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Fact Sheet: West Nile virus[1]

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Introduction

West Nile virus (WNV) is an arbovirus (arthropod-borne virus) transmitted to humans and equines via mosquito bites and a substantial concern to public and veterinary health. West Nile virus was introduced to the United States in 1999, and with over 52,000 reported cases of human infections, it is the most frequent cause of mosquito-borne disease in the continental United States (CDC 2022). Many mosquito species can transmit WNV in the United States, and many wildlife host species can become infected with the virus and transmit it to biting mosquitoes. The many potential hosts and vectors make identifying high risk areas or time periods a complex task.

West Nile virus harms the equine industry, domestic pets, and livestock in the United States. (Bosco-Lauth and Bowen 2019). Multiple equine WNV epizootics (animal outbreaks) have occurred since 1999, with more than 30,000 equine cases reported in the United States (Bosco-Lauth and Bowen 2019). In Florida, a total of 460 WNV infections in people and 757 WNV infections in horses and other equines have been reported between 2001 and 2021 (CDC 2022; FDOH 2022). This publication is intended to provide information about WNV to researchers and stakeholders in mosquito control and public health professions, as well as to the general public.

What is West Nile virus?

West Nile virus naturally circulates in the environment between mosquito vectors and birds, occasionally spilling over (transferring) to humans and equines through the bite of an infected mosquito. The virus is a member of the genus *Flavivirus*, which also includes other arboviruses that are important to human health, such as dengue virus (DENV), yellow-fever virus (YFV), Zika virus (ZIKV), and Saint Louis encephalitis virus (SLEV). The virus is considered endemic, or reported regularly, throughout the United States with locally acquired human infections reported consistently each year (Figure 1) (Lanciotti et al. 1999; Reisen 2013).

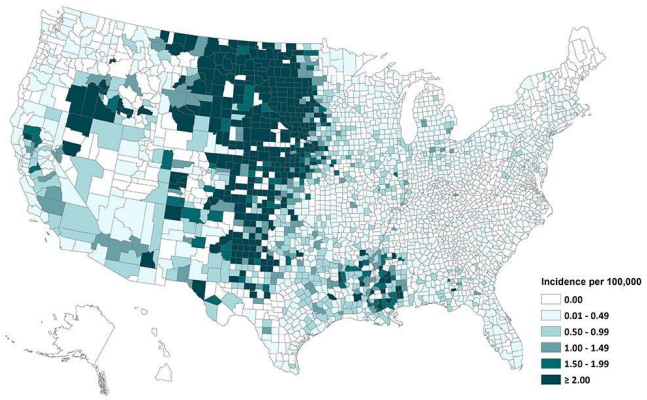


Figure 1. Average annual incidence of West Nile virus neuroinvasive disease reported to CDC by county, 1999–2020.
Credit: CDC 2022

Signs and Symptoms

Although most people infected with WNV are asymptomatic and do not develop noticeable symptoms, 1 out of 5 infected individuals develop flu-like symptoms and can take weeks to recover (CDC 2022). The most common signs and symptoms include fever, swollen lymph glands, nausea, vomiting, muscle aches, joint pain, and rashes (Zou et al. 2010). A smaller percentage of the population infected with WNV (1 out of 150) may develop neuroinvasive disease that leads to encephalitis (inflammation of the brain) or meningitis (inflammation of the membranes covering the brain and spinal cord). Approximately 10% of these neuroinvasive disease cases result in death (Petersen et al. 2013). Although this severe form of the disease can occur across all ages, it is more likely to develop in people over 60 years of age, among which the risk may approach 1 out of 50 infected individuals (Carson et al. 2012).

Diagnosis

Individuals who develop symptoms may seek help from a healthcare provider who can order tests to diagnose WNV infection (CDC 2022). Serological or other molecular tests such as viral isolation and reverse transcriptase PCR are often used to determine whether or not an individual has antibodies to the virus (indicating a past WNV infection) or the actual viral particles circulating in the system (Zou et

al. 2010). WNV is a nationally notifiable disease, and all positive infections are reported to the US Centers for Disease Control and Prevention (CDC). Because WNV can be transmitted through blood transfusions, all blood donations are tested for the virus, and positive infections are reported to CDC.

