



Annual apiculture winter loss reports

Learn about Ontario honey bee colony winter mortality and the management practices used by registered beekeepers to monitor and control pests and diseases.

Introduction

It is difficult to attribute overwinter loss to any single cause. The health of managed honey bees is complex and influenced by several factors including:

- pests
- disease
- genetics
- environmental stressors
- extreme weather
- beekeeper management practices

The annual Ontario Apiculture Winter Loss Survey is one tool for gathering valuable information on honey bee colony mortality and the management practices used by Ontario registered beekeepers to monitor and control pests and diseases.

Managed honey bee colonies experience variable overwinter mortality across Canada. Since 2010, overwinter honey bee mortality in Ontario has been estimated to be as low as 12% as seen in the winter of 2011-2012 and as high as 58% during the winter of 2013-2014.

This page contains annual apiculture winter loss reports published by the Ontario Apiary Program.

Refer to the table of contents to read detailed annual apiculture winter loss reports.

Annual survey

Every spring, the Ontario Ministry of Agriculture, Food and Rural Affairs' (OMAFRA) Apiary Program surveys Ontario beekeepers to estimate honey bee colony mortality during the previous winter. Each year, the Apiary Program publishes a report with the survey results and shares a summary of the results with the [Canadian Association of Professional Apiculturists](#) (CAPA) for their national report.

The [CAPA](#) National Winter Loss Survey Committee establishes the core questions which are asked of the provinces each year to estimate honey bee colony mortality during the winter. Individual provinces can add additional questions if needed to address specific regional issues. [CAPA](#) coordinates how the overall winter loss is reported at the national level to ensure consistency across the provinces and survey years.

For the purpose of this survey, a honey bee colony is defined as a full-sized colony either in a single or

double brood chamber and does not include nucleus colonies (splits). A commercially viable colony is defined as a colony which survived the winter and has a minimum of four frames with 75% of the comb area covered with bees on both sides in a standard 10-frame hive. Dead colonies are included in the count of non-viable colonies.

Geographical regions

The Ontario beekeeping industry is divided into five distinct regions based on geography, climate and weather patterns (Figure 1). The survey is sent to beekeepers across the province and responses are received from all five beekeeping regions.

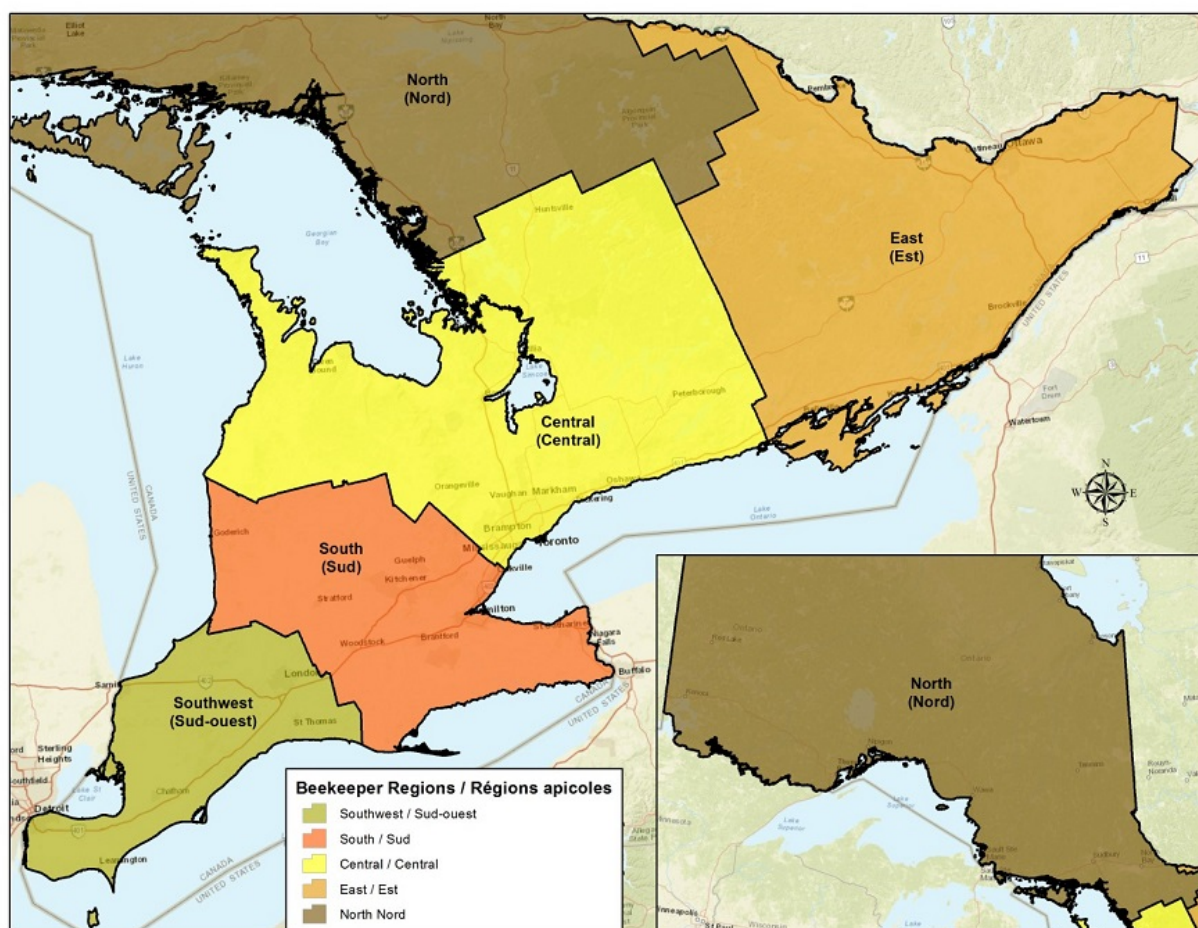


Figure 1. Ontario beekeeping regions: north (brown), east (light orange), central (yellow), south (dark orange) and southwest (green).

[Accessible description of figure 1](#)

How winter loss is calculated

Using the number of colonies reported by beekeepers, the provincial overwinter mortality is calculated using the following formula:

Overwinter Mortality (%)

$$= \left(\frac{\text{total \# of reported dead \& non-viable colonies as of May 15}}{\text{total \# of reported live colonies at the start of the previous winter}} \right) \times 100$$

Figure 2. Overwinter mortality estimate.

[Accessible description of figure 2](#)

Management practices for pests and disease

The winter loss survey also asks beekeepers about their surveillance, management and monitoring of four major pest and disease threats to honey bee colony health:

- varroa mites
- nosema
- American foulbrood
- European foulbrood

Varroa mites (*Varroa destructor*)

Varroa mites are relatively large external parasites that feed on the fat bodies and body fluids of adult and developing honey bees. Varroa mites cause physical damage to their host, weaken bees and transmit a variety of pathogens, particularly viruses. In almost all cases, when varroa mite infestations are not effectively managed, the death of the honey bee colony will follow. Varroa mites are identified by researchers as the primary cause of mortality of honey bee colonies (Guzman *et al.*, 2010). In this survey, beekeepers are asked how they monitored for varroa mite infestations and which treatments are used at the beginning (spring) and the end (fall) of the beekeeping season.

Frequency of monitoring for varroa mites

Regular monitoring for varroa mites is also important for varroa management. This is because varroa mite levels increase throughout the season and beekeepers need to continually assess the population growth of varroa mites in their colonies.

The levels of varroa mites can determine when or what type of treatment is needed. Monitoring after treatment may also provide the beekeeper with information on how effective the treatment was, and if further treatments are required.

A further risk that beekeepers must address through monitoring after treatment is the potential re-infestation of varroa mites from colonies in nearby and neighbouring apiaries.

Typically two periods of monitoring were recommended (spring and fall), but it is now advisable for beekeepers to sample many more times and as regularly as they can work into their management schedule.

Nosema spp. (*N. apis* and *N. ceranae*)

Nosema is a fungal pathogen that invades the digestive system of honey bees. Nosema may be an added stress to honey bee colonies depending on the time of year. For example, a relationship between nosema infections and colony loss during the winter months has not been identified in Ontario conditions, but nosema were demonstrated to impact the development of colonies in early spring (Guzman *et al.*, 2010; Emsen *et al.*,

2016).

American foulbrood (*Paenibacillus larvae*)

American foulbrood (AFB) is caused by a spore forming bacteria, *Paenibacillus larvae*. The clinical symptoms of diseased honey bee larvae can be visually identified in the field while the spores are only visible under a high-power microscope. Honey bee larvae can become infected by ingesting AFB spores present in their food. These spores germinate in the gut of the bee larva and may eventually kill the infected larvae.

European foulbrood (*Melissococcus plutonius*)

European foulbrood (EFB) is typically not as detrimental as American foulbrood, but it has the potential to decimate a honey bee colony under certain conditions. EFB targets and kills young larvae before they reach adulthood. Unlike AFB, EFB does not create spores, making this disease more manageable for both bees and beekeepers.

Resources

Visit ontario.ca/beekeeping for more information about Ontario's apiculture industry or to access resources and services available from the Ontario Ministry of Agriculture, Food and Rural Affairs' Apiary Program, including information on:

- treatment recommendations and best management practices for biosecurity
- high risk pests and diseases
- overwintering

For information on overwinter bee losses across Canada, visit the [Canadian Association of Professional Apiculturists Colony Loss Reports](#).

References

Emsen, B., Guzman-Novoa, E., Hamiduzzaman, M., Eccles L., Lacey, B., Ruiz-Pérez, R., Nasr, M. 2016. Higher prevalence and levels of *Nosema ceranae* than *Nosema apis* infections in Canadian honey bee colonies. *Parasitology Research*, 115:175–181.

Guzman-Novoa, E., Eccles L., Calvete, Y., McGowan, J., Kelly, P. and Correa-Benitez, A. 2010. Varroa destructor is the main culprit for death and reduced populations of overwintered honey bees in Ontario, Canada. *Apidologie*, 4 (4) 443-451.

Accessible image descriptions

Figure 1. Ontario beekeeping regions

Figure 1 shows the division of beekeeping regions in Ontario. The north region includes Manitoulin, Parry Sound, Nipissing, Sudbury, Algoma, Timiskaming, Cochrane, Thunder Bay, Rainy River, and Kenora counties. The east region includes Hastings, Renfrew, Lennox & Addington, Prince Edward, Frontenac, Leeds & Grenville, Lanark, Ottawa, Stormont, Dundas & Glengarry, and Prescott & Russell counties. The central region includes Muskoka, Bruce, Grey, Simcoe, Peel, York, Toronto, Durham, Dufferin, Kawartha Lakes, Haliburton, Peterborough, and Northumberland counties. The south region includes Wellington,

Huron, Perth, Oxford, Norfolk, Brant, Waterloo, Hamilton, Halton, Haldimand, and Niagara counties. The southwest region includes Middlesex, Elgin, Lambton, Chatham-Kent, and Essex counties.

Figure 2. Overwinter mortality estimate

The overwinter mortality estimate, measured in %, is calculated using a formula and data generated from the survey. This formula is 100 multiplied by the total number of honey bee colonies reported dead and non-viable as of May 15 divided by the total number of honey bee colonies reported live at the start of the previous winter.

2022 Apiculture winter loss report

2022 honey bee colony winter mortality

Overwinter mortality for **2021-2022** for commercial beekeepers operating in Ontario was estimated to be **49%**, up significantly from the 18% estimated for the winter of 2020-2021.

The estimate for commercial beekeepers in Ontario was approximately 2% less than the estimated loss reported for small-scale beekeepers (51%).

The 2022 estimation for honey bee loss averaged between all of Canada was 46%.

Who we surveyed

In the spring of 2022, the survey was distributed via email to:

- 203 registered commercial beekeepers (defined as operating 50 or greater colonies)
- 2,466 registered small-scale beekeepers (defined as operating 49 or fewer colonies)

The survey was sent electronically to all registered beekeepers (commercial and small-scale) who provided the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) with their email address. In 2022, OMAFRA distributed the survey to a larger proportion of registered small-scale beekeepers than previous survey years. For comparison, in 2021 the survey was distributed via email to all registered commercial beekeepers and to 400 randomly selected registered small-scale beekeepers. The increased surveying of small-scale beekeepers was due to early reports of high winter mortality by Ontario beekeepers in 2022.

The survey is voluntary and all responses are self-reported by beekeepers. Data is not verified by OMAFRA or any other independent body.

Responses were received from 124 commercial beekeepers and 658 small-scale beekeepers, which represents 29% of beekeepers who received the survey.

Of the beekeepers who were registered in Ontario as of December 31, 2021, responses were received from 54% of commercial beekeepers representing 62,558 colonies and from 22% of small-scale beekeepers representing 5,224 colonies (Tables 1 and 2). Combined, the responses represent 66% of the total number of registered colonies.

Table 1. Number of beekeepers, by region, responding to the 2022 Ontario Apiculture Winter Loss Survey

Beekeeping	# of commercial	% of commercial	# of small-scale	% of small-scale
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regions	beekeeper respondents	beekeeper respondents	beekeeper respondents	beekeeper respondents
Central	46	37%	173	26%
East	21	17%	201	31%
North	10	8%	78	12%
South	31	25%	160	24%
Southwest	16	13%	42	6%
Not specified	0	0%	4	1%

Table 2. Estimated overwinter mortality for 2021-2022

Beekeeper type	# of full-sized colonies put into winter in fall 2021	# of viable overwintered colonies as of May 15, 2022	# of non-viable colonies as of May 15, 2022	Overwinter mortality (%)
Commercial	62,558	32,027	30,531	48.8%
Small-scale	5,224	2,547	2,677	51.2%

Results

The estimated overwinter honey bee mortality and the number of respondents varied by beekeeping region (Table 3). The majority of commercial beekeepers who responded to the survey were from the central and south beekeeping regions. These areas are known to have the greatest number of honey bee colonies in Ontario. Responses from small-scale beekeepers were largely from the central, east and south beekeeping regions (Table 1).

Commercial beekeepers reported the greatest losses in the north region while small-scale beekeepers reported the highest losses in the east region (Table 3). Mortality during the 2021-2022 winter was similar between the beekeeper groups, with the commercial beekeepers being 2.4 percentage points lower than small-scale beekeepers (Table 2).

Table 3. Number of commercial and small-scale beekeeper survey respondents and the % overwinter mortality in 2022 for each beekeeping region in Ontario

Beekeeping regions	# of commercial beekeeper respondents	Commercial beekeeper overwinter mortality (%)	# of small-scale beekeeper respondents	Small-scale beekeeper overwinter mortality (%)
Central	46	49.5%	173	48.5%
East	21	38.1%	201	55.6%
North	10	66.2%	78	48.9%
South	31	51.0%	160	49.7%
Southwest	16	40.3%	42	54.1%
Not specified	0	N/A	4	50.0%
Total	124	48.8%	658	51.2%

When respondents were grouped by operation size (number of colonies managed), the honey bee mortality

during the winter of 2021-2022 ranged from 42.7% to 55.3% (Table 4). Beekeepers operating 501-1,000 colonies reported fewer honey bee colony losses (42.7%) than all other beekeeping operation sizes. The greatest number of survey respondents had beekeeping operations with fewer than 10 colonies and this group reported the highest overwinter honey bee mortality of 55.3%. Beekeepers with 10-49, 50-200, and >1000 colonies had high losses (49.2%, 51.1%, and 50.3% respectively). Beekeepers with 201-500 and 501-1,000 colonies also had high losses, but were lower than the other categories of beekeepers with 45.2% and 42.7% respectively.

Table 4. Overwinter honey bee mortality during the winter of 2021-2022 by size of beekeeping operation (number of colonies operated)

# of respondents	# of colonies reported in the fall of 2021	Overwinter mortality (%)
447	<10	55.3%
181	10-49	49.2%
80	50-200	51.1%
18	201-500	45.2%
13	501-1,000	42.7%
13	>1,000	50.3%

Main factors of bee mortality

Beekeepers were asked to report on what they believed were the main factors contributing to their overwinter honey bee mortalities; they were able to select as many reasons as they felt were applicable. These opinions may be based on observable symptoms or beekeeper experience, judgement or best estimate.

The most commonly reported factors influencing overwinter mortality (Table 5) by commercial beekeepers included:

- ineffective varroa control
- weak colonies in the fall
- weather

The most commonly reported factors influencing overwinter mortality (Table 5) by small-scale beekeepers included:

- weather
- weak colonies in the fall
- ineffective varroa control

32% of commercial beekeepers and 18% of small-scale beekeepers selected “other” for their suspected cause of colony loss. It is noted that 16% and 3% of the ‘other’ responses were attributed to suspected pesticide poisonings by commercial and small-scale beekeepers respectively. In 2021, OMAFRA received 10 in-season honey bee mortality incident reports. Incident reports were shared with the Ontario Ministry of Environment, Conservation and Parks and Health Canada if the report was suspected to be related to pesticide application during the active beekeeping season.

Table 5. Contributing factors to honey bee colony mortality during the winter of 2021-2022 as reported by commercial and small-scale beekeepers

Suspected cause(s) of colony	% of commercial beekeepers	% of small-scale beekeepers
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loss	reporting	reporting
Poor queens	21%	12%
Weak colonies in the fall	35%	28%
Weather	34%	30%
Starvation	19%	13%
Ineffective varroa control	44%	24%
Other	32%	18%
Don't know	28%	21%
Nosema	4%	2%

Management practices for pests and disease

Varroa mites (*Varroa destructor*)

In this survey beekeepers were asked how they monitored for varroa mite infestations (Figure 1) and which treatments were used at the beginning (spring), mid-season and the end (late summer/fall) of the 2021 beekeeping season (Table 6).

