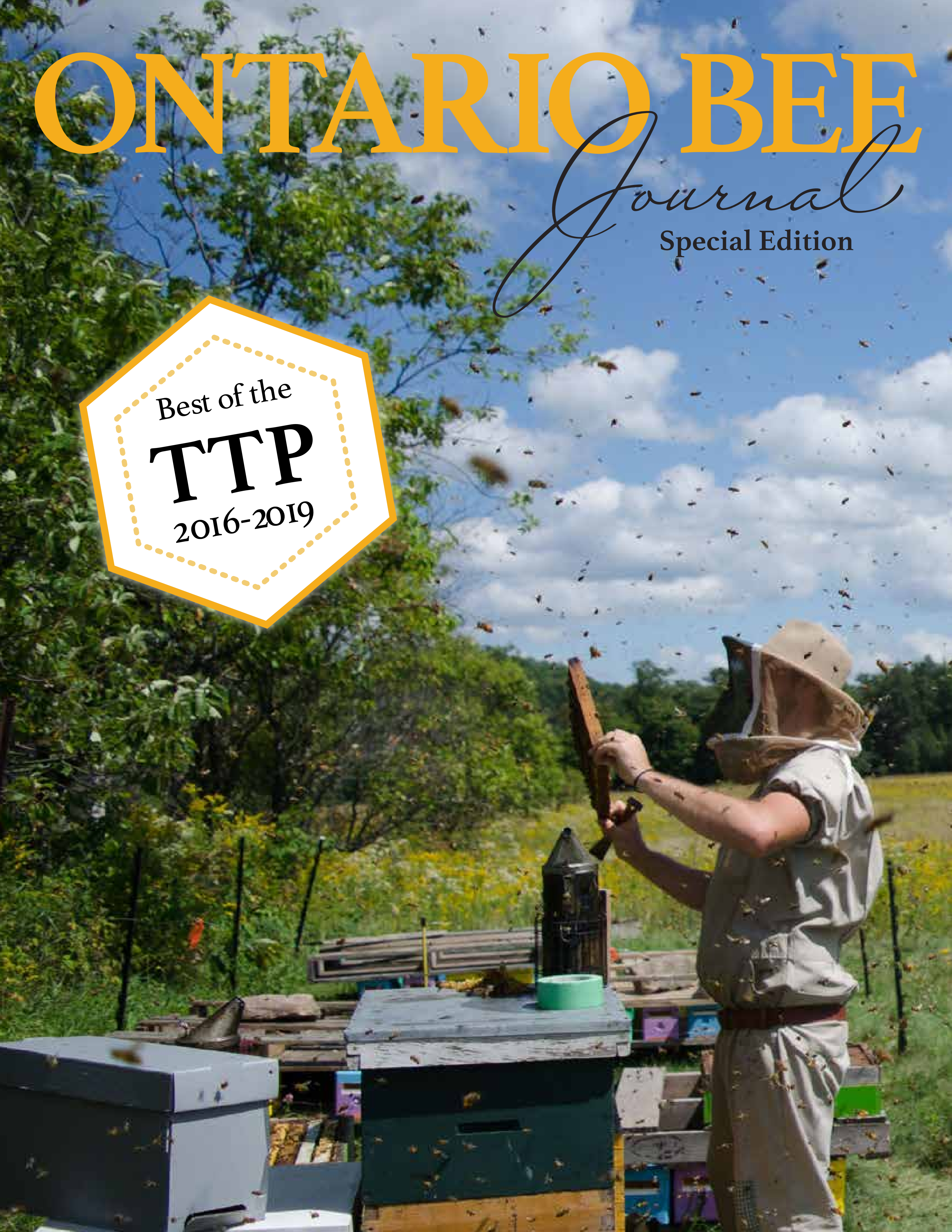
ONTARIO BEE Journal

Special Edition

Best of the TTP 2016-2019





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OBA
ONTARIO BEEKEEPERS' ASSOCIATION
Since 1881

The Ontario Beekeepers' Association is working to ensure a thriving and sustainable beekeeping industry in Ontario.

Ontario Bee Journal
Special edition
Best of the TTP
2016-2019

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Tech-Transfer Program Lead

Les Eccles has been the Tech-Transfer Program lead since 2011. He has both a Diploma in Agriculture and a Bachelor of Science in Agriculture from the University of Guelph. Les first developed his interest in beekeeping at the UoG Apiculture Research Centre with Paul Kelly and Ernesto Guzman. He is also an instructor at Niagara College's Commercial Beekeeping program, and co-operates his own commercial beekeeping business with his wife. Les's special interest is in honey bee breeding and stock replacement. Over the years, he has focused on the development of the Ontario Resistant Honey Bee Selection (ORHBS) program.

Melanie Kempers, B.Sc.
Special Projects Admin/Research Technician

Melanie Kempers grew up on a dairy farm in Prince Edward County. It was her love of agriculture that brought her to Guelph (Moo-U) to obtain a B.Sc. in Agriculture. Not really knowing much about bees, she applied for a summer student job with the "Bee Girls" and stood amongst a swarm in her first week on the job. With that amazing experience, she was hooked. She's the only TTP member to not have bees outside of work, but that's because she's busy with sports, her friendly canine sidekick Violet, and working out at the gym. Melanie loves that beekeeping is never dull and keeps her on her toes!

Daniel Thurston, B.A.
Research Technician

After attending a beekeeping workshop with the TTP, Dan began working as a summer student with the program while studying at the UoG. His interest in beekeeping grew from there and he has been with the team ever since. He enjoys meeting and chatting with other beekeepers (super chatty guy) and collecting things he finds in the field. Dan spends his time away from TTP working at Niagara College and on his own beekeeping business, Thurston Honey Bee Co.

Daniel Borges, M.Sc.
Research Technician

Dan Borges holds a bachelor's degree in Biology from McMaster University and a Bachelor of Education from the University of Toronto. His passion for insects and entomology led him to the University of Guelph, where he completed a master's degree under the supervision of Dr. Ernesto Guzman. His master's work focused on the treatment of Nosema ceranae using natural compounds and probiotics. Dan also teaches at Niagara College, disseminating knowledge about bee biology and entomology. Dan is from the Tri-Cities area and currently lives in Kitchener. He runs a small beekeeping operation selling honey and nucs.

Kelsey Ducsharm, B.Sc.
Research Technician

The newest kid on the block, Kelsey Ducsharm has been with TTP for more than four years. She began as a summer student while attending school at the University of Guelph. After completing her Environmental Science degree, she decided to continue working with honey bees full time. And because that wasn't quite enough bees for her, she now keeps a few hives of her own in her spare time as well.

ONTARIO BEEKEEPERS' ASSOCIATION

TECH-TRANSFER PROGRAM

The Ontario Beekeepers' Association Technology Transfer Program (TTP) was established in the early 1990s by Dr. Medhat Nasr. The three key mandates of the TTP are to conduct research for Ontario's beekeeping industry; to facilitate a honey bee breeding program in Ontario; and to transfer information, skills, and methodologies to beekeepers.

One of the primary mandates of the Tech-Transfer Program is the transfer of knowledge – transforming research into industry use through synthesis, exchange, dissemination, dialogue, collaboration, and brokering among researchers and research users. Essentially, a key goal of the program is to ensure that research happening at the academic level is put into application at the industry level – the way in which this happens is the fun part.

There are various ways to disseminate knowledge, information, and training. Extension work in agriculture has been active since 1906, working closely with universities and colleges to transfer advice and practical tools.

The TTP is unique because it operates directly for the beekeepers of Ontario, focusing on issues which are of importance to them. Base funding is received from the Ontario Ministry of Agriculture, Food and Rural Affairs, and beekeepers donate funds for research. Additional support is sought from agencies which provide funding at a federal or provincial level.

The TTP's areas of focus include developing and maintaining a current Integrated Pest Management approach to beekeeping; assisting in the maintenance of a province-wide breeding program; and testing several aspects of management to promote honey bee health. The TTP also tests a variety of treatments for the control of varroa mites. The goal is to be pro-active and to limit the number of treatments that must be applied each year.

A TTP research crew is based in Guelph. Collaborators include the provincial apiarist, the University of Guelph, and co-operating beekeepers. Projects with collaborators can increase the research capacity and allow the TTP to reach many more beekeepers across Canada and beyond.

Educational, hands-on workshops are conducted every spring at various locations across the province. Introductory Beekeeping, Pest Management for Beekeeping and Introductory Queen Rearing are available for hands on learning. Advanced workshops are also provided for beekeepers looking to refresh their skills or learn new ways to manage the health of their honey bees.

Results of the work undertaken by the OBA's Tech-Transfer Program are presented at semi-annual OBA conferences; at presentations given to local beekeepers' associations across Ontario; to other beekeeping associations in Canada and the US; and to school and community groups with an interest in honey bees.

Donations from beekeepers help keep the program active. Monies received from the industry and members of the public are used to support (and are double, tripled, and even quadrupled by funding agencies) for the various projects that the TTP applies for and administers. The Tech-Transfer Program appreciates your support!

"A KEY GOAL OF THE PROGRAM IS TO ENSURE THAT RESEARCH HAPPENING AT THE ACADEMIC LEVEL IS PUT INTO APPLICATION AT THE INDUSTRY LEVEL."

ASK AN EXPERT

CAN WORKER BEES MOVE EGGS OR LARVAE?

BY MELANIE KEMPERS, TECHNICIAN – TECH-TRANSFER PROGRAM

You may have noticed this question being asked in the October 2015 issue of *American Bee Journal* ("The Classroom" by Jerry Hayes). The response in that issue declared "Honey bees do not have the fine motor control over their mouth parts" indicating that, although bees can consume eggs and larvae, they cannot move them. It was unfortunate that this statement was not backed by a scientific study or reference that would indicate the supporting evidence for this position. Intrigue led me to seek out more information about the truth behind this statement (with a little push from an OBA member).

