

West Nile Virus in the Thunder Bay District, 2009

Dr. Ken Deacon
Bioconsultant

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Thunder Bay District Health Unit
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Table of Contents

List of Figures	3
Executive Summary	4
History of West Nile Virus in North America	6
Illness Caused by West Nile Virus	6
Transmission of West Nile Virus in Humans	7
Mosquito Vectors	7
Objectives of the WNV Surveillance Programme, 2009	9
Larval Mosquito Surveillance	10
Adult Mosquito Surveillance	11
Human Surveillance	15
West Nile Virus Control Measures	16
Conclusions	16
Recommendations for 2010	17
Literature Cited	18

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List of Figures

- Fig. 1 Mosquito larval habitat and complaint sites and location of CDC adult mosquito light traps in the city of Thunder Bay, 2009. 11
- Fig. 2 Location of CDC adult mosquito light traps in the Region of the District of Thunder Bay, 2009. 12
- Fig. 2 Number of individuals of vector mosquito species and non-vector mosquitoes collected in the District of Thunder Bay, 2009. 14

EXECUTIVE SUMMARY

No human case of West Nile Virus (WNV) was reported from the District of Thunder Bay during 2009.

Bird surveillance was considered unnecessary for monitoring of WNV activity in Ontario during 2009; therefore, no dead birds were submitted for WNV testing. CDC adult mosquito light traps provided the information required to evaluate human risk from WNV.

No catch basins were inspected in the City of Thunder Bay during 2009. Frequent rainfall during July and August flushed the catch basins of mosquito larvae making inspections pointless. Effort should be continued to determine the prevalence of *Cx. restuans* in the catch basins during July and August, if weather permits

One complaint about standing water as a potential larval habitat was received during 2009. The site was inaccessible because of fencing; however, the site was pumped dry, then later refilled with water. The site remains a concern that should be monitored.

An extensive wet habitat in a light industrial area located near the centre of the city was examined for larvae as recommended in 2008. No mosquito larvae were found during two hours of searching. This site should be re-examined during August in 2010 to ensure that the area is not used as larval habitat during the summer.

Nineteen CDC adult mosquito light traps were operated consistently for one night per week in the City of Thunder Bay and the Region during the nine week period from 30 June to 26 August for a total of 170 trap-nights. Eight vector species (one enzootic and seven epizootic) were found in the light traps. The traps collected a grand total of 5888 specimens. A total of 4361 individuals were identified from these specimens. The identified specimens contained 635 vectors. The vectors were pooled by species and then 17 of pools of *Cx. restuans* were tested for WNV. No mosquito pool tested positive

for WNV indicating minimal risk to the public. One *Culiseta melanura* pool was tested for Eastern Equine Encephalitis, but was found to be negative for the virus.

An estimate of the total number of each species of mosquito was calculated. *Cx. restuans*, an enzootic vector, totaled 22 individuals or approximately 0.4% of the 5888 mosquitoes. *Culex tarsalis* and *Culex salinarius*, competent vectors capable of transmitting WNV to both birds and mammals, were not recovered during 2009. Epizootic vectors included *Aedes vexans* (n= 296) (5.0%) and six other species. *Cx. pipiens* was not collected.

Only 12.1 accumulated degree-days (AccDD) were recorded in Thunder Bay during 2009. A value of 380 AccDDs is required before an outbreak occurs. The low incidence (0.4%) of the enzootic vector *Cx. restuans*, the absence of *Cx pipiens*, *Cx. tarsalis*, and *Cx. salinarius*, as well as the low AccDD value made the amplification of WNV within the bird community to the point of “spill-over” an extremely unlikely event during the summer of 2009. The risk to humans of acquiring WNV was considered minimal. Neither larviciding nor adulticiding was considered necessary during 2009.

If the climate of Thunder Bay changes to one which is similar to the prairies (hot and dry) or to that of southern Ontario (hot and humid), then there will be increased risk from WNV because of increases of *Cx. restuans*, *Cx. tarsalis*, *Cx. salinarius*, and perhaps the establishment of *Cx pipiens*. Any increase in these extremely competent vectors would result in the increased risk of an outbreak of WNV in the District of Thunder Bay.

