# Teacher Guide: West Nile Virus Education Package

## Summary

**Target class:** Science and Technology 11
**Module:** Science-Health
**Prescribed learning outcome:** D1

**Description:** The goal of this resource package is to familiarize students with Zoonotic diseases in general, and specifically educate them about mosquito and tick borne diseases in BC. The main topic in this unit is West Nile virus. There are 5 lessons in this unit which is designed to fit within the following BC prescribed learning outcome (PLO):

**BC Ministry of Education PLO** (Science and Tech 11-Science module-Health-D1)
Students should be able to:
"Describe how current medical technologies are used to address different types of illnesses with respect to transmission, detection, prevention, and treatment.

**Student Achievement Indicators:**

1. Describe how diseases and illnesses can be transmitted within a population (e.g., STI, SARS, flu, food poisoning)
2. List the technologies used to identify and treat basic types of illnesses (e.g., viral, bacterial, genetic) and injuries
3. Outline methods and technologies involved in the prevention of the transmission of various types of illnesses"

Ministry of Education. (2008) Science and technology 11, Integrated Resource Package 2008. Retrieved from http://www.bced.gov.bc.ca/irp/irp_sci.htm

West Nile virus (WNV) is an emerging infectious disease which has recently arrived in BC. WNV is of interest particularly because it resides in birds and mosquitoes, and can cause serious disease in humans. It is also a preventable disease, so public health has a role in educating people about WNV risk reduction. This package was created to teach high school students about WNV and personal protective measures. It is intended for teachers who are looking to supplement their Science and Technology 11 Health module.

Upon the completion of this module, students will be able to: (1) find, interpret and evaluate health related internet data sources, (2) apply that information to estimate ones own risk of disease and (3) take responsibility for protecting themselves from disease by recognizing that daily activities and behavior can change the risk of contracting some diseases.

## Contents of this Guide:

# 1. Lessons

## **Lesson 1:** Introduction to zoonotic diseases

**BC Ministry of Education PLO** (Science and Tech 11-Science module-Health-D1)
**Student Achievement Indicators:**

1. Describe how diseases and illnesses can be transmitted within a population (e.g., STI, SARS, flu, food poisoning)

Ministry of Education. (2008) Science and technology 11, Integrated Resource Package 2008. Retrieved from http://www.bced.gov.bc.ca/irp/irp_sci.htm

*a.* **Search for Previous Knowledge:** What do we know about zoonotic diseases? *(approx. 20 minutes)*

Before beginning the unit, the teacher can describe what a zoonotic disease is. Then students can share their prior knowledge of zoonotic diseases. The teacher may use the "Think, Pair, Share" technique. First ask the students to individually record a response to the question; what do I know about zoonotic diseases? Pair the students to discuss their responses, and finally ask the pair to share with the class. Encourage students to share personal stories, to think about movies, advertisements or books they have read. Create a list of diseases on the board or a piece of chart paper, which can be used in lesson 2. This activity can help the teacher assess the students' knowledge and perceptions of zoonotic diseases. The background information section on Zoonoses contains a List of Zoonotic Diseases can be used as a resource.

*b.* **Article Review:** How can WNV affect us? *(approx. 2 hours)*

Provide the students with a copy of the CBC article "West Nile: what you need to know" (CBC, 2008) and the Article Summary sheet. The Article Summary asks students to summarize the main points in the article and to reflect on how it affects their lives. The teacher may model how to summarize the first several points with the class. The Article Summary Evaluation can be used for peer evaluation of the student's work. During the peer evaluation, the teacher can ask students to focus on discussing positive aspects of the students work and what needs to be improved on in their next article summary.

Ask students to repeat the process of the article summary using another article on a zoonotic disease. Students may use the evaluation from their original article summary to improve their second article summary.

**Resources:**

- List of Articles
- National Geographic Society. (2010). Virus Crisis (Video). Retrieved from http://video.nationalgeographic.com/video /player/science/health-human-body-sci/health/virus-crisis-sci.html
- CDC. (2007). Introduction (Video, *2 min*), Retrieved from http://www.cdc.gov/ncidod/dvbid/westnile/wnv_communityVideo.htm
- Ministry of Environment. (2007). Diseases you can get from Wildlife. Retrieved from http://www.env.gov.bc.ca/wld/wldhealth/diseases/index.htm

# Article Summary

Name: Block: Date:

A. Reference information
Title:

Author:

Source (publication name, website address):

Date (if online, date accessed and date posted):
Page (journal article only):

B. Summary
Write one sentence which describes the main point in the article:

Five supporting facts (point form)
1.

2.

3.

4.

5.

C. Analysis
Write a paragraph, which includes (not limited to):

- □ What is your personal response to the ideas in the article (example: are you shocked? Why?)
- □ How is the disease transmitted in the population?
- □ How might this impact your life? (Will you change any of your behaviors? Why?)
- □ How is this related to information you already know about human health and the environment?

# Article Summary Peer Evaluation

Name:
Peer Evaluator:

| | 4 | 3 | 2 | 1 |
|---|---|---|---|---|
| **Knowledge (Summary)** | Summary demonstrates that the student has an excellent understanding of the information provided in the article about a disease | Summary demonstrates that the student has an good understanding of the information provided in the article about a disease | Summary demonstrates that the student has an satisfactory understanding of the information provided in the article about a disease | Summary demonstrates that the student has some understanding of the information provided in the article about a disease |
| **Transformation (Analysis)** | Analysis appropriately applies concepts to their own lives | Analysis applies concepts to their own lives | Analysis attempts to apply concepts to their own lives | Analysis shows understanding of the concepts. |

Positive point:

Positive point:

Suggestion for improvement:

# List of Articles

1. CBC In Depth: "West Nile: What you need to know" http://www.cbc.ca/technology/story/2008/08/19/f-westnile.html
2. Georgia Straight "West Nile virus detected in Okanagan region of British Columbia" http://www.straight.com/article-248965/west-nile-virus-detected-okanagan-region-bc
3. CBC "West Nile virus infections plummet thanks to cool summer" http://www.cbc.ca/health/story/2009/09/10/f-west-nile-virus-human-cases.html
4. CBC 2009, "West Nile cases chilled" http://www.cbc.ca/health/story/2009/08/07/west-nile-virus.html
5. Vancouver Sun "B.C. records first native source of West Nile virus" http://www.vancouversun.com/health/records+first+native+sourct+West+Nile+virus/1920900/story.html
6. CBC "Lyme disease: Tiny tick, big problem" http://www.cbc.ca/health/story/2009/06/04/f-lyme-disease-ticks.html
7. BCCDC News release: "Lyme disease in BC" http://www.bccdc.ca/resourcematerials/newsandalerts/healthalerts/2008HealthAlerts/LymeDiseaseBC.htm
8. Delta Optimist "West Nile close but virus yet to make appearance" http://www2.canada.com/deltaoptimist/news/story.html?id=baeae6c9-0485-4227-bb94-fbbb96cab787
9. CBC "Disease without borders" (Malaria) http://www.cbc.ca/health/story/2008/04/25/f-health-malaria.html
10. CBC "Travelers warned after rare virus surfaces in Canada, U.S." (Chikungunya) http://www.cbc.ca/health/story/2006/09/29/chik-fever.html
11. CBC "Gaps found in dengue fever's armor" http://www.cbc.ca/health/story/2009/04/22/dengue-fever.html
12. CBC "Climate change could bring tropical diseases to Ontario: report" http://www.cbc.ca/canada/story/2002/10/24/malaria_021024.html
13. Globe and Mail "West Nile recovery takes a year: study" http://www.theglobeandmail.com/life/west-nile-recovery-takes-a-year-study/article704439/
14. Globe and Mail "Denial is no defense against West Nile" http://www.theglobeandmail.com/news/national/denial-is-no-defence-against-west-nile/article705088/
15. Examiner "Travel health: dengue fever" http://www.examiner.com/x-7707-Tampa-Disease-Prevention-Examiner~y2009m7d21-Travel-health-dengue-fever
16. Guardian "Will a warmer world make us sicker" http://www.guardian.co.uk/environment/2009/aug/03/climate-change-disease
17. CMAJ "West Nile rates soar in 2007" http://www.cmaj.ca/cgi/content/full/177/12/1489?maxtoshow=&HITS=10&hits=10&RESULTFORMAT=&fulltext=west+nile+virus&andorexactfulltext=and&searchid=1&FIRSTINDEX=0&sortspec=date&resourcetype=HWCIT
18. CMAJ "Climate change and infections diseases in North America: the road ahead" http://www.cmaj.ca/cgi/content/abstract/178/6/715?maxtoshow=&HITS=10&hits=10&RESULTFORMAT=&fulltext=west+nile+virus&andorexactfulltext=and&searchid=1&FIRSTINDEX=0&sortspec=date&resourcetype=HWCIT
19. CMAJ "The emergence of lyme disease in Canada" http://www.cmaj.ca/cgi/content/full/180/12/1221?maxtoshow=&HITS=10&hits=10&RESULTFORMAT=&fulltext=lyme+disease&andorexactfulltext=and&searchid=1&FIRSTINDEX=0&sortspec=date&resourcetype=HWCIT
20. CTV "B.C. lab to provide quick testing for animal diseases" http://www.ctv.ca/servlet/ArticleNews/story/CTVNews/20081212/bc_lab_081212/20081212/
21. CTV "Canadians first to illustrate Lyme disease bacterium" http://www.ctv.ca/servlet/ArticleNews/story/CTVNews/20080702/lyme_disease_080702/20080702/
22. CTV "Mosquitoes match wing beats before mating" http://www.ctv.ca/servlet/ArticleNews/story/CTVNews/20090109/mosquito_buzz_090109/20090109/
23. CTV "Will cutting mosquito life span prevent malaria?" http://www.ctv.ca/servlet/ArticleNews/story/CTVNews/20090102/mosquitoes_malaria_090102/20090102/

Last updated: 6/8/2010

## **Lesson 2:** West Nile virus transmission cycle

**BC Ministry of Education PLO** (Science and Tech 11-Science module-Health-D1)
**Student Achievement Indicators:**

1. Describe how diseases and illnesses can be transmitted within a population (e.g., STI, SARS, flu, food poisoning)

Ministry of Education. (2008) Science and technology 11, Integrated Resource Package 2008. Retrieved from http://www.bced.gov.bc.ca/irp/irp_sci.htm

a. **Predicting:** How is WNV transmitted? (*approx.30 minutes*)

Begin by asking students to create a hypothesis of how WNV is transmitted based on information from lesson 1. They can create a labeled diagram or write a flow chart. Students should include the following components: Human, horse, bird, mosquito, and the virus. They should describe what is happening in each stage of the cycle. Students are not expected to know exact transmission cycle, but simply start thinking about the cycle. Next, have students read the WNV Transmission Cycle handout. They can use this handout to revise their original hypothesis of the cycle.