Upon searching for further information about egg relocation and whether worker bees can accomplish this, I discovered that little effort has been spent proving or disproving this phenomenon. I reached out to the leading experts on honey bees in Canada and received several responses. Most observations were noted during experiments conducted for other reasons. These are the responses I received:

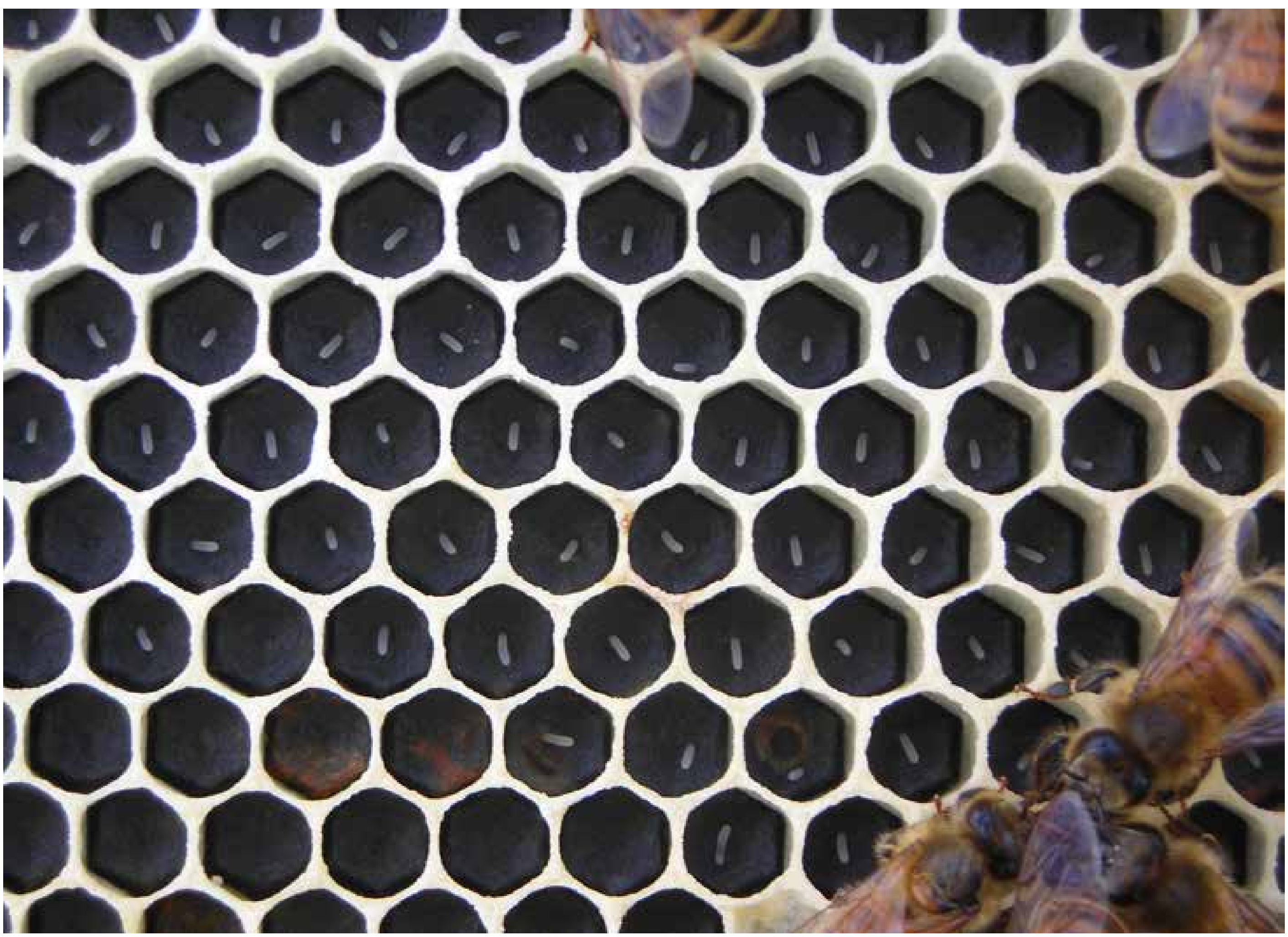
1. A study being conducted on virgin queens utilized hives with full sized frames to house the un-caged virgin queens (one virgin per hive). These colonies did not have a means of producing new brood (no mated queen) so the hives were provided a frame of donated eggs/larvae periodically to maintain new workers over the course of a few months. The bees would then start to rear queens on frames adjacent to the donated frame, which means they must have moved the eggs from one frame to another.
2. One researcher had caged in-hive queens to prepare for the re-queening of several colonies. The new queens were delayed, so the caged queens were left in their respective colonies, within their three-hole wooden cages. When the researcher returned to introduce the new queens, they noticed that developing larvae was found close to and surrounding the caged queens. Eggs were found in the cage with the queen as well as in the cells surrounding where the cage was placed within the colony.
3. Another researcher involved with raising queens noted that, in a Cloake board cell builder system, the queen is confined by queen excluders to the bottom of two brood chambers. Graft frames with empty queen cups are placed in the upper queenless brood chamber the day before grafting. When the graft frame was removed the next day for grafting, there were sometimes eggs in a few of the queen cups, which should have been empty.
4. Mark Winston noted that he had conducted experiments years ago on "emergency queen rearing that demonstrated eggs could be moved. They made colonies queenless, noted where the empty queen cups were located on the first day, and then noted cups with eggs or young larvae the following day or two. The larvae developed into queens, so they weren't worker-laid."
   The studies published with these findings are:
   - Winston, M.L. 1979. Events following queen removal in colonies of Africanized honeybees in South America. *Insectes Sociaux 26*: 373-381.
   - Punnett, E.N. and M.L. Winston. 1984. Events following queen removal in colonies of European-derived honey bee races. *Insectes Sociaux 30*: 376-383

"HONEY BEE WORKERS CAN AND DO MOVE EGGS IN TIMES OF DIRE NECESSITY."

5. On the other hand, in this study – Ellis et al., 2008. Hygropreference and brood care in the honeybee (*Apis mellifera*) – research was based on the fact that bees cannot move eggs. Unfortunately, they did not provide a reference for this fact.
6. One last factor to consider regarding the observation of queens being raised in queenless colonies is the occurrence of thelytoky. Thelytoky is the asexual production of females (females from unfertilized eggs). It is common in the Cape honey bee (*Apis mellifera capensis*). There are reported studies about thelytoky in European honey bees, although it is rare and only exhibited in cases of dire emergency (no queen or brood present for some time). Thelytoky does not appear to occur if a queen is present and therefore would not explain why eggs are sometimes found above a queen excluder in a queenright colony (for example, in the bottom of honey super frames). Otto Mackensen studied thelytoky in the 1940s and found that, indeed, some European honey bee workers did lay female eggs. Gloria DeGrandi Hoffman, research leader and centre director of the U.S.D.A. Agricultural Research Service's Carl Hayden Bee Research Center, went so far as to actually rear queens from the offspring of laying workers in a selected line. So it seems that though thelytoky is rare, it may happen in emergency situations. The studies published with these findings are listed below
   - Mackensen, O. 1943. The occurrence of parthenogenetic females in some strains of honey bees. *J. Econ. Entomol. 36:* 465-467
   - Thelytoky in a Strain of U.S. Honey Bees (*Apis Mellifera L.*) May, 1991 – *Bee Science* G. DeGrandi-Hoffman, E. H. Erickson Jr., D. Lusby, and E. Lusby

In conclusion, from the few studies conducted and the anecdotal observations of leading experts, there is disagreement about the statement that bees cannot move eggs. Although it doesn't really change the way we manage our honey bee colonies, the implication that honey bee workers can and do move eggs in times of dire necessity is a general agreement among Canadian bee researchers.

Have you seen worker bees carrying eggs around your hive? If you see it happen, have your camera handy – it would be a calendar worthy shot!



ASK AN EXPERT

IS WINTER BEE MORTALITY DIRECTLY PROPORTIONAL TO THE COLD?

BY LES ECCLES – TECH-TRANSFER PROGRAM LEAD

Depending on where you are in Ontario, the winter temperature can be a bigger factor than in other areas. It all comes down to a number of cumulative conditions, snow cover being the main one.

If you have good snow cover, colonies can take long periods of severe cold with very little issue. But if colonies don't have that nice insulating layer of snow, they will have much more exposure to the cold and it will be much harder for them to break cluster and move to food stores in other parts of their hive. For example, the Niagara area may be ideal for early spring management and colony development; however, it always concerns me that they receive very little snow cover to protect their colonies during long, cold winters like the ones we had in 2013-2014 and 2014-2015.

The other extreme is our location in Grey County, where the colonies are usually all snugged up under five feet of snow insulation. For the most part, they come out of winter looking just as good as they did in the fall, even with a long cold winter. This answer doesn't take into account the cumulative effects that pesticides and/or Varroa have on overwintering colonies; we're just talking about the effect of cold temperatures. Winters are more dynamic than just cold temperatures.

My biggest fear about the mild winter we're having this year is that, should the temperature suddenly drop to the -20s for two or three weeks, the hives have very little snow to protect them. If this happens, it will be important to check their food reserves in early spring as they may have had to consume larger quantities of food to cope with the colder temperatures.

> "If you have good snow cover, colonies can take long periods of severe cold with very little issue."

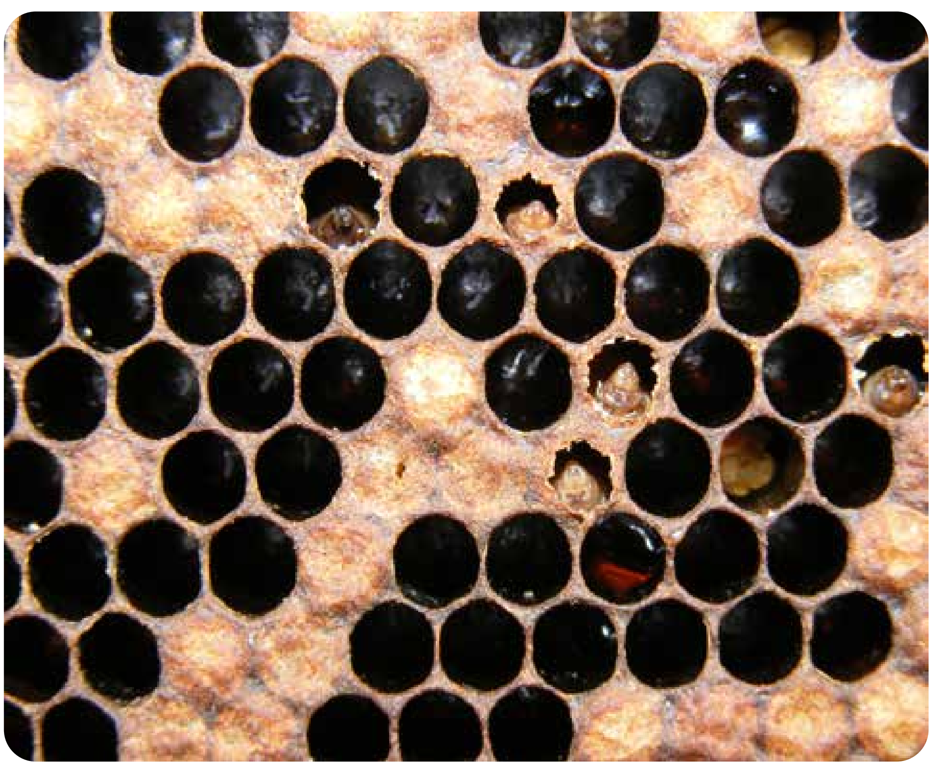
ASK AN EXPERT

WHAT CAN I DO ABOUT CHALKBROOD AND SACBROOD?