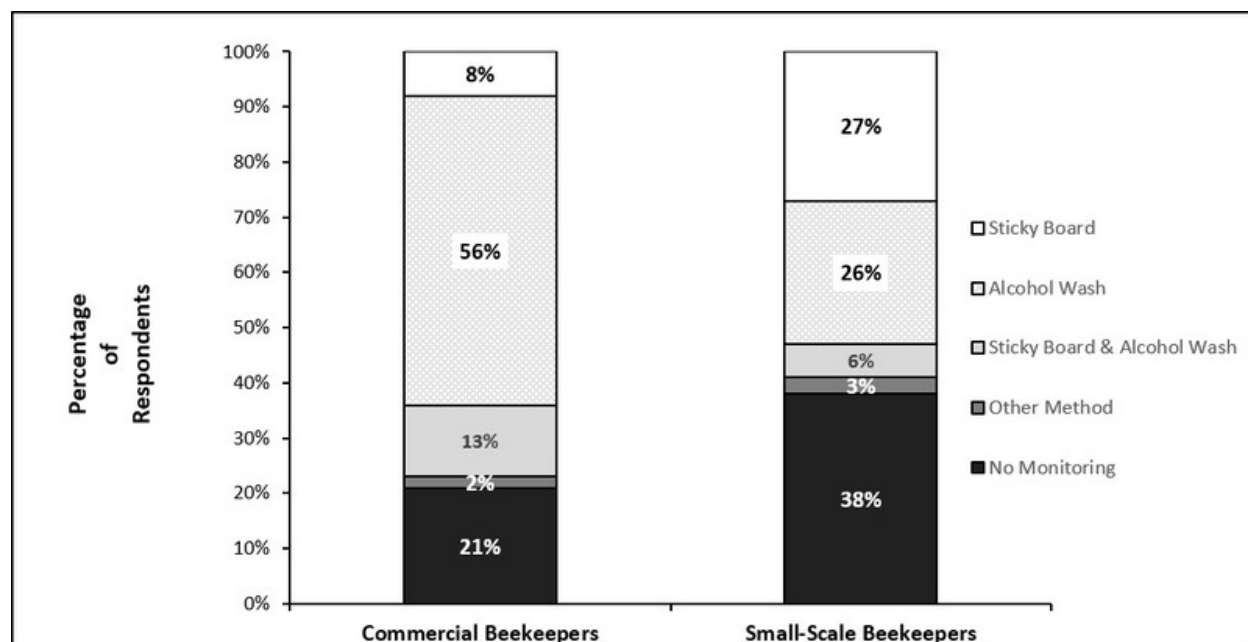


Figure 1. Type of varroa mite monitoring method used by commercial and small-scale beekeepers in 2021.

[Accessible description for Figure 1](#)

Proportion of beekeepers monitoring for varroa mites

Of the beekeepers who responded to the varroa mite monitoring question, 79% of commercial beekeepers and 62% of small-scale beekeepers stated they monitor for varroa mite infestation in their colonies. Of those, a number of monitoring methods were used, the most common being either an alcohol wash or a sticky board.

Some beekeepers used more than one method to monitor for varroa mites. When the response “other” was selected, some beekeepers reported that they visually checked their colonies for varroa mites or used the “sugar shake” method. However, neither of these methods is recommended or recognized as effective, as visually checking for mites is not proven to yield usable information and the sugar shake method can be unreliable and it is not tied to established thresholds for Ontario.

From the data, it appears that most (79%) of the commercial beekeepers represented by this survey are monitoring for varroa mites. However, this figure is down from the 87% of commercial beekeepers who reported they were monitoring for varroa mites in the 2020-2021 season. This is the second year in a row where the number of commercial beekeepers, who indicated that they are monitoring for varroa mites, has decreased. Compared to the 2020-2021 survey, the number of commercial beekeepers who do not monitor for varroa mites increased by 8%.

It is also very concerning that a high percentage (21% commercial and 38% small-scale) of beekeepers who responded to the survey reported no monitoring for varroa mites at all. These numbers represent a high proportion of beekeepers who are not monitoring for varroa mites. Ideally, 100% of beekeepers should monitor for varroa mites as monitoring, along with application of a treatment, is crucial for the management of this honey bee pest. Without the management of varroa mites, colonies are at a high risk of death and/or spreading varroa mites to other nearby colonies. Furthermore, research has demonstrated that inadequate varroa mite control is the primary cause of winter mortality in honey bee colonies in Ontario ^[1].

These results demonstrate the need for further education/training of beekeepers and further messaging on best management practices and integrated pest management. Monitoring for varroa mites needs to improve as this is a key practice to assess colony health and to improve the survival of colonies going into the winter. It is not enough that beekeepers simply treat their colonies without knowing their varroa mite levels.

Frequency of monitoring for varroa mites

It is encouraging to see from the survey data that a good proportion of both commercial and small-scale beekeepers are sampling at least twice per season, and it is even more encouraging to see that there are both commercial and small-scale beekeepers sampling even more frequently at three times per year (Figure 2). A more detailed analysis of those beekeepers who sampled more than three times per year shows that 57% and 51% of commercial and small-scale beekeepers respectively sampled for varroa mites every month (Figure 3). At the same time there is room for improvement for both categories of beekeepers. Monitoring frequently, particularly as the beekeeping season progresses, is one of the most important management practices beekeepers can do to ensure they are applying their varroa treatments in a timely manner and ultimately preventing damaging levels of varroa from occurring.

This is the second year Ontario included a question on the frequency of monitoring.

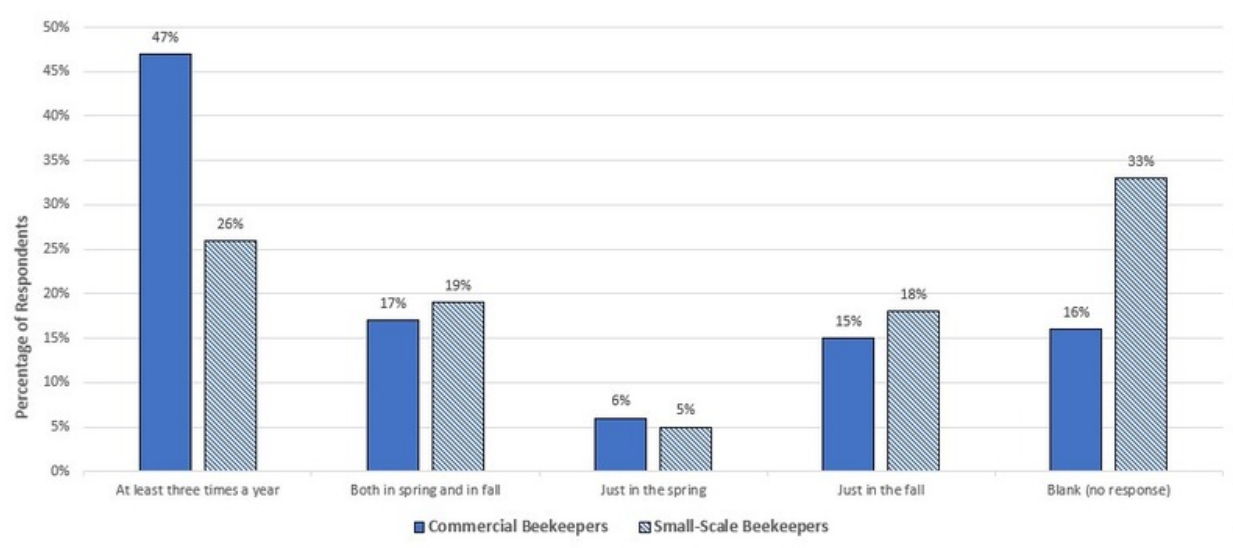


Figure 2. Frequency of varroa mite monitoring by commercial and small-scale beekeepers in 2021.

[Accessible description for Figure 2](#)

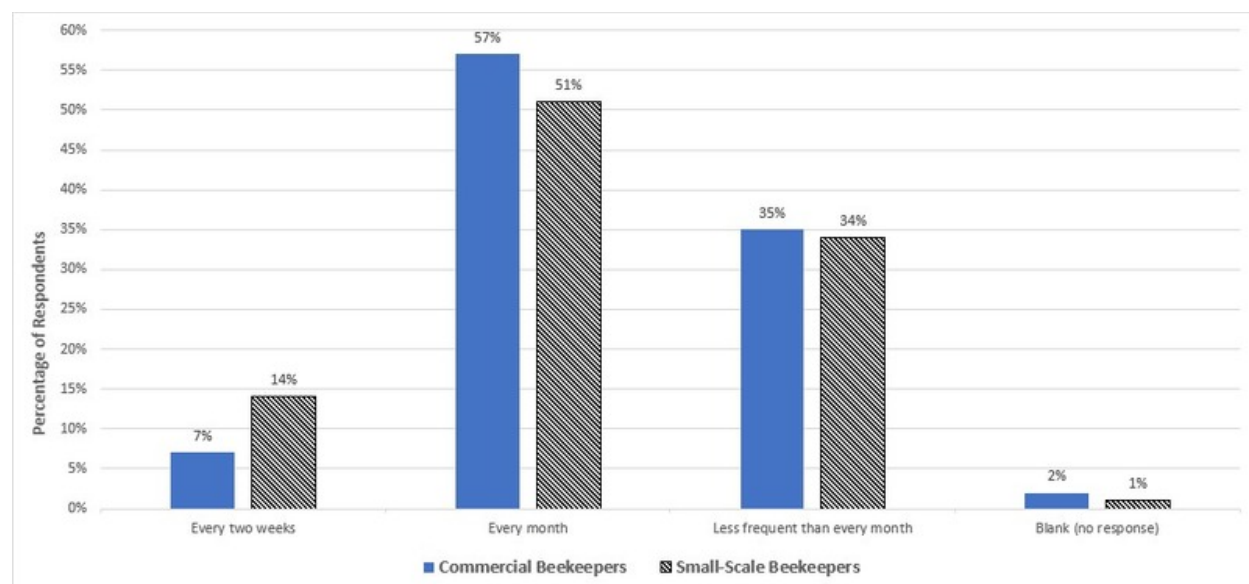


Figure 3. Frequency of varroa mite monitoring by commercial and small-scale beekeepers in 2021 who reported monitoring at least three times a year.

[Accessible description for Figure 3](#)

Treatments used to control varroa mites

Ontario beekeepers use a variety of treatment options to manage varroa mites (Table 6). The survey asked beekeepers to report their use of varroa mite treatment options during three periods in 2021: spring, mid-season and late summer/fall. These periods are defined as:

- Spring – from the end of winter to the start of the honey flow
- Mid-season – from the start to the end of the honey flow
- Late summer/fall – when the last supers were removed for honey production to when colonies were managed for winter

In spring of 2021, the most common method of varroa mite treatment reported by commercial beekeepers was use of Apivar®, while in late summer/fall of 2021 both Apivar® (50%) and oxalic acid (44%) were most commonly used. The most common method of spring varroa mite treatment reported by small-scale beekeepers was use of Apivar® (22%) and Formic Pro (21%), while in late summer/fall of 2021 Apivar® (30%) and oxalic acid (30%) were the most common treatments used.

During the mid-season of 2021, a large proportion of commercial and small-scale beekeepers reported that they did not treat for varroa mites. Of the commercial and small-scale beekeepers who treated for varroa mites during the mid-season, the most common treatment method used by both groups was use of Formic Pro.

The least commonly used treatments by both commercial and small-scale beekeepers were Bayvarol®, ApiLifeVar and Hopguard II. It should be noted that ApiLifeVar and Hopguard II are relatively newer treatments that have been registered for use in Canada.

These results are encouraging as it demonstrates that Ontario beekeepers are likely rotating their miticides, which is an important strategy for delaying the onset of resistant populations of varroa mites. However, there may be some cause for concern from the data as some responses indicated the use of treatments mid-season that are not registered for use during a honey flow.

That being said, these unregistered, mid-season treatments may have been used by beekeepers who had removed their honey supers or were managing their colonies whereby they were not producing honey (such as nucleus colonies or pollination units). Also, the industry appears to be quite reliant on Apivar® as a control method for varroa mites. Should the Ontario industry see development of varroa mite resistance to amitraz (the active ingredient in Apivar®), it may seriously restrict beekeepers' ability to control varroa mites, resulting in increased mortality of colonies in Ontario. While other chemical options are available many of them are temperature dependent (such as formic acid), which may factor into the timing and choice of treatment depending on the weather conditions during a particular season in Ontario.

As amitraz resistance has been documented in varroa mite populations in the [USA](#), it is important to monitor its status in Canada. New compounds will be needed for varroa mite control in order to ensure there is a robust set of options available to beekeepers and to offer the opportunity to rotate treatments so that beekeepers can continue to incorporate effective integrated pest management practices in their beekeeping operation.

It should be noted that varroa mites in Ontario have established resistance (or reduced efficacy) to other compounds (for example, coumaphos, fluvalinate, flumethrin).

Table 6. Treatments reported by commercial and small-scale beekeepers used to control varroa mites in the spring, mid-season and late summer/fall of 2021. Survey respondents could select more than one answer.

Varroa mite treatment (active ingredient)	Spring 2021 % of commercial beekeepers	Spring 2021 % of small-scale beekeepers	Mid-season 2021 % of commercial beekeepers	Mid-season 2021 % of small-scale beekeepers	Late summer/fall 2021 % of commercial beekeepers	Late summer/fall 2021 % of small-scale beekeepers
Apistan® (fluvalinate)	10%	2%	N/A	N/A	5%	2%
CheckMite+™ (coumaphos)	0%	0%	N/A	N/A	1%	0%

Varroa mite treatment (active ingredient)	Spring 2021 % of commercial beekeepers	Spring 2021 % of small-scale beekeepers	Mid-season 2021 % of commercial beekeepers	Mid-season 2021 % of small-scale beekeepers	Late summer/fall 2021 % of commercial beekeepers	Late summer/fall 2021 % of small-scale beekeepers
Apivar® (amitraz)	35%	22%	N/A	N/A	50%	30%
Thymovar (thymol)	1%	1%	N/A	N/A	4%	2%
ApiLifeVar (thymol and essential oils)	0%	0%	N/A	N/A	1%	0%
Bayvarol® (flumethrin)	2%	1%	N/A	N/A	0%	1%
65% formic acid – 40 ml multiple application	15%	5%	N/A	N/A	19%	5%
65% formic acid – 250 ml single application	6%	3%	N/A	N/A	6%	2%
Mite Away Quick Strips™ (formic acid)	3%	6%	8%	5%	4%	6%
Formic Pro (formic acid)	15%	21%	27%	18%	15%	20%
Oxalic Acid	25%	15%	N/A	N/A	44%	30%
Hopguard II (hop compounds)	1%	1%	1%	1%	2%	1%
Other	7%	3%	17%	6%	4%	2%
None	14%	25%	46%	60%	1%	9%

Nosema spp. (*N. apis* and *N. ceranae*)

92% of survey respondents indicated that nosema treatment was not applied in the spring or fall of 2021 (Table 7). Nosema is a disease that has been identified to delay the development of honey bee colonies in spring and reduce the lifespan of individual honey bees, but has not been identified as a factor in colony mortality over winter [1] [2] [3].

Table 7. Treatments reported by commercial and small-scale beekeepers used to control nosema in the spring and fall of 2021

Nosema treatment	Spring 2021 % of commercial	Spring 2021 % of small-scale	Fall 2021 % of commercial	Fall 2021 % of small-scale
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	beekeepers	beekeepers	beekeepers	beekeepers
Fumagillin	6%	7%	7%	7%
Other	2%	1%	2%	1%
None	92%	92%	92%	92%

American foulbrood (*Paenibacillus larvae*)

The majority of commercial beekeepers who responded to this survey question had treated for American foulbrood (AFB) during spring 2021 (59%) and a little more than half had treated during fall 2021 (51%) with oxytetracycline. By comparison, 25% of small-scale beekeepers reported treating for AFB in the spring and in the fall (Table 8).

Table 8. Treatments reported by commercial and small-scale beekeepers used to control American foulbrood in the spring and fall of 2021

American foulbrood treatment	Spring 2021 % of commercial beekeepers	Spring 2021 % of small-scale beekeepers	Fall 2021 % of commercial beekeepers	Fall 2021 % of small-scale beekeepers
Oxytetracycline	59%	25%	51%	25%
Tylosin	0%	0%	1%	0%
Lincomycin	0%	0%	0%	0%
Other	2%	0%	1%	0%
None	39%	75%	48%	75%

Ontario's overwinter mortality

The [Canadian Association of Professional Apiculturists](#) compiles overwinter mortality data provided by each province and publishes an annual report on national honey bee colony losses. Figure 4 compares Ontario's overwinter mortality levels to that of Canada's. The 2022 estimate for commercial beekeepers in Ontario (48.8%) was approximately 3% more than the estimation for bee loss averaged between all of Canada (45.5%).

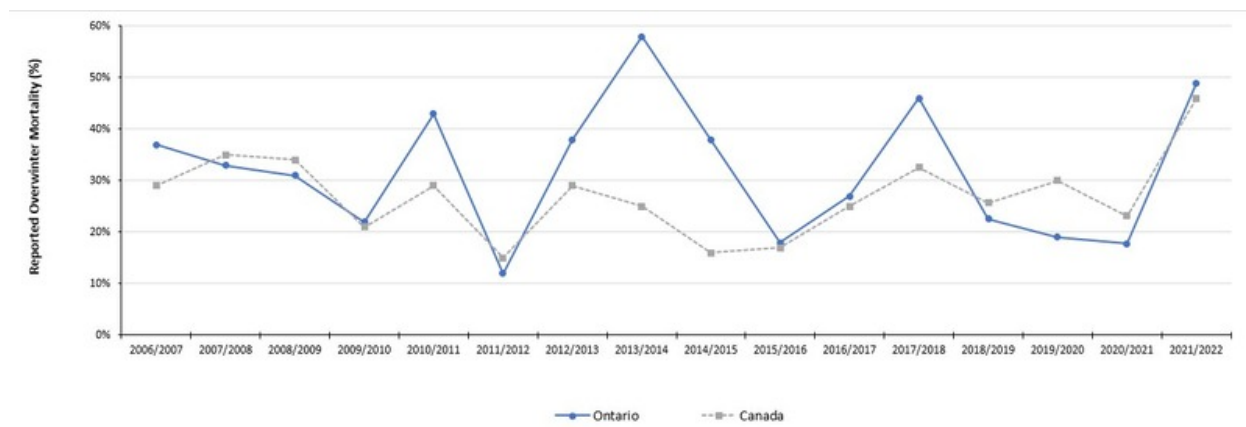


Figure 4. Overwinter mortality (%) reported by commercial beekeepers in Ontario (blue) and Canada (grey) from 2006-2007 to 2021-2022.

[Accessible description for Figure 4](#)

Accessible image descriptions

Figure 1. Type of varroa mite monitoring method used by commercial and small-scale beekeepers in 2021.

Figure 1 shows the type of varroa mite monitoring method used by commercial and small-scale beekeepers in 2021. 8% of commercial beekeepers reported using the sticky board method, 56% used the alcohol wash method, 13% used both sticky board and alcohol wash, 2% used other methods, and 21% reported no monitoring for varroa mites. Twenty-seven% of small-scale beekeepers reported using the sticky board method, 26% used the alcohol wash method, 6% used both sticky board and alcohol wash, 3% used other methods, and 38% reported no monitoring for varroa mites.

