INSPQ INSTITUT NATIONAL DE SANTÉ PUBLIQUE DU QUÉBEC

Report on Surveillance of the West Nile Virus and Other Arboviruses in Québec: 2016 Season

May 2017

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In 2016, the Ministère de la Santé et des Services sociaux (MSSS) asked the Institut national de santé publique du Québec (INSPQ) to add the eastern equine encephalitis virus (EEEV) and the California serogroup viruses (CSGV) to the West Nile virus (WNV) integrated surveillance. The MSSS also requested surveillance of the *Aedes albopictus* mosquito.

During 2016, 30 cases of WNV infection and five cases of encephalitis linked to CSGV were reported to the public health service. All of the cases were acquired in Québec.

Therefore, 53 entomological stations were set up in the province of Québec: three specifically to collect EEEV vectors, nine for *Aedes albopictus* surveillance, and 41 for combined WNV and CSGV surveillance. In all, 935 mosquito pools were tested for WNV, 101 for EEEV, and 91 for CSGV. Among them, 28 (3%), 4 (4%) and 2 (2%), respectively, tested positive for these viruses. No *Aedes albopictus* mosquitoes were collected.

Lastly, eleven wild birds and two horses were reported positive for WNV and two horses were reported positive for EEEV during the year.

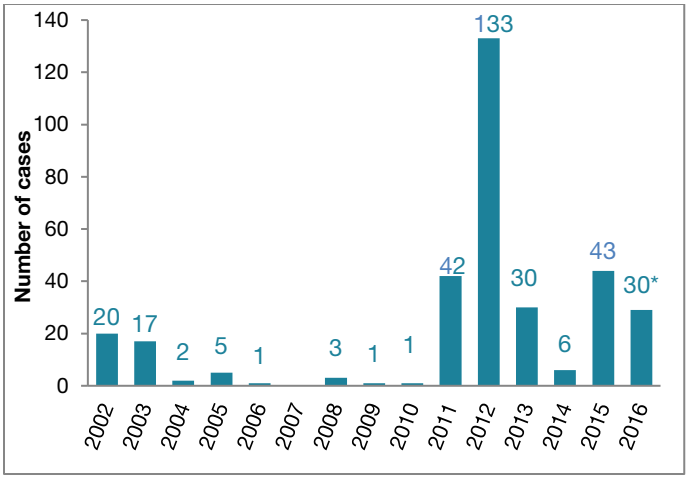
Québec

West Nile virus

Human surveillance

In 2016, Québec's public health service received a total of 30 confirmed cases of WNV infection acquired in Québec, including one case, which was excluded from the analyses, where the infection occurred in 2015. The number of cases reported in 2016 decreased in comparison with the previous season, but remained higher compared to the earlier seasons of low activity (2004–2010) (Figure 1). Nearly 90% of the cases were acquired in the health regions of Montréal (n = 8), Lanaudière (n = 7), Laval (n = 6), and Montérégie (n = 5) (Table 1). The majority of these cases were probably acquired infections in their area of residence, with the exception of one Montréal resident who was infected in Lanaudière and one resident of Gaspésie infected in Laval. The incidence rate was the highest in Laval and Lanaudière.

Figure 1 **Distribution of the number of human cases of WNV infection acquired in Québec, 2002–2016**



Source: SIDVS-VNO, INSPQ, data extraction as of January 23, 2017.

* One case infected in 2015 was excluded from subsequent analyses.

Table 1 **Number of human cases of WNV infection and crude incidence rate by region of acquisition, Québec, 2016**

Region of acquisition	Number of cases[1]	Incidence rate/100 000
Capitale-Nationale	1	0.14
Montréal	8	0.40
Outaouais	1	0.26
Laval	6	1.41
Lanaudière	7	1.41
Laurentides	1	0.17
Montérégie	5	0.33
Total	**29**	**0.35**

Sources: [1]SIDVS-VNO, INSPQ, data extraction as of January 23, 2017. Population estimates for the incidence rate retrieved from the Institut de la statistique du Québec (2016).

All cases were symptomatic. The first case was reported in the Capitale-Nationale region with symptoms starting at the very beginning of July, during CDC week 27 (Table 2). The symptoms of the second human case started six weeks later, towards mid-August (CDC week 33). Subsequently, the active season extended over ten CDC weeks, and the peak of human cases was observed from August 28 to September 17 (CDC weeks 35 to 37). Nearly 66% of cases occurred during this period.