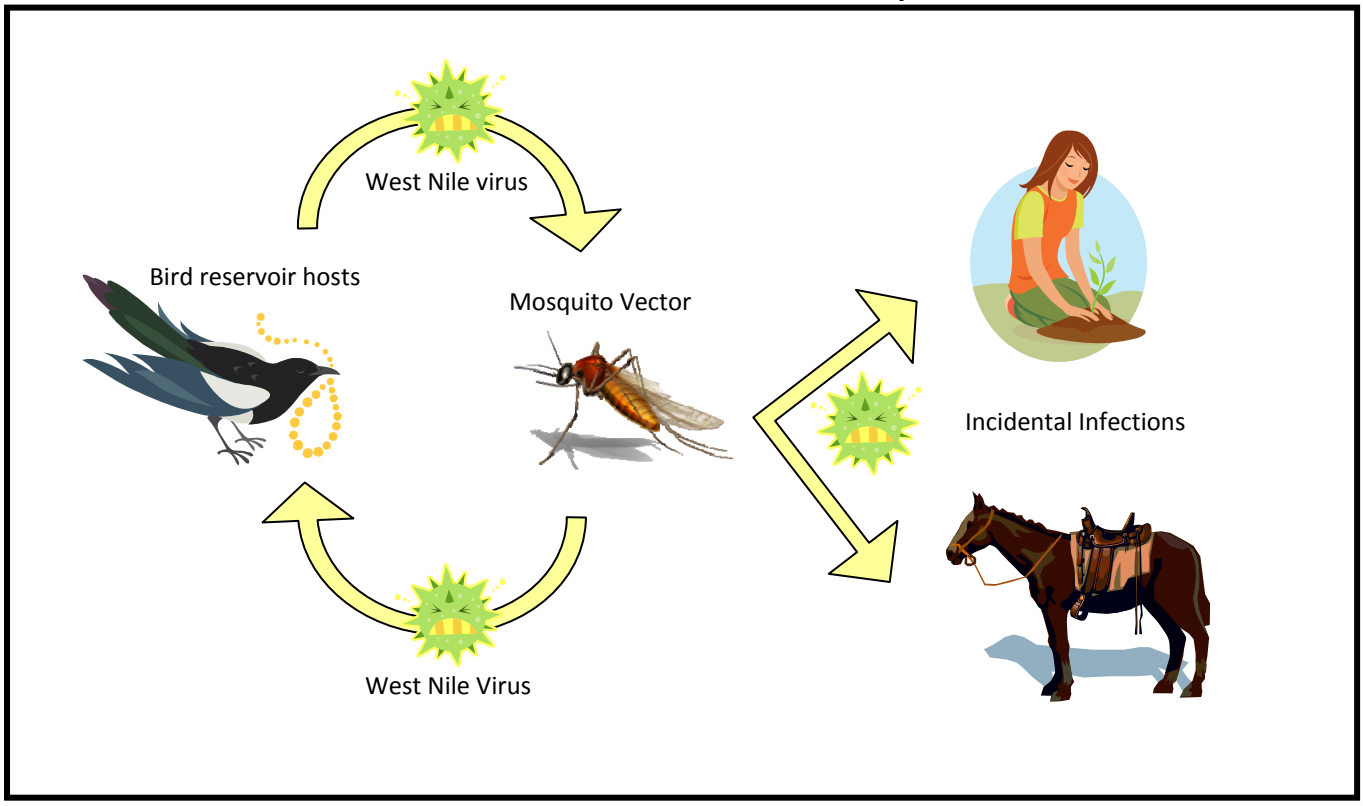
b. **Venn diagram:** How is WNV transmitted compared to another zoonotic disease? (*approx. 45 minutes*)

Ask students to research another human/animal disease transmission cycle to compare to WNV in a Venn diagram. Students can choose from the list of zoonotic diseases they created while brainstorming during lesson 1 or the partial List of Zoonoses provided in the background information. A Venn diagram template is provided in the Transmission Cycle Comparison worksheet. Teachers can suggest that students consider the following: seasonality, types of animals, mode of transportation, timing, distribution, and risk to humans. Students can add a copy of their research to their Venn diagram before beginning their self-evaluation using the Transmission Cycle Comparison Self Evaluation.

**Resources:**

- WNV transmission cycle diagram and description
- CDC. (2007). How the Virus works (Video), Retrieved from: http://www.cdc.gov/ncidod/dvbid/westnile/wnv_communityVideo.htm
- BCCDC (2010). Diseases and conditions. Retrieved from http://www.bccdc.ca/dis-cond/default.htm
- Public Health Agency of Canada. (2008). List of Non-enteric Zoonoses. Retrieved from http://www.phac-aspc.gc.ca/zoono/index-eng.php#nonenteric
- World Health Organization. (2010). Zoonoses and Veterinary public health. Retrieved from http://www.who.int/zoonoses/en/

# West Nile Virus Transmission Cycle Handout




**Transmission Cycle**

Mosquitoes become infected with West Nile virus (WNV) when they feed on the blood of a bird that carries the virus. An infected mosquito can transmit the virus back to another bird, horse or person when they bite. The propagation of WNV occurs between birds and mosquitoes. Human and other animal infections are considered incidental (or "dead end") because they do not pass the virus back to mosquitoes. WNV is not spread through person-to-person contact such as touching, coughing, sneezing or drinking from a shared cup; however people should avoid handling dead animals or birds with their bare hands.

**How likely am I to get sick with WNV from one mosquito bite?**

In areas where mosquitoes do carry the virus, usually only a small number of mosquitoes will be infected. Most of the mosquitoes that bite humans are not able to carry WNV, but there is no easy way to tell the difference between ones that can and ones that can't so it is important to prevent any mosquito bite.

**Who is at risk for WNV?**

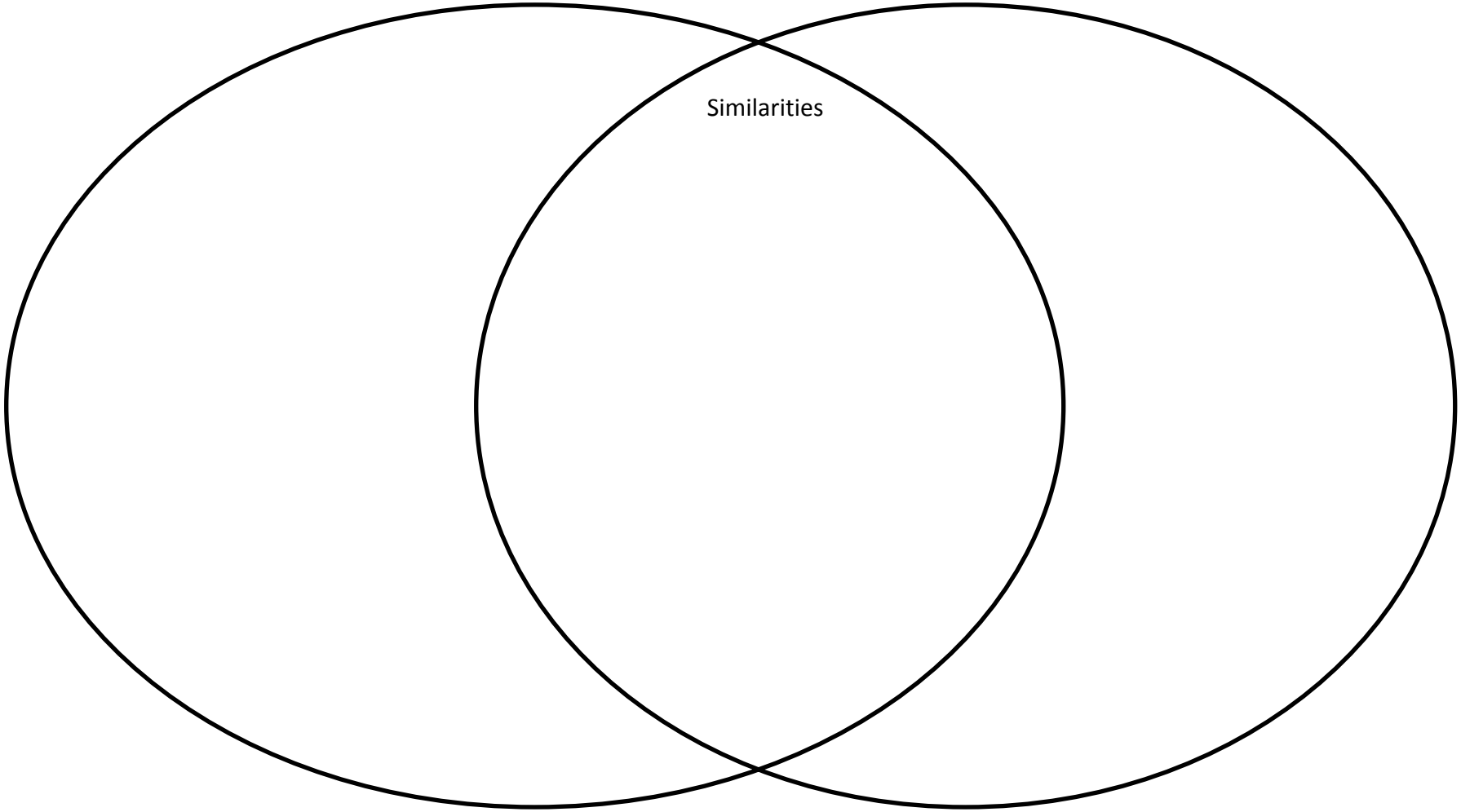
Everyone who is outside during the summer months gardening, golfing, walking, camping etc. is at risk once the virus is in the area, and should take precautions to avoid mosquito bites. The chances of having a severe illness are greater in older people and those with a weakened immune system.

source: www.bccdc.ca/westnile

# Transmission Cycle Comparison

Name: Block: Date:

Instructions: Research a zoonotic disease transmission cycle and compare it to the West Nile virus transmission cycle. Include differences and similarities such as seasonality, animals, modes of transmission, timing, areas of the world and risk to humans. Include a page of background information on the disease you researched for this comparison, and your source of information.



# Transmission Cycle Comparison- Self Evaluation

Name: Block: Date:

Reflect on your Venn diagram of transmission cycles and answer the following questions.

1. How well did you demonstrate your learning?

| | 4 | 3 | 2 | 1 |
|---|---|---|---|---|
| Knowledge | Effectively lists many clear and accurate similarities and differences between the transmission cycles | Lists accurate similarities and differences between the transmission cycles | Lists some obvious similarities and differences between the transmission cycles | Lists few similarities and differences between the transmission cycles |

2. What are you most proud of in the assignment? Why? How can this help you in future assignments?

3. What could you improve on in this assignment? Why?

4. How would you change this assignment in the future?

## **Lesson 3:** Prevention of West Nile virus

**BC Ministry of Education PLO** (Science and Tech 11-Science module-Health-D1)
**Student Achievement Indicators:**

3. Outline methods and technologies involved in the prevention of the transmission of various types of illnesses

Ministry of Education. (2008) Science and technology 11, Integrated Resource Package 2008. Retrieved from http://www.bced.gov.bc.ca/irp/irp_sci.htm

*a.* **Video:** Preventing and protecting ourselves from WNV (*approx. 15 minutes*) Catch student's interest in personal protection and prevention of WNV by reading the online book "The Summer the Town Bit back" (Feinman and Lamb, 2003). This animated book is informative but presented at an elementary level. The teacher can alternatively use the CDC video: Human Disease and Prevention (CDC, 2007). As a class, discuss the main prevention methods outlined in either video. *Note: Since there is no specific treatment or cure for WNV, prevention is especially important.*

b. **Mapping:** Is there mosquito habitat around our home? (*approx. 20 minutes*) Ask students to create a bird's eye view map of their home and yard (or the school property) using the Risk Assessment Map template and identify areas that may be mosquito habitat. On the map students should highlight areas, which can be used for mosquitoes to develop and write a paragraph describing ways to reduce contact with mosquitoes around the home. Use the WNV brochure (BCCDC, 2010) for an example to show students areas around the home that may increase mosquito populations or ways that mosquitoes and families may interact. To evaluate the assignment you may use the Risk Assessment Map Self Evaluation.

c. **Optional extension activities:** Take a tour of school grounds to identify and discuss habitat sources and ways to reduce manmade mosquito habitat that is identified. Alternatively, students could research different types of community-based intervention measures and debate the pros and cons of each method.

**Resources:**

- BCCDC. (2010). West Nile Virus Brochure & Insect Repellant Poster. Retrieved from http://www.bccdc.ca/dis-cond/a-z/_w/WestNileVirus/educmat/default.htm
- Public Health Agency of Canada. (2004). WNV Factsheet Retrieved from http://www.phac-aspc.gc.ca/wn-no/materials/factsheet-eng.php
- Community Based intervention measures, and How to prevent mosquitoes from developing on your property
- Ellen Feinman and Sandra Lamb. (2003). The Summer the Town Bit back. Tumbleweed Press. Retrieved from http://www.tumblebooks.com/syndication/excite/town1.swf
- CDC. (2007). Human Disease (Video) and Prevention (Video), Retrieved from http://www.cdc.gov/ncidod/dvbid/westnile/wnv_communityVideo.htm Note. the repellant permethrin is not registered for use in Canada)

# Risk Assessment: Map your home or school

Name: Block: Date:

Instructions: Draw a **labeled** map of your home and surrounding property. Then highlight all of the mosquito habitats. Finally write a short **paragraph** identifying the ways that you can reduce mosquito habitat and your contact with mosquitoes. (Include at least **7 actions** or changes you can make)

A. Mosquito habitat map of _____

B. Write a paragraph to outline the ways you can reduce mosquito habitat around your home, and protect your family from mosquito bites (at least 7 actions):

# Risk assessment self evaluation

Name:
Block:
Date:

**Checklist for map:**

- □ Title
- □ Legend
- □ North arrow
- □ Labels
- □ Detail
- □ Use of ruler
- □ Identified mosquito habitats

**Rubric for map and paragraph:**

| | 5 | 4 | 3 | 2 | 1 |
|---|---|---|---|---|---|
| Concepts | Displays excellent knowledge of transmission prevention in map and paragraph | Displays strong knowledge of transmission prevention in map and paragraph. | Displays satisfactory knowledge of transmission prevention in map and paragraph | Displays unsatisfactory knowledge of transmission prevention in map and paragraph | Displays poor knowledge of transmission prevention in map and paragraph |

