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ESSENTIALS Most medically important arthropods are insects (including mos- quitoes, midges, other flies, bedbugs, and other true bugs, lice, fleas, and cockroaches) or arachnids (spiders, ticks, mites, scorpions). Clinical features Arthropod-related problems include the following: (1) injuries from direct contact (bites, stings, and other penetrating or crushing in- juries from spines, bristles, or pincers) and the consequences of such contact (envenoming, allergic reactions, secondary infection of wounds, and transmission of infectious agents); (2) infestation of the patient's body, skin, hair, clothes, or immediate environment (myiasis, canthariasis, tungosis, pediculosis, and so on); (3) inhalant allergy; (4) hygiene and aesthetic issues; and (5) the psychological phenomena of delusion and phobia. Treatment and prevention—general aspects Broad principles of management include: (1) Identification of the problem and the kind of arthropod involved. (2) The immediate treatment—if necessary—of allergic reactions or secondary infection. (3) Appreciation of consequences of exposure, such as transmis- sion of infectious agents; many species of dipterans (flies)—including mosquitoes, blackflies, sand flies, tsetse flies, and horse flies—bite humans, and in some regions some of these are important vectors. (4) Use of antimalarials or vaccines and the development of strat- egies to avoid further contact, including eradication of infestations, changes in behaviour, use of repellents and clothing that covers the skin, and bed nets. Travellers and their clinicians should be aware of the risks posed by arthropod-borne infections and ways to prevent them in particular geographical areas. Particular conditions True bugs (Hemiptera)—bedbugs infest dwellings and bite at night: pa- tients may complain of mysterious skin lesions and sleeplessness, and a special search may be necessary to find the bugs. In South America, triatomine bugs bite at night and are vectors of trypanosomiasis. Ticks (Ixodoidea)—these attach themselves while feeding and are noticed by the patient. They are important vectors of many infec- tions, which are often specific to particular genera or species of tick and confined to particular geographical areas. In Europe, tick-related infections include Lyme borreliosis and tick-borne encephalitis. Infestations—clinically important infestations include the fol- lowing. (1) Scabies (infestation of the skin by scabies mites) and pediculosis (infestation of the hair or clothing by head or body lice)—these are cosmopolitan in distribution and usually managed by use of topical acaricides or insecticides, although resistance is a growing problem. (2) Fleas—the human flea is now rare in the

developed world, but infestation of dwellings with cat fleas is com- monly reported. Tungosis is a condition of tropical areas where jigger fleas (not to be confused with similarly named trombiculid mites) burrow into the feet or under the toenails of those who walk about barefoot. (3) Fly and beetle larvae—myiasis, which is the infestation of the body by the larvae (maggots) of dipteran flies, is classified as (a) benign when self-limiting or malign when there is destructive tissue invasion, (b) according to anatomical site (dermal, wound, orbital, ophthalmic, urogenital, intestinal), and (c) according to the species involved. Canthariasis—infestation of the body by beetles or beetle larvae—is clinically similar to myiasis and is rarely reported. Other aspects—some synanthropic insects, especially certain spe- cies of fly, cockroach, and pharaoh's ants, have been implicated in the passive transmission of infections (e.g. shigellosis and hepatitis A). It is generally considered to be in the interests of good hygiene to control these insects in healthcare settings or where food is prepared. Introduction Most arthropods are harmless, but there is a select group of medic- ally significant species. Invertebrates with jointed limbs belong to the phylum Arthropoda. Most of the medically important arthropods are in the classes Insecta (insects) or Arachnida (spiders, ticks, mites, scorpions). Some members of the class Chilopoda (centipedes) may bite humans, and some of the larger members of the Crustacea (crabs, lobsters) may cause injury with pincers or spines. Although they are classified as a separate group, phylum Pentastomida, there is some evidence that the parasitic tongue worms may actually be highly specialized crustaceans (Chapter 8.13). Categories of med- ical significance include: envenoming by bites or stings (Chapter 10.1.2); allergic reactions to bites, stings, hairs, or inhaled allergens; transmission of infectious agents; infestation; the pain and trauma from bites or penetrating spines; phobia and delusory parasitosis. Arthropods may cause nuisance by their presence or the noises they may make, or by being perceived as unhygienic. To allow a logical approach to the management of arthropod-related issues it is helpful to identify the species involved, although as this may not always be 8.12 Nonvenomous arthropods John Paul

 possible, generic approaches may be developed to the management of problems. Bites Arthropod bites are common and often trivial, but bites may be important when associated with envenoming (Chapter 9.2), sensi- tization (leading to pruritus, excoriation, and secondary infection), anaphylaxis, or the transmission of infectious agents. Biting insects may simply be a nuisance (e.g. it may be difficult to tolerate swarms of biting flies, making it difficult to work outdoors and dangerous to operate machinery). Immune response varies with age, past ex- posure, and other factors. Management may be directed towards treatment of the bite, if necessary (topical corticosteroids, sys- temic antihistamines), considering the risk of transmitted infec- tion and prevention of further bites (eradication of ectoparasites, change in behaviour to avoid exposure, repellents, special clothing, insecticide-impregnated bed nets). It is often possible to associate bites with infesting ectoparasites, such as arthropods which remain attached (ticks) or predatory bloodsuckers that are highly visible (mosquitoes, midges, and blackflies, when swarming) and which cause immediately painful bites (tsetse flies, some mosquitoes, tabanid flies). It is harder to ascribe a cause to bites from arthropods which bite at night or when the patient is asleep (some mosquitoes, sand flies, bedbugs, triatomine bugs) or from arthropods that are inconspicuous and do not cause immediately painful bites (harvest mites, some fleas, some biting flies). Bites of larger arthropods typic- ally have a central punctum and a surrounding area of inflammation and are pruritic. In cases of uncertainty it may be necessary to obtain a dermatological opinion to exclude other diagnoses, including or- ganic disorders, artefact, and delusion. Bloodsucking flies (Diptera) Many flies are haematophagous (Table 8.12.1).

