organization, 1983 (unpublished document WHO/VBC/83.874; available on request from Division of Control of Tropical Diseases, World Health Organization, 1211 Geneva 27, Switzerland).

18. Manson-Bahr PEC, Apted FIC. *Manson's tropical diseases*, 18th ed. London, Baillière Tindall, 1982.

19. Rietschel W. Observations on sandfleas (*Tunga penetrans*) in man and dogs in French Guiana. *Tierarztliche Praxis*, 1989, 17: 189–193.

20. Chunge RN. A study of head lice among primary school children in Kenya. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 1986, 80: 42–46.

21. Sinniah B, Sinniah D, Rajeswari B. Epidemiology and control of human head louse in Malaysia. *Tropical and geographical medicine*, 1983, 35: 337–342.

22. Taplin D et al. Permethrin 1% crème rinse for the treatment of *Pediculus humanus* var. *capitis* infestation. *Pediatric dermatology*, 1986, 3: 344–348.

23. Preston S, Fry L. Malathion lotion and shampoo: a comparative trial in the treatment of head lice. *Journal of the Royal Society of Health*, 1977, 97: 291.

24. Donaldson RJ, Logis S. Comparative trial of shampoos for treatment of head infestation. *Journal of the Royal Society of Health*, 1986, 105: 39–40.

25. Sinniah B et al. Pediculosis among rural school children in Kelang, Selangor, Malaysia and their susceptibility to malathion, carbaryl, Perigen and kerosene. *Journal of the Royal Society of Health*, 1984, 104: 114–115.

26. Bowerman JG et al. Comparative study of permethrin 1% crème rinse and lindane shampoo for the treatment of head lice. *Journal of infectious diseases*, 1987, 6: 252–255.

27. Lipkin J. Treating head lice: it's a pesticide issue, too. *Journal of pesticide reform*, 1989, 9: 21–22.

28. Fusia JF et al. Nationwide comparative trial of pyrethrins and lindane for pediculosis in children: experience in north-eastern United States. *Current therapeutic research*, 1987, 41: 881–890.

29. Sholdt LL et al. Effectiveness of permethrin-treated military uniform fabric against human body lice. *Military medicine*, 1989, 154: 90–93.

30. Service MW. *Lecture notes on medical entomology*. London, Blackwell Scientific, 1986.

31. Barclay AJ, Coulter JB. Tick-borne relapsing fever in central Tanzania. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 1990, 84: 852–856.

32. Jaenson TGT. The epidemiology of Lyme borreliosis. *Parasitology today*, 1991, 2: 39–45.

33. Schreck CE, Snoddy EL, Mount GA. Permethrin and repellents as clothing impregnants for protection from the lone star tick. *Journal of economic entomology*, 1980, 73: 436–439.

34. Schreck CE, Mount GA, Carlson DA. Wear and wash persistence of permethrin used as a clothing treatment for personal protection against the lone star tick (Acari: Ixodidae). *Journal of medical entomology*, 1982, 19: 143–146.

35. Schreck CE, Mount GA, Carlson DA. Pressurized sprays of permethrin on clothing for personal protection against the lone star tick (Acari: Ixodidae). *Journal of economic entomology*, 1982, 75: 1059–1061.

36. Schreck CE, Snoddy EL, Spielman A. Pressurized sprays of permethrin or deet on military clothing for personal protection against *Ixodes dammini* (Acari: Ixodidae). 1986.

37. Bloemer SR et al. Management of lone star ticks (Acari: Ixodidae) in recreational areas with acaricide applications, vegetative management, and exclusion of white-tailed deer. *Journal of medical entomology*, 1990, 27: 543–550.

38. Stafford KC, III. Effectiveness of carbaryl applications for the control of *Ixodes dammini* (Acari: Ixodidae) nymphs in an endemic area. *Journal of medical entomology*, 1991, 28: 32–36.

39. Mount GA et al. Area control of larvae of the lone star tick with acaricides. *Journal of economic entomology*, 1983, 76: 113–116.

