2.

Main Vectors

2.1 Introduction

The scope of this chapter is to provide an overview of the main vectors of medical importance encountered in refugee/displaced person camps.

Three types of vectors are discussed; arthropods, snails and rodents. These are the major causes of disease in many tropical and subtropical countries. They can result in a high rate of morbidity and mortality, particularly in temporary settlements.

2.2 Some definitions

2.2.1 Vector

A vector may be any arthropod (insect or arachnid, see Table 2.1.) or animal which carries and transmits infectious pathogens directly or indirectly from an infected animal to a human or from an infected human to another human. This can occur via biting (e.g. mosquitoes, tsetse flies), penetration (e.g. guinea worm), or the gastrointestinal tract (e.g. contaminated food or drink).

2.2.2 Biological vector

The pathogens (parasites or arboviruses) in the infested host, are ingested by the vector where they undergo change and multiplication in order to mature to an infective stage. This usually takes several days before they are capable of being transmitted to a new host (e.g. human malaria parasite).

2.2.3 Mechanical vector

Mechanical vectors transmit diseases by transporting the causative agent from contaminated material (e.g. faeces) on their feet or mouth parts and then spreading the pathogens or parasites on to human food, drink, faces or eyes.

2.2.4 Arthropods

Arthropods are small animals with jointed legs, which include insects (class Insecta – e.g. mosquitoes, flies), arachnids (class Arachnida – e.g. ticks, and mites), crustaceans (e.g. Cyclops, guinea worms), and centipedes/millipedes; all of which differ in respect of their antennae, wings, or legs.

Table 2.1. Classification of the main arthropods of medical importance

ARTHROPODS	
INSECT **Class Insecta** *Identification* 1. Three distinct body regions (head, thorax, abdomen) 2. Three pairs of legs 3. Often have wings 4. One pair of antennae 5. Segmented abdomen	**ARACHNIDS** **Class Arachnida** *Identification* 1. Two distinct body regions (cephalothorax, abdomen) 2. Four pairs of legs (except larval mites, which have three pairs) 3. Never have wings 4. No antennae 5. Abdomen usually not segmented
Order Diptera ■ Mosquitoes ■ Flies	Order Acarina ■ Mites ■ Ticks
Order Heteroptera ■ Bugs	Order Araneida ■ Spiders
Order Anoplura ■ Lice	
Order Siphonaptera ■ Fleas	Order Scorpionida ■ Scorpions
Order Dictyoptera ■ Cockroaches	

Source: Sabatinelli, 1996

2.3 Main vectors often involved in vector-borne disease epidemics

2.3.1 Mosquitoes

Mosquitoes are a large arthropod group with 3,100 species occurring in the world. Only about a hundred of them are vectors of human disease. Mosquitoes can be divided into two subfamily groups;

1. The **anopheline subfamily** including the most important mosquito genus *Anopheles* which is responsible for transmitting malaria. Anopheles are also involved in transmission of filariasis in West Africa.

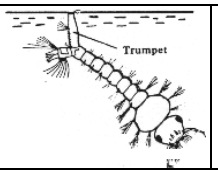
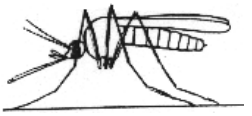
2. The **culicine subfamily** where the important genera *Aedes, Culex*, and *Mansonia* belong. Several diseases are transmitted by them such as yellow fever, and dengue by *Aedes*, encephalitis virus by *Culex*. All of these mosquitoes are also involved in the transmission of filariasis (Table 2.3).

Both male and female mosquitoes feed on sugary secretions such as nectar from plants. In all species, only the female mosquito takes blood-meals from animals and/or humans. The female mosquitoes are attracted by the odour, the carbon dioxide and the heat from animals and humans. The blood sucked is used to provide proteins to mature batches of eggs.

The life cycle of the mosquito consists of four stages (Table 2.2.): the immature stages of egg, larva, and pupa require an aquatic environment. The adult develops in aerial and terrestrial environments.