Bloodsucking flies include members of the suborder Nematocera (mosquitoes, sand flies, balck flies, biting midges) and the suborder Brachycera (horse flies, clegs, snipe flies, stable flies, and keds). All bloodsucking flies are at least a nuisance: the bites are often painful and associated with sensitization. More importantly, biting flies may transmit infection. Mosquitoes (Culicidae) are vectors of filariasis and numerous viral diseases, including yellow fever and dengue fever. Mosquitoes of the genus Anopheles transmit malaria. Depending on species and loca- tion, mosquitoes bite at various times of the day. Mosquitoes may be controlled by reducing their access to stagnant water needed for development of their larval stages and by application of insecticides Table 8.12.1 Bloodsucking flies Family Representative genera (and species) Associated agent or condition Suborder Nematocera Culicidae (mosquitoes) Subfamily Anophelinae Anopheles Malaria, brugian and bancroftian filariasis Subfamily Culicinae Culiseta Western equine encephalitis Culex Bancroftian filariasis Mansonia Brugian filariasis Aedes Eastern equine encephalitis, dengue fever, yellow fever, bancroftian filariasis Haemagogus Yellow fever Sabethes Yellow fever Phlebotomidae (sand flies) Phlebotomus Leishmania spp. Lutzomyia Leishmania spp., Bartonella bacilliformis Simuliidae (blackflies) Simulium Onchocerca volvulus, Mansonella ozzardi, haemorrhagic syndrome of Altimira Ceratopogonidae (biting midges) Culicoides Dipetalonema perstans, Mansonella ozzardi Suborder Brachycera Tabanidae (horse flies, clegs) Haematopota Tabanus Pangonia Chrysops Loa loa Rhagionidae (snipe flies) Symphoromyia Atherix Spaniopsis Austroleptis Glossinidae (tsetse flies) Glossina African trypanosomiaisis Calliphoridae (Congo floor maggot) Auchmeromyia luteola Muscidae Stomoxys calcitrans (stable fly) Hippoboscidae Melophagus ovinus (sheep ked) Lipoptena cervi (deer ked)

section 8 Infectious diseases 1570 Fig. 8.12.1 Reaction to blackfly (Simulium sp.) bites, 48 h after exposure. Algonquin, Ontario, Canada. to dwellings. Use of permethrin-impregnated bed nets has been shown to reduce malaria transmission. Sand flies (Phlebotominae) are mainly tropical and subtropical in distribution and transmit leishmaniasis. In South America, sand flies of the genus Lutzomyia transmit Bartonella bacilliformis. Blackflies (Simuliidae) occur worldwide and are vectors of Onchocerca volvulus and Mansonella ozzardi. Blackfly larvae require well-oxygenated water. Female blackflies pierce the skin and suck blood from the edge of the punc- ture. Substances in blackfly saliva inhibit platelet aggregation, im- pair the final common pathway of the coagulation cascade, and encourage vasodilatation. The bites, oozing blood, have a charac- teristic appearance and may be associated with severe reaction, sometimes referred to as simuliosis or simuliotoxicosis. Puncture sites often become surrounded by a wide zone of haemorrhagic ery- thema and oedema (Fig. 8.12.1). Rarely, haemorrhagic shock may occur. In Brazil, the haemorrhagic syndrome of Altimira has been epidemiologically associated with exposure to blackflies. Blackfly saliva appears to contain immunomodulating substances. In Brazil, the autoimmune condition ‘fogo selvagem’ (a form of pemphigus foliaceus) occurs in simuliid-infested areas (Fig. 8.12.2a). In Britain, blackflies are rarely troublesome to humans except in certain lo- calities. In southern England, the Blandford fly, Simulium postica- tum occurs on the river Stour, Dorset, on tributaries of the river Thames in Oxfordshire, and on other rivers. In 1993, 16% (22% female, 9% male) of Blandford’s inhabitants reported bites. Use of the biological larvicide Bacillus thuringiensis as a control measure was associated with a marked drop in the number of people com- plaining of bites. In Scotland, S. reptans, S. argyreatum, and other species may bite humans. Biting midges (Ceratopgonidae) (Fig. 8.12.3) are vectors of the filarial worms Mansonella (Dipetalonema) perstans and M. ozzardi. In Africa, tabanid flies transmit Loa loa. Tsetse flies are vectors of African trypanosomiasis (see Chapter 8.8.11). Deer keds Lipoptena cervi are highly

evolved louse-like flies with biting mouth parts that feed on deer. Occasionally, deer keds bite people, such as forest workers, hunters, or entomologists (Fig. 8.12.2b). Deer ked derma- titis is a condition where itchy papules exist for weeks to months at the site of bites. Eventually, papules resolve without specific treat- ment. It has been suggested that Bartonella schoenbuchensis may have a role in the aetiology of the conditions as this agent has been detected in deer keds but not as yet in humans. Prevention When visiting locations where biting flies are troublesome, bites may be avoided to some extent by wearing clothing that covers the skin and by use of repellents. True bugs (Hemiptera) Bedbugs The common bedbug Cimex lectularius (Fig. 8.12.4) is cosmopol- itan. In recent years, reports of infestations in developed coun- tries such as the United Kingdom and United States of America have increased. The resurgence has been linked to the emergence of resistance to pyrethroid insecticides used for bedbug control. Infestation may be unrelated to lack of general hygiene but as- sociated with translocation of personal effects or furniture. The (a) (b) Fig. 8.12.2 (a) Endemic Pemphigus foliaceus (‘fogo selvagem’ meaning ‘wild fire’) in a man from a rural area of São Paulo State, Brazil infested with Simulium flies. (b) Deer ked or deer fly without wings (Lipoptena cervi Diptera, Hippoboscidae). (a) Copyright DA Warrell. (b) Copyright J Paul.

