INSECT VECTORS OF TROPICAL PATHOGENS

In the medical field, vectors are understood to be organisms that play a role in the transmission of a pathogen between humans or from animals to humans. In practice, vectors tend to be blood-sucking insects that ingest the disease-causing organism with the blood from an infected host and then inject it into a new host at the time of their next blood-meal. Mosquitoes are best known for their role in transmitting diseases, but some blood-sucking flies can do the same. In the broader sense, organisms not belonging to the family of insects are also defined as vectors: ticks (belonging to the spider family), certain aquatic snails that serve as intermediate hosts for human parasites, and rodents that are reservoir hosts for certain pathogens.

As a rule, the association between a vector and a disease-causing organism is specific. Whatever biologic family a vector may belong to, the distribution of the disease or diseases it transmits is directly linked to its ecology. Transmission is most intense in the ecologic 'heartland' of the vector species, becoming more unstable towards the margins of its distribution. A second important point is the key role that water plays in the ecology of most, though not all vectors. This association determines the boundaries of disease distribution in a significant way. There is no malaria in the Sahara desert because there is no water available for the breeding of malaria mosquitoes. In many parts of the world, the transmission of vector-borne diseases is seasonal, linked to rainfall patterns. Temperature is also a key determinant of the boundaries of disease distribution, either because it limits the distribution of vectors or because below certain minimum night temperatures the pathogen cannot complete its life cycle within the vector. The importance of temperature thus excludes transmission above certain altitudes and beyond certain latitudes.

**Significant disease vectors**

Vectors of disease include anopheline mosquitoes, which are the exclusive vectors of the *Plasmodium* parasites causing malaria. Some 30 species of *Anopheles* play a role in the transmission of malaria, each with its own biologic and ecologic peculiarities. The archetypal species are *Anopheles gambiae* in sub-Saharan Africa, a very efficient vector whose larvae propagate in any sunlit collection of fresh water (including in urban settings), *A. darlingi* in South America, breeding in the clearings of the humid forest areas, *A. culicifacies* in South Asia, linked to standing sunlit pools particularly in irrigation schemes, and *A. dirus* in South-East Asia, which thrives in the humid forest environment. In some parts of the world, anophelines also play a role in the transmission of local viral diseases, particularly in sub-Saharan Africa, and in the transmission of lymphatic filariasis. Local health authorities are able to provide information on the transmission season, and some will also have updated information on the status of insecticide resistance.

Culicine mosquitoes as a group comprise *Culex* species and *Aedes* species. Of the *Culex* species, *C. quinquefasciatus* is the one travellers usually are most aware of, because of the nuisance it causes. It breeds in organically polluted water and is
therefore mainly associated with urban environments. It is sometimes linked to particular agricultural activities such as the production of coco-fibre (coconut husk pits, for instance in Sri Lanka, provide excellent breeding places). This mosquito transmits lymphatic filariasis and some viral diseases, including West Nile fever. Members of the other important *Culex* group, including *C. vishnui* and *C. tritaeniorhynchus*, breed in irrigated rice fields and transmit the virus that causes Japanese encephalitis. The distribution of this virus is limited to an area stretching roughly from Japan and the Democratic People’s Republic of Korea in the north-east to China, South-East Asia and the Indian subcontinent. Outbreaks can occur when two conditions are met: pigs (which serve as the amplifying host of the virus) are present, and a population explosion of the relevant *Culex* species occurs as the result of a dramatic hydrologic change, such as extensive irrigation to start the rice cropping cycle, or massive rainfall in a semi-arid area. While these culicines normally prefer to feed on animals, in extreme conditions virus transmission will spill over into the human population. In countries such as Bangladesh, the transmission risk is considerably reduced because of the absence of pigs.

**Deaths from vector-borne disease**

![Deaths from vector-borne disease map](image)

*Estimates by WHO subregion for 2002 (WHO World Health Report, 2005).*

The boundaries shown on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Coloured lines or maps represent approximate border lines for which there may not yet be full agreement.

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*Aedes* mosquitoes are vectors of the viruses that cause dengue and yellow fever. Unlike *Anopheles* and *Culex* mosquitoes, *Aedes* mosquitoes bite mostly during daytime, but also at night. Both *A. aegypti* and *A. albopictus* have adapted to the man-made environment of human settlements, where they breed in small water collections in and around houses. Their density is usually highest in poor settlements, but even in residential areas conditions may favour their breeding (e.g., air-conditioners or "desert coolers" as they are called in India). Outbreaks of dengue and yellow fever are usually publicized by the media and accompanied by fogging operations conducted by the
municipal vector control program. In such situations travellers should be on the alert for *Aedes* bites.

