Mosquito-Borne Diseases

Mosquitoes cause more human suffering than any other organism -- over one million people worldwide die from mosquito-borne diseases every year. Not only can mosquitoes carry diseases that afflict humans, they also transmit several diseases and parasites that dogs and horses are very susceptible to. These include dog heartworm, West Nile virus (WNV) and Eastern equine encephalitis (EEE). In addition, mosquito bites can cause severe skin irritation through an allergic reaction to the mosquito's saliva - this is what causes the red bump and itching. Mosquito vectored diseases include protozoan diseases, i.e., malaria, filarial diseases such as dog heartworm, and viruses such as dengue, encephalitis and yellow fever. CDC Travelers' Health provides information on travel to destinations where human-borne diseases might be a problem.

Malaria

Malaria is an ancient disease probably originating in Africa. The malaria parasite (*plasmodium)* is transmitted by female *Anopheles* mosquitoes. The term malaria is derived from the Italian 'mal-aria" or "bad air" because it was thought to come on the wind from swamps and rivers. Scientists conducted much research on the disease during the 1880s and early 1900s. Approximately 40% of the world's population is susceptible to malaria, mostly in the tropical and sub-tropical areas of the world. It was by and large eradicated in the temperate area of the world during the 20th century with the advent of DDT and other organochlorine and organophosphate mosquito control insecticides. However, more than one million deaths and 300 - 500 million cases are still reported annually in the world. It is reported that malaria kills one child every 40 seconds. In the United States malaria affected colonization along the eastern shore and wasn't effectively controlled until the 1940s when the Anopheles mosquitoes were controlled. A resurgence occurred during the 1960s and early 70s in the United States due to returning military personnel from Vietnam. *Anopheles quadrimaculatus* was the primary vector of the *Plasmodium vivax* (protozoa) in the United States (Foote and Cook 1959). Antimalarial drugs have been available for more than 50 years and recently scientists in Britain and the United States have cracked the code of the malaria parasite genome, a step that may help boost the campaign against the disease.

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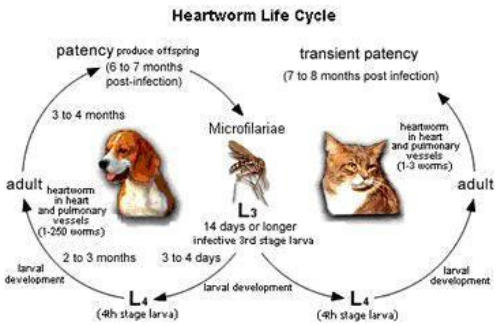
Dog Heartworm (*Dirofilaria immitis*)

Dog heartworm (*Dirofilaria immitis*) can be a life-threatening disease for canines. The disease is caused by a roundworm. Dogs and sometimes other animals such as cats, foxes and raccoons are infected with the worm through the bite of a mosquito carrying the larvae of the worm. It is dependent on both the mammal and the mosquito to fulfill its lifecycle. The young worms (called microfilaria) circulate in the blood stream of the dog. These worms must infect a mosquito in order to complete their lifecycle. Mosquitoes become infected when they blood feed on the sick dog. Once inside the mosquito the microfilaria leave the gut of the mosquito and live in the body of the insect, where they develop for 2-3 weeks. After transforming twice in one mosquito the third stage infective larvae move to the mosquito's mouthparts, where they will be able to infect an animal. When the mosquito blood feeds, the infective larvae are deposited on the surface of the victims skin. The larvae enter the skin through the wound caused by the mosquito bite. The worms burrow into the skin where they remain for 3-4 months. If the worms have infected an unsuitable host such as a human, the worms usually die. The disease in dogs and cats cannot be eliminated but it can be controlled or prevented with pills and/or injections. Some risk is present when treating dogs infected with heartworms but death is rare; still prevention is best. Of course good residual mosquito control practices reduce the treat of mosquito transmission. Until the late sixties, the disease was restricted to southern and eastern coastal regions of the United States. Now, however, cases have been reported in all 50 states and in several provinces of Canada.



Arthropod-borne viruses (arboviruses) are the most diverse, numerous and serious diseases transmitted to susceptible vertebrate hosts by mosquitoes and other blood-feeding arthropods. Arboviral encephalitides are primarily zoonotic, being maintained in complex life cycles involving a nonhuman primary vertebrate host and a primary arthropod vector. These cycles usually remain undetected until humans encroach on a natural focus, or the virus escapes this focus via a secondary vector or vertebrate host as the result of some ecologic change. Humans and domestic animals can develop clinical illness but usually are "dead-end" hosts because they do not produce significant viremia, and do not contribute to the transmission cycle. There are several virus agents of encephalitis in the United States: West Nile virus (WN), eastern equine encephalitis (EEE), western equine encephalitis (WEE), St. Louis encephalitis (SLE), La Crosse (LAC) encephalitis, dengue and yellow fever all of which are transmitted by mosquitoes. Another virus, Powassan, is a minor cause of encephalitis in the northern United States, and is transmitted by ticks. A new Powassan-like virus has recently been isolated from deer ticks. Encephalitis is global, in Asia, for example, about 50,000 cases of Japanese encephalitis (JE) are reported annually.