 tropical bedbug C. hemipterus occurs in tropical and subtrop- ical countries. Epidemiological studies have failed to produce clear evidence of bedbugs as vectors of infections, such as hepa- titis B. They are nocturnal, hiding during the day and feeding at night. Although in some cases bites may go unnoticed and there may be no allergic reaction, bedbugs may cause sleeplessness, and the bites may cause pain and swelling and, exceptionally, dissem- inated bullous eruptions (Fig. 8.12.5). Rooms that are heavily in- fested may acquire an unpleasant odour. Bugs may be found by making special searches at night or by seeking their hiding places during the day. They resemble lentils superficially, being round and flat. Adults reach a length of about 5 mm. Nymphs pass through five instars to reach adulthood after about 4 months. Bedbugs can live for 6 months without feeding, becoming paper-thin. Related bugs which occasionally bite humans derive from pigeons, bats, and martins (C. columbarius, C. pipistrelli, and Oeciacus hirundinis respectively). Infestation may be managed by restricting access of host species to dwellings, but in the United Kingdom, for example, bats are protected under the Wildlife and Countryside Act. Prevention and control Pyrethroid insecticides are widely used to control bedbugs but emergence of resistance means that they are becoming unreliable. As a consequence, alternatives including carbamates, arylpyrroles, neonicatinoids, and organophophates are being used increasingly although availability varies from country to country. Cone-nose bugs Most of the 129 species of cone-nose bugs (family Reduviidae, sub- family Triatominae) occur in the Americas. Seven species occur in Asia and one species, Triatoma rubrofasciata, is cosmotropical. Many triatomines are obligate feeders on the blood of vertebrates. Triatomines transmit South American trypanosomiasis. Important vector species are Rhodnius prolixus, T. infestans, T. brasiliensis, T. dimidiata, and Panstrongylus megistus. The bugs infest dwellings, hiding in crevices during the day and biting at night. Dwellings may be heavily infested: in Columbia, 11 403 specimens of R. prolixus were reported from a house occupied by nine people, all of whom were seropositive for trypanosomiasis. As well as transmitting tryp- anosomiasis, triatomines may cause significant blood loss to occu- pants of infested buildings. Prevention Dwellings are deinfested with insecticides and con- structed to offer few hiding places for the bugs (Chapter 8.8.11). Ticks (Ixodoidea) Hard ticks (Ixodidae) and soft ticks (Argasidae) occur worldwide. Stages of the life cycle are egg, larva (six-legged), and nymph and adult (both eight-legged). Ticks attach and feed with a barbed hypostome and detach when engorged. Smaller stages and ticks in inconspicuous sites, such as the perineum

may feed unobserved. Bites are usually painless but may result in local sensitization, sec- ondary infection, and transmission of infectious agents, including numerous viruses, rickettsias, and Lyme disease (Table 8.12.2). Local reaction to bites may be confused with erythema migrans of Lyme disease, (which expands as a ring with a central punctum— see Chapter 8.6.33). Ticks may be removed by gripping with forceps (or, in the field, with finger and thumbnail), between the skin and Fig. 8.12.5 Erythematous macules of bedbugs. Courtesy of D Hill, Adelaide, South Australia. Fig. 8.12.3 Reaction to midge (Ceratopogonidae) bites, 24 h after exposure. Sligachan, Isle of Skye, United Kingdom. Fig. 8.12.4 Bedbugs Cimex lectularus. Copyright J Paul.

section 8 Infectious diseases 1572 the tick's head and pulling gently. Special tools for removing ticks have been made widely available by the pet industry and such de- vices should work just as well with humans. Toothed devices that work in the manner of combs or forceps that are curved in pro- file (tick tweezers) have the advantage of allowing removal while avoiding squeezing the tick. Careless removal may detach the head or hypostome, leaving a potential source of inflammation and sec- ondary infection. In the United Kingdom, the ticks most often found on humans are the sheep tick Ixodes ricinus (a vector of Lyme dis- ease) and the hedgehog tick I. hexagonus (Fig. 8.12.6). Prevention When visiting tick-infested places, bites may be avoided by tucking trousers into boots and wearing light-coloured clothing which makes ticks highly visible. After visiting tick-infested habitats, searches of the body allows prompt removal of ticks which reduces the chance of disease transmission. Harvest mites (Trombiculidae) In the United Kingdom, larvae of the harvest mite Neotrombicula autumnalis are a common cause of bites in late summer, especially in chalk downland. They are tiny and seldom noticed, crawling rap- idly on to the body, attaching (often under tight-fitting clothes), injecting proteolytic enzymes, feeding on tissue fluid, and then detaching, leaving pruritic, sometimes bullous lesions hours later. For many victims, the cause of irritation remains a mystery. Red bugs or chiggers (confusingly, a term also applied to the flea Tunga penetrans) are names given to trombiculids in the Americas. Bites to the penis, associated with swelling and dysuria, have been described in the paediatric literature as 'summer penile syndrome'. In Asia, trombilucids are vectors of scrub typhus. Prevention Where trombiculids are troublesome, tucking trousers into boots and applying diethyltoluamide or other repellents may be partially effective. Notorious 'mite islands' densely infested with trombiculids in cleared areas of jungle should be avoided. Accidental bites Arthropods which do not normally bite humans but can inflict painful but usually trivial bites when provoked by handling (e.g. by children and entomologists), include predatory true bugs such as the water Table 8.12.2 Ticks and tick-borne diseases Genus and species Geographical distribution Associated infections Argasidae (soft ticks) Ornithodoros spp. Widely distributed Endemic relapsing fever Ixodidae (hard ticks) Amblyomma hebraeum Africa Tick typhus Amblyomma cajennense Americas Rocky mountain spotted fever Dermacentor andersoni North America Colorado tick fever, Rocky Mountain spotted fever Dermacentor marginatus Palaearctic Tick typhus, Omsk haemorrhagic fever Dermacentor silvarum Eastern Palaearctic Tick typhus, tick-borne encephalitis Dermacentor variabilis North America Rocky Mountain spotted fever Haemaphysalis concinna Palaearctic Tick typhus Haemaphysalis spinigera India Kyasanur Forest disease Haemaphysalis turturis India Kyasanur Forest disease Hyalomma spp. Old World Crimean-Congo haemorrhagic fever Ixodes scapularis Eastern North America Lyme disease Ixodes pacificus Western North America Lyme disease Ixodes ricinus Western Palaearctic Lyme disease, tick-borne encephalitis, louping ill Ixodes persulcatus Eastern Palaearctic Tick-borne encephalitis, Omsk haemorrhagic fever Rhipicephalus sanguineus Cosmopolitan Tick typhus Fig. 8.12.6 Upper side of hedgehog tick Ixodes hexagonus, to show

sucking mouthparts (hypostome). Copyright J Paul.