The females are able to lay between 30 and 300 eggs at a time, according to species. The anopheline mosquitoes lay their eggs separately over the surface of any kind of unpolluted water. The culicine mosquitoes, *Culex* and *Mansonia*, lay their eggs on water as an egg-raft form. The eggs of *Aedes* mosquitoes are laid just above the water line or in wet mud. Provided that they are kept dry they can survive for 3 to 4 years and hatch only when flooded by rising water levels or heavy rain (OMS, 1973).

Table 2.2. Characteristics of the different life stages of the mosquito

SUBFAMILIES			
Anopheline	**Culicine**		
Genus Anopheles	Genus Aedes	Genus Culex	Genus Mansonia
Eggs			
 float	 do not float	 raft of 25 - 100 eggs	 Aquatic plant
Larval stage			
			
Pupal stage			
			
Adult stage			
 Long palps	 Short palps		

Source: Adapted from Cheesbrough, 1987

Table 2.3. Behaviour of mosquitoes and diseases they transmit

Genus	*Breeding site*	*Place found*	*Disease and distribution*
Anopheline mosquitoes Anophelines breed in non polluted water Biting period : NIGHT	edges of rivers, swamps, impoundments, ditches, tanks, saltwater habitats protected from wave action, rice fields, temporary rainpools, hoofprints.	Worldwide	■ Malaria: Tropical and sub-tropical areas ■ Bancroftian filariasis: Asia and Africa ■ Brugian filariasis: Asia ■ O'nyong nyong virus: Africa
Aedes mosquitoes One species lives in close association with man, in any kind of human settlement. The *A. aegypti* breeds in any small water collection. Aedes spp. are primarily forest mosquitoes. Biting period : DAY	Tin cans, plastics, car tyres, gutters, ornamental ponds, tanks, jars, any type of container, waste disposal areas, tree holes.	Worldwide	■ Yellow fever: Africa and Americas ■ Dengue: Africa, Americas, Asia ■ Dengue Haemorrhagic fever: Americas, Asia ■ Bancroftian filariasis: Pacific ■ Other arbovirus: Africa, Americas, Asia
Culex mosquitoes *C. quinquefasciatus* breed in any dirty water in urban and rural areas. Other species are also very common in rice fields in Asia. Biting period : NIGHT	*C. quinquefasciatus* Waste water ditches, latrines, septic pits, cesspools, drains, waste disposal.	Worldwide	■ Bancroftian filariasis: Most tropical areas ■ Encephalitis virus: Africa, Americas, Asia, Europe
Mansonia mosquitoes Mainly associated with aquatic plants, in rural areas where irrigation canals occur. Biting period : NIGHT It is a vicious biter	Ditches, ponds, irrigation canals, swamps.	Essentially tropical Worldwide	■ Brugian filariasis: Asia ■ Other arbovirus: Rare in Africa and Americas

Sources: Adapted from Birley, 1991; Thomson, 1995; Sabatinelli, 1996; Chavasse and Yap, 1997; Rozendaal, 1997

At tropical temperatures the larval period is 4-7 days, after which time it become a pupa. The larvae feed on bacteria and small aquatic organisms. All larvae need to come to the surface to breathe, except for the larvae of Mansonia mosquitoes which extract oxygen from the roots of certain aquatic plants.

The pupal stage lasts 1-3 days in warm areas. The pupa does not feed, it breathes air and turns or twists its body with short writhing movements. Rapid metamorphosis occurs inside the pupa.

Male adults which are recognisable by their hairy antennae, generally emerge first and wait to fertilize the emerging female mosquitoes.

2.3.2 Non-biting flies

Domestic flies, including the housefly are probably the most widespread insects in the world and certainly the one most closely associated with man. Like mosquitoes they belong to the order Diptera. All of these species, *Musca domestica* (Housefly), *Musca sorbens* (Facefly), and *Chrysomya spp.* (Blowfly) are considered to be of medical importance because they transmit diseases by transporting pathogens between people or from faeces to food causing diarrhoeal diseases and trachoma.