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Dengue

Dengue is a serious arboviral disease of the Americas, Asia and Africa. Although it has a low mortality, dengue has very uncomfortable symptoms and has become more serious, both in frequency and mortality, in recent years. Aedes aegypti and Ae. albopictus are the vectors of dengue. The spread of dengue throughout the world can be directly attributed to the proliferation and adaptation of these mosquitoes. Over the last 16 years dengue has become more common, for example; in south Texas 55 cases were reported in 1999 causing one death. More recently, Hawaii recorded 85 cases of dengue during 2001 and the Florida Keys reported over 20 cases in 2010. In 2004 Venezuela has reported more than 11, 600 cases classic dengue fever and over 700 cases of DHF. Indonesia dengue outbreak has caused over 600 deaths and more than 54,000 cases. In 1999, Laredo and Nuevo Laredo had an outbreak of almost a 100 cases.

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Yellow fever

Yellow fever, which has a 400-year history, occurs only in tropical areas of Africa and the Americas. It has both an urban and jungle cycle. It is a rare illness of travelers anymore because most countries have regulations and requirements for yellow fever vaccination that must be met prior to entering the country (http://www.cdc.gov/ncidod/dvbid/yellowfever/index.htm). Every year about 200,000 cases occur with 30,000 deaths in 33 countries. It does not occur in Asia. Over the past decade it has become more prevalent. In 2002 one fatal yellow fever death occurred in the United States in an unvaccinated traveler returning from a fishing trip to the Amazon. In May 2003, 178 cases and 27 deaths caused by yellow fever were reported in southern Sudan. In the Americas 226 cases of jungle yellow fever have been reported with 99 deaths (ProMed 12-22-03).

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Eastern Equine Encephalitis (EEE)

Eastern Equine Encephalitis (EEE) is spread to horses and humans by infected mosquitoes. It is among the most serious of a group of mosquito-borne arboviruses that can affect the central nervous system and cause severe complications and even death. EEE is found in North America, Central and South America, and the Caribbean. It has a complex life cycle involving birds and a specific type of mosquitoes including several *Culex* species and *Culiseta melanura*. These mosquitoes feed on infected birds and become carriers of the disease and then feed on humans, horses and other mammals. Symptoms may range from none at all to a mild flu-like illness with fever, headache, and sore throat. More serious infections of the central nervous system lead to a sudden fever and severe headache followed quickly by seizures and coma. About half of these patients die from the disease. Of those who survive, many suffer permanent brain damage and require lifetime institutional care. There is no specific treatment. A vaccine is available for horses, but not humans.

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St. Louis Encephalitis (SLE)

St. Louis Encephalitis (SLE) is transmitted from birds to man and other mammals by infected mosquitoes (mainly some Culex species). SLE is found throughout the United States, but most often along the Gulf of Mexico, especially Florida. Major SLE epidemics occurred in Florida in 1959, 1961, 1962, 1977, and 1990. The elderly and very young are more susceptible than those between 20 and 50. During the period 1964-1998 [35 years] a total of 4478 confirmed cases of SLE were recorded in the United States Symptoms are similar to those seen in EEE and like EEE, there is no vaccine. Mississippi's first case of St. Louis Encephalitis since 1994 was confirmed in June 2003. Previously the last outbreak of SLE in Mississippi was in 1975 with over 300 reported cases. It was the first confirmed mosquito-borne virus in the United States in 2003. It turned up in October 2003 in California Riverside County in sentinel chickens. The last [SLE] human case in California occurred in 1997. In Louisiana in 2003 there was a fatal St Louis Encephalitis case previously listed as a West Nile caused death.

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LaCrosse Encephalitis (LAC)

LaCrosse encephalitis (LAC) is much less common than EEE or SLE, but occurs in all 13 states east of the Mississippi, particularly in the Appalachian region. It was reported first in 1963 in LaCrosse, Wisconsin and the vector is thought to be a specific type of woodland mosquito (*Aedes triseriatus*) called the tree-hole mosquito, with small mammals the usual warm-blooded host. It occurs in children younger than 16 and once again there is no vaccine for LaCrosse encephalitis.

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Western Equine Encephalitis (WEE)

Western Equine Encephalitis (WEE) was first recognized in 1930 in a horse in California. It is found west of the Mississippi including parts of Canada and Mexico. The primary vector is *Culex tarsalis* and birds are the most important vertebrate hosts with small mammals playing a minor role. Unlike LAC it is nonspecific in humans and since 1964 fewer than 1000 cases have been reported As with EEE a vaccine is available for horses against WEE but not for humans. In Arizona 3 counties were found in chicken flocks.

