Canadian Honey Bee Queen Bee Breeders'

Reference Guide

by

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2019

Canadian Honey Bee

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Preface
This queen breeding manual was written as part of the *Beeomics* research project to consolidate the bee breeding and beekeeping information gathered throughout the project and share it more widely with the Canadian public and our regional beekeeping communities.

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The following tech adaptation and transfer team leaders also contributed their expertise to this guide:

Fletcher Colpitts (NB), Les Eccles (ON), Robyn McCallum and Hannah Neil (NS).

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Vivian Butz Huryn (AB) Heather Higo (BC); Liz Huxter (BC) and Janet Wilson (ON).

Most importantly, the 154 beekeepers and 51 bee breeders who participated in our *Beeomics* surveys provided a fascinating glimpse into these critical Canadian industries.

Photo credits

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Introduction

This reference guide provides an overview of Canada's queen bee industry today and the critical role that queen breeding plays in sustaining our domestic beekeeping and pollination-dependent agricultural sectors.

The guide offers some insight into the importance of growing this sector and the opportunities and challenges that will likely accompany growth in this industry. Based on survey results, peer-reviewed scientific and economic research from joint Canadian university and government research projects, as well as consultations with queen breeding experts and stakeholders across Canada.

We also make recommendations for next steps to encourage a strong breeding industry in Canada moving forward.

There are 8 chapters accompanied by a template for a queen transaction agreement and references.

1. Background: bees in Canada. The value of queen bees in Canada and in particular to Canadian agriculture is discussed, including the ongoing health challenges for honey bees and our current culture of mass queen importation.

2. Beekeeping by province. Canada's current beekeeping and queen breeding activities are described province by province using interview data from Provincial Apiculturists, tech transfer team leaders and other regional bee specialists.

3. Technical Transfer Teams in Canada. An overview of the technical ("tech") transfer and adaptation teams as well as their extension work is explored.

4. Queen selection and production. An overview of queen selection and a comparison of several different Canadian bee breeding models are given.

5. Supply and demand. The Canadian bee breeding industry is presented from the perspective of the breeders and beekeepers, based on survey responses and focus group discussions.

6. Queen purchasing. The logistics of queen breeding transactions are outlined including the importance of creating strong networks of bee breeders and buyers through various groups including provincial associations and co-ops and the legal aspects of risk involved in these agreements. A sample template of a queen buying contract is included to provide a guideline for breeders and buyers (Appendix A).

7. Queen biology and breeding. A list of key scientific queen breeding and rearing resources is provided along with a summary of current Canadian queen-related research projects including new "beeomics" tools being developed by Canadian scientists, research into queen overwintering and the development of queen breeding values.

8. Recommendations and next steps. Issues and action items motivated by our research are listed, including how to move forward productively and proactively to create a strong bee breeding industry.

The purpose of disseminating this information is to encourage our beekeeping stakeholders, including industry, policy makers and apicultural specialists, to work together towards achieving a profitable and strong domestic queen-breeding sector.

Our hope is that one day Canadian beekeepers and breeders will minimize some of the risks associated with large numbers of foreign bee imports by optimizing domestic bee breeding and becoming an increasingly self-sustaining queen bee supply industry.

1. Background: Bees in Canada

Honey bees play a critical role in global agriculture with an estimated 35% of our diet dependent on honey bee pollination (Klein *et al*. 2007). In Canada, honey bee colonies pollinate many valuable crops including blueberries, raspberries, cranberries and canola, a crop which contributed $4.6 billion to the Canadian economy in 2016 (Mukezangango and Page 2017). In 2017, there were 10,544 beekeepers in Canada managing 789,598 colonies (Stats Can 2017a). In 2017, Canadian honey bees produced over 92 million pounds of honey, with a total value of $188 million (Stats Can 2017a) (Table 1).

Queen bee. Photo by Paul van Westendorp.

	Honey Production lbs 2017	Colonies 2017	Beekeepers 2017	Winter loss % 2016-17	Winter loss % 2017-18
BC	3,556,000	40,776	2,640	31.4	34.3
AB	39,808,000	311,000	1,360	28.8	33.9
SK	21,965,000	115,000	1,044	23.4	28
MB	17,360,000	111,802	745	17.9	25
ON	4,468,000	105,244	3,331	26.9	45.7
QC	3,967,000	63,500	400	18.3	30.7
NB	201,000	7,100	374	17.6	30.3
NS	552,000	28,876	604	13.2	18.4
PEI	231,000	6,300	46	41.8	41.8
NL	0	119y	45y	18	25.8
YK	0	150	10	N/A	N/A
Total	92,108,000	789,598	10,599	25.1	32.6

Table 1 Canadian honey bee industry statistics *y = responded to regional survey.*

Note: *Provincial bee statistics 2017-2018 data are sourced from Provincial Apiculturists, other regional bee specialists and regional survey data. Otherwise the 2017 AAFC report for beekeeper demographics and honey production (Mukezangango & Page 2017), and Canadian Association for Professional Apiculturists data for recent winter loss data (CAPA 2018) are referenced.*

Due to several complex factors, honey bee health in Canada and worldwide has recently been declining. Canadian beekeepers have lost between 10% and 58% of their colonies each year over the past decade (Currie *et al*. 2010, van der Zee *et al*. 2012, CAPA 2018). Recent scientific studies have pointed to multifaceted and interactive causes of colony loss, including the *Varroa* mite, weather, changes in agricultural systems, beekeeper management,

queen issues and pesticides (Currie *et al*. 2010, Guzman-Novoa *et al*. 2010, Potts *et al*. 2010, vanEngelsdorp *et al*. 2013). One way Canadian beekeepers replace their lost colonies is by purchasing queen bees from abroad each spring to found new colonies. The quantity and value of queen imports into Canada has risen significantly over the past three decades. More than 19,000 queens were imported in 1988 worth $148,754 (average $7.53/queen) (Figure 1) compared to early June of 2017 when Canadian beekeepers had already purchased 207,764 queens from the US and another 18,216 queens from other international sources, resulting in an outpouring of over $7 million ($32 per queen avg.) to non-domestic breeders (Table 2).

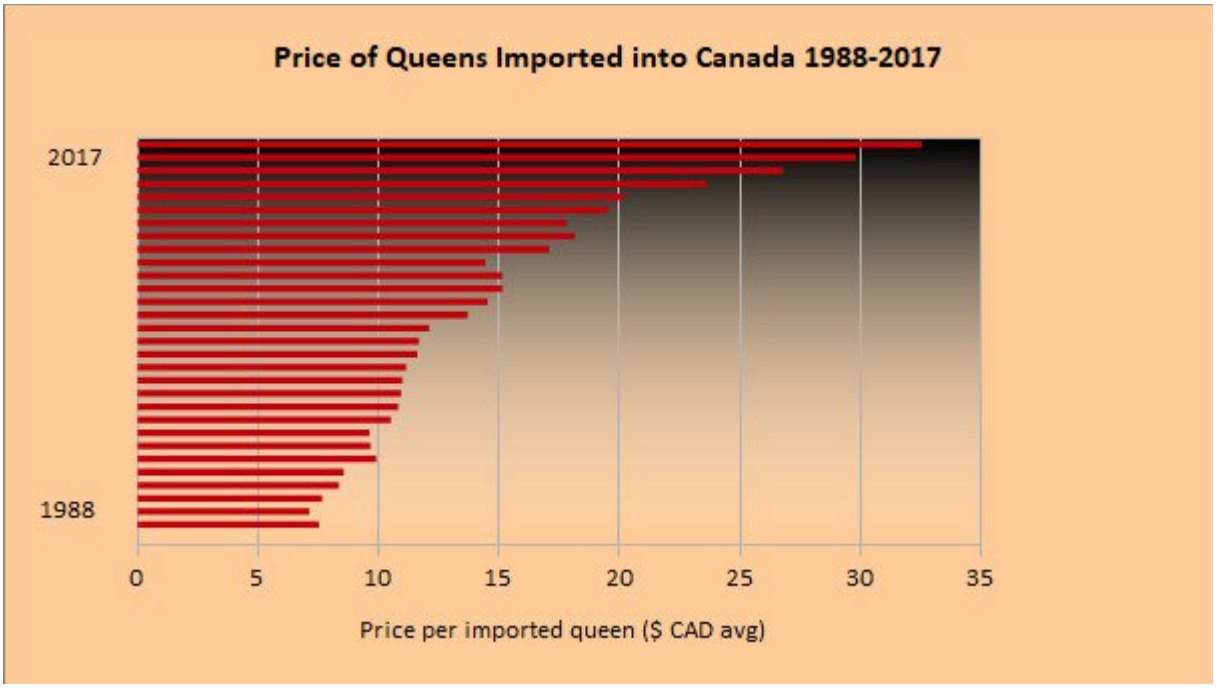


Figure 1. Average price per queen imported into Canada ($CAD)1988-2017

Queen Bee Imports	BC	AB	SK	MB	ON	QC	PEI	Canada
# Q US	14,030	129,160	6,396	33,101	11,515	12,741	821	207,764
$ US	$460,550	$4,151,317	$208,255	$1,109,546	$408,464	$423,724	$26,466	$6,788,322
# Q Other	9,893	908	0	3,618	3,797	0	0	18,216
$ Other	$316,573	$26,580	0	$98,198	$124,368	0	0	$565,719
Total Q	23,923	130,068	6,396	36,719	15,312	12,741	821	225,980
Total $	$777,123	$4,177,897	$208,255	$1,207,744	$532,832	$423,724	$26,466	$7,354,041

Table 2. Canadian Annual Queen Bee Imports[1] (CAD $)- June 2017 (Statistics Canada 2017b).

1 *Note: Queen bee imports are processed for the location of their first port of entry into Canada. Queens arriving from New Zealand and destined for Alberta are processed in B.C. resulting in an overestimate of BC imports & underestimate of AB.*

The trend of increasing queen prices may be indicative of a market that is more accurately reflecting the full value of breeding and queen production, however, buying such large numbers of foreign queens presents challenges to Canadian beekeeping. Importing bees from locales like Hawaii, California and Chile carries the risk of importing diseases and pests (Owen 2017) as well as undesirable genetics as in the case of the Africanized "killer" bee. Beekeepers also take on the risk of importing bees that are not well adapted to our northern climate and struggle to develop strong colonies. Mass importation also creates an unsustainable and precarious dependency on a bee source that is subject to policy decisions like border closures due to disease and pathogen events and other agricultural concerns. Canadian beekeepers are inadvertently supporting foreign queen breeding industries at the expense of our own Canadian breeding economy and overall honey bee health. In a recent beekeeper survey, 154 Canadian beekeepers answered questions about bee health and our domestic queen industry (Beeomics 2017).

Queen health was the number one cause of colony mortality during the 2014-2016 seasons, according to surveyed beekeepers (Figure 2).

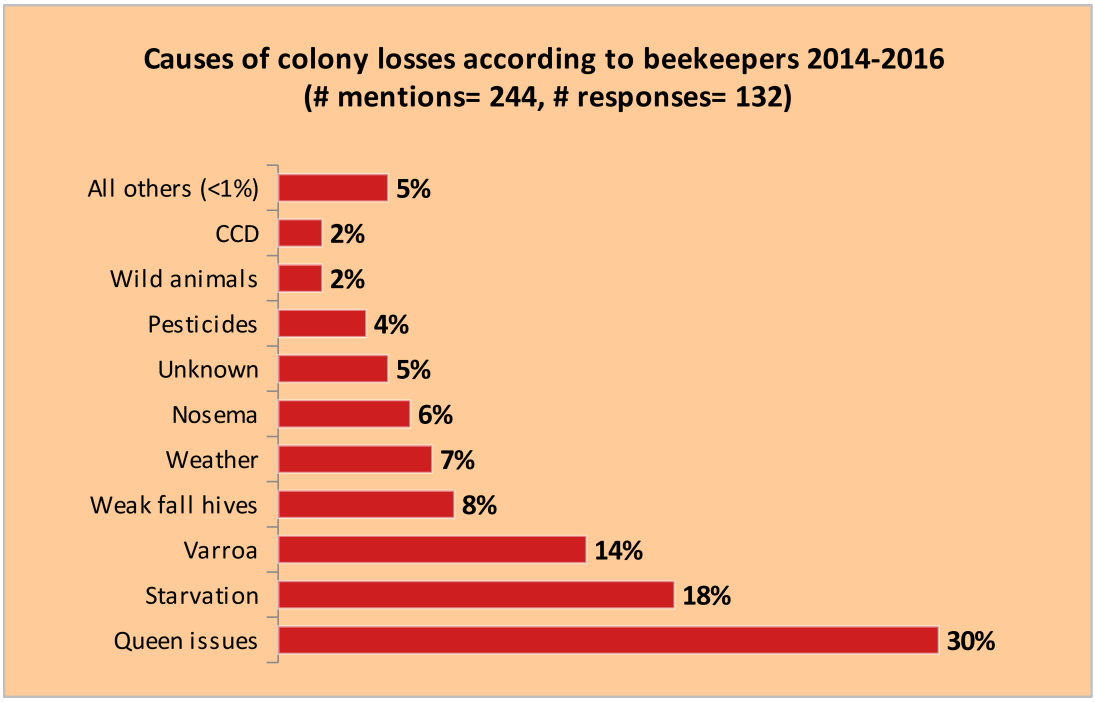


Figure 2. Causes of colony mortality according to beekeepers during 2014-2016.

In addition, 50% of the respondents indicated that they purchase new queens to help replace lost colonies and 40% of those who purchased queens indicated that they were sourced locally[2] (Figure 3).

Given that Canadian beekeepers import over 200,000 queens each year, we know that these survey data are reinforcing a story that is being told by our national statistics.

2. *Note that 40% may be an overestimate of the true number of locally bought queens since the sample of surveyed beekeepers who source their queens from the local co-op are buying almost exclusively foreign queens.*

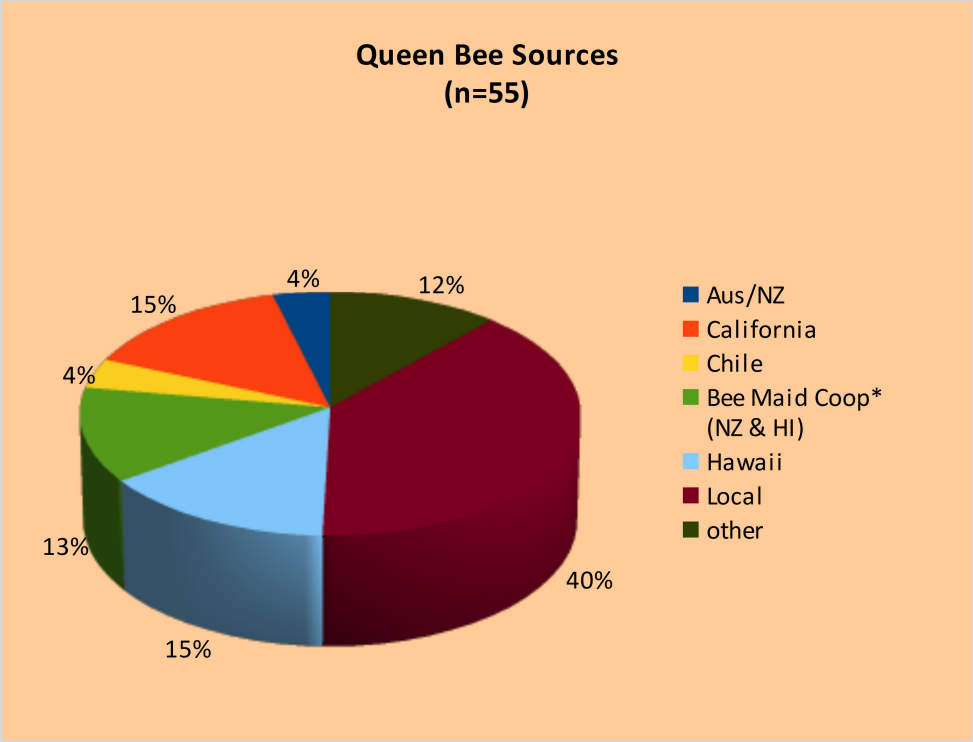


Figure 3. Souces for queens bought by surveyed Canadian beekeepers

** Queens sold from BeeMaid co-op (located in Alberta and Manitoba) are almost exclusively imported from Hawaii, California and New Zealand with few to no local queens*

Important questions have been raised by industry stakeholders in response to this confounding situation of risky yet prolific queen importation :

- Is a flourishing breeding industry not feasible in Canada?
- Is there not enough demand for local queens?
- Are breeders not interested or able to scale up their operations?
- Is there no incentive for new queen bee breeders to enter the industry?