40. Mount GA et al. Insecticides for control of the lone star tick tested as ULV sprays in wooded areas. *Journal of economic entomology*, 1968, 61: 1005–1007.

41. Rupes V et al. Efficiency of some contact insecticides on the tick *Ixodes ricinus*. *International pest control*, 1980, 6: 144–147, 150.

42. Dmitriev GA. The effectiveness of some insecticides against ticks. *International pest control*, 1978, 5: 10–11.

43. Roberts RH, Zimmerman JH, Mount GA. Evaluation of potential acaricides as residues for the area control of the lone star tick. *Journal of economic entomology*, 1980, 73: 506–509.

44. White DJ et al. Control of *Dermacentor variabilis*. 3. Analytical study of the effect of low volume spray frequency. *Journal of the New York Entomological Society*, 1981, 89: 23–33.

45. Mount GA. Control of the lone star tick in Oklahoma parks through vegetative management. *Journal of economic entomology*, 1981, 74: 173–175.

46. Mather TN et al. Reducing transmission of Lyme disease spirochetes in a suburban setting. *Annals of the New York Academy of Sciences*, 1988, 539: 402–403.

47. Deblinger RD, Rimmer DW. Efficacy of a permethrin-based acaricide to reduce the abundance of *Ixodes dammini* (Acari: Ixodidae). *Journal of medical entomology*, 1991, 28: 708–711.

48. Daniels TJ, Fish D, Falco RC. Evaluation of host-targeted acaricide for reducing risk of Lyme disease in southern New York State. *Journal of medical entomology*, 1991, 28: 537–543.

49. Harwood RF, James MT. *Entomology in human and animal health*, 7th ed. New York, Macmillan, 1979.

50. Buescher MD et al. Repellent tests against *Leptotrombidium fletcheri* (Acari: Trobiculidae). *Journal of medical entomology*, 1984, 21: 278–282.

51. Kulkarni SM. Laboratory evaluation of some repellents against larval trombiculid mites. *Journal of medical entomology*, 1977, 14: 64–70.

52. Roberts SH, Zimmerman JH. Chigger mites: efficacy of control with two pyrethroids. *Journal of economic entomology*, 1980, 73: 811–812.

53. Guiart J. In: Gilbert A, Fournier L, eds. *Précis de parasitologie.* [*Handbook of parasitology.*] Library of the Doctorate of Medicine. Paris, J-B Baillière & Sons, 1910.

54. Orkin M, Maibach HI. Scabies therapy. *Seminars in dermatology*, 1993, 12: 22–25.

55. Kolar KA, Rapini RP. Crusted (Norwegian) scabies. *American family physician*, 1991, 44: 1317–1321.

56. Berger TG. Treatment of bacterial, fungal and parasitic infections in the HIV-infected host. *Seminars in dermatology*, 1993, 12: 296–300.

57. Kar SK, Mania J, Patnaik S. The use of ivermectin for scabies. *National medical journal of India*, 1994, 7: 15–16.

58. Macotela-Ruiz E, Pena-Gonzalez G. The treatment of scabies with oral ivermectin. *Gaceta medica de Mexico*, 1993, 129: 201–205.

59. Glazion P et al. Comparison of ivermectin and benzyl benzoate for treatment of scabies. *Tropical medicine and parasitology*, 1993, 44: 331–332.

60. Taplin D et al. Comparison of Crotamin 10% cream (Eurax) and permethrin 5% cream (Elimite) for the treatment of scabies in children. *Pediatric dermatology*, 1990, 7: 67–73.

61. Paller AS. Scabies in infants and small children. *Seminars in dermatology*, 1993, 12: 3–8.

62. Haustein UF. Pyrethrin and pyrethroid (permethrin) in the treatment of scabies and pediculosis. *Hautarzt*, 1991, 42: 9–15.

63. Bischoff E, Fischer A, Liebenberg B. Assessment and control of house dust mite infestation. *Clinical therapeutics*, 1990, 12: 216–220.

64. Van Bronswijk JEMH, Schober G, Kniest FM. The management of house dust mite allergies. *Clinical therapeutics*, 1990, 12: 221–226.