BY LES ECCLES – TECH-TRANSFER PROGRAM LEAD

These diseases are both commonly found in honey bee colonies and are easily identified through visual inspection. Although they both affect the larval stage of honey bee brood, these two diseases are different in a few respects; the main difference being that chalkbrood is a fungal infection while sacbrood is a viral infection.

Chalkbrood receives its name from the transformation of wet larva to a dry chalk-like mummy that can easily be tapped out – or fall out – of the cell when attempting to remove it. It can often be observed on the bottom board or in front of the colony entrance as the nurse bees identify and pull it out of infected cells.



Sacbrood is a fitting name for this disease as it turns larvae into a brown, liquid-filled sac that, if pulled with tweezers, can be removed whole from the cell – although often the sac breaks, spilling the liquid brown remains of the larva.

For the most part, these diseases are easily controlled through good biosecurity measures, honey bee genetics, and overall reduced stress on colonies. For chalkbrood, culling comb and using hygienic honey bees will help reduce or even eliminate cases of the disease. This said, even with hygienic bees and overall healthy colonies, chalk brood can occur if colonies become weak due to a long winter or cool, wet spring when the first brood is being produced and the colony is expanding in the spring. In this case, chalkbrood usually disappears as the colony becomes strong enough to clean out infected cells before visible signs of the disease appear.

Sacbrood, like most viral diseases, is strongly linked to Varroa infestation levels. Because Varroa is a vector for virus, it is more common to observe viral diseases when Varroa levels have been allowed to increase past threshold levels. Hygienic bees may remove sacbrood before it is observed however, in relation to Varroa, it is only a symptom of a larger problem – high Varroa mite levels.

If excessively spotty brood is observed, this can be a sign of not only a failing queen, but also bees cleaning out diseased brood. Viruses can also build up in combs and if the queen is infected, she can lay eggs infected with the virus. To aid with this issue, culling and replenishing a hive with new frames and replacing a potentially infected queen can help reduce the spread of sacbrood even after Varroa mite levels have been controlled.

Although chalkbrood and sacbrood are considered minor pests for honey bee colonies, identification of these diseases should be considered as indicators for improvements that can be made to management by renewing brood comb, replacing existing queens with hygienic stock, and ensuring that Varroa levels stay low and are not allowed to cause damage that can be difficult to recover from well after treatments are applied.

ASK AN EXPERT

HOW CAN I MONITOR FOR AFB IN AUTUMN?

BY DANIEL THURSTON, TECHNICIAN – TECH-TRANSFER PROGRAM

During the fall months, monitoring colonies for pests and diseases is often overwhelmingly focused on Varroa mite control in advance of winter, and for good reason. One honey bee ailment that often does not receive as much attention during the fall, however, is American foulbrood (AFB). This time of year, as honey bees produce their final brood cycles of the season, AFB can continue reproducing if present in a colony. Fall hive inspections provide an opportune time to monitor for AFB as honey supers have likely been removed and brood is still present, allowing irregularities and symptoms of AFB to be identified.

These are the classic symptoms of AFB:

PERFORATED CAPPED BROOD

It is good practice to target cells containing holes in the cappings and investigate what lies beneath for further indication of AFB presence.

DIRTY/GREASY CAPPED BROOD

AFB-infected cells will contain dark, rotten-looking pupae rather than the white colour of healthy larva and pupae. The cappings of AFB-infected cells may appear greasy or moist and sunken or indented as the infection ages.

BROWN ROTTING LARVAE/PUPAE

If infected with AFB, whether the cells are capped or uncovered, the larvae/pupae will be brownish in colour. AFB-infected brood will dissolve into a brown-coloured mush if investigated by the beekeeper.

SCALE

If an AFB-infected cell completes a brood cycle, a dry, brownish-black scale will be left behind in the bottom tip of the cell. This scale is difficult to remove without breaking the cell wall. Identifying this symptom of AFB is helpful in queen-less colonies absent of brood, and in brood-less deadout colonies.

FOUL SMELL

The name American foulbrood is derived from the foul odour that diseased combs can emit. The intensity of this smell can vary depending on the severity of infection and temperature. Individual ability to smell AFB varies greatly and should not dictate diagnosis. Foul odour is a symptom unique to AFB and can assist in monitoring for the disease.

STICK TEST/ROPINESS TEST

The stick test (also called the ropiness test) is the ultimate confirmation of AFB presence in a colony. After uncapping suspect brood cells, insert a small stick or some equivalent (such as a toothpick or matchstick) into the cell and mash up the contents. Starting with the stick still inside the cell, slowly pull it out, allowing the cell contents to be drawn out if they adhere. Mashed cell contents that adhere to the stick and pull out as a ropey brown slime approximately 2 cm (just under an inch) in length will confirm the presence of AFB.

OTHER AUTUMN AFB MONITORING TIPS

When applying prophylactic oxytetracyline in the fall, colonies may not be strong enough to take down treatment. Upon returning to apply the second

and third rounds of antibiotics, the presence of earlier applications still sitting on the top bars may indicate a problem worthy of investigation.

Colonies that were strong and producing bountiful honey early in the season may be disappointing in late season honey production if AFB is present. If AFB has had the chance to establish and damage a colony's strength through the season, then empty supers in the late season may a broader indication of trouble in the hive.

AFB transmission is increased during autumn as strong bee colonies rob out weaker, AFB-infected colonies between apiaries and beekeeping operations, bringing infection back to their strong hive.

Brood chambers should be inspected for AFB prior to opening barrels in a yard, as open-source feeding provides a source of AFB transmission. If AFB is identified in a colony, it should be eradicated before sugar syrup barrels are opened for your colonies (and neighbouring ones) to feed on. If AFB is detected prior to feeding, colonies can be individually top-fed to prevent further disease transmission.

Uniting a weak colony with another in the fall is a common beekeeping practice to hopefully produce one strong colony going into winter. There is an inherent risk in this practice if the cause of weakness has not been thoroughly diagnosed and recognized as free of AFB infection. Unknowingly uniting an AFB-infected colony with a healthy one will ensure that, whether the united colony survives the winter or not, there will be an AFB source in your apiary the following spring when bees begin to rob.

From a biosecurity standpoint, pest and disease transmission – particularly with AFB – can be reduced through proactive management:

- Familiarize yourself with visual AFB symptoms and periods of increased exposure.
- Thoroughly and diligently inspect colonies prior to other fall management practices.
- Consider using or adopting management techniques to protect colonies from infection.
- Sterilize equipment that did, or may have, come in contact with AFB.

If you are concerned about the presence of AFB in a colony, or are unsure about diagnosing the disease, please contact your regional provincial beekeeping inspector to report the problem. Doing so will allow further inspection of your apiary as well as apiaries neighbouring you to find the source of infection. AFB is controlled through cooperation and communication by the beekeeping community as a whole to prevent spread to surrounding apiaries.

This past summer the OBA Technology Transfer Program – in partnership with the University of Guelph's Animal Health Lab, OMAFRA, and volunteer beekeepers from across Ontario – performed a provincial sampling study for AFB strain presence and resistance to antibiotics. Brood comb samples from colonies recognized as healthy (to which antibiotics had and had not been prophylactically applied) and those identified as AFB-infected were collected and analyzed. This sampling will provide insight into the strains of AFB present in Ontario and whether antibiotic resistance is currently found in our province. Additionally, it is hoped that this work will provide an accessible facility for AFB laboratory diagnosis to be performed for beekeepers in Ontario into the future.

"EMPTY SUPERS IN THE LATE SEASON MAY PROVIDE A BROADER INDICATION OF TROUBLE IN THE HIVE."

TTP FEATURE

BEE BIOSECURITY AND BEEKEEPER RESPONSIBILITY

BY LES ECCLES – TECH-TRANSFER PROGRAM LEAD

We hear many key terms with regard to honey bee health that are often co-mingled. Three in particular are:

- Best Management Practices (BMPs)
- Integrated Pest Management (IPM)
- Biosecurity

Although these terms are related, they do have their individual places in beekeeping knowledge and practice. I have listed these terms in this order to show how each falls under the umbrella of the previous one.

BMPs is an all-encompassing term for beekeeping practices that improve honey bee health and production. They go beyond honey bee pest management by including information on such things as equipment use, feed management, pesticide exposure, habitat, honey harvest, and overwintering prep.

IPM is a key BMP and refers to all practices used to diagnose, monitor, manage, and treat honey bee pests and diseases, as well as related record keeping.

Biosecurity is a major component of IPM that uses management strategies to reduce the risk of pests and diseases spreading, as well as the complete reliance on treatment inputs to keep honey bee colonies healthy.

National Biosecurity Standards have been developed for most livestock in Canada, including managed pollinators. The *Honey Bee Producers Guide to the National Bee Farm-Level Biosecurity Standards* is available on the Canadian Food Inspection Agency's website at *www.inspection.gc.ca/animals/terrestrial-animals/biosecurity/standards-and-principles/honey-bee-producer-guide/eng/1378390483360/1378390541968*. This guide outlines the principles of honey bee biosecurity and how to evaluate your management practices in order to make biosecurity improvements. On-farm biosecurity is important for reducing the risks of decreased production, increased treatment and labour costs, and closed export markets. The risk of decreased demand for farm products and services can affect on-farm incomes. Although reduced productivity due to pest and disease impacts is obvious, the management costs associated with resolving these issues in colonies and apiaries may not always be as well understood. Multiple visits to apiaries to apply management and resolve affected colonies, as well as related equipment replacement costs, can increase dramatically when pest and disease issues are not kept from passing thresholds.

Although there is very little risk of honey bee health issues affecting domestic honey consumption, our ability to move bees for pollination and bee sales can be affected. An apiary infected with American Foulbrood (AFB) or high levels of Varroa will not pass inspection for sale or export within Ontario, to other provinces, or out of the country. It should be noted that different provinces and countries have different biosecurity standards for receiving honey bees and thus can affect how a business needs to consider its biosecurity plan and "acceptable" levels of pest pressure. For example, Alberta and Saskatchewan will not approve queen and nuc permits for honey bees with Varroa levels higher than 1% . This means that increased vigilance to keep Varroa levels low throughout the season is a priority if a beekeeper wishes to access these markets. Recently, Small Hive Beetle has become an increased biosecurity concern for inter-provincial trade of bees because not all provinces have established SHB populations and need to mitigate the risk of introducing it. Ontario beekeepers must have inspections for SHB before sending bees to another province, thus biosecurity to prevent SHB in colonies that are to be sent for out-of-province

"...ONLY BEEKEEPERS WHO HOLD A VALID ONTARIO QUEEN AND NUC PERMIT ARE ALLOWED TO SELL BEES."