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West Nile virus (WNV)

West Nile virus (WNV) emerged from its origins in 1937 in Africa (Uganda) into Europe, the Middle East, west and central Asia and associated islands. It is a Flavivirus (family Flaviviridae) with more than 70 identified viruses. Serologically, it is a Japanese encephalitis virus antigenic complex similar to St. Louis, Japanese and Murray Valley encephalitis viruses. Similar to other encephalitises, it is cycled between birds and mosquitoes and transmitted to mammals (including horses) and man by infected mosquitoes. WNV might be described in one of four illnesses: West Nile Fever might be the least severe in characterized by fever, headach, tireness and aches or a rash. Sort of like the "flu". This might last a few days or several weeks. At least 63% of patients report symptoms lasting over 30 days, with the median being 60 days. The other types are grouped as "neuroinvasive disease" which affects the nervous system; West Nile encephalitis which affects the brain and West Nile meningitis (meningoencephalitis) which is an inflammation of the brain and membrane around it. (CDC)

It first appeared in North America in 1999 in New York (Cornell Environmental Risk Analysis Program) with 62 confirmed cases and 7 human deaths. Nine horses died in New York in 1999. In 2001, 66 human cases (10 deaths) were reported in 10 states. It occurred in birds or horses in 27 states and Washington D.C., Canada and the Caribbean. There were 733 horse cases in 2001 with Florida reporting 66% of the cases; approximately 33% were fatal. In 2001 more than 1.4 million mosquitoes were tested for WNV. In the United States (2004) over 43 species of mosquitoes have tested positive for WNV transmission, the Culex pipiens group seems the most common species associated with infecting people and horses. Currently, 65 mosquito and 300 bird species have tested positive in the United States for this virus.

During 2002, the number of areas reporting WNV grew to 44 states and 5 Canadian provinces. The only states not reporting WNV were Alaska, Arizona, Hawaii, Nevada, Oregon and Utah that year. Intrauterine transmission (CDC MMWR) and laboratory infections (CDC MMWR) were reported for the first time. In all over 3800 human cases with 232 fatalities in 39 states and Washington DC were recorded. More than 24,350 horse cases of WNV were confirmed or reported in 2002. There is a vaccine for horses. Even alligators (CDC-EID) were found infected in Georgia.

The first confirmed 2003 WNV infection was in South Carolina on July 7th, 2003. South Dakota confirmed a WNV infection in a dog. The final CDC report list 9858 cases. Nebraska had 1942, Colorado 2947 and Idaho only one (CDC) . In Florida there were 94 human cases with most occuring in the panhandle. Bay county, FL reported 14 cases and one death. Of the more than 9858 cases, 6829 were West Nile Fever (the milder form), 2863 were neuroinvasive (the more severe form) and 166 clinically unspecified. There were over 4200 positive dead birds reported in 39 states and 4500 plus infections in horses in 40 states with more than 425 of these in Colorado. West Nile was reported in 1377 sentinel chicken flocks from 15 states. In Florida 1173 seroconversions to WNV were reported from 34 counties. More than 1950 positive mosquito pools were reported from 32 states and New York City.

In Canada (01-12-04) WNV was been confirmed in 9 Provinces. At least 10 human deaths and more than 1220 cases have been confirmed. Canada reported over 445 presumed or confirmed horse cases in 6 Provinces with over 180 in Alberta Province. Five Provinces have reported positive mosquito pools (>575) with over 290 from Manitoba. Canada confirmed over 1600 positive dead birds from 12000 tests.

Mexico (December 2003) has tested over 590 citizens in 25 states. Six have tested positive with three with the more severe form of WNV. Mexico horse data shows 2475 had positive WN returns in 29 states. Of more than 18000 birds tested 117 were positive. The Pan American Health Organization (PAHO).

Arizona and New Mexico reported the first human cases of WNV on May 26, 2004 and a week later confirmed a total of 7 cases. South Dakota reported it's first case on June 8, 2004. In 2003 South Dakota had 14 deaths and over human cases reported. Wyoming and Florida (http://www.heraldtribune.com/) has joined the list recently. Alabama, Arizona, Texas and Virginia have reported WN V infections in horses. WNV seroconversions have been reported in 64 sentinel chicken flocks from 4 states (Arizona, California, Florida, and Louisiana), and 58 WNV-positive mosquito pools have been reported from 6 states (Arizona, California, Illinois, Indiana, Louisiana, and Pennsylvania).

As of 2010, there have been 30,491 cases of WNV reported to CDC. Of these, 12650 have resulted in meningitis/encephalitis and 1196 were fatal. CDC estimates that there have been at least 1.5 million infections (82% are asymptomatic) and 341,000 cases of West Nile Fever, but the disease is grossly under reported due to its similarity to other viral infections.

Canada's 1st dead bird (a blue jay) from West Nile virus in 2004 was confirmed in Ontario in May 2004. West Nile virus was confirmed in 2 birds in Puerto Rico near the former US Roosevelt Roads Navy Base (southeastern Puerto Rico).

Britain's Health Protection Agency has started its annual surveillance program for possible human cases of West Nile virus infection. The program, which has been used for the last three years, operates during the summer, when there is West Nile virus activity in other countries. The UK has had no reported WNV, but are developing a West Nile Virus Contingency Plan.

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