Alberta 2009 Survey of Honey Bee Colony Winterkill and Management Practices

Final Report

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Executive Summary

In the spring of 2009, Alberta beekeepers once again found high winterkill losses in wintered bee colonies. To determine the extent and possible causes of the winterkill, Alberta Agriculture and Rural Development conducted a survey of 95 beekeepers that have 400 or more colonies. The response rate was 82%. Survey results show that 28% of Alberta bees were killed in the 2008/2009 winter, which is similar to the unusually high winterkill found in the previous two years. Of the surviving colonies, 13% were weak with less than three frames covered with bees in comparison to 8 frames of bees in average strength colonies. Throughout the entire province, 54% of the beekeepers reported losing one-third or more of their productive colonies in 2009 due to winterkill and weak colonies. However, 14% of the beekeepers were able to effectively control Varroa and Nosema and achieve substantially low winterkill and weak colonies (14%).

Overwinter losses in Alberta during 2008/09 may be attributed to a combination of several causes. The most important possible cause for reported high winterkill was increased infestation of Varroa mites and failure of chemical control products. Varroa has become resistant to Apistan and Checkmite+. In 2008 beekeepers used one or a combination of several available treatment measures to control mites but the efficacy of available treatments appeared poor. When Apivar received an emergency registration and became available, 41% of the beekeepers switched to Apivar to achieve an effective treatment to protect winter bees from further damages caused by Varroa mites. Survey participants commented that additional effective control products are desperately needed.

The prolonged winter coupled with a cold, late spring aggravated the winterkill problem in Alberta. Outdoor wintered colonies experienced higher numbers of winterkill and weak colonies than indoor wintered colonies in the same region. Honey bees that wintered outdoors suffered more from Nosema, leading to high percentages of colonies killed or weakened by the end of winter. Participant beekeepers in the survey ranked winter weather similar to Varroa mites' rank as the most important factor causing reported high winterkill in 2008.

Most beekeepers reported high rates of visible Nosema-like symptoms in wintered bee colonies. Despite beekeepers fed fumagillin medicated sugar syrup in the fall to control Nosema, the chemotherapy did not work effectively. Assuming these symptoms were caused by Nosema, the percentage of bee colonies with Nosema like symptoms significantly correlated with winterkilled and weak colonies. To improve Nosema control measures, beekeepers have started to monitor nosema levels in their colonies and improve treatment methods.

Overall the combination of weather, Varroa infestation and Nosema are most likely the cause of high winterkill in Alberta. These factors are currently under study to improve honey bee pest surveillance and management.

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Introduction

Over the winter of 2006/07 and 2007/08, Alberta beekeepers experienced high winterkill in overwintered colonies. The average winterkill was twice the long term average that is considered to be 15%. This high percentage, however, is in line with averages of reported winterkill losses across Canada during the same period. These losses of bee colonies were severe and had become of a considerable concern to the beekeeping industry. The estimated economic losses to the beekeeping industry based on estimates and survey information of winterkill in 2007 were determined to be between $16.7 and $24.65 million in Alberta[1].

In spring of 2009, Alberta beekeepers found high winterkill losses again. To determine the extent of winterkill damage, Alberta Agriculture and Rural Development conducted a survey of 95 beekeepers with 400 or more colonies. These beekeepers operate 207,418 out of 235,000 bee colonies kept in Alberta. The Ag-Info Centre conducted the Bee Loss and Management Survey (Appendix 1) in May 2009.

The data are summarized by five agricultural regions (Appendix 2). Statistical differences were determined by t-tests (one or two-tailed, depending upon hypothesis).

Results

Profile of Participant Beekeepers

Descriptive statistics of responses and bee colonies surveyed and wintered in Alberta in 2008/09 are summarized in Table 1. A total of 78 responses were received (82 percent response rate). The results represent 176,782 colonies of 207,418 colonies (400 or more/beekeeper) in Alberta, about 85% of Alberta's colonies. The number of bee colonies is the largest in southern Alberta followed by the Peace River region (Table 1). Region 2 has a limited number of responses due to having a limited number of commercial beekeepers with 400 colonies or more.

In most regions, the average number of colonies per beekeeper is skewed by a few large beekeeping operations, and thus the median (value where half the cases are higher and half are lower) better represents the "middle" or central value. In spite of beekeepers' efforts to replace their dead outs and increase the number of honey bee colonies in 2008, the number of bee colonies decreased by 8% in Alberta in comparison to number of bee colonies in 2007. In 2008 the total number of bee colonies kept in Alberta was 235,000. In 2009 Alberta beekeepers have continued once again their efforts to replace 2008/2009 dead colonies. The final total number of bee colonies for 2009 will be determined in 2010 survey.

Overwintering Methods

There were differences in the overwintering methods in the various regions. Beekeepers in central regions 2, 3 and 4 primarily overwintered colonies outdoors in

Alberta. In the south region, the majority of colonies were overwintered outdoors, but there were also a significant portion (24%) of colonies overwintered indoors. In region 5 (Peace River region), most colonies were overwintered in British Columbia (48%), indoors (27%), and outdoors in Alberta (25%). The number of colonies wintered in British Colombia increased in 2008/09 in comparison to 2007/08. More beekeepers over-wintered bee colonies in British Colombia for the first time to reduce the stress on bees due to long cold winters in the Peace River region.

Table 1. Descriptive statistics of colonies and wintering methods

Descriptive Statistics	Region					Overall AB
	1	2	3	4	5	
Total colonies overwintered Alberta colonies in fall of 2008						
No. of Cases	17	3	13	22	23	78
No. of Colonies	59,744	12,612	22,703	31,713	50,010	176,782
% of Total Colonies	34%	7%	13%	18%	28%	100%
Average Colonies	3,514	4,204	1,746	1,442	2,174	2,266
Median colonies	2,100	4,700	2,134	973	1,800	1,799
Overwintered colonies indoor in Alberta						
No. of Cases	7	1	2	1	10	21
No. of Colonies	14372	1060	2750	660	13728	32570
Average Colonies	2053	1060	1375	660	1373	1551
Median colonies	850	1060	1375	660	1190	1063
Overwintered colonies outdoor in Alberta						
No. of Cases	14	3	13	19	16	67
No. of Colonies	43872	11552	19953	26970	12182	114529
Average Colonies	3134	3851	1535	1419	761	1709
Median colonies	1950	4700	1300	1000	490	1271
Colonies from Alberta overwintered outside in British Colombia						
No. of Cases	1	-	-	-	7	8
No. of Colonies	1500	-	-	-	24100	25600
Average Colonies	1500	-	-	-	3443	3200
Median colonies	1500	-	-	-	3300	3075

Type of Honey Bee Hives in Alberta

The percentages of beekeepers who keep honey bee colonies in double and single brood chambers were 90% and 34%, respectively (Table 2). These reported percentages include some beekeepers who keep the majority of their bees in double brood chamber and a few in single brood chambers. Most beekeepers preferred to keep honey bee colonies in double brood chambers to ensure that there is enough stored feed for wintering in Alberta. Beekeepers who overwintered indoors or in British Colombia mostly used single brood chamber hives. In recent years a few beekeepers has started to winter bee colonies in single brood chamber hives to improve the efficacy of treatments, specially when formic acid or oxalic acid are used for mite treatments.

Table 2. Percent colonies with double vs single brood chamber

Descriptive statistics	Region					Overall AB
	1	2	3	4	5	
Double						
No. of Cases	15	3	8	16	22	64
Average of % double	97	78	92	94	83	90
Median of % double	100	85	97	100	100	99
Single						
No. of Cases	3	2	5	3	6	19
Average of % single	13	33	13	34	63	34
Median of % single	10	33	15	33	65	35

Honey Production in 2008

Honey production in 2008 for surveyed commercial beekeepers was slightly higher than in 2007 (overall 2007 134 lbs/hive) (Table 3). Honey production in region 1 was lower, partly due to high stocking rates needed for hybrid canola seed pollination. Decreased honey production in the Peace River region may be partly due to weak colonies caused by more splitting of colonies in the spring to replace dead-outs and reported drought during summer in 2008 (Appendices 3 and 4). Overall the honey production in Alberta decreased due to a decrease in total number of bee colonies kept in Alberta because of the reported high winter loss in 2007/08 and low average honey production per hive in the Peace River region.

Table 3. Beekeeper respondent 2008 honey production (lbs/hive).