8.12 Nonvenomous arthropods 1573 boatman Notonecta glauca and the assassin bug Reduvius personatus in the United Kingdom and wheel bugs Arilus spp. in the Americas; larger beetles (Coleoptera); dragonflies (Odonata); and bush-crickets (Orthoptera) such as the wartbiter Decticus verrucivorus. Spines used in defence by the great silver diving beetle Hydrous piceus and larger tropical grasshoppers of the subfamily Cyrtacanthridinae can cause penetrating injury when handled. Pincers of larger crabs and lobsters (Crustacea) can cause crushing injuries of digits and their spines may cause penetrating injury. Infestation Sites of infestation include the hair, body surface, and immediate environment (ectoparasites: lice, fleas); the skin and subdermis (scabies, tungosis, dermal myiasis); wounds, tissues, and orifices (myiasis); and the gastrointestinal tract (myiasis, canthariasis). With ectoparasites, the main problems are related to their bites: diag- nosis and management may be based on the identification of the ectoparasite. Delusory parasitosis is a condition in which the patient becomes convinced of infestation by parasites despite reassurance by the doctor and absence of clinical or laboratory evidence. Scabies The agent of human scabies, a chronic infestation, is the human sca- bies mite Sarcoptes scabiei var. hominis. Scabies mites adapted to other hosts, such as Sarcoptes scabiei var. canis, cause a self-limiting pruritus in humans. Clinical manifestations of scabies are caused by the adult female mite that burrows through the epidermis. The adult female is oval and about 0.33 mm long (Fig. 8.12.7). The fe- male lives for about 1 month, burrowing and ovipositing daily. The burrow may extend to 1 cm in length. Six-legged larvae hatch after a few days and moult to become eight-legged nymphs and later eight-legged adults. Adult males are smaller than females, do not burrow, and die after mating on the epidermis. Scabies is cosmo- politan in distribution. Prevalence rates vary but may be higher in conditions of overcrowding and following social disruption in war- time. Outbreaks may occur in nursing homes and hospitals. Most cases must be acquired by close contact, as the mites do not survive long away from the body. The main presenting symptom is pruritus which occurs with sensitization about 1 month after the onset of in- festation. Symptoms may be worse at night and after a hot bath or shower. Burrows commonly occur in web spaces between the fingers and on the wrists but may be very widespread. There is often evi- dence of excoriation but the appearance of the skin is variable and may show secondary infection, eczematization, lichenification, and papulovesicles (Figs. 8.12.8 and 8.12.9). Careful examination may Fig. 8.12.7 Adult specimen of Sarcoptes scabei. Courtesy of RV Southcott, Adelaide, South Australia. Fig. 8.12.8 Secondarily infected scabies in mother and child. Fig. 8.12.9 Papulovesicular lesions of scabies.

section 8 Infectious diseases 1574 reveal burrows and mites. Diagnosis may be confirmed by micros- copy of scrapings from affected areas, especially interdigital spaces, but many cases are atypical and a dermatological opinion may be required to exclude other causes. Immunosuppressed patients, including transplant recipients and patients with AIDS, are prone to crusting or so-called Norwegian scabies in which crusting lesions of scales and mites accumulate over the hands, feet, and other sites such as eyebrows, but the patient suffers relatively little discomfort. Such cases, and presumably their fomites, are highly contagious. Occasionally the mites Dermanyssus gallinae and Ornithonyssus spp., whose normal hosts are birds, bite humans, causing lesions that resemble scabies. Treatment Treatment of scabies is by topical application of acaricides. Aqueous lotions of 0.5% malathion or 5% permethrin are currently recom- mended in the United Kingdom, given as two treatments a week apart. γ-Benzene hexachloride is also effective. The lotion is ap- plied to the whole body surface of all affected people and left on for 24 h

before being washing off. Itching may persist for several weeks and requires a topical counterirritant and corticosteroid (e.g. crotamiton and hydrocortisone) and a sedating antihistamine (chlorphenamine at night). Ivermectin (200 μg/kg single dose) is used for Norwegian scabies and in patients whose severe excori- ations make topical treatment intolerably irritating and painful. During outbreaks, it may be necessary to treat whole cohorts of pa- tients or healthcare teams. Louse infestation Lice are obligate parasites of animals. They bite using piercing mouthparts to feed on blood or tissue fluids. Three species, of cosmopolitan distribution, are associated with humans: the pubic louse Pthirus pubis, the body louse (or clothing louse) Pediculus humanus (Fig. 8.12.10), and the head louse P. capitis. Body and head lice are morphologically similar and are treated by some au- thors as subspecies or forms of P. humanus. Lice complete their life cycle on their host. Adult females deposit eggs (nits) on hair shafts (pubic and head lice) or on clothing (body louse). Larvae hatch after about 1 week, begin to feed and over the course of about 2 weeks, undergo several moults before reaching adulthood. Adult females live for about 1 month and may lay about 100 eggs. Egg cases re- main where attached and may persist after successful treatment of infestation. Most infestations are probably acquired through close contact with an infested case, but some cases may result from con- tact with clothing, bedclothes, or hairbrushes containing living lice or their eggs, which may be attached to shed hairs. In addition to the aesthetic and social drawbacks of louse infestation, medical problems common to all three taxa relate to sensitization of the host to louse antigens from bites and the resulting pruritus which may lead to excoriation and secondary infection. Louse bites have a central punctum and surrounding small red macule. Body lice may transmit several agents, including those of endemic typhus (Rickettsia prowazekii), trench fever (Bartonella quintana), and relapsing fever (Borrelia recurrentis). Pubic lice (crab lice) The lice (Pthirus pubis) attach themselves to pubic hairs. Rarely, lice may be found on eyebrows, eyelashes (phthirosis palpebrarum), axillary, head, or chest hair. Eggs are deposited on hair shafts. Most infestations are probably acquired through sexual contact with an infested case. Children may acquire phthirosis at atypical sites through close contact with adults. Lice seldom stray from the body. Transmission is possible but unlikely without close contact with an infested case. The main symptom is pruritus, sometimes with excoriation and secondary infection. Grey patches (maculae caeruleae) may occur on the skin. Diagnosis is by observation of the lice, which may be difficult to find, or of eggs or egg cases at- tached to hair shafts. Adults are 1 to 2 mm long. The anterior legs are smaller than the other two pairs. The body is squat and crablike (body length, excluding head, c.1.2 times body width) (Fig. 8.12.11). The original description contained a printing error (pthirus) for phthirus (Greek: louse). Fig. 8.12.10 Louse Pediculus humanus. Head lice and body lice are morphologically similar. Copyright J Paul.
Fig. 8.12.11 Adult specimen of Pthirus pubis. Courtesy of D Hill, Adelaide, South Australia.