Table 2 **Number of human cases of WNV infection by region of acquisition and CDC week, Québec, 2016**

	July	August			September			October		
CDC week[1]	27	33	34	35	36	37	39	40	41	42
Capitale-Nationale	1									
Montréal			1	2	3	1			1	
Outaouais										1
Laval		1	1	2		2				
Lanaudière			2		2	2		1		
Laurentides					1					
Montérégie				3		1	1			
Total	**1**	**1**	**4**	**7**	**6**	**6**	**1**	**1**	**1**	**1**

Source: SIDVS-VNO, INSPQ, data extraction as of January 23, 2017.

[1] According to the date of illness onset.

The characteristics of WNV human cases that occurred in 2016 are given in Table 3. The average age of the cases was 61 years (median: 63 years, minimum: 33 years and maximum: 89 years). Over half of the cases (n = 17) presented neurological involvement. In all, 23 patients were hospitalized, including six patients admitted to intensive care. Almost all cases with a neurological involvement (16/17) were hospitalized and two died following their WNV infection.

Table 3 Characteristics of human cases of WNV infection, Québec, 2016

Characteristics	Number of cases (n = 29)
Sex	
Female	11
Male	18
Age group	
Median age, years	63 (33–89)
< 20 years	0
20–49 years	7
50–59 years	4
≥ 60 years	18
Clinical presentation	
Asymptomatic	0
Non-neurological	12
Neurological	17
Encephalitis	5
Meningoencephalitis	7
Meningitis	4
Encephalomyelitis	1
Case evolution	
Hospitalization	23
Median hospital stay, days[1]	8 (2–19)
Intensive care	6
Median stay in intensive care, days[2]	8 (2–48)
Death[3]	2

Source: *SIDVS-VNO*, INSPQ, data extraction as of January 23, 2017.

1 Estimate for 14 cases: information unavailable for 9 cases.

2 Estimate for 4 cases: information unavailable for 2 cases.

3 Both cases were aged 60 years or older.

Requests for analyses in the Laboratoire de santé publique du Québec (LSPQ)

Between June 1 and November 30, 2016, 879 specimens (from 728 beneficiaries) were received and tested for WNV IgM antibodies by the Laboratoire de santé publique du Québec (LSPQ). The first reactive serum was taken on June 6, which was a much earlier seroactivity than that seen during the past years (July 28 in 2015 and August 6 in 2014). However, this was the case that had been infected in 2015, but diagnosed late in 2016. The first positive IgM serologies were reported in June and their number peaked in September with 23 positive IgM serologies. The majority of positive serologies were found in people over 50 years old (83%).

Analysis of the data by health region indicated that the highest number of requests for serological tests came from Montérégie (n = 280), followed by Montréal (n = 169). These two regions represented respectively 32% and 19% of the requests. The highest rate of positive IgM serologies was observed in Laval (16.1%) and Lanaudière (10.5%).

Entomological surveillance

Entomological surveillance activities were carried out between July 3 and October 1, 2016. The chosen WNV surveillance sites were primarily in zones where WNV activity had been documented in the past.[1] A total of 41 fixed entomological stations[2] using CDC Light Traps were installed in eleven regions of the province.

In total, 16 781 specimens from 935 mosquito pools were tested by RT-PCR (reverse transcription polymerase chain reaction assay). Of these, 28 (3%) were found to be positive for WNV in three of the eleven regions where samples were taken (Montréal, Laval, and Montérégie) (Table 4).

Among these positive pools, 25 were *Culex pipiens-restuans* and three *Aedes vexans.*[3] The first positive mosquito pools were detected during CDC week 27 (July 3 to 9) in the Montréal region, at the beginning of entomological surveillance (Table 8). The period of high viral activity was observed during CDC weeks 33 and 34 (from August 14 to 27) and the last positive mosquito pool was detected during CDC week 38 (September 18 to 24) in Montérégie.

1 The choice of trap sites was calculated using a relevance index (INSPQ, 2016). For each entomological station used in the past for WNV surveillance, this index takes into account the number of WNV pools, the number of operational years, and the total number of human cases to have occurred in a 2-km radius around each station, as well as the population per km^2 in the dissemination area of each entomological station.

