West Nile VirusTransmission and Ecology in Birds

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ABSTRACT: The ecology of the strain of West Nile virus (WNV) introduced into the United States in 1999 has similarities to the native flavivirus, St. Louis encephalitis (SLE) virus, but has unique features not observed with SLE virus or with WNV in the old world. The primary route of transmission for most of the arboviruses in North America is by mosquito, and infected native birds usually do not suffer morbidity or mortality. An exception to this pattern is eastern equine encephalitis virus, which has an alternate direct route of transmission among nonnative birds, and some mortality of native bird species occurs. The strain of WNV circulating in the northeastern United States is unique in that it causes significant mortality in exotic and native bird species, especially in the American crow (Corvus brachyrhynchos). Because of the lack of information on the susceptibility and pathogenesis of WNV for this species, experimental studies were conducted at the USGS National Wildlife Health Center. In two separate studies, crows were inoculated with a 1999 New York strain of WNV, and all experimentally infected crows died. In one of the studies, control crows in regular contact with experimentally inoculated crows in the same room but not inoculated with WNV succumbed to infection. The direct transmission between crows was most likely by the oral route. Inoculated crows were viremic before death, and high titers of virus were isolated from a variety of tissues. The significance of the experimental direct transmission among captive crows is unknown.

KEYWORDS: West Nile virus; ecology in birds

The introduction of West Nile virus (WNV, Flavivirus, Flaviviridae) into the United States in 1999 initiated a human epidemic and caused extensive bird mortality, particularly in the American crow (Corvus brachyrhynchos) in New York City (NYC)1 and brought a new perspective to the status of arboviruses in North America. Originally, the virus responsible for the human epidemic was thought to be St. Louis encephalitis (SLE), a virus closely related to WNV, which regularly occurs through-
out the United States. However SLE virus does not cause mortality in birds. Historical data on WNV in birds from Africa, the Middle East, and Europe suggested that most of the viral strains circulating in nature were not pathogenic to birds either, including hooded crows (Corvus corone). The virus appeared to be a highly virulent strain of WNV introduced possibly from Israel. The crow emerged as a symbol of WNV activity in the northeastern United States because of its high susceptibility to infection with WNV. Enhanced surveillance for the detection of WNV expansion out of the original focus in NYC was established subsequently using mortality in crows as an indicator of WNV activity. In addition, public health departments began using WNV-positive crows to make public health decisions about human risk. A number of other bird species in New York were found infected with WNV, and many may have died from the infection, including in zoological avian collections in the affected area. Thousands of birds, a total of 19 species, died from WNV in the NYC area in 1999, and when the virus reemerged in 2000 and expanded to 12 states, tens of thousands of birds of 54 native bird species died, mostly crows.

The apparent transmission patterns and ecology of WNV that are now occurring within the ecosystems shared by the traditional viruses of SLE and eastern equine encephalitis (EEE) that regularly occur in the United States have become unique to these viruses. The basic transmission cycle for some of the major arboviruses of public health importance in the United States, WNV, SLE, EEE, and western equine encephalitis (WEE), involves birds as the natural hosts and mosquitoes as the primary vectors (Fig. 1). Humans are incidental and dead-end hosts for these viruses; however, except for SLE, the other viruses also cause morbidity and mortality in equines (Fig. 2). West Nile and EEE viruses also cause mortality in birds, although less for EEE than for WNV. Little is known about WNV infections in wild birds, and there is no information available on the effects of this virus on North American bird species or on exotic bird species in zoological collections or endangered species, like the whooping crane. This lack of information on susceptibility and pathogenesis in native birds will hinder efforts to predict possible persistence and reemergence of the virus in affected areas. It will also make it difficult to predict which bird species are at risk from infection, to know which bird species are the best sentinels for detecting virus activity, and to establish effective surveillance networks.

**FIGURE 1.** Basic transmission cycle for some major mosquito-borne arboviruses of birds.
Experimental infection studies were conducted with American crows at the BSL-3 animal facilities at the USGS National Wildlife Health Center to determine their susceptibility and reservoir competence to WNV (R.G. McLean, personal communication). A New York 1999 strain of WNV was inoculated subcutaneously into 10 crows individually held in cages along with 4 control birds in separate cages. All inoculated crows died within seven days, and none of the control birds became infected. Viremias in infected crows were of sufficient titer to infect mosquitoes before the birds died, making them reservoir competent, and high titers of virus were isolated from a variety of tissues. In a second experiment (R.G. McLean, personal communication), nine experimental and seven control crows were housed together in a free-flying arrangement in the same room where they had regular contact with each other. The nine experimental birds were inoculated with the same WNV strain and dosage as in the first experiment, and all nine died between days 5 and 8 postinoculation (PI). Noninoculated control crows began dying at 10 days from the start of the experiment, and 5 of the 7 controls died by day 21 PI. The method of direct transmission between inoculated crows and controls was likely from WNV-laden discharge.
in feces or oral secretions and to other crows through oral ingestion and/or by mutual

grooming of feathers. The significance of this direct transmission of WNV among
crows is unknown at this time. Direct transmission of EEE virus also occurs among
exotic game birds in captivity,11 and EEE and WNV virus may share this method of
transmission (Fig. 3).

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