Treatment

There are currently no medications available that are specific for treating a WNV infection. Over-the-counter pain relievers may be used to reduce fever and relieve some of the symptoms associated with WNV infection. Patients who develop neuroinvasive disease require hospitalization and supportive treatment (CDC 2022; Petersen et al. 2013).

Challenges

Most WNV infections are not reported because approximately only 20% of infected people will develop symptoms, and symptoms of WNV disease are often confused with more common viruses or are similar to other medically important arboviruses (CDC 2022). Serological tests can be misleading at times when WNV and other flaviviruses such as DENV and SLEV can also be present (Petersen et al. 2013). Collectively, these factors lead to underreporting and underestimation of WNV prevalence.

Prevention

Although four effective WNV equine vaccines are available, a need continues for a human-safe vaccine (Kaiser and Barrett 2019). The most effective way to prevent WNV infection currently is to avoid mosquito bites. Wearing clothes that cover exposed skin—for example, long pants and long-sleeved shirts, applying mosquito repellent when outdoors, limiting outdoor activities to daylight hours or away from peak mosquito biting times, and installing screens in windows are some of the most commonly recommended practices to prevent arboviral infections like WNV.

Veterinary Health

Companion animals, livestock, and, most importantly, equines, are also at risk of WNV infections in the United States. (Bosco-Lauth and Bowen 2019). Similarly to human WNV infections, 10% of infected horses will develop neuroinvasive symptoms, which can include high fever, impaired coordination, paresis (partial paralysis), and tremors (Ostlund et al. 2001). Because WNV is endemic to Florida, equine vaccinations against WNV are necessary, and owners are encouraged to administer the vaccine in a 2-dose initial treatment followed by an annual booster (AAEP 2022, Bosco-Lauth and Bowen 2019). Currently, four effective WNV equine vaccines are available(Kaiser and Barrett 2019).

Transmission Cycle

The transmission cycle of WNV is very complex and involves multiple components, including mosquito vectors, vertebrate hosts, and the environment. Multiple modes of transmission exist for WNV, including blood transfusions and organ transplantation between humans, and vertical transmission from female mosquitoes to their eggs. However, the primary route of infection occurs when infected female mosquitoes take a blood meal from vertebrate hosts. Although WNV has been found within multiple mosquito species, the transmission cycle involves relatively few species serving as primary vectors (vectors that efficiently spread WNV among bird populations) or bridge vectors (vectors that transfer WNV from circulation among birds to mammals or other vertebrates) (Figure 2) (Turell et al. 2005; Rochlin et al. 2019). Competent mosquito vectors, often in the genus *Culex*, that primarily feed on avian hosts, acquire WNV during blood feeding from infected birds, which often exhibit high levels of virus circulating in their bloodstream (viremia) (Colpitts et al. 2012; Reisen 2013). After the female ingests WNV during blood feeding, it takes approximately 2–14 days before that mosquito can transmit WNV to a new host. The period varies by mosquito species and is influenced by temperature (Sardelis et al. 2001; Turell et al. 2002; Kilpatrick et al. 2007). When infected WNV mosquito vectors take blood meals from humans, horses, and other mammals, transmission can occur. This is referred to as a spillover event to a “dead end” host because these mammals do not develop high levels of viremia, making it unlikely that mosquitoes feeding on those infected animals will become infected with WNV (Figure 2) (Godsey et al. 2005b; Ronca et al. 2021).

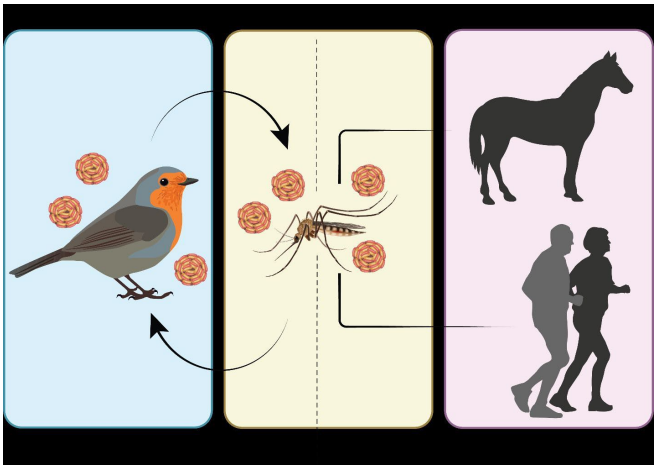


Figure 2. West Nile virus transmission cycle. West Nile virus circulates among birds in an enzootic cycle, vectored by certain species of mosquitoes. When WNV-infected mosquitoes take blood from mammalian dead-end hosts, WNV can "spill over" to infect these hosts. However, mosquitoes that feed on these WNV-infected dead-end hosts in general cannot become infected with WNV.
Credit:

