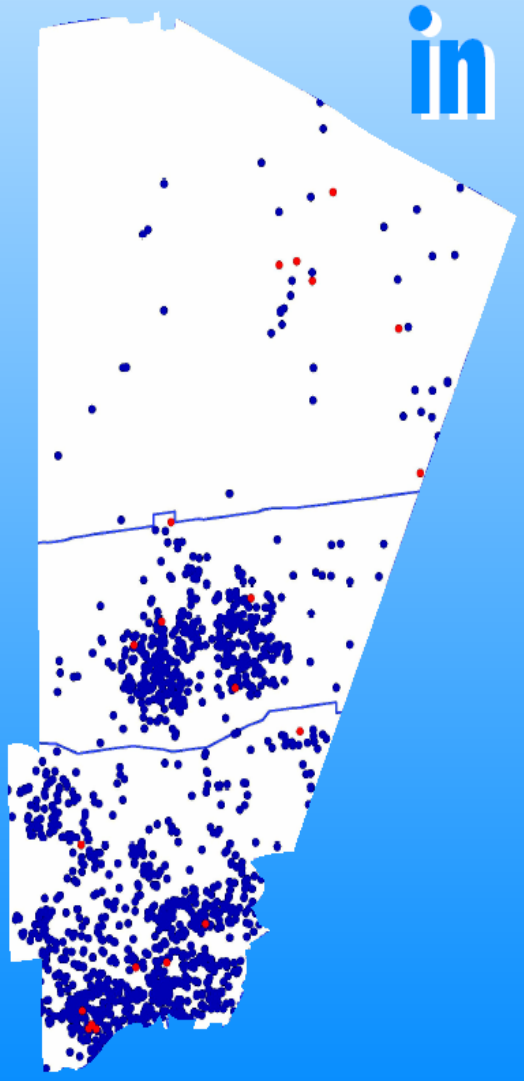
West Nile Virus in the Region of Peel 2002



Region of Peel
Working for you

ACKNOWLEDGEMENTS

This report was authored by: Karen Funnell, Health Analyst; Dr. Howard Shapiro, Associate Medical Officer of Health; Dr. David McKeown, Medical Officer of Health; Andrea Smith, Senior Epidemiologist (Acting); and Kit Ping Wong, Health Analyst.

Considerable input into other aspects of this report was also provided by the following staff:

Howard Beatty, Manager, Environmental Health
Paul Proctor, Supervisor, Communicable Diseases, Environmental Health Division (Acting)
Liz Van Horne, Infection Control Specialist
Donna Nadolny, Manager, Health Planning
Paul Callanan, Director, Environmental Health
Cathy Fisher, Clerk Typist
Holly Greenwood, Supervisor, Healthy Lifestyles
Nancy Lotecki, Supervisor, Communicable Diseases
Annie Kakooza, Information Officer (Acting)
Lucie Imbiscuso, Public Health Inspector

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

EXECUTIVE SUMMARY

WNV is a mosquito-borne infection that first made its appearance in North America in 1999. It is a human, horse and bird neuropathogen that can result in encephalitis, meningitis and sometimes lead to death.

Surveillance information from birds and mosquitoes provides an early warning of risk to human health and helps to guide control and education interventions. In the Region of Peel, WNV was first detected in birds and mosquitoes in 2001, with cases of locally acquired human illness occurring for the first time in 2002.

In 2002, Peel Health conducted surveillance activities in the Region involving dead birds, adult mosquitoes, larval mosquitoes and human cases. An analysis of 2002 surveillance data informed the development of the West Nile Virus Prevention & Control Plan 2003.

Dead Bird Surveillance

By the end of the 2002 mosquito season, over 1,400 dead crows had been sighted and reported to Peel Health. Twenty out of the 71 crows that were submitted for testing were found to be positive for WNV.

The first WNV-positive bird in Ontario in 2002 was found in Mississauga on May 19th. However, it was a sharp rise in dead crow sightings starting in late July and a number of WNV-positive mosquito pools that led to the public being notified of a possible increased risk of human illness.

Adult Mosquito Surveillance

Although 41 species of mosquitoes were found in the Region of Peel in 2002, only a small number were found to be important in the transmission of WNV from mosquitoes to humans. While eight separate species of mosquito were found to be positive for WNV, mosquitoes from the genus *Culex* were the most important, accounting for 30% of the mosquitoes collected and tested and 77% of the WNV-positive pools. *Culex* mosquitoes also exhibited some of the highest WNV infection rates in Peel.

In particular, *Culex pipiens* and *Culex restuans* were key “amplification” species, because they prefer to feed on birds, the main reservoir of WNV, and are effective transmitters of the virus. They are more common in urban and suburban settings and primarily use standing or slow-moving water in which to lay their eggs. They breed quickly, producing as many as four generations such that their numbers greatly increase over the course of the mosquito season.

Very few *Culex* mosquitoes were trapped in the Caledon area compared to Mississauga or Brampton. No WNV-positive pools of mosquitoes were found in Caledon in 2002.

While other species or mosquitoes are more likely to bite people, control of *Culex* mosquitoes is one of the most important strategies to reduce the risk of WNV transmission to humans.

Mosquito Breeding Site (Larval) Surveillance

Larval surveillance provides crucial information for mosquito control interventions. In 2002, a total of 278 sites were surveyed for standing water in Peel: 152 were in Mississauga, 106 in Brampton and 20 in Caledon. The presence of mosquito larvae was identified in 42% of the potential breeding sites from which samples were taken. Ditches and culverts were some of the more numerous breeding sites and often contained mosquito larvae.

Human Case Surveillance

Mosquito-borne acquisition in Canada of WNV disease in humans occurred for the first time in 2002. As of May 28, 2003, 112 residents of Peel had laboratory evidence of WNV infection stemming from the 2002 season: 37 confirmed cases, 20 probable cases, and 55 suspect cases. Of the 57 confirmed and probable cases, 91% were from Mississauga and 9% from Brampton.

As found in other jurisdictions, and contrary to initial expectations, cases of WNV were not limited to older adults or the infirmed, as many of those affected in Peel (32%) were less than 50 years of age. Few confirmed or probable cases of WNV occurred among the very young, while most occurred among the 50-59 and 60-69 year age groups. The rate of diagnoses of WNV disease increased with increasing age.

While most of those infected did not suffer very severe disease, there were two deaths, seven cases of encephalitis and five cases of meningitis among the 57 WNV confirmed or probable cases in Peel. Fairly high proportions of symptoms such as muscle weakness (53%) and changes in mental status (37%) were also observed.

Identification of WNV in humans underscores the importance of active, hospital-based human surveillance programs starting in July through to September, as well as the need to consider WNV as a possible diagnosis when clinicians encounter patients with encephalitis, meningitis, acute flaccid paralysis or non-specific fevers occurring throughout this time period.

CONCLUSION

In Peel in 2002, the first indication of WNV activity was a WNV-infected dead bird found in Mississauga on May 19th. The first human illness onset of August 4th occurred during a spike in reported sightings of dead crows that started July 21st and continued until August 10th. The first WNV-positive pool for adult mosquitoes was from a sample collected on June 20th.

Analysis of the Region of Peel's complete surveillance results shows that these monitoring systems have the potential to predict human risk from WNV in the future. Detailed analysis of information on Peel mosquitoes shows that *Culex* mosquitoes play a key role in local transmission of WNV as reported for other similar areas in the North American literature. In Peel, *Culex* mosquitoes were numerous and had high rates of transmission. It is appropriate that the Peel WNV Prevention and Control Plan focus control efforts on *Culex* mosquitoes.

INTRODUCTION

West Nile Virus (WNV) is a mosquito-borne "flavivirus" that first made its appearance in North America in 1999. It is a human, horse and bird neuropathogen[1] that can result in encephalitis, meningitis and even death.

"West Nile" Virus is so named because it was first isolated and identified in an infected person from the West Nile Province of Uganda in 1937.[2] There have since been reported outbreaks of WNV in Africa, Asia, the Middle East and Europe. There was no known transmission of WNV in the Western Hemisphere until reports of humans with the mosquito-acquired infection occurred in New York City in 1999.

There are several theories as to how the virus arrived in North America. One theory suggests that the virus arrived in an infected migratory or imported bird; another suggests that mosquitoes infected with the virus were accidentally transported to North America with other cargo.[3]

WNV was detected for the first time in Canada in 2001 in birds and mosquitoes from Ontario, including Peel. In 2002, Canadian health authorities documented WNV activity in five provinces: Nova Scotia, Quebec, Ontario, Manitoba and Saskatchewan.[3] Meanwhile, the 2002 WNV epidemic in the United States saw activity reported in 44 states and the District of Columbia. The first cases in California, in a human with no travel history, and Washington, in a horse, meant that the sweep of the epidemic across the North American continent was complete in just three years.[4]

WNV is similar to St. Louis Encephalitis (SLE), a very closely related mosquito-borne virus native to North America. An epidemic of SLE which occurred in the Mississippi and Ohio River basins in 1975 saw 2,100 human cases and 170 deaths with a case fatality ratio of 8%.[4] There were 66 cases associated with this outbreak in southwestern Ontario.[5] WNV & SLE are transmitted primarily by the *Culex* species of mosquitoes and are amplified in birds, although SLE does not kill birds or horses.[4]

WNV is also similar to Japanese Encephalitis Virus (JEV), which occurs widely in eastern and southern Asia.[2] People who have been vaccinated against JEV or Yellow Fever can have equivocal test results for WNV. Equivocal results can also occur from infection with other flaviviruses such as SLE and Dengue.[6]

The WNV Transmission Cycle

Evidence suggests that WNV can remain in an area over the winter months in infected birds and/or mosquitoes,[7] or in unhatched mosquito eggs.[3] A relatively small number of infected mosquitoes and/or birds would therefore be present within the region in early spring. This is when the virus begins to amplify. As certain types of female mosquitoes (*Culex pipiens* and *restuans*) feed on birds to get their blood meal in order to breed, the

virus is transmitted back and forth between the “vector” (the mosquito) and the reservoir “host” population (the bird), causing an increasing number of both birds and mosquitoes to become infected.

Towards mid-to-late summer, certain other mosquito species, such as *Aedes vexans* and *Coquillettidia perturbans,* that feed on both birds and mammals become important in the transmission of WNV to people. By this time, there has been significant amplification of the virus among the bird population. These “bridge vector” mosquitoes that have fed on a WNV-infected bird become infected with WNV. People are infected when they are subsequently bitten by infected mosquitoes. Hence, the period of greatest risk to humans and other mammals is in late summer or early fall when the level of WNV in birds and mosquitoes is at its highest.[2]

This report describes findings from the WNV surveillance activities conducted in Peel Region in 2002 involving dead birds, adult mosquitoes, larval mosquitoes and human cases.

DEAD BIRD SURVEILLANCE

Introduction

To date, approximately 150 species of birds in North America are known to have been infected by WNV.[3,8,9] In Canada, wild birds such as crows, ravens, blue jays, gray jays and stellar's jays have been found to be susceptible to WNV and often die from the infection due to inflammation of the brain and other organs.[9]

The American crow, *Corvus brachyrhynchos*, has been found to be the most sensitive indicator of WNV activity. In 2002 in the United States, crows, blue jays and other members of the family *Corvidae* (called "Corvids") accounted for 90% of WNV-infected birds, with crows having the highest rate of WNV infection.[4] Consequently, it is crows that are most closely monitored by health authorities, including Peel Health.

The wild bird surveillance program operated by the Canadian Cooperative Wildlife Health Centre (CCWHC) has been in place since May 2000.[2] The program tests only members of the crow family (e.g. crows, gray jays, ravens and magpies). In 2000, 2,288 birds were examined and none were found to have WNV present. In 2001, 3,911 birds were tested and 128 (3%) were found to have the virus. In 2002, 3,478 birds were examined and 563 (16%) were found to be WNV-infected.

Surveillance programs for dead birds entail finding birds freshly dead in the wild during mosquito season, collecting their carcasses and testing them for the presence of the virus in their tissues.[2] Factors such as the density of the human population in a given area will affect the number of dead bird sightings in that area. It is important to understand that the purpose of dead bird surveillance is not to monitor the status of bird health with respect to WNV, but rather to establish whether or not WNV is present in a given area.[10] The presence of WNV in dead birds serves as an early warning of risk to human health.

Information about the presence of WNV is important for decision making on WNV control measures. In any given year, once it has been established that WNV is present among some of the birds within a given area, it is assumed that WNV infection exists throughout the flocks of birds in that area, and that any large 'die-offs' are due to WNV. Therefore further testing is no longer required.[10]

Methods

In the spring and summer of 2002, members of the public were asked to contact public health authorities if they found dead crows, taking note of the location and condition of the bird. Municipal animal control services initially collected the dead crows, and public health sent the specimens to the CCWHC laboratory in Guelph, Ontario. Tissue

samples taken in Guelph were sent to Health Canada's National Microbiology Laboratory in Winnipeg for WNV testing and results were then reported back to public health agencies. Beginning in 2003, testing will be done with a new rapid test by the CCWHC laboratory in Guelph, decreasing the time to receive results.

Information on the locations of the dead crows was collected from callers and/or by obtaining actual latitude and longitude measures using hand-held global positioning system (GPS) devices. The information, including date collected and test result, was entered into a geographic information system. Analyses were conducted by week of collection. The numbers used throughout this report to describe the weeks of the year can be found in Appendix A.

The number of dead crow specimens that could be tested in 2002 was limited because of capacity issues at the CCWHC and Health Canada laboratories. Once the virus was identified in crows in Peel, testing was discontinued as it was established that WNV activity was present in the area. Limited testing of dead crows resumed in the fall to see the seasonal extent of WNV infection in birds. Dead crow sightings continued to be reported throughout the fall; however, dead crows were not picked up and sent for testing after October 28, 2002.