The life cycle of the fly consists of four stages : egg, maggot (larva), pupa and adult. The female lays her eggs in moist, organic material. These eggs hatch after 8 to 48 hours and become maggots which thrive on organic matter, animal or human excrement. After a few days to several weeks, depending on the temperature, quantity of food, and the species, the maggot moves underground where it becomes a pupa. It takes 2 to 10 days for the maggot to be transformed into an adult within the pupa. The female rarely lays more than 100 to 150 eggs in each batch, 4 to 5 of which are produced during her lifetime (Busvine, 1980). Adult flies have a lifespan of one to two months depending upon the species and life conditions.

Musca domestica

The housefly, *Musca domestica,* tends to breed in animal excrement in rural areas. In urban areas they breed in organic domestic waste such as vegetable matter. They land on both faeces and human food, and feed on both. Contrary to popular belief, these flies do not lay their eggs in latrines (Chavasse, 1997). The high density of flies associated with a crowded human popula-

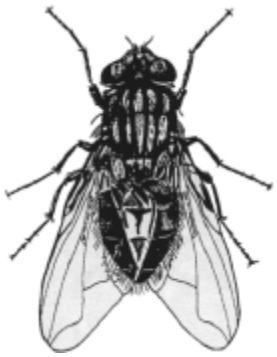


Figure 2.1.
***M. domestica*, (WHO, 1997)**

tion, in unsanitary conditions such as refugee camps, increases the risk of transmission of disease and can cause epidemics.

M. domestica is about 6 to 7 mm long and has a wing span of 13 to 15 mm. It is recognisable due to its greyish colour, and 4 dark longitudinal stripes along the back of the thorax.

As a mechanical vector this species of fly may be responsible for carrying pathogens which cause diseases such as infantile diarrhoea, shigellosis diarrhoea, dysentery, typhoid, and also intestinal worm eggs. It has been proved in Pakistan (Chavasse, 1998) and in the Gambia (Emerson, 1999) that fly control reduced incidence of diarrhoea by about 24 %.

Musca sorbens

Figure 2.3.
***M. sorbens* (WHO, 1997)**

M. sorbens or facefly also acts as a mechanical vector in the transmission of diseases. It has a worldwide distribution in the tropics. These flies breed, amongst other things, in human faeces around settlements. They are also known to feed on the secretion produced by eyes of people, especially children. They do not breed in latrines. The density of these flies may be very high in unsanitary conditions (Chavasse, 1997).

M. sorbens is 6 mm long and has a wing span of around 15 mm. It is grey and has 2 dark stripes on the back side of the thorax.

M. sorbens is responsible for carrying diarrhoeal diseases but it is often implicated in the transmission of the eye disease trachoma, and it has recently been shown in the Gambia that fly control reduced incidence of trachoma by 70 % (Emerson, 1999).

Chrysomya spp.

Figure 2.4.
Chrysomya spp. **(UNHCR, 1996)**

Chrysomya spp. or blowfly is distributed worldwide. It has a strong preference for breeding in all kinds of open latrines, decomposing meat or fish, garbage, and animal excrement. In refugee camps the simple pit latrines often have no lids on the defaecation holes, offering an ideal breeding site for these flies. Blowflies do not enter houses, but are very active in market places. The density of the blowfly population may rise as the number of simple pit latrines in a camp increases (Chavasse, 1997).

The blowfly is robust and measures 10 mm in length with a compact body. Its colour varies between a shiny blue and a shiny green.

Chrysomya spp. act as a mechanical vector and may be responsible for carrying pathogens causing diarrhoeal diseases such as dysentery, and also intestinal worm eggs. If pit latrines are humming with blowflies and crawling with their maggots this will probably be a deterrent for using them.