These questions need to be answered before we move forward with accepting our dependency on foreign queens and risking domestic bee health and economic prosperity.

Queen banking multiple queens in individual cages. Photo by Shane Klassen.

This guide will try to answer some of these questions and suggest the next steps for addressing some of these challenges in the hopes that we can strengthen our domestic queen sector and increase our confidence in a sustainable Canadian beekeeping industry.

2. Beekeeping by Province

Canada is the world's second largest country geographically, comprised of 10 politically autonomous provinces and three territories, covering nearly 10 million km^2. As you travel across the country, you experience year-round frozen polar tundra in the arctic north, temperate rain forests along the west coast, the dramatic snow covered Rocky Mountains, vast summer farm land and unforgiving cold winters in the prairies, coniferous and boreal forests, humid continental regions around the great lakes, and the dramatic, and at times punishing, weather of the Atlantic provinces and eastern coastline. As a result, there is no singular climate or homogeneous beekeeping or bee breeding region in Canada.

To accurately capture and describe this diversity in our current and historic bee breeding practices in Canada, this chapter is divided by province and territory and has been informed by the experiences and knowledge of Provincial Apiculturists and bee specialists in each region. The apicultural research community is comprised of many provincial researchers working either at universities and/or for the provincial governments as well as two federal research scientists employed by Agriculture and Agri-Food Canada (AAFC) based out of the Beaverlodge Research Farm, in Beaverlodge, Alberta.

British Coumbia

Overview

Much of British Columbia's natural vegetation and topography is not conducive to beekeeping. Most beekeeping is concentrated in valley bottoms and the southern portion of the province. However, the concentration of fruit-bearing crops in the Okanagan, Fraser Valley and portions of Vancouver Island with a

Queen rearing apiary in Grand Forks, BC. Photo by Liz Huxter.

relatively mild climate has allowed BC's beekeeping industry to diversify. While honey production remains the main focus for many beekeepers, contract pollination services have become an essential and integral part of commercial beekeeping in the province. In fact, a number of fruit commodity industries have become highly dependent on the ongoing availability of honey bee colonies. BC produces 80% of Canada's raspberries and pollination is key to this industry's success. Honey bees are also essential for BC blueberry pollination where the yield per hectare increases by at least 25% with healthy honey bee pollinators. Migratory Alberta beekeepers also winter colonies in British Columbia and provide bees for pollination.

The close proximity to major consumer centers has also offered beekeepers the opportunity of value-added marketing of hive products. Favourable climatic conditions in southern and central BC, have enabled a small number of beekeepers to focus on queen breeding and bee stock production for sale to beekeepers within and outside of BC (Table 3).

Local Queens raised in BC 2018	Local Queens sold in BC 2018	Imported Queens purchased by BC beekeepers 2018
46,842	18,313	33,128

Table 3. Number of local and imported queens in BC 2018.

Based on the size and demographics of the industry, the primary market for BC queen producers is the large commercial beekeeping industry of the Prairie provinces that supports both honey production and the pollination of canola. The principal limitation for purchasing BC-bred queens is the date of availability of such stock for prairie beekeepers. Historically, BC breeders have been unable to deliver newly-mated queens in April, however, a modification of management may be possible by banking queens for the winter season and making them available in April. Although for queen producers to commit large resources to overwinter queens, a guaranteed price and market must be made available. There is ongoing Canadian research into overwintering and banking queens, which will hopefully provide some further breeding opportunities for BC breeders (see chapter 7 on queen overwintering for more information on research projects).

BC Breeding support

The current Apiculture Program's core business objective is to manage and support bee health in BC. The program does not get involved in the economic opportunities presented with honey sales, queen and stock production, pollination services, etc. These activities are left to beekeepers in a non-regulated environment. Historically, however, the Apiculture Program in BC had two full-time professional Apiculture Extension Specialists until the late 1990s when the BC government reduced and subsequently eliminated the technology transfer programs and activities. As a substitute, new funding sources were developed that enabled commodity groups including beekeepers, to apply for financial support to realize their development objectives.

To encourage bee breeding in BC, consideration may be given to establish a government-supported program where prairie beekeepers are guaranteed the number of queens they have ordered at an agreed price, while the BC producer will have the guarantee of a buyer(s). There is a possibility for training programs to be developed and operated by the sector itself. Such training programs could include training in business administration and running a queen breeding operation according to fiscal and economic parameters.

BC's Apiculture Program has had a long association with BC's beekeepers and has delivered a broad menu of services and supports to the beekeeping community over the decades. While the program has regulatory responsibilities under the provisions of the Animal Health Act (AHA) (preceded by the BC Bee Act) it has de-emphasized regulatory activities and instead emphasized beekeeper education and training. It is felt that when beekeepers are trained and educated in best management practices (BMPs) and apply those to their operations, they meet the intent and most of the provisions of the AHA legislation by default. BC's Apiculture Program has developed a broad spectrum of extension materials that are posted on the BC government website. The program has also been involved in the delivery of training courses at the introductory and advanced levels. In order to reach out to beekeepers in isolated locations and offer them training opportunities, the Apiculture Program offers an introductory beekeeping course free of charge through a series of webinars each spring (email Provincial Apiculturist in Resources/Contacts for more information).

The British Columbia Honey Producers' Association (BCHPA) supports and educates beekeepers in BC and supports the BC Bee

Breeders' Association (BCBBA), a group of enthusiastic bee breeders interested in bringing the production and breeding of honey bee stock to a new level. The members of both associations share a desire to learn more about honey bees and promote effective bee breeding practices in local supply and demand. There is also important selective queen breeding research (the *Beeomics* Project) underway at the University of British Columbia (UBC) led by Dr. Leonard Foster's honey bee research team. The UBC research engages local beekeepers and bee breeders to participate in breeding pilot projects and early adoption of new genomic breeding tools.

Apiary Act, Regulations, Resources

Regulations	
Apiary Act	BC Animal Health Act
Beekeeping regulations	Requirements for bee importation and pest management

Resources /Contacts	
Provincial Apiculturist	Paul van Westendorp
Tech Transfer Team	None
Provincial Beekeepers' Association	BC Honey Producers' Association
Provincial Beekeepers' Association President	Kerry Clark
Provincial Bee Breeders' Association	BC Bee Breeders' Association
Provincial Bee Breeders' Research	BC Bee Breeders' Association research
Provincial Bee Breeders' President	Elizabeth Huxter

Alberta

Overview

Alberta is home to 40% of Canada's honey bees. This large apicultural population is managed for honey production, producing 47% of Canada's total honey output in 2016 (Mukezangango and Page 2017), as well as canola pollination each season. Most of Alberta's three hundred thousand hives forage on commodity canola for several weeks in the peak of summer, producing high value canola honey, and contributing to increased canola output.

According to an AAFC 2017 report on the value of the honey bee industry in Canada, honey bees were estimated to be responsible for nearly half of the pollination that makes the production of hybrid canola seed possible (Mukezangango and Page 2017). Over 60,000 colonies are used for this production in southern Alberta, annually. The contribution of honey bees to canola production (commodity and hybrid seed canola) combined with other agricultural production benefitting from honey bee pollination ranges from $3.97 to $5.5 billion per year (Mukezangango and Page 2017). A report commissioned by the Canola Council of Canada estimates that the aggregate annual impact of canola to Alberta alone (including everything from growing canola to using it for food and fuel) was $7.13 billion dollars per year between 2012 and 2015 (Canola Council of Canada 2016).

As a result of the focus on pollination and honey production and the brief duration of the beekeeping season, Alberta does not produce appreciable quantities of queens for sale, although there are a number of beekeepers who breed queens for their own operations. The long harsh winters make breeding a challenge, however, queens bred in June and July are often used to form nucleus colonies that will be

used for production the following year. Alberta has a long history of importing queens from foreign sources to satisfy the large demand for queens in the spring (Table 4). Beekeepers surveyed report a 9.9% queen loss. Commercial beekeepers in Alberta are the primary importers of Hawaiian and California queens each year (average 207 queens per beekeeper) as they need to have their colonies strong and ready for honey production and canola pollination. These beekeepers need evidence that there is a reliable local source of queens in sufficient quantity that would contribute to high-quality colonies at least as effectively as their imported queens. Most BC queens are not available early enough to meet all of this demand.

Queens imported to Alberta 2016		
Origin	% of total	Cost per queen
Alberta origin (% total)	0.20%	N/A
New Zealand	1.16%	$46.13
British Columbia	1.74%	$39.89
Hawaii	71.97%	$32.40
California	24.88%	$30.85

Table 4. Source and cost of queens imported into Alberta. Emunu 2016 survey of 652 beekeepers.

One possibility in the southern parts of Alberta would be to rear queens in June then mate during pollination in July and overwinter them indoors as singles. In the north, it might also be possible to overwinter small units indoors on comb which would then be used to re-queen in the spring. This is also done in the Peace region with bees in honey production. There is some exciting overwintering research happening across the country but there is always a need for more research to ultimately find good overwintering systems for each bee breeding region.

Another challenge for Alberta queen breeding (and all Canadian breeding) is the availability of breeding equipment, land and skilled labour. Educational workshops led by provincial apiculture specialists would support breeders in building up a supply of skilled labour and a central breeding facility could help to mitigate shortages of land and equipment.

Breeding support in Alberta

The Alberta Beekeepers' Commission (ABC) provides guidance and support to Alberta beekeepers and breeders as does the Provincial Apiculturist. The National Bee Diagnostic Lab (NBDC) offers diagnostic services for honey bee pests, pathogens, and parasites. The NBDC is the result of a partnership between Grand Prairie Regional College (GPRC) and Agriculture and Agri-Food Canada (AAFC at Beaverlodge Research Farm) in response to the needs of the beekeeping industry in Alberta as well as other parts of Canada. The two federal apicultural research scientists are based in Alberta at the Beaverlodge Research Farm and contribute to bee research in Alberta and across Canada.

In collaboration with AAFC and NBDC Beaverlodge, Alberta Agriculture and Forestry researchers are currently doing a stock assessment trial and quality control project comparing imported (HI, NZ) and domestic (BC) queens, which will hopefully offer insight into the true health costs of importing queens and the added value of domestic breeding. There is also currently a research test project underway looking at breeding queens during canola pollination which will be developed into a pilot project for future study.

Apiary Act, Regulations, Resources

Regulations	
Apiary Act	The Bee Act
Beekeeping regulations	The Bee Regulation

Resources /Contacts	
Provincial Apiculturist	Samantha Muirhead (acting)
Tech Transfer Team	None
Provincial Beekeepers' Association	Alberta Beekeepers' Commission
Provincial Beekeepers' Association President	ABC President: Mike deJong ABC Contact: Connie Phillips
Research Scientist (Provincial)	Shelley Hoover
Research Scientists (Federal)	Stephen Pernal, Marta Guarna
National Bee Diagnostics Laboratory	Patricia Wolf-Veiga

Saskatchewan

Overview

Saskatchewan has a typical prairie climate, with hot dry summers and cold harsh winters. In spite of the short bee season, beekeepers in Saskatchewan have been successful at producing large crops of honey through the summers. Sustained high honey yields are labour intensive, particularly with a truncated active season, and often require beekeepers to make a trade-off between honey and queen production. However, there is a culture of self-sufficiency within Saskatchewan and as a result, there is a relatively healthy bee breeding industry, particularly given the climate. There have been local community initiatives to breed stronger, more resistant bees and also several experienced queen breeders producing hardy prairie queens.

There is a producers' list on the Saskatchewan Beekeepers' Association (SBA) website that gives names and contact details for all beekeepers selling bee products and provides free classified ads where queens bred in the province may be advertised. With a short active beekeeping season, local queens are not readily available until mid-June at the earliest. This means, much like the rest of Canada, that queenless colonies in early spring must be re-queened with imported stock or overwintered queens. One of the best overwintering methods according to apicultural experts in Saskatchewan has proven to be overwintering indoors in 3 standard frame nucs and then using the whole nuc as the queen replacement. The other option is to have nucs of larger sizes overwintered as replacement colonies.

Saskatchewan Breeding Support

The Saskatchewan Beekeepers' Development Commission's (SBDC) Tech Adaptation Team (TAT) was established in 2010 and currently employs one full time research technician who works collaboratively with the Provincial Apiculturist. The TAT has funding made available through the Saskatchewan Ministry of Agriculture's Agriculture Development Fund (ADF), AAFC, Saskatchewan Ministry of Agriculture's Agricultural Demonstration of Practices and Technologies (ADOPT), Saskatchewan Beekeepers' Development Commission (SBDC), Alberta Beekeepers' Association, and other funding sources.

Among the objectives of the TAT program are adapting disease and pest management techniques and best management practices developed in other locations to the Saskatchewan environment. The TAT has made a variety of contributions to the local industry including disseminating new research, coordinating and teaching beekeeping courses and outreach with industry groups and NGOs

In 2017, the SBDC ran a queen rearing course north of Shellbrook, SK, covering topics such

as: genetics and stock selection, methods of queen rearing, and record keeping as well as offering hands-on field demos of preparing cell builder colonies, queen cell care, and grafting. There is also hygienic behaviour testing available through the TAT and the team is currently doing a stock assessment trial in an effort to address queen quality control in Saskatchewan.

Apiary Act, Regulations, Resources

Regulations	
Apiary Act	The Apiaries Act 2005
Beekeeping regulations	The Saskatchewan Beekeepers' Strategic Development Plan
Food Act	The Agri-Food Act 2004
Resources /Contacts	
Provincial Apiculturist	Geoff Wilson
Tech Transfer Team	TAT since 2010
Provincial Beekeepers' Association	Saskatchewan Beekeepers' Association
Provincial Beekeepers' Association President	Simon Lalonde(SBDC)
Provincial Beekeepers' Association Contact	Linda Haggerty (SBA)
Pollinator Biosecurity Specialist	Graham Parsons
TAT	Hannah Neil

Manitoba

Overview

Manitoba has a very similar climate to Saskatchewan and Alberta, with generally similar agricultural crops, however, Manitoba has significantly more corn and soybean than the other prairie provinces. Manitoba also shares a border with the US that is predominantly arable land, so both sides of the border have a large number of colonies where bees are able to interact freely, causing Manitoba to be quite vulnerable to pest invasion from the US.

Politically, Manitoba has had a very divided industry on the subject of package bee and queen importation. Some beekeepers believe that the border should be reopened for packaged bees and queens whereas others believe we are better off working toward producing or buying local nucs and queens. However, the majority of Manitoba beekeepers, much like the rest of the Canadian beekeeper population, have developed a reliance on queens very early in the spring to make nucs and replace queens and this demand has historically exceeded supply from locally raised queens at that time of the year. Inconsistent weather in early spring for mating perpetuates the notion that beekeepers cannot rely on local queens. This culture appears to be changing slowly particularly as imported queens now cost as much if not more than local queens.

Manitoba Breeding Support

The Manitoba Beekeepers' Association (MBA) supports beekeepers through its association meetings, semi-annual conferences with guest speakers and updates on research and health guidelines. The Provincial Apiculturist in conjunction with University of Manitoba researchers and local associations help to promote local queen breeding and supply through the coordination and delivery of

introductory and intermediate queen rearing workshops, promoting local queen procurement through coordinating nuc-making workshops.

Apicultural research has been conducted at University of Manitoba for many years. Dr. Rob Currie's work has contributed to research on queen bees, overwintering, pathogens and other colony stressors. The Manitoba Queen Bee Breeders association works cooperatively with University of Manitoba.

Recently, the MBA also had a cost sharing initiative that enabled program applicants to purchase queen rearing equipment and get a rebate of up to 65% of eligible costs, up to a maximum of $1,000.

Manitoba honey producers are eligible for an interest-free cash advance up to $100,000, and subsequently interest-bearing (usually at Prime) to a maximum of $400,000. The advance is typically calculated at approximately 90 cents per pound (with slight variations per given year) for barrels of honey a beekeeper has remaining in inventory (i.e. unsold honey). This program is a tremendous benefit to producers, as repayment of the loan is due only when they sell honey, or by July of the following year. Typically, there is an administration fee and a security holdback of 1% of the loan value. This type of financial support could also be leveraged by breeders in Manitoba who are producing both honey and queen bees to mitigate risk associated with unpredictable environmental conditions when breeding.