Results

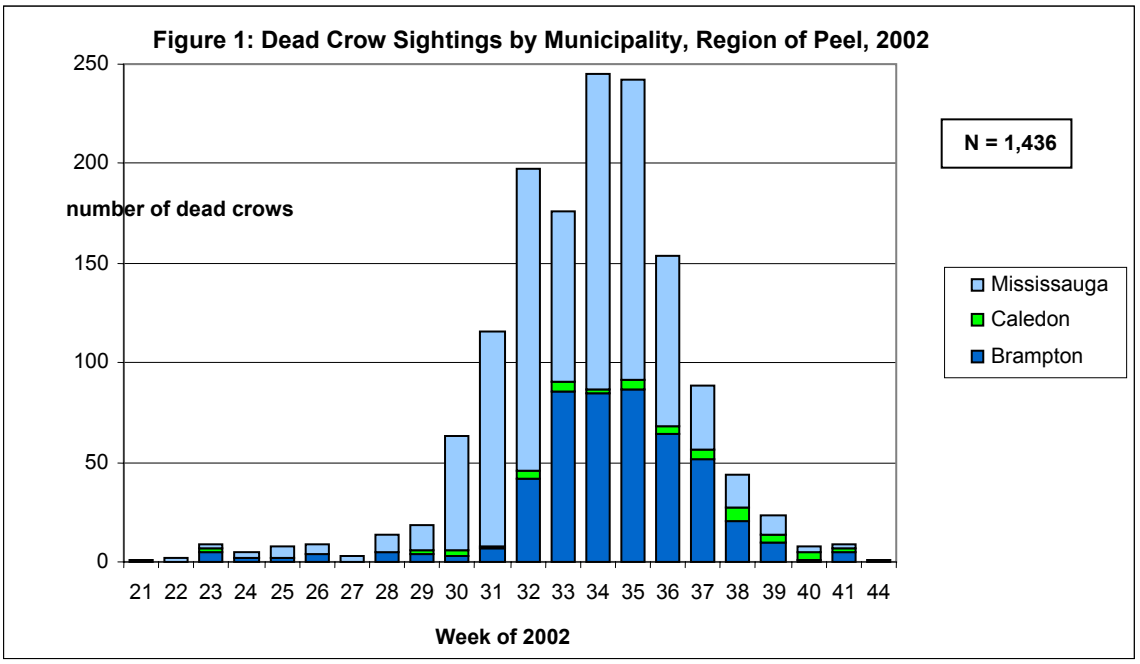
The first WNV-infected dead bird of 2002 in all of Canada was found in Peel on May 19, 2002. A total of 1,436 dead crow sightings were reported to Peel Health in 2002. As of December 17, 2002, at least one positive dead bird had been found in every health unit area across Ontario with the exception of Timiskaming.[11]

Dead birds were collected from May to October, with the last WNV-positive dead bird found on the 28th of October in Caledon. A sharp increase in the number of sightings began to occur in the third week of July (Week 30 – see Figure 1). With the exception of the 2nd week in August (Week 33), this increase continued until it peaked during the last two weeks of August (Weeks 34 and 35), with 245 and 242 dead bird sightings, respectively. The sharp increase in dead bird sightings occurred one-to-two weeks earlier in Mississauga than in Brampton, and appeared to move from the Lake Ontario shoreline northward.

All three area municipalities reported dead crows in 2002; however as expected, more were found in populated areas than in rural areas (Figures 2 and 3). Densities of dead crows reported per square kilometre, were mapped by Forward Sortation Area (FSA – the first three-digits of the postal code) and are depicted in Figure 3. Higher densities of dead crows occurred in the southern areas of Mississauga, with the highest bird densities per square kilometre occurring in the L5H and L5G areas where between 8 and 9.99 dead birds per square kilometre were sighted.

Of the 71 dead crows submitted for testing, 20 (28%) were WNV-positive – nine in Mississauga, six in Caledon and five in Brampton (Figure 2). With the exception of a grouping of four positive crows found in one postal code area (L5J), the rest were fairly evenly distributed across the Region.

A comparison of numbers of WNV-positive crows found in various Ontario health units is shown in Appendix B. Only Simcoe County had a higher number of birds found to be positive (21) than the Region of Peel (20). However, this is a function of testing patterns. For example, testing in an area was stopped after the first few positive results, and then resumed later in the fall to see whether WNV activity in crows had tapered off. In Ontario, a total of 281 dead birds tested positive for WNV in 2002.[12]



Summary

Surveillance programs for dead birds attempt to establish the presence of WNV in the bird population, which serves as an early warning of risk to human health.

By the end of the 2002 mosquito season, over 1,400 dead crows had been sighted in the Region of Peel. Members of the public reported nearly 250 dead crow sightings per week in each of the last two weeks in August.

In conjunction with the CCWHC, the testing of some of the dead crow specimens established that WNV was present in flocks of birds in Peel. Twenty out of the 71 dead crows that were submitted for testing were found to be positive for WNV.

The first WNV positive bird in Canada in 2002 was found in Mississauga on May 19th. However, it was a sharp rise in dead crow sightings starting in late July (Week 30 – July 21-27) along with a number of positive WNV mosquito pools that led to the public being notified of a possible increased risk of human illness from WNV using a mailed letter from the Medical Officer of Health to households in Peel.

Research has shown that the presence of dead birds found to be positive for WNV precedes an increased risk for human illness by a period of two to six weeks.[13] A more detailed temporal analysis comparing the timing of dead bird sightings, positive mosquitoes and human cases in one municipality of Peel will be shown in a later section of this report.

Figure 2: Locations of Dead Crow Sightings, Region of Peel, 2002

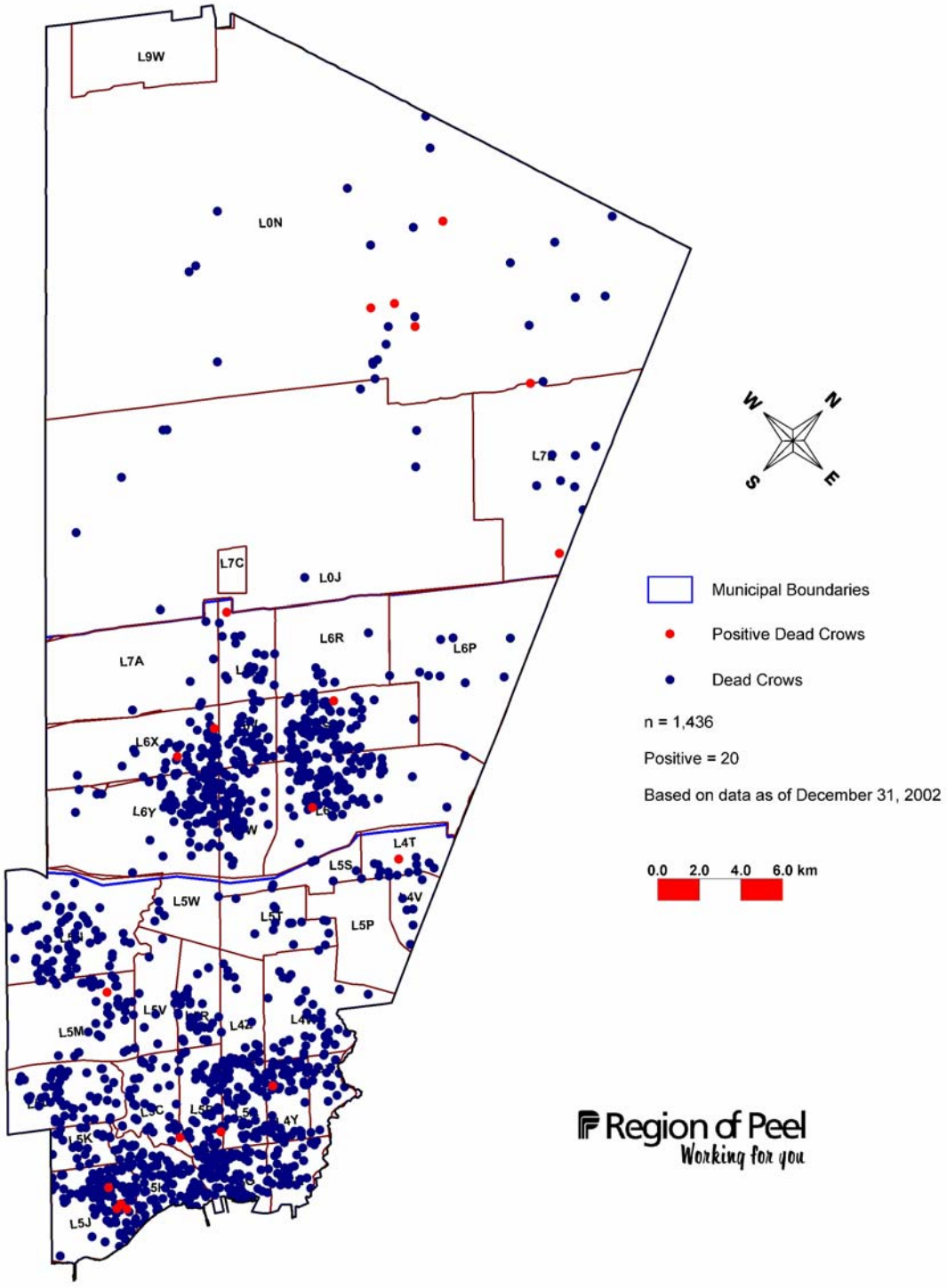
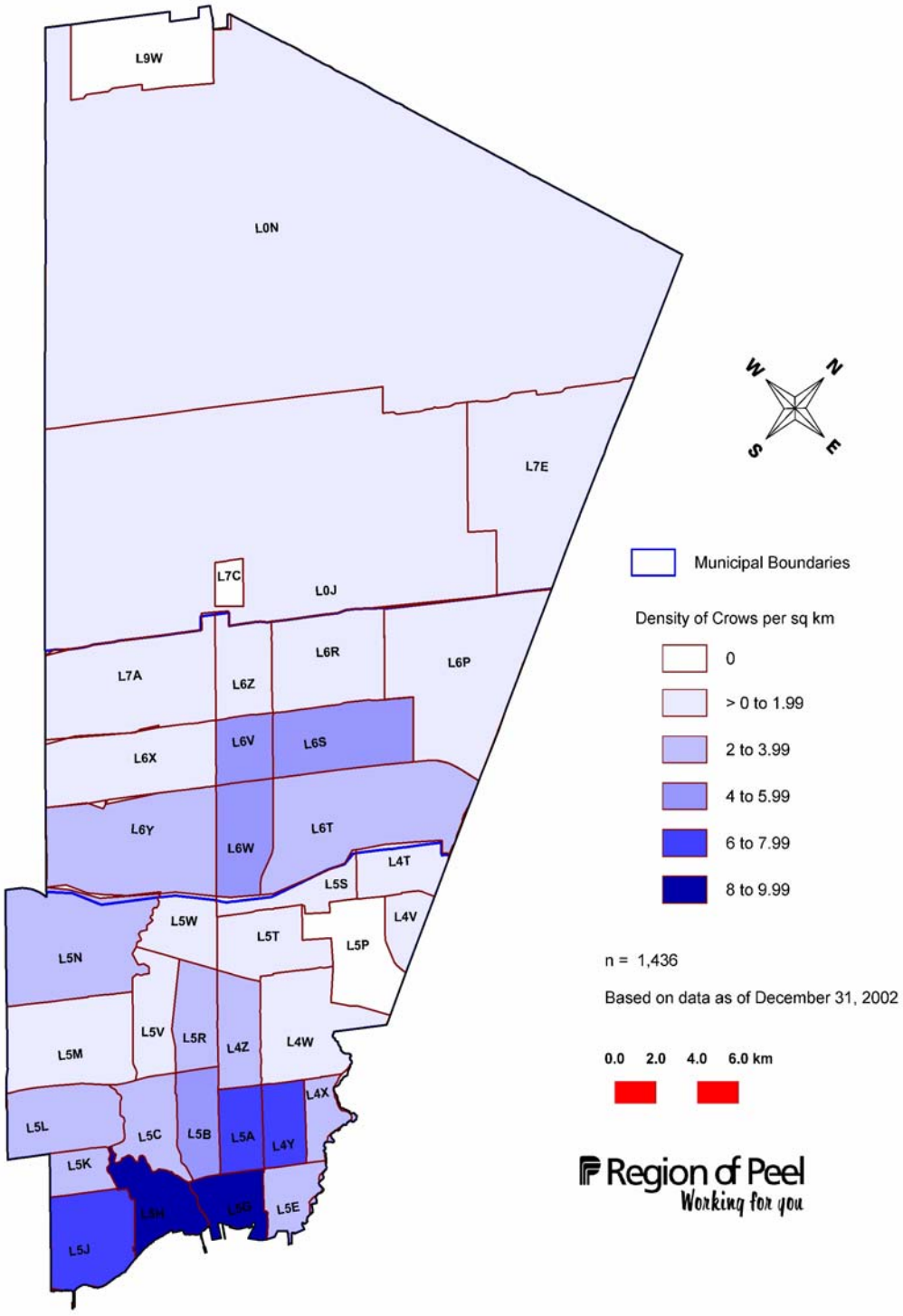


Figure 3: Density of Dead Crows Reported by Forward Sortation Area, Region of Peel, 2002



ADULT MOSQUITO SURVEILLANCE

Introduction

The West Nile virus survives by circulating between bird and mosquito populations. A female mosquito can acquire the infection by obtaining a blood meal from an infected bird and after a two-to-three week incubation period, can then pass the infection by injecting its saliva into another host (bird, horse, human or other animal) when it takes a blood meal.[7] Once in the new host, the virus can multiply, causing illness and possibly death.

There are 74 known species of mosquitoes in Canada;[3] 57 of these have been identified in Ontario.[7] According to Health Canada, only 10 species have been found to be infected by WNV in this country.[3] The most important "amplification" species in Ontario are thought to be *Culex pipiens* and *Culex restuans*. The most important "bridge vector" mosquitoes are highly dependant on local conditions. *Coquillettidia perturbans* and *Aedes vexans* may be the most important bridge vectors in Peel because of their high numbers. Three other species of mosquitoes (*Culex salinarius, Ochlerotatus triseriatus* and *Ochlerotatus* trivittatus) may be more important in the transmission of WNV to humans in Peel, than their small numbers suggest because of their high infection rates and aggressive biting of people.

The purpose of mosquito surveillance programs is to monitor mosquito populations associated with WNV, determine the level of WNV activity among these species and use this information to make decisions regarding the risk for transmission to humans and the need to implement mosquito control plans.