Figure 2. Frequency of varroa mite monitoring by commercial and small-scale beekeepers in 2021.

Figure 2 shows the frequency of varroa mite monitoring by commercial and small-scale beekeepers in 2021. Commercial beekeepers – 47% at least three times a year, 17% both in spring and in fall, 6% just in the spring, 15% just in the fall, and 16% did not respond to this question. Small-scale beekeepers – 26% at least three times a year, 19% both in spring and in fall, 5% just in the spring, 18% just in the fall, and 33% did not respond to this question.

Figure 3. Frequency of varroa mite monitoring by commercial and small-scale beekeepers in 2021 who reported monitoring at least three times a year.

Figure 3 shows the frequency of varroa mite monitoring by commercial and small-scale beekeepers in 2021 who reported monitoring at least three times a year. Commercial beekeepers – 7% every two weeks, 57% every month, 35% less frequent than every month, and 2% did not respond to this question. Small-scale beekeepers – 14% every two weeks, 51% every month, 34% less frequent than every month, and 1% did not respond to this question.

Figure 4. Overwinter mortality (%) reported by commercial beekeepers in Ontario (blue) and Canada (grey) from 2006-2007 to 2021-2022.

Figure 4 shows the % overwinter mortality reported by beekeepers in both Ontario and Canada from 2007 to 2022. The reported overwinter mortality in Ontario and Canada (respectively) was the following: 2007 – 37% and 29%; 2008 – 33% and 35%; 2009 – 31% and 34%; 2010 – 22% and 21%; 2011 – 43% and 29%; 2012 – 12% and 15%; 2013 – 38% and 29%; 2014 – 58% and 25%; 2015 – 38% and 16%; 2016 – 18% and 17%; 2017 – 27% and 25%; 2018 – 46% and 33%; 2019 – 23% and 26%; 2020 – 19% and 30%; 2021 – 18% and 23%; 2022 – 49% and 46%.

2021 Apiculture winter loss report

2021 honey bee colony winter mortality

Overwinter mortality for **2020-2021** for commercial beekeepers operating in Ontario was estimated to be **18%**, down from the 19% estimated for the winter of 2019-2020.

The estimate for commercial beekeepers in Ontario was approximately 19% less than the estimated loss reported for small-scale beekeepers (37%).

The 2021 estimation for honey bee loss averaged between all of Canada was 23%.

Who we surveyed

In the spring of 2021, the survey was distributed via email to:

- 252 registered commercial beekeepers (defined as operating 50 or greater colonies)
- 400 randomly selected registered small-scale beekeepers (defined as operating 49 or fewer colonies)

Due to the COVID-19 pandemic, the survey was sent electronically to beekeepers who provided the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) with their email address.

The survey is voluntary and all responses are self-reported by beekeepers. Data is not verified by OMAFRA or any other independent body.

Responses were received from 90 commercial beekeepers and 138 small-scale beekeepers which represents 35% of beekeepers who received the survey.

Of the beekeepers who were registered in Ontario as of December 31, 2020, responses were received from 43% of commercial beekeepers representing 42,467 colonies and from 5% of small-scale beekeepers representing 1,084 colonies (Tables 1 and 2). Combined, the responses represent 43% of the total number of registered colonies.

Table 1. Number of beekeepers, by region, responding to the 2021 Ontario Apiculture Winter Loss Survey

Beekeeping regions	# of commercial beekeeper respondents	% of commercial beekeeper respondents	# of small-scale beekeeper respondents	% of small-scale beekeepers respondents
Central	33	37%	40	29%
East	13	14%	35	25%
North	6	7%	19	14%
South	31	34%	35	25%
Southwest	7	8%	9	7%

Table 2. Estimated overwinter mortality for 2020-2021

Beekeeper type	# of full-sized colonies put into winter in fall 2020	# of viable overwintered colonies as of May 15, 2021	# of non-viable colonies as of May 15, 2021	Overwinter mortality (%)
Commercial	42,467	34,924	7,543	17.8%
Small-scale	1,086	687	399	36.7%

Results

The estimated overwinter honey bee mortality and the number of respondents varied by beekeeping region (Table 3). The majority of commercial beekeepers who responded to the survey were from the central and south beekeeping regions. These areas are known to have the greatest beekeeping activity. Responses from small-scale beekeeping operations were largely from the central, east and south beekeeping regions (Table 1).

Commercial beekeepers reported the greatest losses in the north region while small-scale beekeepers reported

the highest losses in the south region (Table 3). Overall, mortality during the 2020-2021 winter was approximately 18.9 percentage points lower with commercial than small-scale beekeepers (Table 2).

Table 3. Number of commercial and small-scale beekeeper survey respondents and the % overwinter mortality in 2021 for each beekeeping region in Ontario

Beekeeping region	# of commercial beekeeper respondents	Commercial beekeeper overwinter mortality (%)	# of small-scale beekeeper respondents	Small-scale beekeeper overwinter mortality (%)
Central	33	18.7%	40	36.7%
East	13	13.4%	35	39.6%
North	6	23.6%	19	32.1%
South	31	16.5%	35	40.4%
Southwest	7	22.5%	9	26.4%
Total	90	17.8%	138	36.7%

When respondents were grouped by operation size (number of colonies managed), the honey bee mortality during the winter of 2020-2021 ranged from 14.6% to 38.2% (Table 4). Beekeepers operating >1,000 colonies reported fewer honey bee colony losses (14.6%) than all other beekeeping operation sizes. The greatest number of survey respondents had beekeeping operations with fewer than 10 colonies and this group reported the second highest overwinter honey bee mortality of 33.8%.

This general trend showing beekeepers with the highest number of colonies (501-1,000 and >1,000) having the lowest losses (18.4% and 14.6% respectively) and beekeepers with the lowest number of colonies (<10 and 10-49) having the highest losses (33.8% and 38.2% respectively) is consistent with the trend of commercial beekeepers demonstrating much lower winter loss than small-scale beekeepers (Table 2).

This is the second year in a row where such a large difference in the level of winter loss between commercial and small-scale beekeepers has been reported. This may indicate that commercial beekeepers may have better training, more resources or more experience. However, this may also be an oversimplification of the data as it does not account for the variability in beekeeping practices employed between small-scale beekeepers or the number of respondents by operation size. Whatever the reason for the disparity in winter loss numbers between beekeeper type, this data should be considered for targeting of messaging and training for beekeepers while keeping in mind that management practices and environmental conditions may change and there is a need for both commercial and small-scale beekeepers to be well trained and up to date with credible, regional information and best management practices.

Table 4. Overwinter honey bee mortality during the winter of 2020-2021 by size of beekeeping operation (number of colonies operated)

# of respondents	# of colonies reported in the fall of 2020	Overwinter mortality (%)
106	<10	33.8%
32	10-49	38.2%
57	50-200	29.4%
15	201-500	20.1%
7	501-1,000	18.4%
11	>1,000	14.6%

Main factors of bee mortality

Beekeepers were asked to report on what they believed were the main factors contributing to their overwinter honey bee mortalities; they were able to select as many reasons as they felt were applicable. These opinions may be based on observable symptoms or beekeeper experience, judgement or best estimate.

The most commonly reported factors influencing overwinter mortality (Table 5) by commercial beekeepers included:

- poor queens
- weak colonies in the fall
- ineffective varroa control

The most commonly reported factors influencing overwinter mortality (Table 5) by small-scale beekeepers included:

- weak colonies in the fall
- don't know
- ineffective varroa control

28% of commercial beekeepers and 14% of small-scale beekeepers selected “other” for their suspected cause of colony loss. It is noted that 11% and 4% of the ‘other’ responses were attributed to suspected pesticide poisonings by commercial and small-scale beekeepers respectively.

Table 5. Contributing factors to honey bee colony mortality during the winter of 2020-2021 as reported by commercial and small-scale beekeepers

Suspected cause(s) of colony loss	% of commercial beekeepers reporting	% of small-scale beekeepers reporting
Poor queens	44%	12%
Weak colonies in the fall	37%	25%
Weather	23%	14%
Starvation	18%	7%
Ineffective varroa control	32%	17%
Other	28%	14%
Don't know	19%	18%
Nosema	7%	4%

Management practices for pests and disease

Varroa mites (*Varroa destructor*)

In this survey beekeepers were asked how they monitored for varroa mite infestations (Figure 1) and which treatments were used at the beginning (spring) and the end (fall) of the 2020 beekeeping season (Table 6).

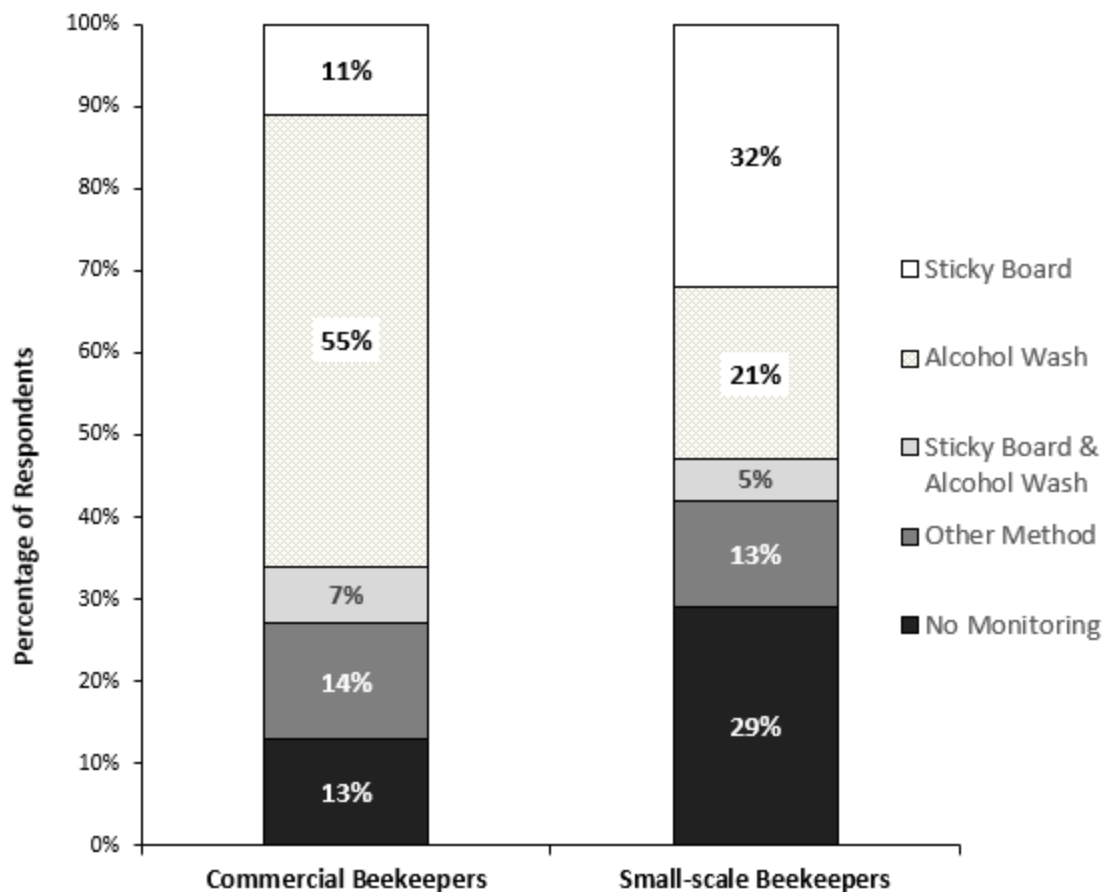


Figure 1. Type of varroa mite monitoring method used by commercial and small-scale beekeepers in 2020.

[Accessible description for Figure 1](#)

Proportion of beekeepers monitoring for varroa mites

Of the beekeepers who responded to the varroa mite monitoring question, 87% of commercial beekeepers and 71% of small-scale beekeepers stated they monitor for varroa mite infestation in their colonies. Of those, a number of monitoring methods were used, the most common being either an alcohol wash or a sticky board.

Some beekeepers used more than one method to monitor for varroa mites. When the response “other” was selected, some beekeepers reported that they visually checked their colonies for varroa mites or used the “sugar shake” method. However, neither of these methods is recommended or recognized as effective, as visually checking for mites is not proven to yield usable information and the sugar shake method can be unreliable and it is not tied to established thresholds for Ontario.

From the data, it appears that most (87%) of the commercial beekeepers represented by this survey are monitoring for varroa mites. However, this figure is down from the 92% of commercial beekeepers who reported they were monitoring for varroa mites in the 2019-2020 season.

Conversely, it remains concerning that a high percentage (29%) of the small-scale beekeepers who responded to the survey reported no monitoring at all. This number represents a very high proportion of beekeepers in this category who are not monitoring for varroa mites. Ideally, 100% of beekeepers should monitor for varroa mites as monitoring, along with application of a treatment, is crucial for the management of this honey bee pest. Without the management of varroa mites, colonies are at a high risk of death and/or spreading varroa

mites to other nearby colonies.

These results demonstrate the need for further education/training of beekeepers and further messaging on best management practices and integrated pest management.

Frequency of monitoring for varroa mites

It is encouraging to see from the survey data (Figure 2) that a good proportion of both commercial and small-scale beekeepers are sampling at least twice per season (on average 30%), and it is even more encouraging to see that many commercial and small-scale beekeepers are sampling even more frequently (three times, every month, or every time in the bee yard). At the same time there is room for improvement for both categories of beekeepers. Monitoring frequently, particularly as the beekeeping season progresses, is one of the most important management practices beekeepers can do to ensure they are applying their varroa treatments in a timely manner and ultimately preventing damaging levels of varroa from occurring.

This is the second year Ontario included a question on the frequency of monitoring; this question was not included in the national Canadian Association of Professional Apiculturists' survey.

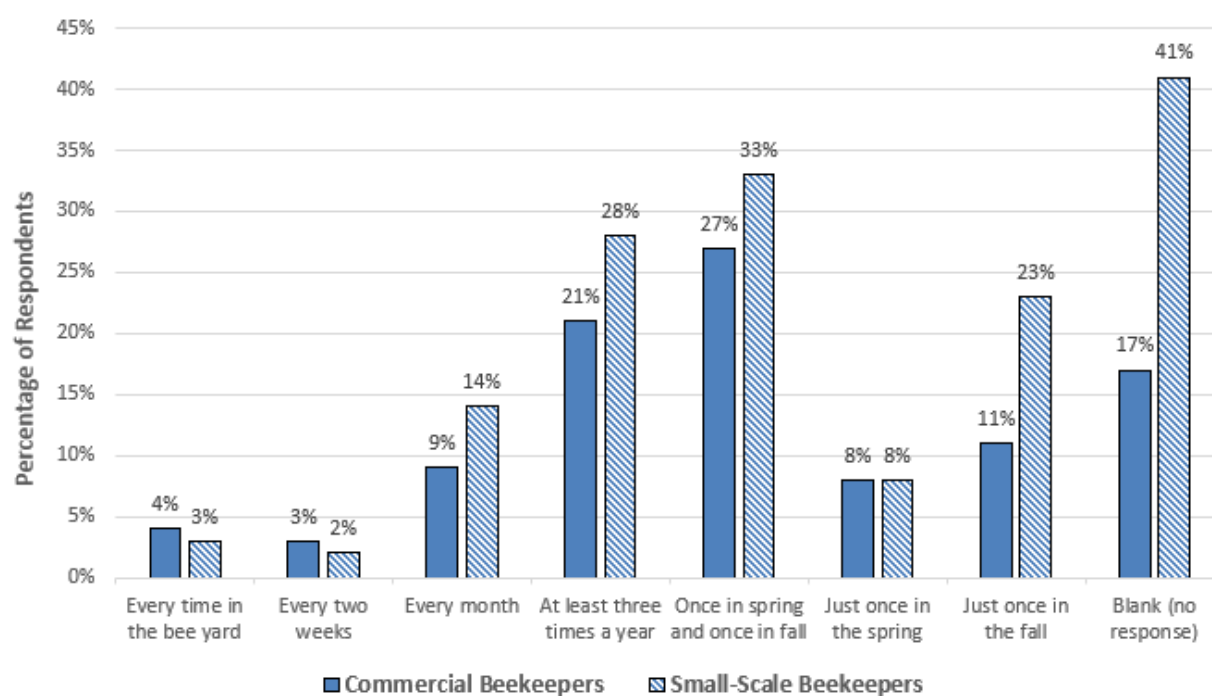


Figure 2. Frequency of varroa mite monitoring by commercial and small-scale beekeepers in 2020

[Accessible description for Figure 2](#)

Treatments used to control varroa mites

Ontario beekeepers use a variety of treatment options to manage varroa mites (Table 6). In spring of 2020, the most common method of varroa mite treatment reported by commercial beekeepers was Apivar®, while in fall of 2020 both Apivar® and oxalic acid were most commonly used by commercial beekeepers. Small-scale beekeepers indicated a preference for Apivar® and oxalic acid as well as Formic Pro and Mite Away Quick Strips™ over other forms of mite control. The least commonly used treatments by both commercial and small-scale beekeepers were Bayvarol®, ApiLifeVar and Hopguard II. CheckMite+™ was not used by any survey respondents. It should be noted that both of the treatments ApiLifeVar and Hopguard II were recently

registered and are newly available to beekeepers in Ontario.

These results are encouraging as it demonstrates that Ontario beekeepers are likely rotating their miticides, which is an important strategy for delaying the onset of resistant populations of varroa mites. However, there may be some cause for concern from the data as the industry appears to be quite reliant on Apivar® as a control method for varroa mites. Development of resistance to amitraz (the active ingredient in Apivar®) may seriously restrict Ontario beekeepers' ability to control varroa mites, resulting in increased mortality of colonies in Ontario. While other chemical options are available many of them are temperature dependent and this may factor into the timing and choice of treatment, depending on the weather conditions (formic acid) during a particular season in Ontario.

As amitraz resistance has been documented in varroa mite populations in the USA, it is important to monitor the status of amitraz in Canada. New compounds will be needed for varroa mite control in order to ensure there is a robust set of options available to beekeepers and to offer the opportunity to rotate treatments so that beekeepers can continue to incorporate effective integrated pest management practices in their beekeeping operation.

It should be noted that varroa mites in Ontario have established resistance (or reduced efficacy) to other compounds (for example, coumaphos, fluvalinate, flumethrin).

Table 6. Treatments reported by commercial and small-scale beekeepers used to control varroa mites in the spring and fall of 2020. Survey respondents could select more than one answer.