History of West Nile Virus in North America

West Nile virus (WNV) first appeared in North America in New York City during August 1999. This mosquito-vectored disease subsequently spread across North America. By the end of the summer of 2009, Alaska was the only state in the continental United States that remained free of WNV in humans, birds, animals, or mosquitoes (Centres for Disease Control 2009a). A total of 663 cases of WNV infections occurred in humans in the United States during 2009, resulting in 30 deaths (Centres for Disease Control 2009b).

WNV was first detected in Canada during 2001 when dead birds tested positive for the virus (Region of Peel 2002). The first human cases of WNV in Canada occurred during 2002 in Ontario and Quebec, with a total of 414 WNV cases and asymptomatic infections. In 2003 a total of 1495 cases occurred, then 26 cases during 2004, 238 cases during 2005, 151 cases during 2006, and 2353 cases during 2007 which decreased to 36 cases during 2008 (Deacon 2009), then 8 cases during 2009 (Public Health Agency of Canada 2009b). The majority of the 2007 WNV cases were from the prairie provinces of Manitoba, Saskatchewan, and Alberta (Public Health Agency of Canada 2009a). The number of deaths attributed to WNV in Canada was 11 during 2002, 10 during 2003, 2 during 2004, 12 during 2005, 2 during 2006, 8 during 2007, 0 during 2008 (Deacon 2009) and 0 during 2009 (Public Health Agency of Canada 2009b). WNV was active only in Ontario, Manitoba, and Saskatchewan, Alberta and British Columbia during 2009 (Public Health Agency of Canada 2009b).

Illness Caused by West Nile Virus

WNV is vectored by infected mosquitoes. Eighty percent (80%) of people infected with WNV are asymptomatic. Twenty percent (20%) of infected people develop West Nile Fever which consists of fever, tiredness, headache, muscle aches, rash and/or swollen glands. Approximately one in 150 people infected with the virus will develop a life

threatening manifestation called encephalitis, *i.e.* a swelling of the brain. Symptoms of West Nile Encephalitis include fever, headache, stiff neck, disorientation, tremors, muscle weakness, paralysis and/or coma (Elliott *et al.* 2003).

West Nile Encephalitis is more common, but not restricted to people over 50 years of age. The severity of the disease increases with age (Drebot & Artsob 2006). From 4% to 14% of people with West Nile Encephalitis will die as a result of their infection, whereas others may experience long-lasting, debilitating problems ranging from memory loss to muscle weakness (Elliott *et al.* 2003).

Transmission of West Nile Virus in Humans

West Nile virus is a mosquito-borne flavivirus which infects primarily birds, producing a transient high viraemia that allows transmission of the virus back to feeding mosquitoes in an amplifying cycle. The virus replicates in only some species of mosquitoes which act as the vectors of this disease. Humans can become infected as a result of bites from mosquitoes that have bitten infected birds. Other less common routes of transmission include: intrauterine, breast milk, blood transfusions, organ transplants, as well as needle stick or sharps injuries. Immunocompromised patients and the elderly are at the greatest risk for encephalitis and death (Groner 2005).

Mosquito Vectors

Mosquitoes either overwinter with the virus or become infected with WNV when they bite infected birds. Replication of the virus occurs in the mosquito at a temperature above 14.3°C (Reisen *et al.* 2006). Infected enzootic vector mosquitoes bite other birds, thus transmitting the infection to the new birds (Elliott *et al.* 2003). The virus undergoes replication in the newly infected birds. These birds then become a source of infection for other mosquitoes as this enzootic phase of the disease progresses in an amplifying

cycle. If amplification begins during the early spring, then by mid-summer a large number of infected birds and mosquitoes are present.