2 Two pools from an additional station designated for EEEV surveillance had some *Culex pipiens-restuans* and were tested for WNV.

3 The mosquito species tested for WNV are *Culex pipiens-restuans* and *Aedes vexans*.

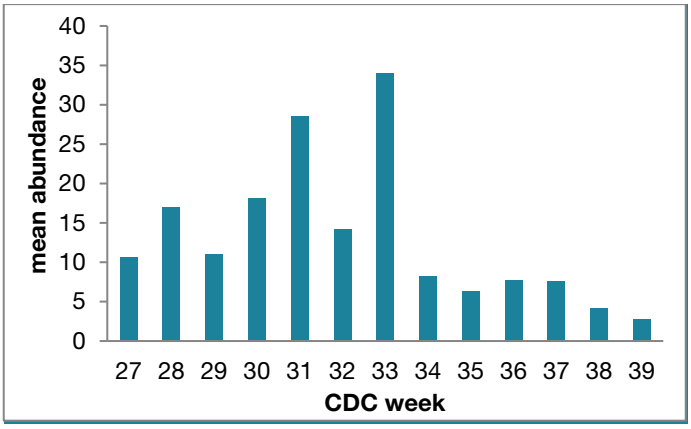
Table 4 Distribution of entomological traps and pools tested for WNV by health region, Québec, 2016

Health region	Number of traps	Number of WNV-positive traps (%)	Number of pools tested for WNV	Number of WNV-positive pools
Capitale-Nationale	3	0	47	0
Mauricie et Centre-du-Québec	6	0	123	0
Estrie	3	0	50	0
Montréal	5	4	120	16 (13%)
Outaouais	3	0	80	0
Abitibi-Témiscamingue	3	0	52	0
Chaudière-Appalaches	3	0	51	0
Laval	4	3	96	6 (6%)
Lanaudière	4	0	76	0
Laurentides	3	0	76	0
Montérégie	5	2	164	6 (4%)
Total	**42**	**9 (21%)**	**935**	**28 (3%)**

Source: GDG Environnement and *SIDVS-VNO*, INSPQ, data extraction as of January 23, 2017.

The mean abundance of *Culex pipiens-restuans* (arithmetic mean of all traps) is presented in Figure 2. The abundance peak observed in week 33 (mid-August) probably came in the wake of high temperatures accumulated over several consecutive weeks. The peak of the infection rate (IR: proportion of mosquitoes infected by WNV)[4] was observed from CDC weeks 34 to 36, while the peak of the vector index (VI)[5] was seen in CDC week 33 (Table 5).

Figure 2 Mean abundance of *Culex pipiens-restuans* in Québec by CDC trapping week for all entomological stations, Québec, 2016



Source: GDG Environnement, data extraction as of January 23, 2017.

[4] The infection rate estimated by Maximum Likelihood (IR-EML) is the most probable proportion of infected mosquitoes, P, (according to binomial distribution) to obtain N of positive pools among N pools of variable size tested.

[5] The vector index is the number of infected mosquitoes per trapping night for a given species. It is the product of the abundance and the infection rate (vector index = average abundance x infection rate).

Table 5 **Infection rate and vector index of *Culex pipiens-restuans* by CDC trapping week, Québec, 2016**

CDC week	Rate of infection/1000	Vector index
27	7.13	0.08
28	0.00	0.00
29	0.00	0.00
30	4.68	0.08
31	6.15	0.18
32	4.19	0.06
33	9.28	0.32
34	18.76	0.15
35	19.73	0.12
36	15.72	0.12
37	0.00	0.00
38	7.74	0.03
39	0.00	0.00