Varroa mite treatment (active ingredient)	Spring 2020 % of commercial beekeepers	Spring 2020 % of small-scale beekeepers	Fall 2020 % of commercial beekeepers	Fall 2020 % of small-scale beekeepers
Apistan® (fluvalinate)	7%	2%	6%	4%
CheckMite+™ (coumaphos)	0%	0%	0%	0%
Apivar® (amitraz)	32%	20%	46%	23%
Thymovar (thymol)	4%	2%	4%	2%
ApiLifeVar (thymol and essential oils)	1%	0%	1%	0%
Bayvarol® (flumethrin)	1%	1%	1%	4%
65% formic acid – 40 ml multiple application	20%	4%	16%	4%
65% formic acid – 250 ml single application	2%	4%	3%	4%
Mite Away Quick Strips™ (formic acid)	6%	10%	6%	12%
Formic Pro (formic acid)	13%	17%	26%	20%
Oxalic Acid	18%	21%	42%	33%
Hopguard II (hop compounds)	0%	1%	2%	1%

Varroa mite treatment (active ingredient)	Spring 2020 % of commercial beekeepers	Spring 2020 % of small-scale beekeepers	Fall 2020 % of commercial beekeepers	Fall 2020 % of small-scale beekeepers
Other	3%	5%	2%	3%
None	19%	25%	2%	7%

Nosema spp. (*N. apis* and *N. ceranae*)

Over 90% of survey respondents indicated that nosema treatment was not applied in the spring of 2020 and approximately 90% of respondents did not treat for the disease in the fall of 2020 (Table 7).

Table 7. Treatments reported by commercial and small-scale beekeepers used to control nosema in the spring and fall of 2020

Nosema treatment	Spring 2020 % of commercial beekeepers	Spring 2020 % of small-scale beekeepers	Fall 2020 % of commercial beekeepers	Fall 2020 % of small-scale beekeepers
Fumagillin	5%	9%	8%	11%
Other	1%	0%	1%	0%
None	94%	91%	90%	89%

American foulbrood (*Paenibacillus larvae*)

The majority of commercial beekeepers who responded to this survey question treated for American foulbrood (AFB) during spring 2020 (65%) and a little more than half treated during fall 2020 (58%) with oxytetracycline. By comparison, 25% of small-scale beekeepers reported treating for AFB in the spring and 26% of small-scale beekeepers treated in the fall (Table 8).

Table 8. Treatments reported by commercial and small-scale beekeepers used to control American foulbrood in the spring and fall of 2020

American foulbrood treatment	Spring 2020 % of commercial beekeepers	Spring 2020 % of small-scale beekeepers	Fall 2020 % of commercial beekeepers	Fall 2020 % of small-scale beekeepers
Oxytetracycline	65%	25%	57%	25%
Tylosin	0%	0%	1%	1%
Lincomycin	0%	0%	0%	0%
Other	0%	0%	0%	0%
None	35%	75%	42%	74%

Ontario's overwinter mortality

The [Canadian Association of Professional Apiculturists](#) compiles overwinter mortality data provided by each province and publishes an annual report on national honey bee colony losses. Figure 3 compares Ontario's overwinter mortality levels to that of Canada's. The 2021 estimate for commercial beekeepers in Ontario (17.8%) was approximately 5% less than the estimation for bee loss averaged between all of Canada (23.2%).

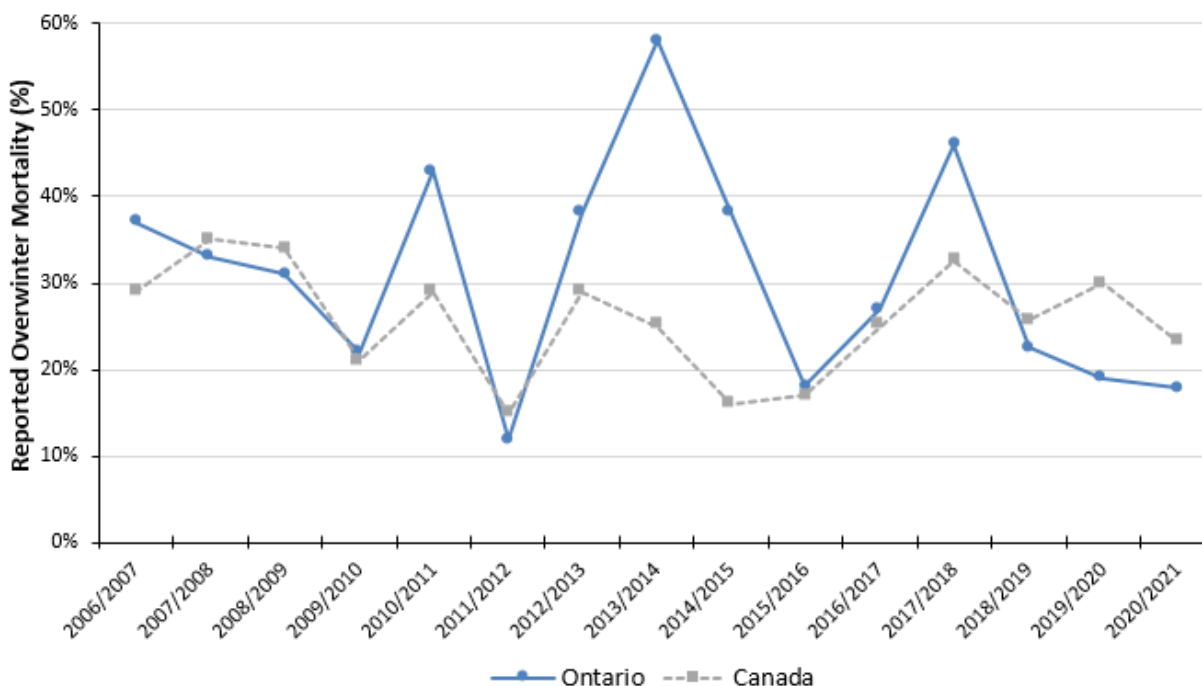


Figure 3. Overwinter mortality (%) reported by commercial beekeepers in Ontario (blue) and Canada (grey) from 2006-2007 to 2020-2021

[Accessible description for Figure 3](#)

Accessible image descriptions

Figure 1. Type of varroa mite monitoring method used by commercial and small-scale beekeepers in 2020.

Figure 1 shows the type of varroa mite monitoring method used by commercial and small-scale beekeepers in 2020. Eleven% of commercial beekeepers reported using the sticky board method, 55% used the alcohol wash method, 7% used both sticky board and alcohol wash, 14% used other methods, and 13% reported no monitoring for varroa mites. Thirty-two% of small-scale beekeepers reported using the sticky board method, 21% used the alcohol wash method, 5% used both sticky board and alcohol wash, 13% used other methods, and 29% reported no monitoring for varroa mites.

Figure 2. Frequency of varroa mite monitoring by commercial and small-scale beekeepers in 2020

Figure 2 shows the frequency of varroa mite monitoring by commercial and small-scale beekeepers in 2020. Small-scale beekeepers – 3% every time in bee yard, 2% every two weeks, 14% every month, 28% at least three times per year, 33% once in spring and once in fall, 8% just once in the spring, 23% just once in the fall, 41% blank (no response). Commercial beekeepers – 4% every time in bee yard, 3% every two weeks, 9% every month, 21% at least three times per year, 27% once in spring and once in fall, 8% just once in the spring, 11% just once in the fall, 17% blank (no response).

Figure 3. Overwinter mortality (%) reported by commercial beekeepers in Ontario (blue) and Canada (grey) from 2006-2007 to 2020-2021

Figure 3 shows the % overwinter mortality reported by beekeepers in both Ontario and Canada from 2007 to 2021. The reported overwinter mortality in Ontario and Canada (respectively) was the following: 2007 – 37%

and 29%; 2008 – 33% and 35%; 2009 – 31% and 34%; 2010 – 22% and 21%; 2011 – 43% and 29%; 2012 – 12% and 15%; 2013 – 38% and 29%; 2014 – 58% and 25%; 2015 – 38% and 16%; 2016 – 18% and 17%; 2017 – 27% and 25%; 2018 – 46% and 33%; 2019 – 23% and 26%; 2020 – 19% and 30%; 2021 – 18% and 23%.

2020 Apiculture winter loss report

2020 Honey bee colony winter mortality

Overwinter mortality for **2019-2020** for commercial beekeepers operating in Ontario was estimated to be **19%**, down from the 23% estimated for the winter of 2018-2019.

The estimate for commercial beekeepers in Ontario was approximately 10% less than the estimated loss reported for small-scale beekeepers (30%).

The 2020 estimation for honey bee loss averaged between all of Canada was 30%.

Who we surveyed

In the spring of 2020, the survey was distributed via email to:

- 119 of the 195 registered commercial beekeepers (defined as operating 50 or greater colonies)
- 300 randomly selected registered small-scale beekeepers (defined as operating 49 or fewer colonies)

Due to the COVID-19 pandemic, the survey was sent electronically to beekeepers who provided the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) with their email address.

The survey is voluntary and all responses are self-reported by beekeepers. Data is not verified by OMAFRA or any other independent body.

Responses were received from 59 commercial beekeepers and 116 small-scale beekeepers which represents 42% of beekeepers who received the survey.

Of the beekeepers who were registered in Ontario as of December 31, 2019, responses were received from 30% of commercial beekeepers representing 40,562 colonies and from 5% of small-scale beekeepers representing 1,033 colonies (Tables 1 and 2). Combined, the responses represent 45.9% of the total number of registered colonies.

Table 1. Number of beekeepers, by region, responding to the 2020 Ontario Apiculture Winter Loss Survey

Beekeeping regions	# of commercial beekeeper respondents	% of commercial beekeeper respondents	# of small-scale beekeeper respondents	% of small-scale beekeepers respondents
Central	21	36%	36	31%
East	11	19%	29	25%
North	1	2%	12	10%
South	19	32%	31	27%
Southwest	7	12%	8	7%

Table 2. Estimated overwinter mortality for 2019-2020

Beekeeper type	# of full-sized colonies put into winter in fall 2019	# of viable overwintered colonies as of May 15, 2020	# of non-viable colonies as of May 15, 2020	Overwinter mortality (%)
Commercial	40,562	32,831	7,731	19.1%
Small-scale	1,033	725	308	29.8%

Results

The estimated overwinter honey bee mortality and the number of respondents varied by beekeeping region (Table 3). The majority of commercial beekeepers who responded to the survey were from the central and south beekeeping regions. These areas are known to have the greatest beekeeping activity. Responses from small-scale beekeeping operations were largely from the central, east and south beekeeping regions (Table 1).

Commercial beekeepers reported the greatest losses in the east region while small-scale beekeepers reported the highest losses in the north region. Overall, mortality during the 2019-2020 winter was approximately 10.7 percentage points lower with commercial than small-scale beekeepers (Table 2).

Table 3. Number of commercial and small-scale beekeeper survey respondents and the % overwinter mortality in 2020 for each beekeeping region in Ontario

Beekeeping region	# of commercial beekeeper respondents	Commercial beekeeper overwinter mortality (%)	# of small-scale beekeeper respondents	Small-scale beekeeper overwinter mortality (%)
Central	21	18.3%	36	26.2%
East	11	30.4%	29	32.3%
North	1	0%	12	37.9%
South	19	16.7%	31	31.0%
Southwest	7	14.9%	8	16.3%
Total	59	19.1%	116	29.8%

When respondents were grouped by operation size (number of colonies managed), the honey bee mortality during the winter of 2019-2020 ranged from 13.5% to 39.6% (Table 4). Beekeepers operating 501 to 1000 colonies reported fewer honey bee colony losses (13.5%) than all other beekeeping operation sizes. The greatest number of survey respondents had beekeeping operations with fewer than 10 colonies and this group reported the highest overwinter honey bee mortality of 39.6%.

This general trend that shows beekeepers with the highest number of colonies (501-1000 and >1000) having the lowest loss (13.5% and 17.6% respectively) and beekeepers with the lowest number of colonies (<10) having the highest loss (39.6%) is consistent with the trend of all commercial beekeepers averaging approximately 10% less winter loss than the small-scale beekeepers (Table 2).

This is the first year in the history of this survey where this large of a difference between commercial and small-scale beekeepers has been reported. This may indicate that beekeepers who are operating higher numbers of colonies may have better training, more resources and more experience. However, this may also

be an oversimplification of the data as it doesn't take into account the variability in beekeeping practices employed between small-scale beekeepers. Whatever the reason, this data should be considered for targeting of messaging and training for beekeepers while keeping in mind that management practices and environmental conditions may change and there is a need for both commercial and small-scale beekeepers to be well trained and up to date with credible, regional information and best management practices.

Table 4. Overwinter honey bee mortality during the winter of 2019-2020 by size of beekeeping operation (number of colonies operated)

# of respondents	# of colonies reported in the fall of 2019	Overwinter mortality (%)
88	<10	39.6%
28	10-49	24.6%
33	50-200	26.6%
12	201-500	27.7%
6	501-1000	13.5%
8	>1000	17.6%

Main factors of bee mortality

Beekeepers were asked to report on what they believed were the main factors contributing to their overwinter honey bee mortalities; they were able to select as many reasons as they felt were applicable. These opinions may be based on observable symptoms or beekeeper experience, judgment or best estimate.

The most commonly reported factors influencing overwinter mortality (Table 5) by both commercial and small-scale beekeepers included:

- poor queens
- weak colonies in the fall
- weather

Other commonly reported contributing factors reported by commercial beekeepers included:

- starvation
- ineffective varroa control

Table 5. Contributing factors to honey bee colony mortality during the winter of 2019-2020 as reported by commercial and small-scale beekeepers

Suspected cause(s) of colony loss	% of commercial beekeepers reporting	% of small-scale beekeepers reporting
Poor queens	46%	18%
Weak colonies in the fall	37%	25%
Weather	37%	19%
Starvation	32%	14%
Ineffective varroa control	27%	12%
Other	15%	16%

Suspected cause(s) of colony loss	% of commercial beekeepers reporting	% of small-scale beekeepers reporting
Don't know	5%	22%
Nosema	3%	3%

Management practices for pests and disease

Varroa mites (*Varroa destructor*)

In this survey, beekeepers were asked how they monitored for varroa mite infestations (Figure 1) and which treatments were used at the beginning (spring) and the end (fall) of the 2019 beekeeping season (Table 6).

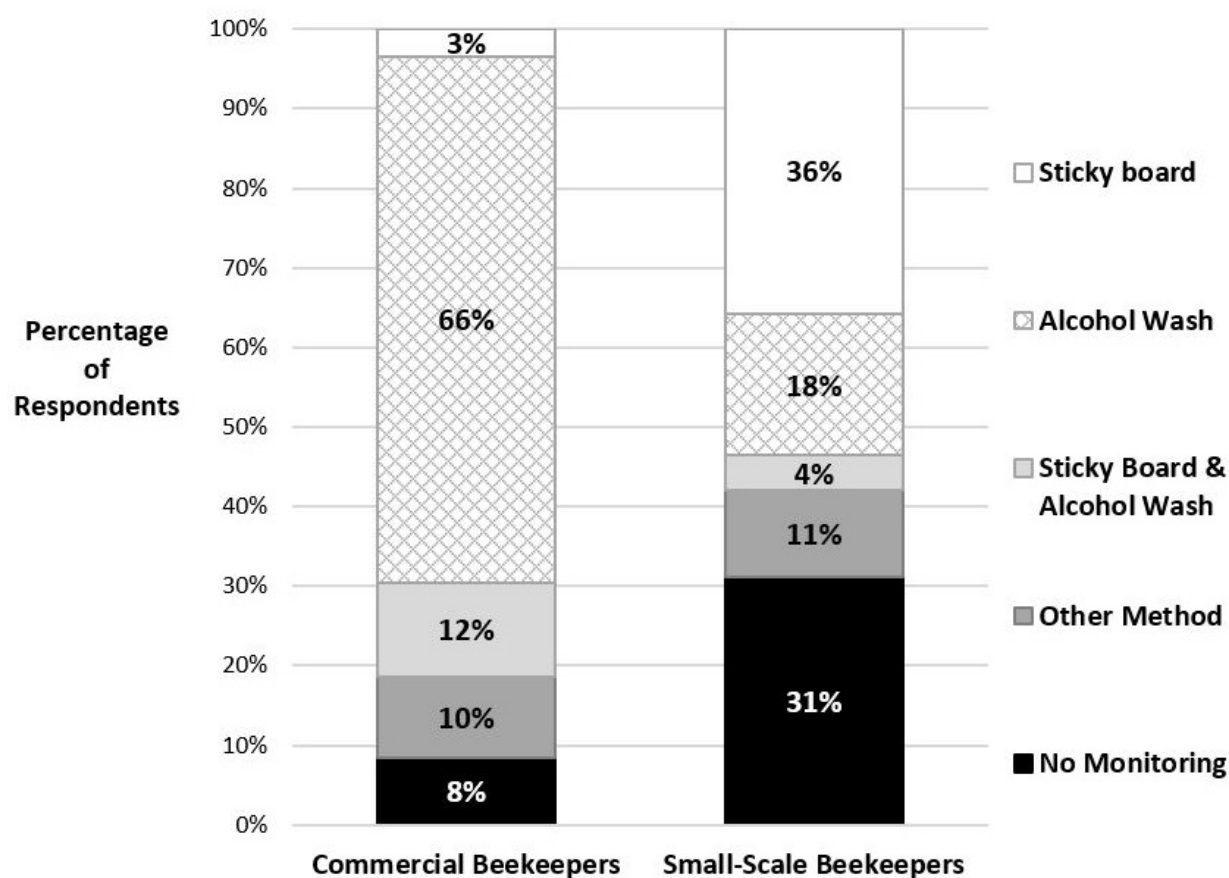


Figure 1. Type of varroa mite monitoring method used by commercial and small-scale beekeepers in 2019.

[Accessible description of figure 1](#)

Proportion of beekeepers monitoring for varroa mites

Of the beekeepers who responded to the varroa mite monitoring question, 92% of commercial beekeepers and 69% of small-scale beekeepers stated they monitor for varroa mite infestation in their colonies. Of those, a number of monitoring methods were used, the most common being either an alcohol wash or a sticky board.

Some beekeepers used more than one method to monitor for varroa mites. When the response “other” was selected, the beekeeper commonly reported that they visually checked their colonies for varroa mites or used

the “sugar shake” method. However, neither of these methods are recommended as visually checking for mites is not proven to yield usable information and the sugar shake method can be unreliable and it is not tied to established thresholds for Ontario.