The primary mosquitoes involved in the enzootic amplification process in Ontario are *Culex pipiens* and *Culex restuans*. These mosquitoes prefer to feed on birds but may also bite humans or other mammals (Wood *et al.* 1979). *Cx pipiens* is now known to be attracted to humans at certain times during its lifecycle which means that this species also acts as an epizootic vector of WNV to humans (Russell 2008). A third *Culex* species, *Culex tarsalis*, is the main mosquito species responsible for the transmission of WNV in western North America (Goddard *et al.* 2002). *Cx tarsalis* is now known from the Thunder Bay District as well as the prairies (Deacon 2006). *Cx. tarsalis* is unusual for the genus *Culex* because it feeds freely on both birds and mammals (Wood *et al.* 1979) thus acting as both the enzootic and epizootic vector of WNV. Epizootic vectors, also called “bridge vectors” transmit WNV from birds to mammals.

Cx. pipiens and *Cx. restuans* prefer to lay their eggs in man-made structures that contain water such as street-side catch basins, road-side ditches, and man-made containers (tires, bottles, buckets, bird baths, roof gutters, swimming pool covers, etc.) where the eggs develop into larvae, then pupae and finally adults (Wood *et al.* 1979). *Cx. tarsalis* lays its eggs in permanent and semi-permanent ponds, irrigation and roadside ditches with emergent vegetation, as well as temporary pools or artificial containers (Wood *et al.* 1979).

“Bridge vectors” are generalist feeders, biting both birds and mammals. “Bridge vectors” are responsible for transmitting WNV from birds to humans during a “spill-over”, (the epizootic phase of the disease) which occurs during the late summer. The “spill-over” occurs only when a large number of infected birds are present. *Aedes vexans* is the principal “bridge vector” in Ontario; however, this species is only moderately effective as a vector (Turell *et al.* 2001). *Ae. vexans* breeds in temporary pools, marshes, and swamps (Wood *et al.* 1979) and is an abundant species in the District of Thunder Bay.

Ochlerotatus canadensis is another species, often abundant in the District of Thunder Bay, with larvae found in small open ponds, temporary woodland pools, roadside ditches, cattail

and sedge marshes, and muskeg pools (Wood *et al.* 1979). *Oc. canadensis* is also considered a moderately effective “bridge vector” of WNV (Belton 2007).

Cx. pipiens, *Cx. restuans*, *Cx. tarsalis*, *Ae. vexans*, and *Oc. canadensis* are found in close proximity to human populations, which makes these mosquitoes important in the transmission of WNV. Both enzootic and epizootic vectors are required in high numbers near humans before WNV can be transmitted to humans.

Objectives of the West Nile Virus Surveillance Programme, 2009

1. A risk analysis of West Nile Virus activity in the Thunder Bay District was to be completed.
2. Mosquitoes in the District of Thunder Bay were to be collected using Centres for Disease Control (CDC) adult mosquito light traps, and identified to species.
3. West Nile Virus prevalence in adult mosquito vector species was to be determined using Reverse Transcription-Polymerase Chain Reaction (RT-PCR).
4. The habitat used by *Culex tarsalis* in the District of Thunder Bay was to be studied, if possible.
5. Larval mosquito habitat was to be identified and inspected in the City of Thunder Bay.
6. Human cases of WNV within the District of Thunder Bay were to be noted.
7. Geographic Information Systems (GIS) mapping was to note:
 - Mosquito species distributions
 - Larval habitat locations
 - Catch basin data
 - High-risk locations
8. All municipalities within the District of Thunder Bay were to be offered a West Nile Virus information presentation outlining the TBDHU Action Plan and research findings, if desired.
9. Science-based information was to be used to determine the need for chemical control of larval and/or adult mosquitoes.
10. The 2009 report on West Nile Virus activity in the District of Thunder Bay was to be completed.

Larval Mosquito Surveillance

Catch basins, ponds, pools, and containers were examined to identify mosquito larval habitat within the City of Thunder Bay. The locations, species present, and stage of development of mosquitoes were recorded using GIS mapping. GIS mapping increased our ability to note sites that contain mosquitoes, especially vector species. These sites can be monitored in the future, and treated with larvicide if required. Catch basins were examined after seven rain-free days, which provides sufficient time for mosquito eggs to hatch and the larvae to develop to a stage that facilitates identification.