Apiary Act, Regulations, Resources

Regulations	
Apiary Act	The Manitoba Bee Act
Beekeeping regulations	The interprovincial movement of bees to and from MB

Resources /Contacts	
Provincial Apiculturist	Rhéal Lafrenière
Tech Transfer Team	None
Provincial Beekeepers' Association	Manitoba Beekeepers' Association
Beekeepers' Association President	Mark Friesen
Provincial Queen Bee Breeders Association	Tim Wendell
University of Manitoba Researcher	Rob Currie

Ontario

Overview

Beekeeping in Ontario is diverse with a few hundred commercial beekeepers (operating 300 to 10,000 colonies) and a few thousand hobbyist beekeepers. The regions of Ontario are heterogeneous with field crops, horticulture and specialty crops all contributing to local agriculture and providing a diversity of bee forage. Beekeepers typically have multifaceted operations with many involved in export and domestic pollination as well as the production of bees (queens, nucleus colonies and full-sized colonies for sale). Ontario beekeepers also have the regional advantage of being able to access a large proportion of the Canadian population to whom they can market honey and bee products.

Ontario Bee Breeding Support

Commercial and non-commercial beekeepers and breeders work closely together and are supported by the Technology Transfer Program (TTP), the Ontario Beekeepers' Association (OBA) and the Ontario Bee Breeders' Association (OBBA). There are almost 30 local beekeeping associations in Ontario to further

support the large numbers of beekeepers in the province and the University of Guelph has a honey bee research center which includes a queen breeding program.

Ontario Tech Transfer team provides outreach for queen breeders. Photo by Alison Van Alten.

The industry works closely with government programs and researchers. The TTP is the oldest in the country, established in the early 1990s. It is a very engaged tech team with a great deal of outreach and support for beekeepers. There is a large number of queen breeders who collaborate with the OBBA, the TTP and the Ontario Resistant Honey Bee Stock selection program (ORHBS) (for more detail on the Ontario breeding model see chapter 4).

Although the TTP and ORBHS have contributed to an increase in bee breeding in Ontario, there remains a large number of beekeepers (mainly commercial) who continue to source their queens from the U.S. A typical Ontario winter makes early spring queen production difficult, especially at the quantity demanded by commercial operations.

Through the TTP and OBBA, there is extensive support and research on issues including overwintering queens and selective breeding, as the province moves towards increased self-sufficiency. The TTP and government apiary program also work closely together with researchers and beekeepers on strategies to mitigate and manage pests and diseases and encourage queen breeding through workshops (introductory and advanced) on beekeeping management for pests and diseases as well as queen rearing. Apiculture specialists work with many breeders directly through the ORBHS which is administered through the OBBA and the TTP and provide assessment and data collection in the field.

The Ontario Bee Journal and OBA website provide bee breeders with the opportunity to advertise and post the availability of their stock and access articles from specialists, experts and peers on queen production and breeding. The Provincial Apiculturist works directly with bee breeders to provide support as needed. Ontario beekeepers suffer from the same pests and diseases as most of the Canadian beekeeping regions, with small hive beetle (SHB) in a limited region.

There are approximately 100 beekeepers in Ontario who hold selling permits that allow them to sell honey bees throughout the season to beekeepers and many beekeepers who export stock to other Canadian provinces as well as to the US. The Bees Act requires that beekeepers must be inspected and hold a valid permit in order to sell honey bees and used beekeeping equipment within Ontario. A valid permit is also required for the import of any honey bees or used beekeeping equipment into Ontario – this would include any queens imported into Ontario. The Apiary Program provides these permits.

Apiary Act, Regulations, Resources

Regulations	
Apiary Act	Bees Act
Beekeeping regulations	Regulation of the beekeeping industry in Ontario

Resources /Contacts	
Provincial Apiculturist	Paul Kozak
Tech Transfer Team	TTP since early 1990's
Provincial Beekeepers' Association	Ontario Beekeepers' Association
Provincial Bee Breeders' Association	Ontario Bee Breeders' Association
Provincial Beekeepers' Association	Lorna Irwin
University of Guelph Researcher	Ernesto Guzman
Tech Team Program	Les Eccles
Queen rearing program	Information on the ORHBS program 519-836-3609
Queen manual	Queen Rearing Manual (TTP) & Elemental Genetics and Breeding for the Honey Bee (Ernesto Guzman)

Quebec

Overview

Beekeeping started in Québec around 1870 at about the same time as organized agriculture. Quebec has a short beekeeping season with cold and rainy springs that often delay the availability of queens early in the season. Short and unpredictable falls also put pressure on beekeepers to winterize their colonies at the beginning of September to ensure proper feeding and to effectively control the *Varroa* population going into winter. Quebec also has high variability in weather within the province.

Quebec beekeepers have a honey flow from mid-June to the end of July and another in August. Beekeepers in Quebec produce bulk honey but in lower quantities than the western provinces.

There are 3 major pollination-dependent crops: apple (very early in the season-May), followed by blueberries in northern Quebec (slightly later than apple, at the end of May), and cranberries in central Quebec (July). Each year blueberry crops need an average of 35,000 hives for pollination whereas only 15,000 are needed for cranberries. Over 80% of all managed colonies in Quebec are used for these pollination services.

The majority of beekeepers in Quebec are hobbyists with fewer than 10 hives each. However, there are commercial operations, such as Miels d'Anicet that manages 1,500 colonies for honey production and produces 10,000 queens annually. Overall Quebec produced 26,264 local queens and sold 16,570. The total value of queen sales was $462,500 in 2016, an average of $27.91 per queen.

Quebec CRSAD team operates a queen breeding and research facility. Photo by Melissa Girard.

Despite efforts at self-sufficiency, including bee colony multiplication at a commercial scale, Quebec beekeepers have not been able to supply all the hives needed for pollination and as a result, beekeepers rely on imports. At the beginning of the season, large quantities of queens are imported for pollination preparation

including queen replacement and nuclei production.

Quebec Bee Breeding Support

La Fédération des Apiculteurs du Québec (FAQ) offers beekeepers a support network to connect and share beekeeping successes and challenges, attend conferences, find hive products for sale and learn about new research. The FAQ also provides information about further education in beekeeping management from Alma College. The Centre de Recherche en Sciences Animales de Deschambault (CRSAD) offers an in-person support service by an agronomist (Provincial beekeeping consultant) who gives tech service advice about all beekeeping needs for any interested beekeepers. There is also a research team stationed at CRSAD affiliated with the University of Laval that conducts research and participates in knowledge transfer activities. The CRSAD manages 400-450 research colonies per year, including 150 breeding program colonies (10-12 lines). Quebec also has an association entitled, Quebec Reference Center for Agriculture and Agri-Food (CRAAQ) that develops new books in apiculture, organizes conference days for beekeepers and provides general reference support to beekeepers and breeders in Quebec. The CRSAD research center works closely with the industry for adapting research to industry needs. As well, a veterinarian from the provincial Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec. (MAPAQ) is the Provincial Apiculturist and her inspectors primarily help beekeepers with bee health problems, a service that is free when you register your hives each year.

Queen breeding is an active industry in Quebec despite the weather and relatively few beekeepers. A CRSAD breeding program was launched 2010 to improve honey bee health and performance of colonies. CRSAD does the majority of queen breeding in Québec with a few queen producers participating in queen production including Anicet Desrochers, Miels d'Anicet, who sends genetic materials to California for propagation.

Apiary Act, Regulations, Resources

Regulations	
Apiary Act	Animal Health Protection Act
Beekeeping regulations	Importing bees into Quebec from other provinces
Apiary Registration	Registration Form (French) Registration (English)

Resources /Contacts	
Provincial Apiculturist	Julie Ferland
Tech Transfer Team	TTP since early 2006
Provincial Beekeepers' Association	Federation des apiculteurs du Quebec
Provincial Beekeepers' Association President	Stéphane Leclerc
University Laval Researcher	Pierre Giovenazzo
Research Centre	Centre de recherche en sciences animales de Deschambault
Tech Team Program	Nicholas Tremblay
Commercial bee breeder	Miels D'Anicet
College program contact	Steve Simard
Queen manual	Queen rearing manual (in french/en francais).

Atlantic Canada

Due to limited information on specific provincial beekeeping practices in parts of this region, we

have provided as much provincial information as possible but also have included a more general overview of Atlantic Canada's new tech team and their role in supporting beekeeping in the Maritimes. All detailed regional information that is provided comes from the Provincial Apiculturists.

Overview and Tech Team support

The Maritimes in general experience very humid/moist conditions and a short beekeeping season. Drones are not plentiful until late June into July and there is not a strong history of queen breeding across the Maritimes with the few queen breeders mostly producing queens on a small scale for sale and/or for their own operation. There are several challenges facing queen breeders in Atlantic Canada including: a limited queen breeding/mating season; limited success with overwintering mated nucs; lack of availability of queens in early spring for splits or before blueberry pollination; and a lack of accessible courses/training. Beekeepers are also unable to access skilled bee workers for general beekeeping or bee breeding, particularly in the more remote areas.

The first-ever Atlantic Tech Transfer Team for Apiculture (ATTTA) was created through Perennia Food and Agriculture Inc. in September 2016 as a joint initiative supported by government, provincial beekeepers and wild blueberry associations and processors. Perennia Food and Agriculture Inc. is a provincially owned development company that works with farmers, fishermen, processors and food entrepreneurs to grow their businesses. The majority of the project is funded under Growing Forward 2, the five-year framework agreement for agriculture which is cost-shared 60-40 between the federal and provincial governments with contributions from the provincial commodity associations.

ATTTA works with the bee and blueberry industries to review current honey bee management practices across the country and customize them for the region's more than 38,000 commercial bee colonies and nearly 39,000 hectares of blueberries. Atlantic Canada is one of the world's largest producers and exporters of wild blueberries. In 2015, the blueberry industry in Atlantic Canada had a farm gate value of over $83 million. This number more than doubles when processing revenue is factored in. ATTTA provides basic beekeeping information and support that has been missing in the region for 30 years. The tech team also has a research agenda that focuses on *Nosema* monitoring, pollination stocking density, miticide efficacy, resistance testing as well as queen breeding research.

There are limited options for beekeepers interested in taking extended learning courses on queen rearing in Atlantic Canada. Many of the queen breeders are open to sharing information with one another and are eager to participate in queen research. Prince Edward Island (PEI) offers a queen subsidy for buying or breeding queens (honey bee queen replacement project through Agriculture Livestock Enhancement Program). The project subsidizes PEI beekeepers to buy queens (local or imported) through the PEI government (Agriculture and Fisheries) in an effort to encourage better colony health through re-queening (stronger genetics, less disease, stronger queens, better brood etc.). ATTTA began a five-year queen breeding/rearing case study on a commercial operation in New Brunswick (NB) in the spring of 2018.

Atlantic Resources

Resources /Contacts	
Bee Breeding Resources	ATTTA's new comprehensive website.

New Brunswick

Apiary Act, Regulations, Resources

Regulations	
Apiary Act	NB Apiary Inspection Act
Beekeeping regulations	Honey Bee Regulatory Information and Forms
Importation information	New Brunswick honey bee importation information

Resources /Contacts	
Provincial Apiculturist	Chris Maund
Chief Apiary Inspector	Fletcher Colpitts
Tech Transfer Team	ATTTA since 2016
Tech Transfer lead	Robyn McCallum
Provincial Beekeepers' Association	New Brunswick Beekeepers' Association
Provincial Beekeepers' Association President	Chris Lockhart

Nova Scotia

Nova Scotia (NS) has a strong agricultural sector that is dependent on honey bee pollination. Blueberries, apples and other tree fruit are the major crops. Since the early 1950's beekeepers have been encouraged to breed their own queens. Endel Karmo, Provincial Apiculturist 1950-1977, promoted queen bee production to ensure strong colonies were available for apple and blueberry pollination. His expertise helped inspire a "Mighty Bee" breeding program based on Buckfast genetics through the 1980's and 1990's. Semen imported from Brother Adam's Buckfast Abbey project in the UK was used by NS breeders Don Amirault and Norm Donovan to inseminate queens and raise tracheal mite-resistant stock. Kevin Spicer worked with Don Amirault and continues to raise over 2,000 queens for sale. NS currently has over 28,000 colonies of bees, the majority of which are used for pollination (18,851 in 2017). The largest beekeeping operation in NS belongs to blueberry producer-packer, Bragg Lumber Company. They employ a trained beekeeper who manages the rearing of thousands of queen bees for their own use.

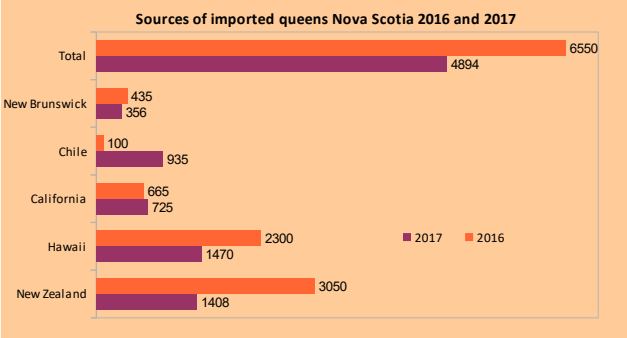


Figure 4. Sources of imported queens into Nova Scotia in 2016 and 2017.

Apiary Act, Regulations, Resources

Regulations	
Apiary Act	Nova Scotia Bee Act
Beekeeping regulations	Bee import permits, queen order forms, pollination contracts.

Resources /Contacts	
Provincial Apiculturist	Jason Sproule
Tech Transfer Team	ATTTA since 2016
Provincial Beekeepers' Association	NS Beekeepers' Association
Provincial Beekeepers' Association Contact	NSBA
ATTTA	Robyn McCallum
Queens buy/sell	Where to Buy Queens

Prince Edward Island

Overview

The majority of honey bee colonies on PEI are managed commercially for the pollination of lowbush (wild blueberries) which occurs in the late spring each year. Most beekeepers import queens annually from out-of-country to fulfill their needs (1,540 imported in 2018, Menzies, pers. comm.) with very few breeding their own (1,217 in 2018, Menzies, pers. comm.).

The relatively cool climate on PEI has historically not allowed for local queens to be bred and available prior to the pollination season and the small number of local queens only become available in the summer. The handful of beekeepers who breed queens do so to supplement their own operations. Many beekeepers who rent hives for pollination also extract honey produced from naturally available sources of flora and managed crops (e.g. canola). Beekeepers do not rely on the income generated from honey production which is seen as supplementary to the revenue generated from pollination contracts and even the largest beekeepers in this province have other trades, such as lobster fishing. Through the National Bee Diagnostic Survey led by the Grand Prairie Regional College in Beaverlodge AB, PEI honey bees are reported to have every disease and pest found elsewhere in Canada except for small hive beetle (as of 2018).

PEI breeding support

The PEI Pollination Expansion Program (PEP) provides financial assistance to beekeepers purchasing equipment for the purpose of queen breeding but is not specific to queen breeding equipment. The Atlantic Tech Transfer Team for Apiculture (ATTTA) has a Pan-Atlantic (i.e. all four Atlantic provinces) mandate to put on workshops, some of which demonstrate and teach queen breeding, such as The Modern Beekeeper Workshop held through Dalhousie Agricultural Campus in Bible Hill, NS. Thus far the tech transfer team has not developed a specific breeding program, however, the team is going to be collaborating with an Atlantic Canadian beekeeper in a pilot project to facilitate his queen breeding endeavour (i.e. provide education and administer hygienic behaviour assays). What they learn from this project will be communicated to the industry as a whole to help other queen breeders in the area. No specific networking framework exists to connect beekeepers and breeders. The University of Guelph has a honey bee research center which includes a queen breeding program where PEI breeders can access information. There are numerous remote areas in the Maritimes (more so in NS and NB) where controlled mating could occur through selected lineages so that queens could be bred and sold locally in the Maritimes, as they are in Ontario.

Beekeepers in PEI are not all members of the Prince Edward Island Beekeepers' Association (PEIBA), a resource and network that could assist in breeder-beekeeper connections and share research updates.