From the data, it appears that most (92%) of the commercial beekeepers represented by this survey are monitoring for varroa mites. This is good news as monitoring, along with application of a treatment, is crucial for the management of varroa mites. Without the management of varroa mites, colonies are at a high risk of death and/or spreading varroa mites to other nearby colonies.

Conversely, it was concerning that over 30% of the small-scale beekeepers who responded reported no monitoring at all. This is a really high proportion of beekeepers in this category who are not monitoring for varroa mites. The proportion of monitoring for varroa mites should ideally be 100% for all beekeepers.

These results demonstrate the need for further education/training of beekeepers and further messaging on best management practices and integrated pest management.

Frequency of monitoring for varroa mites

It is encouraging to see from the survey data (Figure 2) that both commercial and small-scale beekeepers are sampling at least twice per season (roughly 30%) and it is even more encouraging to see that approximately 10% or more commercial and small-scale beekeepers are sampling more frequently (three times; every month; every time in the bee yard). At the same time there is room for improvement for both categories of beekeepers, again through training/education and messaging on best management practices and integrated pest management.

It should be noted that this is the first year Ontario included a question on the frequency of monitoring; this question was not included in the national CAPA survey.

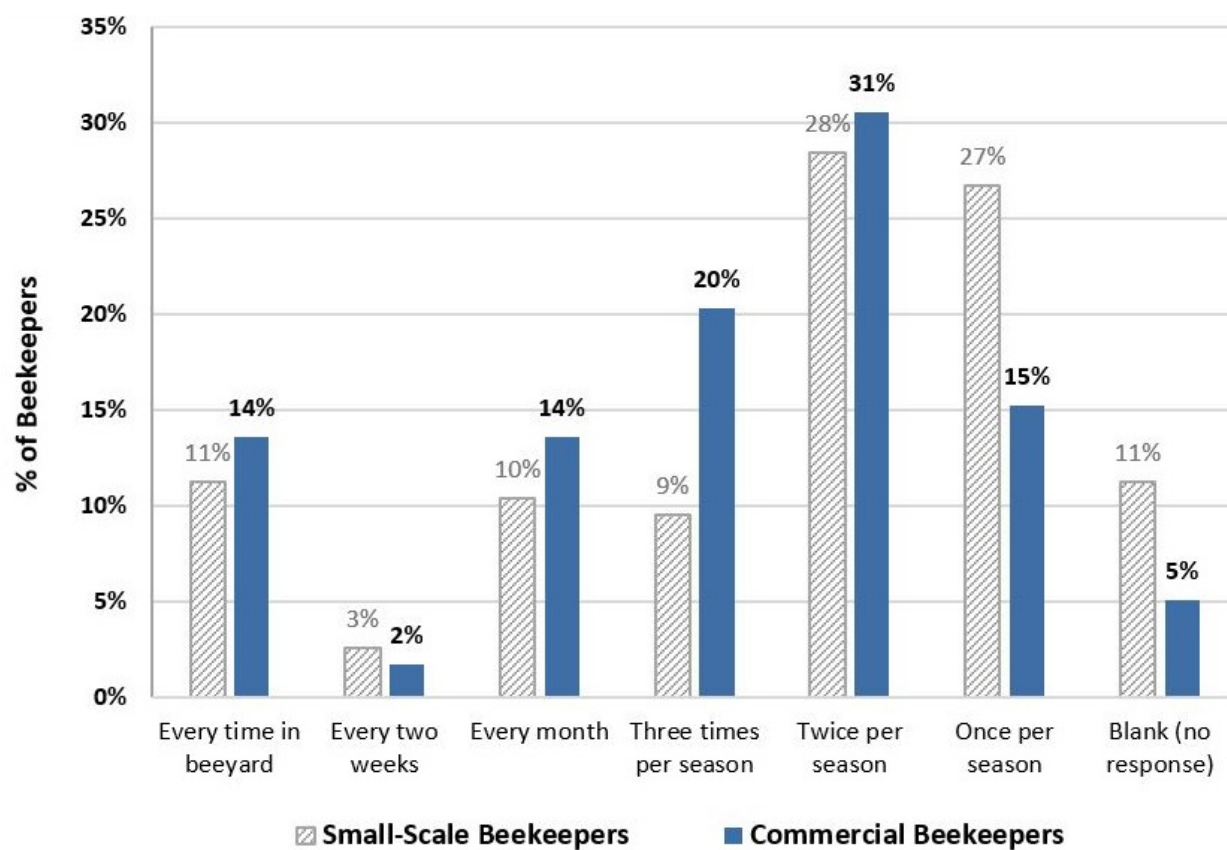


Figure 2. Frequency of varroa mite monitoring by commercial and small-scale beekeepers in 2019.

[Accessible description of figure 2](#)

Treatments used to control varroa mites

Ontario beekeepers use a variety of treatment options to manage varroa mites (Table 6). In spring of 2019, the most common method of varroa mite treatment reported by commercial beekeepers was Apivar® while in fall of 2019 both Apivar® and oxalic acid were most commonly used by commercial beekeepers. Small-scale beekeepers indicated a preference for Apivar® and oxalic acid as well as Mite Away Quick Strips™ over other forms of mite control. The two least commonly used treatments by both commercial and small-scale beekeepers were CheckMite+™ and Thymovar.

These results are encouraging as it demonstrates that Ontario beekeepers are rotating their miticides which is an important strategy for delaying the onset of resistant populations of varroa mites. However, there may be some cause for concern from the data as the industry appears to be quite reliant on Apivar® as a control method for varroa mites. Development of resistance to amitraz (the active ingredient in Apivar®) may seriously restrict Ontario beekeepers' ability to control varroa mites resulting in increased mortality of colonies in Ontario. While other chemical options are available, many of them are temperature dependent and this may factor into the timing and choice of treatment depending on the weather conditions (formic acid) during a particular season in Ontario.

As amitraz resistance has been documented in varroa mite populations in the USA, it will be increasingly important to monitor the status of amitraz in Canada. New compounds will be needed for varroa mite control in order to ensure there is a robust set of options available to beekeepers and the opportunity to rotate treatments so that beekeepers can continue to incorporate effective integrated pest management practices in their beekeeping operation.

It should be noted that varroa mites in Ontario have established resistance (or reduced efficacy) to other compounds (for example, coumaphos, fluvalinate, flumethrin).

Table 6. Treatments reported by commercial and small-scale beekeepers used to control varroa mites in the spring and fall of 2019. Survey respondents could select more than one answer.

Varroa mite treatment (active ingredient)	Spring 2019 % of commercial beekeepers	Spring 2019 % of small-scale beekeepers	Fall 2019 % of commercial beekeepers	Fall 2019 % of small-scale beekeepers
Apistan® (fluvalinate)	7%	4%	5%	7%
CheckMite+™ (coumaphos)	0%	0%	0%	1%
Apivar® (amitraz)	29%	21%	57%	20%
Thymovar (thymol)	5%	3%	3%	1%
Bayvarol® (flumethrin)	9%	6%	7%	4%
65% formic acid – 40 ml multiple application	21%	10%	14%	5%
65% formic acid – 250 ml single application	5%	4%	9%	5%

Varroa mite treatment (active ingredient)	Spring 2019 % of commercial beekeepers	Spring 2019 % of small-scale beekeepers	Fall 2019 % of commercial beekeepers	Fall 2019 % of small-scale beekeepers
Mite Away Quick Strips™ (formic acid)	12%	25%	12%	26%
Oxalic Acid	14%	21%	52%	29%
Other	14%	4%	9%	4%
None	12%	15%	0%	18%

Nosema spp. (*N. apis* and *N. ceranae*)

Approximately 90% of survey respondents indicated that nosema treatment was not applied in the spring of 2019 and similarly, approximately 90% of respondents did not treat for the disease in the fall of 2019 (Table 7).

Table 7. Treatments reported by commercial and small-scale beekeepers used to control nosema in the spring and fall of 2019

Nosema treatment	Spring 2019 % of commercial beekeepers	Spring 2019 % of small-scale beekeepers	Fall 2019 % of commercial beekeepers	Fall 2019 % of small-scale beekeepers
Fumagillin	7%	8%	7%	8%
Other	3%	3%	4%	1%
None	90%	89%	89%	91%

American foulbrood (*Paenibacillus larvae*)

The majority of commercial beekeepers who responded to this survey question treated for American foulbrood (AFB) during spring 2019 (71%) and during fall 2019 (61%) with oxytetracycline being the most commonly reported treatment. By comparison, 35% of small-scale beekeepers reported treating for AFB in the spring (one beekeeper reported two treatment types) and 31% of small-scale beekeepers used AFB treatments in the fall (Table 8).

Table 8. Treatments reported by commercial and small-scale beekeepers used to control American foulbrood in the spring and fall of 2019

American foulbrood treatment	Spring 2019 % of commercial beekeepers	Spring 2019 % of small-scale beekeepers	Fall 2019 % of commercial beekeepers	Fall 2019 % of small-scale beekeepers
Oxytetracycline	71%	34%	57%	30%
Tylosin	0%	0%	4%	0%
Lincomycin	0%	0%	0%	0%
Other	0%	2%	0%	1%
None	29%	65%	39%	69%

Ontario's overwinter mortality

The [Canadian Association of Professional Apiculturists](https://www.ontario.ca/document/annual-apiculture-winter-loss-reports...) compiles overwinter mortality data provided by each province and publishes an annual report on national honey bee colony losses. Figure 3 compares Ontario's overwinter mortality levels to that of Canada's. It is worth noting that the 2020 estimate for commercial beekeepers in Ontario was approximately 10% less than the estimation for bee loss averaged between all of Canada (30.2%).

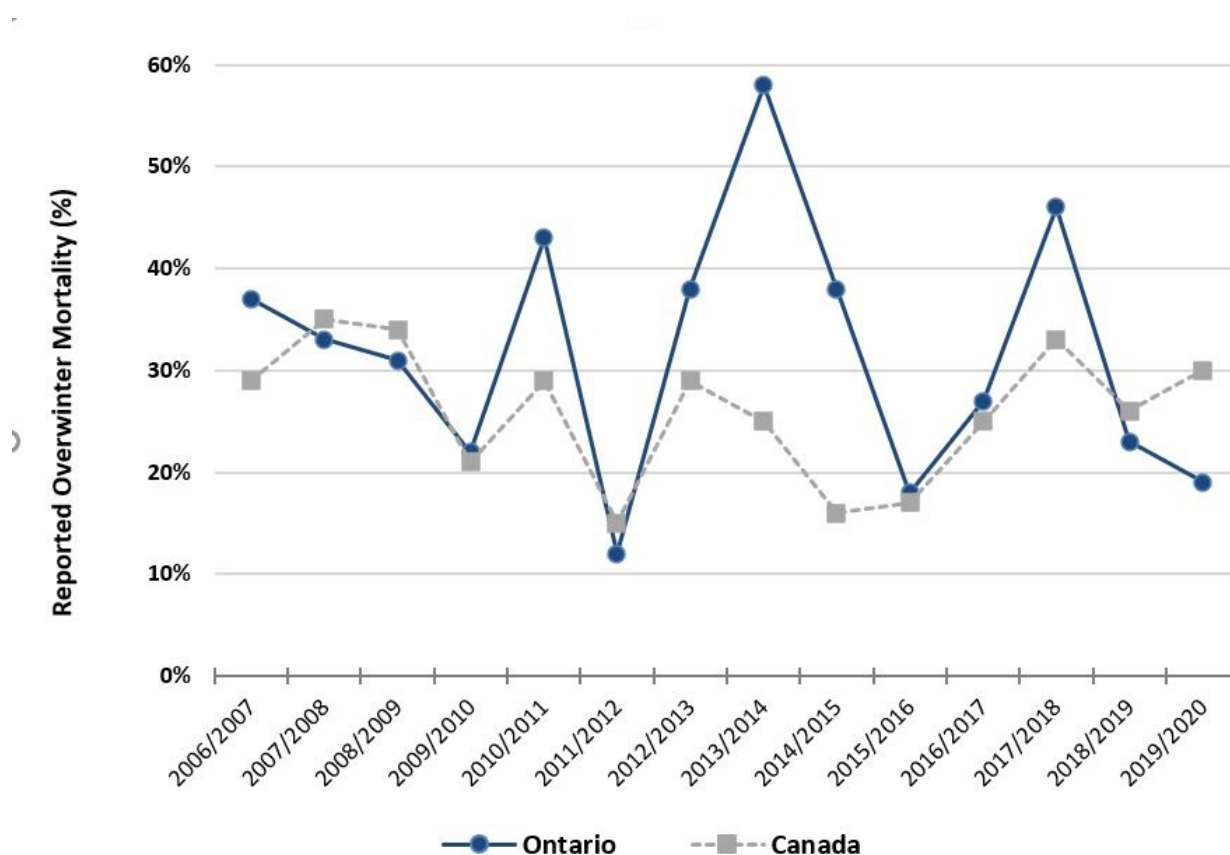


Figure 3. Overwinter mortality (%) reported by commercial beekeepers in Ontario (blue) and Canada (grey) from 2006-2007 to 2019-2020

[Accessible description of figure 3](#)

Accessible image descriptions

Figure 1. Type of varroa mite monitoring method used by commercial and small-scale beekeepers in 2019

Figure 1 shows the type of varroa mite monitoring method used by commercial and small-scale beekeepers in 2019. Three % of commercial beekeepers reported using the sticky board method, 66% used the alcohol wash method, 12% used both sticky board and alcohol wash, 10% used other methods, and 8% reported no monitoring for varroa mites. Thirty-six% of small-scale beekeepers reported using the sticky board method, 18% used the alcohol wash method, 4% used both sticky board and alcohol wash, 11% used other methods, and 31% reported no monitoring for varroa mites.

Figure 2. Frequency of varroa mite monitoring by commercial and small-scale beekeepers in 2019

Figure 2 shows the frequency of varroa mite monitoring by commercial and small-scale beekeepers in 2019. Small-scale beekeepers – 11% every time in beeyard, 3% every two weeks, 10% every month, 9% three times per season, 28% twice per season, 27% once per season, 11% blank (no response). Commercial beekeepers – 14% every time in beeyard, 2% every two weeks, 14% every month, 20% three times per season, 31% twice per season, 15% once per season, 5% blank (no response).

Figure 3. Overwinter mortality (%) reported by commercial beekeepers in Ontario (blue) and Canada (grey) from 2006-2007 to 2019-2020

Figure 3 shows the % overwinter mortality reported by beekeepers in both Ontario and Canada from 2007 to 2020. The reported overwinter mortality in Ontario and Canada (respectively) was the following: 2007 – 37% and 29%; 2008 – 33% and 35%; 2009 – 31% and 34%; 2010 – 22% and 21%; 2011 – 43% and 29%; 2012 – 12% and 15%; 2013 – 38% and 29%; 2014 – 58% and 25%; 2015 – 38% and 16%; 2016 – 18% and 17%; 2017 – 27% and 25%; 2018 – 46% and 33%; 2019 – 23% and 26%; 2020 – 19% and 30%.

2019 Apiculture winter loss report

2019 Honey bee colony winter mortality

Overwinter mortality for **2018-2019** for commercial beekeepers operating in Ontario was estimated to be **23%**.

The estimated loss reported for small-scale beekeepers was 26% and the 2019 estimation for honey bee loss averaged between all of Canada was 26%.

Who we surveyed

In the spring of 2019, the survey was distributed to:

- 218 registered commercial beekeepers (defined as operating 50 or greater colonies)
- 400 randomly selected registered small-scale beekeepers (defined as operating 49 or fewer colonies)

The survey is voluntary and all responses are self-reported by beekeepers. Data is not verified by the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) or any other independent body.

Responses were received from 87 commercial beekeepers and 181 small-scale beekeepers which represents 43% of beekeepers who received the survey.

Of the beekeepers who were registered in Ontario as of December 31, 2018, responses were received from 40% of commercial beekeepers representing 48,418 colonies and from 6.5% of small-scale beekeepers representing 1,592 colonies (Tables 1 and 2). Combined, the responses represent 50% of the total number of registered colonies.

Table 1. Number of beekeepers, by region, responding to the 2019 Ontario Apiculture Winter Loss Survey

Beekeeping regions	# of commercial beekeeper respondents	% of commercial beekeeper respondents	# of small-scale beekeeper respondents	% of small-scale beekeepers respondents
Central	33	37.9%	63	34.8%

Beekeeping regions	# of commercial beekeeper respondents	% of commercial beekeeper respondents	# of small-scale beekeeper respondents	% of small-scale beekeepers respondents
East	14	16.1%	41	22.7%
North	2	2.3%	28	15.5%
South	32	36.8%	41	22.7%
Southwest	6	6.9%	8	4.4%

Table 2. Estimated overwinter mortality for 2018-2019

Beekeeper type	# of full-sized colonies put into winter in fall 2018	# of viable overwintered colonies as of May 15, 2019	# of non-viable colonies as of May 15, 2019	Overwinter mortality (%)
Commercial	48,418	37,469	10,949	22.6%
Small-scale	1,592	1,186	406	25.5%

Results

The estimated overwinter honey bee mortality and the number of respondents varied by beekeeping region (Table 3). Commercial beekeepers reported the greatest losses in the north region while small-scale beekeepers reported the highest losses in the east region. Overall, mortality during the 2018-2019 winter was approximately 2.9 percentage points lower in commercial than small-scale beekeepers (Table 2).

Table 3. Number of commercial and small-scale beekeeper survey respondents and the % overwinter mortality in 2019 for each beekeeping region in Ontario

Beekeeping region	# of commercial beekeeper respondents	Commercial beekeeper overwinter mortality (%)	# of small-scale beekeeper respondents	Small-scale beekeeper overwinter mortality (%)
Central	33	20.5%	63	20.5%
East	14	23.4%	41	35.2%
North	2	38.5%	28	21.0%
South	32	23.9%	41	27.1%
Southwest	6	18.3%	8	20.0%
Total	87	22.6%	181	25.5%

When respondents were grouped by operation size (number of colonies managed), the honey bee mortality during the winter of 2018-2019 ranged from 13.0% to 32.2% (Table 4). Beekeepers operating 501 to 1000 colonies reported fewer honey bee colony losses (13%) than all other beekeeping operations. The greatest number of survey respondents had beekeeping operations with fewer than 10 colonies and this group reported an average overwinter honey bee mortality of 27.7%. Operations with 201 to 500 colonies reported the highest overwinter honey bee mortality (32.2%).

