West Nile Virus in B.C.

Culex pipiens, a WN virus vector

The following article was prepared by Dr. Paul McElligott, R.P.Bio., APBBC Public Issues Chair, using information from a wide range of sources including a popular article by Dr. Robbin Lindsay (Health Canada), information provided by members of the APBBC West Nile Virus Committee (Jennifer Burleigh, Eric Lafroth, Paul Van Poppelen, Gillian Radcliffe, Jane Rchardson), and from the web sites listed.

Overview

In the fall of 1999, an exotic mosquito-transmitted virus, closely related to the North American St. Louis encephalitis (SLE) virus, was first detected in the western hemisphere. The first North American report of West Nile (WN) virus was in New York City, where it caused illness and mortality in birds, notably Corvidae (i.e., crows, ravens, jays, and magpies), as well as humans and horses. Since 1999, WN virus has steadily increased its geographic range and its impact on human and animal health in North America.

Certain *Culex* mosquitoes, which are primarily bird-feeding, appear to drive a cycle of bird-mosquito-bird transmission. However, under the right conditions the virus can "spill-over" to infect horses and people. The spread of WN virus has been facilitated, at least in part, by the movement of infected birds (e.g., during spring migration and short-range local movements during the mosquito season).

From 1999 to 2001, there was a moderate number (20-66) of human cases of WN virus infection in the US, with a 10% mortality rate. A similar trend in mortality was observed in US horse populations, although there were more cases of infection. The situation changed dramatically in 2002, when the number of cases increased to 4,161 in humans (7% mortality), and 14,717 in horses (30% mortality). An explanation for this phenomenal increase in human and horse cases may be that, in 2002, WN virus entered geographic areas that historically have supported intense activity of other arthropod-borne viruses (arboviruses), such as SLE.

In Canada, we have experienced a pattern of virus incursion and spread similar to that observed in the U.S. WN virus was first reported in dead birds and mosquitoes in August, 2001, when virus activity was restricted to the most southerly health units in Ontario. Human infections with WN virus were not reported in 2001. In 2002, WN virus was again documented in southern Ontario, this time 11 weeks earlier than in 2001. WN virus-infected birds were subsequently reported throughout southern Quebec, Manitoba, Saskatchewan, Nova Scotia, and throughout the remainder of Ontario. Surveillance detected WN virus in a total of ten mosquito species, though the majority of the positives were from *Culex* species. About 360 horse cases were reported in Saskatchewan, Manitoba, Ontario and Quebec. Humans infected with WN virus were also reported, with over 500 probable cases and 17 deaths in Ontario. In Quebec the numbers were much lower, with only eight cases of infection and one death. The majority of the human cases in Ontario occurred in the area where WN virus was reported in 2001, which is the same area where an incursion of SLE virus occurred in 1975-1976.

Overall, the WN virus outbreak in 2002 marked the largest mosquito-borne epidemic ever documented in North America. In addition, novel or rarely reported modes of WN virus transmission were demonstrated (i.e., transmission *via* organ transplantation, blood transfusion, breast milk, and intra-uterine). In 2002 there was continued documentation that WN virus can cause disease in a wide range of animals (especially birds) which may have significant implications for some wildlife populations, especially captive and/or endangered species.

To date there have been no reported cases of mosquito-borne WN virus in BC or the Yukon. Will WN virus continue to expand its range in North America, into British Columbia? Probably. Will it have a similar impact on human or animal health as 2002? This is much less clear. In Manitoba, human cases were not reported in 2002, despite relatively intense virus activity in birds and horses.

<u>Vectors</u>

WN virus has been isolated from more than 70 species of mosquitoes worldwide. Although many mosquito species are capable of carrying the WN virus, it is expected that only a small number (13) of species found in BC could serve as suitable vectors (Table 1).

Table 1.

Potential WN virus vectors found in BC (modified from Belton, P. 2003. British Columbia mosquitoes as vectors of West Nile virus. http://www.sfu.ca/~belton/summary.pdf).

Species	Competence	Feeding Preference
Culex tarsalis	+++	birds, mammals
Aedes (Oc.) togoi	+++?	birds, mammals
Cx. pipiens	++	mostly birds
Culiseta inornata	++	birds, mammals
Aedes (Oc.) dorsalis	++	mammals, occasionally birds
Ae. (Oc.) melanimon	++	probably as above
Aedes vexans	+	mostly mammals
Mansonia (Coquilletidia) perturbans	+	birds, mammals
Aedes (Ochlerotatus) canadensis	+	general feeder
Anopheles punctipennis	+	birds mammals
Aedes (Oc) hendersoni	+?	birds? mammals