## **Lesson 4:** Surveillance and testing for WNV

**BC Ministry of Education PLO** (Science and Tech 11-Science module-Health-D1)
**Student Achievement Indicators:**

5. List the technologies used to identify and treat basic types of illnesses (e.g., viral, bacterial, genetic) and injuries

Ministry of Education. (2008) Science and technology 11, Integrated Resource Package 2008. Retrieved from http://www.bced.gov.bc.ca/irp/irp_sci.htm

a. **Graffiti:** Hypothesizing about how to Identify WNV (*approx. 15 minutes*)

Before learning about the technologies used to identify WNV, the students can use the Graffiti technique to predict, hypothesize and share their prior knowledge. For the Graffiti exercise, the teacher puts 4 pieces of chart paper around the class with the following headings; Human Immune Response and Serology, The Mosquito Trap, Horses and WNV, Mosquito Vectors in BC, and Bird surveillance & testing. The students are then placed in groups and given a felt pen. The groups will visit each chart paper with a different heading and add a comment, diagram, prediction or question to the chart paper. As the activity continues, encourage students to also respond to other comments. Following the activity, the teacher can lead a discussion (identify gaps and praise suggestions) on each topic using the comments on the chart paper.

b. **Posters:** Identifying WNV in humans, animals and insects (*approx. 80 minutes*)

To learn about different technologies used in surveillance and testing of WNV, students will take notes on the topic handouts and create a poster to share with the class. First create groups of 2. Ask each group to pick one of the 5 topics, and read the associated handout. While reading the related material, they may take notes using the WNV Testing and Surveillance Notes template. Some vocabulary may be unfamiliar to students so, the teacher can encourage the students to write down questions on the template and use resources such as a dictionary or the internet to answer their questions. Students can then record their information on the poster to share with the class. These posters can be placed around the room for other students to examine. Have the students rotate to each to each poster and record the key information. After the students have taken notes on a poster, ask them to help evaluate the poster by leaving one compliment and one question on a sticky note beside the poster.

**Resources:**

- Primary resources included in the five topic handouts
- Background materials: Surveillance in BC
- CDC. (2007). Conclusion (Video), Retrieved from http://www.cdc.gov/ncidod/dvbid/westnile/wnv_communityVideo.htm
- Public Health Agency of Canada. (2009). West Nile Virus Monitor- Surveillance. Retrieved from http://www.phac-aspc.gc.ca/wn-no/surveillance-eng.php
- CDC. (2003). Epidemic/Epizootic West Nile Virus in the United States: WNV Guidelines for Surveillance Prevention and Control. Retrieved from http://www.cdc.gov/ncidod/dvbid/westnile/resources/wnv-guidelines-aug-2003.pdf

# WNV Testing and Surveillance Notes

Name (s):

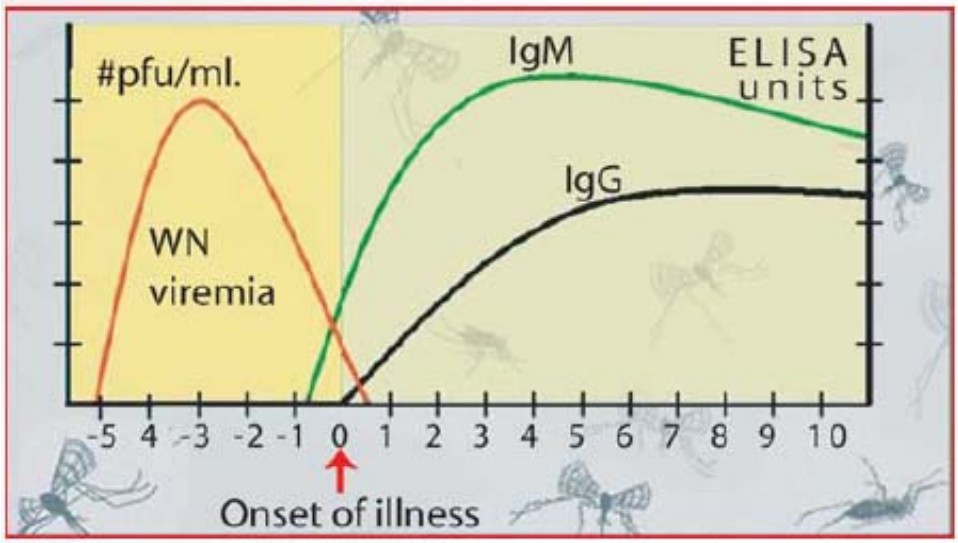
Topic:

| Key Information | Questions (Information or vocabulary that is unclear) | Explanations/ Definitions |
|---|---|---|
| | | |

**Topic 1: Human Immune Response and Serology.**

Human testing for WNV in BC occurs through routine testing of blood and organ donations, as well as testing blood samples from doctors. Testing the blood supply is one way to get a better idea of the amount of WNV infection in BC, since only a small portion of people who acquire WNV get sick and see their doctor. A doctor may choose to perform testing on a suspected case of WNV. Then a blood sample is sent to the provincial laboratory at BCCDC, where it undergoes a series of tests. Patients are classified as a case of West Nile non-Neurological Syndrome (WN-non-NS) or West Nile Neurological Syndrome (WNNS) according to both self-reported symptoms and clinical information collected from the patient's physician. Cases would be further categorized as probable or confirmed depending on the level of specificity associated with the laboratory test performed. (BCCDC, 2009)

There are a variety of tests which are used in BC including Serological tests by enzyme immunoassay (EIA), polymerase chain reaction (PCR), hemagglutinin inhibition (HI), and plaque reduction neutralization tests (PRNT) (PHSA, 2010). Serological testing (EIA) measures the antibody (immunoglobulin) response from an infection and can determine if the infection occurred recently or in the past. The graph below shows how the antibody response behaves after infection and how different test IgM and IgG results can determine how recent the infection occurred. IgM antibodies will appear 7-10 days after someone has been infected and IgG antibodies appear 2-3 weeks later, rising for several weeks (PHSA, 2010). To complete serological testing, two blood samples must be taken 2-3 weeks apart to be able to determine how the IgM and IgG levels are changing in relation to each other (PHSA, 2010).




"Illustration of the phasing of the development of viremia, onset of illness, and development of the antibody response in West Nile virus infection" (Hazell, 2004)

Unfortunately EIA testing can only determine infection by a Flavivirus, but not specifically WNV. There are other diseases (Flavivirus) which would also trigger a positive EIA test result including the tropical mosquito borne disease; Dengue. To get confirmation of WNV other tests such as PCR, HI, or PRNT must be performed. (PHSA, 2010)

**FAQ:**

1) What does IgG and IgM mean?

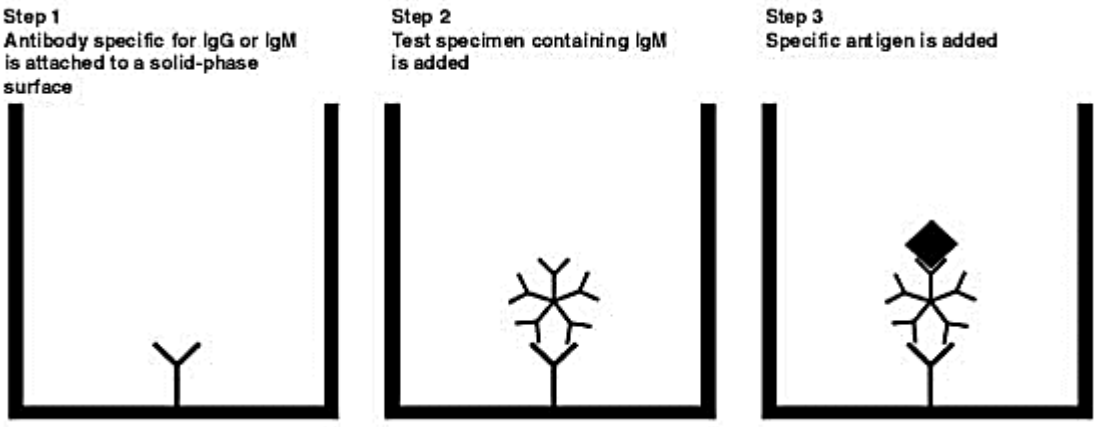
"IgG stands for immune globulin G and IgM stands for immune globulin M. Both are types of antibodies. IgM is generally produced the first time a host is exposed to an antigen. IgM will eventually decline, and then the host produces IgG, which lasts much longer. Detection of IgM indicates acute or primary infection, IgG indicates past infection or immunity.

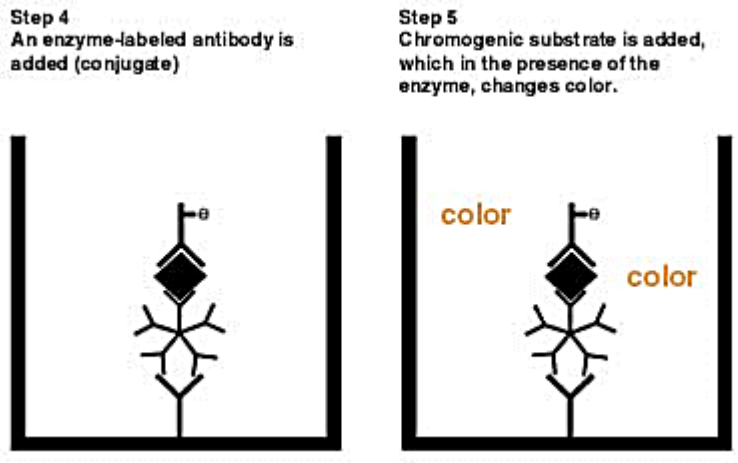
What are paired sera, and when are they needed?
Serum (sera is plural) is the liquid portion left after the cells are removed from whole blood. Serum contains antibodies. Paired sera are required when the only test available to detect a certain disease can only detect specific IgG or total antibody. Sera drawn from a patient 14-21 days apart are tested simultaneously. If there is a significant rise in titer (amount of antibody), significant decrease in titer, or seroconversion, the patient is considered to have a current infection."
(Texas Dept of Health Services, 2004a)

2) What are Enzyme Immunoassays (EIA)

"There are two general approaches to diagnosing diseases by immunoassays: testing for specific antigens or testing for antigen-specific antibodies. Enzyme linked immunosorbent assays (ELISA), also known as enzyme immunoassays (EIA), are tests designed to detect antigens or antibodies by producing an enzyme triggered color change.

A capture EIA is designed to detect a specific type of antibody, such as IgG or IgM.






1. *Antibody specific for IgG or IgM is attached to a solid-phase surface (plastic bead or microtiter well)*
2. *Test specimen containing IgG or IgM is added*
3. *Specific antigen is added*
4. *An enzyme-labeled antibody specific to the test antigen is added (conjugate)*
5. *Chromogenic substrate is added, which in the presence of the enzyme, changes color. The amount of color that develops is proportional to the amount of antigen-specific IgG or IgM in the test specimen.*

A four fold change in antibody titer or the presence of WN-specific IgM in CSF confirms a recent infection. Reactive IgM results in a single serum sample is considered only presumptive evidence of recent infection, because the IgM can be detected for months after WN infection."
(Texas Dept of Health Services, 2004b)

**Resources:**


- [PHSA] BCCDC Public Health & Microbiology Reference Laboratory. (2010). Guide to programs and services: Zoonotic Diseases & Emerging Pathogens (ZEP) Program. Retrieved from http://www.phsa.ca/AgenciesAndServices/Services/PHSA-Labs/About-PHSA-Labs/BCCDC-Public-Health-Microbiology-Lab.htm
- BCCDC Epidemiology Department. (2009). BC West Nile Virus Surveillance Program Report. Retrieved from www.bccdc.ca/westnile
- Hazell, S. (2004). Serological diagnosis of West Nile Virus. Medical Laboratory Observer. 36(6). Retrieved from http://www.mlo-online.com/articles/june04.pdf
- Texas Dept of Health Services. (2004a). Frequently Asked Questions about Serology. Retrieved from http://www.dshs.state.tx.us/LAB/sero_faqs.shtm
- Texas Dept of Health Services. (2004b). Enzyme Immunoassays. Retrieved from http://www.dshs.state.tx.us/LAB/serology_eia.shtm


**Additional sources of information**


- PHAC. (2008). National Surveillance for West Nile Virus, Diagnostic Test Criteria. Retrieved from http://www.phac-aspc.gc.ca/wnv-vwn/hmncasedef-eng.php
- Bookrags. (2005). Antigens and Antibodies. Retrieved from http://www.bookrags.com/research/antigens-and-antibodies-wap/

## Topic 2: The Mosquito Trap

Mosquito surveillance in BC consists of trapping and testing in high WNV risk areas. The gravid trap is one type of mosquito trap that is sometimes used. Gravid traps use stagnant water to attract females who are looking for a spot to lay their eggs. The mosquito trap that is currently used in BC is the CDC miniature light trap as shown in the images below. This trap uses a variety of attractants to lure adult mosquitoes into the trap. A black light bulb is used to attract mosquitoes to the trap. Dry ice is also used as an attractant, because as it sublimates, $CO_2$ is released which mimics animal respiration and attracts mosquitoes. There are two physical mechanisms, a fan and a trap door that ensure mosquitoes are captured in the collection chamber. After a night of the trap running, the mosquitoes must be collected and transported to the lab for testing. To facilitate the transfer of mosquitoes from the trap to the shipping containers, they are put in the freezer for fifteen minutes which temporarily knocks them out. It is important that the mosquitoes remain alive until they are frozen, which improves the condition of the specimen for identification and testing. The purpose of mosquito surveillance is to test for WNV but an additional benefit is to determine the distribution and abundance of the species which are known to carry WNV (such as Culex).