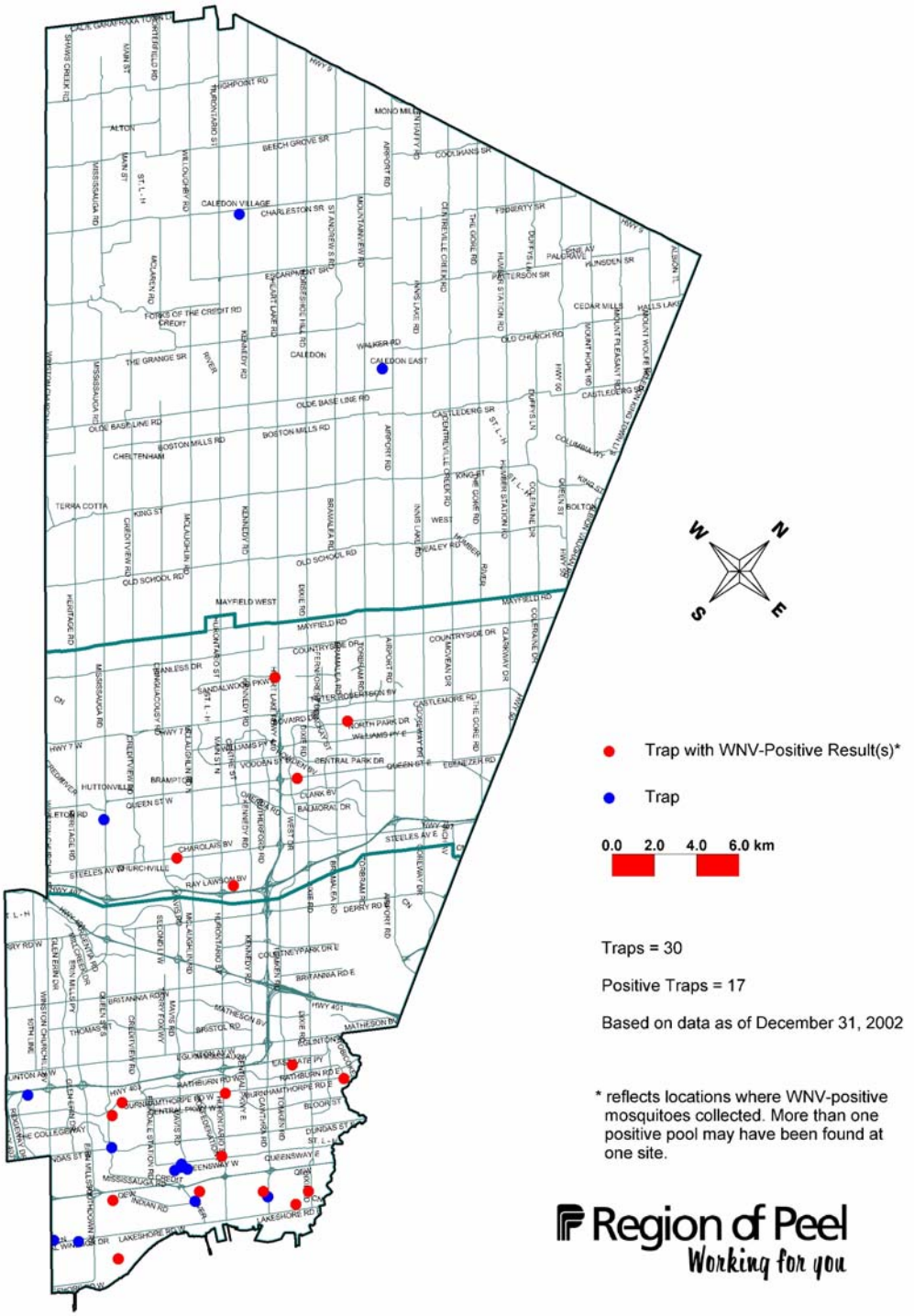
Methods

Two types of specialized traps used to capture adult mosquitoes were deployed in 20 fixed and 10 temporary locations across the Region of Peel from May 27 to October 17, 2002. CDC miniature light traps use carbon dioxide as bait to attract host-seeking adult female mosquitoes looking for a blood meal. Gravid traps are designed to attract adult female mosquitoes searching for a suitable site in which to lay their eggs.[14]

Adult mosquito traps were placed as shown in Figure 4. There were 22 sites in Mississauga, six in Brampton and two in Caledon. In all, 30 sites had light traps deployed and 25 sites had gravid traps set over the course of the mosquito season.

Adult mosquitoes were collected each week from the mosquito traps, refrigerated and transported alive via courier to the Department of Biological Sciences at Brock University in St. Catharines, Ontario. The trap contents were counted and separated into males (which feed on nectar and do not take blood meals) and females. The females were separated into species, recounted and then “pooled” by species, date of collection and location for testing. Pools generally numbered less than or equal to 50 adult female mosquitoes.

Figure 4: Locations of Mosquito Traps and Traps with WNV-Positive Results, Region of Peel, 2002



When species could not be distinguished, they were either classified as a group (e.g. *Culex pipiens/restuans*) or to the level of genus (e.g. *Culex spp.*). Some mosquitoes ended up being classified as unknown or "extras", likely because the specimens were either unusable due to the natural aging process, or were damaged during collection, shipping or storage, making them difficult to identify.[14]

Initially, all testing of female mosquitoes was conducted at Health Canada's National Microbiology Laboratory in Winnipeg, Manitoba. Later in the year, Brock University developed its own testing capability as part of a pilot program, which allowed some of the viral testing to be done at their facility. The remainder of Peel's specimens was tested by Health Canada for the presence of WNV, and final results were communicated in April, 2003.

Counts of mosquitoes by species, date collected, trap type and site were entered into an Excel spreadsheet by staff at Brock University; the file was then distributed to the public health units that had submitted specimens. Once they became available, positive pool test results were communicated to public health units via electronic mail.

Upon notification of laboratory evidence of a human case in Peel, the first known human case of WNV encephalitis acquired in Canada, additional light traps were set in the southern part of Mississauga to better monitor the risk of human infection in that area.

Results

In Peel, nearly 42,000 mosquitoes were trapped over the course of the 2002 season; however, only a portion of these was suitable for testing for the presence of WNV. Thus, a total of 24,269 adult female mosquitoes of 41 different species were collected and submitted for testing (Table 1).

The first notification in 2002 of a positive pool of mosquitoes identified in Ontario was a pool that had been collected in Mississauga on June 20, 2002 (Appendix C).[15] As of May 23, 2003, 128 positive mosquito pools from the 2002 season had been identified in the Region of Peel. These included results from two of three area municipalities: 83% (106) of the positive pools were from Mississauga and 17% (22) were from Brampton (Table 2). No positive pools were identified in Caledon. Locations of WNV-positive mosquitoes found in Peel are identified by a red symbol in Figure 4.

Table 1: Number of Female Adult Mosquitoes Collected by Species and Municipality, Region of Peel, 2002

Species Name	Brampton	Caledon	Mississauga	Peel
Coquillettidia perturbans	340	271	7383	7994
Aedes vexans	1536	27	2765	4328
Culex pipiens/restuans	582	5	2459	3046
Culex spp.	369	5	1445	1819
Culex pipiens	317	2	977	1296
Culex restuans	93	5	863	961
Ochlerotatus excrucians	160	3	533	696
Aedes vexans/cantator	390	2	231	623
Aedes/Ochlerotatus spp.	324	6	263	593
Ochlerotatus triseriatus	24	3	548	575
Ochlerotatus trivittatus	103	3	300	406
Ochlerotatus canadensis	88	6	143	237
Anopheles punctipennis	17	3	125	145
Culex salinarius	10	0	105	115
Anopheles quadrimacultaus	41	10	8	59
Culex pipiens/salinarius	6	0	50	56
Aedes cinereus	47	0	6	53
Culex territans	0	0	34	34
Ochlerotatus triseriatus/hendersonii	0	0	31	31
Ochlerotatus dorsalis	8	0	9	17
Aedes vexans nipponi	4	0	7	11
Ochlerotatus sticticus	1	0	10	11
Culiseta inornata	0	0	10	10
Anopheles spp.	3	2	1	6
Uranotaenia sapphirina	1	0	3	4
Culex quinquefasciatus	1	0	2	3
Ochlerotatus cantator	0	0	3	3
Ochlerotatus hendersonii	0	0	3	3
Ochlerotatus stimulans	0	0	3	3
An. quadrimaculatus/walkeri	1	0	1	2
Culex erythrothorax	0	0	2	2
Culiseta spp.	0	0	2	2
Anopheles barberi	0	0	1	1
Anopheles walkeri	0	1	0	1
Culex reevesi	0	0	1	1
Culex restuans/salinarius	0	0	1	1
Culiseta morsitans	0	0	1	1
Oclerotatus sollicitans	0	0	1	1
Orthopodomyia alba	0	0	1	1
Psorophora ferox	0	0	1	1
Psorophora spp.	0	0	1	1
Unknown	8	0	1108	1116
Total	4474	354	19441	24269

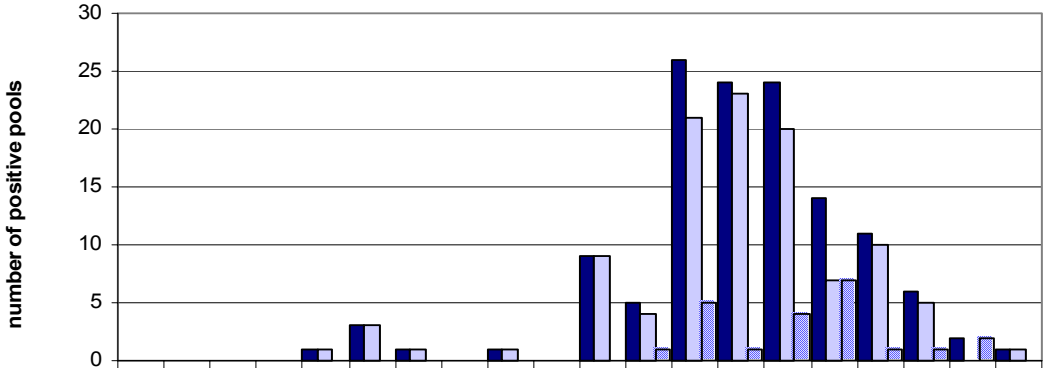
A comparison of the number of positive pools and their dates of collection by Health Unit in Ontario can be found in Appendix C. Only Toronto had a higher number of positive pools identified (175) than Peel (128). Across Ontario, there was a total of 598 WNV-positive mosquito pools in 2002.[15]

Overall, eight separate species of mosquito were found to be positive in Peel (Table 2). In general, *Culex* mosquitoes were the most important, and accounted for 30% of the mosquitoes that were collected and tested and over three-quarters (77%) of the WNV-positive mosquito samples. However, WNV was not isolated in all species within the genus *Culex*.

Because of their importance in the bird-mosquito amplification cycle, certain *Culex* species were combined for analysis. *Culex pipiens, Culex restuans*, *Culex pipiens/restuans*, and *Culex spp.* mosquitoes that could not be separated into species accounted for 29% (7122/24,269) of the mosquitoes collected and 68% (87/128) of the WNV-positive pools in Peel. Meanwhile, the bridge vector species *Coquillettidia perturbans* and *Aedes vexans* combined for 51% (12,322/24,269) of mosquitoes collected and 13% (17/128) of the positive pools.

A temporal analysis of WNV-positive mosquito pools by week of collection was conducted by municipality and is shown in Figure 5. Overall, 20% (26/128) of the positive pools in Peel were collected during week 33 (August 11-17). The highest number of positive pools collected in any one week in Mississauga (23) occurred in week 34 (August 18-24), while the highest number of positive pools collected in Brampton (7) occurred in week 36 (September 1-7).

Figure 5: WNV-Positive Mosquito Pools by Week of Collection and Municipality, Region of Peel, 2002



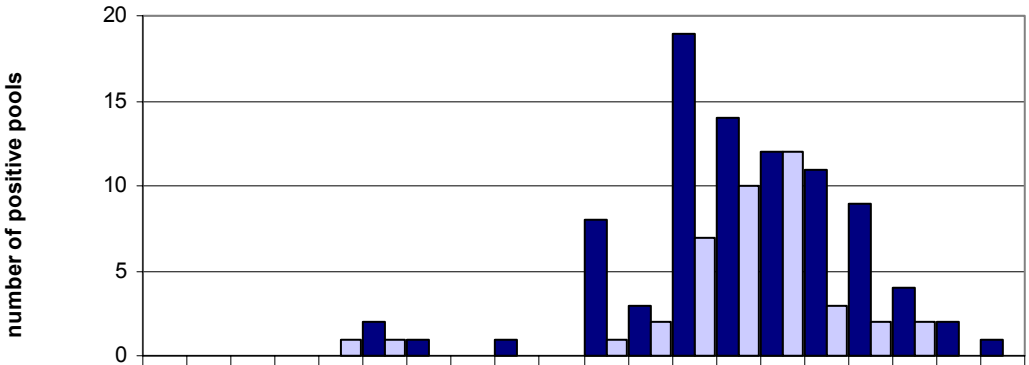
	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Peel	0	0	0	0	1	3	1	0	1	0	9	5	26	24	24	14	11	6	2	1
Mississauga	0	0	0	0	1	3	1	0	1	0	9	4	21	23	20	7	10	5	0	1
Brampton	0	0	0	0	0	0	0	0	0	0	0	1	5	1	4	7	1	1	2	0

Week of 2002

Note: No WNV-Positive Mosquito Pools were found in Caledon in 2002

Another analysis of the timing of WNV-positive mosquito pools can be seen in Figure 6. For this analysis, the *Culex* group included *Culex pipiens, restuans, pipiens/restuans* and those not able to be identified (spp.), but excluded *Culex pipiens/salinarius*. While the first WNV-positive mosquito pools containing species from the C*ulex* group were found within one week of the first positive bridge vector species, a difference was observed between these two groups throughout the remainder of the mosquito season. The number of positive pools for the *Culex* group increased from two during week 26 (June 23-29), peaked at 19 positive pools during week 33 (August 11-17), after which it gradually decreased throughout the remainder of the mosquito season. WNV-positive pools among bridge vector species began to increase after week 32 (August 4-10) and peaked during week 34 (August 18-24).

Figure 6: Number of WNV-Positive Mosquito Pools by Selected Species and Week of Collection, Region of Peel, 2002



	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Culex Group*	0	0	0	0	0	2	1	0	1	0	8	3	19	14	12	11	9	4	2	1
Bridge vectors**	0	0	0	0	1	1	0	0	0	0	1	2	7	10	12	3	2	2	0	0

Week of 2002

* Culex Group includes Cx. pipiens, Cx. restuans, Cx. pipiens/restuans and those not able to be identified (Cx. spp.), but excludes Cx. pipiens/salinarius and Cx. salinarius.

** Bridge vector mosquitoes include An. punctipennis, Ae. vexans, Cq. perturbans, Cx. pipiens/salinarius, Cx. salinarius, Oc. triseriatus and Oc. trivittatus

The minimum infection rate (MIR) is an indicator of the prevalence of WNV, transmission intensity and thus risk of disease to humans.[14] MIRs of WNV in certain species, expressed as the number infected per 1,000 specimens tested, are shown in Table 2 by municipality and overall. Higher MIRs are usually indicative of greater WNV activity among a given species, but can become unreliable if based on small numbers.[14]

Overall, the highest MIRs based on samples of 1,000 or more mosquitoes in Peel, were observed among *Culex spp.* (18.1 per 1,000) followed by *Culex pipiens* (13.1 per 1,000) (Table 2). The third highest MIR occurred in *Culex pipiens/restuans* (9.5 per 1,000). This likely reflects the infection rates found in identified *Culex* species which contribute to these larger categories (i.e. *Culex restuans* < *Culex pipiens* < *Culex salinarius*). While higher MIRs were calculated for other mosquito species, they were based on samples of less than 1,000 mosquitoes and are more likely to be unstable. These include *Culex pipiens/salinaris* (53.6 per 1,000) and *Culex salinarius* (69.6 per 1,000), as well as other mosquito species.