Descriptive Statistics	Region					Overall AB
	1	2	3	4	5	
No. of Cases	16	3	12	19	23	73
Average (lbs per hive)	77	99	156	175	149	139

2008 Precipitation

The survey asked beekeepers to rate their summer and fall precipitation (heavy, moderate or dry). In region 1, the majority of beekeepers rated summer moisture as moderate and fall as moderate to dry. Regions 2 had moderate moisture in the summer but dry in the fall. Region 4 was rated as moderate to dry in the summer and dry in the fall. In the Peace region 5, the majority rated summer moisture as mostly dry and the fall as moderate.

This generally agrees with the Alberta precipitation map for the growing season from April through September of 2008 (Appendices 3 and 4). However, the Alberta fall/winter precipitation map shows that drier conditions than normal were experienced in regions 1 and 2. Region 3 and 4 had average rainfall while the Peace areas of region 5 experienced dry conditions in summer (Appendices 3 and 4). The dry summer and fall that coincided with the bloom period in various locations across Alberta probably explains in part the lower honey production in the Peace River region (Region 5).

Winterkill and Weak Colonies

The average winterkill was 28% in Alberta (Table 4). The winterkill averages were not significantly different from south to north in Alberta in 2009. For outdoor wintering, honey bee colonies in the Peace region reported the highest winterkill (37%), followed by regions 2, 3, 4, and 1, respectively. The reported high winterkill in the Peace region was largely due to the colder winter for longer duration in northern Alberta. March temperatures in 2009 were colder than normal (Appendix 5) which would affect the Peace region relatively more than other regions. It is noticeable that winterkill increased in region 1 in 2009 in comparison to winterkill in 2008. This increase in winterkill may be caused by high failure rates of Varroa control after using formic acid and reported cold temperatures during the application time (Appendices 5A and 5B).

The higher mortality with outdoor wintering methods suggested that winter weather can be one factor contributing to the winterkill. Winter weather received the highest rank overall when beekeepers were asked to rank five suggested main causes of winterkill. These results show that the health of wintered colonies as well as the temperature during winter can be important factors in wintering success.

The average winterkill indoors (23%) in Alberta was lower than winterkill in outdoor wintered honey bee colonies (31%). For the two regions having the most indoor wintering (regions 1 and 5), there was a significant statistical difference ($p=0.04$) between mortality for indoors in region 1 in comparison to region 5. In Northern Alberta mature colonies and newly made colonies (splits) were wintered indoors. Southern Alberta beekeepers winter newly made colonies (splits) indoors to provide better conditions for survivorship (Table 3 and 4). Generally, new bee colonies made out of splits with young queen and strong healthy bee populations have low winter mortality.

The average winterkill for beekeepers who wintered in British Colombia was 14%. This reported percentage of winterkill was significantly lower than reported winterkill for honey bee colonies wintered in Alberta (28%). These honey bee colonies wintered in British Colombia do not suffer from long cold winter months. Moreover, honey bees have more suitable climate to stay active, less stress from Nosema and other pests, and better access for management by beekeepers through winter.

The weak colonies percentage was highest in region 2 followed by region 5. The winterkill percentage was not statistically correlated to weak colonies in spring. In comparison between weak colonies for colonies wintered outdoors to colonies wintered indoors, there was significant difference ($p<0.06$). Colonies wintered outdoors had lower percentage of weak colonies than colonies wintered indoors (Table 4). This is an expected result given that cold temperatures in the winter and early spring will have a detrimental effect on the survivorship of weak colonies overwintered outdoors. Averages of total winterkill and weak colonies are summarized in Table 4. The Peace River region had the highest average of winterkill and weak colonies (46%) in 2008/09. Overall Alberta beekeepers reported on the average 40% of bee colonies were killed and weak in 2008/09.

In 2008/09 winter, 54% of Alberta beekeepers reported losing more than one-third of their productive colonies due to winterkill and weak colonies (Table 5). The average winterkill and weak colonies was 52% for this group of beekeepers. These results are similar to previously reported results of high winterkill and weak colonies in 2006/07 and 2007/08. The rest of the beekeepers (46%) reported 24% of winterkill and weak colonies. This group includes 14% of the beekeepers who reported 14% winterkill and weak colonies. Unlike reported winterkill and weak colonies in 2007/08, there was a substantial group of beekeepers (56%) who controlled mites and reduced winterkill and weak colonies to 24%. Moreover, in the Peace River region only 25% of the producers lost more than 50% of their productive colonies. This is an improvement from earlier results in 2008 that showed 50% of the producers reported losing over half of their productive colonies.

Table 4. Dead and weak colonies found in spring of 2009.

Descriptive statistics	Region					Overall AB
	1	2	3	4	5	
% Winterkill 2008/09						
Average % dead outdoor AB	28	32	29	29	37	31
Average % dead indoor AB	14	23	10	45	25	23
Average % dead outdoor BC	10	-	-	-	18	14
Average dead in region	26	29	28	29	27	28
Median dead in region	25	25	22	30	26	26
% Winterkill in previous 5 years before 2006/07						
Average % winterkill previous 5 years before 2006/07	15	21	22	17	20	19
% Weak colonies in spring 2009						
Average of % Weak outdoor	10	13	13	9	16	12
Average of % weak indoor	13	40	8	10	17	16
Average of % Weak BC	3				30	27
Average of Total % weak	9	22	12	9	19	13
Median Total Weak	8	22	10	9	20	10
% winterkill in 2008/09 and Weak colonies in spring 2009						
Average of % winterkill + weak colonies	35	43	40	38	46	40
Median % winterkill + weak colonies	32	40	26	40	42	33

Table 5. 2009 Summary of winterkill and weak colonies occurred in winter 2008/09 in Alberta.

% winterkill category	Beekeepers (%)	Average of % Winterkill +weak
>33	54	50
21-32	32	28
[20	14	14

Bee Disappearance and Starvation

Disappearance was reported in every region (Table 6). Approximately 94% of the respondents answered this question. Responses showed that 86% of the respondent beekeepers did not report disappearance of bees. Currently, when bees disappear and causes of disappearance are unknown.

The majority of responses did not report starvation (74%) (Table 6). However, large percentages of beekeepers in regions 5 and 4 reported starvation of bee colonies as shown in Table 5. This apparent starvation can be due to the long winter and cold spring. Beekeepers were not able to get into their colonies in time to start feeding bees in early spring to prevent starvation. This starvation can be one of the causes to explain high winterkill in these two regions.

Starvation was ranked by participants as least important cause of winterkill in the final question of the survey. This discrepant result is likely due to beekeepers feeding enough syrup to their bees in the fall to go through winter. However, in years when it is too cold bees will not move around the hives to utilize stored food during winter and early spring. This is known as spring starvation and can lead to higher winterkill in later parts of winter and early spring. The responses in this survey suggest that disappearance or starvation were not major factors in the higher overwinter losses in Alberta in 2009.

Nosema

The majority (71%) of responses indicated that Nosema-like infection symptoms were noticed in every region in spring of 2009 (Table 7). The symptoms of *Nosema apis* infection include disjointed wings, distended abdomens and fecal material on combs and the entrance of hives. The particular symptom of fecal material on combs and the entrance of beehives are often correlated with dysentery. When dysentery occurs, the disease is aggravated and effectively spreads throughout the colony causing the colony to deteriorate beyond help. Results from 2007/2008 confirmed that colonies with symptoms of Nosema-like infection were infected with Nosema.

We reported in 2007 that a new species of Nosema, *Nosema ceranae*, was found in Alberta in addition to the known *N. apis.* This species of Nosema does not leave any visible symptoms on the hive to use as an indication for infection. Therefore, we don't know how wide spread this species is in Alberta. Microscopic and genome analyses are currently conducted to confirm the cause of Nosema like infection in honey bee colonies in Alberta. The winterkill percentage was not statistically different between the no and yes groups overall. This may be due to a large number of yes responses involving low levels of Nosema based on visible symptoms observed by beekeepers (see Figure 1).

In the yes group reporting Nosema-like infection, the percentage of colonies infected is highest in regions 4 and 5. There were a few high responses that skewed the averages in several regions, and thus median values are usually much lower (Table 7).

Table 6. Bee disappearance and starvation responses.