1. Juice Cooler
2. PVC tubing
3. Black light
4. Battery in bag
5. Collection chamber

Recommended set up of CDC Light Trap

*CDC light trap with dry ice container*

"Once collected the insects can then be identified and counted to provide a statistical representation of the population density and type of species in any given area. Collecting a sample of mosquitoes using this light trap can provide invaluable information necessary for evaluation and control of the mosquito population."
(Curtis Dyna-Fog ltd, 2010)

Trap Placement

"Proper location of light traps is particularly important. In general, the best catches are made where cover is good and the humidity is relatively high. Locations a short distance into the margins of wooded areas and swamps are very desirable; traps over open water or in open pasture are typically less productive. Traps should be suspended 5-6 feet above the ground, preferably 30 feet or more from buildings. To be avoided are areas near other sources of artificial light, sites exposed to strong winds, places near buildings housing animals, or those areas exposed to industrial fumes and smoke. For mosquito control operations, one or more traps should be located between known breeding sources and inhabited areas; others are best located in critical spots such as near residential and recreational sites. A single trap usually reflects mosquito flight activity within a few yards of its location. A trap may represent an area as large as a block, but this information is not always reliable, and a sufficient number of traps must be utilized to assure a representative sample. The actual number required will depend upon a number of factors including the degree of accuracy required, the manpower available, size of area involved, etc. If a site fails to produce the expected number of mosquitoes, judging from collections in other traps in the area, the trap is relocated. Sometimes a shift of only a few yards makes a considerable difference in the number of mosquitoes attracted."
(John W. Hock Co, 2004)

Mosquito testing is performed by using the polymerase chain reaction (PCR) technique:

Once the mosquito submissions arrive at the lab, they are separated into sex and taxonomic groupings: 1) Aedes, 2) Anopheles, 3) Coquillettidia, 4) Culiseta and 5) Culex. Mosquitoes are sorted on a chill table (to prevent denaturation of any viral RNA) and identified to genus or, in the case of Culex, to species. Only female Culex mosquitoes are tested for the virus in groups of up to 50 mosquitoes per pool, by PCR. The remaining mosquitoes are identified but not tested.

**Resources:**

- Curtis Dyna-Fog ltd. (2010). Mosquito light traps. Retrieved from http://dynafog.com/other/mosquito_light_trap/
- John W. Hock Co. (2004). Manual for CDC Miniature Light Trap. Retrieved from http://www.johnwhock.com/download/manuals/instr_512_CDCMiniature.pdf
- BCCDC Epidemiology Department. (2009). BC West Nile Virus Surveillance Program Report. Retrieved from www.bccdc.ca/westnile

**Additional sources of information:**

- American Mosquito Control Association. (2005). Traps. Retrieved from http://www.mosquito.org/mosquito-information/traps.aspx
- BCCDC. (2009). Distribution of mosquito species in BC over time. Retrieved from http://www.bccdc.ca/NR/rdonlyres/4815030E-8A78-4E63-8DAC-1F90D79159A0/0/Genus_Species_Distribution_Over_Time_BC09.pdf

**Topic 3: Horses and WNV**

**"Symptoms in Horses**

Most horses bitten by a mosquito infected with WNV will not develop clinical disease. They develop an asymptomatic infection, eliminate the virus and are none the worse for it. Symptoms in those horses that do become sick can include listlessness, a change in demeanor, drooping lips, muscle twitching, a lack of co-ordination, weakness in the limbs, partial paralysis or an inability to get up. A fever is not always present. A veterinarian should examine infected horses because these clinical signs are similar to those caused by Western Equine Encephalitis, Eastern Equine Encephalitis and Rabies.

To prevent handlers from being hurt, caution must be exercised when handling horses affected by nervous disorders, such as WNV.

There is no specific treatment for horses affected with WNV. Up to 35 per cent of horses showing clinical disease may die or have to be euthanized because of complications of the disease. Some recovered horses may exhibit permanent neurological deficits.

**Testing Horses**

Horses are incidental hosts and the level of virus in their blood is very low for a short period of time. Mosquitoes feeding on infected horses are not likely to become infected. There is no scientific evidence to indicate that WNV can be transmitted directly from horses to other species, including humans. Therefore, quarantine of affected horses is not necessary. Detection of exposure to WNV in most horses is restricted to a blood test that identifies antibodies to WNV. Routine testing of horses is not recommended, even if the virus has been confirmed in the area. Specialized laboratory tests can confirm the presence of WNV in the brain or spinal cord of horses dying or being euthanized and are available to your veterinarian.

**Treatment for Horses**

There is no specific therapy for WNV infection. Veterinarians use supportive therapy such as intravenous fluids and good nursing care to prevent secondary infections.

**Protecting Horses from Infection with WNV**

Although the risk of disease in any individual horse is very low, the consequences for some affected horses can be severe. Preventive measures should be discussed with your local veterinarian. These measures include minimizing exposure to Culex *tarsalis* mosquitoes. This species of mosquito breeds in small, warm, still puddles of water. These puddles of water include those found in poorly drained eavestroughs, bird baths, discarded rubber tires and even hoof prints formed in mud. Consideration must be given

to providing screened housing and avoiding outdoor activities during peak times of mosquito feeding, such as dawn and dusk. Using topical insect repellents and/or smudges may also be useful. Reduce potential mosquito breeding sites by eliminating standing water, cleaning water troughs weekly and keeping grass levels short around buildings." (Government of Alberta, 2007)

**Vaccination**

There are vaccines for WNV in horses; however they have to be repeated yearly to provide protection. There are some horse owners who find it too expensive to vaccinate their horses. The vaccines approved for use on horses in Canada are identified at the following CFIA webpage: http://active.inspection.gc.ca/scripts/database/vetbio_submit.asp?lang=e&species=5&manufacturer=all. The Association of American Equine Practitioners has recommended that all horses in North America be immunized, since the distribution of WNV and the population of mosquito vectors change unpredictably every year (American Association of Equine Practitioners, 2005).

**Resources:**

- Government of Alberta. (2007). West Nile Virus. Retrieved from http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex5455
- American Association of Equine Practitioners. (2005). West Nile Virus Vaccination Guidelines. Retrieved from http://www.aaep.org/pdfs/AAEP_WNV_Guidelines_2005.pdf

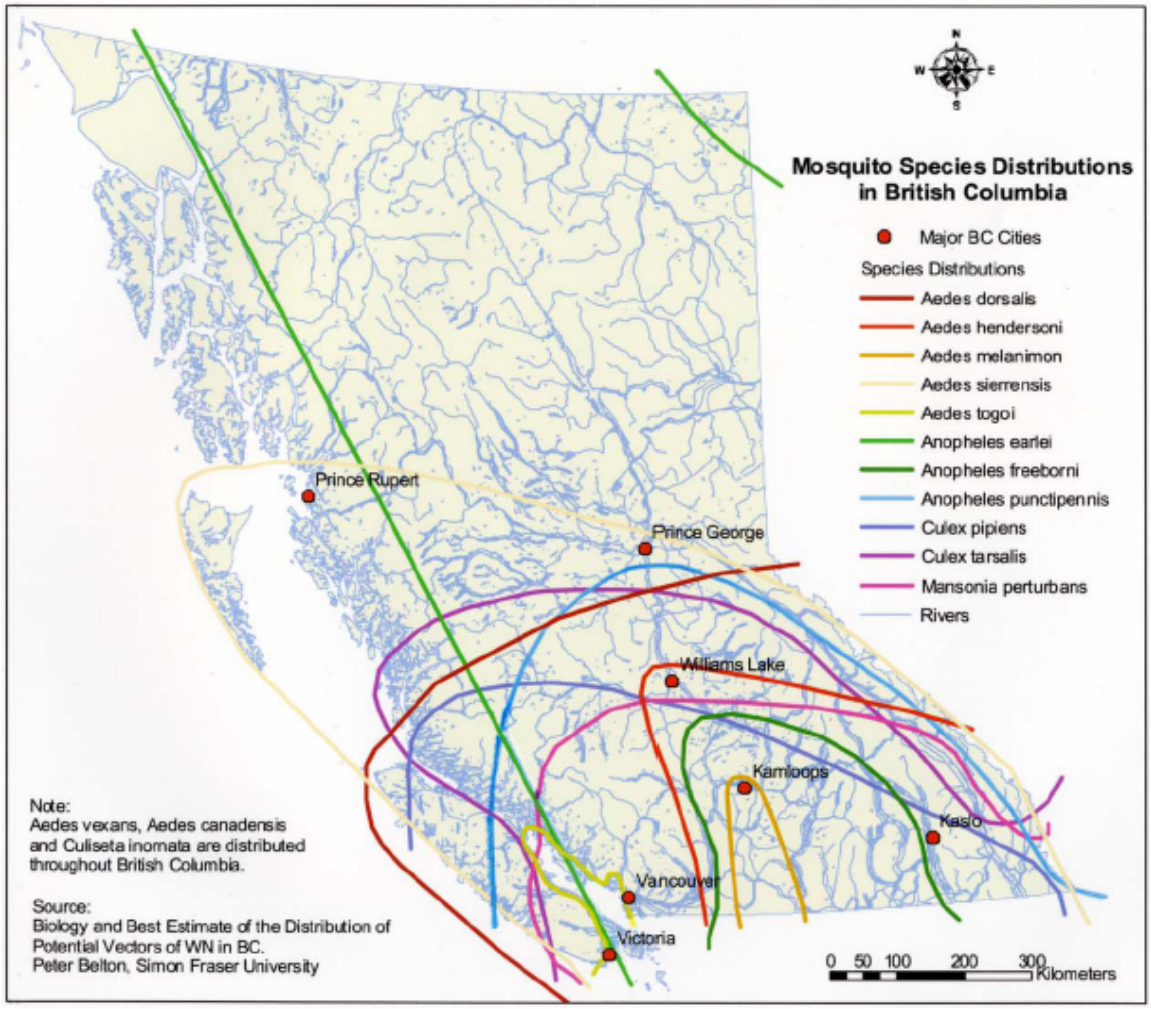
**Additional sources of information:**

- BC Veterinary Medical Association. (2002). West Nile Virus in Domestic Animals. Retrieved from http://www.bcvma.org/cfm/index.cfm?It=103&Id=10
- CDC. (2007). Animal Infection (Video), Retrieved from http://www.cdc.gov/ncidod/dvbid/westnile/wnv_communityVideo.htm
- CDC. (2010). Q&A: West Nile Virus in Horses. Retrieved from http://www.cdc.gov/ncidod/dvbid/westnile/qa/wnv_horses.htm
- USDA. (n.d.). Animal Health Monitoring and Surveillance. Retrieved from http://www.aphis.usda.gov/vs/nahss/equine/wnv/index.htm

**Topic 4: Mosquito Vectors in BC**

One purpose of mosquito trapping is to determine the distribution of mosquitoes across the province. Only a subset of mosquitoes are competent vectors of WNV which means they are able to: (1) carry the virus and (2) transmit the infection during a blood meal. A list and description of WNV vector species can be found in the document "British Columbia Mosquitoes as Vectors of West Nile Virus" at http://www.sfu.ca/~belton/summary.pdf (Belton, 2007).

There are many factors which may influence the range of each mosquito species including climate, predators, habitat, and food sources. The map below shows the estimated range of 14 different species based on mosquito trap results. There are only a few mosquitoes which are considered WNV vectors, two specific species we are interested in are the Culex *pipiens* and Culex *tarsalis*.