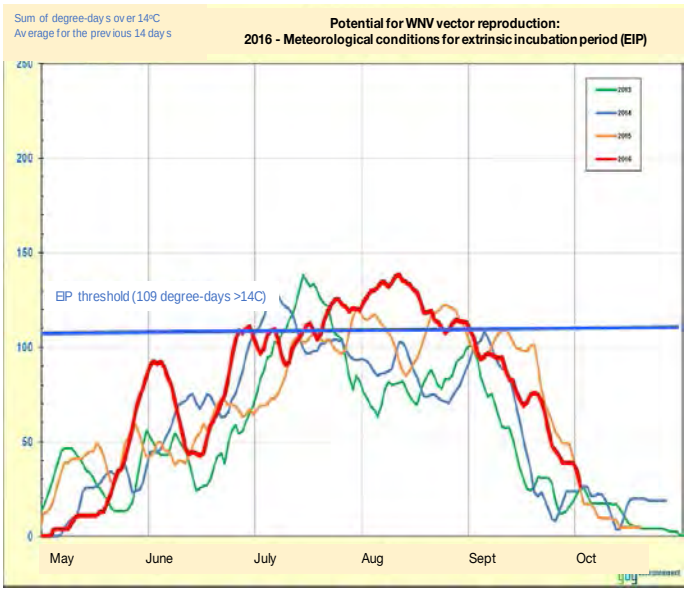
Source: GDG Environnement and *SIDVS-VNO*, INSPQ, data extraction as of January 23, 2017.

Weather monitoring

Weather monitoring was carried out to determine the time or times in the season that are the most favourable for WNV amplification in infected mosquitoes. In California, it was shown that WNV reproduces in *Culex tarsalis* when an accumulation threshold of degree-days over 14.3 °C is reached (Reisen, 2006). By calculating the sum of degree-days above 14.3 °C from the average temperature of the 14 previous days, the curve for the extrinsic incubation period (EIP) can be found. This curve is affected by weather conditions and presents a value that can be associated with one of the risk factors for the spread of WNV. The theoretical threshold for potential WNV amplification in mosquito vectors has been established at 109 degree-days.[6]

The curve of degree-days in 2016 was above the theoretical threshold at the end of June (CDC week 27, Figure 3) and then in the week of July 23 (CDC week 29). It remained above the threshold for six consecutive weeks (until the end of CDC week 34). In terms of the number of consecutive days, this was the longest period above the threshold in the last four years (Figure 3).

Figure 3 **Curve for WNV extrinsic incubation period, Québec, 2013–2016**



Source: GDG Environnement (2016), meteorological data retrieved from the McTavish weather station in Montréal.

Animal surveillance

For wild animals, passive WNV surveillance is carried out by the Centre québécois sur la santé des animaux sauvages (CQSAS)[7], whereas in domestic animals it is managed by the Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ, 2016).

6 Weather monitoring in Québec is used only on an exploratory basis because 1) the method used has not been specifically validated for Québec and 2) the main vector of WNV (*Culex tarsalis*) is a different species than the one observed in Québec (*Culex pipiens-restuans*).

7 WNV surveillance in wild animals is part of mortality and morbidity surveillance in wild animals. The animals submitted for analysis are collected in the context of other surveillance programs that target a variety of animal diseases (for birds, this is within the framework of avian flu surveillance). Animal carcasses are reported by individuals through a MAPAQ-managed phone line (1-877-644-4545); then a wildlife officer fetches the carcasses, which are next sent to the CQSAS for necropsy. In the case of a suspected WNV infection at the time of necropsy, tissue samples are submitted for RT-PCR (reverse transcription polymerase chain reaction assay) analysis to the Complexe de pathologie et d'épidémiosurveillance du Québec. Lastly, the data are compiled by the CQSAS (CQSAS, 2016).

Between August 23 and October 6, 2016, eleven wild birds belonging to seven different species[8] tested positive for WNV (Stéphane Lair, personal communication) (Table 6). The first WNV-positive bird was an American crow found on July 27 in Otterburn Park, in Montérégie, and the second was a red-tailed hawk found on September 6 in Mont-Saint-Hilaire, also in Montérégie.

Furthermore, two horses were confirmed positive for WNV in Mauricie and Centre-du-Québec and in Lanaudière. It should be pointed out that a large proportion of horses are currently vaccinated for WNV in Québec.

Table 6 Number of wild birds classified by species and confirmed positive for WNV by the CQSAS, Québec, 2016

Species	Number of cases
Sharp-skinned hawk	3
Merlin	2
Northern goshawk	2
American crow	1
Red-tailed hawk	1
Great horned owl	1
Cooper's hawk	1
Total	**11**

Source: Lair S., Centre québécois sur la santé des animaux sauvages.

Eastern equine encephalitis virus

Human surveillance

No case of human infection by EEEV has been reported in Québec to date. It should be noted that among arboviruses, only cases of viral encephalitis transmitted by arthropods are reported diseases (MADO) in Québec. However, in view of the symptomatology of infections caused by these viruses, EEEV infections should very probably be reported.