**Sandflies** are tiny flies that propagate in moist debris. They transmit the protozoal parasite that causes leishmaniasis. In general terms, sandflies breed in humid places on damp soil rich in humus. The species belonging to the genus *Phlebotomus* are linked to poor housing conditions, while the *Lutzomyia* species are linked to forest or rainforest ecosystems, where they breed in rotting leaves between the buttresses of tree trunks. The sandfly bite is typical in that it shows the place of the bite with a non-swollen reddish circle around it. In popular language, reference is made to certain biting midges in beach resorts as sandflies, but these do not transmit any disease.

In sub-Saharan Africa, **tsetse flies** (*Glossina* species) are significant vectors of the much-feared trypanosomes which cause sleeping sickness. In reality, the distribution of tsetse flies is far wider than that of human sleeping sickness, which is found in only a limited number of foci. Riverine forests in an otherwise savannah landscape are the preferred habitat of these flies. In most game parks where the average tourist minibus may be invaded by a swarm of tsetse flies, the painful bite is more to be feared than the transmission of trypanosomiasis.

**Blackflies** are small flies capable of transmitting onchocerciasis (river blindness). Infection with the filarial parasite *Onchocerca volvulus* can be easily treated with ivermectin. Blindness occurs only after many years of exposure leading to a parasite overload. Blackflies come in large swarms and therefore cause considerable nuisance, making places near breeding sites (the larvae develop under rocks in fast streaming, oxygenated water) practically uninhabitable.

Blood-sucking **triatomine bugs** transmit the trypanosomes that cause Chagas disease, which is limited to the Americas. They live in cracks of adobe housing, sometimes in palm-leaf roofs or occasionally in the peri-domestic environment in woodpiles, chicken coops or goat pens.

**Ticks** are less well-known as vectors, although their fame has risen since Lyme disease has become a public health issue in the temperate zones of the United States and Europe. Forest zones with wildlife such as deer are risk areas where this spirochaete can be contracted. Tickborne encephalitis and Kyasanur Forest disease are serious viral infections with a high mortality rate. In infested areas, precautionary measures are highly recommended. Other tickborne diseases include the various rickettsial fevers (spotted fever and tick-bite fever), Crimean-Congo hemorrhagic fever, tularemia, ehrlichiosis and relapsing fever (borreliosis).

While aquatic **snails** do not play an active role in transmitting a pathogen from one individual to another as do insect vectors, they are an indispensable intermediate host for the development of a number of parasite species, notably the blood flukes causing schistosomiasis. This disease is contracted through direct water contact, giving the schistosome larvae an opportunity to adhere to the skin and penetrate. Habitats which
may harbour parasites are shallow shores of lakes and streams, with abundant aquatic vegetation where snails flourish. Recently, however, an intermediate host snail species has been discovered in Lake Malawi, which thrives in sandy coasts with little or no aquatic vegetation.

Rodents are major reservoir hosts of a range of pathogens, including those causing plague (transmitted from rats to humans by fleas), leishmaniasis (notorious in some of the Central Asian republics), leptospirosis, and a number of viral and rickettsial diseases. The time between the moment of contact with a vector and the clinical symptoms may vary considerably - from 8 days in the case of malaria, to months or years in the case of schistosomiasis. For some infections, again like malaria, one infective mosquito bite is enough, while for others long-term exposure is required to develop certain symptoms (e.g., river blindness).

**Some popular misconceptions**

Over time, some anecdotal knowledge has developed with respect to vectors of diseases, which needs rectification.

- *Mosquito population densities are a good indicator of when protective measures are needed.* This is not true as a general statement. First of all, for many people the sound of mosquitoes will be the main way to judge density, but some of the most significant vectors (e.g., anopheline vectors of malaria) do not make a noise. Also, recent research in West Africa has shown that transmission levels may sometimes be inversely related to mosquito densities. This is particularly important to bear in mind, because density and nuisance are often the incentive to sleep under a mosquito net. In many places, however, mosquito nets should always be used.

- *When the lawns around a house are well-manicured, there is no risk of mosquito vectors.* Clean and well-managed environments will generally provide less opportunities for mosquito propagation, but cutting the grass short has no impact.

- *Vigilance is required only around dusk.* While it is correct that a number of mosquitoes go in search of a bloodmeal in the early hours of the evening, and wearing protective clothing and repellents at that time helps reduce the risk of malaria, there are also vectors that are active during the morning and the evening, and sometimes even during daytime, such as some *Aedes* mosquitoes.

- *Cattle will distract mosquitoes from biting humans.* This is a complex issue and should not be relied on without in-depth knowledge of the biology of local vectors. While certain mosquito species feel a greater attraction to take a bloodmeal from cattle, for example, rather than humans, such barriers are not absolute; in many instances the presence of cattle actually works to increase the number of mosquitoes.

- Finally, there is absolutely no evidence that the human immunodeficiency virus can be transmitted by insects.