(Belton, 2009)

WNV and the environment

There are many environmental factors that may influence the distribution and transmission of WNV. Heat and moisture are two such factors. Temperature controls

the time it takes to develop from egg to adult, as well as the incubation period of the virus within the mosquito. The intrinsic incubation period is the amount of time necessary for the mosquito to become infective (able to pass on the infection) after acquiring the virus through a blood meal; this only occurs once the virus migrates to the mosquitoes' salivary glands. After that point the mosquito may infect any animal which it bites through its saliva which is released during a bite.

Moisture is necessary for mosquitoes to develop since their early life stages are dependant on water. There are also more complex factors in WNV transmission which are still being studied, such as types of land use, connectivity of habitat, and bird migration routes.

Climate and Related Factors

Air temperature plays a critical role in the development of mosquito populations and WNV in a region. Many jurisdictions use some form of temperature monitoring to gauge or associate relative risk within that region, often creating a numerical value to express the seasonal temperature accumulations. One such example is called degree days which adds up daily temperature totals measured against a set minimum base temperature for mosquito activity. Such values could be measured between years to compare mosquito development and possible WNV risk. Ambient temperatures also affect the amount of time it takes the mosquito to become infective after obtaining a blood meal from an infected bird. Therefore, hotter years not only have potentially more mosquitoes, but also a more infective mosquito population.

Water temperature drives the speed of the mosquito life cycle, with warmer temperatures facilitating quicker emergence from the aquatic portion of the life cycle. Circumstances affecting water temperature could include land features that affect exposure to sun, such as topography or aspect, building cover or foliage. It is likely Culex mosquitoes choose smaller bodies of stagnant water because these waters tend to be warmer and their eggs will develop more quickly.

Mosquitoes

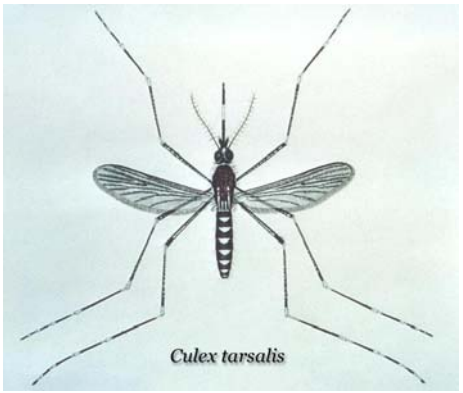
Mosquitoes are the vector for WNV. Mosquitoes that transfer disease within bird populations are called amplifying vectors. The most important mosquito species for the amplification of the disease is considered Culex *pipiens*, the common house mosquito. This mosquito prefers to bite certain kinds of birds, and tends only to bite mammals if birds are not readily available.

Mosquitoes that bite birds and mammals are called bridge vectors. Culex *tarsalis* is the classic bridge vector mosquito for WNV in North America, and because of this relationship, the most important mosquito for human illness.

Mosquito oviposition (the egg laying process) varies significantly between mosquitoes. Some mosquitoes lay their eggs singly in soil in anticipation of future flooding, singly in water near vegetation, or in the case of Culex, as egg (rafts) of a few hundred in smaller bodies of stagnant, organically enriched water. Some mosquitoes have only one large

hatch or generation per season and die off over the course of the season. Others like Culex mosquitoes are multigenerational, whereby the adult female after taking a blood meal can deposit an egg raft and in one or two weeks her offspring will emerge to similarly seek a blood meal and lay their own egg raft. This generational cycle continues through the summer months, ending in mid to late August when diminishing daylight triggers diapause. Mosquitoes emerging after diapause tend to not seek a blood meal, but rather obtain nutrients from flower nectar in preparation to hibernate over winter as adults. They will only seek blood meals in the following spring to obtain the necessary nutrients to lay egg rafts to commence the cycle in the following summer.

"**Culex *tarsalis*** is a native species, widely distributed in ditches and permanent and semipermanent pools in grassland and open woodland in the southern third of the Province. Specimens have recently been found in southern Vancouver Island. It is a proven virus vector, implicated in our human cases of Western Equine Encephalomyelitis (WEE) in the 1970's. They are present and bite mostly in the early morning and evening all summer. All our Culex and Anopheles species and most Culiseta overwinter as mated females and emerge in early spring for blood meals.




**Source: CDC.** http://phil.cdc.gov

**Cx. *pipiens*** was probably introduced to the west coast of North America in the late 1800's. Since the 1920's it has spread across the south of the Province and into Vancouver Island and is now one of the commonest mosquitoes in artificial containers (e.g. rain barrels and paddling pools) drainage ditches and storm sewers, particularly those contaminated with organic matter. It feeds primarily on birds but comes indoors to bite on warm summer nights, often making itself heard in the bedroom. It is a proven vector of WNV, WEE and St Louis Encephalitis (SLE). It was found in Prince George in 2004 and may be widely distributed in the southern half of the Province."
(Belton, 2007)

**Resources**


- Belton, P. (2007). British Columbia Mosquitoes as Vectors of West Nile Virus. Retrieved from http://www.sfu.ca/~belton/summary.pdf
- Belton, P. (2009). Mosquito Species Distributions in British Columbia. Retrieved from http://www.sfu.ca/~belton/summary.pdf


**Additional sources of information:**


- National Geographic. (2010). The Mosquito (Video). Retrieved from http://video.nationalgeographic.com/video/player/animals/bugs-animals/other-bugs/mosquito.html
- The American Mosquito Control Association. (2005). Retrieved from http://www.mosquito.org

**Topic 5: Bird surveillance and Testing**

Birds are the natural host for WNV. The disease has been identified in over 300 bird species (326) (CDC, 2009), although some species are more susceptible and either die or get sick. Robins and passerine birds are commonly infected, however they do not often die from the infection. They are associated with the amplification of WNV in endemic areas of North America due to their common distribution, general ability to fight off the disease, and attractiveness to some types of mosquitoes. The corvid family of birds however has high mortality from WNV infection and therefore they are used as an effective indicator for WNV in a region. The corvid family includes crows, ravens and jays. There has been an observed decline (45% in some areas) in the crow population in areas of the US after WNV was introduced (LaDeau, et al., 2007)

Crows also congregate at roosts, where they meet every evening in very large numbers. There are a number of crow roosts known in the lower mainland, and these close quarters may be an important location for mosquito to bird amplification of WNV.

Migration and post-nesting dispersion are two focal points of bird behavior potentially critical to the seasonal spread of WNV. Migration is an activity performed yearly by most bird species and at some point usually involves the movement of birds into or out of a region. It is the contact between the migrated bird, the mosquito and fledging bird offspring thought to drive the dispersion or spread of the disease within a given region.

Corvid surveillance is achieved through two mechanisms in BC. During the summer months, samples of dead corvids from Health Authorities are submitted for WNV testing. Health Authorities collect birds in a number of different ways - some employ city parks department staff, others use the SPCA as a collection point and still others hire designated staff to respond to public calls and collect birds for testing.

Depending on your region, call the appropriate number below to report a dead corvid for WNV testing in summer months.

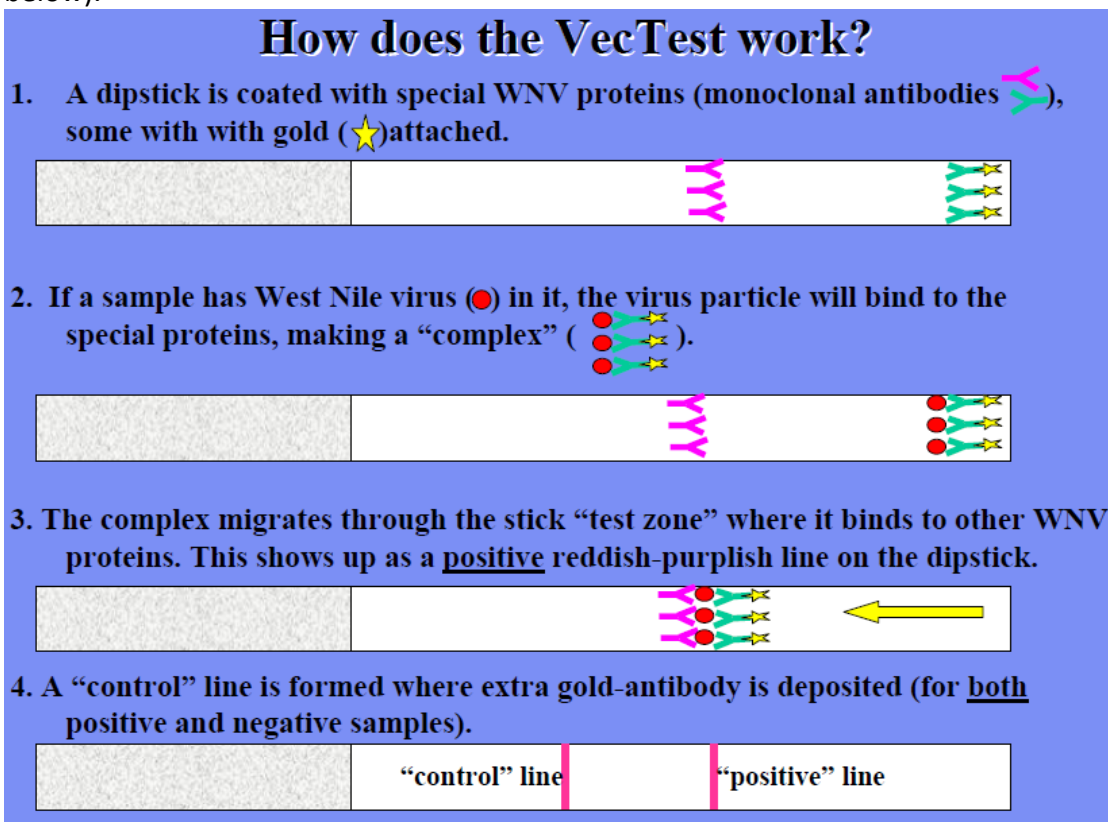
- Fraser Health Authority: call toll free 1-888-WNV-LINE (1-888-968-5463)
- Interior Health Authority: call toll free 1-866-300-0520

- Vancouver Island Health Authority: call toll free 1-866-WNV-VIHA (1-866-968-8442)
- Vancouver Coastal Health Authority: call toll free 1-877 WNV-VCHA (1-800-968-8242)
- Northern Health Authority does not currently test birds for WNV, however corvids found in this area can be reported online as described below.

In addition to testing birds, an on-line form is available at the BCCDC website (http://westnile.bccdc.ca/ ) for the public to report sightings of dead corvids. The locations of birds tested and reported online were used to create corvid density maps for regions of the province with sufficient data. These can be used as baseline values against which to assess corvid mortality, a potential indicator that WNV has been introduced into an area.

There are safety concerns with the handling of dead birds, and you should not touch or pick up birds with bare hands. Contact your local health authority for disposal or collection instructions.

After being reported to a call line, and safely picked up by the Health Authority, the dead corvids are frozen and shipped to the Animal Health Center for testing. The birds are tested for WNV using the commercially available VEC test (as described in the figure below).