Different mosquito species can be responsible for WNV transmission depending on the season or the location (Reisen 2013; Rochlin et al. 2019). Mosquitoes from the *Culex* subgenus *Culex* are the most important vectors for WNV. In Florida, the mosquito species *Culex quinquefasciatus* Say (Figure 3) and *Culex nigripalpus* (Figure 4) Theobald are considered the most important mosquito species for WNV transmission (Godsey et al. 2005a; Kilpatrick et al. 2006).



Figure 3. Adult female *Culex quinquefasciatus*, an important vector of West Nile virus in the United States, collected in Indian River County, Florida.
Credit: Lawrence Reeves, UF/IFAS

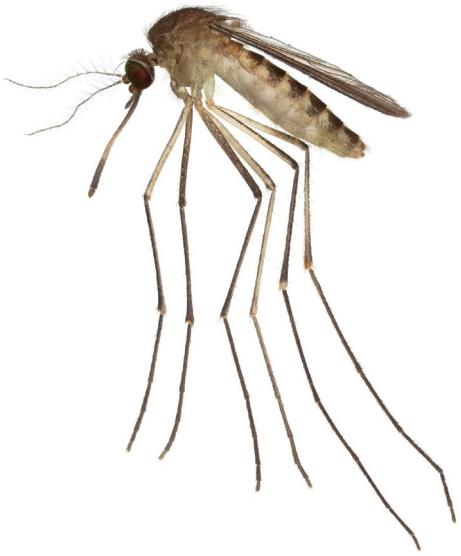


Figure 4. Adult female *Culex nigripalpus*, an important vector for West Nile virus in Florida and the southeastern United States, collected in Indian River County, Florida.
Credit: Lawrence Reeves, UF/IFAS

Culex quinquefasciatus are found more commonly in urban areas. The females of this species prefer semi-permanent freshwater habitats to lay their eggs. In urban and agricultural settings, such habitats include unmaintained swimming pools and a variety of catch basins, retention ponds, or artificial containers that are rich in organic material (Day et al. 2015; Hill and Connelly 2019; Rochlin et al. 2019). *Culex nigripalpus* tends to be found in mixed vegetative semi-urban and rural habitats since the females prefer to lay eggs in freshly flooded roadside ditches or agricultural furrows. They are also known to oviposit in a variety of aquatic habitats, including artificial containers (Day 2004; Rey et al. 2006). *Culex quinquefasciatus* plays an important role in maintaining the virus within bird populations, referred to as the enzootic cycle, and is capable of serving as a bridge vector, transmitting the virus to humans or other dead-end hosts (Saleem and Lobanova 2020). This mosquito species is considered the primary vector of WNV in the southeast region of the United States. In Florida, however, it is unclear whether this species plays a more important role than *Culex nigripalpus* in WNV transmission (Sardelis et al. 2001; Godsey et al. 2005b; Vitek et al. 2008; Day et al. 2015; Rochlin et al. 2019).

In Florida, *Culex nigripalpus* undergoes a seasonal change in its host use. *Culex nigripalpus* feeds primarily from birds in the winter and spring but shifts to feeding primarily from mammals in the summer and fall (Edman and Taylor 1968). This seasonal change is thought to drive the timing of amplification (increase in transmission) of WNV among populations of wild birds and spillover to humans and other dead-end hosts.

In the western United States, *Culex tarsalis* (Figure 5) is also an important WNV vector in addition to *Culex quinquefasciatus*, and *Cx. tarsalis* is also found in Florida. Like *Culex nigripalpus*, *Culex tarsalis* undergoes a seasonal shift in its host use, feeding primarily from birds early in the year and shifting toward mammals later in the year (Tempelis et al. 1965).