2.3.3 Lice

Three species/subspecies of human louse occur in the world. They are all, male and female, blood-sucking ectoparasites. The body louse (*Pediculus humanus humanus*), the head louse (*Pediculus capitis*) and the pubic or so-called crab louse (*Pthitrus pubis*) have approximately the same biology. Three stages constitute their life cycle; egg, nymph, and adult. Only the body louse is a vector of disease (typhus). The others do not transmit disease but may cause irritation and severe itching. Lice are spread by close contact between humans.

Pediculus humanus humanus (Body louse)

The body louse is found attached to clothing in close contact with the skin. The females lay and glue their eggs (also called nits) at a rate of about 10 eggs a day onto fibres of clothing, especially on woollen material. They never attach their eggs to human body hairs (Busvine, 1980). Eggs hatch

Figure 2.5.
Pediculus humanus humanus
(UNHCR, 1996)

after one week. The nymphal stage lasts from 8 to 9 days. The adult stage lasts up to 10 days during which many blood meals are taken.

The adult body louse is between 3 to 4.5 mm long. It is wingless and has a flattened body.

The body louse is responsible for the transmission of typhus, not directly by biting, but by causing itching in the human host. Scratching favours the penetration of the contaminated faeces of the louse or the contaminated louse itself into the skin, which may cause epidemic typhus. It can also carry relapsing fever and trench fever.

2.3.4 Mites

Mites belong to the order Acarina (Class Arachnida). There are over a thousand species which are parasitic on mammals, birds, and some species on humans. Two species of human mite are of medical importance; the biting mites called "chiggers" (Trombiculid mites), and scabies mites (*Sarcoptes scabeie*). Scabies mites are common in human settlements such as refugee camps.

Mites have eight legs and a body with little or no segmentation. They are very small, 0.5 mm to 2 mm in length. In most species, their life cycle consists of four stages; egg, larva, nymph and adult. Transmission of scabies mites between humans occurs by direct contact.

Biting mites (trombiculid mites)

After emerging from the eggs the larvae crawl onto vegetation or into woodlands seeking an animal or human host. They attack and feed on the skin of reptiles, mammals, birds and humans. On human they seek out areas where clothing is tight against the skin. The larvae feed on the host only once, then between two days and one month later the larvae drop to the ground and enter the soil to develop into nymphal and adult stages (Rozendaal, 1997). The nymph and the adult never feed on animals or humans. They feed on small insects and their eggs or on other mites.

These mites transmit rural typhus in Asia and Pacific, known as scrub typhus.

Scabies mites

Figure 2.6.
Scabies mite (UNHCR, 1996)

Almost the complete life of the scabies mite is spent on and in the human skin where they feed, procreate and lay their eggs. The adult *Sarcoptes scabeie* burrow winding tunnels of 1.5 mm in length in the surface of the skin. Scabies mites are found everywhere on the body. Scabies disease results from an allergicreaction to the infection of the skin caused by the burrowing of the mites.

2.3.5 Fleas

The fleas, both male and female are blood-feeding and belong to the order Siphonaptera. Around 3,000 species occur worldwide, but only a dozen species take a blood-meal on humans. Rat fleas (*Xenopsylla cheopis*) and human fleas (*Pulex irritans*) are the most important from a medical viewpoint. They jump from the ground to the lower parts of human legs, but can bite them anywhere on the body. Fleas are able to survive more than one month without having a meal and their lifespan may reach 17 months while taking regular blood meals (Sabatinelli, 1997).

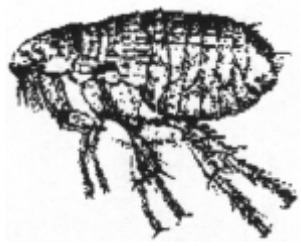


Figure 2.7.
A female flea (WHO, 1997)

Four stages constitute the life cycle of fleas; egg, larva, cocoon (where it pupates), and adult. Eggs are dropped on the ground near to the sleeping place of the host. They hatch after a period of 2 to 14 days. Eggs produce larvae which live among debris, dirt and dust, organic debris provides the main food. The larva spins a silken cocoon over a two to three week period and then pupates for one to two weeks before becoming an adult (Service, 1986).