Table 2: Minimum Infection Rates by Species, Municipality and Overall, Region of Peel, 2002

Municipality	Species	Number Collected and Tested	Positive Pools*	MIR**
Mississauga	*Aedes vexans*	2765	9	**3.25**
	Anopheles punctipennis	125	1	8.00 †
	Coquillettidia perturbans	7383	8	**1.08**
	Culex pipiens	977	11	11.26 †
	Culex pipiens/restuans	2459	24	**9.76**
	Culex pipiens/salinarius	50	3	60.00 †
	Culex restuans	863	8	9.27 †
	Culex salinarius	105	7	66.67 †
	Culex spp.	1445	25	**17.30**
	Ochlerotatus triseriatus	548	4	7.30 †
	Ochlerotatus trivittatus	300	6	20.00 †
Brampton	*Aedes vexans*	1536	2	**1.30**
	Culex pipiens	317	6	18.93 †
	Culex pipiens/restuans	582	5	8.59 †
	Culex salinarius	10	1	100.00 †
	Culex spp.	369	8	21.68 †
Caledon	(none)	0	0	
Peel	*Aedes vexans*	4328	11	**2.54**
	Anopheles punctipennis	145	1	6.90 †
	Coquillettidia perturbans	7994	8	**1.00**
	Culex pipiens	1296	17	**13.12**
	Culex pipiens/restuans	3046	29	**9.52**
	Culex pipiens/salinarius	56	3	53.57 †
	Culex restuans	961	8	8.32 †
	Culex salinarius	115	8	69.57 †
	Culex spp.	1819	33	**18.14**
	Ochlerotatus triseriatus	575	4	6.96 †
	Ochlerotatus trivittatus	406	6	14.78 †
Total		24269	128	

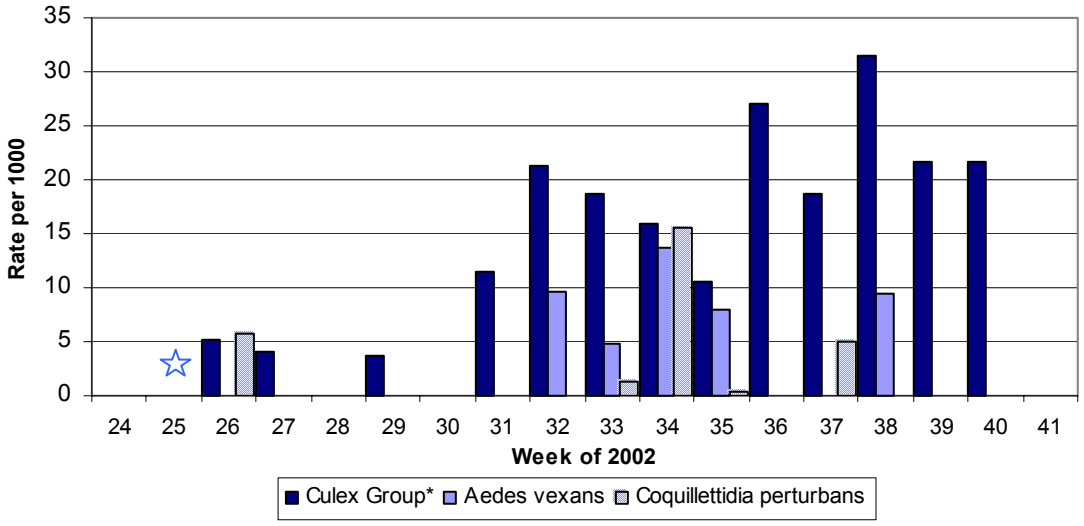
* Positive pools number 132 in Ontario's report (Appendix C), but 2 pools belonged to Toronto and 2 others could not be reconciled with site or date information to determine the number of mosquitoes tested, and so were excluded.

** The Minimum Infection Rate (MIR) is calculated as the number of positive pools of infected mosquitoes of a given species divided by the total number of mosquitoes of a given species that were tested for the presence of the virus, expressed per 1,000.

† MIRs based on numbers < 1000 are more likely to be unstable than those based on numbers ≥ 1000 (bolded).

MIRs were also calculated for certain species by week of collection. In Figure 7, the *Culex* group of mosquitoes (including *Culex pipiens, Culex restuans*, *Culex pipiens/restuans*, and *Culex spp.* mosquitoes that could not be separated into species) had the highest MIRs (31.5 per 1,000 in week 38, September 15-21), and these continued to be above 20.0 per 1,000 in weeks 39 and 40 (ending October 5). This means that their level of infectivity carried well into the fall. Meanwhile, the bridge vector mosquitoes *Aedes vexans* and *Coquillettidia perturbans* had their highest MIRs during week 34 (August 18-24), at 13.6 and 15.6 per 1,000, respectively.

Figure 7: Minimum Infection Rates for Selected Mosquito Species by Week, Region of Peel, 2002



*Includes *Cx. pipiens, Cx. restuans, Cx. pipiens/restuans and Cx. spp.*

☆ One MIR for *Coquillettidia perturbans* in week 25 not plotted due to small numbers

Table 3 shows the exact dates and weeks when the first notification of positive viral test results was made, by species. The first positive pool (*Coquillettidia perturbans*) was found very early in the mosquito season.

Table 3: First Notification of Positive Viral Test Results by Mosquito Species and Date Collected, Region of Peel, 2002

Mosquito Species	Date Collected	Week
Coquillettidia perturbans	20/06/2002	23
Culex restuans	25/06/2002	26
Culex spp.	25/06/2002	26
Culex pipiens/restuans	04/07/2002	27
Culex pipiens	30/07/2002	28
Culex salinarius	30/07/2002	31
Aedes vexans	08/08/2002	32
Ochlerotatus trivittatus	13/08/2002	33
Culex pipiens/salinarius	20/08/2002	34
Ochlerotatus triseriatus	20/08/2002	34
Anopheles punctipennis	29/08/2002	35

The four charts in Appendix D show the level of mosquito activity (# of mosquitoes trapped) by week for the 11 groups or species of mosquitoes for which positive viral results were found. Note that the scales in the charts are different. It is evident from these analyses that certain species appeared to have more than one peak period of activity.

The trapping of mosquito populations can be a function of weather conditions, particularly rain (which increases their numbers due to availability of standing water and thus breeding sites), wind (which tends to decrease numbers collected) and temperature. It is also possible that a generational effect (i.e. a new generation having hatched) is being observed in these charts particularly for *Culex pipiens*. It appears to have 3 increasing peaks or generations which is consistent with the biology of this mosquito.

Summary

Although 41 species of mosquitoes were found in the Region of Peel in 2002, only a small number were found to be important in the transmission of WNV from mosquitoes to humans. While eight separate species of mosquito were found to be positive for WNV, mosquitoes from the genus *Culex* were the most important, accounting for 30% of the mosquitoes tested and 77% of the WNV-positive pools. *Culex* mosquitoes also exhibited some of the highest WNV infection rates in Peel.

In particular, *Culex pipiens* and *Culex restuans* were key "amplification" species, because they prefer to feed on birds, the main reservoir of WNV, and are effective transmitters of the virus. They are more common in urban and suburban settings and use primarily standing or slow-moving water in which to lay their eggs.[7] They breed quickly, producing as many as four generations such that their numbers greatly increase over the course of the mosquito season.

It is interesting to note that very few *Culex* mosquitoes were trapped in the Caledon area compared to Mississauga or Brampton. No WNV-positive pools of mosquitoes were found in Caledon in 2002.

While other species of mosquito are more likely to bite people, control of *Culex* mosquitoes is one of the most important strategies to reduce the risk of WNV transmission to humans.[4]

MOSQUITO BREEDING SITE (LARVAL) SURVEILLANCE

Introduction

The life cycle of a mosquito includes four stages: egg, larva, pupa and adult. Three of these stages often take place in water. Many mosquito species lay their eggs in or near water, where the eggs then hatch into larvae.[7]

A random selection of road-side catch basins was surveyed for the presence of mosquito larvae in 2001. Mosquito larvae were found in 77% (20 of 26) of the catch basins examined.[16]

In order to ascertain the anticipated volume of adult mosquitoes in an area, as well as to identify their stage of development, samples of standing water were obtained from various areas throughout the Region of Peel in 2002.

Methods

Areas of high risk, those near populations deemed at the time to be of higher risk of serious symptoms related to WNV disease, such as the elderly or ill, were identified using mapping software. These locations were surveyed for standing or slow-moving water. If larvae were found, samples or "dips" were taken from the site using a dipper. Mosquito larvae were collected, counted and an attempt was made to identify the stage of development of the larvae, known as the instar stage.

As positive birds and/or human cases were identified, further potential breeding sites were surveyed around these locations for the presence of mosquito larvae.

Information about the location of potential mosquito breeding sites, including address or latitude/longitude co-ordinates and type of physical feature, was recorded along with the date of collection. Once results were obtained, this information was entered into an Excel spreadsheet for analysis and charting.

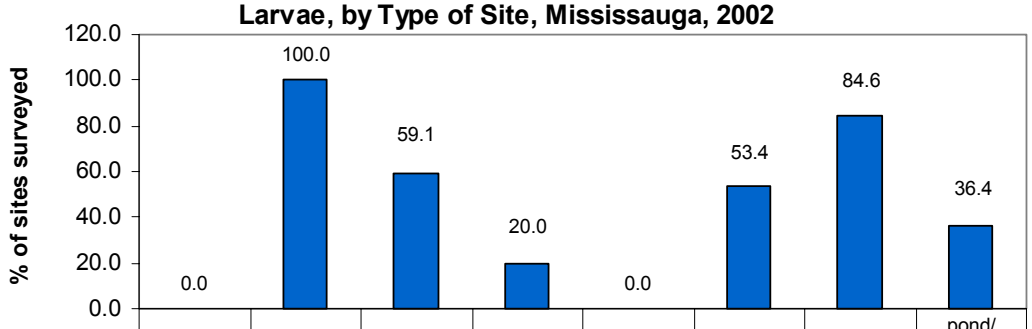
Results

A total of 278 sites were surveyed in Peel: 152 were in Mississauga, 106 in Brampton and 20 in Caledon. The presence of mosquito larvae was identified in 42% (118 of 278) of the potential mosquito breeding sites from which samples were taken in 2002. Results by municipality and type of site are shown in Figures 8 – 10.

In Mississauga, 55% of sites sampled contained mosquito larvae (84 of 152), whereas proportions were much lower in the other two area municipalities. Just under one-third

of Brampton sites (30% or 32 of 106) were found to have larvae, while in Caledon, only 10% of sites (2 of 20) contained larvae.

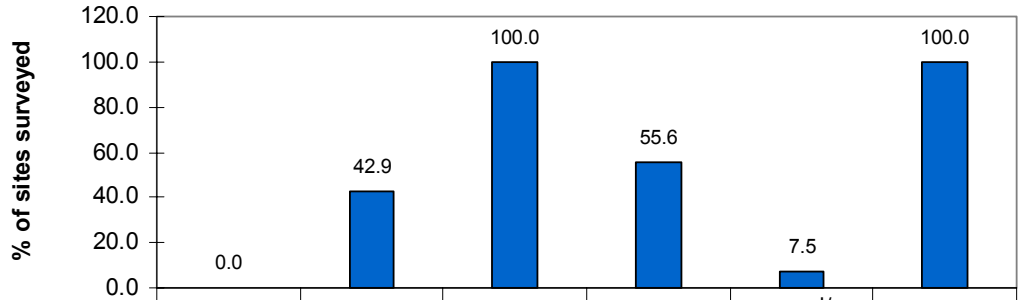
Figure 8: Proportion of Potential Mosquito Breeding Sites with Larvae, by Type of Site, Mississauga, 2002



	lake	marsh	ditch	field pool	river	creek/ floodplain	culvert	pond/ retention pond
% with larvae	0.0	100.0	59.1	20.0	0.0	53.4	84.6	36.4
# with larvae	0	1	13	1	0	39	22	8
# with no larvae	2	0	9	4	1	34	4	14
total # sites	2	1	22	5	1	73	26	22

site description

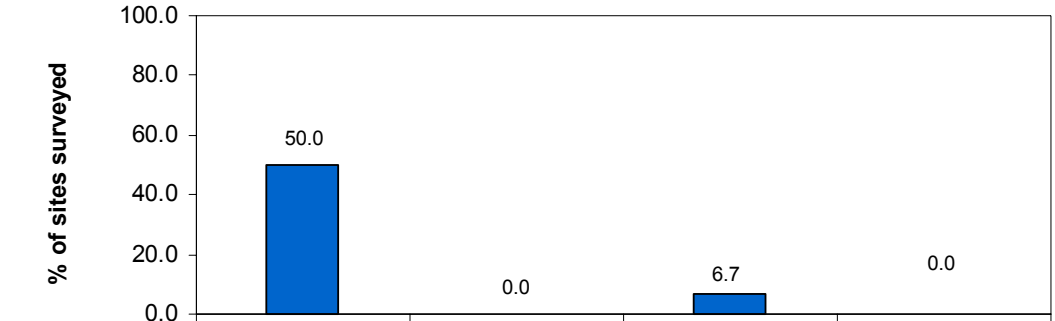
Figure 9: Proportion of Potential Mosquito Breeding Sites with Larvae, by Type of Site, Brampton, 2002



	lake	ditch	field pool	creek/ floodplain	pond/ retention pond	woodland pool
% with larvae	0.0	42.9	100.0	55.6	7.5	100.0
# with larvae	0	21	2	5	3	1
# with no larvae	5	28	0	4	37	0
total # sites	5	49	2	9	40	1

site description

Figure 10: Proportion of Potential Mosquito Breeding Sites with Larvae, by Type of Site, Caledon, 2002



	ditch	creek/ floodplain	ponds/ retention ponds	woodland pool
% with larvae	50.0	0.0	6.7	0.0
# with larvae	1	0	1	0
# with no larvae	1	2	14	1
total # sites	2	2	15	1

site description

Overall, man-made structures such as ditches and culverts tended to have higher proportions of larvae present than naturally-occurring sites that were surveyed. Nearly 85% of culverts and 47% of ditches surveyed contained larvae, compared to 32% of lakes, marshes, rivers and woodland pools.

Flood plains of creeks were also more likely to contain larvae than the creeks themselves. Mosquito larvae were often found in puddles adjacent to the main body of the pond or other water source. Over half of all creeks and floodplains surveyed (52%) contained mosquito larvae.

Summary

Larval surveillance provides crucial information for mosquito control interventions. In 2002, a total of 278 sites were surveyed for standing water in Peel: 152 were in Mississauga, 106 in Brampton and 20 in Caledon. The presence of mosquito larvae was identified in 42% of the potential breeding sites from which samples were taken. Ditches and culverts were some of the more numerous breeding sites and often contained mosquito larvae.

HUMAN CASE SURVEILLANCE

Introduction

Human illness caused by mosquito-borne WNV acquired in Peel occurred for the first time in 2002. In 1999, a Peel resident who had traveled to New York City acquired the infection there and subsequently died upon returning to Peel.