Apiary Act, Regulations, Resources

Regulations	
Apiary Act	Animal Health and Protection Act: Bee Health Regulations
Apiary identification	Animal Health and Protection Act: Premises Identification Regulations

Resources /Contacts	
Provincial Apiculturist	Cameron Menzies
Tech Transfer Team	ATTTA 2016
Provincial Beekeepers' Association President	David MacNearney
ATTTA	Robyn McCallum

Queen replacement program	PEI queen replacement/subsidy/ pollination expansion program information
Community FaceBook page	PEI Beekeepers Community

Newfoundland/Labrador

The island of Newfoundland benefits from the work of dedicated beekeepers who have strived to control imports, improve genetics and maintain their varroa and tracheal mite-free status. Beekeeper and queen bee breeder Wally Skinner and his two daughters Andrea Skinner (Newfoundland Bee Company) and Alison Van Alten (Tuckamore Honey Company, Ontario) have played a significant role in building the genetics of the local bee stock (Armitage, 2018). Island beekeepers are in a unique position to provide healthy varroa mite-free bees.

Queen breeding apiary site Bonavista Peninsula, NL. Photo by Peter Armitage.

Changeble weather is often an issue. In 2016 beekeepers reported up to 9% summer-fall losses of colonies for unknown reasons.

In June 2017, the Newfoundland and Labrador Beekeeping Association (NLBKA) research committee carried out an inaugural survey of beekeepers to better understand the region's winter losses.

Survey Highlights

- Surveyed beekeepers ranked poor winter conditions and queen failure as the primary factors contributing to winter loss.
- Proper management could reduce the amount of winter loss, particularly if beekeepers replace their queens in early summer.
- 92% of surveyed beekeepers reported queens between 6 and 24 months of age, while the remaining 8% reported queens over 2 years old.
- 30% of surveyed beekeepers re-queened their colonies during the summer of 2017.
- 38% responded that they never replace their queens.
- Beekeepers reported that they sourced the majority of their queens from local Newfoundland breeders and the rest from splits or swarms.

Apiary Act, Regulations, Resources

Regulations	
Apiary Act	Animal Health and Protection Act: Bee Health Regulations

Resources /Contacts	
Provincial Apiculturist	Karen Kennedy
Tech Transfer Team	None
Provincial Beekeepers' Association	NLBKA
Beekeepers' Association President	Catherine Dempsey
Research committee	NLBKA research committee

Yukon

Overview

The agrologist operates out of the Yukon Agriculture Branch and provides support to local beekeepers as part of the official position. There is on-going work to establish a local chapter for beekeepers within the Yukon Agricultural Association (YAA). There is no bee-related legislation in the Yukon and beekeeping is essentially unregulated. The provincial agrologist is working with the city of Whitehorse to set up a system for urban bee permits and three local beekeepers are trying to get a local club started.

There are no operations that are operated as a primary or sole source of income, however, the number of hives has doubled in the last 5 years and 2017 was the first year that bees were being used to pollinate berry crops. There are currently two semi-commercial operations in the Yukon performing pollination work on several haskap berry fields with up to 40 hives each and plans for expansion in the next few years.

Yukon's climate has typically been too cold and inconsistent to have a successful breeding program with inadequate summer conditions (< 20°C) for successful mating. Yukon also has low hive densities and small spread out apiaries which leads to inadequate drone density and diversity. There have been sporadic successes (swarm related or splits) some years when there has been warm weather at the right time. The vast majority of queens are imported from elsewhere. In theory, it would be possible to have bee breeding in some areas of Yukon where there is more summer heat.
The beekeeping group in Yukon (150+ members) currently interacts and shares through a closed Facebook page (Beekeeping North of 60 (Yukon)). This group has been connecting with beekeepers in Northern BC recently to participate in the BC bee course and to access BC queens and nucs.

Apiary Act, Regulations, Resources

Regulations	
Apiary Act	General agricultural regulations.

Resources /Contacts	
Provincial Apiculturist	Randy Lamb
Tech Transfer Team	None
Provincial Beekeepers' Association	Yukon Agricultural Association
Provincial FaceBook	YAA Facebook Page

Municipal Initiatives	
OCP	City of Whitehorse Community Plan
Urban agriculture	City of Whitehorse's Urban agriculture strategy

Northwest Territories and Nunavut

There is no agricultural branch or department that regulates or supports honey bees in these regions yet. There is minimal beekeeping activity as of 2018 with three hobby beekeepers in the last two years (two in Yellowknife and 1 in Inuvik). Any breeding that is done up to this point has been for the producer's own use.

3. Technical Transfer Teams in Canada

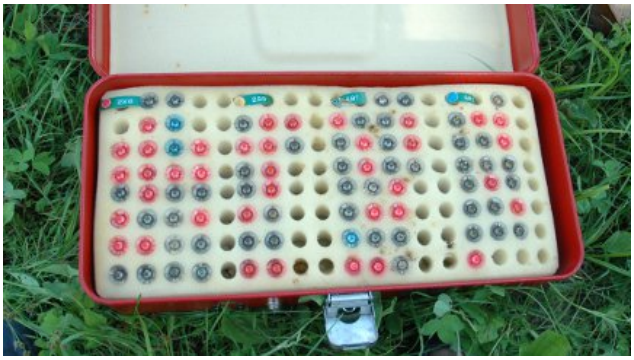
Queen rearing apiary Deschambault QC. Photo by Melissa Girard.

As of 2018, there were four tech transfer teams across Canada in Saskatchewan, Ontario, Quebec, and the Atlantic provinces.

These teams provide beekeepers with extensive scientific and practical support in the management of their beekeeping operations. To varying degrees, the tech teams also support bee breeders in their breeding and rearing operations and encourage resistant and strong domestic queen production. Team members should be contacted by beekeepers for testing and other operational support. For tech team contact information see the tables of resources for each province in Chapter 2 Beekeeping by Province.

Overview of these four tech teams and their scope, funding structures, mandate and accomplishments.

4. Queen selection and production



Selection and rearing of queens is important for a strong industry. Photo by Melissa Girard.

There is a need for a strong queen industry in Canada and it is essential that we understand the current selection and breeding infrastructures across the country. We examine different frameworks for queen selection and production including a centralized model of production that would take advantage of some economies of scale and would offer new and emerging breeders the opportunity to pay a fee and have access to breeding services and equipment as well as expertise based out of a centralized research facility. New and ongoing research into the economics of Canadian queen production as well as the need for future market research into the demand and supply potential for queens within Canada is also discussed.

Selection

Queen selection/breeding and queen production/rearing are two very distinct processes. There is a carefully detailed discussion of genetics and selection in the Ontario Introductory Queen Rearing Manual (Van Alten *et al*. 2013). Most breeders select bees based on current phenotypic behaviour in the field and/or historical records of performance over several seasons. For example, a breeder may select bees from a

colony that has shown great prowess in spring build-up, overwintering, disease resistance and/or honey production. The measurements of any of these qualities would be taken through the season in the field by the beekeeper and can be time consuming and resource intensive yet essential if a breeder is to select the best possible bees for breeding. The resources, labour and equipment needed for selection varies by operation as do the traits that a breeder is selecting for.

One specific desirable honey bee trait is hygienic behaviour, a social immunity trait that results in disease resistance as the colony removes brood pathogens from the hive. HB is typically measured by freeze-killing pupae in a defined area of comb, often with liquid nitrogen, and then counting the number of uncapped cells that have had their contents removed within 24 or 48 hours. Colonies selected for this trait will remove virtually all cells within 24 hours. This field-assisted selection for hygienic behavior requires the availability of liquid nitrogen to freeze the brood, as well as specialized training, time and resources to perform the test and to accurately record and analyze the results. This field-based testing and selection can only be performed on a relatively small number of bee colonies at one time, restricting the subset of bees for the selection pool and ultimately reducing the chance of detecting the desired trait or behavior. Although only a small percentage of bee breeders engage in hygienic behaviour testing as it is expensive in time and resources, as disease and pathogens become more pervasive, the demand for more hygienic colonies increases along with the need for testing expertise and accuracy.

One alternative to field testing is the use of molecular diagnostics, specifically marker-assisted selection (MAS), which uses molecular markers to aid the identification of colonies carrying specific traits of interest (e.g. hygienic behavior). For more details on on-going MAS research, refer to Chapter 7. The current market cost of MAS testing is around $30 for a sample which would yield a breeder queen who could then be used to produce 10 or (many) more production queens, lowering the cost to at most $3 per queen[3]. Using MAS to test one sample for multiple traits including hygienic behaviour, honey production, gentleness and overwintering success makes MAS a more efficient and cost-effective tool when compared to phenotypic field testing. Depending on the market price of queens in a breeder's region, MAS testing allows for a healthy per queen profit, particularly as the number of production queens increases (Bixby *et al*. 2017). As MAS research continues to be refined and the number of traits that can be identified and validated in the lab increases, queen prices (values) are likely to rise in response.

Queen breeding and production: Individualized vs. Centralized model

The current structure of the honey bee queen breeding industry in Canada is fragmented with few breeders, most running their own operations independently of other breeders and without much communication or collaboration with local government or breeding associations. There are some exceptions, namely Ontario, that has a well-developed breeding program supported by the OBBA, the TTP and the provincial government. The OBBA webpage lists queen and nuc producers as well as breeders involved in the selective breeding program through the ORHBS program that supports breeders in their selection and propagation of resistant stock. These programs in Ontario have been critically important to the success and progress of breeding in that region making Ontario a role model for other Canadian provinces.

British Columbia is one of the only other provinces with a province-wide dedicated

3. A beekeeper may take several samples, increasing the cost of testing and beekeepers may also choose to test daughters (production queens) as well as queen mothers to ensure heritability, increasing the cost of testing. A beekeeper must also consider the costs and labour associated with taking the sample and shipping to the lab.

breeding group, the BCBBA, supported by the BCHPA. The BCBBA also lists their members on their website along with helpful notes about each producer's location and type of operation (queen sales, nuc sales, cells etc.).

Although there is currently no national website or list of Canadian queen bee breeders, Ontario and BC have given us a good starting point for gaining knowledge about the industry in these important regions.

We also have data on the number of queens imported into Canada by province (Table 2) (Statistics Canada 2017b) and the number of queens produced and sold in BC (BC Beekeeping Productions Statistics 2018), arguably our largest breeding province due to its mild climate. A beekeeping survey of Alberta beekeepers in 2016 (Emunu 2016) also offers some clues about the importance of the queen breeding industry to Alberta and finally a national *Beeomics* survey of breeders across the country conducted in 2015-2016 gives us further insight into this illusive agricultural sector.

Following are the key findings of what we know about our queen breeding industry based on survey data, personal communication with apicultural experts, and federal and provincial importation and production data.

Key Findings of Survey

- Canada imported 225,980 queens by June of 2017, mostly from the US (Hawaii and California).
- The average price of queens in 2017 was over $32.
- Alberta imported 58% of Canada's foreign queens in 2016 in response to honey production and canola pollination needs, requiring thousands of strong healthy colonies.
- British Columbia raised over 24,000 queens in 2016 and sold fewer than 20% of those queens, indicating that the majority of queens produced in BC in 2016 were for the breeder's own use.
- About half of the queens produced by Canadian breeders are sold in a given year (based on the 2015-2016 national bee breeder survey of 51 breeders representing 10-20% of all Canadian breeders).
- There is disparity between the Canadian demand for queens and our breeding industry's current capacity to meet the required quantity and timing (given the importation numbers and the high proportion of queens used within the producer's own apiaries).
- Educating beekeepers on the value and availability of local queens is a key challenge.
- Challenges to increasing our queen production are meeting early spring demand and a lack of resources and skilled labour.
- Most breeders do not charge a premium for their queens even though most beekeepers would pay a premium for local bees.
- The majority of surveyed bee breeders would be interested in paying to have access to selective breeding research and testing.

Ontario Tech Transfer Team checking queen mating nucs. Photo by Alison Van Alten

The Ontario Model

Ontario beekeeping has had the significant advantage since the early 1990s of a provincially co-funded and well run tech transfer program and its associated extension work. The Ontario Ministry of Agriculture, Food, and Rural Affairs (OMAFRA) provides funding for three main bee projects including training and workshops, ORHBS program and providing information for regional beekeeping associations.

As well, additional projects are also supported through provincial and federal funding partners.The TTP has a 3-year funding and support agreement with OMAFRA that has been renewed every 3 years since the early 90s. The ORHBS breeding program is a major part of this agreement. The relationship between the TTP/ORHBS and the provincial government in Ontario is based on the recognized shared value of supporting and enhancing queen bee breeding and beekeeping in Ontario.

Breeders who take part in the ORHBS must first be a member of the OBA at a cost of between $40 for new members with less than 50 colonies to $250 for commercial members with additional fees for liability insurance and other services. Next, the beekeepers must become members of the OBBA and pay a $100 fee at which point they can become part of the ORHBS program for an additional $200. As part of the ORHBS, colony testing and support is offered. ORHBS participants determine a colony's potential based on desirable field output such as honey, lack of defensiveness, and overwintering success.

Each bee breeder is then visited by a member of the TTP who conducts hygienic testing in spring and summer on these pre-selected colonies. Colonies scoring well in the hygienic behaviour test are also screened for resistance to tracheal mites. Breeders can take the initiative and send a sample of these tested colonies to check for mites and other diseases.

Queens from colonies scoring well on these tests (exhibiting hygienic behaviour and mite/disease resistance) are selected as breeders for the next generation of bees. Progeny queens produced by these breeders are also submitted for analysis to ensure they are well mated and healthy.

The first 10 colonies tested cost $150, which includes hygienic behabiour, *Varroa*, *Nosema* and tracheal mite assessments. Subsequent testing for batches of 10 colonies is an additional $50. For example, for an OBBA member to have 30 colonies tested the cost would be $450 calculated as follows.

ORHBS Breeder program	Cost
ORHBS membership	$200
First 10 colonies	$150
20 more colonies	$100
Total cost	$450

ORHBS members are also eligible to collaborate on research projects, use the central isolated mating yards, and share in discussions on breeding protocols and program coordination directly with the TTP team.

There are significant advantages of engaging in ORHBS networking. Among the many educational opportunities offered is the

collaborative program framework which results in a consistent protocol for effective methods of breeding. The ORHBS members may all have different end goals for breeding but they use the same methods of selection and evaluation so they can compare and speak about the program in a consistent manner, resulting in a high standard of breeding across the province.

Another key advantage is the transfer of knowledge which happens at all levels of bee breeding. There are new members learning from members who have years of experience as well as small-scale breeders collaborating with commercial breeders. ORHBS members are integrated into all levels of the research and extension program which is a significant buy-in that keeps the program and research projects relevant to the beekeepers. Feedback from ORHBS members indicates that this program is integral to the success of bee breeding across Ontario. Many bee breeders indicated that they would be willing to increase their financial contribution to the program to ensure access to the services.

The Ontario model shows a dedicated group of beekeepers, bee breeders and apicultural extension workers who are committed to improving bee health in Ontario. The program works well because all partners are invested in the outcome, and as a result work together to set priorities with the overall objective of improving breeding outcomes in Ontario.

To meet their shared goals, the program offers important educational components such as the OBA Tech Transfer Queen Rearing Workshop where breeders learn about raising queens and the Tech Transfer Bee Breeding Workshop with training on ORHBS breeding strategies. These workshops are designed to ensure a high level of competency and consistency among Ontario queen bee breeders.

The Ontario example effectively leverages the expertise of scientists, apiculturists and experienced bee breeders in a collaborative setting to maximize breeding efficiency and outcomes from both experienced and new breeders.

Transferring an egg from breeder comb to graft into queen cell. Photo by Melissa Girard

Although this type of breeding program requires a financial commitment from local governments, the funding is spread out among all the stakeholders, creating a co-operative environment underpinned by an effective incentive structure.

Uzunov *et al*. (2017) provide an important analysis for understanding the complexities of queen breeding. The authors point out that there is a significant difference between simply propagating and multiplying queens based on fecundity and queen size for example (both necessary traits in their own right but not sufficient for a successful selective breeding program) and creating a nuanced, successful selection program based on the objective of improving the genetic composition of each successive generation.

Scientifically-based breeding requires significant expertise in the economic and scientific selection of traits and would benefit greatly from the adoption of laboratory testing tools. The average breeder may not alone have the resources available to carry out a scientifically-based breeding program but could very well improve their stock with some support from

local researchers and access to isolated mating yards and testing facilities.