Table 4. Overwinter honey bee mortality during the winter of 2018-2019 by size of beekeeping operation

(number of colonies operated)

# of respondents	# of colonies reported in the fall of 2018	Overwinter mortality (%)
135	<10	27.7%
44	10-49	24.7%
43	50-200	28.2%
22	201-500	32.2%
13	501-1000	13.0%
8	>1000	22.5%

Main factors of bee mortality

Beekeepers were asked to report on what they believed were the main factors contributing to their overwinter honey bee mortalities; they were able to select as many reasons as they felt were applicable. These opinions may be based on observable symptoms or beekeeper experience, judgment or best estimate.

The most commonly reported factors influencing overwinter mortality (Table 5) by commercial beekeepers included:

- starvation
- poor queens

The most commonly reported factors influencing overwinter mortality (Table 5) by small-scale beekeepers included:

- weather
- starvation
- weak colonies in the fall

Table 5. Contributing factors to honey bee colony mortality during the winter of 2018-2019 as reported by commercial and small-scale beekeepers

Suspected cause(s) of colony loss	# of commercial beekeepers reporting	# of small-scale beekeepers reporting
Starvation	42	42
Poor queens	38	29
Weather	35	50
Ineffective varroa control	19	12
Nosema	14	3
Weak colonies in the fall	32	42
Other	19	19
Don't know	11	29

Management practices for pests and disease

Varroa mites (*Varroa destructor*)

In this survey, beekeepers were asked how they monitored for varroa mite infestations (Figure 1) and which treatments were used at the beginning (spring) and the end (fall) of the 2018 beekeeping season (Table 6).

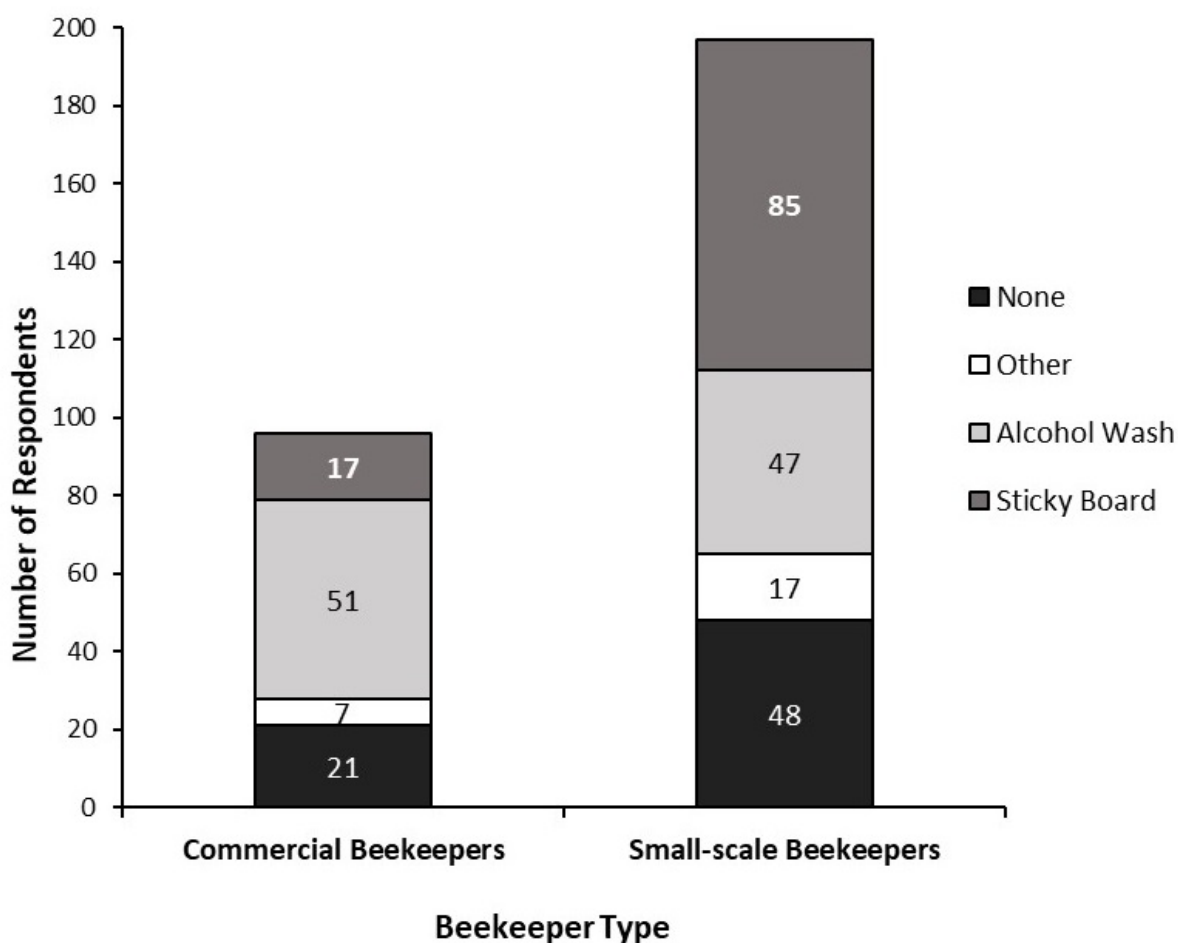


Figure 1. Type of varroa mite monitoring method used by commercial and small-scale beekeepers in 2018. Survey respondents could reply with more than one answer.

[Accessible description of figure 1](#)

Proportion of beekeepers monitoring for varroa mites

Of the beekeepers who responded to the varroa mite monitoring question, 75% of commercial beekeepers and 73% of small-scale beekeepers stated they monitor for varroa mite infestation in their colonies. Of those, a number of monitoring methods were used, the most common being either an alcohol wash or a sticky board.

Some beekeepers used more than one method to monitor for varroa mites. When the response “other” was selected, the beekeeper commonly reported that they visually checked their colonies for varroa mites or used the “sugar shake” method. However, neither of these methods are recommended as visually checking for mites is not proven to yield usable information and the sugar shake method can be unreliable and it is not tied to established thresholds for Ontario. It should also be noted that this survey only addresses whether monitoring took place and does not address the frequency of monitoring.

Treatments used to control varroa mites

Ontario beekeepers use a variety of treatment options to manage varroa mites (Table 6). In spring and fall of 2018, the most common method of varroa mite treatment reported by commercial beekeepers was Apivar®. The survey results suggest that commercial beekeepers also have a preference for using 65% liquid formic acid (40 ml multiple application), Mite Away Quick Strips™ and oxalic acid. Small-scale beekeepers indicated a preference for Mite Away Quick Strips™ over other forms of mite control options.

Bayvarol® was a new treatment option added to the 2019 survey and the survey results indicate that this is not a popular treatment option with either commercial or small-scale beekeepers. The two least commonly used treatments by both commercial and small-scale beekeepers were CheckMite+™ and Thymovar. However, the results are encouraging as they demonstrate that Ontario beekeepers are rotating their miticides which is an important strategy for delaying the onset of resistant populations of varroa mites.

Table 6. Treatments reported by commercial and small-scale beekeepers used to control varroa mites in the spring and fall of 2018. Survey respondents could select more than one answer.

Varroa mite treatment (active ingredient)	Spring 2018 # of commercial beekeepers	Spring 2018 # of small-scale beekeepers	Fall 2018 # of commercial beekeepers	Fall 2018 # of small-scale beekeepers
Apistan® (fluvalinate)	6	4	8	8
CheckMite+™ (coumaphos)	0	1	1	0
Apivar® (amitraz)	29	17	42	33
Thymovar (thymol)	1	3	3	7
Bayvarol® (flumethrin)	4	4	10	6
65% formic acid – 40 ml multiple application	17	11	19	12
65% formic acid – 250 ml single application	2	8	4	11
Mite Away Quick Strips™ (formic acid)	13	58	20	57
Oxalic Acid	10	20	38	48
Other	4	5	2	7
None	18	51	2	24

Nosema spp. (*N. apis* and *N. ceranae*)

The majority of survey respondents did not treat for nosema during 2018 (Table 7). Eighty-nine% of beekeepers (both commercial and small-scale) who responded to this survey question indicated that nosema treatment was not applied in the spring and 86% of respondents did not treat for the disease in the fall of 2018.

Table 7. Treatments reported by commercial and small-scale beekeepers used to control nosema in the spring and fall of 2018

Nosema treatment	Spring 2018 # of commercial	Spring 2018 # of small-scale	Fall 2018 # of commercial	Fall 2018 # of small-scale
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	beekeepers	beekeepers	beekeepers	beekeepers
Fumagillin	8	18	8	19
Other	0	3	2	5
None	75	148	71	144

American foulbrood (*Paenibacillus larvae*)

The majority of commercial beekeepers (81%) who responded to this survey question treated for American foulbrood (AFB) during 2018 and the most common treatment reported was oxytetracycline (Table 8). Thirty-six% of small-scale beekeepers reported treating for AFB in the spring and 37% of small-scale beekeepers used AFB treatments in the fall (Table 8). Lincomycin, a new treatment option in 2019, and Tylosin were the least used treatment options.

Table 8. Treatments reported by commercial and small-scale beekeepers used to control American foulbrood in the spring and fall of 2018

American foulbrood treatment	Spring 2018 # of commercial beekeepers	Spring 2018 # of small-scale beekeepers	Fall 2018 # of commercial beekeepers	Fall 2018 # of small-scale beekeepers
Oxytetracycline	61	57	57	62
Tylosin	1	0	0	0
Lincomycin	1	0	1	0
Other	0	0	0	0
None	21	105	25	108

Ontario's overwinter mortality

The [Canadian Association of Professional Apiculturists](#) compiles overwinter mortality data provided by each province and publishes an annual report on national honey bee colony losses. Ontario beekeepers have frequently reported overwinter mortalities higher than the national average (Figure 2).

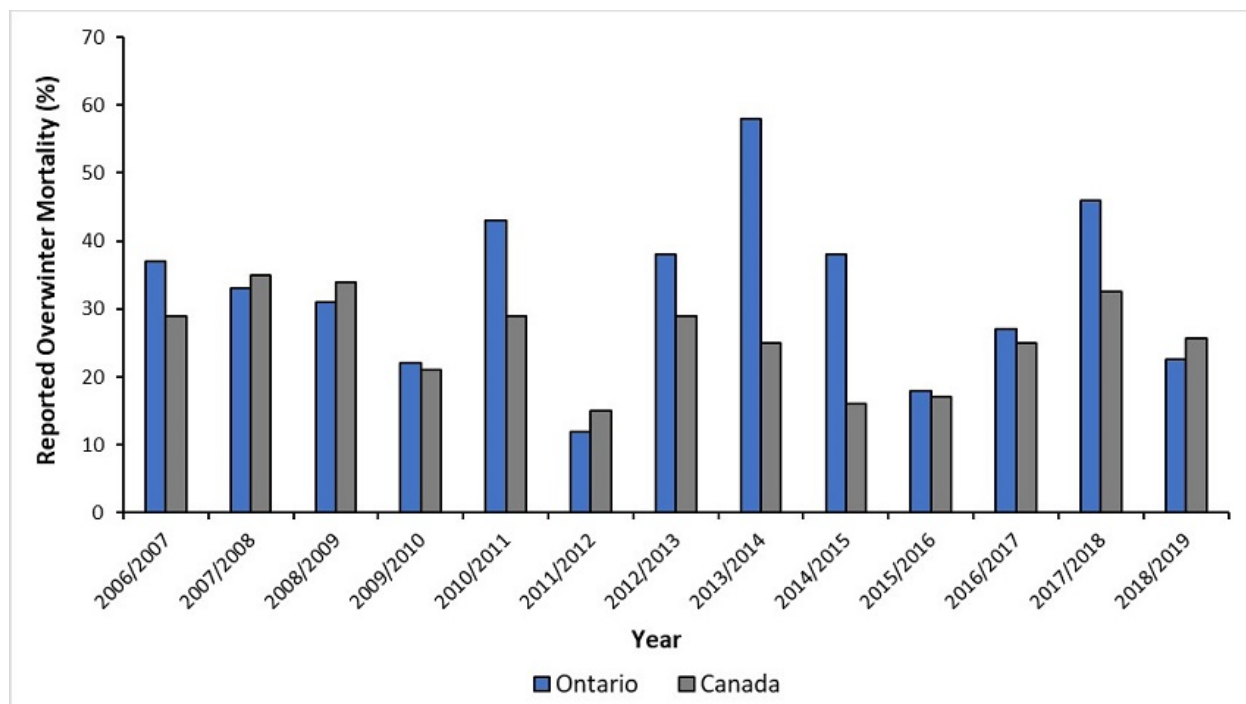


Figure 2. Overwinter mortality (%) reported by commercial beekeepers in Ontario (blue) and Canada (grey) from 2006-2007 to 2018-2019.

[Accessible description of figure 2](#)

Accessible image descriptions

Figure 1. Type of varroa mite monitoring method used by commercial and small-scale beekeepers in 2018. Survey respondents could reply with more than one answer.

Figure 1 shows the type of varroa mite monitoring method used by commercial and small-scale beekeepers in 2018. Survey respondents could reply with more than one answer. Commercial beekeepers reported 17 uses of the sticky board method, 51 uses of the alcohol wash method, 7 uses of other, with 21 reporting no monitoring for varroa mites. Small-scale beekeepers reported 85 uses of the sticky board method, 47 uses of the alcohol wash method, 17 uses of other, with 48 reporting no monitoring for varroa mites.

Figure 2. Overwinter mortality (%) reported by commercial beekeepers in Ontario (blue) and Canada (grey) from 2006-2007 to 2018-2019

Figure 2 shows the % overwinter mortality reported by beekeepers in both Ontario and Canada from 2007 to 2019. The reported overwinter mortality in Ontario and Canada (respectively) was the following : 2007 – 37% and 29%; 2008 – 33% and 35%; 2009 – 31% and 34%; 2010 – 22% and 21%; 2011 – 43% and 29%; 2012 – 12% and 15%; 2013 – 38% and 29%; 2014 – 58% and 25%; 2015 – 38% and 16%; 2016 – 18% and 17%; 2017 – 27% and 25%; 2018 – 46% and 33%; 2019 – 23% and 26%.

2018 Apiculture winter loss report

2018 Honey bee colony winter mortality

The number of colonies operated by beekeepers fluctuates throughout a year. After a decrease in colony

numbers over the winter months, a beekeeper can build up colony numbers during the summer months by splitting larger, healthy colonies into smaller nucleus colonies. As of December 31, 2017, Ontario beekeepers had registered 105,244 colonies which represents the number of registered colonies that were alive going into the winter of 2017-2018.

Overwinter mortality for **2017-2018** for commercial beekeepers operating in Ontario was estimated to be **46%**.

The estimated loss reported for small-scale beekeepers was also 46% and the 2018 estimation for honey bee loss averaged between all of Canada was 33%.

Who we surveyed

In the spring of 2018, the survey was distributed to:

- 186 registered commercial beekeepers (defined as operating 50 or greater colonies)
- 400 randomly selected registered small-scale beekeepers (defined as operating 49 or fewer colonies)

Beekeepers had the option of responding to the survey:

- electronically via an online survey
- by submitting a completed hard copy
- by phone

The survey is voluntary and all responses are self-reported by beekeepers. Data is not verified by the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) or any other independent body.

Responses were received from 117 commercial beekeepers and 118 small-scale beekeepers which represents 40% of beekeepers who received the survey.

Of the beekeepers who were registered in Ontario as of December 31, 2017, responses were received from 63% of commercial beekeepers representing 63,236 colonies and from 4% of small-scale beekeepers representing 1,287 colonies (Table 1 and Table 2). Combined, the responses represent 61% of the total number of registered colonies.

Table 1. Number of beekeepers, by region, responding to the 2018 Ontario Apiculture Winter Loss Survey

Beekeeping regions	# of commercial beekeeper respondents	% of commercial beekeeper respondents	# of small-scale beekeeper respondents	% of small-scale beekeepers respondents
Central	41	35.0%	29	24.6%
East	23	19.7%	36	30.5%
North	5	4.3%	17	14.4%
South	36	30.8%	27	22.9%
Southwest	12	10.3%	9	7.6%

Table 2. Estimated overwinter mortality for 2017-2018

Beekeeper	# of full-sized	# of viable overwintered	# of non-viable	Overwinter
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type	colonies put into winter in fall 2017	colonies as of May 15, 2018	colonies as of May 15, 2018	mortality (%)
Commercial	63,236	34,327	28,909	45.7%
Small-scale	1,287	702	585	45.5%

Results

Both registered commercial and small-scale beekeepers in Ontario reported an approximate 46% overwinter mortality during the winter of 2017-2018 (Table 2). In Canada, 15% is the maximum level of overwinter loss considered to be acceptable and sustainable by the industry (Furgala and McCutcheon, 1992; CAPA, 2007 to 2016).

The estimated overwinter honey bee mortality and the number of respondents varied by beekeeping region (Table 3). Commercial beekeepers reported the greatest losses in the east region while small-scale beekeepers reported the highest losses in the south region. Overall, mortality during the 2017-2018 winter differed by approximately 0.2 percentage points between commercial and small-scale beekeepers (Table 2).

Table 3. Number of commercial and small-scale beekeeper survey respondents and the % overwinter mortality in 2018 for each beekeeping region in Ontario

Beekeeping region	# of commercial beekeeper respondents	Commercial beekeeper overwinter mortality (%)	# of small-scale beekeeper respondents	Small-scale beekeeper overwinter mortality (%)
Central	41	52.8%	29	44.2%
East	23	56.2%	36	45.1%
North	5	42.0%	17	45.3%
South	36	43.6%	27	50.7%
Southwest	12	32.7%	9	25.4%
Total	117	45.7%	118	45.5%

When respondents were grouped by operation size (number of colonies managed), the honey bee mortality during the winter of 2017-2018 ranged from 41.6% to 46.8% (Table 4). Beekeepers operating 201 to 500 colonies reported fewer honey bee colony losses (41.6%) than all other beekeeping operation sizes. Similar to previous years, the number of respondents in the 501 to 1000 colonies category remained low, however the percent in overwinter mortality reported in this group tripled.

The greatest number of survey respondents had beekeeping operations with fewer than 10 colonies and this group reported an overwinter honey bee mortality of 43%. Unlike previous years, operations with greater than 1000 colonies reported the greatest overwinter honey bee mortality (approximately 47%).