While most human WNV infections are without symptoms, about one in five people infected with WNV develops a mild illness.[17] The incubation period is estimated to be three to 14 days, with symptoms lasting approximately three to six days. The mild form of WNV infection is described as a sudden onset of fever that is often accompanied by malaise, headache, nausea, vomiting, anorexia, eye pain, myalgia, and less commonly, rash and/or swollen lymph nodes.[17]

Approximately one case in 150 infections develops severe neurologic disease, with encephalitis being reported more often than meningitis. The greatest risk factor for developing severe WNV disease is increased age.[17,18] Symptoms among those with severe disease include fever, muscle weakness, gastrointestinal symptoms and a change in mental status. Some cases also experience a rash on their neck, body, arms or legs. A small number of patients experience severe muscle weakness and paralysis. Other symptoms include seizures, optic nerve involvement, cranial nerve abnormalities and ataxia.[17]

In 2002, diagnosis was made through the detection of an increase in total antibody to WNV found in two separate samples of blood taken at least one week apart.[19] As there is no cure for WNV, treatment is supportive in nature, and involves hospitalization, administering intravenous fluids, providing respiratory support and preventing secondary infections for patients with severe disease.[17]

The 2002 WNV epidemic in North America included the first documented cases of person-to-person WNV transmission through organ transplantation,[20] blood and blood product transfusion[20] and perhaps breastfeeding,[21] as well as a case of intrauterine infection.[22] A poliomyelitis-like syndrome was recognized among some West Nile patients with onset of acute flaccid paralysis (AFP) during the early stages of infection in the United States.[23] Parkinsonism and Rhabdomyolysis[24] were also seen in rare instances.

Modifiable risk factors for WNV include known travel in an area previously identified as having WNV activity, having received blood, blood products or organ transplants from an infected donor, or acquiring the infection through occupational exposure. Two laboratory workers in the United States became infected by suffering occupational injuries, such as lacerations or needle-stick punctures, while working with specimens containing WNV.[1]

Methods

Physicians and infectious disease specialists identified patients with suspected WNV infection causing viral encephalitis, viral meningitis or other illnesses consistent with WNV infection, based on their clinical symptoms and patient histories. Blood tests were ordered which would specifically look for antibodies to WNV. Preliminary testing was conducted at the Ontario Central Public Health Laboratory in Toronto, while final confirmatory testing was done at Health Canada's National Microbiology Laboratory in Winnipeg. Once suspected cases were identified, they were immediately reported to public health officials for notification and follow-up.

In the Region of Peel, standardized medical information, including demographics, symptoms, risk factors (such as travel history or having received blood products), and test results were entered into an Access database. Cases were reviewed by an Infection Control Specialist. Later, address information was also entered into a geographic information system so that the incidence of the disease could be mapped.

Test results were delayed due to the volume of tests submitted to the provincial and federal laboratories. In addition, the confirmation process took several weeks since the test required the growth of WNV in culture. This resulted in late information regarding changes in the status of individuals (i.e. identifying whether they were not a case, suspect, probable or confirmed) and delays in reporting the number of known cases. Provincial case definitions used in the Region of Peel are found in Appendix E.

Results

In late August 2002, the Region of Peel and the Ontario Ministry of Health and Long-Term Care jointly announced the identification of the first known human case of WNV encephalitis acquired in Canada in a Region of Peel resident.

As of May 28, 2003, there were 112 residents of Peel who had had laboratory evidence of WNV infection stemming from the 2002 season as follows: 37 confirmed cases, 20 probable cases, and 55 suspect cases. Most of these cases reported onset of symptoms having occurred in August and September. An additional 29 residents were either found to not be cases, or there was not enough information to determine their status at the time this report was prepared.

The remainder of the analyses of human WNV in this report will focus on the 37 confirmed and 20 probable cases in Peel.

By municipality, Mississauga residents accounted for 92% (34) of confirmed human cases of WNV disease in Peel, while Brampton accounted for the remaining 8% (three cases) (Table 4). Mississauga also accounted for 90% of probable cases (18), while

Brampton had 10% (two cases). There were no confirmed or probable cases among residents of Caledon.

Table 4: Confirmed and Probable Human WNV Cases by Municipality of Residence, Region of Peel, 2002

Municipality	Confirmed		Probable		Total	
	number	percent	number	percent	number	percent
Mississauga	34	91.9	18	90.0	52	91.2
Brampton	3	8.1	2	10.0	5	8.8
Caledon	0	0.0	0	0.0	0	0.0
Peel	37	100.0	20	100.0	57	100.0

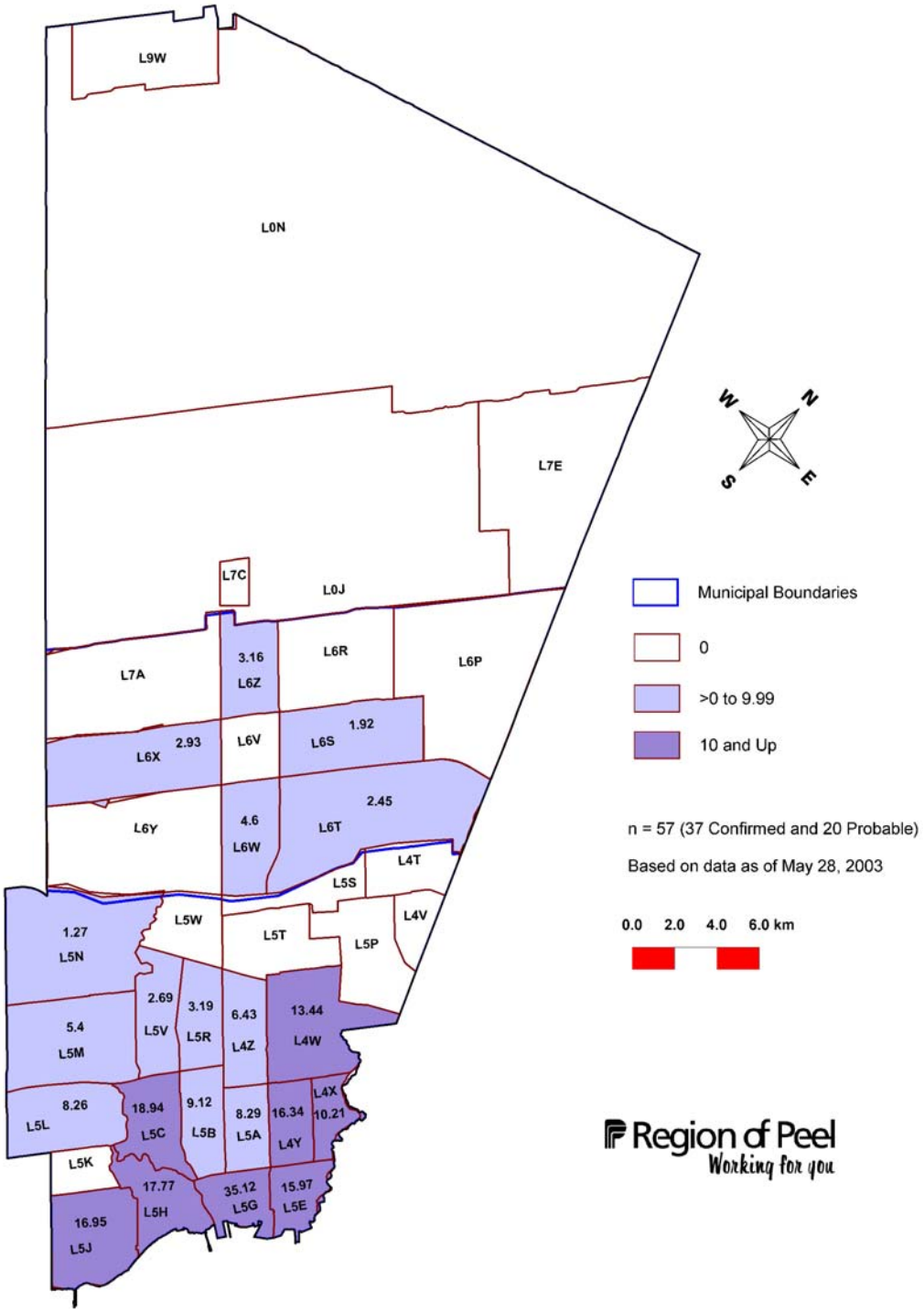
Rates of WNV infection per 100,000 population were mapped by Forward Sortation Area (FSA – the first three digits of the postal code) and are depicted in Figure 11. This figure shows that higher incidence rates occurred in the southern parts of Mississauga, along the Lake Ontario shore and Etobicoke creek, somewhat similar to the mapping analyses of dead crows (Figures 2 and 3). The highest rates of WNV infection in humans occurred in the L5G area of Mississauga (35.1 cases per 100,000 population), followed by L5C (18.9 per 100,000) and L5H (17.8 per 100,000). These three postal code areas all border the Credit River basin near Lake Ontario.

Among confirmed human cases, the median age of infected persons was 60.3 years (range: seven to 82 years); for probable cases, the median age was 50.0 years (range: five to 70 years). There were slightly more females than males among the confirmed and probable cases in Peel (31 females versus 26 males). Among females, the highest proportion of WNV cases occurred in the 60-69 year age group (29%); the highest proportion among males occurred in the 50-59 year age group (35%) (Table 5). The distribution of Peel's WNV cases shows that, regardless of sex, fewer cases occurred among the younger age groups.

Table 5: Confirmed and Probable Human WNV Cases by Age Group and Sex, Region of Peel, 2002

Age Group	Female		Male		Total	
	number	percent	number	percent	number	percent
0 - 9	0	0.0	2	7.7	2	3.5
10 - 19	1	3.2	0	0.0	1	1.8
20 - 29	3	9.7	0	0.0	3	5.3
30 - 39	1	3.2	1	3.8	2	3.5
40 -49	6	19.4	4	15.4	10	17.5
50 -59	6	19.4	9	34.6	15	26.3
60 - 69	9	29.0	4	15.4	13	22.8
70 - 79	4	12.9	6	23.1	10	17.5
80 +	1	3.2	0	0.0	1	1.8
Total	31	100.0	26	100.0	57	100.0

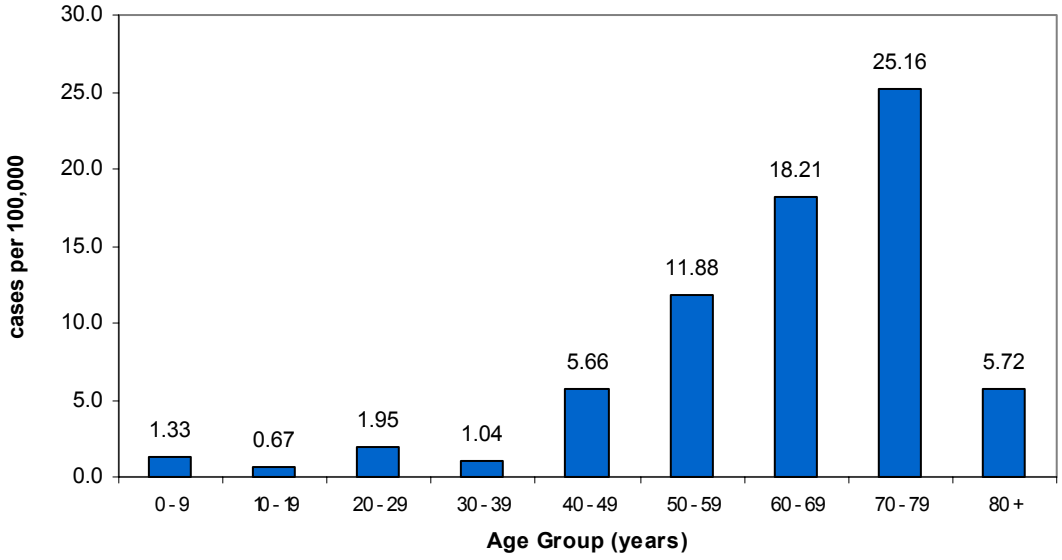
Figure 11: Rates of Confirmed and Probable Human WNV Infection by Forward Sortation Area, Region of Peel, 2002

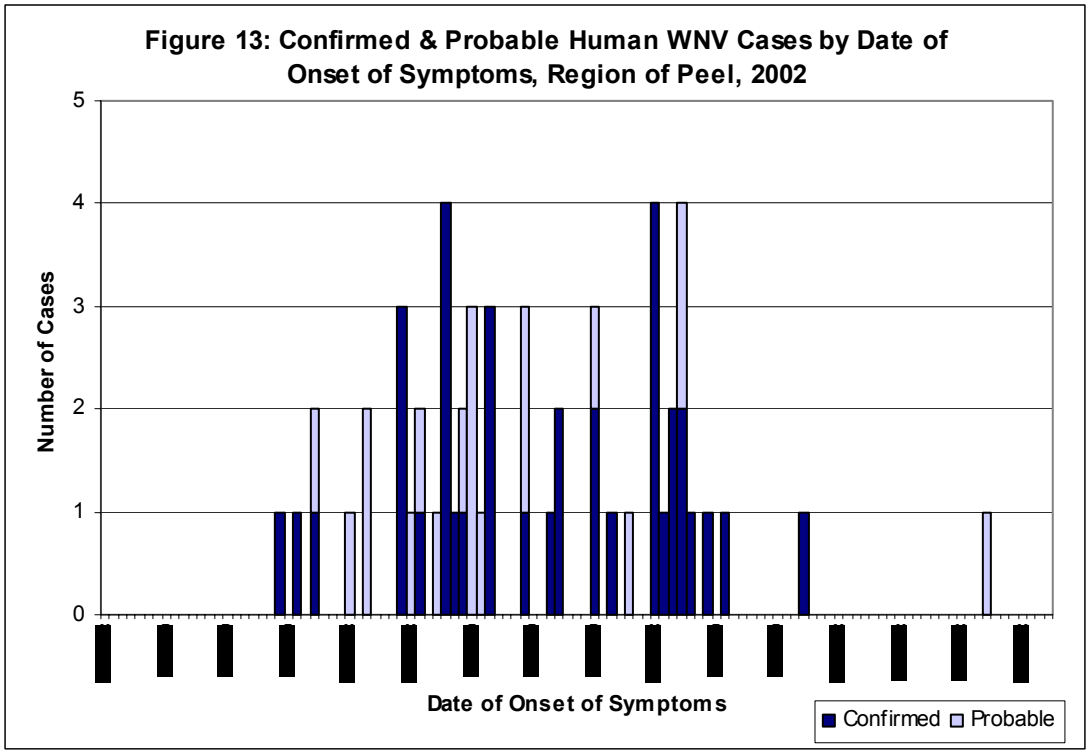


The incidence of confirmed and probable WNV cases among Peel residents generally increased across age groups: older adults were more likely to meet the case definitions for these categories than were younger residents (Figure 12). Rates of WNV were fairly constant among those 0-39 then began to increase at approximately ages 40-49, and continued to increase with advancing age, with the exception of those 80 years and older. The highest rate was observed among 70-79 year-olds where a rate of 25.2 cases per 100,000 population was observed. The rate among residents 80 years and older was lower at 5.7 per 100,000. This may be due, in part, to small numbers of cases. In addition, those 80 years and older may be less likely to be active outdoors than younger age groups. However, contrary to initial expectations, cases of WNV were not limited to older adults or the infirmed, as many of those affected (32% or 18 of 57) were less than 50 years of age.