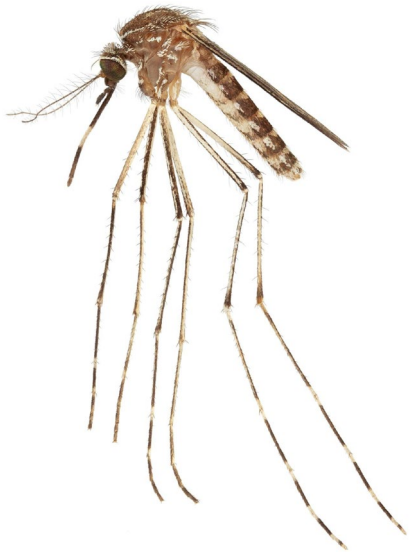


Figure 5. Adult female *Culex tarsalis*, an important vector for West Nile virus in the western United States, collected in Santa Cruz County, Arizona. Credit: Lawrence Reeves, UF/IFAS

West Nile virus has been detected in multiple vertebrate animals ranging from reptiles to mammals, but avian species are considered to be the main hosts because of their ability to become infected with and amplify the virus for subsequent transmission (Komar 2000; Klenk and Komar 2003; Colpitts et al. 2012; Reisen 2013; Taieb et al. 2020). In Florida, several songbirds that are known to be competent WNV amplifying hosts are distributed throughout all or parts of the state according to their residential distributions or overwintering routes (Foppa et al. 2011; eBird 2021). These include mourning doves (*Zenaida macroura*), common grackles (*Quiscalus quiscula*), northern cardinals (*Cardinalis cardinalis*), and the endangered Florida scrub jays (*Aphelocoma coerulescens*) (Kilpatrick et al. 2007; Kain and Bolker 2019). Migratory birds may play an important role in WNV transmission in Florida, as they often congregate in great numbers and occupy the same area for a period of time in the winter and early spring months (Shaman et al. 2005; Day et al. 2015; eBird 2021).

What are the chances of becoming infected with WNV?

While WNV peak infection rate in birds is in late spring and early summer, human outbreaks usually happen in late summer and early fall. This time lag in the observed high proportions of infected avian amplifying hosts and mammalian dead-end hosts is assumed to be connected by the vertebrate immunization time (the time it takes for a large proportion of wild vertebrate hosts to become immunized to WNV via previous infection), as well as the mosquito abundance and host use (Edman and Taylor 1968; DeGroote et al. 2012). The risk of WNV transmission to humans generally is greatest from mid to late summer in Florida and much of the conterminous United States (Figure 6) (Petersen et al. 2013).

Overall, the number of human WNV cases in Florida is low; however, periodic outbreaks occurring in 2003, 2012, 2018, and 2020 highlight the need for continued vigilance to protect against mosquito bites that may result in transmission (Table 1).

Table 1. Human cases of WNV and neuroinvasive disease during outbreak years in Florida.

Year	Total Cases	Neuroinvasive Cases	Region
2003	94	61	Panhandle and Northern Florida
2012	73	52	Panhandle and Northern Florida
2018	35	30	Panhandle and Northern Florida
2020	51	44	South Florida

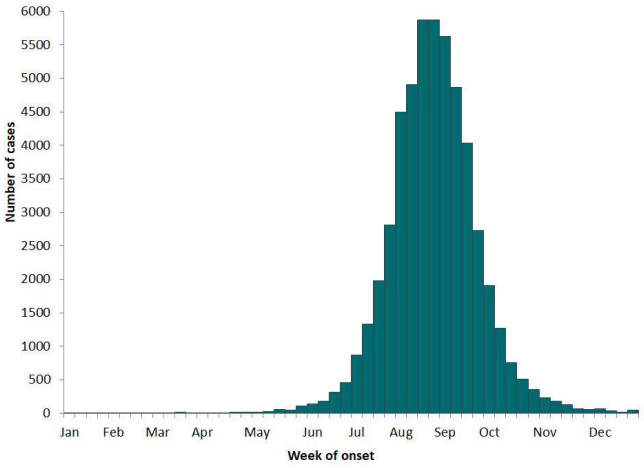


Figure 6. West Nile virus disease cases reported to CDC by week of illness onset, 1999–2020. Credit: CDC 2022

Additional Resources

The following State of Florida resources provide additional information about WNV human and equine health:

- Florida Department of Health
- Florida Department of Agriculture and Consumer Services

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