In 2016, 76 requests for EEEV serological analyses were transmitted to the LSPQ. None were positive.

Entomological surveillance

In 2016, entomological surveillance of EEEV was carried out in three fixed traps in Lanaudière, given that this region had reported the greatest number of outbreaks in horses since 2008 (MAPAQ). A CDC Light Trap was set in each of the following sectors: Lanoraie, Lavaltrie, and Saint-Thomas. Besides the collected mosquitoes in these sectors, *Culiseta melanura* (the main EEEV vector in birds) found in other stations designated for WNV surveillance were also tested for EEEV (recommendation from the INSPQ WNV scientific expert panel).

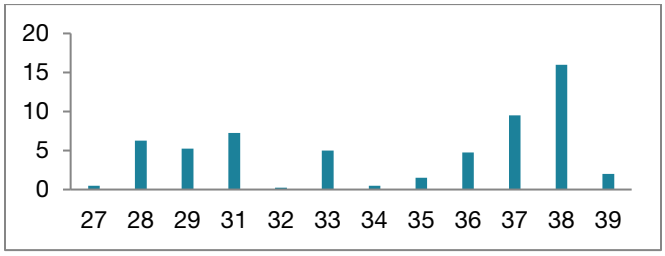
In 2016, a total of 1 620 specimens taken from 101 mosquito pools[9] were tested for EEEV. They included 744 *Coquillettidia perturbans*, 644 *Aedes vexans*, 228 *Culiseta melanura* and 4 *Ochlerotatus canadensis*. 4/101 of the tested pools were EEEV-positive and all came from the same trap (LAN 001) in the Lanaudière region. The species of positive mosquitoes were *Culiseta melanura* and *Coquillettidia perturbans*. The positive pools were detected in CDC weeks 33 (week of August 14 to 20) and 38 (from September 18 to 24) (Table 8).

The abundance of *Culiseta melanura* was generally low but constant during the entire collection period (Figure 4). It is a multivotine species that produces several generations per year and lives in woodland marshes; this type of setting is not frequently used for WNV surveillance sites.

[8] The bird species collected are basically birds of prey, which are the main species targeted by the avian flu surveillance program: sharp-skinned hawk, merlin, northern goshawk, red-tailed hawk, great horned owl, Cooper's hawk and American crow.

[9] The 101 pools tested for EEEV were found in Lanaudière (n = 84), Mauricie and Centre-du-Québec (n = 7), Abitibi-Témiscamingue (n = 4), Chaudière-Appalaches (n = 3), Laurentides (n = 2), and Estrie (n = 1).

Figure 4 **Mean abundance of *Culiseta melanura* in Québec by CDC trapping week, Québec, 2016**



Source: GDG Environnement, data extraction as of January 23, 2017.

Animal surveillance

Two EEEV positive horses were reported in the region of Lanaudière in 2016. After the peaks of the outbreaks, since 2008 a large proportion of horses have been vaccinated in Québec. No other animal surveillance is currently carried out for EEEV in Québec.

California serogroup viruses

Human surveillance

In Québec, no surveillance of human CSGV infection is currently being carried out. Infections caused by these viruses are therefore probably underrepresented in the MADO file since only cases leading to encephalitis are reported diseases.

In 2016, five confirmed[10] cases of encephalitis linked to CSGV were reported in Québec: all were caused by the *Jamestown Canyon* virus. This was the largest number of cases reported since 2003 (zero to two cases reported from 2005 to 2015).

The five cases occurred in men. Two of these cases were acquired in Montérégie, one in the Capitale-Nationale, one in Mauricie and Centre-du-Québec, and one in Estrie (Table 6). The symptoms of the first case started during the week of June 19 (CDC week 25). Two deaths were reported.

Table 7 **Characteristics of human encephalitis cases caused by CSGV, Québec, 2016**

Characteristics	Number of cases (n = 5)
Sex	
Male	5
Age group	
< 20 years	1
20–49 years	2
50–59 years	0
≥ 60 years	2
CDC week[1]	
25 (June 19–25)	1
29 (July 17–23)	1
30 (July 24–30)	1
35 (Aug 28–Sept 3)	1
37 (Sept 11–17)	1
Health region	
Capitale-Nationale	1
Mauricie et Centre-du-Québec	1
Estrie	1
Montérégie	2
Deaths[2]	2

Source: MADO file, data extraction as of April 3, 2017.