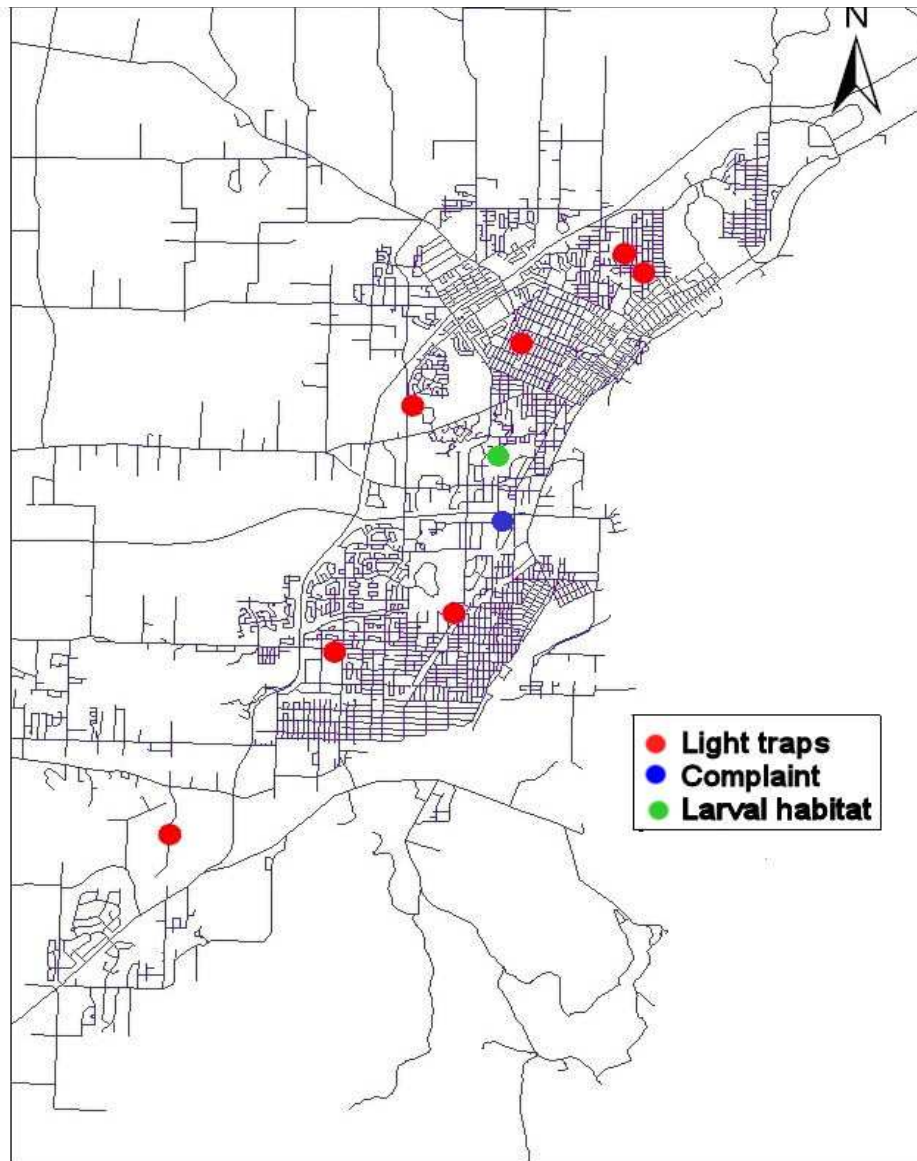
No catch basins were inspected in the City of Thunder Bay during 2009. Frequent rainfall during July and August flushed the catch basins of mosquito larvae making inspections pointless. Effort should be continued to determine the prevalence of *Cx. restuans* in the catch basins during July and August, if weather permits

One complaint about standing water as a potential larval habitat was received during 2009 (Fig 1). The site was visited on 1 June but was inaccessible because of fencing. This site was visited on 10 September the previous year when it was spot checked extensively, but no larva was found after 150 dips (Deacon 2009). This site was pumped dry, but later refilled with water. The site remains a concern that should be monitored.