 Treatment Aqueous carbaryl, permethrin, phenothrin, or malathion is applied to the whole body and left on for 1–2 days. This is repeated a week later to kill newly hatched larvae. Sexual contacts must be treated. Head lice Head lice infest the scalp and rarely other body sites. They lay their eggs at the base of hair shafts. Infestation is more common in chil- dren than in adults and more common in females than in males. Prevalence rates vary but may be very high in certain communities or institutions, such as schools. Prevalence rates may be high despite good standards of hygiene. Most cases probably occur as a result of close contact. The main symptom is pruritus which may be associ- ated with excoriation, secondary infection, and lymphadenopathy. Diagnosis is by observation of lice, which generally remain close to the scalp, or of eggs or egg cases, attached to hairs (Fig. 8.12.12). A fine comb (nit comb) may be used to

collect material to make the diagnosis. Adults are 3–4 mm long. Treatment Insecticide lotion (malathion, permethrin, phenothrin, dimeticone, or carbaryl) is applied to the scalp overnight. This is repeated a week later to destroy newly hatched larvae. Permethrin failure has been reported from many parts of the world. Compared with labora- tory reference strains, lice collected from infestations failing to re- spond to permethrin have shown relative resistance to the agent. In Israel, there is evidence that permethrin resistance may be due to monooxygenase plus nerve insensitivity resistance mechan- isms. Malathion resistance has been reported and may be due to a malathion-specific esterase. Pediculocides should be used with caution in children and asthmatics. Regular and fastidious use of a nit comb may be used (on its own or in combination with a pediculocide) to treat infestation. There is much anecdotal evidence, that combing can be effective, and it avoids concerns of pediculocide toxicity and resistance, but a study in Wales showed combing to be less effective that chemical treatment. In institutions, coordinated treatment campaigns may be required to prevent reinfestation. Body lice Body lice infest clothing and body hair. They lay their eggs on clothing, often along seams. Body lice are morphologically like head lice but slightly larger. Body louse infestation is associated with poor hygiene and social deprivation, as may occur in wartime. Transmission occurs as a result of close contact or through contact with infested clothing. Bites occur on the body, resulting in pruritus which may be associated with excoriation, eczematization, and secondary infection. Diagnosis is confirmed by finding lice, usually on clothing. Treatment Infestation may be treated by topical application of carbaryl or malathion to the whole body, repeated a week later to kill newly hatched larvae. Hot washing of clothing will destroy adults and early stages. Fleas (Siphonaptera) Fleas are bloodsucking ectoparasites. There are thousands of species, adapted to various host animals. Adults are a few millimetres long, brown, laterally compressed, and typically very active. Adults move through the fur or under clothing but can survive in the environment for long periods without feeding. Eggs are dropped to the ground, where the larvae develop, feeding on organic matter. The pupa may remain in the environment for long periods before the adult emerges. Increasing standards of hygiene in developed countries have made the human flea Pulex irritans a rarity. Most flea bites in Britain are now due to cat and dog fleas, Ctenocephalides felis (Fig. 8.12.13) and C. canis, either through direct exposure to an in- fested animal or to an environment exposed to an infested animal, possibly months previously. Flea bites result in intense pruritus at the bite site. There is a central punctum and there may be bulla for- mation (Fig. 8.12.14). Flea bites often occur in groups. Although patients may not witness fleas, clues that bites have been caused by fleas include intense pruritus, the appearance of bites in small linear groups, and a history of exposure to a flea-ridden animal or its do- main. Troublesome bites may be treated with topical corticosteroids and systemic antihistamines. There is circumstantial evidence that

Fig. 8.12.12 Nits attached to hair. Photograph from a patient with pediculosis showing several hair fibres with numerous egg cases attached. Courtesy of D Hill, Adelaide, South Australia. Fig. 8.12.13 Cat flea Ctenocephalides felis, a common cause of flea bites in humans. Copyright J Paul.

 cat fleas may act as vectors of Bartonella henselae, the agent of Cat- scratch disease. In the Netherlands cat fleas were shown to harbour Bartonella clarridgeiae and Rickettsia felis, both of which have been reported, albeit rarely, as agents of human disease. Prevention Good domestic hygiene is important. Infested animals and envir- onments should be treated with insecticides. Certain species of flea are vectors of several infectious diseases including plague and murine typhus. Tungosis Tungosis is infestation by a flea Tunga penetrans, known as the jigger, chigger, chigoe (popular names shared with trombiculid mites) or sand flea. Tungosis is