1 According to the date of symptom onset.

2 One patient 30 to 34 years old, and one aged 60 years or older.

Requests for analyses in the Laboratoire de santé publique du Québec

The LSPQ received 105 requests for CSGV serological tests. Twenty-five specimens (24%) were IgM positive for the *Jamestown Canyon* virus and 14 (33%) were IgM positive for the *Snowshoe Hare* virus. Among them, 13 (52%) and 5 (33%) specimens respectively were confirmed by a PRNT test for both viruses. The confirmation of neutralizing antibody titers for the *Jamestown Canyon* virus was detected in 15 specimens that came from Montérégie (n = 5), the Capitale-Nationale (n = 4), Estrie (n = 3), Mauricie and Centre-du-

10 IgM screening is done to confirm a case. If it is positive, a confirmatory PRNT test must be made. Since cross-reactions are possible between the *Jamestown Canyon* virus and the *Snowshoe Hare* virus, the highest PRNT titer generally indicates which virus is responsible for the acute disease.

Québec (n = 2), and Outaouais (n = 1). The presence of neutralizing antibodies for the *Snowshoe Hare* virus was detected in eight specimens that came from Montérégie (n = 5), the Capitale-Nationale (n = 2), and Outaouais (n = 1).

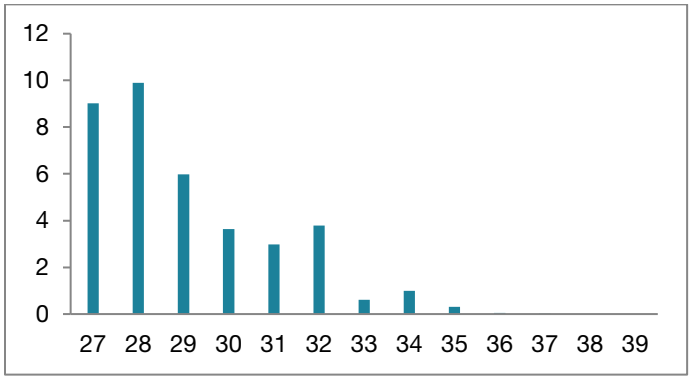
Entomological surveillance

A total of 472 specimens from 91 mosquito pools[11] were tested for CSGV in 2016. Among them, 403 *Ochlerotatus stimulans*, 42 *Ochlerotatus abserratus*, 26 *Ochlerotatus communis*, and 1 *Ochlerotatus fitchii*. Two pools tested positive for the *Snowshoe Hare* virus and came from the same trap (VAL 002) in the region of Abitibi-Témiscamingue.

The two positive mosquito pools for CSGV included the species *Ochlerotatus stimulans*. The positive pools were detected during CDC weeks 29 (July 17 to 23) and 34 (August 21 to 27) (Table 8).

Ochlerotatus stimulans is a species whose infectious larvae emerge as soon as the snow melts. The adults are therefore present very early in the season (at the beginning of May). This species was at its peak abundance at the beginning of the collection period in July (CDC weeks 27 and 28) and subsequently decreased (Figure 5).

Figure 5 **Mean abundance of *Ochlerotatus stimulans* by CDC trapping week, Québec, 2016**



Source: GDG Environnement, data extraction as of January 23, 2017.

Surveillance of *Aedes albopictus*

Entomological surveillance of *Aedes albopictus* was carried out in 2016. This particular vector was targeted because of its vector competence for emerging exotic diseases (Zika, Chikungunya, dengue, etc.) and because the CDC reported that it had currently spread to the middle of New York State and to Vermont. It could serve as a potential indicator of the way in which invasive mosquito species are accidentally introduced by mechanical means.

Therefore, from July to October 2016, active surveillance of *Aedes albopictus* took place in nine fixed stations in the regions of Montréal (Montréal airport: four traps, Port of Montréal: two traps), Estrie (Stanstead: one trap), and Montérégie (Saint-Bernard-de-Lacolle: one trap, Saint-Régis: one trap). These sites were all selected because they correspond to potential entry points for invasive mosquito species: they include a port, an airport and border regions with the United States in the south of Québec. A BG-Sentinel 2-type trap was installed in each of these stations.