Responses	Region					Total	Overall Winterkill (%)
	1	2	3	4	5		
Disappearance	Number of responses						
No. of cases	17	3	13	22	23	78	
No. of responses to this question	17	3	12	22	21	73	
No. of no responses	12	2	8	14	13	63	
No responses (%)	71	67	67	64	62	86	
No. of cases	16	3	11	21	23	74	
Starvation							
No. of no responses	14	3	9	15	14	55	26
No. of yes responses	2	-	2	6	9	19	32
Yes responses (%)	12	-	18	29	39	26	

Table 7. Nosema-like infection response

Responses	Region					Overall AB	Overall Winterkill (%)
	1	2	3	4	5		
	Number of responses						
No. of no responses	4	1	1	8	7	21	23
No. of yes responses	13	2	9	12	16	52	29
Yes group only	% colonies with Nosema-like symptoms						
Average % colonies	15	41	23	27	21	22	
Median % colonies	10	41	8	23	15	15	
% use fall fumagillin	100	67	100	95	100	92	

Using only "Yes" responses to Nosema-like symptoms noticed in the spring, region 2 reported the highest percentage (41%) of bee colonies showing Nosema-like symptoms

Table 7). In the rest of the regions, the percentage of bee colonies that showed Nosema-like symptoms ranged from 10-23%. The percentage of colonies with Nosema-like symptoms reported by beekeepers was generally low (22%) in 2008/09 in comparison to 2007/08 when beekeepers reported 31% (ranged 5-70%).

The majority of beekeepers (97%) use fumagilin for Nosema treatment. All beekeepers applied fumagillin during fall for protecting winter bees from damages caused by Nosema. However, in 2008 we found that 78% of beekeepers started to apply fumagillin to treat colonies in spring due to high visible symptoms found on winterkilled hives.

A positive non significant correlation (r^2=0.06) was found between percentages of colonies with Nosema. The correlation between the percentages of winterkill and weak colonies and percentages of Nosema-like symptoms was significant (r^2 = 0.1425, $p<0.01$). The reported correlations in 2009 was lower than correlations reported in 2008 (Figure 2 and 3). The reported difference may be due to an increase (92% of beekeepers) in the use of fumagillan for Nosema control, achieving better control of Nosema in 2009 than 2008.

Figure 1. 2009 % Nosema and winterkill (%)

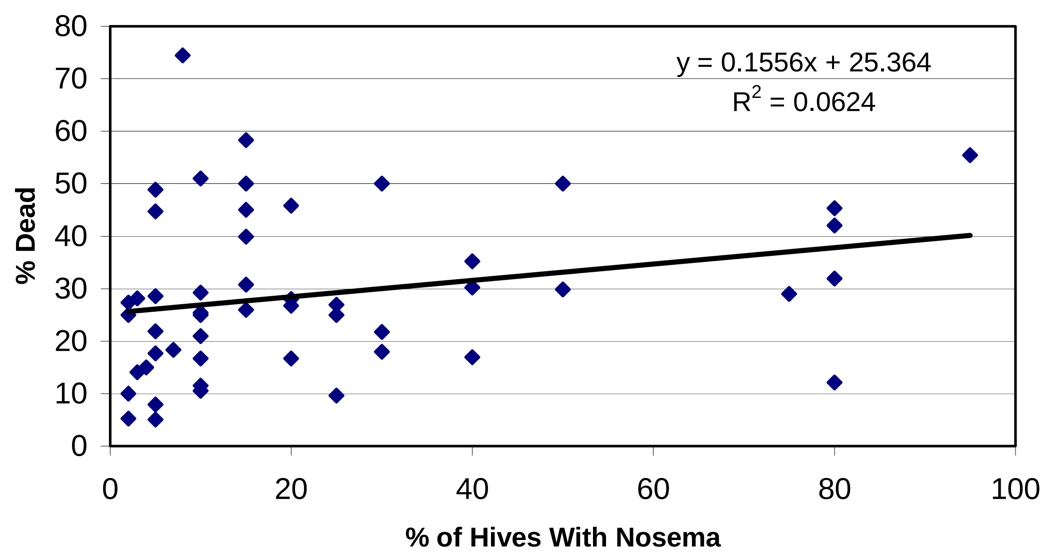


Figure 2. 2009 % Nosema and winterkill and weak (%)

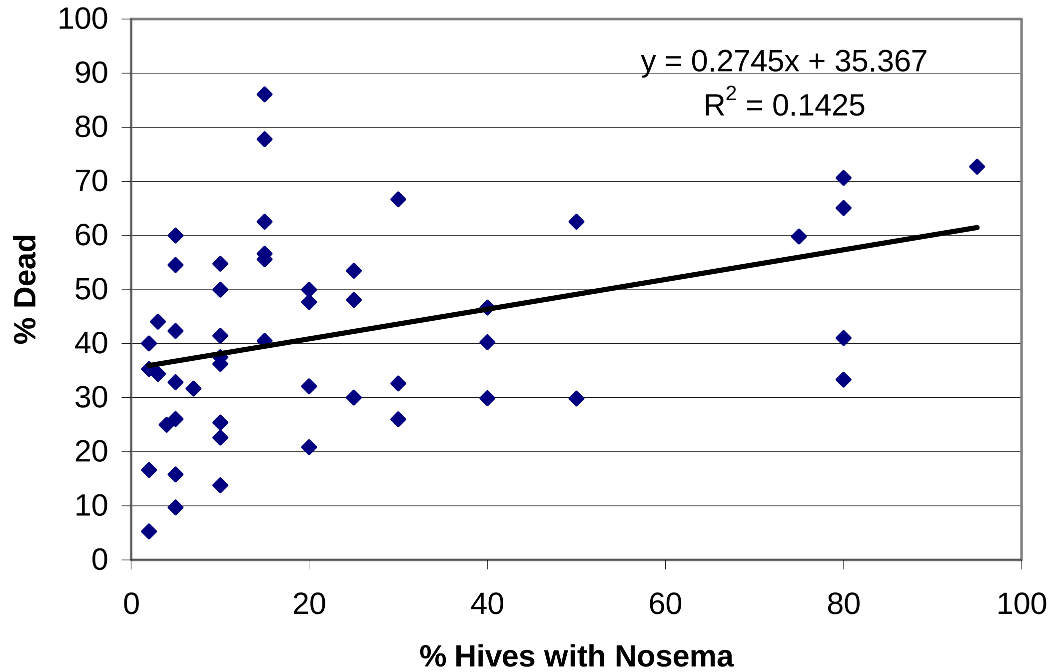
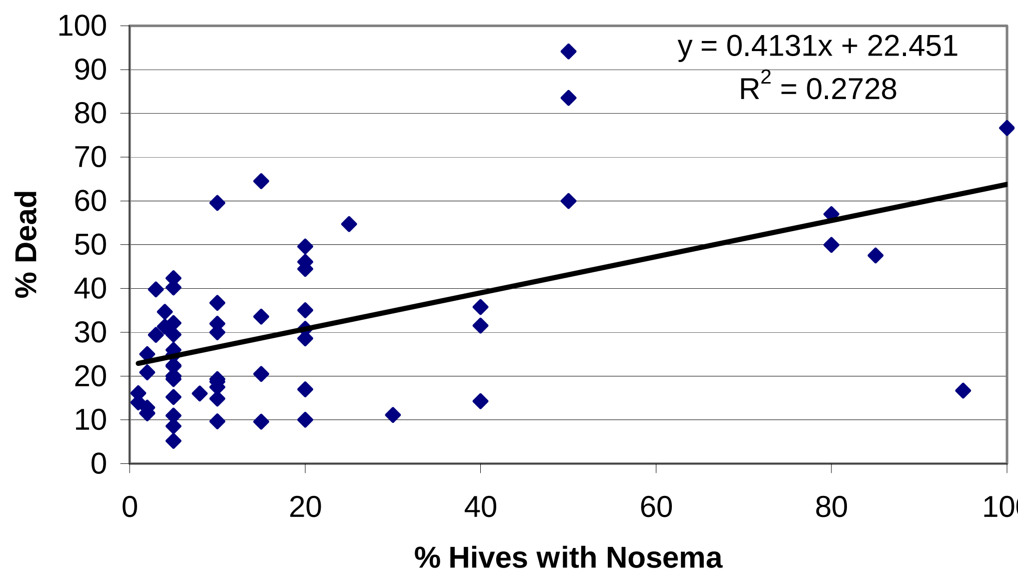


Figure 3. 2008 % Nosema and winterkill (%)



Nosema Monitoring:

In previous years, beekeepers only use visible symptoms at the entrance of bee hives as indication for Nosema-like infection. As Nosema has been suspected to be one of the possible causes of reported high winterkill, beekeepers have started to monitor Nosema infection rates in their bee colonies using a microscopic examination (Table 7). A significant portion (27%) of beekeepers started to use microscope to examine bees for Nosema infections. This has been a significant improvement over the previous years where visual examination was the most popular method used for monitoring Nosema.

Table 7. Method used in Nosema monitoring.