The adults vary in size from 1 mm to 4 mm. The body is compressed and flattened laterally. Black or dark brown are the main colours. Fleas do not develop wings but they have powerful hind legs to propel them through jumps of 20 cm vertically and 30 cm horizontally.

Fleas can act as vehicles for parasitic tapeworms (in humans). They cause irritation and sometimes allergies and they are also involved in bubonic plague and murine typhus.

2.3.6 Rodents

Rats are located in almost all human communities. Three species of medical importance have been found and may present a danger to the human population. They belong to the family Muridae, and are *Rattus norvegicus*, *Rattus rattus* and *Mus musculus* (Table 2.4.). All are very close to man, and found in rural and urban areas.

Table 2.4. The three main rodents of medical importance

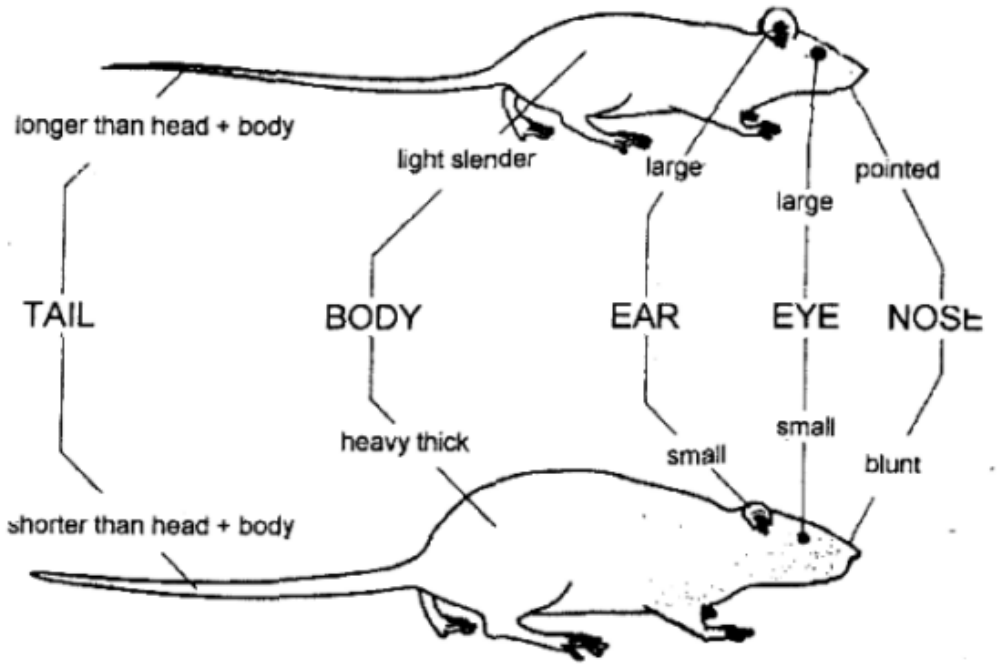
Species	*Rattus norvegicus*	*Rattus rattus*	*Mus musculus*
Other name	Brown rat or Norway rat	Roof rat or Black rat	House mouse
Weight	500 g	250 g	20 g
Length	45 cm	40 cm	18 cm
Habitat	Principally in sewers and holes and feeds on garbage.	Under the roof of any type of building.	Around supplies of grain, cereals, and flour.

Source: Sabatinelli, 1996

Rats feed on any kind of food. They cause destruction of foodstuffs by contamination through urine, faeces, or by simple contact. This can result in important financial and nutritional losses to the population, especially in emergency situations when essential supplies are already critical (Pan American Health Organization, 1982).

Female rats give birth to 5-8 young which become adult and reach sexual maturity in two months.

Roof Rat - *Rattus rattus*



Norway Rat - *Rattus norvegicus*

Figure 2.8. Morphological differences between rats
Centre for Disease Control, US Public Health Services, Atlanta

Rats may transmit diseases such as Lassa and leptospirosis to humans through contact with faeces, urine, and nasal or oral secretions of infected rats. They also act as reservoirs for pathogens which cause Murine typhus, and plague (through fleas), lyme disease, and relapsing fever (through ticks) (Chavasse and Yap, 1997).