One new larval habitat (Fig. 1) was examined during 2009 following the 2008 recommendations for actions (Deacon 2009). An extensive wet habitat in a light industrial sector located near the centre of the city was examined intensively on 3 September. No mosquito larvae were found during a two hour survey. This site should be re-examined during August in 2010 to ensure that the area is not used as larval habitat during the summer.

GIS mapping has greatly increased our ability to note areas of concern within the city, thereby facilitating precise larviciding if the need should arise. Sampling of catch basins

Fig. 1 Mosquito larval habitat and complaint sites and location of CDC adult mosquito light traps in the city of Thunder Bay, 2009.



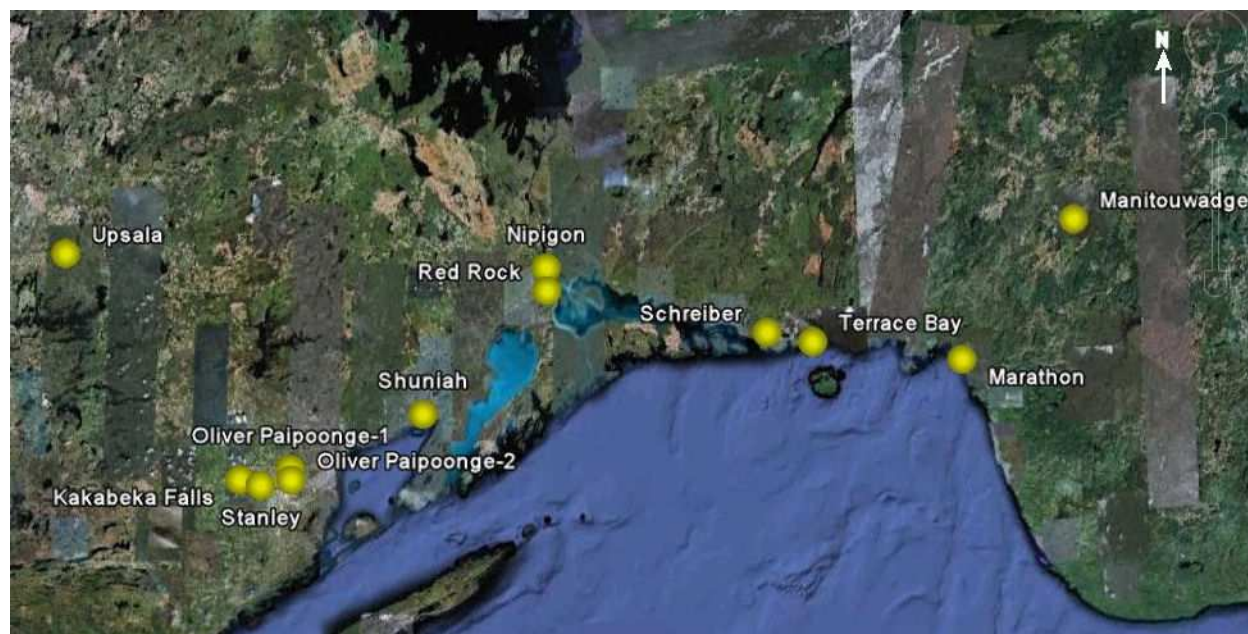
and larval habitat is essential to provide a better understanding of the mosquito species present and their abundance in the City.

Adult Mosquito Surveillance

Nineteen CDC adult mosquito light traps were operated one night per week at fixed, secure locations: seven within the city of Thunder Bay (Fig. 1); and 12 in the

surrounding “Region” (Fig. 2). The light traps were located at the same sites as 2008. Light traps were set for nine weeks from 30 June to 26 August during 2009 for a total of 170 trap-nights. One light trap was inoperable on one occasion during the summer.

Fig. 2 Location of CDC adult mosquito light traps in the Region of the District of Thunder Bay, 2009.