(California Department of Health Services, 2006)

Other Bird Surveillance Programs

Live bird testing is another method of WNV surveillance used in the United States and Canada. The use of sentinel chicken flocks is not common, but is one example of live bird testing. Small flocks of chicken are strategically placed in pens in a region and changes in blood antibodies for WNV are regularly measured. Since chicken do not get sick or die from WNV they are considered excellent for this purpose, especially since they can develop high levels of virus in their system (Brault, 2009). Mist net traps use large fine meshed nets placed in common bird throughways to capture migrating or dispersing birds travelling through known bird corridors. These birds are bled, tagged and released, and the blood is tested in a similar manner to sentinel chicken testing. Mist net trapping is labour intensive, and sentinel chicken flocks are expensive to maintain, so neither weigh heavily in local WNV risk assessments. (Brault, 2004)

**Resources**


- Brault, A. (2004). Changing Patterns of West Nile virus Transmission: Altered Vector Competence and Host Susceptibility. Vet Res. 40(2): 43
- California Dept of Health Services. (2006). Vec Test Tutorial [PowerPoint slides]. Retrieved from http://www.westnile.ca.gov/website/tutorials/vectest_ramp_tutorial_4_15_05.pdf
- [CDC] Centers for Disease Control and Prevention. (2009). West Nile Virus, Vertibrate Ecology. Retrieved from http://www.cdc.gov/ncidod/dvbid/westnile/birdspecies.htm
- LaDeau, S., Kilpatrick, A. & Marra, P. (2007). West Nile virus emergence and large-scale declines of North American bird populations. Nature, 447, 710-713. Retrieved from http://www.nature.com/nature/journal/v447/n7145/abs/nature05829.html


**Additional sources of information:**


- Canadian Cooperative Wildlife Health Centre. (2010). West Nile Virus. Retrieved from http://www.ccwhc.ca/west_nile_virus.php
    - Canadian Cooperative Wildlife Health Centre. (2010). Bird Identification. Retrieved from http://www.ccwhc.ca/wnv_bird_identification.php
- BCCDC. (2009). Kernel Density Mapping of Dead Corvids. Retrieved from https://maps.bccdc.org/pdf/WNv%20Bird%20Density%202008.pdf
- Wikipedia. (2010). The American Crow. Retrieved from http://en.wikipedia.org/wiki/American_Crow

## **Lesson 5:** Summary Project

**BC Ministry of Education PLO** (Science and Tech 11-Science module-Health-D1)
**Student Achievement Indicators:**

1. Describe how diseases and illnesses can be transmitted within a population (e.g., STI, SARS, flu, food poisoning)
2. List the technologies used to identify and treat basic types of illnesses (e.g., viral, bacterial, genetic) and injuries
3. Outline methods and technologies involved in the prevention of the transmission of various types of illnesses

Ministry of Education. (2008) Science and technology 11, Integrated Resource Package 2008. Retrieved from http://www.bced.gov.bc.ca/irp/irp_sci.htm

a. **Project:** What did I learn about WNV? (*approx. 2+ hours*)

In this activity students can demonstrate what they have learned in the unit in a project format. Ask students to compile their work from lessons 1-4 for their final assessment. They will present this information in a variety of formats, which are presented in the West Nile Virus Final Project Outline. This project can be assessed using the provided rubric in the West Nile Virus Project Evaluation. It may be helpful to introduce the topic at the beginning of the unit, so students can plan their project throughout the lessons.

# West Nile Virus Final Project Outline

Name: Block: Date:

This project is designed for you to demonstrate your knowledge on the topics included in the West Nile virus unit, in ONE format of your choice.

**The TOPICS that must be included (not limited to) are:**

Lesson 1: General information about West Nile virus
Lesson 2: Information about a Zoonotic disease from your article
Lesson 3: The transmission cycle for West Nile virus and the disease that you researched
Lesson 4: Ways to prevent West Nile virus
Lesson 5: Information about surveillance and testing for West Nile virus

**You will show what you have learned during the unit using ONE of the following FORMATS:**

a) Public information brochure
b) Radio series or announcement
c) Video
d) PowerPoint

**Any other ideas? Consult with your teacher first.**

# West Nile virus Project Evaluation:

Name: Block: Date:

| | 5 | 4 | 3 | 2 | 1 |
|---|---|---|---|---|---|
| Concepts x2 | Displays excellent knowledge of concepts. | Displays strong knowledge of concepts. | Displays satisfactory knowledge of concepts. | Displays unsatisfactory knowledge of concepts. | Displays poor knowledge of concepts. |
| Transforming x2 | Effectively apply concepts to the presentation format. | Appropriately apply concepts to the presentation format. | Applies concepts to the presentation format. | Attempts to apply concepts to the presentation format. | Few concepts are applied to the presentation format. |

Mark: /20

Epidemiology Services
BC Centre for Disease Control
www.bccdc.ca

# Teacher Feedback Form: West Nile Virus Education Packages

Please help us improve this unit by providing your valuable feedback

**Grade:** **School District:** **Subject area:**

**How effective was this unit in your class?**

**Did you use any resources that were not listed? (Please specify)**

**Did you use any other teaching strategies?**

**Would you like any other topics to be included?**

**What changes would you suggest to the lessons?**

**Would you use this unit again, or recommend it to others?**

**Any other Comments/suggestions?**

**Please complete and fax to BCCDC Epidemiology Services: 604-707-2516**

## 2. Extension Activities

a. What is the difference between insect repellants, and pesticides? What is the difference between DDT and DEET? Why do you think people confuse these products?
b. How do insect repellants work to repel mosquitoes? Design your own ideal insect repellant technology.
    - National Geographic. (2010). New Laser Zaps Mosquitoes in Slow-Motion Video. Retrieved from http://video.nationalgeographic.com/video/player/news/animals-news/anti-mosquito-laser-vin.html
c. Research treatment methods for Rabies/Lyme disease/hantavirus or other Zoonotic diseases.
d. Hypothesize how climate change and increasing temperatures may impact the distribution of a mosquito or tick borne disease.
e. Examine how the virus develops within the vector/animal, and how the anatomy of the vector aides in transmission.
f. Research how a specific Zoonotic disease may impact ones lifestyle, and what the recovery process may be.
g. Discuss the physical clues to know when someone is sick with WNV or Lyme disease. Research why this type of reaction occurs.
h. Research the different types of larvicide, and discuss the environmental impacts of those pesticides. (Hint. search for biological larvicide for mosquitoes)
i. Rank this priority list of actions to take to reduce WNV carrying mosquitoes and explain why you would prefer to use some actions over others. Possible actions include: education about using insect repellant, removing standing water from ditches and artificial containers, applying pesticides to kill mosquitoes in their larval stage in the water, and applying pesticides to kill adult mosquitoes when they are flying in the air. Would your priority list change if someone you know got sick with WNV?
j. Look at life cycle of the mosquito and identify mosquitoes under microscope (and compare to ticks)

## 3. Resource list for further information

Public Health:

- Public Health Agency of Canada: http://www.phac-aspc.gc.ca
- Provincial Health Services Authority: http://www.phsa.ca
    - BC Cancer Agency
    - BC Centre for Disease Control

        News releases and health alerts
        http://www.bccdc.ca/resources/news-alerts/default.htm
    - BC Children's Hospital & Sunny Hill Health Centre for Children
    - BC Provincial Renal Agency
    - BC Transplant
    - BC Women's Hospital & Health Centre
    - BC Mental Health and Addiction Services
    - Forensic Psychiatric Services
    - Cardiac Services BC
    - Riverview Hospital
- Health Authorities (map: http://www.health.gov.bc.ca/socsec/provmap.html):
    - Northern Health Authority - http://www.northernhealth.ca
    - Interior Health Authority - http://www.interiorhealth.ca
    - Vancouver Island Health Authority - http://www.viha.ca
    - Vancouver Coastal Health Authority - http://www.vch.ca
    - Fraser Health Authority - http://www.fraserhealth.ca

West Nile Virus:

- BCCDC WNV pages: http://www.bccdc.ca/westnile
- HealthLink BC File #88 West Nile Virus: http://www.healthlinkbc.ca/healthfiles/hfile88.stm
- PHAC WNV Monitor http://www.phac-aspc.gc.ca/wnv-vwn/index-eng.php
- American Mosquito Control Association: http://www.mosquito.org/ (see "mosquito information")

## 4. Background information for teachers and students

### Public Health in BC

Public health is a system of health care designed to maximize the health of communities by implementing programs designed to protect communities from illness, prevent disease from causing illness in a community, and promote systems that will facilitate healthier populations. These systems of care are often designed to reduce the burden of costs due to acute health care such as hospitalization costs, and to facilitate healthier and more productive individuals.

The World Health Organization goes further to state that health is: "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity." (WHO, 2009a)

Public Health in BC is led by the Provincial Health Officer in the Ministry of Healthy Living and Sport, the Medical Health Officers in each of the 5 Health Authorities, and the Provincial Health Services Authority. Major roles for public health include surveillance of disease in a population, immunization, food and water safety, and other communicable/infectious disease reduction strategies.

More public health resources:

- Canadian Public Health Association. (n.d.). Celebrating Public Health. Retrieved from http://cpha100.ca/12-great-achievements
- Association of Schools of Public Health. (2009). This is Public Health (video). Retrieved from www.thisispublichealth.org/video_lowres.html

### Zoonotic diseases

Zoonoses are a broad classification of diseases which can be transmitted from animals (or reptiles or birds) to humans. There are many different transmission pathways of zoonoses, including by direct contact with the animal, by the animal contaminating air or water with the infectious agent, or by a bridge vector between the animal and the human, such as a mosquito (Baum, 2004).

Definition: "A zoonosis is any disease or infection that is naturally transmissible from vertebrate animals to humans. Animals thus play an essential role in maintaining zoonotic infections in nature. Zoonoses may be bacterial, viral, or parasitic, or may involve unconventional agents. As well as being a public health problem, many of the major zoonotic diseases prevent the efficient production of food of animal origin and create obstacles to international trade in animal products."(WHO, 2009b)

Select zoonotic diseases

The following is a list of selected zoonotic diseases identified as of current or future concern in the WHO Region of the Americas:

- West Nile virus
- rabies (vampire bats, raccoons, monkeys)
- equine encephalitides (Venezuelan-equine encephalomyelitis, eastern equine encephalomyelitis)
- Hanta virus
- arenaviruses
- avian influenza
- pox viruses (e.g. monkeypox)
- yellow fever
- HIV/AIDS
- plague
- tularaemia
- anthrax
- Lyme disease
- Leptospira
- brucellosis
- bovine tuberculosis
- Bordetella bronchispectica
- Bartonella
- pet-associated salmonellosis
- chlamydia
- Q fever
- typhus
- Ehrlichia/ anaplasmosis
- Rocky Mountain spotted fever
- Febre maculosa - spotted fever
- Leishmania (cutaneous and visceral)
- Echinococcus multilocularis
- American trypanosomiasis (Chagas disease)
- cysticercosis
- Trichinella
- Cryptosporidium
- Giardia
- Toxoplasma
- Baylisascaris
- BSE
- variant Creutzfeldt-Jakob disease (vCJD)
- coccidioidomycosis
- West Nile virus (South America)
- yellow fever
- SARS
- imported arboviruses (e.g. Rift Valley fever virus, Ross River virus)
- arenaviruses
- hepatitis E (porcine)
- Borna viruses
- pox viruses
- Streptobacilliary rat bite fever
- Bartonella
- meliodosis (Burkholderia pseudomallei)
- plague
- Echinococcus spp.
- chronic wasting disease
- vCJD

(WHO, 2004)

*"Did You Know...?*
*Approximately 75% of recently emerging infectious diseases affecting humans are diseases of animal origin; approximately 60% of all human pathogens are zoonotic."*
*(NCZVED, 2009)*

Prevention

Prevention must be tailored to the specific human/animal interaction which allows transmission. Prevention techniques which are common to some zoonoses include; (1) proper cooking of meats (ie. tapeworms, samonella), (2) proper drinking water sanitation (ie. giardia, leptospirosis), (3) immunization of the human or animal (ie.

rabies, WNV equine vaccine, yellow fever), and (4) protecting yourself from bites (ie. dengue, Lyme disease, WNV). (Gale, 2008)

Main risk factors

The WHO has also listed risk factors (human actions, activities, or changes in demographics) involved in the emergence of zoonotic diseases in the WHO Region of the Americas.