"Varroa mites are still the number one cause of overwinter loss in Ontario, and will be for many years to come."

pollination must be implemented. Understanding your markets will help you understand the type of biosecurity plan that will fit your business goals.

The key components of honey bee biosecurity, in order, are:

- **Prevention** – keep pests/diseases out
- **Isolation** – keep pests/diseases in
- **Shut down** – remove high-risk colonies from operation

Prevention does not always mean the prevention of new pest entry into colonies. For example, Varroa is so widespread that we can only control the level of Varroa pressure, but we are unable to eliminate the Varroa population. We can, however, take steps to prevent colonies with high levels of Varroa from collapsing and spreading mites to other colonies that have low levels. This is often a biosecurity concern in late summer and early fall, when Varroa populations have reached levels high enough to cause colonies to collapse. The collapsed hives are then robbed out by healthy colonies, causing a domino effect of Varroa infestation. This has been coined the "Varroa bomb" scenario by Dr. Dennis van Engelsdorp.

The cornerstone of beekeeping biosecurity was built on AFB prevention and control, and references can be found in even the oldest beekeeping manuals. The *Ontario Bees Act* states that any clinical case of AFB must be destroyed and that no bees can be sold from apiaries that are AFB-positive. This was the earliest form of biosecurity in beekeeping (even if the word may not have been used at the time). Other important biosecurity protocols that can be implemented to prevent AFB include culling comb on a three-to-five-year rotation and disinfecting hive tools between bee yards.

Another important aspect of AFB biosecurity is taking precautions when obtaining swarms, especially if they are from an unknown apiary. AFB spores are easily carried on adult honey bees and can infect the equipment they come in contact with – this colony could then become the source of infection for the rest of your apiary.

Both of the above examples using Varroa and AFB – arguably the most important honey bee pests affecting our industry – demonstrate ways you can prevent the introduction of pests and diseases to your apiary. If you keep bees for any significant period of time, sooner or later you will likely end up with an increased pest pressure level or a clinical case of AFB. Honey bees, unlike other livestock, cannot be confined to barns or fields to prevent contact with other animals that may transmit pests and diseases. There will always be the risk of a tree with an established colony and a continual cycle of swarms moving in, succumbing over time to Varroa or AFB and leaving resources to be robbed out, allowing for contact with healthy colonies and leaving empty comb for new swarms to move into and continue the cycle.

identified disease that requires depopulation under the *Bees Act*, however the OMAFRA apiary program does have the power to order the treatment or depopulation of any highly infested colony for other pests and diseases. There is an argument that colonies collapsing from Varroa infestations are as great a biosecurity concern as AFB, and that they should also be depopulated and burned to prevent the "Varroa bomb" that contaminates the rest of the apiary. Some of the newest research on the impact of Varroa mites by Dr. Rob Currie is demonstrating the legacy of high Varroa infestations – likely due to virus transmission from the remaining bees and comb – well after treatments have been successfully applied and Varroa populations have decreased. Varroa mites are still the number one cause of overwinter loss in Ontario, and will be for many years to come.

There are also inherent biosecurity risks associated with normal beekeeping practices that need to be considered. The driving force behind beekeeping and the relative importance to agriculture and food production is pollination services. The need for high numbers of honey bees to provide these services in order to ensure pollination occurs at the rate needed to make food production profitable for farmers and affordable for consumers requires the movement of colonies from various locations. For some crops, the demand is so high that colonies from numerous producers must be located on the same site. This is a unique livestock biosecurity risk, not unlike cattle going to stockyards

There are numerous routes of exposure and once the infection reaches clinical or collapsing status, proceeding to "keep in" mode must take place. The *Ontario Bees Act* allows for the provincial apiary program to quarantine sick colonies and yards however, as responsible beekeepers, we should not rely on this service and must ensure that we do our own due diligence to ensure affected colonies are properly isolated.

"Shut down" is the final resort to control the spread of pests and diseases. The most notorious "shut down" disease is AFB. Under the *Ontario Bees Act*, colonies with clinical AFB must be depopulated (burning the equipment and the bees). The foolish beekeeper believes it's too expensive to burn colonies – the wise beekeeper knows it's too expensive not to. The highly contagious spread from clinically infected AFB colonies to healthy colonies can quickly make a lit match the cheapest treatment you can apply, rather than having to do the same to many more colonies. AFB is the only

"The foolish beekeeper believes it's too expensive to burn colonies – the wise beekeeper knows it's too expensive not to."

and then being dispersed to multiple farms after they are sold. These colonies are sharing forage and a certain amount of drifting between colonies will occur. Fortunately, the *Bees Act* and the corresponding regulations in other provinces require inspection of colonies before they are moved to reduce the risk of disease spread. AFB, Varroa, and Small Hive Beetle are the main diseases that inspectors look for. Beekeepers also need to communicate with growers to be aware of what other colonies may be arriving at the same pollination site and discuss biosecurity concerns that need to be managed.

When purchasing bees, remember that only beekeepers who hold a valid Ontario queen and nuc permit are allowed to sell bees. These beekeepers will have been inspected by the OMAFRA apiary program to ensure their bees are not a high biosecurity risk.

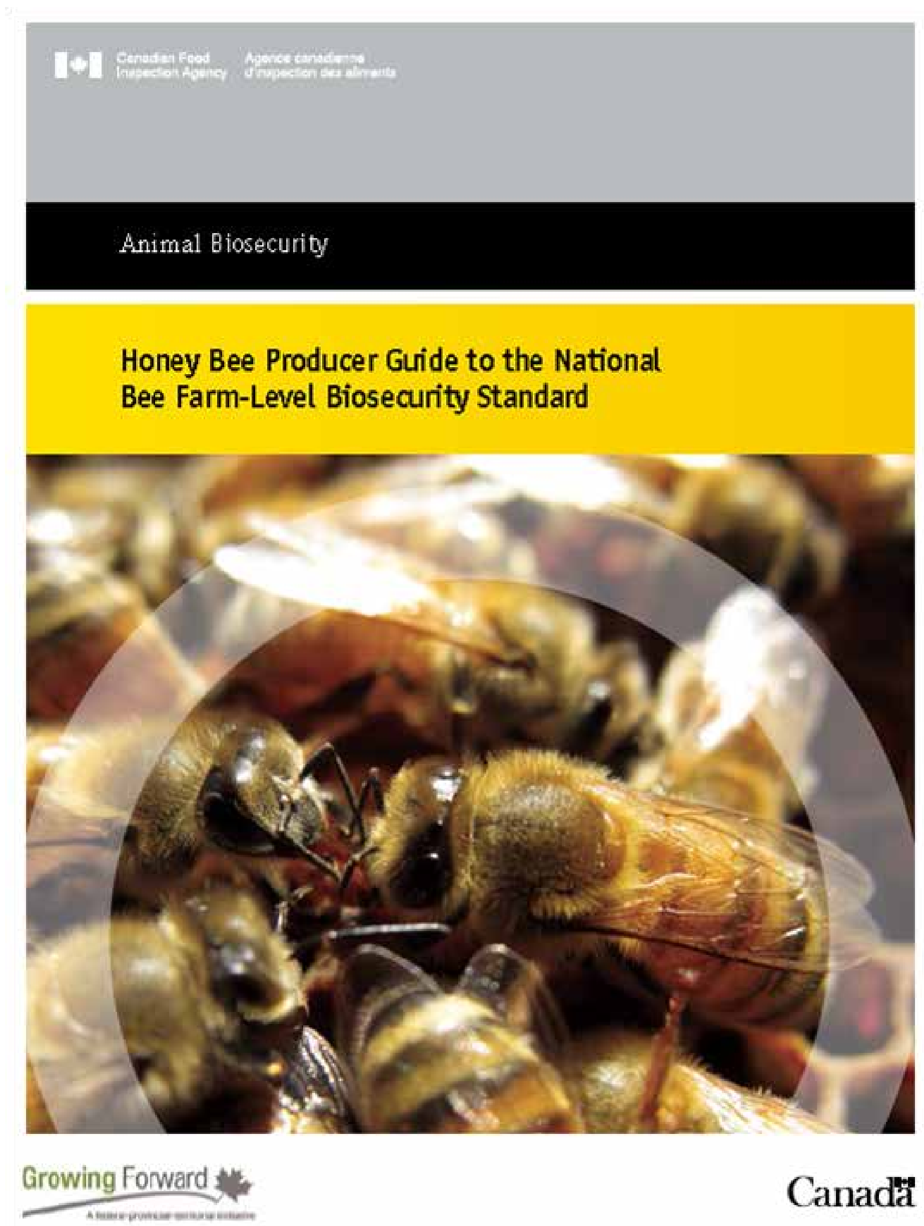
Understanding biosecurity principles and risks is the first step in making a plan. As part of Growing Forward 2 (2013-2018) the Ontario Soil and Crops Improvement Association (OSCIA) offered workshops across Ontario that provided training and planning for on-farm biosecurity evaluations and plans. Attendees completed a bee biosecurity evaluation and received information about how to develop a biosecurity plan for their own apiaries. For commercial beekeepers, the bee biosecurity workshops were a prerequisite for applying for Growing Forward 2 producers' grants.

Honey bee biosecurity is an important concept and tool to use with your Integrated Pest Management program. With global markets moving agricultural products at a rapid rate (and from all corners of the world), and as more beekeepers enter the industry and more colonies are kept in close proximity, biosecurity will only become more important. For the moment, biosecurity planning and implementation is voluntary and it is up to us, as an industry, to adopt these concepts to protect honey bee health and pollination services. Biosecurity management will also help our industry keep treatment products working when needed for longer periods of time by not relying on them as the sole and repeated method to control pests and diseases, which contributes to resistance-building.

Finally, biosecurity is not only important to protect your own honey bees, but also to be a responsible beekeeper and not expose your neighbouring beekeepers' apiaries to outbreaks of Varroa and AFB.

Two of the most important workshops a beekeeper can take in Ontario are the OBA TTP Integrated Pest Management (IPM) workshop and the Bee Biosecurity workshop. The information and skills obtained in these sessions will impact most of the work a beekeeper will focus on and think about in the bee yard. Remember, beekeeping is only profitable if the honey bee colonies are healthy enough to do it for you the next year.