Hybrid vs. Independent Breeding Models

Ontario offers one example of a successful collaborative breeding program as described by Uzunov *et al*. (2017), where scientific selection is supported by researchers and tech team members with access to technical facilities and isolated mating yards who collaborate with breeders to breed and rear strong queens. Even in Ontario, however, there are continued struggles such as the difficulty of encouraging commercial beekeepers to buy local and simultaneously scaling up queen output to meet demand, particularly early in the season.

Ontario is an example of a *hybrid model of breeding* where there is a central organization, TTP and the ORHBS, running a breeding program that encourages individual breeders to take part in the services, education and support offered to its members. The bee breeders maintain their own operations but they rely on the expertise and testing available from the TTP. Even the isolated mating yards are only facilitated through the TTP and the breeders are responsible for providing stock and working in the yards when they send queen cells or harvest the mated queens. The overarching objective of the program is to educate breeders and arm them with the expertise and skills to continue breeding strong queens regardless of the current political funding climate and resulting available resources.

In Canada, aside from the Ontario example, most breeders are operating within a mostly *independent breeding model* where each breeder makes their own investments into equipment, training, skilled labour, land and other resources and has little or no support from apiculturists or other specialists. There are other tech transfer teams across the country in Saskatchewan, Quebec and the Atlantic provinces, however there is very little in terms of formal bee breeding support aside from some educational opportunities and a few dedicated tech team members with bee breeding expertise and a personal desire to enhance breeding in their regions.

The effectiveness of the independent framework depends entirely on the background of the individual breeders and what resources and investments they have available within their own operation and region. The majority of selection is done by these bee breeders in the field, for example using the liquid nitrogen 24-hour hygienic behaviour freeze test, or counting mite drops on a sticky board to assess *Varroa* levels.

These field tests are resource intensive and the level of precision of these test results varies greatly with breeder experience and regional pressures. Although these tests can result in some degree of selection accuracy, having access to more reliable science-based measures of assessment such as lab tests and more experienced technicians would enable bee breeders to enhance their breeding program more quickly and with more success.

As new breeding tools, such as MAS, become more widely available, there will be centralized facilities (labs) such as the NBDC in Beaverlodge, Alberta and the CRSAD research center in Deschambault, Quebec that may be able to provide this specialized testing. In addition, these facilities could also offer more comprehensive services to breeders, such as access to isolated mating yards, breeding expertise and other supports much like the TTP does for the ORHBS program in Ontario.

Having access to central testing facilities through a breeding program such as the ORHBS educates queen breeders about new research and pest management tools and encourages them to take advantage of new technical tools for testing and queen bee breeding selection. To increase Canadian queen bee production, it is essential that the industry has access to the newest most effective management tools, breeding strategies

and most importantly support from regional apiculturists and research programs.

A *hybrid* model may be an ideal framework for new and inexperienced bee breeders who could sharpen their skills and knowledge of breeding practices utilizing the land and resources available without having to make a prohibitively costly investment early on but still comfortably enter the industry and contribute to the domestic production of strong queens.[4]

This type of queen breeding model makes the clear distinction between the highly technical selection process which involves detailed record keeping and laboratory testing (done by experts in the lab and controlled, isolated apiaries) and the queen production using these outcomes (done by the beekeeper either at a centralized site or in their own operation). The idea is that scientists and apiculture specialists, who have access to the resources needed to achieve consistently high standards of bee selection, would focus on selecting queens that the breeders would then take and propagate.

A hybrid model also offers an opportunity to provide a brokerage service between queen buyers and queen producers in a specific region. Centralizing the knowledge of the types and quantities of queens available at a given time allows either a web-based application or an apiculture team member at a testing/breeding facility to connect the producer with interested buyers.

Queen bee insemination. Photo by Melissa Girard.

One of the challenges of mitigating the risks of importing bees is to maximize the domestic breeding potential within each region and developing the most accessible and effective platform for making these connections. A central facility may provide the right opportunity for this type of brokerage.

In Europe, the SmartBees program provides an interesting hybrid example of a science-led, supported bee breeding program where there is centralized testing and continual breeding support by apicultural experts with an emphasis on encouraging individual breeding operations in an effort to realize more sustainable beekeeping in local regions.

4. There are queen bee breeders in Canada who do not want selection intervention and will continue to pursue their own breeding endeavors outside of a hybrid model. Many of these breeders do this successfully based on decades of careful breeding work and investment in excellent equipment and ideal land.

5. Supply and Demand

Beekeeper & Breeder Industry Surveys 2015-2017

Caging a mated queen. Photo by Heather Higo

There is an opportunity for Canadian queen breeders to increase their domestic share of the honey bee queen market in Canada. Scaling up Canadian queen breeding and production could be profitable, particularly when breeders take advantage of specialized scientific breeding programs and new breeding tools (Bixby *et al*. 2017) and would undoubtedly have a positive impact on our beekeeping and agricultural autonomy. To leverage this opportunity, it is critical to have buy-in from both queen producers and queen buyers. Bee breeders and beekeepers must be fully engaged in adopting this domestically-focused model and supporting one another in this transition.

During 2015-2016, the *Beeomics* research team recruited beekeepers to complete a queen industry survey. Simultaneously queen breeding focus groups were held in B.C, Alberta, Saskatchewan, Manitoba and Ontario as part of the provincial beekeeper association meetings. Over 150 Canadian beekeepers (1.8% of all beekeepers in Canada in 2015) managing 106,592 colonies (14.8% of all Canadian colonies in 2015) completed this survey with the vast majority also participating in focus group discussions about the future of our queen breeding industry in Canada (Figure 5).

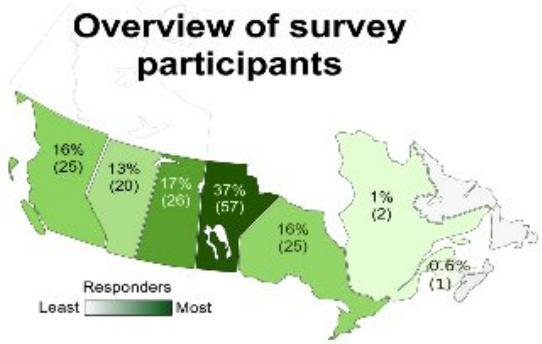


Figure 5. Geographic distribution of beekeeper survey respondents.

In early 2016, the *Beeomics* research team developed and launched a queen breeder survey and by early 2017, 51 queen breeders had responded (Figure 6).

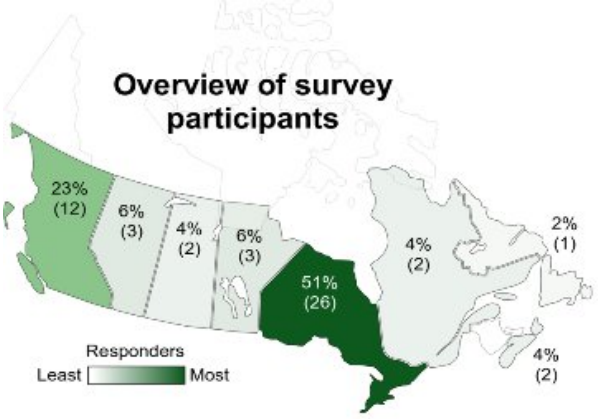


Figure 6. Geographic distribution of bee breeder survey respondents.

Based on published queen breeder lists and discussions with breeders and Provincial Apiculturists, we estimate that approximately 5-10% (425-850) of our 8,500 Canadian beekeepers breed queens, and thus our surveyed breeders represent approximately 6-

12% of our estimated breeder pool. These surveyed breeders managed over 27,000 honey bee colonies in 2015-2016 and had an average of 18 years of bee breeding experience

As discussed in chapter 2, Ontario and British Columbia are the only two provinces with publicly available breeder lists, making the recruitment of breeders from these areas much more direct and explaining the disproportionate response rate from those two provinces. The queen breeders surveyed showed a strong commitment and passion for their work and a willingness to invest in the breeding industry with 96% indicating that they were actively involved in some form of selective breeding in their operations and over 70% expressing interest in adopting new laboratory selection tools being developed by Canadian researchers. Canadian beekeeper and queen breeder survey data show that beekeepers and breeders have a mutual interest in increasing our domestic queen supply and if supported are eager to work together to create an established network between breeders and buyers and a strong and consistent supply of Canadian queen bees.

Beekeeper Demand, Breeder Supply and the Queen Industry: Challenges

There are important roadblocks in the quest for increasing local queen supply that must be understood and addressed. The timing of queen breeding including production and delivery in a northern country presents some challenges, particularly as the needs of beekeepers and pollination-dependent crop producers are generally highest at the beginning of the season. Another significant barrier for breeders is the lack of access to resources and skilled labour. The barriers to developing a strong queen industry according to our surveyed breeders are identified in Figure 7.

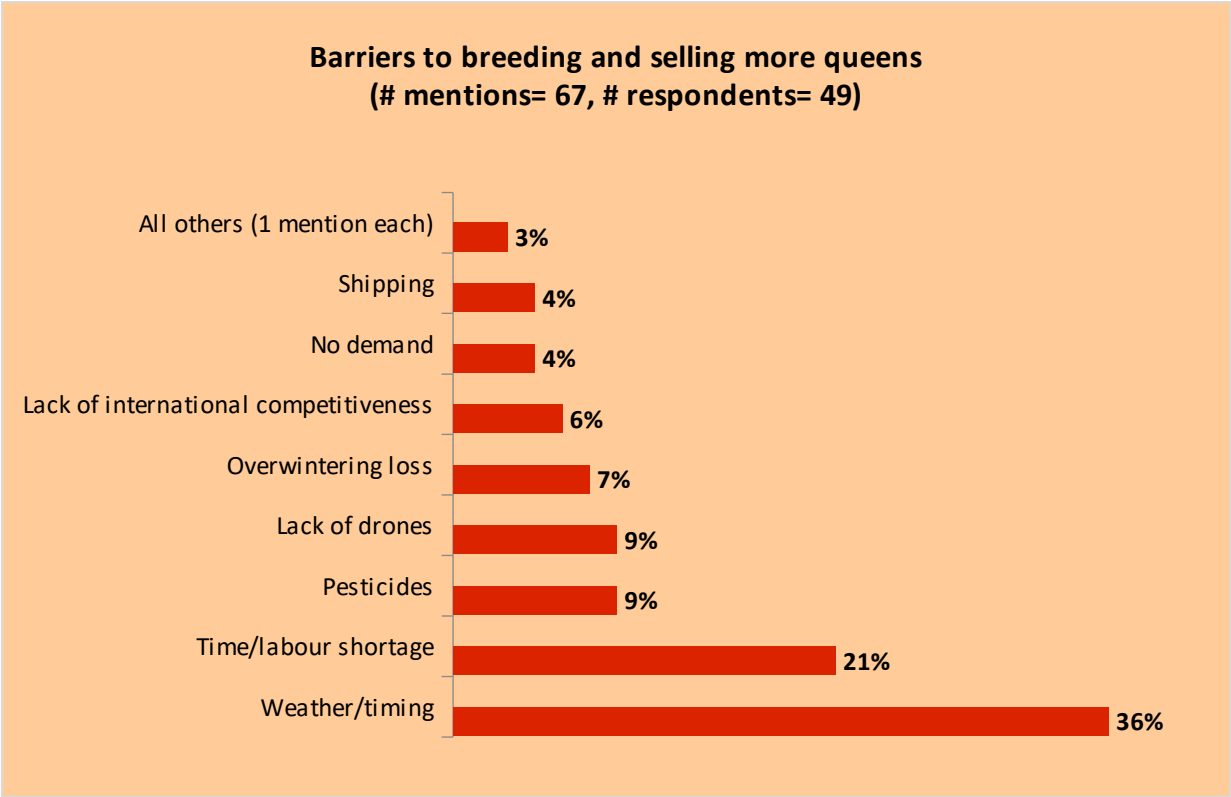


Figure 7. Barriers to queen production and delivery identified in bee breeder survey.

A significant percentage of survey responses by beekeepers indicated that queen issues were the cause of their colony mortality over the previous season with starvation and *Varroa* the next most important causes of colony mortality.

When asked about the risks that beekeepers believe threaten beekeeping in Canada, pesticides, *Varroa*, and importing issues were the top three (Figure 8).

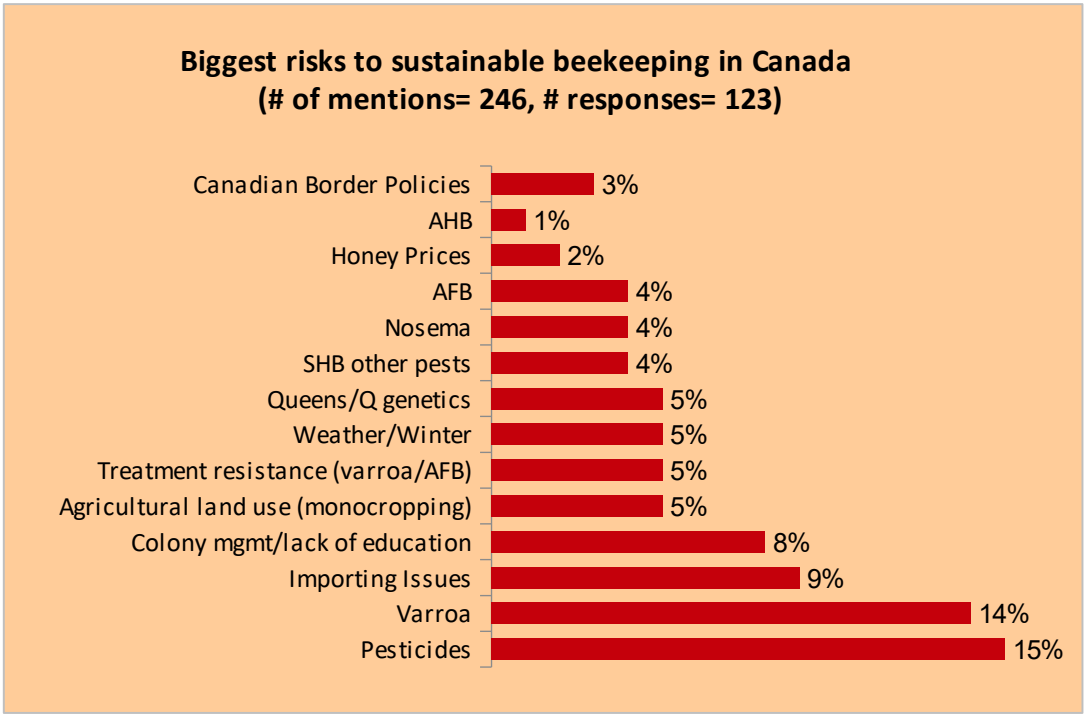


Figure 8. Biggest risks to sustainable beekeeping in Canada according to survey responses.

Survey responses and focus group discussions brought forth a strong industry perspective that Canadian beekeepers and breeders need to accept some importation as a necessary risk but also contemplate a cultural shift away from the current scale of reliance on foreign sources. These responses also highlighted the collective desire and need for self-sufficiency by embracing the daily challenges of breeding with a strong skill set and a willingness to prioritize local queens. Surveyed breeders are keen to expand their production as long as they are adequately supported and fairly compensated.

The following quotes come directly from beekeeper and bee breeder survey responses as well as focus group discussions and illustrate the current challenges facing our bee breeders and the development of a domestic queen bee breeding industry.

Challenges for domestic breeding

"The biggest obstacle to queen breeding in this country is the myth that we can't supply our own queens or that we need something big and technical to do it. Our winters cull poor stock. Diseases cull poor stock. Tracking honey production is simply a matter of numbers on hives and a scale, much like the dairy industry. We just need to then breed from good producing survivors. It's not rocket science."

"Just as John Gruzka (former Provincial Apiculturist for Saskatchewan) taught Saskatchewan beekeepers to raise queens, every researcher, technical adaptation team [or tech transfer team], and Provincial Apiculturist should be teaching beekeepers to do the same and that they don't need anything special."

"[The issue is] weather, and having surviving stock that can be used as well as competing with package producers and import stock that is not constrained by local weather (early to market). We must maintain isolated yards away from the poor import stock!"