Ae. (Oc.) sierrensis	+	mammals

Two of these species (*Culex tarsalis*, *Aedes* [*Ochlerotatus*] *togoi*), can be considered highly competent vectors. *Culex tarsalis* is one of the most important mosquito vectors of arboviruses in western North America, where it is responsible for the maintenance, amplification and epidemic transmission of SLE and western equine encephalitis viruses in irrigated and riparian habitats. This species is also a vector of Llano Seco, Turlock, Gay Lodge, and Hart Park viruses, and several species of avian malaria. *Culex tarsalis* is an efficient experimental vector of Japanese and Venezuelan equine encephalitis viruses. It typically breeds in newly-created, sunlit, surface-water pools that are frequently surrounded by grasses and annual vegetation. The larvae tolerate a wide range of water conditions, and may be abundant in agricultural tailwater, alkaline lake beds, fresh and saline wetlands, secondary treated sewage effluent, and oilfield run-off. Permanent water with a fixed depth rarely supports abundant populations, unless it is intermittently perturbed, and excessive organic pollution is not tolerated. In Canada, *Culex tarsalis* overwinter as unfed, mated females that need to blood-feed before they can produce their eggs in the spring. During the spring, when population abundance is low, most females feed on birds shortly after sunset. During late summer, when abundance is high, bird mosquito-avoidance behavior diverts many females to feed on mammals including rabbits, horses, cattle and man. This host shift is important in virus transmission to horses and man. Dispersal is primarily during host-seeking flights (up to 27 km), which average about 100 m a day from breeding sites.

Aedes togoi is an introduced species from Asia, where it is a vector of Japanese B encephalitis, filariasis (*Wucheraria bancrofti*), elephantiasis (*Brugia malayia*), and dog heartworm (*Dirofilaria immitis*). In North America, its distribution is confined to BC and parts of Washington State. *Ae. togoi* breeds mainly in pools near the surf zone in coastal areas, but has also been found some distance inland in stone basins, reservoirs and other artificial containers. Females are strong fliers and persistent biters. Like *Culex tarsalis*, *Aedes togoi* feeds on both birds and mammals.

Management of WN Virus in BC

Details of BC's WN virus strategy have been developed by a provincial working group that includes public health inspectors, physicians, veterinarians, wildlife experts, entomologists and pesticide officers. The multi-agency management group has representation from the BCCDC, regional health authorities and the B.C. ministries of Health; Planning; Water, Land and Air Protection; and Agriculture, Food and Fisheries. BC's WN virus strategy includes seven components:

i) Local governments and regional health authorities are encouraged to plan the most appropriate measures to control mosquitoes that carry WN virus. An integrated pest management (IPM) approach is preferred (see below).

ii) Public education will emphasize measures to prevent localized mosquito breeding in peoples' yards, and prevention of mosquito bites.

iii) Dead crows, collected by regional health authorities around the province, will be sent to the Animal Health Centre in Abbotsford and tested for WN virus. WN virus infection in crows usually precedes any human illnesses, therefore crows that test positive for WN virus will be the first indication the virus is present in an area.

iv) BCCDC and several local governments have purchased traps that will be used to capture samples of adult mosquitoes in all regions of the province. The mosquito samples will be sorted by species and tested for WN virus at BCCDC.

v) Up-to-date summaries of crow and mosquito test results will be available on BCCDC's website (hhtp://www.bccdc.org) throughout the summer. This information will help to guide the public and health and municipal officials in addressing the identified health risks associated with WN virus.

vi) Testing for WN virus will be available to patients through their physicians at BCCDC Laboratory Services. WN virus infections are being made reportable in BC, which requires physicians to notify the medical health officer in their region of all probable and confirmed cases.

vii) Public health officials continue to work with the Canadian Blood Services to protect the blood supply by identifying WN virus infections in persons who may have recently donated or received blood or blood products. BCCDC is also working with the BC Transplant Society to reduce the risk of infection through organ and tissue transplants.

Mosquito Control

Regarding mosquito control, the current policy advocated by the BC WN virus working group is to avoid mosquito control until such time as WN virus is confirmed in dead corvids. Instead of control, the BC Centre for Disease Control (CDC) emphasizes public protection (e.g., use of repellents and appropriate clothing), and private property preventative treatments (e.g., removal of stagnant water sources, such as flooded planters from near homes).

Modifications or insecticide treatments of ditches, swamps, streams, lakes and other water bodies that are not man-made and self-contained must be authorized by the Ministry of Water, Land and Air Protection and/or Fisheries and Oceans Canada. Furthermore, Environment Canada, which issues standard conditions for pesticide application in British Columbia, limits the use of the most commonly-used mosquito larvicide (*Bacillus thuringensis israelensis* [Bti]), to waterbodies that are not contiguous with fish-bearing streams, and to isolated, impounded or stagnant waterbodies adjacent to, but not flowing into, streams and rivers.