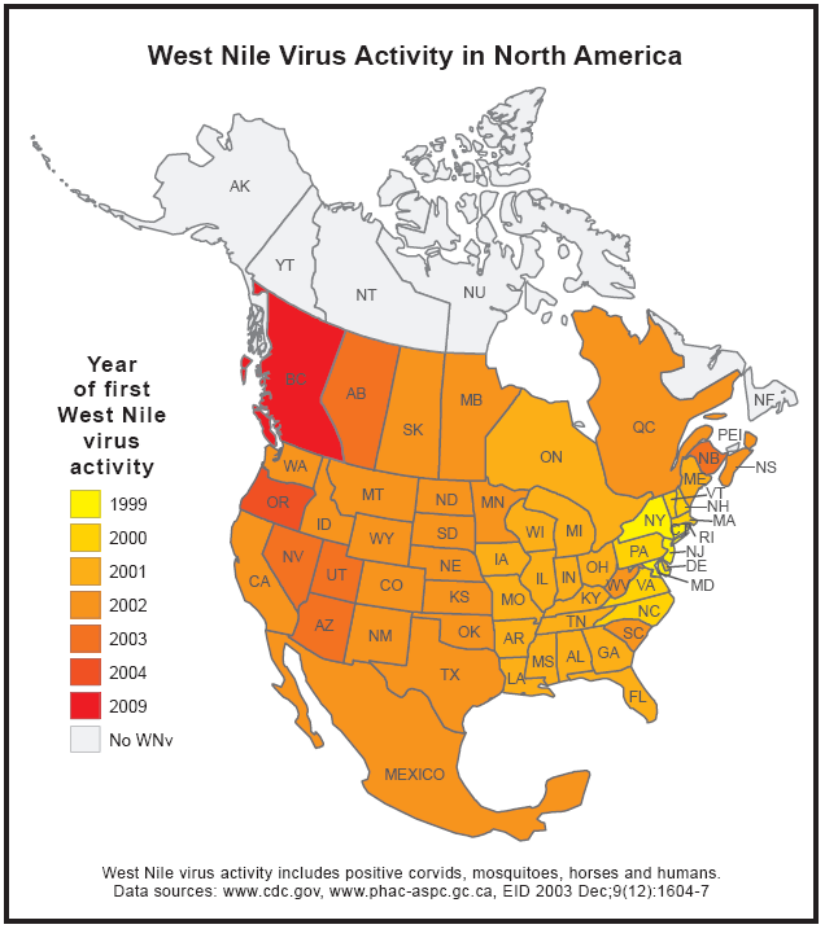
- ageing population
- immunosuppression
- importation of exotic mosquitoes and other arthropods
- increase in urbanization
- increase in wildlife populations by conservation
- modified environment (e.g. feeding deer in winter)
- human–animal bonds
- climate variability (e.g. change in vector distribution)
- displacement of animals due to forest fires or other natural events (e.g. floods, hurricanes)
- ecotourism (e.g. recreational use of wild lands)
- disruption of habitat (e.g. rainforest) by deforestation and mining for economic interest
- immigration, legal and illegal
- increasing poverty in some countries in Latin America (includes issues of malnutrition, overcrowding, insect pests and vermin populations)
- lack of access to health care
- ethnic food preferences (e.g. eating wild animals)
- occupation-associated risks
- exotic animals being kept as pets
- legal and illegal importation of animals for pets
- intentional introduction of non-indigenous species
- intentional release of an agent
- laboratory biosecurity

(WHO, 2004)

# WNV basics

## History

West Nile Virus (WNV) is an infection of birds spread by mosquitoes which was first identified in Africa in 1937. Mosquitoes pick up the virus by biting an infected bird, and the virus is then transmitted to humans through the bite of an infected mosquito. Until 1999, WNV was commonly found in Africa, Eastern Europe, West Asia and the northern Mediterranean area: there have been outbreaks of WNV in Egypt, Israel, India, France, Romania and the Czech Republic. In 1999, the first North American cases occurred in New York City. It is not known how the virus was introduced into the New York area. Since then, it has established itself in nearly all of the United States (lower 48 States) and much of Canada. WNV was first detected in BC in August 2009, in the Southern Okanagan and Fraser Valley regions.




## Transmission

Mosquitoes become infected with WNV when they feed on the blood of a bird that carries the virus. An infected mosquito can transmit the virus back to another bird, horse or person when they bite. The propagation of WNV occurs between birds and mosquitoes. Human and other animal infections are considered incidental (or "dead end") because they do not pass the virus back to mosquitoes. WNV is not spread through person-to-person contact such as touching, coughing, sneezing or drinking from a shared cup; however people should avoid handling dead animals or birds with their bare hands. Less commonly, WNV can be transmitted through blood transfusion and organ transplants if the donor was recently infected with WNV. WNV can also be transmitted from a mother to her unborn child or through breast milk, but these events are rare. The benefits of breastfeeding outweigh the risk from WNV.

Symptoms

Symptoms begin approximately three to 14 days after being bitten by an infected mosquito. Recovery from symptoms may occur in about a week with West Nile non-neurological syndrome and may take a year or more for the more severe form, West Nile neurological syndrome.

| Symptoms of WNV | **West Nile non-neurological syndrome** (aka West Nile fever) | **West Nile neurological syndrome** |
|---|---|---|
| *May include some or all of these symptoms* | • fever<br>• headache<br>• muscle weakness<br>• muscle and/or joint aches<br>• malaise<br>• rash<br>• sensitivity to light | • severe headache<br>• stiff neck<br>• meningitis<br>• encephalitis<br>• paralysis |

*How serious is WNV?*

Most infected people will never know they've had the disease, however the illness can be severe for those who do become sick. Research indicates that only about one out of every five people who are bitten by a mosquito and infected with WNV will develop symptoms. Most people who do develop symptoms will experience varying degrees of an illness known as West Nile Non-neurological Syndrome. Even non-neurological forms of the disease may cause lasting health effects, including muscle weakness, memory problems and fatigue which may continue for months. In less than one per cent of infected individuals (about 1 in 150), WNV can cause severe illness resulting in hospitalization. This includes swelling of the brain (encephalitis), inflammation of the lining of the brain (meningitis) or polio-like paralysis. The fatality rate is about 0.1 per cent.

*Who is at risk for WNV?*

Everyone who is outside during the summer months gardening, golfing, walking, camping etc. is at risk once the virus is in the area and should take precautions to avoid mosquito bites. To determine if the virus is in your area visit www.bccdc.ca/westnile. While anyone can be infected with WNV, the chances of having a severe illness are greater as you get older, even if you are healthy. You may also be at greater risk if you have a weakened immune system.

*How likely am I to get sick with WNV from one mosquito bite?*

In areas where mosquitoes do carry the virus, usually only a small number of mosquitoes will be infected. Most of the mosquitoes that bite humans are not able to carry WNV, but there is no easy way to tell the difference between ones that can and ones that can't so it is important to prevent any mosquito bite.

Prevention

Since there is no specific treatment or cure for West Nile virus, prevention is especially important. You can **protect yourself from bites**, and **prevent mosquitoes from developing on your property** by following the 4 D's.

**The 4 D's:**

- □ **Drain** standing water on your property where mosquitoes develop
- □ **Dusk** and **Dawn** is when mosquitoes are most active- protect yourself at these times
- □ **Dress** in loose long sleeved shirts and pants - avoid dark colors which can attract mosquitoes
- □ **Defend** yourself from bites by using insect repellants containing DEET, oil of lemon eucalyptus or soybean oil

- **Protect yourself from bites**

Use insect repellent! See the BCCDC Insect Repellant poster available from http://www.bccdc.ca/dis-cond/a-z/_w/WestNileVirus/educmat/default.htm

*Can I use citronella oil as a mosquito repellent?*

Citronella oil has been available in Canada to use on the skin as a mosquito repellent for many years. It is not as effective as DEET or lemon eucalyptus oil and recently there has been some concern about its safety when used on the skin. The PMRA is reviewing its use in Canada and no new products are currently being licensed. For more information visit the Public Health Agency of Canada website: http://www.hc-sc.gc.ca/cps-spc/pubs/pest/_decisions/rev2008-03/index-eng.php

- **Prevent mosquitoes from developing on your property**

Unlike birds or other insects, most mosquitoes do not fly very far and tend to stay close to their breeding sites. You are most likely to be bitten by a mosquito from your own backyard!

- Clean up areas where mosquitoes like to lay their eggs. It doesn't take much time (~1 week), or water for mosquitoes to develop from eggs into adults.
- Take a look around your home and get rid of mosquito-friendly places that would make good breeding sites or resting places for mosquitoes.
- Remove any type of standing water at least once a week.
- Clean up and empty containers that collect water such as old tires, flower pots, wheelbarrows, barrels, tin cans or even small containers like bottle tops.
- Drill holes in the bottom of used containers so water can't collect.
- Change water in bird baths at least once a week.
- If you have a swimming pool, immediately remove water that collects on pool covers and make sure the pool's pump is circulating
- Turn over wading pools when not in use.
- Check leaves and drains: don't let things pile up.

- Clear leaves and twigs from eaves troughs, storm and roof gutters throughout the summer.
- Check flat roofs frequently for standing water.
- Make sure drains and drainage ditches are not clogged.
- Stop mosquitoes from entering your home; check windows and door screens for holes and make sure they fit snugly into the frames, so mosquitoes cannot get in.

Treatment

Presently, there are no specific medications that can cure illness from WNV. Rest, fluids and sometimes care in hospital is the only treatment so far.

*Is there a vaccine against WNV?*

No, a human vaccine for WNV doesn't exist to protect people. A vaccine is currently being used for horses and has been used experimentally in other animals.

Source: BCCDC. (2010). West Nile Virus. Retrieved from www.bccdc.ca/westnile

# WNV program in BC

*The details of this program will change over time. For the most recent information visit www.bccdc.ca/westnile*

## A. Surveillance

Surveillance activities for WNV focus on three target groups – humans, dead corvids and mosquitoes. The objectives for WNV surveillance are:

1. To monitor WNV activity in various species in BC in order to:
    a. Predict increased risk to human health
    b. Inform public health decisions
    c. Guide communication strategies
    d. Monitor the effectiveness of control measures
2. To optimize mosquito control decision-making by identifying:
    a. The geographic and temporal distribution of potential vector species in BC
    b. Mosquito development sites

Human surveillance involves several stakeholders including BCCDC Epidemiology and Laboratory Services, Canadian Blood Services (CBS), BC Transplant Society and the Health Authorities. Physician requests for WNV testing received by BCCDC labs are also tracked. Data sharing protocols with CBS were developed to ensure prompt deferral of blood collected from suspected WNV-infected persons and to allow BCCDC to monitor asymptomatic infections identified through screening of the blood supply. From May to November, all organs intended for transplant are screened by BCCDC labs prior to transplanting. In the low risk period (December through April) only organs from donors with a travel risk are screened.

Information on any probable human cases is communicated to the requesting physician as well as to public health to enable administration of a case questionnaire to collect information on symptoms, travel history and likely mode of transmission. Cases are classified as a case of West Nile non-Neurological Syndrome (WN-non-NS) or West Nile Neurological Syndrome (WNNS) according to both self-reported symptoms and clinical information collected from the patient's physician. Cases are further categorized as probable or confirmed depending on the level of specificity associated with the laboratory test performed. Case definitions can be found at the following Public Health Agency of Canada website: http://www.phacaspc.gc.ca/wnv-vwn/hmncasedef_e.html.

Laboratory testing can tell if someone has an acute (new) infection through a variety of different tests. Serological testing, plaque-reduction neutralization testing (PRNT), and reverse transcriptase-polymerase chain reaction testing (PCR) are some testing methods utilized to detect WNV illness in humans. There is also routine testing of all organ and blood donors for WNV to ensure that people do not receive infected blood or organs.

Crows and other birds in the corvid family (ravens, jays and magpies) generally get very ill from infection with WNV and most die quickly. Because of this dead corvids can be a

good indicator that WNV has entered an area. Corvid (crows, ravens, magpies and jays) surveillance is achieved through two mechanisms. Samples of dead corvids from health authorities are submitted each week for WNV testing. Birds are collected in a number of different ways - some employ city parks department staff, others use the SPCA as a collection point and still others hire designated staff to respond to public calls and collect birds for testing. This testing is performed at a designated lab using a commercially available dipstick test (VEC test) for initial screening. In addition to birds tested, an on-line form is available at the BCCDC website (http://westnile.bccdc.ca/ ) for the public to report sightings of dead corvids. With few exceptions, dead corvids sighted by the public and reported through the online form are different from those picked up for testing. The locations of birds tested and reported online are used to create corvid density maps for regions of the province with sufficient data. These can be used as baseline values against which to assess corvid mortality, a potential indicator that virus has been introduced into an area.

Mosquito surveillance focuses on WNV testing, identification and distribution of adult mosquitoes. Based on several years of baseline data, the start of mosquito surveillance activities was delayed until June 1st from 2006 forward (was previously May 1st). Some traps are operated in more than one location on two different days of the week. Traps run overnight and the catches are sent in coolers to BCCDC for identification and testing.

The BCCDC laboratory separates mosquito submissions into sex and taxonomic groupings: 1) Aedes, 2) Anopheles, 3) Coquillettidia, 4) Culiseta and 5) Culex. Mosquitoes are sorted on a chill table (to prevent denaturation of any viral RNA) and identified to genus or, in the case of Culex, to species. If a trap fails to capture any mosquitoes, the information (i.e. trap malfunctioned, no mosquitoes trapped or trap was not run) is faxed to the lab and recorded. Beginning in 2006, only female Culex mosquitoes were tested for the virus in groups of up to 50 mosquitoes per pool, by PCR. The remaining mosquitoes are identified but not tested. When traps contained more than 500 mosquitoes, the entire sample is sorted to selectively pick out all the female Culex mosquitoes for PCR testing. A fraction of the remainder (½, ¼, ⅛, etc.) is identified and the total number for each genus in the trap extrapolated.

Ongoing, prospective, cumulative temperature degree-day maps are used to help forecast higher risk areas for WNV. Degree day assessments can assist in predicting the number of generations of mosquitoes expected in a given area and the speed of virus replication. Mosquito, bird, geographic and temperature data are integrated using an interactive online mapping tool (http://www.bccdc.ca/westnile/). This was developed to assist users with geo-spatial risk assessment to help target appropriate mosquito control activities.