Note: *Growing Forward 2 was replaced in 2018 by the Canadian Agricultural Partnership (CAP) program. Information on grants available to beekeepers and prerequisites such as the Bee Biosecurity Workshop can be found at* www.ontariosoilcrop.org/canadian-agricultural-partnership/.



ASK AN EXPERT

DID WAX MOTH KILL MY COLONY?

BY DANIEL BORGES, TECHNICIAN – TECH-TRANSFER PROGRAM

The question of whether wax moth can kill a colony or not is a common one, in part because the signs can seem to overwhelmingly point to "yes." A beekeeper may open a hive that they haven't checked on in a while and find it empty of bees and absolutely filled with wax moth larvae or the webbing that they leave behind as they tunnel through wax. In a situation like this, it is easy to conclude that wax moths were responsible for killing the colony.

There are two species of wax moth that are of concern to beekeepers – the greater wax moth (*Galleria mellonella*) and the lesser wax moth (*Achroia grisella*). The two species have an almost identical life cycle and look very similar, with the lesser wax moth being slightly smaller. Both species can cause considerable damage to both comb and equipment. However, wax moths are opportunistic pests and very rarely cause damage to healthy colonies.

The life cycle of both species of wax moth goes through the same four stages as a honey bee – egg, larva, pupa, and adult. The female wax moth enters the hive at night and lays eggs in protected, out-of-the-way places. The eggs hatch into grub-like caterpillars. The larval stage is the only life stage that feeds, and it is the larvae that cause all of the damage. The larvae feed on wax, pollen, honey, bee faeces, bee pupal casings, and even brood. As they tunnel through the wax and feed, they spin a tough, protective silk web. In addition to the damage caused by feeding and defecating through the wax, this silk webbing can cover the comb, even fusing frames together when the infestation is bad enough.

Upon reaching maturity, the larvae chew canoe-shaped indentations into the hive woodenware and spin a cocoon. The cocoons are often found on the sides of the hive box or on top of the frames. After emerging, the adults leave the hive to mate, and the females return to lay more eggs. Under warm temperatures and the right conditions, wax moth can complete their life cycle in only 26 to 33 days.

While wax moths cannot kill a colony, they are very quick to colonize and

> “Confining brood production to the brood chamber also keeps the majority of stored pollen out of the honey supers, making them wholly unattractive to wax moth.”

infest weak or compromised colonies. In a strong, populous colony, workers will chase away or harass female moths, preventing them from laying eggs. Worker bees will also remove wax moth larvae that they find in the hive. However, when a colony is small and weak, queenless, or in the process of crashing from high Varroa mite loads, wax moth can reproduce unchecked and severely infest the colony, taking over in a relatively short amount of time. With this in mind, the best control for wax moth is to keep strong, healthy, and populous colonies. It is important to make sure that weak colonies are promptly diagnosed for queen or disease/parasite issues, and that the issue is dealt with as soon as possible. This may mean re-queening a weak colony, or some kind of management or treatment intervention for pests or diseases.

While having strong, healthy colonies will prevent wax moth infestation, these pests can cause huge amounts of damage to stored equipment, particularly to empty brood comb. A number of management strategies can be used to help prevent wax moth damage to stored equipment. Though it may not seem intuitive, one of the best preventative measures is to use queen excluders. Wax moths are particularly attracted to dark, older brood comb that contains high amounts of pollen, bee faeces, and bee pupal casings; they generally avoid newly-drawn comb and comb used solely for honey storage. Wax moth larvae cannot pupate and complete their life cycle if they feed solely on wax – they require the protein they obtain from pollen and bee pupal casings. Using queen excluders prevents the production of brood in the honey supers and keeps them clean of these food sources required by wax moth larvae. Confining brood production to the brood chamber also keeps the majority of stored pollen out of the honey supers, making them wholly unattractive to wax moth.

Whether honey supers or drawn, used brood comb, it is important that equipment be stored properly to prevent wax moth damage. Storing equipment in a cool place is particularly helpful, as freezing temperatures will kill all wax moth life stages. While having a freezer storage unit is an ideal situation, it is expensive and impractical, especially for smaller-scale beekeepers. Keeping supers and drawn comb in an unheated garage or shed, or even out in the yard, will mean that stored equipment will be protected from wax moth throughout the winter.

During the summer, it is important that stored equipment be sealed, with no holes or cracks for female moths to enter and lay eggs. Even if a freezer storage unit isn’t available, freezing individual frames or boxes for a short period of time can be an effective way to kill wax moth before storing the equipment. At temperatures of around 5 to -7°C, all wax moth life stages will be killed within four to five hours. Keep in mind that wax moth eggs on equipment that was not treated with freezing can hatch and infest stored equipment that was treated.

While not as commonly used, some beekeepers have had success using light and ventilation to prevent wax moth damage. Equipment stored in a room with a constant light source and running fans is generally unattractive to female moths and will be avoided. Out in the yard, stacking boxes on their side to allow light and ventilation can have a similar effect, though this can pose a biosecurity risk from robbing bees and is not recommended.

In addition to these strategies, maintaining proper apiary hygiene will also help prevent wax moth damage. Scrape down bottom boards and clean burr comb from frames and hive bodies periodically to eliminate wax moth hiding places and food sources. Make sure that these scrapings are disposed of properly and not left in the yard. Finally, replacing old brood frames every three to four years eliminates thick, dark comb that is extremely attractive to wax moth. As an added bonus, this also helps reduce disease spores and pesticide residues that accumulate in wax over time.

There are no registered chemical treatments for the control of wax moth. While mothballs and fumigants containing paradichlorobenzene are used elsewhere, they are not registered in Ontario, pose a considerable risk of contaminating honey and hive products, and should not be used.

TTP FEATURE

CULTURAL MANAGEMENT STRATEGIES FOR COMBATING VARROA

BY DANIEL THURSTON, TECHNICIAN – TECH-TRANSFER PROGRAM

Beekeeping has surged in popularity in recent years, and with it, the vast online collection of beekeeping articles, websites, and forums containing helpful and accurate information – but also misleading content.

All beekeepers, regardless of management strategy, would be pleased to see a reduction in the harm caused by pests and diseases, as well as improved colony health. You would be hard-pressed to meet a beekeeper who likes having to introduce chemicals into their colony, or who would like to see further inputs required to keep their colonies strong and healthy. The difference between conventional beekeeping philosophy and treatment-free is the way in which beekeepers work toward these goals.

CULTURAL CONTROL

Common methods of Varroa cultural control include splitting or creating natural brood breaks, and the practice of drone brood removal. While not a substitute for treating colonies, mite reproduction can be considerably slowed mid-season by using these management techniques.

Varroa mites reproduce in conjunction with bee brood development. With every round of bee brood maturation, mites reproduce under capped cells, growing exponentially in population along with the colony. This becomes increasingly damaging as the bee colony shrinks in size approaching the end of the season while the mite population stays constant or continues to increase. By fall, colonies can be so full of Varroa and the associated viruses they transmit that colony health may seriously decline if action isn't taken.

Colonies left without attention to mite infestation will usually perish in late fall or during winter. While cultural control practices are not substitutes for treatments, their use can have a large impact on colony health. There is much to be said about slowing the growth of Varroa through heavily splitting colonies. Beekeepers selling nucs or making many splits to increase colony numbers will often find lower mite levels as Varroa populations have been disrupted and the number of mites per hive reduced early in the season. If splitting with introduced queen cells, further cultural control is exerted through the natural break in brood production until the new queen emerges, mates, and begins laying eggs.

Beginning beekeepers who have purchased a nuc will also often find lower mite levels in their late-season colonies – this is particularly true if nucs were purchased late in the season, as the colony will have grown from only a couple frames of brood, carrying a much smaller mite load than if a full colony had been purchased.

The longer maturation period of drone brood is attractive to Varroa mites as it provides the opportunity for increased offspring production. A drone-specific brood frame, foundationless frame, or medium frame placed in a deep brood chamber can be provided to allow the bees to build drone comb where reproducing mites will become concentrated. The capped drone brood can then be scraped off every 22-28 days , removing many reproducing mites from the colony.

"COMMON METHODS OF VARROA CULTURAL CONTROL INCLUDE SPLITTING OR CREATING NATURAL BROOD BREAKS, AND THE PRACTICE OF DRONE BROOD REMOVAL."

MONITORING

The practice of integrated pest management (IPM) has been examined in past *Ontario Bee Journal* articles in great detail as the adoption of an IPM program is essential to the long-term sustainability of Ontario's beekeeping industry. Along with IPM methods related to treatment diversification and adopting cultural control practices, one of the most important recommendations is related to monitoring. Mite monitoring should take place throughout the beekeeping season, allowing beekeepers to accurately manage colonies and apply treatments as needed so as to prevent the development of chemical resistance and to ensure colony health. Monitoring is an essential tool for living colonies as well as those that have perished, as there are many factors that can influence colony death.

The honey bees we keep are not native to Ontario (or even to North America) and have not evolved in conjunction with their greatest threats. Many of these pests were introduced relatively recently – even to honey bees in their native range in Europe. Honey bees are kept as livestock and should be treated as such, including the practices of animal husbandry.

Although some may keep bees as pets, allowing livestock or pets to suffer with pests and diseases is considered inhumane and would not be overlooked should a dog, cat, pig, or cow fall victim to a similar condition. As beekeepers, we have an obligation to monitor for animal distress and to care for and bring attention to concerns of health – not turn a blind eye or ignore a preventable problem.

SELECTIVE BREEDING

Treatment-free beekeeping and conventional beekeeping share many of the same ideals, and this also applies to breeding. The treatment-free philosophy places emphasis on survivability or genetic stock, and the bettering of honey bees through treatment avoidance. The idea is that survivor stock that

is able to make it through the winter has done so without a 'treatment crutch' and can be bred from to encourage survivability. This approach poses a significant biosecurity risk as the untreated colony (dying or dead) may be robbed out by bees from other hives in the area, exposing them to pests and/or diseases that they would then carry back to their own hives and spread further among the local bee population.

The conventional approach to breeding involves monitoring colonies for beneficial characteristics suited to survival, success, and manageability, and then encouraging selected genetics. Bee breeders expend great efforts (and expense) in monitoring and selecting stock that performs well and that they prefer working with – and they don't wish to lose the colony's genetics (although applying selection pressure may sometimes not work in their favour). Selection pressure is placed on colonies to assess (and ultimately breed for) pest and disease resistance – but it is done in a way that avoids the creation of a biosecurity threat.

A number of selection strategies can be used to reduce reliance on chemicals for the control of honey bee pests and diseases in the long term, including hygienic testing, Varroa sensitive hygiene (VSH), breeding programs such as the one used by the Ontario Resistant Honey Bee Selection (ORHBS) program, and monitoring for grooming behaviour.