In Washington State, the state Department of Ecology advocates an IPM approach to mosquito control, if control is required, through:

i) Minimization of mosquito breeding sites,

ii) Monitoring for high mosquito populations and disease,

iii) Establishing the targeted density of the population based on health, public safety, economic and aesthetic thresholds,

iv) Treating mosquitoes to reduce populations below the targeted threshold using strategies that may include biological, cultural, mechanical, and chemical control methods and that must consider human health, ecological impact, feasibility, and cost effectiveness, and

v) Evaluating the effects and efficacy of pest treatments.

To control mosquitoes around private homes or offices, the Washington DOE's recommended best management practices focus eliminating mosquito breeding sites, using repellents, and protecting domestic animals. The following is a general list of actions that can be taken around private homes and offices. Additional information is available from the sites listed below.

- Empty or turn over anything that holds standing water—old tires, buckets, wheelbarrows, plastic covers, and toys.
- Change water in birdbaths, fountains, wading pools, and animal troughs weekly.
- Remove all human-made potential sources of stagnant water where mosquitoes might breed.
- Drill holes in the bottoms of containers that are left outdoors.
- Clean and chlorinate swimming pools that are not in use and be aware that mosquitoes can breed in the water that collects on swimming pool covers.
- Aerate ornamental pools and use landscaping to eliminate standing water that collects on your residence; mosquitoes can potentially breed in any stagnant puddle that lasts more than 4 days.
- Recycle unused containers—bottles, cans, and buckets that may collect water.
- Make sure roof gutters drain properly, and clean clogged gutters in the spring and fall.
- Fix leaky outdoor faucets and sprinklers.
- Keep all ornamental shrubs and bushes trimmed and pruned to open them up to light and air flow. This will not only give mosquitoes fewer places to hide, but will promote growth and vigor in the plants
- Stock water gardens that have no surface outlet with mosquito-eating fish (e.g., goldfish, mud minnow, stickleback, and perch). Tadpoles, dragonfly larvae, diving beetles, back swimmers, and water boatmen also prey on mosquito larvae.
- Make sure window and door screens are "bug tight." Repair or replace if needed.
- Stay indoors at dawn and dusk when mosquitoes are the most active.
- Wear a long sleeve shirt, long pants, and a hat when going into mosquito-infested areas such as wetlands or woods.
- Use mosquito repellant when necessary, and carefully follow directions on the label.
- To protect your horses and other equines, talk to your veterinarian about the West Nile virus vaccine. The vaccine requires two doses three to six weeks apart, and

immunity may not be achieved until up to six weeks after the second dose. An annual booster should be given a few weeks to a month prior to the start of the mosquito season in your area.

- Veterinarians should be consulted if you have concerns about your household pets or other animals. Repellents may be used in some instances.
- Thoroughly clean livestock watering troughs weekly.
- Do NOT drain or fill wetlands. Wetlands perform at least three classes of functions: hydrologic functions (i.e., flood peak reduction, shoreline stabilization, or groundwater exchange), water quality improvement (sediment accretion, filtration or nutrient uptake), and food-chain support (structural and species diversity components of habitat for plants and animals, including threatened endangered and sensitive species). Given the critical functions wetlands perform, it is not a good idea to drain wetlands as a method for mosquito control. Since most predation on mosquitoes occurs when they are larvae, the best mosquito control is to target the larvae, either by fostering predators native to the area of control (amphibian larvae, aquatic salamanders, small fish) or by selective larvicides such as BTI. Wetland literature suggests that dragonflies are probably the only significant predator on adult mosquitoes. Mosquito "outbreaks" occur in destabilized wetland and stream ecosystems where the predators of the larvae are excluded. It is the wetlands we have changed and tampered with that tend to have the most mosquito problems.

<u>Use of Bti for Mosquito Control</u>

The procedure for determining when to apply Bti in water bodies is comprehensively described in study guides for professional mosquito and blackfly control applicators. As these persons are the only individuals s permitted to apply Bti in public water bodies, it can be assumed that the procedures described are quite rigorously followed. However, Bti (e.g., Aquabac™) is also available to private individuals off-the-shelf for private use. Because the standard "professional" procedures require knowledge beyond that to be expected from most private individuals, it is worthwhile here to point out the pitfalls of indiscriminate BTi application in private water bodies.