Table 4. Overwinter honey bee mortality during the winter of 2017-2018 by size of beekeeping operation (number of colonies operated)

# of respondents	# of colonies reported in the fall of 2017	Overwinter mortality (%)
75	<10	43.4%

# of respondents	# of colonies reported in the fall of 2017	Overwinter mortality (%)
43	10-49	45.9%
71	50-200	42.5%
20	201-500	41.6%
8	501-1000	45.3%
18	>1000	46.8%

Main factors of bee mortality

Beekeepers were asked to report on what they believed were the main factors contributing to their overwinter honey bee mortalities; they were able to select as many reasons as they felt were applicable. These opinions may be based on observable symptoms or beekeeper experience, judgment or best estimate.

The most commonly reported factors influencing overwinter mortality (Table 5) by commercial beekeepers included:

- weather
- poor queens

The most commonly reported factors influencing overwinter mortality (Table 5) by small-scale beekeepers included:

- weather
- weak colonies in the fall

Table 5. Contributing factors to honey bee colony mortality during the winter of 2017-2018 as reported by commercial and small-scale beekeepers

Suspected cause(s) of colony loss	# of commercial beekeepers reporting	# of small-scale beekeepers reporting
Starvation	30	21
Poor queens	50	16
Weather	74	46
Ineffective varroa control	34	14
Nosema	22	10
Weak colonies in the fall	36	30
Other	46	25
Don't know	24	27

Management practices for pests and disease

There are many theories which aim to explain the observation of increased overwinter honey bee mortality in recent years. The scientific literature suggests that honey bee health is complex and that there are many factors that contribute to honey bee colony health. For example, colonies may be weakened or killed by pests and/or diseases, such as infestation by the parasitic mite, *Varroa destructor*. Poor management practices,

including small cluster size, inadequate food stores and inadequate control of varroa mites may contribute to winter losses. Other factors such as severe weather, habitat loss and exposure to pesticides are environmental stressors which may potentially impact colony health.

While some factors contributing to colony mortality, such as severe weather, are not within the direct control of the beekeeper, monitoring for and the treatment of pests and diseases can be controlled by the beekeeper. For this reason, the 2018 winter loss survey focused on the surveillance, management and monitoring of three major pest and disease threats to colony health:

- varroa mites
- nosema
- American foulbrood

Varroa mites (*Varroa destructor*)

In this survey, beekeepers were asked how they monitored for varroa mite infestations (Figure 1) and which treatments were used at the beginning (spring) and the end (fall) of the 2017 beekeeping season (Table 6).

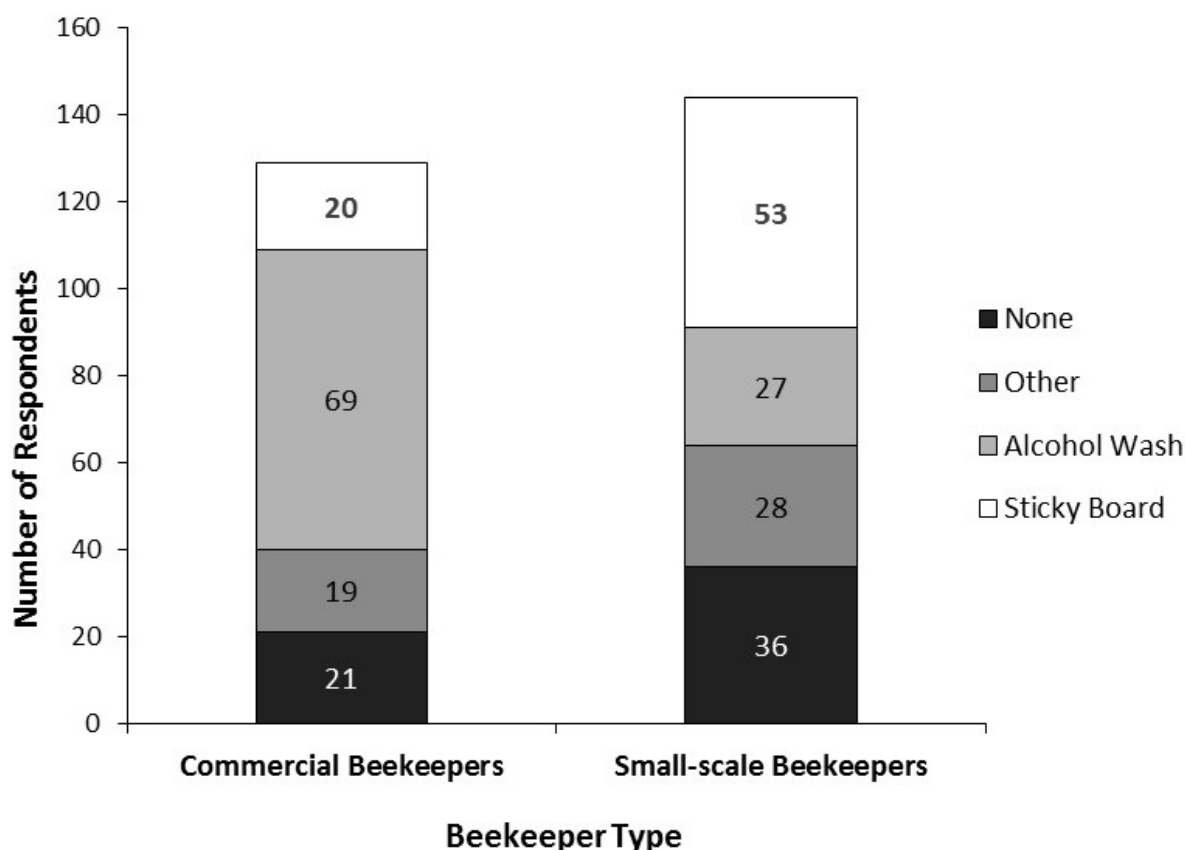


Figure 1. Type of varroa mite monitoring method used by commercial and small-scale beekeepers in 2017. Survey respondents could reply with more than one answer.

[Accessible description of figure 1](#)

Proportion of beekeepers monitoring for varroa mites

Of the beekeepers who responded to the varroa mite monitoring question, 84% of commercial beekeepers and

75% of small-scale beekeepers stated that they monitor for varroa mite infestation in their colonies. Of those, a number of monitoring methods were used, the most common being either an alcohol wash or a sticky board.

Some beekeepers used more than one method to monitor for varroa mites. When the response “other” was selected, the beekeeper commonly reported that they visually checked their colonies for varroa mites or used the “sugar shake” method. However, neither of these methods are recommended as visually checking for mites is not proven to yield usable information and the sugar shake method can be unreliable and it is not tied to established thresholds for Ontario.

Treatments used to control varroa mites

Ontario beekeepers use a variety of treatment options to manage varroa mites (Table 6). In spring and fall of 2017, the most common method of varroa mite treatment reported by commercial beekeepers was Apivar®. Commercial beekeepers also reported using 65% liquid formic acid (40 ml multiple application), Mite Away Quick Strips™ and oxalic acid. Small-scale beekeepers indicated a preference for Mite Away Quick Strips™ over other forms of mite control options. Although there has been documented resistance to some mite control products such as Apistan® and Checkmite+™, there have been no documented cases of Apivar®-resistant varroa mites in Ontario to date.

The two least commonly used treatments by both commercial and small-scale beekeepers were Checkmite+™ and Thymovar. To slow the development of resistance to chemical treatments, Ontario beekeepers are advised to rotate varroa mite treatments as part of an integrated pest management strategy.

Table 6. Treatments reported by commercial and small-scale beekeepers used to control varroa mites in the spring and fall of 2017. Survey respondents could select more than one answer.

Varroa mite treatment (active ingredient)	Spring 2017 # of commercial beekeepers	Spring 2017 # of small-scale beekeepers	Fall 2017 # of commercial beekeepers	Fall 2017 # of small-scale beekeepers
Apistan® (fluvalinate)	5	5	15	5
CheckMite+™ (coumaphos)	0	1	0	0
Apivar® (amitraz)	33	11	57	17
Thymovar (thymol)	3	4	5	2
65% formic acid – 40 ml multiple application	29	9	29	12
65% formic acid – 250 ml single application	7	6	11	5
Mite Away Quick Strips™ (formic acid)	17	27	24	37
Oxalic Acid	14	3	47	23
Other	11	7	3	6
None	25	47	4	29

Nosema spp. (*N. apis* and *N. ceranae*)

The majority of survey respondents did not treat for nosema during 2017 (Table 7). Eighty-one% of

beekeepers (both commercial and small-scale) who responded to this survey question indicated that nosema treatment was not applied in the spring and 80% of respondents did not treat for the disease in the fall of 2017.

Table 7. Treatments reported by commercial and small-scale beekeepers used to control nosema in the spring and fall of 2017

Nosema treatment	Spring 2017 # of commercial beekeepers	Spring 2017 # of small-scale beekeepers	Fall 2017 # of commercial beekeepers	Fall 2017 # of small-scale beekeepers
Fumagillin	20	17	21	22
Other	1	5	0	2
None	94	94	90	90

American foulbrood (*Paenibacillus larvae*)

The majority of commercial beekeepers (74%) who responded to this survey question treated for American foulbrood (AFB) during 2017 and the most common treatment reported was oxytetracycline (Table 8). Thirty-one% of small-scale beekeepers reported treating for AFB in the spring and 40% of small-scale beekeepers used AFB treatments in the fall (Table 8). Although oxytetracycline-resistant AFB has been detected in other jurisdictions such as the USA, there have not been any documented cases of resistant forms in Ontario to date.

Table 8. Treatments reported by commercial and small-scale beekeepers used to control American foulbrood in the spring and fall of 2017

American foulbrood treatment	Spring 2017 # of commercial beekeepers	Spring 2017 # of small-scale beekeepers	Fall 2017 # of commercial beekeepers	Fall 2017 # of small-scale beekeepers
Oxytetracycline	80	35	75	43
Tylosin	0	0	0	0
Other	0	0	0	1
None	34	78	40	66

Ontario's overwinter mortality

Ontario is working collaboratively at the national level coordinating the winter loss survey with all other provinces and the [Canadian Association of Professional Apiculturists](#) (CAPA). This has the advantage of leveraging consistent and accurate methods in gathering data and assessing pest, disease and management issues across Canada, while allowing for each province to focus on their own unique areas of interest and coordinate with existing programs. CAPA has compiled overwinter mortality data provided by each province and published an annual report on national honey bee colony losses since 2007. Ontario beekeepers have frequently reported overwinter mortalities higher than the national average (Figure 2).

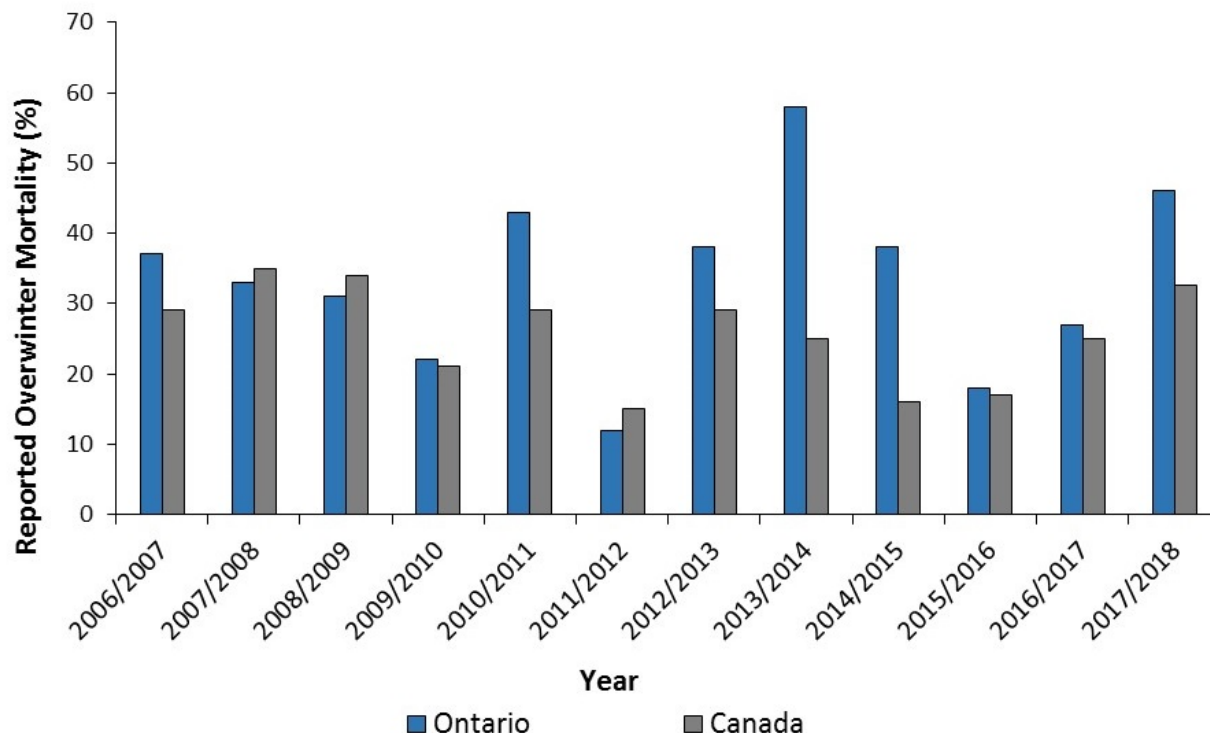


Figure 2. Overwinter mortality (%) reported by commercial beekeepers in Ontario (blue) and Canada (grey) from 2006-2007 to 2017-2018.

[Accessible description of figure 2](#)

Since 2010, Ontario beekeepers have reported annual overwinter honey bee colony losses of 15% or greater in all years except 2012 (12%). In Canada, 15% is the maximum of overwinter losses considered to be acceptable and sustainable by the apiculture industry (Furgala and McCutcheon, 1992; CAPA, 2007 to 2016). During the winter of 2013-2014, Ontario beekeepers reported a record 58% overwinter mortality. In 2014-2015 and 2015-2016, the estimated overwinter mortality declined to 38% and 18% respectively. This was followed by an increase to 27% and 46% overwinter mortality in 2016-2017 and 2017-2018 respectively.

General comments and discussion

The annual Ontario Apiculture Winter Loss Survey is a valuable tool for gathering information on colony mortality and the management practices used by beekeepers to monitor and control pests and diseases. Honey bee colony mortality differs from year to year, among different beekeeping regions as well as between individual beekeeping operations. This survey alone cannot paint a complete picture of honey bee health as honey bee health is complex and it is difficult to attribute overwinter losses to any single cause. The main stress factors influencing declines in the number of pollinators in Ontario have been identified as:

- extreme weather and climate change
- disease, pests and genetics
- reduced habitat and poor nutrition
- exposure to pesticides

A number of actions have been taken by the provincial government, with ongoing efforts to support the sector including:

- investing \$1 million in innovative pollinator health research

- working to restore and protect pollinator habitat across the province
- developing and delivering a suite of activities and programs designed to enhance beekeeper knowledge of emerging issues and research and best management and integrated pest management practices

Additionally, commercial beekeepers have access to a production insurance plan to help them manage financial loss from overwinter bee colony damage or loss. [Bee Health Production Insurance](#) gives participating beekeepers the confidence and security to reinvest in their operations, encouraging greater innovation, profitability and job creation and provides them with the same financial support that beekeepers in other provinces receive. The government is working to strengthen the apiculture industry. [OMAFRA](#) is committed to working with farmers, beekeepers and other stakeholders to implement long-term, sustainable initiatives to improve the health of bees and other pollinators.

References

[Canadian Association of Professional Apiculturists](#) (CAPA) Statement on honey bee losses in Canada. 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015 and 2016.

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Accessible image descriptions

Figure 1. Type of varroa mite monitoring method used by commercial and small-scale beekeepers in 2017

Figure 1 shows the type of varroa mite monitoring method used by commercial and small-scale beekeepers in 2017. Survey respondents could reply with more than one answer. Commercial beekeepers reported 20 cases of the sticky board method, 69 cases of the alcohol wash method, 19 cases of other and 21 cases of no monitoring for varroa mites. Small-scale beekeepers reported 53 cases of the sticky board method, 27 cases of the alcohol wash method, 28 cases of other and 36 cases of no monitoring for varroa mites.

Figure 2. Overwinter mortality (%) reported by commercial beekeepers in Ontario (blue) and Canada (grey) from 2006-2007 to 2017-2018

Figure 2 shows the % overwinter mortality reported by beekeepers in both Ontario and Canada from 2007 to 2018. The reported overwinter mortality in Ontario and Canada (respectively) was the following: 2007 – 37% and 29%; 2008 – 33% and 35%; 2009 – 31% and 34%; 2010 – 22% and 21%; 2011 – 43% and 29%; 2012 – 12% and 15%; 2013 – 38% and 29%; 2014 – 58% and 25%; 2015 – 38% and 16%; 2016 – 18% and 17%; 2017 – 27% and 25%; 2018 – 46% and 33%.

2017 Apiculture winter loss report

2017 Honey bee colony winter mortality

The number of colonies operated by beekeepers fluctuates throughout a year. After a decrease in colony numbers over the winter months, a beekeeper can build up colony numbers during the summer months by splitting larger, healthy colonies into smaller nucleus colonies. As of December 31, 2016, Ontario beekeepers had registered 97,342 colonies which represents the number of registered colonies that were alive going into winter of 2016-2017.

Overwinter mortality for **2016-2017** for commercial beekeepers operating in Ontario was estimated to be **27%**.

The estimated loss reported for small-scale beekeepers was 29% and the 2017 estimation for honey bee loss averaged between all of Canada was 25%.

Who we surveyed

In the spring of 2017, the survey was distributed to:

- 179 registered commercial beekeepers (defined as operating 50 or greater colonies)
- 400 randomly selected registered small-scale beekeepers (defined as operating 49 or fewer colonies).

Beekeepers had the option of responding to the survey:

- electronically via an online survey
- by submitting a completed hard copy
- by phone

The survey is voluntary and all responses are self-reported by beekeepers. Data is not verified by the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) or any other independent body.

Responses were received from 98 commercial beekeepers and 133 small-scale beekeepers which represents 40% of beekeepers who received the survey.

Of the beekeepers who were registered in Ontario as of December 31, 2016, responses were received from 55% of commercial beekeepers representing 44,183 colonies and from 5% of small-scale beekeepers representing 1,098 colonies (Table 1 and Table 2). Combined, the responses represent 47% of the total number of registered colonies.