The TTP has a long tradition of supporting Ontario's bee breeders through the ORHBS program – in 2016, we provided hygienic testing for 17 members of the Ontario Bee Breeders' Association (OBBA). In addition, through a partnership with LUSH Cosmetics and their Sustainable LUSH (SLUSH) fund, a project was developed this year to monitor the grooming behaviour of breeder colonies belonging to six

Ontario bee breeders. Work published by University of Guelph researcher Dr. Ernesto Guzman suggests that selection for heritable mite grooming behaviour in bees is an important component of combating Varroa mite populations.

Monitoring breeder colonies for grooming behaviour and encouraging these genetics is another step towards easing beekeeper dependence on chemical Varroa control. The monitoring equipment that was used in this project has been made available to the participating breeders for further use. Additionally, this selection technique and its method will be included in upcoming TTP Bee Breeding workshops and was presented during the breeding day of the 2017 OBA spring meeting.

If you are considering treatment-free beekeeping, it is important to take both IPM and genetics into consideration before you begin. Many online resources suggest that trapping or catching 'feral survivor stock' from trees, walls, or other cavities is the best way to begin. The logic behind this is that the bees have survived free of any beekeeper interference and boast superior genetics. This, unfortunately, is not likely to be the case.

A colony saved from a cavity will probably have been a swarm from a neighbouring bee yard. They may carry pests and diseases from their original source, or they may exhibit symptoms that developed during their time living on their own – it's difficult to say, as no monitoring has taken place. There is no guarantee that these bees have survived on their own for years, or even weeks. The swarm that originally inhabited the cavity could have died from pests or diseases, and the comb may have sat dormant until another swarm moved in. These bees may not have any beneficial genetic characteristics at all.

Additionally, any natural re-queening likely involved mating with neighbouring drones belonging to conventionally kept colonies. When collecting 'survivor stock,' be sure to follow IPM recommendations to segregate the colony and monitor its health. Take advantage of pre-existing beneficial genetics from a local breeder to re-queen your catch. Alternatively, avoid the risk and consider buying selected genetics from a breeder to begin with, as they will likely be an improvement over the alternatives.

Decades of time and work have contributed to our current knowledge of bees and beekeeping. Ontario is home to many resources dedicated to the care and health of honey bees through IPM and breeding programs. The allure of treatment-free beekeeping, on the other hand, poses many risks. Through the myriad resources currently at our disposal – and many more currently being researched and compiled – beekeeping goals can be achieved through hard work and determination that is both safe and humane.

"MITE MONITORING SHOULD TAKE PLACE THROUGHOUT THE BEEKEEPING SEASON, ALLOWING BEEKEEPERS TO ACCURATELY MANAGE COLONIES AND APPLY TREATMENTS AS NEEDED."

ASK AN EXPERT

WHAT, WHEN, AND HOW SHOULD I FEED MY BEES IN SPRING?

BY DANIEL THURSTON, TECHNICIAN – TECH-TRANSFER PROGRAM

Unlike fall feeding which prepares the bees for winter, spring feeding isn't considered essential colony management. Colonies that have been put into winter strong and healthy, with a young queen, – and that have been fed properly in fall – rarely require additional feeding come spring.

During late winter and early spring, colonies can be checked for food stores by lifting the hive from one side to get a feel for its weight. A colony that has depleted its food stores will lift with very little resistance and feel virtually empty. In contrast, a colony with food stores still intact will require more effort to lift and will feel heavy.

Gauging the approximate weight can be tricky at first, but the differences will become clear once a couple of hives have been lifted. A scale is not necessary to assess whether colonies require emergency spring feeding. For reference, however, OMAFRA's best management practices recommend colonies weigh 32-45 kg (70-100 lb.) in advance of winter. An empty colony, depending on equipment, weighs approximately 15 kg (33 lb.).

If colonies require emergency spring feeding to supplement lack of food stores, feed them a 1:1 sugar syrup (for example, eight cups of sugar dissolved in eight cups of water). Sugar syrup will provide the bees with the carbohydrates required to keep warm and fed until the first nectar sources become available.

The most common method of emergency spring feeding is a top feeder. Various styles can be purchased or made at home, all of which provide access to feed directly above the warmth of the brood chamber without requiring the bees to fly.

Alternatively, a small pail or other sealed container with small holes punched in the centre of the lid can be placed above the colony for the bees to feed from. Many inner covers are designed with a hole in the centre to accommodate pail top feeders, allowing bees to access the feeder and syrup from inside the hive. Pail feeders can also be placed directly on the top bars of the brood chamber with an additional medium or deep box to accommodate the height, and the inner cover placed above to protect from the elements and critters. When the pail feeder is placed upside-down on the hive, the syrup will drip until a vacuum is created in the container (it doesn't take long).

Another apparatus that can be used for emergency spring feeding is a large or extra large ziplock bag. Lay a half-filled bag over the top bars of the brood chamber and, using a sharp knife, cut two slits in the bag to allow the bees access. Once empty, the bag can be refilled using the space between the slits as a handle.

Top feeders, whether commercially produced or made from pails or baggies, are used for emergency spring feeding because they provide food directly to the hive, in small quantities, with minimal disruption to the colony. Spring feed is provided when outdoor temperatures are too cool for bees to forage, or when nectar-producing flowers are not yet available.

Barrel feeding in early spring does not always work. Barrels of feed are usually stored over winter and need time to warm up before foraging bees are attracted to them. Outdoor temperatures also have to be warm enough

"IF FEEDING PROTEIN PATTIES, BEEKEEPERS SHOULD BE PREPARED TO OFFER A CONTINUAL SUPPLY UNTIL POLLEN BECOMES NATURALLY AVAILABLE."

for the bees to forage. Also, spring bees seem to focus their foraging efforts on pollen rather than nectar, likely to stimulate and maintain brood rearing in the colony at that time of year.

During late winter and early spring, colonies use pollen stored the previous season to begin raising brood. Ontario honey bee colonies are usually capable of collecting and storing enough pollen to adequately supply their needs before pollen sources become available in the surrounding environment. The practice of feeding pollen or pollen supplements in the late winter and early spring has less to do with survival and more to do with boosting colony productivity. Beekeepers provide colonies with pollen as a protein source to trigger brood production and get a head start on the season.

If feeding protein patties, beekeepers should be prepared to offer a continual supply until pollen becomes naturally available in the environment. Colonies will expand with access to abundant protein as they would in the spring and summer months. A colony that has grown in accordance with artificial resources can be damaged if left in a dearth after being triggered to grow.

It is also important to note that increased brood production also means increased opportunities for Varroa to begin reproduction earlier in the year. Feeding protein to colonies early in the season is an effective method of growing colonies to be split for building colony numbers, but it can also be an effective way to stimulate and increase swarming if the colonies are not divided.

"Emergency" spring feeding is different from "stimulation" spring feeding. Commercial beekeepers will often feed sugar syrup and pollen patties in the spring, regardless of colony stores, in order to stimulate the colony to rear brood. This gives the beekeeper a jump on the season, especially if the spring season is cooler and wetter than normal (which can prevent colonies from foraging on spring flowers). This type of feeding is not required by the casual beekeeper, neither is it necessary to improve colony health. It is, essentially, a production strategy that allows commercial beekeepers to expand colonies quickly in order to provide enough bees for spring pollination services and to maximize seasonal yields.

In 2012/2013, the TTP worked with commercial pollination beekeepers to develop Best Management Practices in pollination colonies. Different pollen substitutes and amounts were tested for their efficacy and application timing in Ontario and Maritime pollination colonies. To read more about this work visit: *www.ontariobee.com/outreach/ttp*

ASK AN EXPERT

HOW CAN I ASSESS THE STRENGTH OF MY COLONIES IN THE SPRING?

BY MELANIE KEMPERS, TECHNICIAN – TECH-TRANSFER PROGRAM

Since strength can be subjective, it may be hard to know if your colony is "strong" or "weak". As the old saying goes, ask 10 beekeepers the same question, you'll get 15 different answers. As frustrating as that may be, it shows how dynamic the industry is. Beekeeping is unique to each hive owner – however, accepting a standardized approach to assessing colony strength can be beneficial to Ontario beekeepers collectively.

Dr. Ernesto Guzman, along with Dr. Keith Delaplane and Dr. Jozef van der Steen, published a paper on a standardized method for calculating strength: "Standard methods for estimating strength parameters of *Apis mellifera* colonies" (It's a good read, if you're into that sort of thing). The paper was directed at assessing colonies in research projects, but it can still give you a good idea of the ways in which colonies can be analyzed.

At one extreme is a digital method for counting bees and brood. Software is now available that can analyze photographs of frames of bees and brood in order to calculate population levels. This process is slow and can be disruptive to the hive, and sometimes can only count bees and capped brood (software isn't able to identify larvae or eggs). The frames are placed in a cradle and a photo is taken. The frame is cleared of bees and the picture taken again. This is completed for both sides of all the frames in the hive. The pictures are uploaded and results are provided in measurements of area (cm^2). This type of strength analysis is typically used in controlled scientific research. It is known as objective analysis, where human interpretation is removed.

Since we can't all own expensive equipment to count bees and brood, the next best option is a visual assessment. Visual evaluation is a subjective analysis. It can be quick, minimally disruptive, and just as accurate when the subjective assessor is properly trained. Assessing a colony for bees, brood, pollen, and honey can be done on a frame-by-frame basis or collectively through cluster size analysis (bees), weighing (honey), and quick frame checks (pollen and brood). When analyzing cluster size, it is a good idea to pull at least one frame to see if the bees are one inch or five inches down from the top bars. I have been tricked by a colony that looked strong from the top bars (five frames with bees on both sides in early spring) only to discover that the bees were only one inch down from the top bar – so the colony was, in fact, weak (and queenless).

To understand if the colony is "strong" or "weak", the values will need to be correlated and parameters considered.

"A VIABLE COLONY IS FOUR FRAMES WITH 75% BEE COVERAGE ON BOTH SIDES (OR THREE FRAMES WITH 100% COVERAGE) BY MAY 15TH."

For the most part, strength is directly related to population. Factors such as the number of bees flying from the entrance, or how loud the hum is when the hive body is tapped, do not accurately indicate the strength of the colony. Opening the hive and looking into the brood chamber is the most accurate way to evaluate strength.

Time of year, time of day, environmental influences, queen status, overall colony health, and past management can all influence colony strength. Time of year is the most variable. For example, four frames of bees (where bees cover the majority of both sides of the frames) counted in early spring (April) on a sunny day (with some flying foragers) and with a healthy laying queen would be considered strong. However, that same assessment in early summer (June) would indicate that the colony is weak. Frames of bees, in this case, doesn't mean that only four frames are 100% covered with bees. It could mean that six frames are 65% covered – but when totalled, they are equal to four full frames.