"[Overwintering] is key to supplying the spring market. We are working on [overwintering] methods in Ontario and have had encouraging success to move forward, improve and expand this practice. Challenges will be the number of queens available for overwintering because most queens can be sold pre-winter. Overwintered queens are worth more to the queen producer than for sale. I estimate that if I use an overwintered queen for my own colony production it will increase the value of the queen to $300 because I can produce a productive colony early (which is also why other beekeepers want them). I would need surplus queens that I would not need myself to justify selling them. Canada currently imports approx. 200,000 queens in the spring. We would need very large numbers of producers and queens to even enter that market and have a significant impact."

"Queens from northern producers can be superior to foreign sources but availability is usually later, so customers looking for local queens must adjust their management. Currently, most beekeepers prioritize early and mass bulk queens must be imported meaning that local queen breeding in our country may only be viable for customers who are most interested in high quality queens with attributes suitable for local conditions."

"Self-sufficiency [is viable] for small beekeepers only. I do not think that the market for supplying large producers will open up to local stock. Their business plans usually include the use of import packages and queens from February to April. I do not split or breed until May."

"Year-round employment is a major hurdle because in general beekeepers can only employ workers for seasonal work. The skill involved in queen rearing/breeding (2 very different things) is high compared to other beekeeping work, which increases the difficulty because highly skilled people usually do not stay if they cannot maintain full-time work. Training for us is a smaller concern compared to the above. The only way to overcome this is to become large enough to maintain skilled employees in the off season with other tasks".

Beekeeper Demand, Bee Breeder Supply and the Queen Industry: Industry Buy-in.

Despite the barriers that breeders and beekeepers face in the uphill push for more domestic queen production, there is also motivation from both the demand and supply sides for Canada to make significant strides in capturing a greater percentage of the queen market. The surveys point to some positive overlap between queen demand and supply in May/June (Figure 9), which at the very least may allow a percentage of current imports to be replaced by local production and if combined with successful queen overwintering research outcomes may provide an opportunity for even greater domestic production in the future, further minimizing our importation risks. The data for queen imports to Canada (Figure 10) confirm our finding of a peak in May (Statistics Canada. 2017b), at a time when an increased domestic supply of queens may be feasible for queen bee breeders.

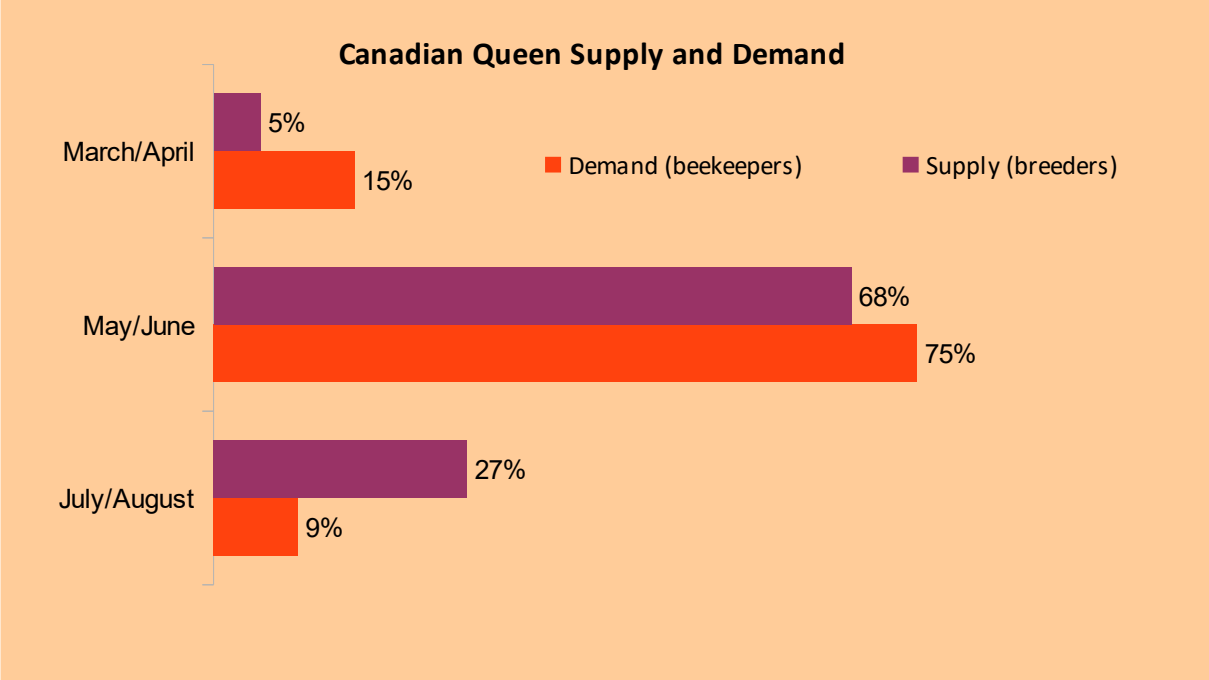


Figure 9. Canadian queen supply vs. beekeeper demand for queen delivery from survey responses.

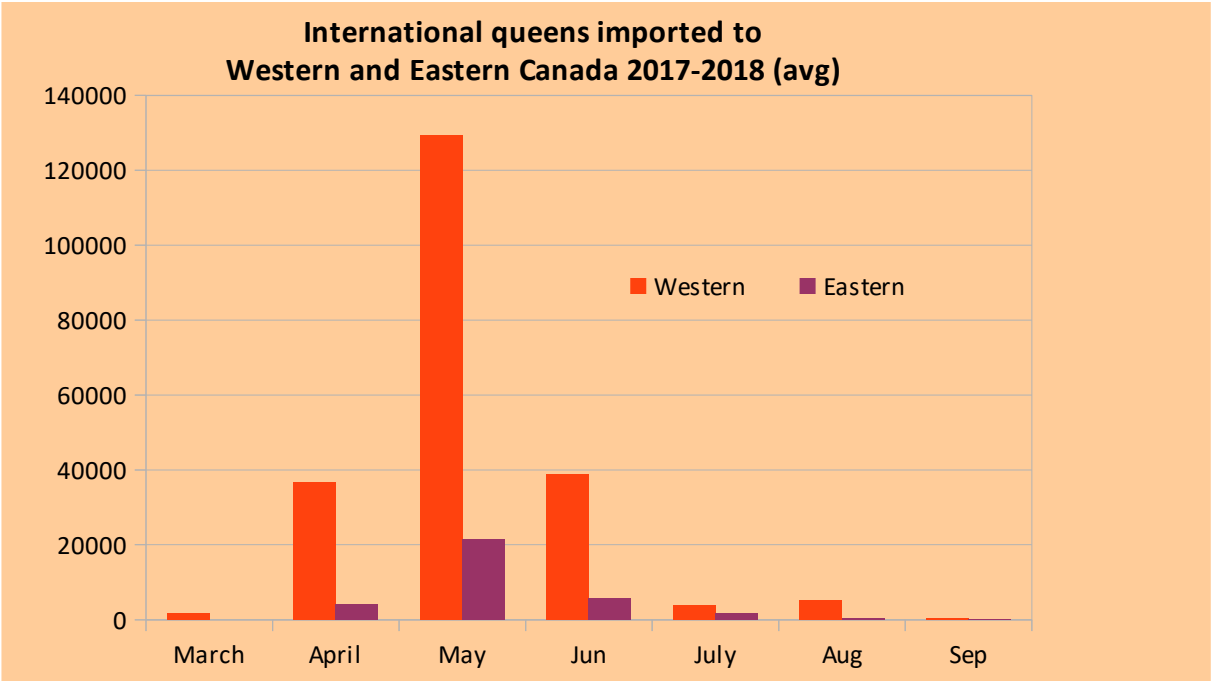


Figure 10. Number of queens from international sources imported to western and eastern Canada.

Our sample of surveyed beekeepers recognize the impact that breeding strong domestic queens has on colony outcomes as 96% of respondents indicated that they would rather choose a local queen if one was available and would be willing to pay a significant premium if

she was selectively bred with certain desirable traits.

The following quotes come directly from beekeeper and bee breeder survey responses as well as focus group discussions and illustrate the current climate of demand for local queens and optimism about our domestic breeding industry that many beekeepers and breeders share.

Demand for domestic stock

"Definitely local! There are problems with imported queens- they barely last one season and the egg laying and brood diminishes."

"Buy local! I pay US$32 per imported queen, but if you add in the 29% [of colonies] that do not accept the queen, it pushes the price up to US$45."

"[If we buy local] we could manage the risk of depending on stock from another country where things can happen out of our control."

"I have experienced a high level of uncertainty in procuring imported queens in the past year. My orders for queens have been significantly reduced by the queen broker because of high demand in the country of origin."

"Cross-border trade is a vector of novel pathogens and pests."

"Self-reliance and sustainability are huge factors in forwarding beekeeping in Canada. With less reliance on others we have more control from within for healthy, productive hives."

"I would avoid buying an imported queen at any cost. There are plenty of local bee breeders who are raising queens adapted to this climate - I would want to buy from and support them (in addition to raising my own)."

"[Queen breeding] is a challenging and rewarding job that is essential to the efficiency of the bee industry in Canada."

"Breeding is selecting stock suitable to local conditions, eliminating the possibility of importing new pests and diseases, saving money, and it's fun!"

"I feel that self-sufficiency in raising our own queens is imperative in the event of disease or other problems at current, traditional sources. Locally adapted bees tend to be more productive and more likely to survive."

"We desperately need to get moving on a domestic queen and bee breeding industry before we lose New Zealand and/or Hawaii. We have to stop the permitting of USA imports to the [commercial beekeepers], who then put the rest of us in peril."

"If we hypothetically imagined a new bee disease which will grant closing the border, this will be devastating to the beekeeping industry in Canada. I am not sure what is chance of this hypothetically imagined scenario but I am sure no one can afford it."

At this pivotal time for our beekeeping and bee breeding industries in Canada, survey results and focus group data suggest a willingness on behalf of the industry to bring the focus on queens to local markets while also adopting new technologies to facilitate efficiency and colony health. If Canadian queen breeders, beekeepers, researchers, policy makers and pollination-dependent agricultural producers and stakeholders together champion a stronger domestic approach to beekeeping, we can begin to move towards greater agricultural sustainability.

6. Queen Purchasing

Marked queen for insemination. Photo by Melissa Girard.

Transactions and Networking

Successful queen bee breeding requires not only technical beekeeping experience but also some advertising/marketing knowledge and access to local associations and their publications in order to create the connection between bee breeder and potential buyer. A queen breeder also requires access to market information such as current queen pricing data and queen transaction templates that include clauses clearly outlining the risks and responsibilities of the two parties involved.

Historically, queen sales in Canada have been conducted mostly by word of mouth with little advertising and few formal written contracts. As this industry develops, the infrastructure supporting bee breeders and queen buyers has begun to take shape in a few areas of the country.

The BCBBA website has a list of all its queen producers and their contact information as well as their specific hive products for sale. The BCBBA also has a list of key questions for queen purchasers to ask of the bee breeder to minimize risks and clarify the queen bee buying agreement. In BC, queen bee breeders who produce queens to sell outside their operation are supposed to be inspected at the beginning of the season by an inspector and then if deemed acceptable, are issued a permit for the remainder of the bee season. However, local bee breeders have indicated that a lack of resources has meant that early season inspections do not always happen.

The OBA has a list of its members as well as an updated list of the members who are collaborating with the TTP on the ORHBS program to breed resistant queens. OMAFRA regulates the permitting, including queens, nucs and colonies and has an updated list of all the Ontario beekeepers who have obtained special permits to sell these products. These queen breeders and their bees are also inspected by the province of Ontario prior to any queen sales.

Most provinces have some type of regulation around importing bees (whether domestically across provincial borders or internationally), although few require queen bee breeders to be permitted or inspected to sell queens. Where they exist, these lists and registration policies affecting current producers provide beekeepers in these regions with an accessible network of legitimate bee breeders to contact and ultimately buy their bees from based on inspected products, regional proximity, past customer reviews, pricing, timing and other factors.

According to surveyed beekeepers and bee breeders, there is still a need for increased communication between bee breeders and buyers and between government regulators and beekeepers. A national queen bee breeding website is currently being developed to assist with communication in the industry. The website will have provincial and regional links outlining

the current regional bee breeding regulations and policies and a list of bee breeders as well as any funding or educational support available in each area and will hopefully play an integral role in facilitating queen buying transactions. To enhance the utility of the website, an organization such as a local bee co-op could leverage its position in the industry (perhaps using a particular location on the website as a communication platform) to support queen breeding through a brokerage system. The co-op (brokerage) would act as the main point of contact for both breeders and buyers who communicate their queen supply and queen demand needs in terms of quantity and timing. The broker then has an updated list of available queens and can connect bee breeders with appropriate buyers. The issue of liability within this brokerage context (or any queen transaction) should be clearly outlined in a contractual agreement, ideally using a template that is consistent across the region or province (see Appendix A for an example template).

The following are quotes from beekeeper and bee breeder surveys and focus groups, reinforcing industry's need for improved communication and clear guidelines for queen bee breeding.

Communication issues

"We currently connect through word-of-mouth recommendations. A common website would probably be a very good addition."

"The most challenging part of breeding is developing a market for my queens."

"Rules regarding selling/buying, permits, and transport of queens for local consumption are not commonly known. Importation of foreign queens must follow regulations but interprovincial rules are also less well known. Information of this kind on a common website would be very helpful for buyers and sellers of queens. Perhaps Provincial Apiarists and CAPA could assist in compiling information about any of these regulations."

Steps Necessary to Promote Secure and Successful Queen Sales.

1. Connecting local bee breeders and buyers.

Advertising and networking should happen through national/regional website(s) and local association meetings and publications. Local co-op or other brokers may be a useful tool.

2. Queen transaction.

Once the negotiations are complete, details of the agreement need to be formally communicated to both parties in a queen contract that states the responsibilities (and expectations in terms of management protocol) of both the bee breeder and buyer before, during and after the transaction and in the event of adverse circumstances such as weather affecting delivery dates, under-performing queens, or queen mortality (see example template in Appendix A). The bee breeder and buyer may also want to investigate an insurance program to mitigate the financial risk associated with poor queen outcomes such as poor mating, weak queens, queen losses and weather impacting queen delivery dates. Even if both breeder and beekeeper are negotiating a queen transaction in good faith, there are factors that are beyond their control and insurance may help to manage this risk. The Alberta Agriculture Financial Services Corporation has an overwintering colony insurance program and may offer a similar program for queen breeders (see below).

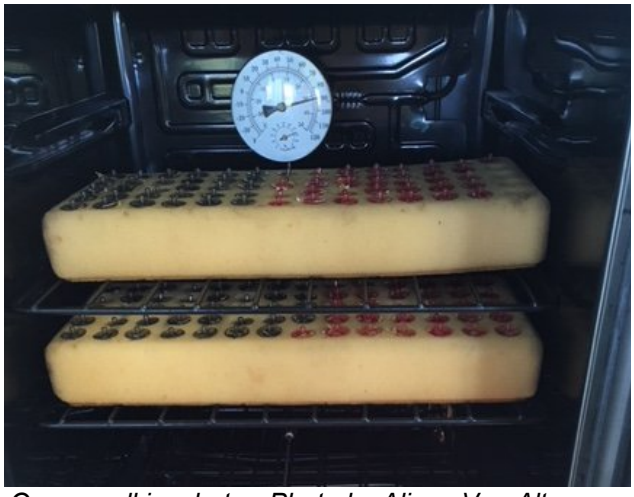
3. Queen shipping.

It would be very helpful if couriers understood queen bee shipment handling so more couriers were willing to ship queen bees. Our postal system will ship queens but the cost is high relative to the speed of shipment. Shipping by air is only viable for large shipments due to the

high cost. A comprehensive guide to the current honey bee shipping constraints and costs as well as the shipping companies that accept queens would be useful as would some consultations with shipping companies to increase the shipping options.

4. Follow up and feedback.

Upon the completion of a queen purchase, feedback should be given to the bee breeder to further inform their operation and support future breeding successes. Thoughtful customer reviews should also be communicated to the broker (co-op) if applicable and otherwise to the local association to inform future queen purchases.



Queen cell incubator. Photo by Alison Van Alten.