a zoonosis that affects a range of domestic ani- mals as well as humans. The gravid female, about 1 mm long, bur- rows into exposed skin (usually the foot), or under a toenail, and swells to about 1 cm in diameter, causing local inflammation and discomfort. The wearing of footwear prevents infestation. In the developed world tungosis is regarded as an easily treatable condi- tion that is occasionally seen in returning travellers. Lesions may be enucleated surgically, and the diagnosis confirmed by histology. Local remedies in endemic areas (tropical Africa and the Americas) of shelling out fleas may leave cavities prone to secondary infection and lethal tetanus. In endemic areas of the tropics, such as in parts of Brazil and Uganda, high levels of infestation may cause significant disability and morbidity. Myiasis Myiasis is the infestation of living animals by the larvae of flies (Diptera). Useful schemes of classification of myiasis include those based on the anatomical site (dermal, subdermal, wound, naso- pharyngeal, orbital, ophthalmic, aural, urogenital, pulmonary, in- testinal) and on the species of fly involved. Myiasis caused by flies whose larvae are obligate parasites of living tissues may be termed specific or primary myiasis. Myiasis associated with larvae which feed on decaying organic matter may be termed opportunistic or secondary myiasis. Myiasis due to larvae which find their way into the body (especially the gastrointestinal tract) by chance may be called accidental myiasis. Of the many species listed as possible agents (Table 8.12.3), most are opportunists whose saprophagous larvae feed on decaying organic matter, which might include nec- rotic wound tissue. Opportunists usually confine themselves to dead tissue and may even benefit the healing process. There is no dip- terous obligate intestinal parasite of man. Intestinal myiasis may be caused by coprophagous larvae which invade the rectum or by resilient maggots, such as those of the false stable fly Muscina stabulans and the cheese skipper Piophila casei which survive when swallowed in food and may cause intestinal dis- turbance and scarring. Intestinal myiasis may be spurious, following diagnosis based on observation of rapidly hatching larvae on freshly passed faeces. Rat-tailed maggots, larvae of drone flies Eristalis spp., are sometimes referred for identification to laboratories and numerous case reports link these maggots to intestinal myiasis. As the maggots naturally live in aqueous environments that are rich in organic matter, the finding of maggots in latrines may represent spurious association in some cases. Flies from several genera, not- ably Fannia, may cause urogenital myiasis. Scuttle flies (Phoridae) have been reported to cause pulmonary myiasis, possibly following inhalation of the gravid female fly. A small number of flies are obli- gate parasites of living tissues and a few species are closely associated with, but not specific to, humans. Many cases of myiasis are benign, self-limiting, and relatively harmless, but aural, nasopharyngeal, and malign wound myiasis are potentially lethal entities that may require removal of the larvae and possibly reconstructive surgery. Myiasis is diagnosed by observing dipteran larvae in a lesion. Identification of larvae may require entomological expertise but management of the patient, which depending on the type of lesion, may involve the re- moval of larvae, surgical exploration, debridement, or treatment of secondary infection, should be based on clinical assessment. Dermal myiasis The human bot fly Dermatobia hominis is a common cause of dermal myiasis in the American tropics. The female fly lays her eggs on biting arthropods, such as mosquitoes. The eggs hatch when in con- tact with skin into which the larva burrows. The larval stage lasts about 10 weeks, a boil with a small aperture forming as the larva grows. Such boils are not infrequently seen in Europeans returning from the neotropics. The larva may grow to more than 1 cm in length (Fig. 8.12.15). An early symptom is sporadic pain caused by the spiny larva. Unless in an unusual anatomical site, such as close to the eye, infestation is generally harmless. Secondary infection of the Fig. 8.12.14 Flea bites; erythematous macropapule with central bite point visible. Courtesy of D Hill, Adelaide, South Australia.

8.12 Nonvenomous arthropods 1577 wound is the most common complication. Larvae may be removed through a simple incision. Alternatively, a commercially available snake venom extractor (not recommended for snake bite) has been shown to serve as a useful tool for removal of the larvae. Remedies which include application of raw meat or glue to the lesion may not be successful. Squeezing may rupture the larva to evoke a local granulomatous reaction. The tumbu fly Cordylobia anthropophaga is widespread in the Afrotropical region. There have also been rare reports of apparent acquisition in Spain and Portugal. The female oviposits on sand and also on drying clothes. Ironing destroys eggs. Contact with viable ova on clothing leads to infestation. The larvae pierce the skin and grow rapidly. An uncomfortable boil forms which oozes serosanguinous fluid (Fig. 8.12.16). Fever and lymphadenopathy may occur. Larvae reach maturity in about 10 days. Larvae may be removed through a simple incision, but with care it may be possible to express larvae following application of petroleum jelly (Fig. 8.12.17). The larvae of warble flies Hypoderma spp. occasionally cause dermal myiasis in humans. Larvae of horse bot flies Gasterophilus spp. cannot complete their life cycle in humans but they can pierce human skin, where they wander for a week or so, causing intense itching (creeping eruption). Wound myiasis Many dipterous species are known to cause wound myiasis, but most of them are facultative feeders on necrotic tissue and are rarely Table 8.12.3 Flies associated with myiasis in humans Genus and species Common name Distribution Type of myiasis Psychodidae Telmatoscopus albipunctatus Moth fly Widely distributed Intestinal, nasal Phoridae Megasalia Scuttle flies Cosmopolitan Wound, intestinal, urogenital, pulmonary Syrphidae Eristalis tenax Common drone fly Widely distributed Rectal Piophilidae Piophila casei Cheese skipper Widely distributed Intestinal Muscidae Fannia canicularis Lesser house fly Cosmopolitan Urogenital Musca domestica House fly Cosmopolitan Wound, intestinal Muscina stabulans False stable fly Cosmopolitan Intestinal Stomoxys calcitrans Stable fly Cosmopolitan Intestinal Calliphoridae Auchmeromyia luteola Congo floor maggot Africa Sanguinivorous Calliphora spp. Bluebottles Widely distributed Wound, intestinal Cochliomyia hominivorax New World screw worm Americas Primary Cochliomyia macelleria Secondary screw worm Americas Wound Cordylobia anthropophaga Tumbu fly Africa Subdermal Cordylobia rodhaini Lund's fly Africa Subdermal Chrysomya bezziana Old World screw worm Africa, Asia Wound, auricular Lucilia spp. Green bottles Widely distributed Wound Sarcophagidae Wohlfahrtia magnifica Wohlfahrt's myiasis fly Southern Palaearctic Primary Wohlfahrtia vigil Grey flesh fly North America Dermal Wohlfahrtia nuba Southern Palaearctic Wound Sarcophaga spp. Flesh flies Widely distributed Intestinal, wound Gasterophilidae Gasterophilus spp. Horse bot fly Widely distributed Dermal (creeping), tracheopulmonary Cuterebridae Cuterebra spp. Rabbit bot fly Americas Subdermal, nasal, tracheopulmonary Dermatobia hominis South American bot fly Neotropics Subdermal Oestridae Oestrus ovis Sheep nasal bot fly Widely distributed Ocular myiasis Hypoderma spp. Warble flies Holarctic Dermal (creeping), ophthalmic, oral