For the national colony loss survey collected by CAPA, a "viable colony" is four frames with 75% bee coverage on both sides (or three frames with 100% coverage) by May 15th. So the early spring (April) assessment of four frames (100% coverage) is indeed a "strong" colony.

Time of day should also be considered if assessing multiple colonies, multiple yards, and/or multiple times throughout the season. If the assessments are consistently conducted between 10 am and 2 pm, the level of foraging bees will remain equal. However, if some assessments are done at 8 am and some at 5 pm, the values may not be comparable as foragers may be present at 8 am but not at 5 pm.

The next step should be to assess the level of brood in the hive. Again, the time of year will influence the judgement of strength. One full frame of brood (covering both sides) in early April would be indicative of a healthy colony. Brood means capped brood, open brood, and eggs. Seeing all three stages of brood means that the queen is actively laying. The absence of any stage can indicate a problem.

Colonies from the same source (sister queens, or queens from the same breeder) should progress at similar rates. The frames of brood should continue to increase as the season and resources progress. A surge of brood may occur once dandelions are in full bloom because nectar and pollen provide an important resource for spring build-up. The brood quality should also be considered. Is the brood spotty, full of empty cells, or does it have an irregular pattern? A healthy queen should be utilizing a majority of the open cells and have a spiral pattern to her laying.

Honey collection can be considered once fresh nectar becomes available. Some beekeepers like to keep their hives on scales so that increases in weight can be followed. Keep in mind, however, that a colony that doesn't have to look after brood will collect more nectar than one that has brood-rearing responsibilities – so evaluation of honey collection should always consider whether the colony is queenright.

The level of pests and diseases in the colony can also affect colony strength. Monitoring should come into play during spring management to evaluate the level of Varroa and Nosema. This is a good reason to have more than one colony. Comparing side by side colonies can indicate when one is doing well and the other is lagging behind, which may be due to a pest or disease problem.

Management practices can alter colony strength. If a nuc was pulled, frames of brood were pulled, bees were donated, the colony was relocated, or the queen was replaced, the resulting strength will not be in line with the seasonal norm. Accurate record-keeping will help keep track of colony changes and allow you to understand changes in strength.

When checking your colony this spring, keep in mind the different ways in which strength can be analyzed. On May 15th, see if your colony meets the four frames of bees covering 75% parameter set out by CAPA.

Also, check out TTP's online Fact Sheets and Publications section for a Spring Colony Management pamphlet that gives guidance on how to deal with weak, moderate, and strong colonies, and also what to do with colonies that didn't make it: *www.ontariobee.com/outreach/fact-sheets-and-publications.*

ASK AN EXPERT

SHOULD I TRY TO CATCH A FALL FLOW?

BY KELSEY DUCSHARM, TECHNICIAN – TECH-TRANSFER PROGRAM

The honey season doesn't have to end with the winding down of summer: the aster and goldenrod blooms of fall offer an abundant source of nectar for our honey bees. As tempting as it can be to try to catch as much of this flow as possible to increase honey yields, there is one important factor that needs to be considered before going for it: Varroa mites.

The end of summer is a critical time for your colonies' health. It is important to make sure they are as healthy and strong as possible going into the winter months. A large part of this is ensuring that Varroa mite levels in your colonies are below recommended thresholds by the start of October. This will prevent bees raised for winter being weakened past the point of recovery.

Varroa mite levels should be managed throughout the season and kept under recommended thresholds through careful monitoring. Late summer/early fall is a particularly critical time for Varroa mite management due to in-hive populations. To fully understand this concept, it is necessary to examine the population dynamics of Varroa mites in honey bee colonies.

Varroa mites reproduce in the capped brood cells of honey bees. One female mite can lay one-to-two daughters in worker brood and two-to-three daughters in drone brood. Additionally, these mites are not limited to one reproductive cycle. This reproductive pattern causes mite populations to grow exponentially in the colony. The stronger and more productive a colony is, the more brood there will be – and the more Varroa mites it will produce.

In late summer, when honey bee populations naturally decrease in preparation for winter, the Varroa mite population will continue to increase. This results in a surge in the number of mites per bee in the colony. Consequently, the honey bees can become overrun by Varroa mites and vulnerable to the viruses they carry – as well as other damage Varroa can cause such as weakened immune systems, poor nutrition uptake, and shortened lifespans. It is important to manage the level of Varroa mites before this point to prevent the irreparable damage they will cause your bees.

To determine whether or not you should leave your honey supers on into the fall, monitor Varroa mite levels during late August and early September. If your Varroa numbers are low (less than 3% in a standard alcohol wash) you are safe to keep your supers on during the fall flow. If your Varroa numbers are high (greater than 3%) you should immediately remove supers and treat your colonies. (Instructions for the alcohol wash test can be found on the OMAFRA Infosheet "Varroa Mite – Sampling and Monitoring Infestation Levels" at *www.ontariobee.com/sites/ontariobee.com/files/document/Copy-of-Varroa-sampling-EN.pdf*)

There are many options available for treating for Varroa mites. Keep in mind that many treatments have conditions and limitations, such as extended time frames and temperature ranges. Remember to monitor mite levels before and after treatment to ensure the treatment was effective. If Varroa levels are still above the threshold, another treatment will need to be applied to ensure the mite population is well controlled before winter.

The extra honey you may get by keeping your supers on through the fall nectar flow will never pay for the colonies you lose because of Varroa mite infestations. Manage your bees intelligently and they will thank you for it next season.

For more information, visit:

- Varroa Mite Sampling and Monitoring Infestation Levels: *www.ontariobee.com/sites/ontariobee.com/files/document/Copy-of-Varroa-sampling-EN.pdf*
- Ontario Treatment Recommendations for Honey Bee Disease and Mite Control: *www.omafra.gov.on.ca/english/food/inspection/bees/2014-treatment.htm*

"THE EXTRA HONEY YOU GET BY KEEPING YOUR SUPERS ON THROUGH THE FALL FLOW WILL NEVER PAY FOR THE COLONIES YOU LOSE BECAUSE OF VARROA."

TTP FEATURE

RUNNING SINGLE BROOD CHAMBERS

BY LES ECCLES – TECH-TRANSFER PROGRAM LEAD

I often take it for granted that when I began keeping bees, I was taught beekeeping management styles that, for some, seem not to be the norm – such as barrel feeding, marking queens, and not using gloves. Something I still get a lot of questions about is how I can keep honey bee colonies in single brood chambers, and how I overwinter them with enough food stores. This might not be the norm, but for most beekeepers who use singles it is the only way – and they dread having to ever manage a double brood chamber colony again. This article will focus mostly on the benefits of singles over doubles, and improvements to managing colony health and overwintering.

One of the most common questions about single brood chambers is whether the queen has enough space to produce brood. Although double brood chambers may have brood in both the top and bottom boxes, if you calculate the surface area you will see that a 10-frame single is more than enough space for a queen to lay and hatch brood in a sustainable cycle. Recently Devan Rawn, former TTP technician and owner of Shelter Valley Bee Company in Grafton, produced a video about single brood chambers – and, specifically, brood area – that summarizes this process: Watch it at *www.youtube.com/watch?v=YjyNcyVvbEI.*

After the question of sufficient space has been answered, it's all about "how can you overwinter colonies in singles?" Preparing for overwintering actually begins right from the start of the season – how you manage colonies throughout the season and how this management results in optimal colony conditions for successful overwintering. Management efficiencies in single brood chamber colonies result in more consistent and healthier colonies going into winter.

1. Single brood chamber colonies make it quicker and easier to check for queens, queen health, and colony health. This increases the likelihood that colonies will be inspected and taken care of because basic tasks can be accomplished more efficiently. Although a single brood chamber uses half the equipment of a double, it takes less than half the time to properly monitor.
2. Monitoring for Varroa mites using a screened bottom board is more accurate with a single brood chamber because the majority of the brood nest is located directly above the screen and sticky board. In a double, a significant portion of the brood nest can be in the top box – thus, as mites drop, they may not fall all the way down to the sticky board, giving you an artificially low Varroa count.
3. Treatment applications are more targeted and accurate in a single brood chamber because there is less area to cover. Treatment appli-

cation methods are largely based on ensuring contact with bees in a very complex environment. When that treatment environment is doubled, it becomes even more difficult to ensure sufficient contact. The way to ensure treatment contact in a double is to increase, and even double, the application rate. For example, acaricide strip treatments require twice as many strips in a double compared to a single brood chamber to ensure bees contact the strips where they are located; this means twice the cost to treat a double, as well as residues left behind in brood comb that can contribute to low-dose residuals which, in turn, can lead to resistance-building.

4. Antibiotic applications for American Foulbrood are more accurate and effective when bees have easy and quick access to the treatment. Because spring application of antibiotic treatments needs to begin in early April – to ensure sufficient withdrawal time before honey supers are applied – it can be difficult for the colony to break cluster and "take-down" the multiple treatments. A single brood chamber places the treatment as close to the bees as possible, without having to crack a double box, and with less frame area over which to distribute the treatment.
5. Drone brood removal, as a cultural management technique for Varroa control, is easier to implement in a single brood chamber because you can more accurately position the frame where drone brood rearing will occur, on the outer parts of the brood nest. If not positioned properly, the bees will fill the drone frame with honey – which is more likely to happen in a double brood chamber if the drone frame is not positioned close enough to the brood rearing site.
6. Because colony health issues are generally concentrated in the brood chamber, single brood chambers reduce the number of frames needed to be removed in order to cull equipment contaminated by viral, fungal, and pesticide residues which build up over time. The general rule is to cull one third of your frames annually – in a single, you should replace three frames a year; in a double, you would need to replace six.
7. Because a single brood chamber colony uses most of its surface area for brood production, there is much less space for food storage in the box – therefore, more honey is concentrated above the queen excluder, thus maximizing the honey harvest. Contrary to some who believe this means less honey for the bees for winter, this actually gives the beekeeper more control over what type and quality of food is fed to and stored by the bees for winter. Removing as much honey as possible from a colony in the fall, allowing for the maximum space to feed 16 litres of 2:1 sugar syrup, ensures more consistent quality and predictable food for the colony to overwinter on. This also reduces the amount of defecation and risk of dysentery that can stress confined colonies over winter months.

“Single brood chamber colonies make it quicker and easier to check for queens, queen health, and colony health.”