The first confirmed human case, a 66 year-old male with no history of travel, had onset of symptoms on August 4, 2002. The first reports of human cases were preceded by a sharp increase in the number of crow deaths in late July and early August.[7] The last confirmed human case had onset of symptoms on October 3, 2002 (Figure 13).

Figure 12: Age-Specific Rates of Confirmed & Probable Human WNV Infection, Region of Peel, 2002





Proportions of WNV cases with possible risk factors are found in Table 6. Persons with confirmed or probable WNV were asked if they had traveled in the last two weeks prior to the onset of their symptoms. Fifteen of 37 confirmed cases (41%) and six of 20 probable cases (30%) replied that they had traveled, with the most frequent destination mentioned being somewhere in Ontario, followed by the United States and elsewhere in Canada (Table 7). No WNV cases in Peel had been recipients of blood products (Table 6).

Table 6: Confirmed and Probable Human WNV Cases by Possible Risk Factors, Region of Peel, 2002

	Confirmed		Probable		Total	
Possible Risk Factor	number	percent	number	percent	number	Percent
Traveled in last two weeks?	15	40.5	6	30.0	21	36.8
Received Blood?	0	0.0	0	0.0	0	0.0
Total	37	100.0	20	100.0	57	100.0

Table 7: Reported Travel Destinations of Human WNV Confirmed & Probable Cases, Region of Peel, 2002

	Confirmed		Probable		Total	
Destination	number	percent	number	percent	number	Percent
Canada	2	13.3	1	16.7	3	14.3
Europe	0	0.0	1	16.7	1	4.8
Ontario	8	53.3	3	50.0	11	52.4
USA	5	33.3	1	16.7	6	28.6
Total	15	100.0	6	100.0	21	100.0

Symptoms of those with confirmed or probable WNV infection are listed in Table 8. The most common symptom was fever, reported by 76% of confirmed cases and 90% of probable cases. Between 50% and 60% of all cases reported headaches, fatigue and muscle weakness, while rashes were reported by 43% of confirmed cases and 60% of probable cases. One confirmed case in Peel also presented with a poliomyelitis-like syndrome. [25]

Twenty-one of 37 confirmed cases (57%) and seven of 20 probable cases (35%) required hospitalization for their symptoms (Table 9). Of the 28 confirmed and probable cases admitted to hospital, seven (25%) had encephalitis, five (18%) had meningitis, and six (21%) had sepsis as their primary diagnoses, while the remainder did not have a primary diagnosis identified upon admission (Table 10). One additional confirmed case with meningitis was seen in the Emergency Room, but was not admitted to hospital.

Table 8: Confirmed and Probable Human WNV Cases by Reported Symptoms*, Region of Peel, 2002

	Confirmed		Probable		Total	
Symptom	number	percent	number	percent	number	Percent
Fever	28	75.7	18	90.0	45	78.9
Headache	19	51.4	16	80.0	34	59.6
Fatigue	22	59.5	12	60.0	33	57.9
Muscle Weakness	22	59.5	9	45.0	30	52.6
Rash	16	43.2	12	60.0	27	47.4
Change in Mental Status	16	43.2	5	25.0	21	36.8
Anorexia	10	27.0	2	10.0	12	21.1
Vomiting	7	18.9	4	20.0	11	19.3
Nausea	4	10.8	4	20.0	8	14.0
Lymphadenopathy	0	0.0	2	10.0	2	3.5
Total	37	100.0	20	100.0	57	100.0

* More than one symptom is possible. Numbers do not sum to totals.

Table 9: Confirmed and Probable Human WNV Cases by Admission to Hospital, Region of Peel, 2002

	Confirmed		Probable		Total	
Admitted to Hospital?	number	percent	number	percent	number	Percent
Yes	21	56.8	7	35.0	28	49.1
No	15	40.5	12	60.0	27	47.4
unknown	1	2.7	1	5.0	2	3.5
Total	37	100.0	20	100.0	57	100.0

Table 10: Confirmed and Probable Human WNV Cases by Primary Diagnosis Among Those Admitted to Hospital (n=28), Region of Peel, 2002

Primary Diagnosis	Confirmed		Probable		Total	
	number	percent	number	percent	number	Percent
Encephalitis	5	23.8	2	28.6	7	25.0
Meningitis	2	9.5	3	42.9	5	17.9
Sepsis	6	28.6	0	0.0	6	21.4
None identified	8	38.1	2	28.6	10	35.7
Total	21	100.0	7	100.0	28	100.0

Of the 57 persons with confirmed or probable WNV, two (4%) died, most likely due to infection with WNV. The first death occurred in a 70 year-old male resident of Mississauga. It was not known whether he had traveled within Ontario; however, he had not traveled to a WNV-endemic area. He had not received blood nor had he received vaccines (Yellow Fever, Japanese B Vaccine) that can cause equivocal results in blood tests for WNV.

The second death occurred in a 72 year-old male resident of Brampton. This person did not have a history of travel, nor had he received blood or the vaccines mentioned above.

Neighbouring Halton Region to the west had 56 confirmed and three probable WNV cases for a total of 59, most of which occurred in the southern municipalities of Oakville and Burlington.[26] Halton had no deaths associated with WNV among their cases.[27]

The Halton Region Health Department is participating in a seroprevalence study in conjunction with the McMaster University Institute of Environment and Health, the Ontario Ministry of Health and Long-Term Care and Health Canada. In March 2003, nurses took samples of blood from a random selection of Oakville residents which are being tested to determine the prevalence of WNV antibody in residents' blood. Results will be reported later this year, and will provide invaluable information about the extent of WNV infection in south Oakville.[28]

Meanwhile in Toronto to the east, there were 127 confirmed and 41 probable cases of WNV among their residents in 2002. None of the 12 deaths among this group were proven to be caused by WNV disease.[29] Contrary to initial expectations, serious WNV disease was not confined solely to those who were elderly or had pre-existing medical conditions.[30,31] Many of those affected were less than 50 years of age, and had been experiencing good health until the time of their infection with WNV.

In all of Ontario, there were 307 confirmed cases of WNV in 2002, with an additional 83 probable cases (Appendix F).[32] Seventeen deaths occurred among these individuals;

however, four deaths were not related to WNV. Three deaths were due to WNV infection, four listed WNV as a contributory cause, and six may have been associated with WNV but as of April 23, 2003 were still being investigated.[32]

Summary

Mosquito-borne acquisition in Canada of WNV disease in humans, occurred for the first time in 2002. As of May 28, 2003, 112 residents of the Region of Peel had laboratory evidence of WNV infection stemming from the 2002 mosquito season: 37 confirmed cases, 20 probable, and 55 were suspect cases. Numbers of confirmed and probable cases were higher than originally thought due to late reports of test results.

Of the 57 confirmed and probable cases, the majority (91%) was from Mississauga and the remainder (9%) from Brampton. The highest rates of WNV infection among humans occurred in the southern areas of Mississauga (postal code areas L5G, L5H and L5C), all of which border the Credit River basin near Lake Ontario, but are well-populated and contain much human development.

As found in other jurisdictions, and contrary to initial expectations, cases of WNV were not limited to older adults or the infirmed, as many of those affected in Peel (32%) were less than 50 years of age. Few confirmed or probable cases of WNV occurred among the very young, while most occurred among the 50-59 and 60-69 year age groups. The rate of diagnoses of WNV disease increased with increasing age after approximately age 40.

While most of those infected did not suffer very severe disease, there were two deaths, seven cases of encephalitis and five cases of meningitis among the 57 WNV confirmed or probable cases in the Region of Peel, along with fairly high proportions of symptoms such as muscle weakness (53%) and changes in mental status (37%).

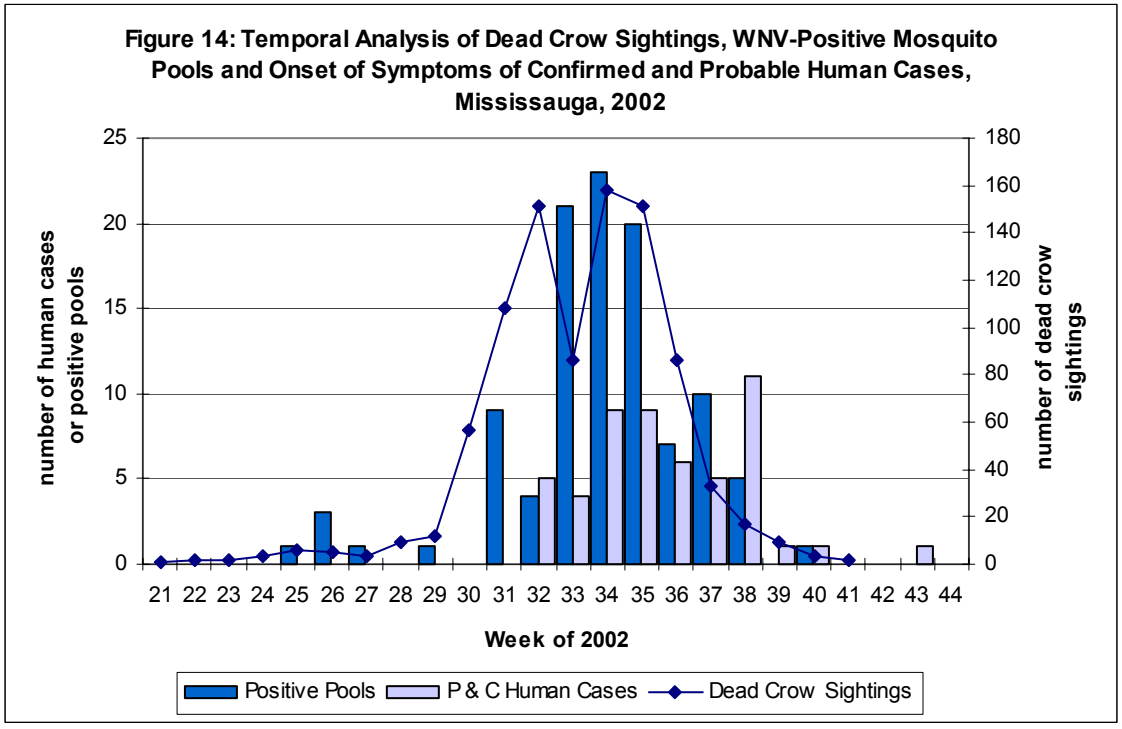
Identification of WNV in humans underscores the importance of active, hospital-based human surveillance programs starting in July through to the end of September, as well as the need to consider WNV as a possible diagnosis when clinicians encounter patients with encephalitis, meningitis, AFP or non-specific fevers occurring throughout this time period.[4,7]

Presently, there is no vaccine available for use in humans.[9] A human vaccine against WNV is under development by several commercial manufacturers,[33] with availability some years away.

COMPARISON OF THE TIMING OF DEAD CROW SIGHTINGS, WNV-POSITIVE MOSQUITO POOLS AND HUMAN CASES IN MISSISSAUGA

It has been suggested that one of the key surveillance factors which serves as a predictor of potential human infection is the reporting of dead birds of the crow family.[13,26] A recent U.S. study using data from 2001 and 2002 found that areas where a WNV-infected bird had been found early in the season were several times more likely to also report a human case than were areas that did not find infected birds early in the season.[34]

Figure 14 shows dead crow sightings, WNV-positive mosquito pools and onset of human WNV confirmed and probable cases by week in Mississauga. While dead crow sightings began to occur during week 21, the first WNV-positive mosquito pool was collected during week 25 and the first human case of WNV occurred during week 32. The initial peak in dead crow sightings preceded the peak of positive mosquito pools by approximately two weeks.



As previously mentioned the location and intensity of dead crow sightings correlated fairly well with the location and intensity of human illness from WNV (Figures 3 & 11). The first peak of human cases occurred approximately one-to-two weeks after both the peak of dead crow sightings and WNV-positive mosquito pools. The second peak in human cases seems to have occurred one week after a second smaller peak in positive

mosquito pools. The decrease in dead crow sightings is most likely due to low numbers of crows remaining after the intense outbreak of WNV in this population rather than a decrease in the amount of WNV in mosquitoes and birds.

The period of sustained and high rates of WNV infection in mosquitoes also coincided with human illness from WNV. The number of WNV positive mosquito pools seems to precede the number of human cases of WNV by a week or two, showing the value of this monitoring system.

Thus, dead crow sightings, adult mosquito trapping and testing of specimens are critical surveillance activities for the early identification of the presence of WNV in a given area, and provide key information in the assessment of human health risk among residents in the Region of Peel.

OTHER ANIMAL SURVEILLANCE

Wild birds are usually the most predominant host animal for WNV; however, the virus can also infect amphibians, domestic poultry, domestic mammals (especially horses), and apes and monkeys.[9]

In 2002, there were no reports of WNV infection in other animals such as horses, dogs or cats in the Region of Peel. Other municipalities in Ontario reported WNV activity among horses, including 41 probable or confirmed in Windsor-Essex and 12 in the Niagara region. A total of 107 horses were either presumptive (6) or confirmed (101) as having WNV in Ontario in 2002.[35]

In North America in 2002, there were over 14,000 horses reported as having clinical illness due to WNV.[2] A vaccine manufactured in the United States has been available in Canada since September 2001 to protect horses from disease caused by WNV. Initially allowed for use under an "emergency use permit system", the vaccine was licensed and registered for use in Canada as of February 2003.[36] Numbers of infected horses would be expected to decline in the future with increased use of this vaccine.

CONCLUSION

In Peel in 2002, the first indication of WNV activity was a WNV-infected dead bird found in Mississauga on May 19th. The first human illness onset on August 4th occurred during a spike in reported sightings of dead crows that started July 21st and continued until August 10th. The first WNV-positive pool for adult mosquitoes was from a sample collected on June 20.

Analysis of the Region of Peel's complete surveillance results shows that these monitoring systems have the potential to predict human risk from WNV in the future. Detailed analysis of information on Peel mosquitoes shows that *Culex* mosquitoes play a key role in local transmission of WNV as reported for other similar areas in the North American literature. In Peel, *Culex* mosquitoes were numerous and had high rates of transmission. It is appropriate that the Peel WNV Prevention and Control Plan focus control efforts on *Culex* mosquitoes.

While rates of human illness from WNV increase with increasing age, a large number of Peel residents under 50 years of age were diagnosed with disease from WNV. Use of this type of information is crucial to refining Peel's WNV public education program.

This report has provided and demonstrated the importance of detailed information from WNV surveillance in Peel. It is one of three essential pillars in a full WNV prevention and control program along with public education and mosquito reduction.