Resources for Queen Transactions	
BC queen inspections	Listing of inspectors and regions
BC Breeders' Info	BCBBA producers
BC Breeders' questions for queen producers	BCBBA questions for queen producers
BC Breeders' questions for nuc producers	BCBBA questions for nuc producers
Ontario Resistant Honey Bee Selection	The Ontario RHBS members
Alberta Financial Services Corporation insurance documents	Sample insurance program documents for overwintering bees
Alberta insurance rates	Overwintering insurance rates and coverage 2017 AFSC
Alberta insurance definitions	Overwintering insurance agreement definitions
Alberta insurance description	Overwintering insurance description
Queen purchase contract	Queen buying contract

Queen cell cups. Photo by Melissa Girard.

7. Queen biology and breeding

The following quote was received from a queen bee breeder in the survey. It illustrates the importance of increasing the tools available to queen bee breeders.

"Beekeepers need to be educated on the dangers of relying on imported queens that not only carry disease, but are often not adapted to their climate. There are so many great local bee breeders who can provide queens and nucs and who should be supported. I think adding to the tools that these breeders can use to improve their stock is a fantastic idea and a great way to improve the Canadian queen and nuc industry. Not only increasing the tools at their disposal but increasing the number of queen breeders in the country will help to create a more competitive, healthy beekeeping industry."

Grafting selected honey bee larvae into queen cell cups. Photo by Melissa Girard.

Scientific Breeding Resources

Successful honey bee queen breeders must have an in-depth knowledge of honey bee biology including honey bee genetics and the role of the breeder in the selection process. We recommend several excellent resources for beekeepers and bee breeders interested in learning more about bee biology and breeding, including:

Queen cells ready for mating nucs. Photo by Melissa Girard.

Ontario Beekeepers' Association Technology Transfer Program, The Ontario Introductory Queen Rearing Manual

Ernesto Guzman, Elemental Genetics and Breeding for the Honey Bee

Both of the above are available through the OBA website

Another excellent resource on queen breeding is the seminal work by **Harry Laidlaw and Robert Page (1997),** Queen Rearing and Bee Breeding

With a strong foundation in breeding and genetics, queen breeders can embark on exciting selection initiatives based on their own experience, current research, and regional honey bee health concerns and needs. Canadian apicultural researchers are at the forefront of scientific discoveries with several projects currently promising to provide the beekeeping and queen bee breeding industries with enhanced opportunities and new breeding tools in the future.

Canadian Scientific Initiatives To Advance Domestic Breeding

Marker Assisted Selection: The *Beeomics* queen research project
Principal Investigators: Leonard Foster (UBC), Amro Zayed (York U).

Honey bees, like many other social insects, live in a small nest environment in very high densities, making honey bees particularly vulnerable to disease and pathogens due to the high likelihood of transmission among nest mates (Schmid-Hempel 1998). As a result, honey bees have evolved individual and colony-level defense mechanisms such as social immunity, which manifests as grooming or hygienic behavior within the colony (Spivak and Reuter 2001, Evans *et al*. 2006). Hygienic behavior is a heritable social immunity trait in honey bees that confers disease resistance to the hive by eliminating brood pathogens from the colony (Spivak and Reuter 2001). Colonies with queens selected for hygienic behavior have shown lower levels of *Varroa* than control colonies when left untreated, with no significant difference in honey and brood production (Spivak and Reuter 2001, Guarna *et al*. 2017). In Canada, selective bee breeding for qualities like hygienic behaviour is currently being done by a small subset of queen breeders who choose traits based on behaviors exhibited by bees in the field (field-assisted selection, or FAS).

There are cost, resource, and efficacy barriers that limit the widespread adoption of FAS resulting in few breeders engaging in this process and even fewer achieving accurate and effective results (Spivak and Gilliam 1998, Pernal *et al*. 2012). Field testing for hygienic behavior, in particular, relies on a trait-specific test that cannot be used to test for other characteristics such as gentleness or honey production.

An alternative to FAS is the use of molecular diagnostics, specifically marker-assisted selection (MAS), which uses molecular markers to support the identification of bees within a colony who carry specific traits of interest (honey production) or the lack of undesirable traits (e.g., aggression). MAS in honey bees is based on finding proteomic markers within the bee protein and has the potential to provide more rapid selection pressure in queen breeding than FAS, as it would enable bee breeders to test a larger number of colonies, maximizing genetic diversity in the selection pool. Once additional markers are identified in the lab (currently being done as part of the *Beeomics* project at several locations across Canada), marker tests can include a number of different traits simultaneously and can be assayed by multiple reaction monitoring in the same analysis at virtually no increased cost (Parker *et al*. 2014). Once a heritable trait has been identified and linked to particular protein markers by researchers, beekeepers would be able to collect and send samples of bees to a diagnostic lab for testing, receiving the result by mail shortly afterwards. The results could then be used to screen for potential queen breeder colonies according to the beekeeper's own breeding priorities or selection index.

BC queen bee producers, Kettle Valley Queens. Photo by Liz Huxter.

A large majority of beekeepers we surveyed were interested in participating in their local queen economy and preferred local bees. Surveyed bee breeders wanted to take part

in new integrated pest management strategies including implementing new selection tools to create stronger Canadian bees.

The top seven bee traits sought after by surveyed beekeepers were honey production, gentleness, overwintering ability, hygienic behavior, mite resistance, brood pattern and bees being disease free, collectively representing 69% of all responses (Figure 11).

These traits are all key variables being studied in the *Beeomics* project with the objective of providing multi-trait analysis of bees (encompassing these traits among others) to beekeepers during the life of the project. Eighty-nine percent of beekeepers expressed a strong or moderate interest in sending samples of their bees to an independent lab such as the NBDC for trait analysis using MAS.

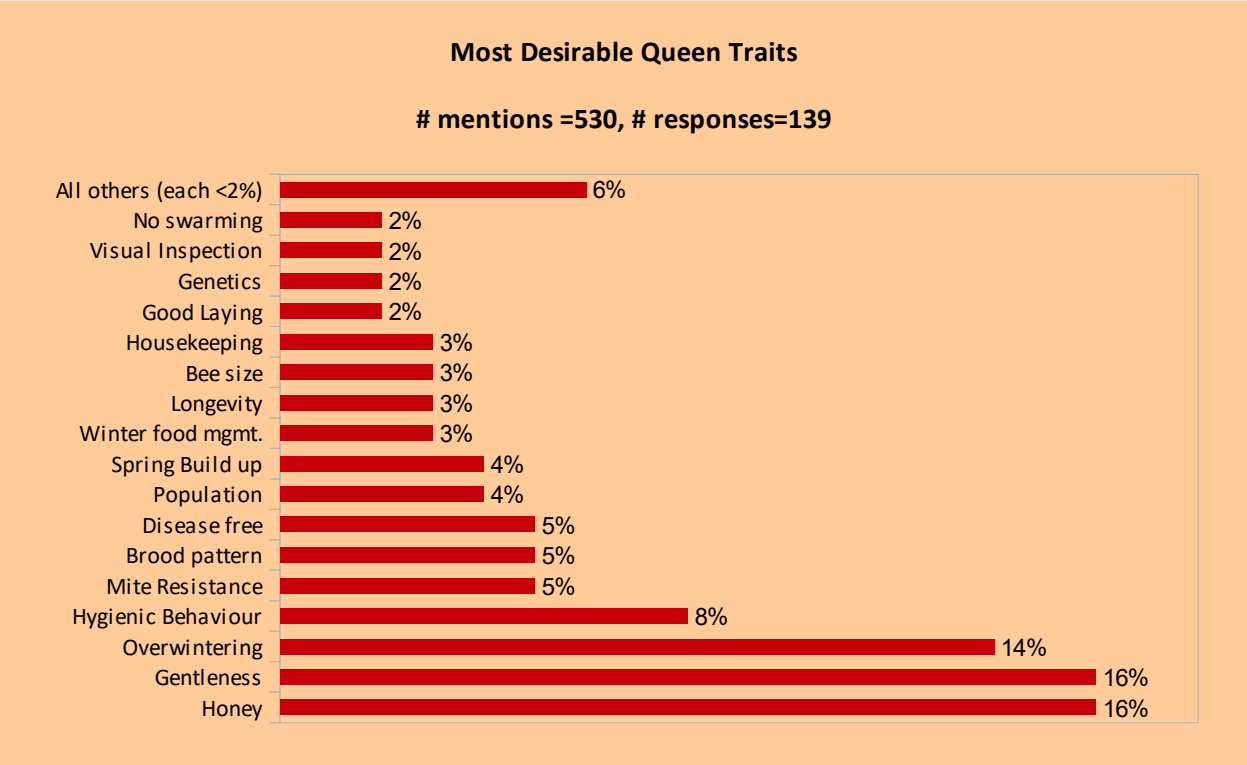


Figure 11. Most desirable qualities in a honey bee queen according to surveyed beekeepers.

There was a concern raised by beekeepers that local queens are undervalued, making local bee breeding operations not financially viable. The survey responses indicate that queens selected for a beekeeper's top two traits are very highly valued. This would suggest that Canadian queen breeding operations that engage in accurate and consistent selective breeding (potentially through MAS), would be in a position to succeed economically.

Breeding Values for Honey Bees

Genetic selection of the honey bee (*Apis mellifera* L.) in a northern climate

Principal Investigators: Ségolène Maucourt, Claude Robert, Pierre Giovenazzo

Animal breeding, in combination with developments in agricultural technology, has made remarkable progress in increasing production of many domestic species. However, these important tools are poorly exploited in the honey bee (*Apis mellifera* L.) industry because of the complex genetic and reproductive features of the bee. In recent years, new mathematical approaches have allowed the application of statistical models in honey bee breeding programs and the use of breeding values to improve genetic selection. The aim of our project is to adapt statistical models currently used for breeding in the dairy cow and pig industry in Quebec for the genetic evaluation and performance monitoring of the honey bee.

This project will

- identify honey bee performance traits with high heritability within the colonies of the CRSAD honey bee breeding program,
- develop a breeding plan to improve the genetic potential and produce superior queen bee breeding stock,
- measure the impact of male selection on the breeding values of honey bee colonies.

This novel approach will improve honey bee performance of traits relating to yield stability and sustainability of our northern climate beekeeping industry.

Overwintering/Banking queens

The following quote is from an apicultural specialist regarding the importance of queen banking to meet the demand for large numbers of bees in spring.

"Being able to produce queens in May/June is not the main issue. Being able to produce enough in those months is. The imports supply a massive number of beekeepers at the same time which Canadian queen producers are not able to produce all at once. Queen production numbers take place over a season, not in 1 or 2 weeks. Queens that are imported are coming from places that can produce and bank large numbers of queens over a couple months which are all shipped at once. To meet demands we need to be able to bank queens from the year before in large numbers to be available to meet spring queen demands."

Beekeepers continue to rely on imported queens to build up their splits in the spring to compensate for winter losses. The imported queens present a host of issues including that their southern climate origin prevents them from having the adaptation necessary to survive long, northern winters unlike domestic Canadian bees (Parker *et al*. 2010). One of the most important areas of bee, and specifically queen, research in Canada is how to successfully and cost effectively overwinter queens in northern regions.

The objective of overwintering queens would be to develop an efficient method to bank large numbers of queens or overwinter nucs that would ultimately replace a good proportion of the queens that are imported each year in the spring. Influential work done by Wyborn (1993) laid the groundwork for queen overwintering research over the past few decades. Wyborn demonstrated that queen banking for a period of 6 months in Canadian winter conditions using wooden screened storage containers using a colony banking technique can be economically profitable and biologically sustainable. Since that time, *Varroa* has become a significant issue requiring increased treatment and resulting cost increases by the queen breeder, however, queen prices have also risen, more than balancing out the increased costs. There is exciting overwintering research being done in Canada which will hopefully be a promising step towards greater sustainability in the future.

Four-way nuc with mini frames for queen rearing. Photo by Alison Van Alten.

Current and Recent Overwintering/Banking Projects Underway in Canada

A. Experimental queen overwintering study at University of Guelph (2015-2016)

Principal Investigators: Shane Klassen (graduate student, U of Guelph), Ernesto Guzman and Paul Kelly (Honey Bee Research Center, U of Guelph).

Recent research is providing evidence that honey bees adapt to their local environment. A Canadian study by Parker *et al*. (2010) showed that bees adapted to colder winters by increasing the rate of protein expression responsible for mitochondria production, and therefore metabolism. This adaptation allows bees to generate more heat, helping them to survive a cold northern winter. Bees adapted to warmer southern climates lacked this adaptation and had a reduced ability to survive a cold winter. This finding may be part of the reason Ontario has been experiencing incredibly high winter losses, as many of our queens are imported. We have been taking bees bred for warm climates and expecting them to survive our cold and long winters.

One very attractive solution is to produce local queens in the late summer and store them throughout the winter for use in the early spring. To further investigate this theory, a study was conducted at the University of Guelph Honey Bee Research Center during the winter of 2015/2016 to test the wintering of mated queen bees. In order to store several mated queens in a single hive, “bank” frames were constructed containing 24 queen cages each, 12 on each side. These cages had screen mesh on one side allowing the queens to be fed by worker bees. The bank frames containing mated queens were stored in queenless hives made by combining two strong colonies, each in a single deep brood chamber, creating a very strong colony. The queens of these colonies were removed and the following day the banks were introduced. This took place in mid-October. Two of the bank hives remained outdoors and were insulated with a commercially available hive wrap. The other two were placed in the indoor wintering facilities at the University of Guelph.

By early March, the queen banks wintered indoors were moved outside and queen survival in all 4-bank hives was evaluated. Of the queen banks wintered indoors, the survival rates were 6% and 71%. The survival rates of the queen banks wintered outdoors were 29% and 76%. Upon inspection, it was noticed that the two colonies with the high survival rates had a significantly higher population of bees than the hives with poor survival rates. Because good results were obtained from hives wintered both indoors and out, we conclude that it is possible to bank queens indoors or outdoors with good results. The take home message is that a high worker population is crucial for successfully banking queens.

B. Mass winter storage of honey bee queens in Canada

Principal Investigators: Andrée Rousseau (CRSAD) and Pierre Giovenazzo (Université Laval).

There is a high demand for quality queens to replace dead or deficient queens after wintering of colonies in Canada. Replacement queens are imported mainly from US queen breeders but there is growing concern amongst Canadian beekeepers regarding the sustainability of our industry and the importance to increase self-sufficiency. Canadian queens are now being successfully produced by an increasing number of queen breeders across Canada with support from various breeding programs. These locally bred queens are available from early June until early September. The queens from the last production cycle are often unused and could be stored until the following spring to replace part of the imported queens. Our project aims to assess the potential of queen overwintering systems at temperatures below and above cluster formation to maximize queen survival and quality. This project will test 4 storing/banking methods for queens from September to April. Young mated queens will be produced during the last breeding cycle in September and will be wintered in environmentally controlled rooms at the following conditions:

- *Control Group 1)* Queens stored individually within 4 frame colonies at 4-6°C;
- *Experimental Group 2)* Queens stored individually in small cages and grouped together (queen bank) within a queenless colony below cluster formation temperature at 4-6°C;
- *Experimental Group 3)* Queens stored individually in small cages and grouped together (queen bank) within a queenless colony near cluster formation temperature at 10 -13°C;
- *Experimental Group 4)* Queens stored individually in small cages and grouped together (queen bank) within a queenless colony above cluster formation temperature at 15-18°C.

Wintering success of queens in control and various experimental groups will be evaluated using the following performance criteria: queen survival; queen weight; queen size; and viability of the spermatozoa in the spermatheca. A subsample of surviving wintered queens will be introduced in colonies to evaluate their performance in terms of colony development and honey production.

C. Overwintering queens: Ontario (OBA) and British Columbia (BCBBA)

Principal Investigators: Les Eccles (OBA-TTP), Heather Higo (BCBBA)

Ontario

In Ontario, our team has been working informally on overwintering queens over the last few years and are now formalizing scientific projects to advance the methods of overwintering queens. The work on overwintering queens in queen banks is based on Margriet Wyborn's work, however we have made some small modifications to try to improve the consistency of results. We have had success rates as high as 75% and as low as 35%. However, even with a 35% success rate, we have calculated that these queens are worth more than if they had been sold the previous fall at $30 a queen.
We made nucs in mid-late April with 2 frames of bees and had full-sized colonies by the end of May, so the value is very high for any queen that can be overwintered successfully.

This winter we have expanded our number of overwintered queens to approximately 350 queens in the queen bank project and we are working on decreasing the "preference" aspect in which workers care for some queens over others. We definitely feel that preference is the main issue for the banks as all of the surviving queens were grouped together in their cages despite the cluster being around all of the cages.