Responses	Region					Total	Overall % AB
	1	2	3	4	5		
No. of Cases	17	3	13	22	23	78	
Bee Guts	1	1	1	1	2	6	8
Microscope	1	1	2	3	10	17	22
Bee Guts and Microscope	-	-	1	1	2	4	5

Overall, Nosema infection in the spring of 2009 continued to be significantly associated with higher percentage of dead and weak colonies. In northern climates, Nosema is considered a silent killer of honeybees, and it has not been monitored in bee colonies. Beekeepers will only use visible symptoms as indicators for Nosema infection. This type of monitoring is not a reliable mean for diagnostics. It is encouraging to find that 27% of beekeepers have started to use microscopic examinations for diagnostics of Nosema in honey bees. When beekeepers were asked to rank possible causes of winterkill, Nosema was ranked one of the top four possible causes of high winterkill in Alberta.

Varroa Mites

Spring Treatment

Beekeepers treated more for Varroa using multiple methods and changing Varroa mite control products to deal with resistance to synthetic miticides (Table 8 and 9). The most popular Varroa treatment in spring 2008 was formic acid by itself or in combination with other treatments (Table 8 and 9). In some cases when treatments with Apistan and Checkmite+ failed, beekeepers used formic acid as a supplementary treatment to suppress mite populations in bee colonies.

The percentages of beekeepers using formic acid in spring 2006, 2007, and 2008 were 26, 41, and 60%, respectively. Beekeepers are responding to finding Varroa resistant to applied synthetic miticides by using formic acid more frequently when weather permits. They also responded to recommendations to move the application time to late spring early summer when ambient temperatures meet the required temperature range for formic acid to work effectively. The percentages of beekeepers who applied formic acid using Mitewipe, Miteaway II and Mitegone were 87%, 11% and 2%, respectively. These data show that the most common formic acid application method was the use of Mitewipe (40ml-80ml/hive), once every 7-10 days, 2-6 times/season. Beekeepers have been able to adapt this method to their locations and management systems. Thus, they were able to improve the efficacy of formic acid with non significant side effects on bees when weather permitted.

Table 8. Varroa mites - spring 2008 treatments

Treatment Method	Responses
APS	7
APS,FAMW	3
APS,FAMW,MWII	1
APS,FAMW,OAL	1
APS,FAMW,OAS	2
APS,MWII	1
APS,OAL	1
APS,OAS	1
CM	9
CM,APS	3
CM,APS,FAMW	3
CM,APS,FAMW,MWII, MG,OAL,OAS,O	1
CM,FAMW	6
FAMW	19
FAMW,MWII	1
FAMW,OAL	1
FAMW,OAS	2
MWII	1
O	1
OAL	2
OAS	4
Grand Total	70

	Apistan	Check-mite+	Formic Acid	Oxalic Acid Liquid &Sublimated
2009 Survey % of responses that included treatment	34	31	60	9/14
2008 % of responses that included treatment:	29	20	44	7/12
2007 % of responses that included treatment:	39	22	27	9/2
2006 % of responses that included treatment:	27	24	15	8

APS - Apistan; FAMW - Formic Acid Mite Wipe; MWII - Miteaway II; APS - Apistan; CM – Checkmite+; OAS - Oxalic Acid Sublimation; OAL - Oxalic Acid Liquid; MG - Mitegone; O – Other

Table 9. Summary of various methods used for Varroa control in spring 2008.

Varroa control method	# of beekeepers*	% used control method
Checkmite+	22	31.43
Apistan used	24	34.29
Formic Acid Mite wipe	40	57.14
Miteway II used	5	7.14
Mitegone used	1	1.43
Oxalic acid liquid	6	8.57
Oxalic acid sublimation	10	14.29
Other control methods	3	4.29

* A beekeeper used single or multiple methods to control varroa mites

Table 10. Summary of beekeepers percentages used various methods for applying formic acid in spring 2008.

Formic acid method of application in spring 2008	Percentages
% beekeepers used Mitewipe	87
% beekeepers used Miteaway II	11
% beekeepers used mitegone	2

Fall Treatment

The majority (87%) of beekeepers felt they had enough time to treat for Varroa mites in the fall of 2008 after harvesting honey (Table 11). If time was not enough for varroa treatment and the ambient temperatures dropped, treatments would become ineffective. Consequently, irreversible damage will be caused by Varroa mites to honey bees and high winterkill will be reported. For example, in many cases after noting the failure of treatments by Apistan or Checkmite+, some beekeepers then treated with Apivar, formic acid or oxalic acid late in the fall, but the early cold onset of winter greatly reduced the efficacy of the treatment even Apivar. By this time, Varroa had already damaged winter bees and additional treatments added more stress on the honey bees. In fact in most of these cases winterkill occurred in late fall or early part of winter. Beekeepers who had time for treatments reported 27% winterkill in comparison to beekeepers who did not have enough time (41%) (Table 11).

Formic acid was the most used Varroa treatment in the fall of 2008 followed by Apivar when it had become available in late September (Table 12). In 2008 the percentage of responses that included treatment with formic acid in fall treatments did not change from 2007/2008. Formic acid was used mostly in a combination with other treatments such as oxalic acid, Apistan, and Apivar. It was mainly used as a supplementary treatment to increase the efficacy of mite control and protect winter bees from further damage by mites.

Compared to the fall of 2007, Apistan and CheckMite$^+$ use has substantially declined to 10% and 2%, respectively (Table 12). The use of formic and oxalic acid has increased, apparently due to decreasing efficacy and development of resistance by mites to the first two miticides. When Apivar became available 41% of the beekeepers switched their treatment to Apivar to ensure achieving effective control of Varroa mites. Apivar was used to rescue the bees from the devastative high mite populations in regions where other treatments including formic acid failed due to resistance and cold temperatures. In some cases Apivar was used too late to rescue the hives because of significant damage to winter bees caused by Varroa.

Table 11. Was there enough time to treat for Varroa mites in fall 2008?

Descriptive statistics	Overall	% of responses	Overall winterkill %
# of No responses	8	13	41
# of Yes responses	53	87	27

Table 12. Varroa mites - fall 2008 treatments

Treatment Method	Responses
APS	3
APS, FAMW	1
APS, MWII	1
APV	14
APV, FAMW	2
APV, FAMW, OAS	1
APV, OAS	2
CM	1
FAMW	10
FAMW, APS	1
FAMW, APV	3
FAMW, APV, MWII	1
FAMW, APV, OAS	2
FAMW, CM	1
FAMW, CM, OAL	1
FAMW, OAL	2
FAMW, OAS	1
FAPV, AMW	1
MWII	6
MWII, OAS	1
OAL	1
OAS	7
Total	63

2008 % of responses that included treatment				
Apivar	Apistan	Checkmite	Formic Acid	Oxalic Acid Liq/Sub
41	10	2	57	6/22
2007 Fall treatments and % of responses				
	18	21	57	16/12
2006 Fall treatments and % of responses				
	24	22	40	14

% dead in 2008 fall treated: 27
% dead in 2008 fall Untreated: 41

% dead and weak in 2008 fall treated: 39
% dead and weak in 2008 fall untreated: 57

APS - Apistan; FAMW - Formic Acid Mite Wipe; MWII - Miteaway II; APS - Apistan; APV - Apivar; CM - Checkmite; OAS - Oxalic Acid Sublimation; OAL - Oxalic Acid Liquid

Table 13. Percentages of beekeepers that included various treatments for Varroa control in fall 2008.

Varroa control method	# of beekeepers	% of responses that included treatment
Apivar	26	41
Checkmite+	1	10
Apistan	6	2
Formic Acid Mitewipe	26	41
Miteway II	9	14
Mitegone	0	0
Oxalic acid liquid	4	5
Oxalic acid sublimation	14	22

The most common formic acid application method used by 74% of the beekeepers was was Mitewipe in fall 2008 (Table 14). Beekeepers applied 40ml-80ml/hive, once every 7-10 days, 2-3 times in fall 2008. The percentage of beekeepers who applied formic acid using Miteaway II was 11%. Mitegone was not used as a fall method for applying formic acid. and 2%, respectively. Beekeepers have been able to adapt this method to their locations and management systems. Thus, they were able to improve the efficacy of formic acid with non significant side effects on bees when weather permit.

Table 14. Percentages of beekeepers used various methods for applying formic acid in fall 2008.