Table 1. Number of beekeepers, by region, responding to the 2017 Ontario Apiculture Winter Loss Survey

Beekeeping regions	# of commercial beekeeper respondents	% of commercial beekeeper respondents	# of small-scale beekeeper respondents	% of small-scale beekeepers respondents
Central	40	40.8%	46	34.6%
East	13	13.3%	37	27.8%
North	5	5.1%	12	9.0%
South	29	29.6%	29	21.8%
Southwest	11	11.2%	9	6.8%

Table 2. Estimated overwinter mortality for 2016-2017

Beekeeper type	# of full-sized colonies put into winter in fall 2016	# of viable overwintered colonies as of May 15, 2017	# of non-viable colonies as of May 15, 2017	Overwinter mortality (%)
Commercial	44,183	32,294	11,889	27%
Small-scale	1,098	777	321	29%

Results

Registered commercial and small-scale beekeepers in Ontario reported an approximate 27% and 29% overwinter mortality, respectively, during the winter of 2016-2017 (Table 2). In Canada, 15% is the maximum level of overwinter loss considered to be acceptable and sustainable by the industry (Furgala and McCutcheon, 1992; CAPA, 2007 to 2016).

The estimated overwinter honey bee mortality and the number of respondents varied by beekeeping region (Table 3). Commercial beekeepers reported the greatest losses in the south region while small-scale beekeepers reported the highest losses in the eastern region. Overall, mortality during the 2016-2017 winter differed by approximately 2 percentage points between commercial and small-scale beekeepers (Table 2).

Table 3. Number of commercial and small-scale beekeeper survey respondents and the % overwinter mortality in 2017 for each beekeeping region in Ontario

Beekeeping region	# of commercial beekeeper respondents	Commercial beekeeper overwinter mortality (%)	# of small-scale beekeeper respondents	Small-scale beekeeper overwinter mortality (%)
Central	38	19%	46	29%
East	10	26%	37	40%
North	4	12%	12	22%
South	29	33%	29	25%
Southwest	11	20%	9	18%
Total	92*	27%	133	29%

*Responses were not received from 2 respondents from the central region, 3 from the east region and one from the north region.

When respondents were grouped by operation size (number of colonies managed), the honey bee mortality during the winter of 2016-2017 ranged from 15.4% to 35.1% (Table 4). Beekeepers operating 501 to 1000 colonies reported fewer honey bee colony losses (15.4%) than other beekeepers. Similar to previous years, the number of respondents in the 501 to 1000 colonies category was low and this apparent reduction in mortality among this group could be due to the small sample size.

The greatest number of survey respondents had beekeeping operations with fewer than 10 colonies. As in previous years, operations with fewer than 10 colonies reported the greatest overwinter honey bee mortality (35%). This group may be comprised of new beekeepers and persons who keep bees as a hobby. Therefore, this group may not have as much experience as commercial beekeepers which could contribute to the increased overwinter mortality.

Table 4. Overwinter honey bee mortality during the winter of 2016-2017 by size of beekeeping operation (number of colonies operated)

# of respondents	# of colonies reported in the fall of 2016	Overwinter mortality (%)
97	<10	35.1%
35	10-49	26.8%

# of respondents	# of colonies reported in the fall of 2016	Overwinter mortality (%)
56	50-200	29.2%
19	201-500	22.5%
6	501-1000	15.4%
9	>1000	29.1%

Main factors of bee mortality

Beekeepers were asked to report on what they believed were the main factors contributing to their overwinter honey bee mortalities; they were able to select as many reasons as they felt were applicable. These opinions may be based on observable symptoms or beekeeper experience, judgment or best estimate.

The most commonly reported factors influencing overwinter mortality (Table 5) by commercial beekeepers included:

- poor queens
- starvation
- weak colonies in the fall

The most commonly reported factors influencing overwinter mortality (Table 5) by small-scale beekeepers included:

- weather
- weak colonies in the fall

Table 5. Contributing factors to honey bee colony mortality during the winter of 2016-2017 as reported by commercial and small-scale beekeepers

Suspected cause(s) of colony loss	# of commercial beekeepers reporting	# of small-scale beekeepers reporting
Starvation	33	21
Poor queens	40	15
Weather	26	28
Ineffective varroa control	30	23
Nosema	9	2
Weak colonies in the fall	32	26
Other	23	25
Don't know	23	20

Management practices for pests and disease

There are many theories which aim to explain the observation of increased overwinter honey bee mortality in recent years. The scientific literature suggests that honey bee health is complex and that there are many factors that contribute to honey bee colony health. For example, colonies may be weakened or killed by pests and/or diseases, such as infestation by the parasitic mite, *Varroa destructor*. Poor management practices,

including small cluster size, inadequate food stores and inadequate control of varroa mites may contribute to winter losses. Other factors such as severe weather, habitat loss and exposure to pesticides are environmental stressors which may potentially impact colony health.

While some factors contributing to colony mortality, such as severe weather, are not within the direct control of the beekeeper, monitoring for and the treatment of pests and diseases can be controlled by the beekeeper. For this reason, the 2017 winter loss survey focused on the surveillance, management and monitoring of three major pest and disease threats to colony health:

- varroa mites
- nosema
- American foulbrood

Varroa mites (*Varroa destructor*)

In this survey, beekeepers were asked how they monitored for varroa mite infestations (Figure 1) and which treatments were used at the beginning (spring) and the end (fall) of the 2016 beekeeping season (Table 6).

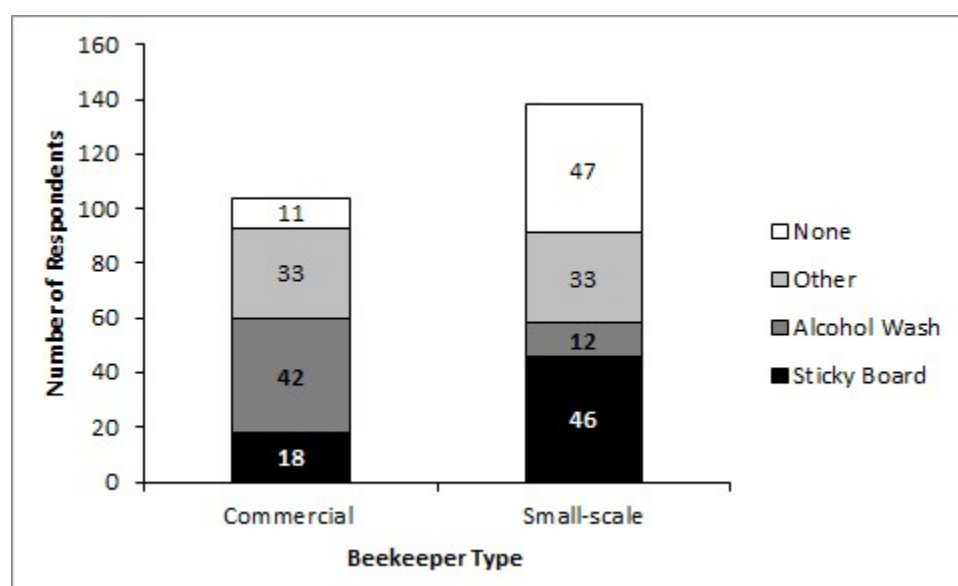


Figure 1. Type of varroa mite monitoring method used by commercial and small-scale beekeepers in 2016. Survey respondents could reply with more than one answer.

[Accessible description of figure 1](#)

Proportion of beekeepers monitoring for varroa mites

Of the beekeepers who responded to the varroa mite monitoring question, 89% of commercial beekeepers and 65% of small-scale beekeepers advised that they monitor for varroa mite infestation in their colonies. Of those, a number of methods were used, the most common being either an alcohol wash or a sticky board.

Some beekeepers used more than one method to monitor for varroa mites. When the response “other” was selected, the beekeeper commonly reported that they visually checked their colonies for varroa mites or used the “sugar shake” method. However, neither of these methods are recommended as visually checking for mites is not proven to yield usable information and the sugar shake method can be unreliable and it is not tied to established thresholds for Ontario.

Treatments used to control varroa mites

Ontario beekeepers use a variety of treatment options to manage varroa mites (Table 6). In spring and fall of 2016, the most common method of varroa mite treatment reported by commercial beekeepers was Apivar®. Commercial beekeepers also reported using 65% liquid formic acid (40 ml multiple application), Mite Away Quick Strips™ and Apistan®. Small-scale beekeepers indicated a preference for Mite Away Quick Strips™ over other forms of mite control options. Although there has been documented resistance to some mite control products such as Apistan® and Checkmite+™, there have been no documented cases of Apivar®-resistant varroa mites in Ontario to date.

The two least commonly used treatments by both commercial and small-scale beekeepers were Checkmite+™ and Thymovar. To slow the development of resistance to chemical treatments, Ontario beekeepers are advised to rotate varroa mite treatments as part of an integrated pest management strategy.

Table 6. Treatments reported by commercial and small-scale beekeepers used to control varroa mites in the spring and fall of 2016. Survey respondents could select more than one answer.

Varroa mite treatment (active ingredient)	Spring 2016 # of commercial beekeepers	Spring 2016 # of small-scale beekeepers	Fall 2016 # of commercial beekeepers	Fall 2016 # of small-scale beekeepers
Apistan® (fluvalinate)	7	7	14	15
CheckMite+™ (coumaphos)	1	1	1	2
Apivar® (amitraz)	23	7	46	19
Thymovar (thymol)	1	3	3	3
65% formic acid – 40 ml multiple application	16	20	15	20
65% formic acid – 250 ml single application	4	6	6	3
Mite Away Quick Strips™ (formic acid)	13	26	21	36
Oxalic Acid	6	5	30	19
Other	3	7	1	4
None	32	57	7	28

Nosema spp. (*N. apis* and *N. ceranae*)

The majority of survey respondents did not treat for nosema during 2016 (Table 7). Seventy-three% of beekeepers (both commercial and small-scale) who responded to this survey question indicated that nosema treatment was not applied in the spring and 71% of respondents did not treat for the disease in the fall of 2016.

Table 7. Treatments reported by commercial and small-scale beekeepers used to control nosema in the spring and fall of 2016

Nosema	Spring 2016	Spring 2016	Fall 2016	Fall 2016
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treatment	# of commercial beekeepers	# of small-scale beekeepers	# of commercial beekeepers	# of small-scale beekeepers
Fumagillin	16	35	21	34
Other	0	3	0	3
None	76	92	72	92

American foulbrood (*Paenibacillus larvae*)

The majority of commercial beekeepers (78%) who responded to this survey question treated for American foulbrood (AFB) during 2016 and the most common treatment reported was oxytetracycline (Table 8). Forty-one% of small-scale beekeepers reported treating for AFB in the spring and 44% of small-scale beekeepers used AFB treatments in the fall (Table 8). Although oxytetracycline-resistant AFB has been detected in other jurisdictions such as the USA, there have not been any documented cases of resistant forms in Ontario to date.

Table 8. Treatments reported by commercial and small-scale beekeepers used to control American foulbrood in the spring and fall of 2016

American foulbrood treatment	Spring 2016 # of commercial beekeepers	Spring 2016 # of small-scale beekeepers	Fall 2016 # of commercial beekeepers	Fall 2016 # of small-scale beekeepers
Oxytetracycline	71	52	70	51
Tylosin	1	0	1	0
Other	1	1	2	1
None	22	79	23	75

Ontario's overwinter mortality

The [Canadian Association of Professional Apiculturists](#) compiles overwinter mortality data provided by each province and publishes an annual report on national honey bee colony losses. Ontario beekeepers have frequently reported overwinter mortalities higher than the national average (Figure 2).

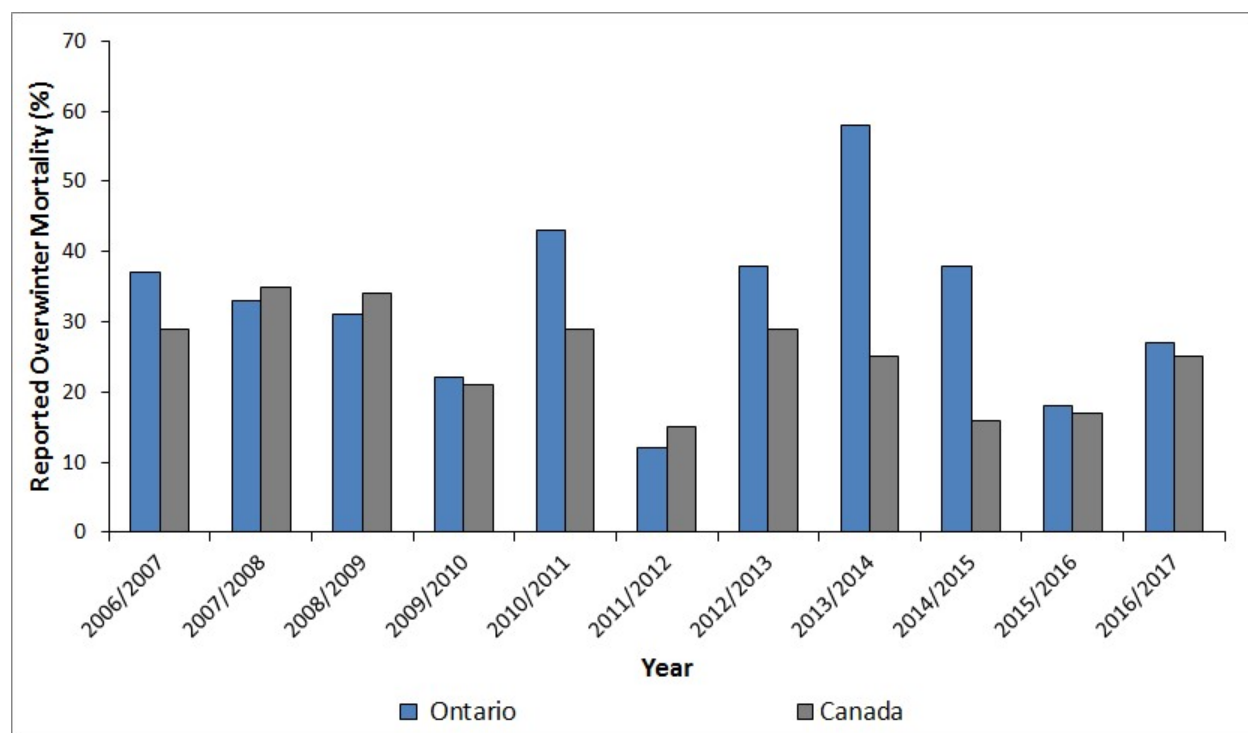


Figure 2. Overwinter mortality (%) reported by commercial beekeepers in Ontario (blue) and Canada (grey) from 2006-2007 to 2016-2017.

[Accessible description of figure 2](#)

Since 2010, Ontario beekeepers have reported annual overwinter honey bee colony losses of 15% or greater in all years except 2012 (12%). In Canada, 15% is the maximum of overwinter losses considered to be acceptable and sustainable by the apiculture industry (Furgala and McCutcheon, 1992; CAPA, 2007 to 2016). During the winter of 2013-2014, Ontario beekeepers reported a record 58% overwinter mortality. In 2014-2015 and 2015-2016, the estimated overwinter mortality declined to 38% and 18%, respectively. This was followed by a 27% overwinter mortality in 2016-2017. While Ontario beekeepers have reported overwinter mortality higher than the national average in recent years, colony losses are lower compared to reported losses for beekeepers in the United States. American beekeepers reported 40.5% losses in 2015-2016 followed by 33% overwinter mortality in 2016-2017 (Steinhauer et al., 2017).

General comments and discussion

The annual Ontario Apiculture Winter Loss Survey is a valuable tool for gathering information on colony mortality and the management practices used by beekeepers to monitor and control pests and diseases. Honey bee colony mortality differs from year to year, among different beekeeping regions as well as between individual beekeeping operations. This survey alone cannot paint a complete picture of honey bee health as honey bee health is complex and it is difficult to attribute overwinter losses to any single cause. The main stress factors influencing declines in the number of pollinators in Ontario have been identified as:

- extreme weather and climate change
- disease, pests and genetics
- reduced habitat and poor nutrition
- exposure to pesticides

Ontario's Pollinator Health Action Plan was developed to help address several of the key stressors on pollinator health. Implementation of the action plan is ongoing and includes:

- investing \$1 million in innovative pollinator health research
- working to restore and protect one million acres of pollinator habitat across the province
- developing and delivering a suite of activities and programs designed to enhance beekeeper knowledge of emerging issues and research, best management and integrated pest management practices

Additionally, commercial beekeepers have access to a production insurance plan to help them manage financial loss from overwinter bee colony damage or loss. [Bee Health Production Insurance](#) gives participating beekeepers the confidence and security to reinvest in their operations, encouraging greater innovation, profitability and job creation and provides them with the same financial support that beekeepers in other provinces receive. The government is working to strengthen the apiculture industry. [OMAFRA](#) is committed to working with farmers, beekeepers and other stakeholders to implement long-term, sustainable initiatives to improve the health of bees and other pollinators.

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Accessible image descriptions

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Figure 1 shows the type of varroa mite monitoring method used by commercial and small-scale beekeepers in 2016. Survey respondents could reply with more than one answer. Commercial beekeepers reported 18 cases of the sticky board method, 42 cases of the alcohol wash method, 33 cases of other and 11 cases of no monitoring for varroa mites. Small-scale beekeepers reported 46 cases of the sticky board method, 12 cases of the alcohol wash method, 33 cases of other and 47 cases of no monitoring for varroa mites.

Figure 2. Overwinter mortality (%) reported by commercial beekeepers in Ontario (blue) and Canada (grey) from 2006-2007 to 2016-2017

Figure 2 shows the % overwinter mortality reported by beekeepers in both Ontario and Canada from 2007 to 2017. The reported overwinter mortality in Ontario and Canada (respectively) was the following: 2007 – 37% and 29%; 2008 – 33% and 35%; 2009 – 31% and 34%; 2010 – 22% and 21%; 2011 – 43% and 29%; 2012 – 12% and 15%; 2013 – 38% and 29%; 2014 – 58% and 25%; 2015 – 38% and 16%; 2016 – 18% and 17%; 2017 – 27% and 25%.

Footnotes

- [1] [^] Guzmán-Novoa, E., L. Eccles, Y. Calvete, J. McGowan, P. Kelly and A. Correa-Benítez (2010). Varroa destructor is the main culprit for the death and reduced populations of overwintered honey bee

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- [3] ^Emsen, B., A. De la Mora, B. Lacey, L. Eccles, P. G. Kelly, C. A. Medina-Flores, T. Petukhova, N. Morfin and E. Guzman-Novoa (2020). Seasonality of *Nosema ceranae* infections and their relationship with honey bee populations, food stores, and survivorship in a North American region. *Veterinary Sciences* 7(3): 131.

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