section 8 Infectious diseases 1578 destructive to the host although the presence of maggots in a wound may cause distress. Debridement of necrotic tissue will control such infestation. In contrast, under controlled conditions, clinicians may introduce maggots to promote healing. Causes of malign myiasis include the New World screw worm Cochliomyia hominivorax in the Americas, the Old World screw worm Chrysomya bezziana, and Wohlfahrt's wound myiasis fly Wohlfahrtia magnifica in the Old World. Their larvae are obligate parasites of living tissue. Eggs are laid on wounds, in ears, and on mucous membranes. The larvae (Fig. 8.12.18) burrow in groups into healthy tissue, causing widespread destruction which may be mutilating or fatal (Fig. 8.12.19). Secondary bacterial infection or secondary wound myiasis may ensue. All species may cause naso-

pharyngeal, aural, orbital, genital, and malign wound myiasis. Infestation is best avoided by cleaning and dressing wounds as they occur. Treatment involves surgical removal of the larvae, de- bridement of affected tissue, and treatment of secondary infection. Reconstructive surgery may be required. Ophthalmomyiasis (ocular myiasis) Fewer than 5% of cases of human myiasis affect the eye. Usually only external structures such as the lids and conjunctivae are in- fested but some fly larvae can penetrate the conjunctiva or sclera, causing corneal ulceration and damage to anterior and posterior internal structures that may result in blindness. The usual cause of ophthalmomyiasis externa is Oestrus ovis, the cosmopolitan sheep and goat nasal botfly, whose natural host is herbivorous mammals. Although most common in tropical developing countries (especially North Africa, the Middle East, and the Caribbean) it still occurs rarely in Western cities. Female flies eject their larvae into the nostrils of the host, where they mature. Human victims may give a history of having been buzzed in the face or struck on the eye by an insect and later of developing irritation and redness of the eye, foreign body sensation, pain, lacrimation, palpebral oedema, and signs of puru- lent conjunctivitis or a stye (hordeolum). O. ovis larvae rarely develop Fig. 8.12.15 Two third larval instars of the human bot fly Dermatobia hominis (c.13 mm long) extracted from a facial ‘boil’ in a European who had been visiting Guyana. Fig. 8.12.16 Skin lesion caused by larva of the Tumbu fly Cordylobia anthropophaga in a Peruvian man who had been working in Zambia. Copyright DA Warrell. Fig. 8.12.17 Larvae of African tumbu fly Cordylobia anthropophaga, a common agent of dermal myiasis. Fig. 8.12.18 Larvae of the New World screw worm Cochliomyia hominivorax (c.8 mm long) extracted from the wound illustrated in Fig. 8.12.19. These were sent to the Natural History Museum in London where they were identified. Larvae of the second myiasis species (C. macellaria) were also found in the sample and were probably collected from the edges of the wound. Courtesy of Dr Martin JR Hall, Medical and Veterinary Division, Natural History Museum, London.

8.12 Nonvenomous arthropods 1579 beyond the first instar in humans and so symptoms are self-limiting, but they may be more rapidly relieved by slit lamp examination and removal of larvae which cling to the conjunctivae and may cause fol- licular conjunctival reaction and pseudomembrane formation. Other causes of human ophthalmomyiasis include Rhinoestrus purpureum, Dermatobia hominis, Hypoderma spp., (Oestridae); and Cochlyomyia hominis, Lucilia spp., Phormia spp. (Calliphoridae). Larvae of Hypoderma, Cochlyomyia, Dermatobia, and Oedemagena tarandi are more dangerous as they may burrow into the eye, resulting in pain, nausea, and destruction. They must be surgically removed. Nosocomial myiasis Hospitalized patients with exposed wounds, ulcers, or medical de- vices that breach the skin are susceptible to wound myiasis. Patients with impaired mobility or decreased levels of consciousness are also susceptible to infestation of the airways and urogenital tract. Cases of nosocomial myiasis have been reported from developed countries as well as from hospitals in resource-poor settings. Many reported cases involve infestation with opportunistic species including mem- bers of the genera Lucilia, Sarcophaga, and Musca. Cases of infest- ation with the New World screw worm Cochliomyia hominivorax in hospitalized patients have been reported in the Americas. Flies are attracted to necrotic tissues and readily gain access through open windows but may even reach patients through open doorways in air-conditioned rooms. Canthariasis Infestation of the body by beetles (Coleoptera) or their larvae is called canthariasis. Clinically, it may resemble myiasis but is much rarer. Larvae swallowed with food may dwell temporarily in the intes- tines, causing discomfort and may be detected in excreta. Beetles occasionally invade orifices. In Sri Lanka, scarabid dung beetles have been reported to invade the rectum. A specimen of the Asian carabid

ground beetle Scarites sulcatus was recovered from the vagina of a women complaining of vaginal discharge who had visited Pakistan (Fig. 8.12.20). In Israel, the dung beetle Maladera matrida has been reported to invade the external auditory canal. In Oman, two cases of invasion of the external auditory canal by the ground beetle Crasydactylus punctatus were reported. In one case, the beetle reached the middle ear causing sensorineural hearing loss. (See also venomous coleoptera, Chapter 10.1.2.) Allergy A wide range of immunological responses to arthropod bites has been described, from local pruritus to anaphylaxis. The dead re- mains, cast skins (exuviae), and faeces of many arthropods include sensitizing agents. They may act as contact or inhalant allergens, following domestic or occupational exposure resulting in derma- titis, conjunctivitis, rhinitis, and asthma. Allergic patients may show specific IgE antibody to a wide range of domestic pests including house flies, clothes moths, cockroaches, carpet beetles Anthrenus sp., silverfish Ctenolepisma longicaudata, and house dust mites Dermatophagoides spp. Dermatophagoides spp. are a common cause of allergy in the United Kingdom and exposure to cockroach al- lergens in household dust has been associated with asthma in the United States of America. Following mass emergence, nonbiting midges (Chironimidae) and the exuviae of mayflies (Ephemeroptera) and caddis flies (Trichoptera) may act as inhalant allergens. Chironimid midges occur worldwide and are especially troublesome in the Sudan, where Cladotanytarsus lewisi (green nimitti midge) breeds in dammed stretches of the Nile, causing seasonal epidemic allergy. Chironimid haemoglobin has been shown to be allergenic. The rearing of chironimid larvae as food for fish has been associated with occupa- tional allergy. Entomologists who collect insects by sucking them into pooters may develop inhalant allergy to their subject of study. Occupational Fig. 8.12.20 An Asian carabid beetle Scarites sulcatus, from a patient complaining of vaginal discharge; a rare example of genital canthariasis. Fig. 8.12.19 Fatal myiasis (New World screw worm). Historical illustration of a 50-year-old Honduran woman who complained of a small chronic ulcer on the right cheek; on admission to hospital she was found to have a huge ulcer exposing the bones of the face and forehead and destroying the tissues of the cheek and face, right eye, and orbit. More than 300 larvae were removed (see Fig. 8.12.18). From Harrison JHH (1908). A case of myiasis. J Trop Med Hyg, XI, 20.