Formic acid method of application in spring 2008	% of beekeepers used control method
% beekeepers used Mitewipe	**74**
% beekeepers used Miteaway II	**26**
% beekeepers used Mitegone	**0**

Overall, Varroa continued to be a major pest without effective treatments. Varroa has become resistant to Apivar and Checkmite+. Beekeepers started to phase out the use of Checkmite+ and a low percentage of beekeepers used Apistan. In 2008 beekeepers used one or a combination of several available treatment measures to control mites. Formic acid was the most commonly used agent for mite control in spring and fall. The majority of beekeepers used Mitewipes as the method of choice to apply formic acid to meet their locations and management systems as weather permited. When Apivar was approved for an emergency registration by Pest Management and Regulatory Agency (PMRA) and became available in late September 2008, 41% of the beekeepers switched to Apivar to achieve effective treatment and protect winter bees from further damage caused by Varroa mites.

Beekeepers who treated their colonies in the fall reported 27% and 12% winterkill and weak colonies, respectively. However in the untreated group, the percentages of winterkill and weak colonies were 41% and 16%, respectively. These results showed that failure to treat mites can cause significant losses of honey bee colonies and Varroa requires effective treatments for use by beekeepers.

Tracheal Mites

The majority of respondents treated for tracheal mites in the spring of 2008 (Table 16) and fall of 2008 (Table 15) whereas two years ago, 57% were not treating in the spring. When treating for tracheal mites, most beekeepers (88%) use formic acid. Analyses of bee samples collected in 2007 showed that 10% of beekeeping operations still have tracheal mite infestations higher than the economic threshold (10%). Therefore, beekeepers were recommended to increase the use of formic acid for treating tracheal mites. Keep in mind that formic acid can be used to treat for both Varroa and tracheal mites, with more applications needed for Varroa. Thus, by using formic acid beekeepers are able to control both Varroa mites and Tracheal mites if weather permits.

Table 15. Tracheal mite treatments in spring of 2008

Treatment Method	Responses		Percentage of responses that included treatment			
FAMW	31		Formic	Oxalic	Menthol	Other
ME	1		88	2.5	10	7.5
ME, O	1					
MW II	1		2008 Spring treatment %			
O, CHECKMITE	1		49	9	2	4
O, OXALIC	1		2007 Spring treatment %			
FAMW, MW II	2		41	3	8	5
FAMW, ME	2		2006 Spring treatment %			
Total	40		26	8	-	13

ME - Methanol; FAMW - Formic Acid Mite Wipe; MWII - Miteaway II; O - Other

Table 16. Fall 2008 tracheal mite treatments

Treatment Method	Responses		Percentage of responses that included treatment:			
ME	1		Formic	Oxalic	Menthol	Other
MW II	10		67	2.2	2.2	11
O	3		Fall 2007 treatment %			
O, OXALIC	1					
O, FAMW	1		63	6	3	1
FAMW	29		Fall 2006 treatment %			
FAMW, MW II	1					
Total	46		50	-	3	10

ME - Methanol; FAMW - Formic Acid Mite Wipe; MWII - Miteaway II; O – Other

American Foul Brood

The percentage of beekeepers that used Oxytetracycline for American foul brood treatment was 54 % and 36% in spring and fall, respectively (Table 17). Beekeepers did not use Tylosin for spring treatments. It was only used for fall treatments by 29% of the beekeepers where American foul brood was found to be resistant to Oxtetracycline. 11% of beekeepers also used irradiation to sterilize their equipment to reduce the use of antibiotics. The treatments are similar to those used in the spring of 2007. Results also showed that 46% of the beekeepers did not treat for American foul brood in the spring. The percentage of beekeepers who did not treat in the fall was 32%. There was no difference in winter losses between the untreated and treated group (data not shown).

Overall beekeepers are sparsely using antibiotics for American foul brood treatments. They did not use Tylosin in the spring to protect honey from any contamination with residues. They only use Tylosin in the fall when bees have several months to utilize this antibiotic to protect bees with negligible risk of contaminating produced honey.

Table 17 . American foul brood treatments in 2008.

Treatments	Values
Spring 2008:	
No. Responses	78
No Beepeeres used OX	42
% beekeepers used OX	54%
% beekeepers used TY	0%
Fall 2008:	
No. Responses	78
No Beepeeres used OX	28
% beekeepers used OX	36%
Ox, TY	2
% beekeepers used OX+TY	3%
No Beepeeres used TY	23
% beekeepers used TY	29%

Fall Feeding

Nearly all the respondents used sugar syrup as the fall food source (Table 18) and bees took some or most of the fall feed source down into the hive (Table 19).

Table 18. Fall 2008 bee feed source.

Fall Food Source	% of responses
Corn syrup	1
Sugar syrup	77

Table 19. Observations on bees taking fall food source into hive.

Did bees take feed down	% of responses
No	1
Yes	76

The majority of respondents (72%) reported that brood chambers were not plugged with honey. The winterkill was similar between the no and yes groups (Table 20).

Table 20. Brood chambers filled with honey.

Responses	Region					Provincial	Overall winterkill %
	1	2	3	4	5		
# of No responses	15	2	7	10	8	42	29
# of Yes responses	2	1	5	10	15	33	27

Time for Development of Winter Bees

The majority of respondents (60%) felt that there was enough time for winter bees to develop in the fall of 2008 (Table 21). There was more winterkill (p=0.005) and winterkill +weak (p=0.001) in the combined group "not enough time + not sure" than the group reporting enough time for winter bee development. In 2008 the late fall temperatures in some regions were slightly warmer than normal (see appendix 5). Consequently in most cases, the warm fall and early harvest of honey likely contributed to good winter bee development.

Table 21. Was there enough time in the fall for winter bees to develop?

Responses	Region					Total	Overall Winterkill (%)	Overall dead + weak colonies (%)
	1	2	3	4	5			
	number of responses							
No responses	2	1	1	2	4	10	41	62
Yes responses	15	2	11	19	19	15	26	37

Ranking of Four Suggested Winterkill Causes

This question was not answered consistently by beekeepers – some just checked relevant causes (no ranking), others only indicated one or two major causes, and others added other pertinent factors. Varroa mite and winter weather were ranked the most important factors (highest number of responses as 1 and 2) possibly caused reported high winterkill in Alberta. The cold spring and Nosema were ranked 3 and 4, respectively and starvation was rated least important. An additional cause mentioned by beekeepers was queen failure after introduction. Causes of failing queens are unknown at this time.

It is noted that beekeepers have still given Nosema low rank. It is important to understand that beekeepers depend on visible symptoms for Nosema diagnosis. They rarely monitored Nosema levels in their colonies throughout the year. Therefore, the role of Nosema as an important cause of winterkill is underestimated.

Comments Provided by Participants

Most participants provided comments that have been summarized into the following:

- The spring of 2009 was exceptionally cold which contributed to winterkill
- Varroa mites were a significant problem
- Need more effective pest control products registered
- High queen loss or problems with various queen sources
- Nosema was a significant problem, but no monitoring method in place
- Need to open borders for packages.

There were two aspect identified in the comments that were not addressed by the survey questions. These two aspects are the impact of queen source on the queen's performance and the impact of multiple pest treatments on the queen's health and bees' winterability.

Conclusions

Survey results show that 28% of Alberta bees died during the 2008 / 2009 winter, similar to the last two previous year. These recent winterkills are twice the long-term average (15%) in Alberta. It was also reported that 13% of the surviving colonies were weak with less than three frames covered with bees. The recovery of these weak colonies was hindered by the cold spring. The survivorship and production of these weak colonies in 2009 is questionable. The averages of winterkill plus weak colonies percentage ranged from 35% to 46% across Alberta. Overall in the province, 54% of the beekeepers reported losing over one third of their bees in 2009 due to winterkill and weak colonies. The Peace region suffered the highest winterkill and weak colonies (46%) in 2008. This reported high losses of bees (46%) in the Peace region in 2009 is lower than winterkill and weak colonies reported in 2008 (56%).

The average number of overwinter colonies per beekeeper decreased in the fall of 2008 compared to 2007, which indicates that they are still recovering to rebuild after the high winterkill losses of 2007/08.