Source: BCCDC. (2009). 2009 BC West Nile Virus Surveillance Program Report. Available from www.bccdc.ca/westnile

**B. Risk Reduction**

The second branch of British Columbia's WNV program focuses on strategies related to risk reduction and relies on information gathered through disease surveillance. The two primary forms of risk reduction are:

- Public Education – This form of communication focuses on the distribution of accurate messaging to the public on various means of personal protection, especially to those living in or travelling to areas with known disease activity. It also identifies target populations or subsets of populations more likely to acquire the disease or suffer significant impacts from illness related to the disease.

- Mosquito control – This involves the reduction of mosquito populations as a tool to reduce human illness by reducing human mosquito interactions. Activities related to mosquito control follow a recognized hierarchy of interventions incorporating Integrated Pest Management (IPM) techniques. Most community level programs by law must incorporate an IPM approach to reduce mosquito populations, legislated through the British Columbia Ministry of Environments Integrated Pest Management Act. These practices are employed in concert with public education initiatives and each step in the hierarchal ladder implemented only when surveillance practices demonstrate a need based on continued disease activity, increased risk to human populations and time of year. The order of mosquito control practices are:

  1. Source reduction: Source reduction involves the physical removal of the mosquito breeding habitat by activities such as turning over containers that hold water, cleaning bird baths and clearing gutters and ditches of debris to ensure water movement.

  2. Habitat modification: Habitat modification involves making changes to an existing breeding habitat. This would include making the sides of ditches very steep to reduce mosquito development potential, or inserting pumps or fountains into ponds to keep water agitated.

  3. Larvaciding: Larvaciding is the use of pesticides applied to the aquatic environments where the mosquito larvae are developing. Larvacides are perhaps the most effective means of mosquito control, yet maintain a high degree of environmental compliance. This is because the two primary forms of larvacides are very specific in their destructive properties to mosquito larvae. The first is bacteria-based whereby the bacteria produce toxins which attack and destroy the gut of the mosquito larvae. The two main bacteria used for mosquito control are Bacillus thurengiensis israeliensis (Bti) and Bacillus Sphaericus (Bsp). Because of their specific nature they have minimal impact on non-target organisms and as such are favored by environmental organizations.

  Juvenile growth regulators are the other main product used to control mosquitoes in their larval form. In essence this product mimics a mosquito juvenile hormone,

tricking the mosquito into never completing the aquatic life cycle and eventually dying. Methoprene™ is the primary juvenile growth regulator used in Canada.

5. Adulticiding: Adulticiding is the last technique available for use in mosquito control. It is generally regarded as a last resort to reduce the risk of WNV in human populations because it has higher environmental impact on non target species, and it is thought to be less effective than Larviciding. It does, however, quickly knock down mosquito populations, which might have an overriding importance, given the seriousness of indicators through the human bird and mosquito surveillance program.

In Canada, there are two pesticides registered through the Pest Management Regulatory Agency (PMRA) for use as adult mosquito control agents, Malathion and Pyrethrin (or its synthetic analog Pyrethroid). Both are applied using Ultra Low Volume methods, meaning the spray droplet size is very small. Only Malathion is approved for aerial application (plane or helicopter), where as both Malation and Pyrethrin may be applied by backpack or truck-mounted ground-based sprayers.

Sources:
Ministry of Environment. (2007). Integrated Pest Management. Retrieved from http://www.env.gov.bc.ca/epd/ipmp/regs/ipmdef.htm

[PMRA] Pesticide Management Regulatory Agency. (2004). Consumer product Safety: Mosquito Control. Retrieved from http://www.hc-sc.gc.ca/cps-spc/pest/part/protect-proteger/use-utiliser/_mosquito-moustique/index-eng.php

## WNV and the environment

There are many environmental factors that may influence the distribution and transmission of WNV. Heat and moisture are two such factors. Temperature controls the time it takes to develop from egg to adult, as well as the incubation period of the virus within the mosquito. Moisture is necessary for mosquitoes to develop since their early life stages are dependant on water. There are also more complex factors in WNV transmission which are still being studied, such as types of land use, connectivity of habitat, and bird migration routes.

Climate and Related Factors

Air temperature plays a critical role in the development of mosquito populations and WNV in a region. Many jurisdictions use some form of temperature monitoring to gauge or associate relative risk within that region, often creating a numerical value to express the seasonal temperature accumulations. One such example is the degree day calculation in which daily temperature totals are added up when they exceed a threshold value, and measured against a set minimum base temperature for mosquito

activity (UC Davis, 2003). Such values could be measured between years to compare mosquito development and possible WNV risk. Ambient temperatures also affect the amount of time it takes the mosquito to become infective after obtaining a blood meal from an infected bird. Therefore, hotter years not only have potentially more mosquitoes, but also a more infective mosquito population.

Water temperature drives the speed of the mosquito life cycle, with warmer temperatures facilitating quicker emergence from the aquatic portion of the life cycle. Circumstances affecting water temperature could include land features that affect exposure to sun, such as topography or aspect, building cover or foliage. It is likely that *Culex* mosquitoes choose smaller bodies of stagnant water because these waters tend to be warmer and their eggs will develop more quickly.

Birds

Birds are the natural host for WNV. The disease has been identified in 326 bird species (CDC, 2009), although species vary in their susceptibility, with some dying or getting sick, while others recover. Birds that suffer high mortality rates from WNV are not the best hosts for viral amplification and transmission, but may be ideal for surveillance purposes. The corvid family is a good example of these types of birds. Good hosts are those which can incubate lots of virus, don't die, but rather provide a good reservoir of disease. In this case, vectors such as mosquitoes acquire WNV through a blood meal and transfer the disease to other animals on subsequent blood meals. Robins and Sparrows are two species of birds associated with the amplification of WNV in endemic areas of North America, due to their common distribution, general ability to fight off the disease, and being a preferential biting host for some types of mosquitoes. Evidence suggests human outbreaks coincide with the switch in mosquito biting behavior from bird to human in August due to the loss of avian hosts, especially the American Robin to migration. (Kilpatrick, 2006)

Migration and post-nesting dispersion are two focal points of bird behavior potentially critical to the seasonal spread of WNV. Migration is an activity performed yearly by most bird species and at some point usually involves the movement of birds into or out of a region that could circulate WNV year round. It is the contact between the migrated bird, the mosquito and fledging bird offspring thought to drive the dispersion or spread of the disease within a given region.

Mosquitoes

Mosquitoes are the vector for WNV. After taking an infected blood meal, the mosquito won't become infective until the incubation period is completed and the virus is present in the saliva, which is injected into the host during feeding. Mosquitoes that transfer the virus between birds are called amplifying vectors. The most important mosquito species for the amplification of the disease in urban areas is considered Culex *pipiens*, the common house mosquito. This mosquito prefers to feed on birds, and tends only to bite mammals if birds are not readily available (Belton, 2007). Mosquitoes that bite

birds and mammals are called bridge vectors. Culex *tarsalis* is the classic bridge vector mosquito for WNV in North America, and because of this relationship, the most important mosquito for human WNV illness.

Mosquito oviposition (the egg laying process) varies significantly between mosquitoes. Some mosquitoes lay their eggs singly in soil in anticipation of future flooding, singly in water near vegetation, or in the case of Culex, on egg (rafts) of a few hundred in smaller bodies of stagnant, organically enriched water. Some mosquitoes have only one large hatch or generation per season and die off over the course of the season. Others like Culex mosquitoes are multigenerational, whereby the adult female after taking a blood meal can deposit an egg raft and in one or two weeks her offspring will emerge to similarly seek a blood meal and lay their own egg raft. This generational cycle continues through the summer months, ending in mid to late August when diminishing daylight triggers diapause. Mosquitoes emerging after diapause tend to not seek a blood meal, but rather obtain nutrients from flower nectar in preparation to hibernate over winter as adults. They will only seek blood meals in the following spring to obtain the necessary nutrients to lay egg rafts to commence the cycle in the following summer.

## 5. References

American Association of Equine Practitioners. (2005). West Nile Virus Vaccination Guidelines. Received from http://www.aaep.org/pdfs/AAEP_WNV_Guidelines_2005.pdf

Baum, S. (2004). Zoonoses. Current Infectious Disease Reports, 6, 343–344

BCCDC. (2010). West Nile Virus. Retrieved from www.bccdc.ca/westnile

BCCDC Epidemiology Department. (2009). BC West Nile Virus Surveillance Program Report. Retrieved from www.bccdc.ca/westnile

Belton, P. (2007). British Columbia Mosquitoes as Vectors of West Nile Virus. Retrieved from http://www.sfu.ca/~belton/summary.pdf

Brault, A. (2004). Changing Patterns of West Nile virus Transmission: Altered Vector Competence and Host Susceptibility. Vet Res. 40(2): 43

[CBC] Canadian Broadcasting Corporation. (2008). West Nile: What you need to know. Retrieved from http://www.cbc.ca/technology/story/2008/08/19/f-westnile.html

[CDC] Centers for Disease Control and Prevention. (2009). West Nile Virus, Vertibrate Ecology. Retrieved from http://www.cdc.gov/ncidod/dvbid/westnile/birdspecies.htm

Curtis Dyna-Fog ltd. (2010). Mosquito Light Traps. Received from http://dynafog.com/other/mosquito_light_trap/

Gale Encyclopedia of Medicine. (2008). Zoonosis. The Gale Group, Inc. Retrieved from http://medical-dictionary.thefreedictionary.com/Zoonotic+vector

Government of Alberta. (2007). West Nile Virus. Retrieved from http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex5455

Health Canada. (2004). Consumer product Safety: Mosquito Control. Retrieved from http://www.hc-sc.gc.ca/cps-spc/pest/part/protect-proteger/use-utiliser/_mosquito-moustique/index-eng.php

John W. Hock Co. (2004). Manual for CDC Miniature Light Trap. Received from http://www.johnwhock.com/download/manuals/instr_512_CDCMiniature.pdf

Kilpatrick, A., Kramer, L., Jones, M., Mara, P. & Daszak, P. (2006). West Nile Virus Epidemics in North America are Driven by Shifts in Mosquito Feeding Behavior. PLoS Biology, 4(4)

LaDeau, S., Kilpatrick, A. & Marra, P. (2007). West Nile virus emergence and large-scale declines of North American bird populations. Nature, 447, 710-713. Retrieved from http://www.nature.com/nature/journal/v447/n7145/abs/nature05829.html)

Ministry of Education. (2008) Science and technology 11, Integrated Resource Package 2008. Retrieved from http://www.bced.gov.bc.ca/irp/irp_sci.htm

Ministry of Environment. (2007). Integrated Pest Management. Retrieved from http://www.env.gov.bc.ca/epd/ipmp/regs/ipmdef.htm

[NCZVED] National Center for Zoonotic, Vector-Borne, and Enteric Diseases. (2009). Retrieved from http://www.cdc.gov/nczved/

[PHSA] BC Centre for Disease Control Public Health & Microbiology Reference Laboratory. (2010).Guide to programs and services: Zoonotic Diseases & Emerging Pathogens (ZEP) Program. Retrieved from http://www.phsa.ca/AgenciesAndServices/Services/PHSA-Labs/About-PHSA-Labs/BCCDC-Public-Health-Microbiology-Lab.htm

[PMRA] Pesticide Management Regulatory Agency. (2004). Consumer product Safety: Mosquito Control. Retrieved from http://www.hc-sc.gc.ca/cps-spc/pest/part/protect-proteger/use-utiliser/_mosquito-moustique/index-eng.php

Texas Dept of Health Services. (2004a). Frequently Asked Questions about Serology. Retrieved from http://www.dshs.state.tx.us/LAB/sero_faqs.shtm

Texas Dept of Health Services. (2004b). Enzyme Immunoassays. Retrieved from http://www.dshs.state.tx.us/LAB/serology_eia.shtm

[UC Davis] University of California and California State Department of Agriculture and Natural Resources: Integrated Pest Management Program. (2003). How to manage pests -Degree days. Retrieved from http://www.ipm.ucdavis.edu/WEATHER/ddconcepts.html

[WHO] World Health Organization. (2004). Report of the WHO/FAO/OIE Joint Consultation on Emerging Zoonotic Diseases. Geneva, Switzerland. Retrieved from http://whqlibdoc.who.int/hq/2004/WHO_CDS_CPE_ZFK_2004.9.pdf

[WHO] World Health Organization. (2009a). WHO Definition of Health. Retrieved from http://www.who.int/about/definition/en/print.html

[WHO] World Health Organization. (2009b). Zoonoses. Retrieved from http://www.who.int/topics/zoonoses/en/

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