REFERENCES

1. Centers for Disease Control and Prevention, Morbidity and Mortality Weekly Report. *Laboratory-Acquired West Nile Virus Infections – United States, 2002.* December 20, 2002:51 (50):1133-1135. [cited 2003 Apr 30]:[3 screens]. Available from URL: http://www.cdc.gov/mmwr/pdf/wk/mm5150.pdf

2. Leighton F. *West Nile Virus in Canada 2003*. [cited 2003 Apr 30]:[6 screens]. Available from URL: http://wildlife.usask.ca/bookhtml/arbovirus/arbown.htm

3. Health Canada. *Fact Sheet #2 – West Nile Virus: General Overview*. 2003 April. [cited 2003 Apr 30]:[3 screens]. Available from URL: http://www.hc-sc.gc.ca/pphb-dgspsp/publicat/info/pdf/wnv2003-generaloverview_e.pdf

4. Centers for Disease Control and Prevention, Morbidity and Mortality Weekly Report. *Provisional Surveillance Summary of the West Nile Virus Epidemic – United States, January-November 2002.* December 20, 2002:51 (50):1129-1133. [cited 2003 Apr 30]:[5 screens]. Available from URL: http://www.cdc.gov/mmwr/pdf/wk/mm5150.pdf

5. Leighton F. *St. Louis Encephalitis Virus*. [cited 2003 Jun 20]:[3 screens]. Available from URL: http://wildlife.usask.ca/bookhtml/arbovirus/arbosle.htm

6. Centers for Disease Control and Prevention. *Questions and Answers about Laboratory Practice (FAQ)*. [cited 2003 Jun 25]:[2 screens]. Available from URL: http://www.cdc.gov/ncidod/dvbid/westnile/lab_faq.htm

7. Region of Peel. *Region of Peel West Nile Virus Prevention & Control Plan 2003*. February 2003.

8. Centers for Disease Control and Prevention. West Nile Virus Basics – Prevention: Avoid Mosquito Bites to Avoid Infection. [cited 2003 May 16]:[4 screens]. Available from URL: http://www.cdc.gov/ncidod/dvbid/westnile/index.htm

9. Canadian Cooperative Wildlife Health Centre. *What is West Nile Virus?* [cited 2003 Apr 30]: [2 screens]. Available from URL: http://www.wildlife.usask.ca/WestNileAlertHTML/WestNileAlertEng2.htm

10. Ontario Ministry of Health and Long-Term Care. *Public Information: West Nile Virus 2003*. 2003 April. [cited 2003 Apr 30]:[1 screen]. Available from URL: http://www.health.gov.on.ca/english/public/program/pubhealth/westnile/wnv_03/wnv_birds.html

11. Ontario Ministry of Health and Long-Term Care. *Public Information: West Nile Virus 2002 - Birds*. 2003 April [cited 2003 Apr 30]:[1 screen]. Available from URL: http://www.health.gov.on.ca/english/public/program/pubhealth/westnile/wnv_02/wnv_birds.html

12. Health Canada. *Dead Birds Submitted for West Nile Virus Diagnosis by Health Unit in Ontario as of December 17, 2002*. [cited 2003 Apr 29]: [1 screen]. Available from URL: http://www.wildlife.usask.ca/WestNileAlertHTML/WestNileOntarioENG-02.htm

13. Canadian Cooperative Wildlife Health Centre. *West Nile Virus Surveillance Program 2003: Looking For West Nile Virus in Dead Corvids*. [cited 2003 Apr 30]:[1 screen]. Available from URL: http://www.wildlife.usask.ca/WestNileAlertHTML/WestNileAlertEng1.htm

14. Centers for Disease Control and Prevention, National Center for Infectious Diseases, Emerging Infectious Diseases. *West Nile Virus Isolates from Mosquitoes in New York and New Jersey, 1999*. 2001 July-August [cited 2003 May 16]:[11 screens]. Available from: URL: http://www.cdc.gov/ncidod/eid/vol7no4/nasci.htm

15. Ontario Ministry of Health and Long-Term Care. *Public Information: West Nile Virus 2002-Mosquitoes*. 2003 April [cited 2003 Apr 30]:[1 screen]. Available from URL: http://www.health.gov.on.ca/english/public/program/pubhealth/westnile/wnv_02/wnv_mosquitoes.html

16. Paul Proctor, Supervisor, Communicable Diseases, Environmental Health Division (Acting), Region of Peel Health Department: personal communication, 2003.

17. Centers for Disease Control and Prevention. *West Nile Virus (WNV) Infection – Information for Clinicians*. 2002 August 20. [cited 2003 Apr 30]:[2 screens]. Available from URL: http://www.cdc.gov/ncidod/dvbid/westnile/resources/fact_sheet_clinician_082102_0802.pdf

18. Petersen L, Marfin A. *West Nile Virus: A Primer for the Clinician.* Annals of Internal Medicine. 2002 August 6:137 (3): E173-E179. [cited 2003 Apr 30]: [7 screens]. Available from URL: http://www.annals.org/issues/v137n3/pdf/200208060-00009.pdf

19. Health Canada. *Fact Sheet #5 – West Nile Virus: Diagnosis and Testing*. 2003 April. [cited 2003 Apr 30]:[2 screens]. Available from URL: http://www.hc-sc.gc.ca/pphb-dgspsp/publicat/info/pdf/wnv2003-diagnosistesting_e.pdf

20. Centers for Disease Control and Prevention, Morbidity and Mortality Weekly Report. *Update: investigations of West Nile Virus infections in recipients of organ transplantation and blood transfusion – Michigan, 2002.* October 4, 2002:51 (39):879. [cited 2003 Apr 30]:[3 screens]. Available from URL: http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5139a2.htm

21. Centers for Disease Control and Prevention, Morbidity and Mortality Weekly Report. *Possible West Nile Virus Transmission to an Infant through Breastfeeding – Michigan, 2002.* October 4, 2002:51 (39):877-878. [cited 2003 Apr 30]:[3 screens]. Available from URL: http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5139a1.htm

22. Centers for Disease Control and Prevention, Morbidity and Mortality Weekly Report. *Intrauterine West Nile Virus Infection – New York, 2002.* December 20, 2002:51 (50):1135-1136. [cited 2003 Apr 30]:[2 screens]. Available from URL: http://www.cdc.gov/mmwr/pdf/wk/mm5150.pdf

23. Centers for Disease Control and Prevention, Morbidity and Mortality Weekly Report. *Acute Flaccid Paralysis Syndrome Associated with West Nile Virus Infection – Mississippi and Louisiana, July – August 2002.* September 20, 2002:51 (37):825-828. [cited 2003 Apr 30]:[5 screens]. Available from URL: http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5137a1.htm

24. Sejvar J. *Emerging clinical syndromes of West Nile Virus Infection*. Presentation at the Fourth National Conference on West Nile Virus in the United States, New Orleans, Louisiana, February 9-11, 2003. Available from URL: http://www.cdc.gov/ncidod/dvbid/westnile/conf/pdf/Sejvar_4th03.pdf

25. Liz Van Horne, Infection Control Specialist, Region of Peel Health Department: personal communication, June 11, 2003.

26. Halton Region Health Department. *West Nile Virus Vector Control Program*. February 2003.

27. Burgess Hawkins, Public Health Inspector, Halton Region Health Department: personal communication, May 29, 2003.

28. Halton Region Health Department. *Questions and Answers about West Nile Virus Seroprevalence Study*. March 2003.

29. Joe Fortuna, West Nile Virus Coordinator: personal communication, June 11, 2003.

30. Toronto Public Health. *Protocol for the Control of Mosquito Larvae to Prevent and Control West Nile Virus (WNV).* January 2003.

31. Pepperell C, Rau N, Krajden S, Kern R, Humar A. *West Nile Virus Infection in 2002: Morbidity and Mortality Among Patients Admitted to Hospital in southcentral Ontario.* Canadian Medical Association Journal 2003 May 27, 2003;168 (11):1399-1405.

32. Ontario Ministry of Health and Long-Term Care. *Public Information: West Nile Virus 2002-Humans*. 2003 April [cited 2003 Apr 30]:[2 screens]. Available from URL: http://www.health.gov.on.ca/english/public/program/pubhealth/westnile/wnv_02/wnv_humans.html

33. Centers for Disease Control and Prevention. *West Nile Virus: Questions and Answers – Prevention*. [cited 2003 Jun 26]:[2 screens]. Available from URL: http://www.cdc.gov/ncidod/dvbid/westnile/qa/prevention.htm

34. Guptill S, Julian K, Campbell G, Price S, Marfin A. *Early-Season Avian Deaths from West Nile Virus as Warnings of Human Infection.* Emerging Infectious Diseases. 2003 April:9: (4):483-484. 2003 April [cited 2003 Apr 30]: [2 screens]. Available from URL: http://www.cdc.gov/ncidod/EID/vol9no4/pdfs/02-0421.pdf

35. Ontario Ministry of Health and Long-Term Care. *Public Information: West Nile Virus 2002-Horses*. 2003 April [cited 2003 Apr 30]:[1 screen]. Available from URL: http://www.health.gov.on.ca/english/public/program/pubhealth/westnile/wnv_02/wnv_horses.html

36. Donna Hutchings, Senior Veterinary Biologics Evaluator, Canadian Food Inspection Agency: personal communication, June 23, 2003

37. Sykes, J.B. (editor). *The Concise Oxford Dictionary of Current English*. 6th ed. Oxford University Press, Walton Street, Oxford; 1976

APPENDICES

Appendix A

WEST NILE VIRUS WEEK CODES FOR 2002
*** Week includes dates from Sunday to Saturday**

Week Number	Dates Included
21	May 19-May 25
22	May 26-June 1
23	June 2-June 8
24	June 9-June 15
25	June 16-June 22
26	June 23-June 29
27	June 30-July 6
28	July 7-July 13
29	July 14-July 20
30	July 21-July 27
31	July 28-Aug 3
32	Aug 4-Aug 10
33	Aug 11-Aug 17
34	Aug 18-Aug 24
35	Aug 25-Aug 31
36	Sept 1-Sept 7
37	Sept 8-Sept 14
38	Sept 15-Sept 21
39	Sept 22-Sept 28
40	Sept 29-Oct 5
41	Oct 6-Oct 12
42	Oct 13-Oct 19
43	Oct 20-Oct 26
44	Oct 27-Nov 2

Appendix B

Dead Bird Surveillance for West Nile Virus by Health Unit, Ontario, 2002

Region	First Positive Bird Found	Last Positive Bird Found	Total Positive
Algoma	19-Jul-02	26-Sep-02	9 (confirmed)
Brant	16-Jul-02	26-Aug-02	7 (confirmed)
Chatham-Kent	12-Jun-02	05-Aug-02	11 (confirmed)
Durham	22-Jul-02	07-Aug-02	5 (confirmed)
Eastern Ontario	25-Jul-02	01-Aug-02	4 (confirmed)
Elgin-St. Thomas	30-Jul-02	09-Aug-02	6 (confirmed)
First Nations (near Brant)	02-Oct-02	07-Oct-02	2 (confirmed)
Grey Bruce	25-Jul-02	15-Aug-02	3 (confirmed)
Haldimand-Norfolk	12-Jul-02	08-Aug-02	5 (confirmed)
Haliburton-Kawartha-Pine Ridge	18-Jul-02	06-Aug-02	5 (confirmed)
Halton	15-Jun-02	13-Aug-02	14 (confirmed)
Hamilton	12-Jul-02	09-Oct-02	18 (confirmed)
Hastings-Prince Edward	06-Aug-02	22-Aug-02	12 (confirmed)
Huron	19-Jul-02	18-Aug-02	5 (confirmed)
Kingston, Frontenac, Lennox and Addington	06-Aug-02	21-Aug-02	11 (confirmed)
Lambton	17-Jul-02	06-Aug-02	8 (confirmed)
Leeds-Grenville-Lanark	26-Jul-02	03-Oct-02	5 (confirmed)
Middlesex-London	17-Jun-02	06-Aug-02	15 (confirmed)
Muskoka-Parry Sound	17-Jul-02	06-Sep-02	4 (confirmed)
Niagara	11-Jul-02	06-Aug-02	11 (confirmed)
North Bay	26-Aug-02	26-Aug-02	1 (confirmed)
Northwestern	08-Aug-02	18-Sep-02	3 (confirmed)
Ottawa	23-Jul-02	07-Aug-02	4 (confirmed)
Oxford	04-Jun-02	06-Aug-02	7 (confirmed)
Peel	**19-May-02**	**25-Oct-02**	**20 (confirmed)**
Perth	02-Jul-02	03-Aug-02	8 (confirmed)
Peterborough	N/A	22-Aug-02	4 (confirmed)
Porcupine	01-Sep-02	01-Sep-02	1 (confirmed)
Renfrew	25-Jul-02	30-Sep-02	4 (confirmed)
Simcoe	02-Aug-02	29-Oct-02	21 (confirmed)
Sudbury	30-Aug-02	26-Sep-02	2 (confirmed)
Thunder Bay	31-Jul-02	30-Sep-02	4 (confirmed)
Toronto	03-Jul-02	24-Aug-02	8 (confirmed)
Waterloo	10-Jul-02	09-Oct-02	12 (confirmed)
Wellington-Dufferin-Guelph	19-Jul-02	05-Aug-02	5 (confirmed)
Windsor-Essex	18-Jun-02	07-Aug-02	9 (confirmed)
York	15-Jul-02	31-Jul-02	8 (confirmed)
ONTARIO TOTAL			**281 confirmed**

Data as of April 30, 2003.
Source: Ontario Ministry of Health and Long-Term Care. (See internet site: http://www.health.gov.on.ca/english/providers/program/pubhealth/westnile/wnv_02/wnv_birds.html).