For this project, we are investing in infrared cameras to better observe the cluster

movement in the banks. This will allow us to make more observations about how the cluster is interacting with the banked queens overtime. What is working very well is the overall health and strength of the bees in the banks themselves. So far, the bees have come through winter in good health with little change in population and as a result can be used to reintroduce queens. One of the significant advantages has been no loss or sacrifice of bees when the banks are made because the bees are recovered in the spring when re-introduced with a queen.

The other queen project we are working on simultaneously is overwintering in 4-way mating nucs with queens in overwintering rooms using queens from team members' own colonies. We have about 170 queens in these 4-way nucs being overwintered. The tech team is working with the ORHBS program on this and have just started to communicate with the BCBBA (see below for more BCBBA project details). We have more overwintering methods that we plan to implement in the long run but can only change one or two things at a time so we that there are enough replications to properly assess the effect on the queen banks.

British Columbia

The work being done in BC on overwintering queens in banks is not as well-structured and organized as the projects in Ontario and Quebec. However, the BCBBA has several members who have been trialing overwintering following the methods of Margriet Wyborn in addition to other members who have been overwintering successfully in small 4-ways and nucs. Members want to learn from each other to improve our success rates, and we will collate the results from the methods used last winter prior to us setting up in late summer/early fall this year for the 2018/19 winter. One of our challenges is the vastly different environments (temperatures/humidity/length of winter) in different areas of the province which may influence the success of methods used in different areas. BCBBA members are excited about the potential for bringing queens through the winter and several are planning more rigorous trials this winter. Members of the BCBBA are interested in the work being done by the Ontario tech team and are looking forward to fruitful collaborations in the future.

D. Private initiatives

There are a number of private beekeepers across Canada who have indicated that they are investing significant resources into overwintering research within their own bee breeding operations. As these are private enterprises with only private investment there is no funding mandate to disclose the research methods or outcomes and we will have to be patient and await the word that there are strong overwintered queens for sale in the future.

Honey bees caring for larvae in queen cups. Photo by Alison Van Alten.

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8. Recommendations and next steps

Ninety-three percent of all respondents of the beekeeper survey indicated that increasing domestic queen supply would strengthen beekeeping overall in Canada. There is a strong desire among beekeepers to address the key issues facing honey bees in Canada by

Domestic queen bee supply would strengthen beekeeping in Canada. Photo by Melissa Girard.

adopting more effective bee breeding strategies and tools and supporting local bee breeders.

One of the challenges for the queen bee breeding industry and its stakeholders in Canada is to accept the reality that early pollination needs will likely always require some imported queens (although as the research on queen overwintering progresses, the extent of our reliance on imported queens may evolve), while continuing to encourage and champion as much domestic supply as possible without succumbing to the ease of mass importation. With each queen that is supplied domestically instead of imported, we reduce our risks associated with imports including the vulnerability in any given season to a loss of a large percentage of queens due to border closures.

Taking steps to foster our bee breeding industry as it grows will involve a multifaceted approach- including providing breeders and beekeepers with access to the newest queen bee breeding research and pilot projects, support with resource and labour shortages, technical breeding and queen production support from Provincial Apiculturists and/or tech transfer teams, a connection with scientific apicultural researchers and a platform (and possibly a broker) for efficient and effective networking and facilitation of transactions between bee breeders and buyers.

It is also important that all of the players involved in our pollination-dependent agricultural system in Canada work together. Pollination-dependent crop producers are important stakeholders in the queen industry as they rent colonies for pollination and depend on the quality of the queens and colonies for their crop output. Local farmers need to support beekeepers and their bees by planting bee-friendly forage for pollination around their crops and utilize new technologies to minimize spraying impacts on bees such as the BeeConnected app .

As we move towards greater sustainability within our beekeeping industries, there are challenges that will arise and steps that need to be taken to maximize the industry's potential.

The following list of twelve issues and action items is the culmination of the research that was done to develop this reference guide including insights drawn from many interviews with apicultural specialists, beekeepers and queen breeders across Canada.

Twelve identified issues and action items

1. In-depth supply and demand research needed on Canadian honey bee queens.

Issue*:* A comprehensive understanding of the queen demand and supply chains within Canada would allow for greater domestic breeding success. Survey data suggest great potential for synergy between queen bee breeders and buyers but it is critical to understand the precise breeding capacity of small and large operations, the timing of production and the willingness and ability of buyers to adapt to local supply conditions. There seems to be a disparity in the entrepreneurial mindset of Canadian bee breeders compared to their American counterparts. It is essential that we better understand the reason for the lack of commercialization of queen bee breeding in Canada and the most effective incentive structure to encourage this.

Action: Provincial Apiculture specialists could begin a pilot project to interview local bee breeders in an effort to determine breeding capacity as well as any barriers to increased commercialization. The project should also include developing profiles of local demand in each region.

2. Commercial beekeeper engagement.

Issue*:* Large commercial beekeepers play an essential role in promoting and supporting domestic queen markets in Canada. Essentially, the bee breeding industry needs buy-in from these large operations to have a chance at capturing a reasonable share of Canada's queen market and making an impact on mitigating the risks of importation.

Action: Initiate a cross-country project to engage commercial beekeepers in our domestic queen bee breeding movement, emphasizing colony health and economic advantages of local queens. Promote this through tech teams, Provincial Apiculturists and regional associations.

3. A network must be established for buying queens.

Issue: Queen breeders must have ready access to an updated and reliable list of queen buyers and vice versa in order for the domestic bee breeding industry to develop. It is essential that these relationships be supported throughout the duration of the transaction including before and after the queen/cells have been delivered and through the contract negotiations. Miscommunication and disillusionment between parties can result in non-fulfilled contractual agreements and fewer future sales

Action: The upcoming national/regional queen bee breeding website will allow for networking between the demand and supply sides to take place and for transactions to be completed. Encouraging local co-ops or other industry players to engage a functioning brokerage system for queen transactions would be a key part in achieving success. The broker would have updated information from buyers and bee breeders in all locations and would facilitate local queen buying transactions. To further minimize risks and maximize success, a provincial and/or national template for queen buying needs to be created and used consistently by queen bee breeders, buyers and brokers (see Appendix A for an example).

4. Local bees for sale at co-op or central source.

Issue: To encourage local buying, beekeepers need to be able to find domestic queens at their local co-op and/or from a central local supply source.

Action: Having the local bee co-ops or other local supplier carry as much local stock as possible would be an important step towards supporting and encouraging local queen production. As mentioned above, the co-op may also be in a position to engage a broker to manage queen transactions and ensure efficient and optimal connections are made throughout the season to benefit all parties including the co-op.

5. Affordable queen marketing.

Issue*:* Breeders need access to affordable and targeted marketing platforms to better connect with buyers in the community.

Action*:* Regional and provincial apicultural publications and websites are an excellent forum for advertising local bees. As well, these platforms could assist in promoting the paradigm that “local is better” and providing evidence of the significant risks of importation.

6. Queen breeding success requires a solid infrastructure.

Issue*:* To build the queen breeding industry, we need more queen breeders and more queens produced per breeder. There are few resources available to most queen breeders (aside from a few provinces with strong tech teams and/or breeding associations). It is critical to have an infrastructure set up that will entice new breeders to enter the market and for new and existing breeders to be educated and trained as necessary and connected to local buyers.

Action: The industry needs initiatives that will support training for breeders and new queen buyers (e.g. a caring for queens course), as well as provide access to a skilled, seasonal labour force. Breeders may also benefit from some risk mitigation measures (e.g. agricultural insurance) that encourage queen breeding in the face of environmental and other challenges and allow the industry to scale-up at a healthy rate. It may also be beneficial to have incentive programs to encourage re-queening and proper queen management (as is the case in P.E.I.). A standardized training program recommended for all Canadian bee breeders and beekeepers on proper queen selection, rearing and care could maximize the opportunities for success during and after queen transactions and encourage future transactions.

Note: *It is imperative to have ongoing consultations and collaboration over any new policy or industry initiatives with regional beekeeping and bee breeding associations to ensure stakeholder compliance and support.*

7. Formal regional support needed.

Issue: Active engagement between queen bee breeders and apicultural breeding specialists (Provincial Apiculturists, and apicultural researchers with breeding expertise, breeding research labs and technology transfer programs focused on queen breeding) is essential to promote science-based breeding selection using new technologies and to encourage strong queen rearing following local best practice guidelines.

Action: Each beekeeping region needs to have a well-funded and healthy support system such as a technology transfer or adaptation team and/or partnerships with local apicultural specialists and/or research agencies. The tech teams and/or apicultural support system would inspect and monitor bee breeding and beekeeping operations to ensure high quality standards are met for queen breeding, re-queening frequency and that proper protocols are met for receiving local queens. For those regions without this type of support, a regional working group comprised of apicultural specialists could strategize the most cost-effective and practical approach to intensifying

bee breeding support in their regions. It is essential that each province incentivize beekeepers and breeders to register their operations to encourage accurate record keeping and regional community involvement and support in training and research.

8. Informal community support is also key.

Issue: Queen breeding operations benefit from hands-on support from within their community in the form of active associations hosting regular workshops and training sessions as well as knowledge sharing between breeders.

Action*:* Associations may need policy or funding support to build up their membership and host researchers and other apicultural speakers. Meetings and workshops need to be held locally (or on a web-based platform) so beekeepers in remote parts of the province do not have to travel significant distances (at significant cost) to learn and network. A formal mentorship program between more experienced and less experienced queen bee breeders may also be beneficial.

9. Expanding testing and selective breeding capabilities of research labs may add value.

Issue*:* For the majority of queen bee breeders who would benefit from scientific and technical support, it would be valuable to have a local research facility or lab where testing and selection is facilitated. Modeled after the Ontario example, a hybrid breeding model may offer needed support, training and quality assurance for new and existing bee breeders. A government supported program such as this one shares the risk between stakeholders and allows the breeders to produce high quality queens with greater support and confidence.

Action: There are several existing facilities that conduct testing for honey bees and could potentially be encouraged to take part in a more holistic breeding strategy. This would require stakeholder engagement at the government, research institution and industry levels to develop a sustainable strategy for moving forward. CRSAD and NBDC are two facilities that may have the capacity to expand their mandate in the future to include even more science-based bee breeding support (with additional funding and breeding specialists) and possibly access to other queen breeding resources such as isolated mating yards and targeted apicultural expertise. This initiative requires significant human and financial resource mobilization and ought to be implemented in small attainable steps with on-going apicultural expert consultation.

10. Centralized selective breeding is an option.

Issue*:* To minimize more of the risks associated with individual bee breeding operations, a few apicultural specialists have suggested that we move to an even more centralized version of the bee breeding model where all selection in a particular region takes place in a central scientific lab and then queen production is done by local queen bee breeders who receive the selected stock from the lab.

Action: This initiative would require a central testing/research facility such as in Beaverlodge, Deschambault, and potentially southern British Columbia where the breeding season is extended. These central facilities would take on much of the bee breeding for the surrounding region and would collaborate with a group of queen producers who would then propagate and distribute/sell the selectively bred queens to local beekeepers. The program could be supported by a nominal fee from each queen sold. There is also potential for this type of program to be supported and standardized at a national level to promote consistent testing and coordinated breeding support.

11. Ongoing research support is critical.

***Issue**:* As the industry expands, it is important for governments and research institutions to continue to support breeding research projects and for beekeepers and breeders to have access to all new research into key areas such as queen overwintering.

***Action**:* A continued collaborative effort is required of policy makers, apicultural specialists and researchers, local and regional associations, Provincial Apiculturists, bee breeders and beekeepers to encourage new research projects both through funding and in-kind funding support such as partnerships for pilot projects and knowledge sharing with researchers and industry members. As well, new research must reach industry through effective and timely publication in local bee publications and through conference presentations.

12. Technology adoption requires short-term support system.

***Issue**:* Beekeeper focus group participants and Provincial Apiculturists have suggested that a tech transfer team or other industry support framework be engaged on a short-term basis to facilitate the adoption of new technologies such as MAS testing or queen overwintering into beekeeping communities.

***Action**:* For regions without a well-developed support team, perhaps a few apicultural experts or local research specialists could be deployed on short term contract to ease the transition of bringing a new breeding technology into a population. For example, as MAS testing comes to market, some beekeepers and breeders would benefit from having a technician available to assist with sampling, mailing samples, receiving and interpreting results and strategizing and implementing changes to the operation to incorporate the new results. Another example involves queen overwintering where researchers will hopefully soon be able to show that queen overwintering can be successful. In this case, breeders will need additional resources and support as they make the transition to adopt this practice into their operations. Queen overwintering will likely require some investment up front for equipment and resources but will create considerable added value once the industry is able to provide a larger number of queens earlier in the season. A hybrid, or even more centralized queen bee breeding model may be a good platform for overwintering. The centralized facility would invest in overwintering equipment and other resources that would then be available to participants for a fee. Beekeepers could then choose to invest in similar equipment for their own operation or continue to use the facility to overwinter their queens.

Appendix A: Agreement for Sale and Purchase of Queens

Between

(the vendor/breeder)

and

(the purchaser)

AGREEMENT FOR SALE AND PURCHASE OF QUEEN BEES

AGREEMENT FOR SALE AND PURCHASE OF QUEEN BEES

This agreement dated: _____day of _____20____

Between _____(vendor/breeder)

And _____(purchaser)

The vendor has agreed to sell the queen(s) (as defined at clause 1 below) on the terms and conditions set out in this agreement.

Possession date: _____

Value of Queen(s): $_____per queen (+GST if any)

Number mated queens $_____(modify for queen cells)

Total Purchase Price: $_____(plus GST if any)

Deposit: $_____to be paid on both parties signing this agreement

Balance of payments: $_____(circle either a) or b) below)

a) to be paid in full on the possession date or
b) to be paid on _____(insert payment date/s)

The Vendor is registered under the GST Act in respect of the transaction evidenced by this Agreement and/or will be so registered at the Possession Date.

GENERAL TERMS OF SALE

(should include some or all of the following items, at the discretion of both parties):

Description of queen(s): The Vendor undertakes to deliver a healthy, disease-free queen(s) at time of purchase. The age of the queen(s) is estimated at 6 months, 12 months, 18 months, 24 months (strike out not applicable). The queen(s) has been successfully mated as far as the vendor can ascertain, but the vendor accepts no liability for any queen failure after possession date, or unless otherwise stated in the agreement.

PURCHASER:

Inspection/Site Visit: The purchaser may visit the vendor's breeding operation within 30 days prior to the possession date at an agreed upon day and time to inspect the mating nucs and queen rearing locations. (It is recommended that if the purchaser is not an experienced beekeeper, that the purchaser engage an experienced beekeeper to accompany the beekeeper on the site visit).

Collection of the Queen(s): The Purchaser will at his own expense collect or have the queen(s) collected through an approved and reliable carrier from the Vendor. If the queen(s) is being mailed, the vendor will add the shipping cost onto the final queen price.

Other responsibilities: (Any additional responsibilities of the purchaser should be clearly outlined here. For example, the purchaser must have completed some type of "queen care" education module or course prior to the possession date.)

Risks and liability: (The expectations of the purchaser in the case of an adverse occurrence must be clearly outlined here. For example, what action, if any, does the purchaser take in the case of weather impacting the possession date or poorly mated queen after possession).

VENDOR:

The vendor may visit and inspect the purchaser's beekeeping operation prior to the possession date at an agreed upon day and time to ensure proper management is in place to receive and adequately introduce the queen(s) to a colony.

Other responsibilities: (Any additional responsibilities of the vendor should be clearly outlined here. For example, the vendor must have specific safeguards in place to mitigate poor weather outcomes and the impact on queen mating and the possession date.)

Risks and liability: (The expectations of the vendor in the case of an adverse occurrence should be clearly outlined here. For example, what action, if any, does the vendor take in the case of weather impacting the possession date or poorly mated queen after possession).

Default: If either the vendor or the purchaser is unable to fulfill the contract, the details of what next steps must be taken are clearly outlined here.

Signed by the Vendor: _____

Date: _____

Name: _____

Address: _____

Email Address:_____

Registered number: _____

Witness:_____

Signed by the Purchaser:_____

Date: _____

Name: _____

Address:_____

Email Address:_____

Registered number:_____

Witness:_____

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