The contents of the light traps were analysed by Entomogen Inc. The species of mosquitoes were identified unless the trap contained more than 100 individuals. These larger samples were counted and subsampled with at least 100 individuals identified randomly. The remaining mosquitoes were referred to as “extras”. The light traps collected “extras” on 10 occasions during the 2009 trapping season. Entomogen Inc. also performed the viral analyses of the vector mosquitoes.

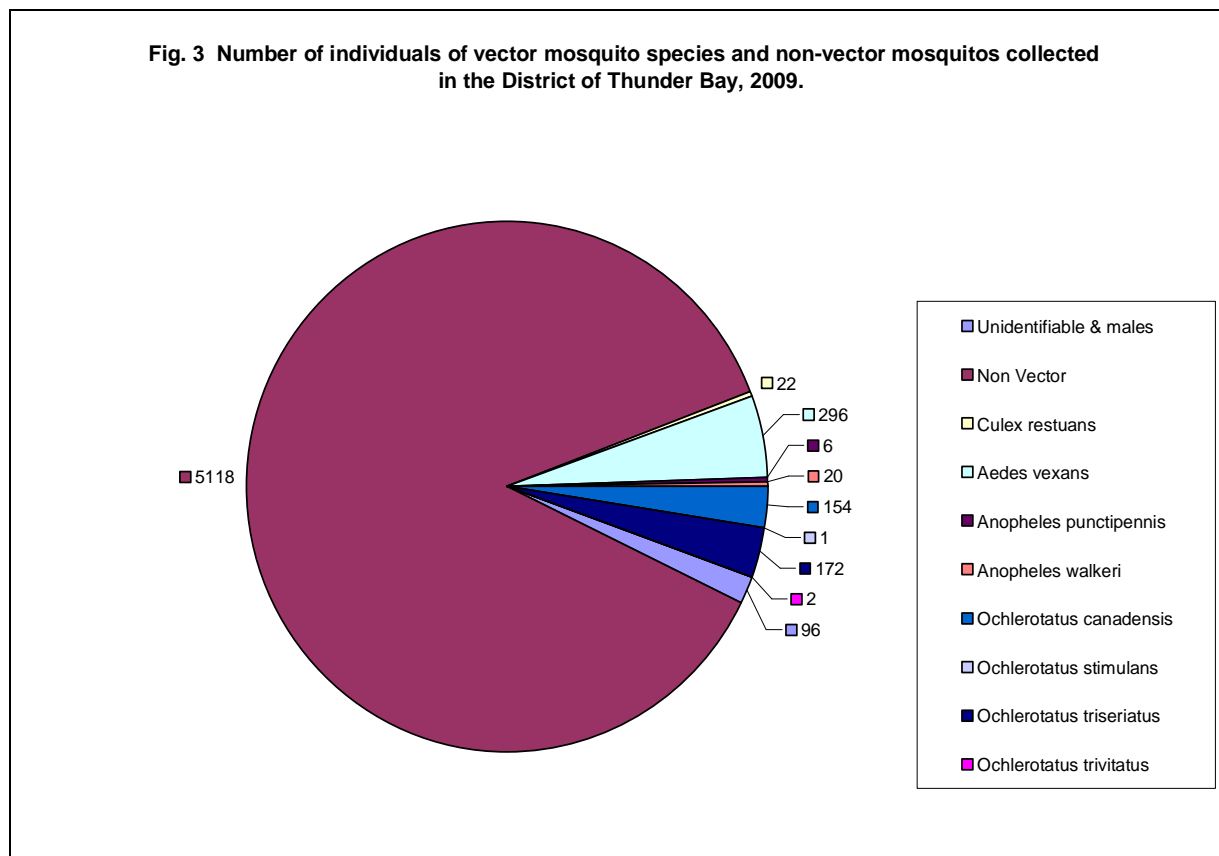
Eight vector species (one enzootic and seven epizootic) were found in the light traps. The light traps collected a grand total of 5888 specimens. Of this grand total, 87 individuals were unidentifiable or were unidentified males (males do not blood feed; therefore, they do not transmit WNV) leaving 5881 specimens for species determination. A total of 4361 individuals were identified from these specimens, of which 635 were vectors. These vectors were pooled by species and 17 pools of Cx

restuans were tested for WNV using Reverse Transcription-Polymerase Chain Reaction (RT-PCR). No mosquito pool tested positive for WNV. One *Culiseta melanura* pool was tested for Eastern Equine Encephalitis, but was found to be negative for the virus.