Appendix C

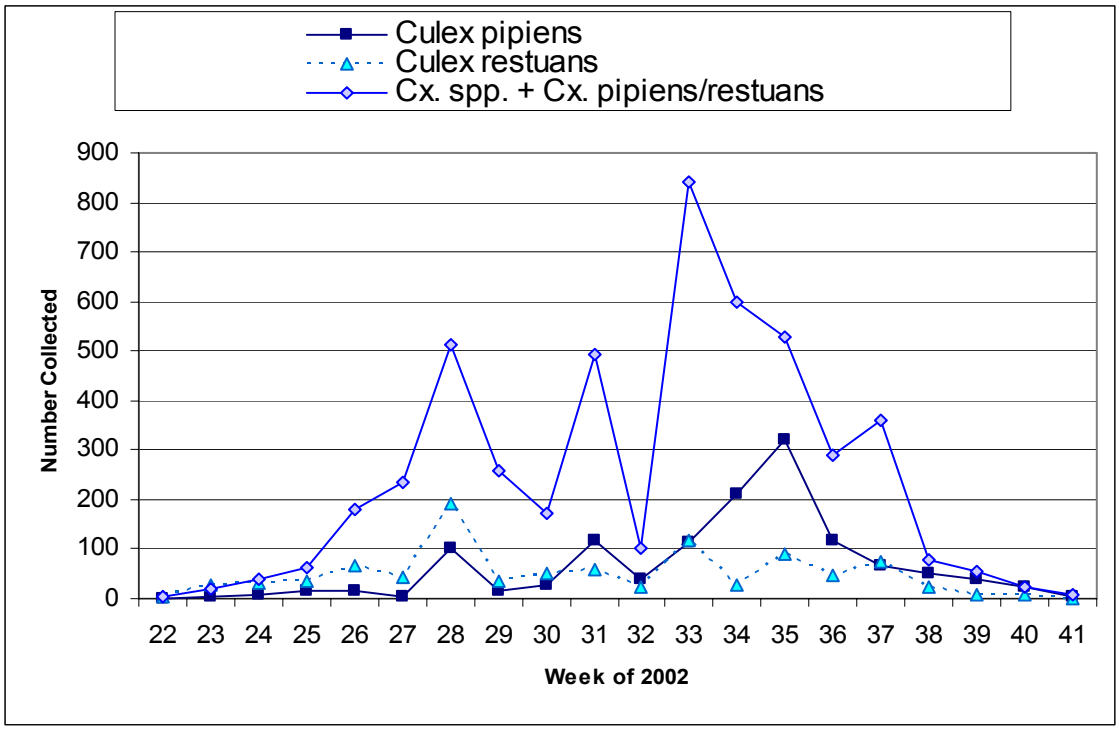
Adult Mosquito Surveillance for West Nile Virus by Health Unit, Ontario, 2002

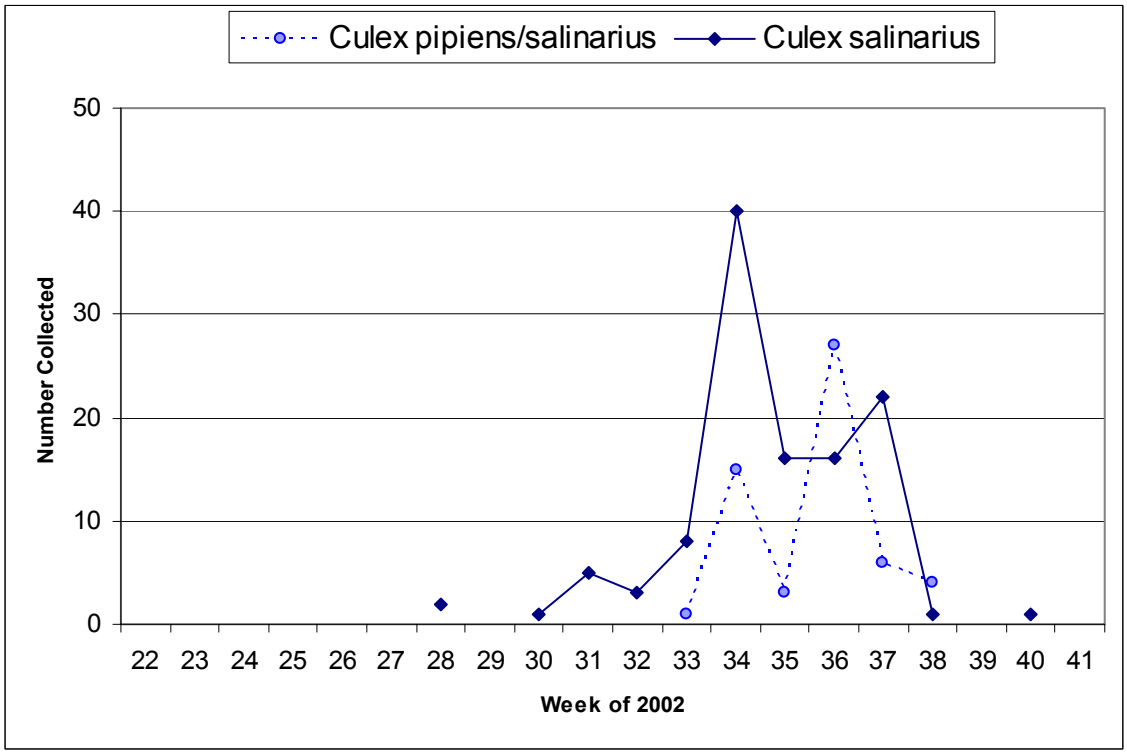
Region	First Positive Pool Found	Last Positive Pool Found	Total Positive Pools
Brant	September 18, 2002	September 19, 2002	2
Chatham-Kent	July 23, 2002	September 5, 2002	11
Durham	August 14, 2002	September 18, 2002	13
Eastern Ontario	July 23, 2002	August 12, 2002	2
Haldimand-Norfolk	August 15, 2002	September 12, 2002	6
Haliburton-Kawartha-Pine Ridge	August 29, 2002	August 29, 2002	1
Halton	July 24, 2002	September 17, 2002	72
Hamilton	July 25, 2002	September 11, 2002	11
Hastings-Prince Edward	August 29, 2002	August 29, 2002	1
Middlesex-London	August 1, 2002	October 10, 2002	22
Niagara	July 30, 2002	September 20, 2002	15
Oxford	July 25, 2002	September 12, 2002	18
Peel	**June 20, 2002**	**October 1, 2002**	**132***
Perth	July 30, 2002	August 28, 2002	4
Peterborough	August 29, 2002	September 5, 2002	3
Simcoe	September 4, 2002	September 5, 2002	3
Toronto	July 23, 2002	October 1, 2002	175
Waterloo	July 31, 2002	September 25, 2002	12
Wellington-Dufferin-Guelph	August 22, 2002	August 22, 2002	1
Windsor-Essex	July 23, 2002	October 1, 2002	80
York	July 10, 2002	September 25, 2002	14
ONTARIO TOTAL			**598**

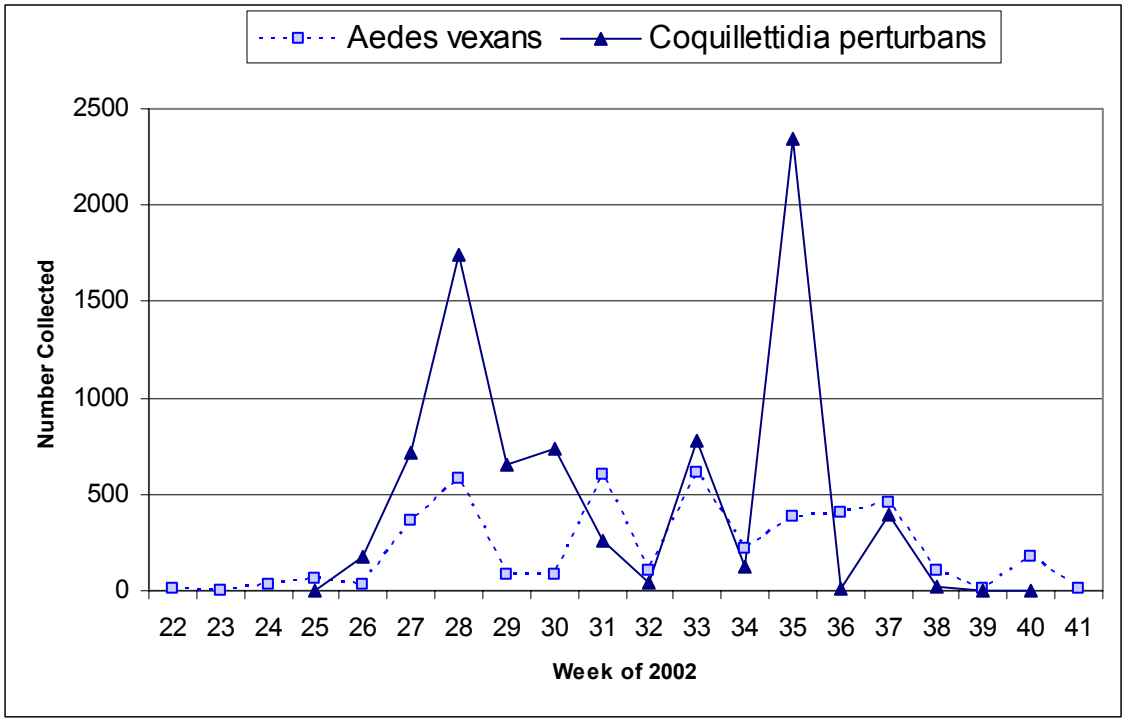
* Total of 132 includes two pools belonging to Toronto and two pools for which site, date and number of mosquitoes data could not be reconciled.

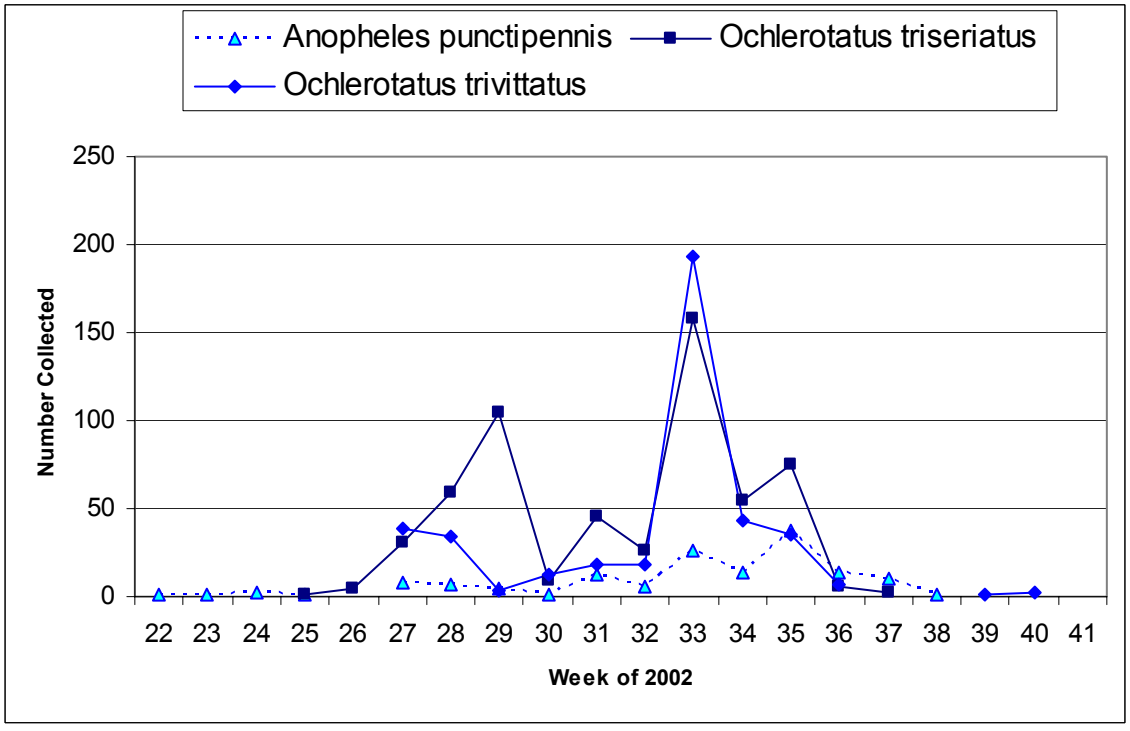
Data as of April 30, 2003.
Source: Ontario Ministry of Health and Long-Term Care. (See internet site: http://www.health.gov.on.ca/english/providers/program/pubhealth/westnile/wnv_02/wnv_mosquitoes.html).

Appendix D
Mosquito Activity Among WNV-Positive Species, Region of Peel, 2002






Aedes vexans
Coquillettidia perturbans
Number Collected
2500
2000
1500
1000
500
0
22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Week of 2002


Anopheles punctipennis
Ochlerotatus triseriatus
Ochlerotatus trivittatus
Number Collected
250
200
150
100
50
0
22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Week of 2002

Appendix E
Human Case Definitions used in the Region of Peel, 2002

The following are the case definitions for "Probable" and "Confirmed" West Nile Virus (WNV) cases used by the Ontario Ministry of Health and Long-Term Care in 2002. (See internet site:
http://www.health.gov.on.ca/english/providers/program/pubhealth/westnile/wnv_02/wnv_humans.html)

Probable Case

A person who has symptoms and history consistent with WNV illness, and who has laboratory tests demonstrating a four-fold or greater change in haemagglutination inhibition or enzyme-linked immunosorbent assay (ELISA) titres in paired acute and convalescent sera.

Confirmed Case

A person who has symptoms and history consistent with WNV illness, and who has laboratory tests demonstrating:

(a) a four-fold or greater change in haemagglutination inhibition or enzyme-linked immunosorbent assay (ELISA) titres in paired acute and convalescent sera with confirmation by a Plaque Reduction Neutralizing Test (PRNT),

or

(b) isolation of WNV from or demonstration of WNV antigen or genomic sequences in tissue, blood, cerebrospinal fluid, or other body fluid. Detection of WNV genome should be shown by at least two different amplification assays that target distinct regions of the viral RNA,

or

(c) demonstration of IgM antibody to WNV in CSF by IgM-capture ELISA with confirmation by a PRNT.

Appendix F

Human Case Surveillance for West Nile Virus by Health Unit, Ontario, 2002

Region	Total Probable Cases	Total Confirmed Cases
Brant	0	1
Chatham-Kent	1	2
Durham	1	2
Grey Bruce	0	1
Haldimand-Norfolk	0	3
Halton	3	57
Hamilton-Wentworth	4	8
Lambton	1	1
Middlesex-London	3	6
Muskoka-Parry Sound	0	1
Niagara	3	16
Peel	**20**	**38***
Perth	0	1
Toronto	44	127
Waterloo	0	3
Windsor	3	35
York Region	4	6
ONTARIO TOTAL	**87**	**308**

* The total of 38 confirmed cases includes one case found to belong to Halton Region.

Data as of April 30, 2003.
Source: Ontario Ministry of Health and Long-Term Care. (See internet site:

http://www.health.gov.on.ca/english/providers/program/pubhealth/westnile/wnv_02/wnv_humans.html)

Glossary of Terms

Ataxia: difficulty coordinating movement or body functions [37]

Encephalitis: inflammation of the brain [37]

Flavivirus: the genus in which the WNV is classified. WNV is a single-stranded RNA virus of the family *Flaviviridae* [18]

Host: an animal or plant having received a parasite which then resides within the animal or plant [37]

Instar: stage in life of an insect, including shedding or casting off of outer skin or shell [37]

Malaise: bodily discomfort, especially without development of a specific disease [37]

Meningitis: inflammation of the lining of the brain or spinal cord [37]

Meningoencephalitis: inflammation of brain, lining of the brain or spinal cord [37]

Myalgia: muscle soresness or pain [37]

Neuropathogen: an agent which causes disease of the nervous system [37]

Sepsis: blood poisoning [37]

Seroprevalence: testing blood for the presence or absence of an antibody within the blood. When a person has been exposed to a virus, their immune system will create antibodies to try to combat the virus [28]

Vector: carrier of disease or infection from one organism to another [37]