In Canada, the overall overwinter mortality in 2008/2009 exceeded one third, which is twice the long-term average (15%)[2]. Average wintering losses in certain provinces such as New Brunswick (43%, representing only 2% of the country's colonies) and Ontario (31%, representing 12 percent of the country colonies) were very high in 2008-09. The reported high regional losses are of much greater concern across Canada. In 2008/2009 the Canadian overall average of winterkill and spring dwindling (weak colonies) is 34%. Average winter losses with spring dwindling was the highest in Alberta

(44%), followed by Prince Edward Island (40%), Ontario (31%), Manitoba (30%) and, BC (24%),

This year, losses in Alberta may be attributed to a combination of several potential causes:

- **Increasing infestation by Varroa mites and failure of chemical control products.**

  Varroa continued to be a major pest without effective treatments. Varroa has become resistant to Apivar and Checkmite+. Beekeepers started to phase out the use of Checkmite+ and a low percentage of beekeepers used Apistan. In 2008 beekeepers used one or a combination of several available treatment measures to control mites but the efficacy of available treatments appears poor. Formic acid was the most commonly used agent for mite control in spring and fall. The majority of beekeepers used Mitewipes as the method of choice to apply formic acid to meet their location and management systems as weather permited. When Apivar became available, 41% of the beekeepers switched to Apivar to achieve effective treatment and protect winter bees from further damage caused by Varroa mites. Monitoring showed that bee colonies treated with Apivar exihibited high efficacy (>95%) in killing mites. Beekeepers who treated their colonies in the fall reported 27% and 12% winterkill and weak colonies, respectively. However in the untreated group, the percentage of winterkill and weak colonies was 41% and 16%, respectively. These results showed that failure to treat mites can cause significant losses of honey bee colonies and Varroa requires effective treatment for use by beekeepers. Survey participants ranked Varroa mites as the most important factor contributing to winterkill, and many commented that additional effective control products are desperately needed.

- **The unusually cold conditions during the 2009 late winter/spring.**

  The prolonged winter with a cold, late spring aggravated the winterkill problem in Alberta. Outdoor wintered colonies experienced higher numbers of dead and weak colonies than indoor wintered colonies in the same region. Honey bees wintered outdoors experienced a very cold spring and were not able to defecate in early spring. Consequently, high percentages of colonies died or were weakened (spring dwindled) by high levels of Nosema. Participants ranked winter weather as the most important factor along with Varroa mites causing high winterkill.

- **Nosema infestations are prevalent but beekeepers don’t normally monitor this disease. The efficacy of the applied control product is questionable due to method of application.**

  Nosema is often responsible for winter loss, late winter and early spring dwindling and supersedure. In the spring of 2009, most beekeepers reported Nosema-like symptoms in spite of 100% of beekeepers applied fumagillin for Nosema treatment in the fall. Assuming Nosema-like symptoms were caused by Nosema, the percentage of infection by Nosema was positively correlated with winterkill and winterkill plus weak colonies. In addition, the prolonged cold spring weather increased the incidence of Nosema-like symptoms in northern and central regions of Alberta. Beekeepers started to monitor Nosema using microscopic examinations. This is a positive step to diagnose and treat bee colonies in timely manner to protect bees from damages caused by Nosema. Nosema was another important factor explaining winterkill determined by survey participants.

- **A small group did not have enough time for winter bee development.**

  The combination of fall weather conditions and labor availability affected some beekeepers and the development of winter bees in their colonies. The number of dead and weak colonies was substantially higher in this group.

References:

Chaudhary, N. and Nasr, M. 2007. Estimation of Potential Economic Losses for the Alberta Beekeeping Industry Due to Winter Losses in 2007. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/prm11698/$file/potential_loss_bee_industry.pdf?OpenElement **Accessed July 12, 2009.**

Pernal, S. et al. 2009. CAPA Report- 2009. http://www.agrireseau.qc.ca/apiculture/documents/Canadian%20Wintering%20Loss%20Report%202009.pdf Accessed July 12, 2009.

Appendix 1. Winterkill survey for 2008/2009.

Alberta Bee Winterkill and Management Practices Survey 2008/2009
Alberta Agriculture and Rural Development – Agriculture Research Division

The information that may identify you on this form is being collected to develop recommendations for best management practices by the Provincial Apiculturist, under the authority of Section 33 (c) of the *Freedom of Information and Protection of Privacy Act* (FOIP Act). If you have any questions about the collection, contact the Provincial Apiculturist, 17507 Fort Road NW, Edmonton, Alberta, T5V 6H3, Phone 780-415-2314.

a. Beekeeper Name: ______________________________
b. City/Town: ________________________ Telephone - Number:________________________
c. e-mail address______________________________
d. Total number of colonies over-wintered in fall of 2008: __________________

Answer questions e-i only for colonies overwintered outdoors in Alberta:

e. Number of colonies wintered outdoors in Alberta in fall of 2008: __________________
f. Number of colonies found dead in spring 2009: _________
g. Number of colonies found weak with 1 to 3 frames of bees in spring 2009: ______
h. Number of colonies surviving with 4 to 8 frames of bees in spring 2009: __________
i. Number of colonies surviving with more than 8 frames of bees in spring 2009 _______

Answer questions j-n only for colonies overwintered indoors in Alberta:

j. Number of colonies wintered indoors in Alberta in fall of 2008: __________________
k. Number of colonies found dead in spring 2009: _________
l. Number of colonies found weak with 1 to 3 frames of bees in spring 2009: _______
m. Number of colonies surviving with 4 to 8 frames of bees in spring 2009: _______
n. Number of colonies surviving with more than 8 frames of bees in spring 2009 _______

Answer questions o-s only for colonies overwintered outdoors in BC:

o. Number of colonies wintered outdoors in B.C. in fall of 2008: _____________
p. Number of colonies found dead in spring 2009: ____________
q. Number of colonies found weak with 1 to 3 frames of bees in spring 2009: _____
r. Number of colonies surviving with 4 to 8 frames of bees in spring 2009: _______
s. Number of colonies surviving with more than 8 frames of bees in spring 2009: _______

Varroa Mite Monitoring:

t. Did you monitor bees for Varroa mites in 2008? Yes ___ No ___
u. If yes, what method used:
Mite wash ___, Sticky board ___, 300 Bee shaker ___, uncapping fork ____
v. How many times did you monitor: in spring 2008:______ and in fall 2008:_________
w. Did you monitor after treatment: in spring 2008______ , in fall 2008:_______

<u>Varroa Management in 2008:</u>

x. Does your Varroahave resistance to CheckMite: Yes _____ No ______
y. Does your Varroahave resistance to Apistan: Yes _____ No _____

Spring 2008 Varroa treatment:

z. Treatment used in spring 2008: None ___
aa. CheckMite ___ Did it provide good control: Yes ____ No _____
bb. Apistan used ___ Did it provide good control: Yes _____ No _____
cc. Formic Acid mite wipe used: how many times:______
dd. Did Formic Acid mite wipe provide good control in spring: Yes ____ No _____
ee. Miteaway II: ____ Did it provide good control in spring: Yes _____ No _____
ff. Mitegone: _____ Did it provide good control: Yes ____ No ____
gg. Oxalic acid liquid ___, how many times: ____ , Did it provide good control: Yes ____ No ____
hh. Oxalic acid sublimation _____ Did it provide good control: Yes ___ No ___
Others (Please specify):

Fall 2008 Varroa treatment:

ii. Treatment None: ______
jj. Did you have enough time to treat for Varroaafter harvesting honey in fall 2008: Yes ___ No ___
kk. CheckMite ___ Did it provide good control: Yes ___ No ___.
ll. Apistan ___ Did it provide good control: Yes ___ No ___.
mm. Apivar_____ Did it provide good control: Yes ___ No ___.
nn. Formic Acid mite wipe__ how many times:___ Did it provide good control: Yes ____ No ____
oo. Miteaway II: ____ Did it provide good control: Yes _____ No _____
pp. Mitegone: _____ Did it provide good control: Yes _____ No ______
qq. Oxalic acid liquid ___ Did it provide good control: Yes _____ No ______
rr. Oxalic acid sublimation ___ Did it provide good control: Yes ____ No _____

Tracheal Mite Monitoring:

ss. Did you monitor bees for tracheal mites? Yes _____ No _____
tt. If yes, What method used: 300 bees apiary sample: _____25-50 bees colony sample:
How many times did you monitor: in spring 2008:______ and in fall 2008:_________

Tracheal mite treatment:

uu. Treatment in spring 2008: No ___ Yes ____
vv. What did you use in spring 2008: Formic Acid mite wipe___ how many times:______
Miteaway II: ____ Mitegone: _____Menthol_______
Others (Please specify):
____

ww. What did you use in fall 2008: Formic Acid mite wipe___ how many times:______
Miteaway II: ____ Mitegone: _____Menthol_______
Others (Please specify):
____

American Foul Brood (AFB):

xx. Do you have Oxytetracycline Resistant AFB? Yes ____, No _____,

AFB Treatment:

yy. AFB treatment in spring 2008: None ___
zz. Used Oxy tet in sugar syrup in spring 2008: ___ Icing sugar mix:_____
aaa. AFB treatment in fall 2008: None_____
bbb. Used Oxy tet in sugar syrup in fall 2008: In sugar syrup ___ Icing sugar mix_______
ccc. Used Tylosin in fall 200: in icing sugar mix: ________, in sugar syrup ___