The approximate total number of each species of the unidentified specimens was estimated based on the ratio of the individuals identified to the individuals remaining as “extras” in the light traps per sampling event. The number of identified individuals of each species was multiplied by this factor to obtain an estimate of the approximate total number of individuals of each species collected on that night. After this conversion, vector species numbered approximately 673 individuals, whereas non-vector species numbered 5119 individuals and unidentifiable specimens/males numbered 96 individuals. These values are a more accurate reflection of the number of each species within the mosquito community throughout the entire summer.

Cx. restuans, an enzootic vector recovered from the light traps, totaled 22 individuals (Fig. 3), about 0.4% of all the mosquitoes collected. The epizootic vectors were *Ae. vexans* (n= 296) (5.0%), *An. punctipennis* (n= 6) (0.1%), *Anopheles walkeri* (n= 20) (0.3%), *Oc. canadensis* (n= 154) (2.6%), *Oc. stimulans* (n= 172) (2.9%), *Ochlerotatus triseriatus* (n= 2) (0.03%), and *Ochlerotatus trivittatus* (n= 1) (0.02) (Fig. 3).

Cx pipiens, one of the main enzootic vectors of WNV in southern Ontario could possibly be present in the District of Thunder Bay, but still has not been positively identified after seven years of monitoring. Hundreds of *Culex* larvae have been reared to the adult stage each year of the study and all adult males have been positively identified as *Cx. restuans* only. The population of *Cx. restuans* has varied from a high of 3.0% (2007) to a low of 0.5% (2005) and now a new low of 0.4% (2009) of the mosquitoes collected. No indication of an apparent trend towards an increase or decrease in number is evident. The fluctuation is probably related to the extremely different weather experienced each summer since the start of mosquito surveillance in 2003.



Culex salinarius and *Cx tarsalis* were not recovered during 2008; however, these species are of continuing concern with regards to WNV in Thunder Bay. *Cx. salinarius* was previously reported in 2003 and again in 2005 (Deacon 2009). *Cx. salinarius* is a competent vector of WNV (Andreadis *et al.* 2004) ; however, the numbers of this species in the District of Thunder Bay are extremely low. Monitoring must continue to determine changes in the abundance of *Cx. salinarius* and the potential threat this species may pose to public health.

Cx. tarsalis is of even greater concern as a vector of WNV. *Cx. tarsalis* is a competent vector of WNV (Goddard *et al.* 2002), readily feeding on both birds and mammals, including humans (Wood *et al.* 1979). These characteristics allow *Cx. tarsalis* to act as both an enzootic and epizootic vector. The distribution of *Cx. tarsalis* is described as present in western North America with some populations found in southeastern Ontario, and even Florida (Wood *et al.* 1979). The collection of specimens from Kakabeka Falls to Geraldton during 2005, one specimen from Red Rock during 2006, and eight

specimens from around the City of Thunder Bay during 2007 (Deacon 2009) indicates that *Cx. tarsalis* is established and widespread within the Boreal forest in the District of Thunder Bay. More information is needed about the biology of *Cx. tarsalis* to explain the occurrence of this species in the Boreal forest and to examine the effect that weather has on its abundance. Additional information will help predict the nature of the threat posed by *Cx. tarsalis* to public health.

The Ontario Ministry of Health and Long-Term Care now uses accumulated degree-days (AccDD) (based on average daily temperatures above a threshold temperature of 18.3°C) to evaluate the risk of a WNV outbreak (Hunter & Gasparatto 2009). The replication of WNV depends on ambient temperature. Mosquitoes require at least 380 AccDD before a serious risk of a WNV outbreak occurs. Only 12.1 AccDD were recorded in Thunder Bay during 2009 (Environment Canada 2009), which is well below the required 380 AccDD.