No pool of *Aedes albopictus* was found in the nine stations assigned for its surveillance.

Limitations of surveillance data

The 2016 season is the first time when other viruses as well as WNV have been objects of entomological surveillance in Québec. Limitations of integrated WNV surveillance are detailed in the WNV integrated surveillance analysis plan (INSPQ, 2014). The limitations associated with surveillance of other arboviruses will be specifically described in the following paragraphs.

For human surveillance, the number of reported cases associated with the arboviruses surveyed is very probably underestimated. Indeed, unlike those of WNV, cases of EEEV and CSGV are not reported by the LSPQ, but only by physicians when the disease leads to viral encephalitis. Numerous infections caused by these arboviruses are asymptomatic and do not develop into neurological lesions. Moreover, the observed increase in the number of encephalitis cases associated with CSGV

[11] The 91 pools tested for CSGV were collected in Abitibi-Témiscamingue (n = 31), Mauricie et Centre-du-Québec (14), Laurentides (n = 9), Capitale-Nationale (n = 7), Montérégie (n = 7), Outaouais (n = 7), Estrie (n = 5), Chaudière-Appalaches (n = 5), Lanaudière (n = 5), and Laval (n = 1).

in 2016 by comparison with previous years seems sudden. Nevertheless, it should be mentioned that for several years (1989–2005) no diagnostic test for these viruses was available in Québec (Drebot, 2005). Perhaps health professionals are becoming more aware of these diseases and are requesting more diagnostic tests for them (for example, two probable cases of encephalitis linked to CSGV were reported in 2015 as opposed to five confirmed cases in 2016). In any case, educational efforts should be directed towards clinicians in order to obtain a clear picture of the situation.

For entomological surveillance, with the exception of the three stations focused on EEEV, the other traps were set according to WNV sampling criteria. However, CSGV mosquito vectors are very different from those of WNV and are more commonly found in forest zones (Rocheleau, 2016). Furthermore, the larvae of these mosquitoes are known to emerge as soon as the snow melts in the spring, and they are basically a univoltine species (a single mosquito generation per year). Mosquito collection began in July when the CSGV vector population was already declining.

As concerns EEEV, although the *Culiseta melanura* collected from the WNV-CSGV stations were all negative, they were not collected in an environment that favoured the EEEV transmission cycle (damp forest zones) (Rocheleau, 2016). The abundance of mosquito vectors for EEEV and CSGV is therefore probably underestimated.

Given the high number of mosquitoes collected in each station, only a subsampling of them was tested by the LSPQ. This might reduce the sensitivity of the system in detecting positive pools, and consequently lead to an underestimation of the IR and VI of the vectors. One must also be cautious in interpreting the IR and VI. It is difficult to extrapolate these results from the collection area to the whole health region because a mosquito generally travels an average of 1.15 km around the collection station (Hamer, 2014). As concerns the invasive mosquito species *Aedes albopictus*, the surveillance used was limited in terms of sensitivity because of the number of stations designated for it.

Lastly, animal surveillance itself also has some limitations. Birds, which are significant host amplifiers for WNV and EEEV, do not appear to play a major role in the CSGV transmission cycle. In addition, since birds move over long distances, they provide very little information about local viral activity. In Québec, the majority of horses are vaccinated for WNV and EEEV and therefore may be immunized for these viruses.

Table 8 Number of positive mosquito pools for different arboviruses by region and CDC trapping week, Québec, 2016

CDC week[1]	Month	WNV				EEEV	CSGV
		Montréal	Laval	Montérégie	Total	Lanaudière	Abitibi-Témiscamingue
27	July	2	0	0	2	0	0
28		0	0	0	0	0	0
29		0	0	0	0	0	1
30		2	0	0	2	0	0
31	August	2	1	1	4	0	0
32		1	1	0	2	0	0
33		4	2	0	6	2	0
34		3	1	1	5	0	1
35		2	0	0	2	0	0
36	September	0	1	3	4	0	0
37		0	0	0	0	0	0
38		0	0	1	1	2	0
39		0	0	0	0	0	0
Total (%)[2]		16 (13%)	6 (6%)	6 (4%)	28 (3%)	4 (4%)	2 (2%)

1 Corresponds to mosquito-trapping week.

2 Percentage in relation to total number of pools from each health region tested by the LSPQ.

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