section 8 Infectious diseases 1580 exposure to deer keds Lipoptena cervi has been associated with al- lergic rhinoconjunctivitis in forest workers in Finland. Larvae of the beetles Tenebrio molitor (mealworm) and Alphitobius diaperinus (lesser mealworm), which are reared for fish bait and animal food, have been associated with rhinoconjunctivitis, contact urticaria, and asthma. Beetles which infest stored grain, including Tenebrio moli- tor, Tribolium confusum (confused flour beetle), Sitophilus sp. (grain weevil), and Alphitobius diaperinus have been associated with occu- pational allergy in grain workers or bakers. Allergy has been associ- ated with other beetles, including Dermestes peruvianus (hide beetle), Gibbium psylloides (mite beetle), and Harmonia axyridis (Asian lady- bird). Insect allergy can be investigated by skin prick tests, measure- ment of allergen-specific serum IgE, and monitoring of respiratory function following allergen exposure. Insects and hygiene Synanthropic insects which feed or wander over faeces, wounds, and food may serve as passive vectors of bacterial and viral dis- eases. Such insects include pharaoh’s ants Monomorium pharao- nis, flies, and cockroaches (Dictyoptera). Despite many reports of the isolation of pathogenic bacteria and viruses from these in- sects, there have been few epidemiological studies to define their importance as passive vectors, although is generally accepted that the presence of these insects in hospitals should be monitored and controlled. Flies Many species of fly (especially of the suborder Cyclorrhapha), fre- quent human and animal food, wounds, eyes, and faeces. Such

flies vomit and defecate where they feed. Numerous pathogenic bacteria and viruses have been isolated from flies, suggesting that they may act as passive vectors of bacterial and viral diseases. A controlled study in the Gambia, where fly control was associated with fewer new cases of trachoma, suggested that flies may act as vectors of the trachoma agent Chlamydia trachomatis. In the Gambia, Musca sor- bens is the most common eye-visiting fly. In Pakistan, a controlled study showed fly control to be significantly associated with a re- duction in incidence of childhood diarrhoeal illness. In Israel, fly control was associated with a reduction in cases of shigellosis. Flies may be controlled by using insecticides or fly traps in dwellings and latrines. Ants Pharaoh's ants Monomorium pharaonis L. commonly infest hos- pitals, where they invade sterile packs and wound dressings. They are potential passive vectors: bacteria including salmonella and staphylococcus have been isolated from these ants, which should therefore be controlled with insecticides. In Iran, ants of the genus Pheidole have been associated with sudden localized hair loss from the scalp. Patients in different parts of the country reported awakening to find collections of hair on their pillows and ants on their beds or scalps. Cockroaches Cockroaches are omnivorous scavengers. A few of the 3500 described species have become cosmopolitan synanthropes. The main pest species are the common cockroach Blatta orientalis, the American cockroach Periplaneta americana, the German cockroach Blattella germanica, and the banded cockroach Supella longipalpa. Other species may be locally important (e.g. Ectobius lapponi- cus), described by Linnaeus as infesting dried fish in Lapland. The common pest species are mostly of tropical origin and require tem- peratures of 25–33°C, but B. orientalis will tolerate 20°C. In cooler climates they are restricted to permanently heated areas and can occur in large numbers in hospitals and in sewers. Many patho- genic viruses, including poliomyelitis virus and coxsackie A virus, and bacteria, including Shigella spp., have been isolated from cock- roaches. There is evidence that cockroaches acted as vectors of hepatitis A during an outbreak in California and of Salmonella typh- imurium on a paediatric ward in Belgium. Cockroaches are potential allergens, 7.5% of healthy individuals being skin-test positive in one study. Cockroaches wander over sleepers and are attracted to nasal and oral secretions. Herpes blattae is a dermatitis described from Réunion and attributed to cockroach allergy. Cockroaches some- times wander into ears and nostrils, where they become trapped or reluctant to leave. Lignocaine (lidocaine) spray is reported to hasten the exit of such visitors. Eye-frequenting moths and beetles Like the oriental eye fly (Siphunculina funicola, Diptera, Chloropidae), some nocturnal moths of the families Pyralidae, Noctuidae, and Geometridae in Africa and Southeast Asia habitually feed on the lachrymal secretions of animals. They may visit human eyes, causing a certain amount of discomfort, and may transmit eye infections, including trachoma and viral conjunctivitis. They may also cause mechanical damage to the cornea. The moths stimulate the flow of secretions by vibrating and probing with their probosces. Implicated species include Lobocraspis griseifulva, Arcyophora spp., and Filodes fulvidorsalis. Calyptra eustrigata is a skin-piercing, bloodsucking noctuid moth from Malaya. Such Lepidoptera may be avoided by sleeping under a net. In Australia, a beetle, Orthoperus sp. has been associated with corneal erosion. FURTHER READING Aguilera A, et al. (1999). Intestinal myiasis caused by Eristalis tenax. J Clin Microbiol, 37, 3082. Auerbach PS (ed) (2012). Wilderness medicine, 6th edition. Elsevier Mosby, Philadelphia, PA. Boggild A, et al. (2002). Faruncular myiasis: a simple and rapid method for extraction of intact Dermatobia hominis larvae. Clin Infect Dis, 35, 336–8. Doggett SL, et al. (2012). Bed bugs: clinical relevance and control options. Clin Microbiol Rev, 25, 164–92. Feldmeier H, et al. (2003). Severe tungosis in underprivileged commu- nities: case series from Brazil. Emerg Infect Dis, 9, 949–55. Liebold K (2003). Alopecia induced by ants. Trans Roy Soc Trop Med Hyg, 93, 427. Roberts DT (ed) (2000). Lice and scabies: a health

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