Although fairly specific to Diptera (i.e., true flies), Bti is not specific to mosquitoes. It will also affect or kill the larvae of other flies, such as chironomid midges, which inhabit the same water bodies as larval mosquitoes. Larval chironomids can fulfill an important ecological function as primary consumers; in some water bodies, they consume 50-100% of the algal production. Other fly larvae, such as larval crane flies (Tipulidae), some chironomids, and mosquito larvae themselves serve an important ecological role by feeding on detritus (i.e., dead plant and animal matter). Therefore, a simple Bti treatment program may dramatically alter an aquatic ecosystem, potentially resulting in eutrophication and a lack of utilization of organic material.

Before applying Bti for mosquito control, a private individual should carefully consider the potential ecological consequences. It may also be wise to seek advice from regional or provincial health authorities, and consult best management practices (e.g., from

Washington State, see link) regarding when, where, how, and how often to control mosquitoes if reducing the risk of WN virus is the goal of the control program. Often, mosquito species that are major backyard biting nuisances (e.g., *Aedes vexans*) play very little role in WN virus transmission.

Health Risks

West Nile virus can cause West Nile Fever. Other viruses in the same family include dengue virus, yellow fever virus, and the viruses responsible for SLE and Japanese encephalitis. Most people infected with WN virus will experience no symptoms at all. About 20% of those infected with WN virus will develop mild flu-like symptoms lasting a week or less. Symptoms typically include fever, headache, and body aches; a rash on the trunk of the body and swollen lymph glands may also be present. In less than one percent of cases, WN virus can cause meningitis (inflammation of the lining of the brain and spinal cord) or encephalitis (inflammation of the brain). For unknown reasons, people over 50 years of age are most at risk for severe illness.

Environmental Risks

According to Dr. Robbin Lindsay, the Head of Field Studies at the Canadian Centre for Human and Animal Health, the environmental risks posed by pesticides and wetland habitat destruction, in the context of ongoing WN virus control efforts, have been greatly overrated. Large-scale pesticide applications are few, and are confined to areas with high human population densities. Vast quantities of toxic pesticides are not being sprayed over parks or sparely-populated areas because this is not even remotely cost-effective, and municipalities do not tend to have funds available for this sort of thing. Similarly, large-scale wetland poisoning and drainage are not occurring, because they are ineffective, and simply too expensive.

Dr. Lindsay believes that WN virus in humans in western Canada is likely to mainly be a problem in populated areas, since this is where the most competent vector, *Culex tarsalis*, tends to be most common. There is little to fear in less populated areas, where *Aedes* and other mosquito species predominate.

Further Information

For further information about WN virus, the APBBC recommends that interested members should consult official information sources, such as the Health Canada and BCCDC web sites. The following information sources are available on-line:

The BC Centre for Disease Control's WN virus site:
http://www.bccdc.org/content.php?item=148&PHPSESSID=d7d97f48d7a404836201b30054784294

Health Canada's WN virus site:
http://www.hc-sc.gc.ca/english/westnile/index.html

The Canadian Cooperative Wildlife Health Centre's WN virus surveillance program site:
http://wildlife.usask.ca/english/frameWestNile.htm

The American Mosquito Control Association's WN virus site:
http://www.mosquito.org/WN virusteaser/WN virusteaser.htm

The Centers for Disease Control WN virus site:
http://www.cdc.gov/ncidod/dvbid/westnile/index.htm

The Cornell University Environmental Risk Analysis Program WN virus site:
http://environmentalrisk.cornell.edu/WN virus/default.cfm

Ornithological Society of North America WN virus site:
http://www.nmnh.si.edu/BIRDNET/WN virus.html

US National Biological WN virus information site:
http://westnilevirus.nbii.gov/wildlife.html

King County, Washington WN virus site:
http://www.dnr.metrokc.gov/dnradmin/press/2002/0916wnv.htm

Washington State Department of Ecology best management practices for mosquito control:
http://www.ecy.wa.gov/programs/wq/pesticides/final_pesticide_permits/mosquito/mosquitocontr-bmpsfinal.pdf

Health Canada municipal mosquito control guidelines:
http://212.187.155.84/wnv/Subdirectories_for_Search/Glossary&References_Contents/MiscellaneousContents/73MosquitoCanada/Canada_Municipal_Mosquito_Control_Guidelines.pdf

Final Comment (from *Public Panic over West Nile Virus*, by Michael Gochfeld):

"In weighing the risks and benefits of mosquito control, we should also consider the disease itself and the risk to the human population. The media always paired the words "lethal" or "deadly" with "West Nile" or "encephalitis", reinforcing in the public's mind the danger from the disease. But it would be equally appropriate to characterize West Nile Virus infection as "inapparent", "usually asymptomatic", or "occasionally serious." Seven deaths in a population of over 10 million people over a one month period is certainly tragic, but pales besides the number of deaths from many other diseases that are addressed less aggressively."