The low incidence (0.4%) of the enzootic vector *Cx. restuans*, the absence of *Cx. pipiens*, *Cx. tarsalis*, and *Cx. salinarius*, as well as the low AccDD value made the amplification of WNV within the bird community to the point of “spill-over” an extremely unlikely event during the summer of 2009. The risk to humans of acquiring WNV was considered minimal. If the climate of Thunder Bay changes to one which is similar to the prairies (hot and dry) or to that of southern Ontario (hot and humid), then there will be increased risk from WNV because of increases of *Cx. restuans*, *Cx. tarsalis*, *Cx. salinarius*, and perhaps the establishment of *Cx. pipiens*. Any increase in these extremely competent vectors would result in increased risk of an outbreak of WNV in the District of Thunder Bay.

Human Surveillance

No human cases of WNV were noted in the District of Thunder Bay during 2009, although two cases were reported during 2007 (Deacon 2009). Mosquitoes have tested positive for WNV in the Algoma Health District (OMHLTC 2005) to the east of the

TBDHU and one human case of WNV was reported from the Northwestern Health Unit during 2006 (Northwestern Health Unit 2006) to the west of the TBDHU. The risk of an individual acquiring WNV in the TBDHU remains low; however, continued monitoring of the adult mosquito community is necessary and the identification of larval habitat is essential if control measures are found to be necessary in the future.

West Nile Virus Control Measures

Neither larviciding nor adulticiding was required within Thunder Bay District. WNV control measures in Thunder Bay District focused on reducing mosquito-breeding sites on private and municipal property, and on providing information to the public about the prevention of mosquito bites. During 2009, this information was disseminated to the public through pamphlets and the media. Pamphlets and/or posters were offered to health unit district offices, hospitals, children's daycare centres, seniors' centres, long-term care facilities, doctors' offices, pharmacies, golf clubs, municipal offices, community centres, resorts, sport shops, campuses, recreational camps, tree planting camps, garden centres, and parks.

The TBDHU conducted a number of media interviews about WNV during the spring and summer of 2009. Personnel also staffed display booths, which were designed to convey essential information about the risk from WNV in Thunder Bay.

Conclusions

The data collected during 2009 have again demonstrated the potential for an outbreak of WNV if environmental conditions change. *Cx. pipiens*, *Cx. tarsalis* and *Cx. salinarius* were not collected. The vector species *Cx. restuans* decreased to the lowest level recorded to date at 0.4% of the mosquitoes recovered in the District of Thunder Bay. These observations lead to the conclusion that WNV posed a minimal risk to human health during 2009, but that risk will increase as the climate changes to one more typical of southern Ontario or western Canada. Any change which increases the numbers of the extremely competent vectors *Cx. restuans*, *Cx. tarsalis*, *Cx. salinarius*, and perhaps

the establishment of *Cx pipiens* would result in the increased risk of an outbreak of WNV in the District of Thunder Bay.

More information is required about catch basins, larval habitat, and the adult mosquito communities. Public outreach encouraging personal protection measures to reduce exposure to mosquitoes and the reduction of artificial breeding sites should continue. A larviciding programme to augment these proposed actions should be considered only if there is a significantly increased risk of human infection by WNV. Contingency plans for pesticide treatment should be developed now to prepare for the possibility that changing weather related to global climate change creates conditions more conducive for the transmission of WNV in Thunder Bay.

Recommendations for 2010

1. Continue the adult mosquito surveillance programme within the City of Thunder Bay and in the Region using CDC light traps.
2. Continue the catch basin monitoring program, if weather permits, to identify the mosquito species that are present and the abundance of those mosquitoes within the catch basins of the City of Thunder Bay.
3. Continue the identification of larval mosquito habitat within the City of Thunder Bay.
4. Continue to monitor larval mosquito habitat that has been reported by, and is of concern to, the public.
5. Continue the use of GIS mapping to store all habitat, catch basin, and mosquito trap locations and data.
6. Investigate the biology of *Cx. tarsalis*, if weather permits, to determine where this critical species occurs in the Boreal forest.

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