2.3.7 Other vectors

The vectors described in Table 2.5 are of medical importance in certain areas. If a camp is located where these arthropods exist they may cause problems depending upon the sanitary conditions of the affected people.

Table 2.5. Vector description and main diseases they transmit

Vector (genus)	*Particularity*	*Breeding sites and habits*	*Disease and distribution*
Tabanid or Horsefly *1. Chrysops*	They are very robust Length; 6 to 10mm	Only the female feeds on any animal. She lays 100 to 1000 eggs according to species. They breed in moist and wet ground.	■ *Loa loa* filariasis: West and Central Africa
Tsetse fly Glossina *Mortisans group* (savannah flies) *Palpalis group* (river bank flies)	Very long proboscis wide wings 9 to 25mm in length	Both males and females suck blood. Tsetse flies are viviparous. They deposit their larvae in damp ground and arid areas.	■ Sleeping sickness: Africa
Sandfly *Phlebotominae*	Less than 3mm long Very long legs	The females only are blood-sucking at night. They are located in the tropics and subtropical areas south of Europe. They breed in moist and wet ground.	■ Cutaneous and visceral (Kala Azar) Leishmaniasis occur in Sudan, Latin Americas, India, Asia, Middle East, and Southern Europe
Bedbug *Cimex spp.* Reduviid bugs	7mm long brownish insects flat and oval body	They lives in temperate and tropical zones. They are active only at night where they feed on humans and animals.	■ Bedbugs cause nuisance such as itchiness: Worldwide ■ Chagas disease is transmitted by triatomine bugs in South and Central Americas, and in some parts of Caribbean
Blackfly *Simuliidae*	Small insect, 1 to 6mm in length	They bite during the day. Only the female sucks the blood of animals and humans. They breed and live in all kinds of unpolluted water, vectors in Africa breed only in fast flowing oxygenated streams or rivers. They have a worldwide distribution.	■ Onchocerciasis or river blindness: Africa, and some parts of Latin America

Vector (genus)	*Particularity*	*Breeding sites and habits*	*Disease and distribution*
Cockroach	5 to 73mm in length two pairs of wings flattened appearance Yellow-brown to dark colour	These insect are very agile and fast and live in colonies. They have a preference for man-made structures where it is warm. In the tropics they may live and breed outdoors. Latrines may be infested in a refugee camp. They are particularly active at night.	■ Cockroaches act as mechanical vectors and may transmit diarrhoeal diseases, typhoid fever, dysentery, viral diseases: Worldwide
Tick Hard tick Soft tick	7 to 20mm in length Hard back Soft back	Both males and females feed on warm-blooded animals and humans. They are attracted by the carbon dioxide from their prey. Hard ticks are located in vegetation and soft ticks live in close association with available prey. They can survive several years of starvation.	■ Relapsing fever: Worldwide ■ Q-fever: Africa, Americas ■ Lyme disease Arbovirus diseases: Worldwide Ticks are very painful biters and can cause serious loss of blood
Cyclops (Cyclopidae family)	Small crustacean 0.5 to 2mm in length	These are the intermediate host of the guinea worm. They live in any artificial or natural accumulation of stagnant water which may be used as drinking water.	■ Guinea worm or Dracunculiasis: Africa
Water snail (mollusc) 1. *Biomphalaria* 2. *Bulinus* 3. *Oncomelania*	Aquatic snails	Snails are found in all suitable types of water except for salty and acidic waters. Snails serve as an intermediate host of shistosomiasis worms.	■ Shistosomiasis (or bilharzia): In the tropics, mainly in Africa and East Asia

Source: Adapted from Birley, 1991; Thomson, 1995; Sabatinelli, 1996; Chavasse and Yap, 1997; Rozendaal, 1997