Nosema Monitoring:

ddd. Did you monitor bees for Nosema? Yes ___ No ___
eee. If yes, What method used: check bee guts:_____ microscope examination: ______
fff. spore counts in spring 2008: _____ spore counts in fall 2008: _____
ggg. How many times did you monitor: in spring 2008: ____ and in fall 2008: ______

Nosema treatment in 2008:

hhh. Did you feed Fumagillin in spring 2008: Yes ___ No ___
What formulation: sugar syrup: ______ Drench: ______
Other formulation: _____________Please specify: _______________________
iii. Did you feed Fumagillin in fall 2008: Yes ____ No ____
What formulation: sugar syrup: ______ Drench: ______
Other formulation: _____________Please specify:_______________________

Fall 2008 Management and Observations:

jjj. What did you feed bees in the fall:
Nothing ___ Sugar syrup ___ Corn syrup ___
kkk. Did the bees take the feed down: Yes ___ No ___
lll. Were brood chambers plugged with honey in the fall of 2008: Yes ___ No ___
mmm. Do you think your bees had enough time to produce winter bees: Yes ___ No ___

General Observations in Spring 2009:

nnn. Did bees disappear: Yes ___ No ___
ooo. Did bees starve: Yes ___ No ___
ppp. Did you see any Nosema like infection signs on bee hives: Yes ___ No ___
qqq. Percentage of colonies with Nosema like infection signs:____%
rrr. What do you think caused your 2009 winterkill?
Rank each of the following based on their importance (1 is most important):
Varroa mite control failure _______ Nosema control failure ______
Starvation ________ Harsh winter weather ________
Cold/late spring________ Others (Please specify): ________________________

General Production Management Information:

sss. How do you run your colonies? Singles:_____ Doubles: _________ Triples:________
ttt. Percentages of Singles:_______ Doubles:______ Triples:__________
uuu. Average 2008 honey production: _______________lb /hive
vvv. Number of colonies rented in 2008 for: Hybrid canola:______BC berries:_______
www. Average rental fees for Hybrid canola:$ _____/hive BC berries: $ _____/hive
xxx. Rain in summer 2008: Heavy ____ Moderate ____ Dry ____
yyy. Rain in fall 2008: Heavy ____ Moderate _______ Dry ______
zzz. Do you use irradiation to sterilize AFB infected bee hives? Yes ____, No _____
aaaa. Do you use acetic acid to sterilize Nosema infected bee hives? Yes ___, No___
bbbb. What percentage of combs do you replace in brood chambers annually:__________

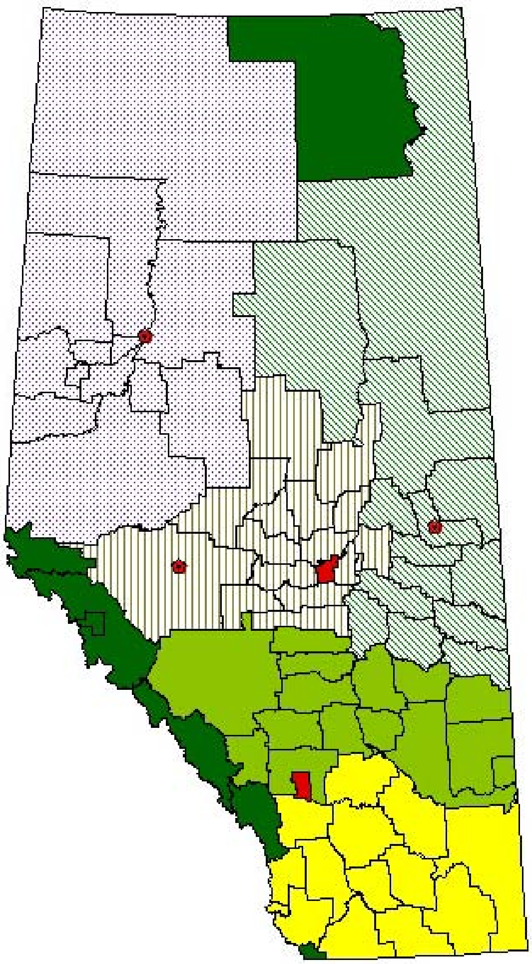
Bee and Queen Production and Purchasing in 2008:

cccc. Number of bee colony splits made in your operation in 2008: _________
dddd. Number of queens purchased in 2008:
Australia: _______ New Zealand: ______Hawaii: __________USA: _______Chile: ______
B.C. queens_______, SK queens: _______, ON queens: ______, MB _____ QC queens: _______
eeee. Number of packaged bees purchased in 2008 from:
Australia ______, New Zealand _______, Others, Please specify sources_________________
ffff. Number of bee nucs purchased in 2008 from:
B.C _______, AB_______, SK_______,ON _______, MB ______
gggg. Number of bee colonies purchased from:
B.C._____ , AB _____ , SK ______, ON ______, MB _______
hhhh. Number of queens reared in your operation:
Queens produced in 2008 _______, Queens sold in 2008 _________
iiii. Percentage of queens failed: ________ Queens became drone layers________

Commentes:

____

Appendix 2. Alberta map and regions



Region 1 South

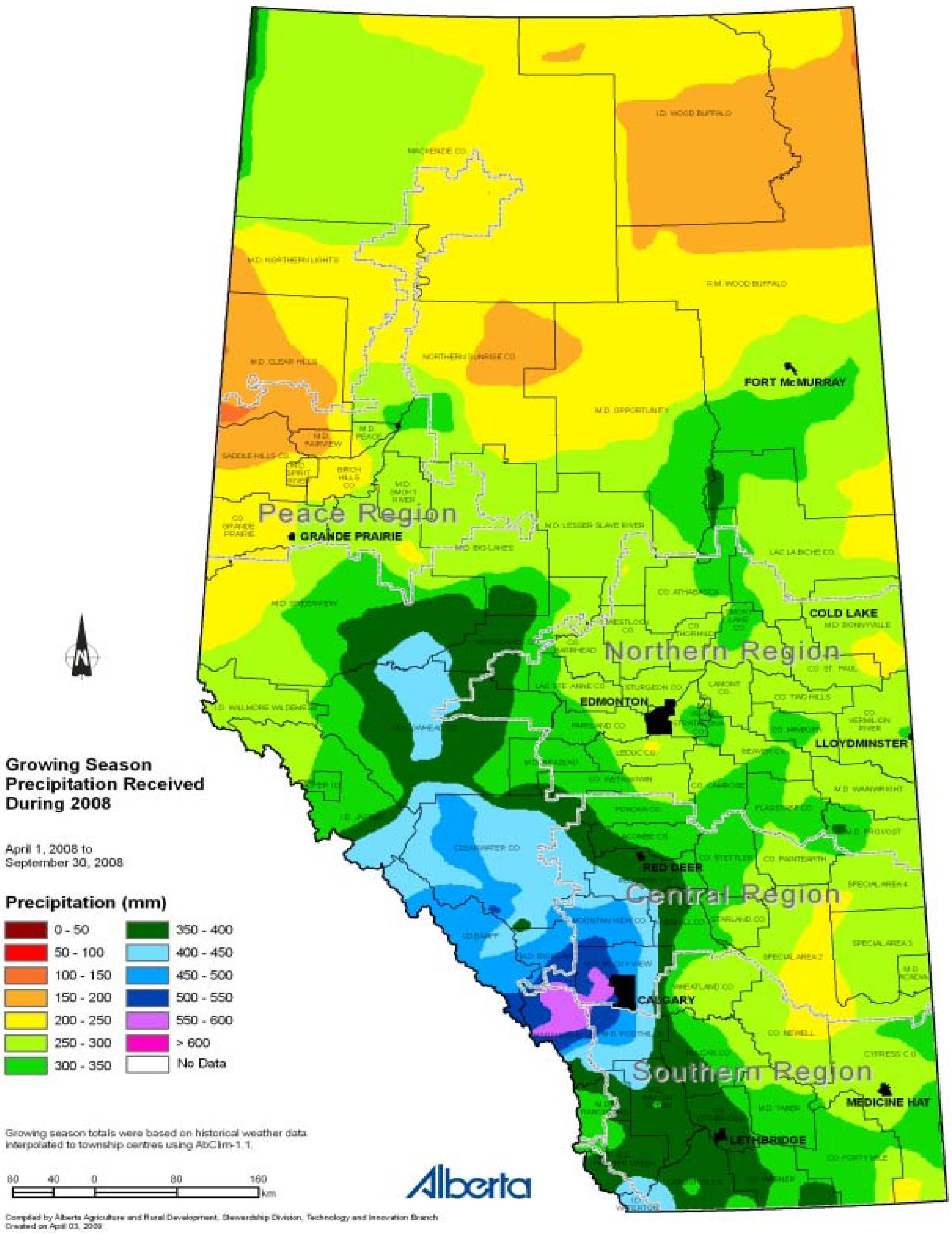
Region 2 Central

Region 3 North East

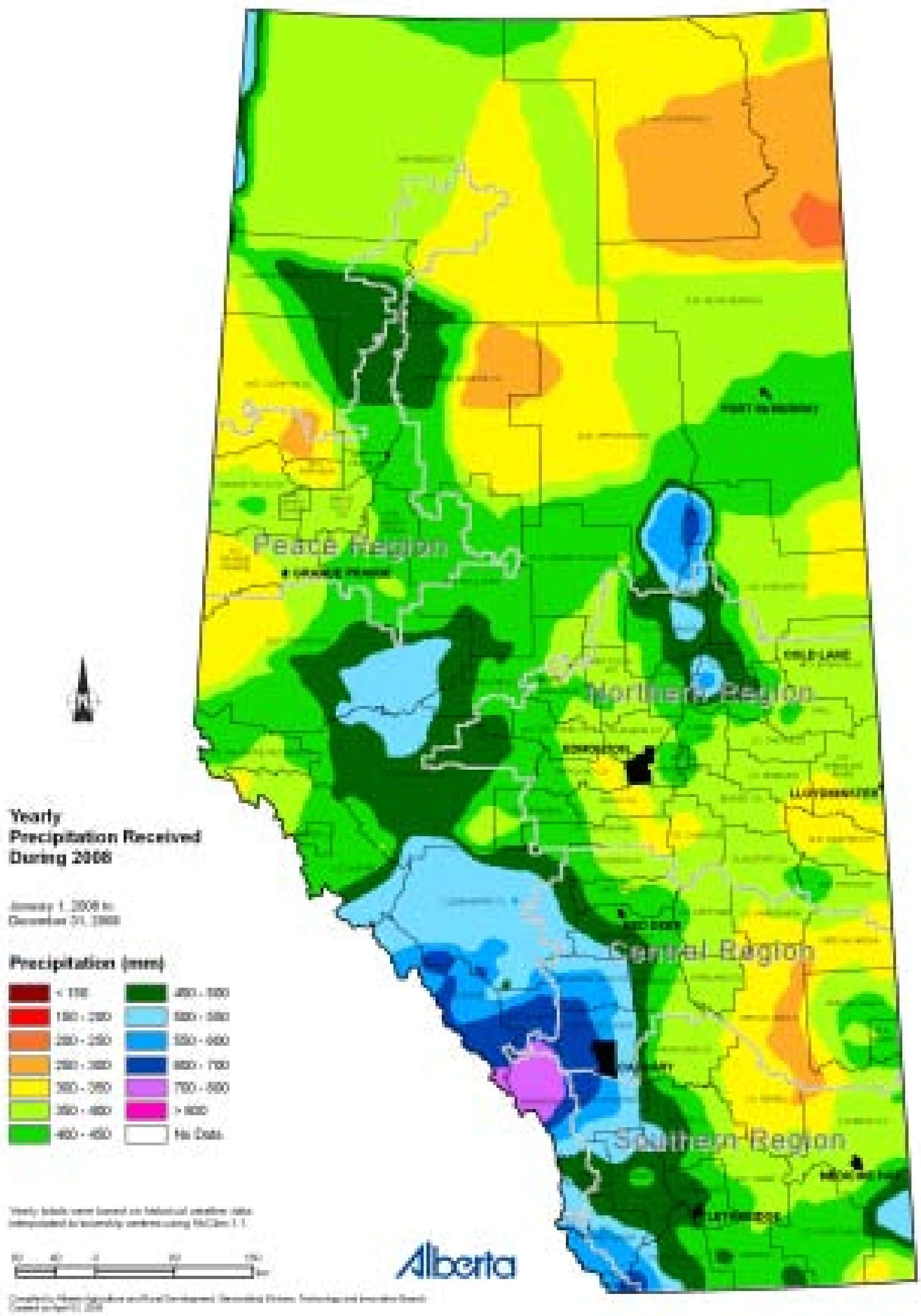
Region 4 North West

Region 5 Peace River

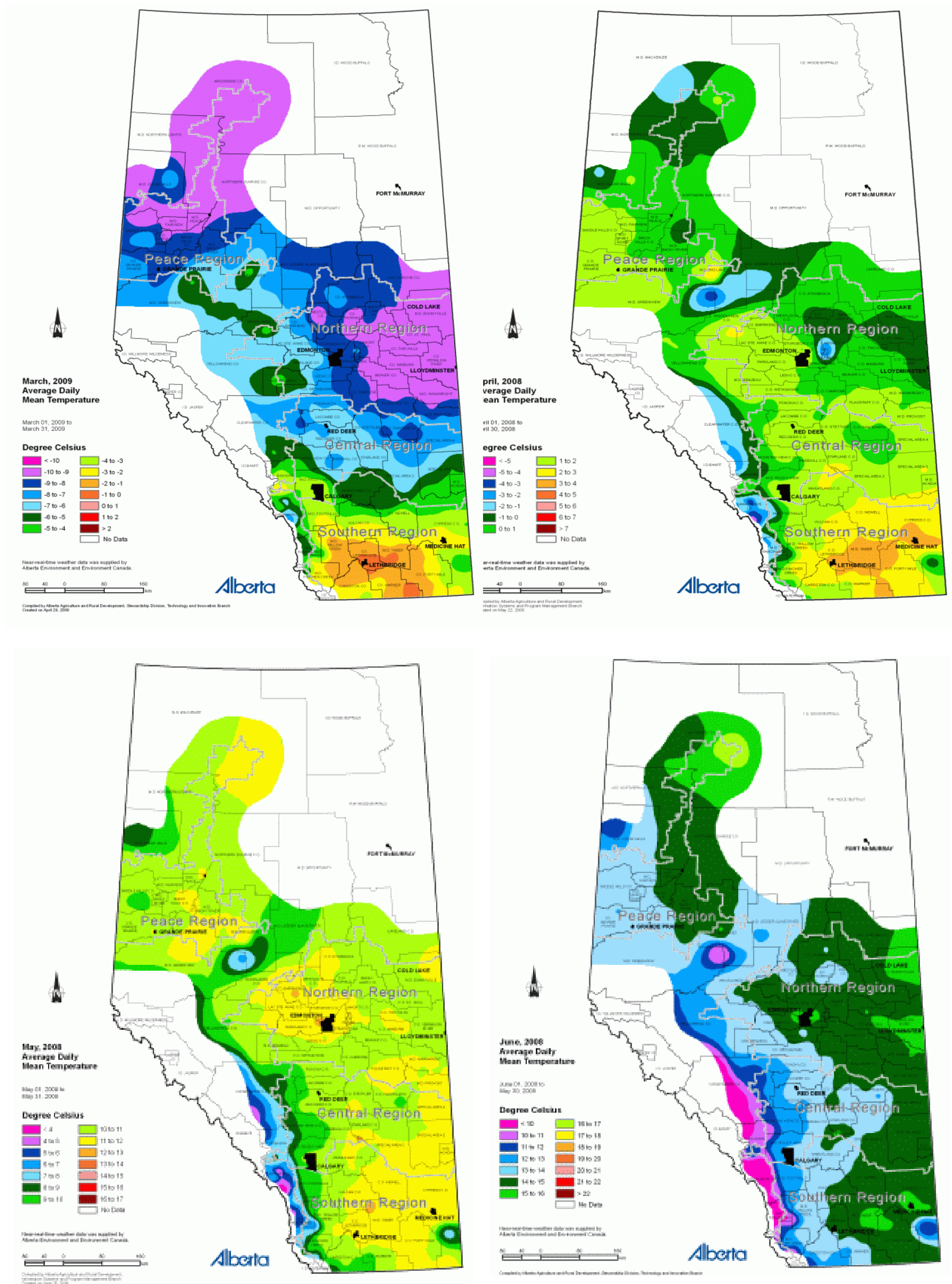
APPENDIX 3. Growing season precipitation received in Alberta 2008.



APPENDIX 4. Yearly precipitation received in Alberta 2008.



APPENDIX 5A. Average daily mean temperatures March 2008-June 2008 in Alberta



APPENDIX 5B. Average daily mean temperatures, September and October 2008 in Alberta**.**