8. Food stored for winter in a single brood chamber is concentrated in a smaller area of the hive, requiring less movement by the cluster to find and relocate to feed stores during cold weather. Honey bee clusters tend to move from the bottom to the top of a hive over the winter and are less likely to move back down even though there may still be stored food. A single brood chamber ensures they are closer to stored food at all times over the wintering period.
9. Temperature maintenance is more efficient with half the space for a colony to keep warm.

Although this article is heavily focused on the benefits of managing single brood chambers over doubles, the key word here is “management”. Double brood chambers do give more leeway and can be more forgiving for beekeepers who are just starting out. One thing to be aware of when managing a single brood chamber is that you will need to add space (in the form of honey supers) earlier in spring in order to give more room for the growing adult bee population. Although the single brood chamber is more than enough space for brood production, your first two supers are needed to give space for the quickly expanding bee population, not just honey storage.

In general, if colonies are fed properly in the fall, spring feeding for a single is not necessary and they should have sufficient stores to last until the first nectar flow. However, during a spring where colonies are strong and no spring nectar flow is available, singles can be at more risk of starvation in early May than doubles. This was particularly the case during the spring of 2017 when many colonies were kept from nectar sources in early May by the relentless rains – this resulted in starvation in a portion of healthy and heavy spring colonies. Double brood chambers generally hold more extra feed than necessary, and if the bees survive winter they are less likely to run into this problem; however, they may also be less likely to survive winter due to the advantages of singles outlined above.

Spring feed issues can be avoided by monitoring feed stores and supplementary spring feeding – late April through early May. (For more information about spring feeding, link to the TTP’s Spring Colony Management fact sheet at *www.ontariobee.com/sites/ontariobee.com/files/document/Spring%20Colony%20Management%20web.pdf)*

I am often surprised, when giving workshops at local beekeeping associations to hear from beekeepers who think they have to keep colonies in double brood chambers – or that singles won’t work in the North. Although there are some feed considerations, it should be noted that singles are also managed in Manitoba, Saskatchewan, and Alberta where the climate is similar to that of Northern Ontario. If you are considering trying single brood chambers after primarily using doubles, begin with just a few to see how you like it, how your bees fare, and if it suits your beekeeping management style. I’m still looking for a beekeeper who switched to singles and went back to doubles.

ASK AN EXPERT

HOW SHOULD I ADJUST MY MANAGEMENT PRACTICES FOR SMALL HIVE BEETLE?

BY DANIEL THURSTON, TECHNICIAN – TECH-TRANSFER PROGRAM

Preparing for the presence of a new honey bee pest in advance of its arrival is an effective method of mitigating serious impact at the time of establishment. One area of emphasis important to the prevention of damage caused by small hive beetle (SHB) is in the honey house and during honey harvest.

SHB causes the greatest amount of damage during its larval stage as it tunnels through comb to feed on pollen, brood, and honey. As the larvae feed, they defecate on the honey, introducing yeasts that cause the honey to ferment and bubble. Honey that has been spoiled by SHB carries a rotten fruit smell and is unfit for human consumption.

The warm temperature and humidity of honey houses – paired with the availability of stored comb, honey, and wax – provide the ideal environmental conditions for small hive beetle to reproduce. Dehumidifiers can be used to maintain relative humidity below 50%, reducing conditions that SHB favour.

Supers sitting on strong colonies are protected from SHB damage by bees working in the hive. Therefore, one of the primary best management practices (BMPs) recommended for SHB control is to maintain strong, healthy, and populous colonies. Doing so allows the bees to deter SHB in the hive in the same way that they manage wax moth infestations.

Hive resources become vulnerable to SHB when they are no longer patrolled and protected by the bees – for example, honey supers sitting unattended on bee escapes or in a warming room are an easy target. For this reason, hygienic and preventative measures should be taken in the honey house to avoid damage:

- Supers should be promptly extracted once removed from the protection of colonies – ideally within 24-48 hours, and at maximum within a week's time.
- It is recommended that queen excluders be used in hive management to separate honey storage from brood and pollen storage. If separated, SHB larva will have fewer resources once honey supers are removed from the hive.
- Maintaining clean extraction facilities can prevent opportunities for SHB to feed in the honey house – spills and honey product debris should be promptly removed, and wax cappings and scrapings should be stored in beetle-tight containers.
- Sharing extraction facilities increases the risk of SHB transmission. Beekeepers should openly communicate and agree to follow biosecurity BMPs for SHB prevention.
- Post-extraction supers and frames can be stored in a cold room below 10 degrees Celsius and/or with relative humidity below 50% to prevent further SHB damage.

For more information related to small hive beetle management visit *www.omafra.gov.on.ca/english/food/inspection/bees/shb-bmp.htm*.

"HONEY THAT HAS BEEN SPOILED BY SHB CARRIES A ROTTEN FRUIT SMELL AND IS UNFIT FOR HUMAN CONSUMPTION."

ASK AN EXPERT

DOES OXALIC ACID HARM OR KILL BROOD?

BY MELANIE KEMPERS, TECHNICIAN – TECH-TRANSFER PROGRAM

I've been getting this question a lot lately. It occurred to me that there might be some confusion regarding the use of oxalic acid and why we offer the suggestions and recommendations that we do.

First, let's talk about our own safety. Beekeepers need to be aware that "organic" doesn't mean "100% safe to use without risk." Oxalic acid can have toxic effects on humans through contact or when inhaled/ingested. It is a relatively strong acid and must be handled with care. Over exposure can lead to joint pain, kidney stones, and kidney failure. Respiratory masks, acid-resistant gloves, and protective eyewear are a MUST when handling oxalic acid. If using multiple evaporation tools at once, the risk of inhaling oxalic acid vapour is increased.

Now let's address the bees' safety – specifically the brood. When treatments are brought forth for registration, a package of information is also presented. Part of this information includes the hazards to bees, so studies are conducted to see what side effects occur when using the product. Information regarding the product's efficacy is also studied. These efficacy studies indicated that using oxalic acid during the broodless period was ideal. This was not because they showed any deleterious effects on brood, but because oxalic acid showed poor efficacy during a brood period.

I'll say that again – oxalic acid did not significantly bring down the level of Varroa mites when brood was present. Levels of efficacy during a brood period have been reported as 24-52%, depending on the oxalic acid concentration and number of applications. One application of oxalic acid showed 24%, while multiple applications increased to 52%. However, other studies showed longterm negative effects on bees when multiple applications were used, so multiple applications were not recommended. These studies were conducted using the trickle method.

Due to the poor efficacy of oxalic acid during times when brood was present, not a lot of research was needed to see if there were side effects on brood (as opposed to adult bees). However, the desire to use oxalic acid more often has led to more studies being conducted. These recent studies indicate that trickling and spraying oxalic acid is more detrimental than sublimation (heat vapourization). One study showed that, four months after application, there was less brood in the colonies that were given oxalic acid by trickling or spraying and more brood in the colonies that were treated via sublimation in comparison to the control colonies. However, the decrease

in brood production was not significant in terms of overall colony strength and health. Studies outlining the longterm side effects on brood of using the sublimation method are limited but are most likely going to become a necessity.

So, in conclusion, if oxalic acid is applied accordingly at the proper dosage and rate (1-2 applications via trickling at 3.5%, or 2 grams via sublimation), the side effects on brood and bees are minimal. But to achieve high efficacy rates (over 90%), oxalic needs to be applied when there is no brood in the hive.

The reason we recommend using oxalic acid only during broodless periods is because of the EFFICACY, not the damage. Stay tuned – new applications of oxalic acid are being studied, and this may change...

"TO ACHIEVE HIGH EFFICACY RATES, OXALIC NEEDS TO BE APPLIED WHEN THERE IS NO BROOD IN THE HIVE."

TTP FEATURE

PREPARING BEES FOR WINTER

BY DANIEL THURSTON, TECHNICIAN – TECH-TRANSFER PROGRAM

This time of year always seems to arrive sooner than expected. Wasn't it just a few short months ago that we were all eagerly removing the wraps from our hives and anticipating the coming season?

Recently, my colleague Les Eccles has been promoting the concept that overwintering bees has less to do with winter than it does year-round hive management. How a colony overwinters is influenced far more by the culmination of every decision the beekeeper makes from the very beginning of the beekeeping season to the very end. That said, the decisions beekeepers make during fall management can greatly impact how colonies overwinter.

Following the below recommendations, beekeepers can make informed fall management decisions and plan for the following year with eagerness:

FEED

The energy bees use to keep warm during the winter months is supplied by food stored in comb where brood was raised during the summer months. Without sufficient food stores, a colony will be unable to maintain warmth in the hive, leading to death. Providing colonies with 15 litres of clean, supplemental sucrose feed provides an easily digestible food source for the winter months. Begin feeding immediately following honey super removal, allowing feeding to take place while temperatures support bee flight and movement. Colonies should weigh 70-90 lb. if overwintering in single brood chambers, and 100-120 lb. if in double brood chambers. To allow feed to be cured and stored quickly, fall feed is usually provided in 70% sucrose form.

HEALTH

In order for colonies to survive the winter, they must be healthy. Hive management promoting healthy colonies is a perfect example of how decisions made throughout the beekeeping season impact overwintering. This is particularly true when it comes to maintaining Varroa mite populations below treatment thresholds. Through regular monitoring of Varroa mite levels, beekeepers can make informed management decisions about how and when to treat for mites. Informed management should lead to colonies being healthy and carrying Varroa populations below treatment thresholds in advance of winter. It is important that Varroa mite infestations are addressed early to avoid viruses overwhelming colonies during late summer and early fall when colony populations shrink, winter bees are raised, and mite populations continue to grow.

Proactive monitoring and management of all honey bee pests and diseases is important to ensure a colony's health throughout the season and in advance of winter. A beekeeper's best line of defence against colony mortality is learning to recognize, understand the biology of, and manage the pests and diseases that honey bees are susceptible to.

POPULATION

The warmth maintained inside the hive during the winter months is generated by the bees present within. For this reason, a colony must be populous going into winter. A large cluster in the hive during the winter months will not require as much energy and feed to maintain temperatures. Larger clusters will

> **"How a colony overwinters is influenced by the culmination of every decision the beekeeper makes from the very beginning of the beekeeping season to the very end."**

also have less difficulty moving to food sources among the frames of stored food, avoiding starvation as a result. In preparation for winter, small colonies, if healthy, can be united to ensure they are populous going into winter.

A secondary consideration of population in advance of winter is the queen. Healthy, young, well-mated queens are able to provide a colony with a strong workforce of bees in the fall and are less likely to fail during overwintering. Active hive management, inspections, and record keeping can assure beekeepers that colonies enter fall queen-right with a healthy, young, established, and well-mated queen.

WRAPPING

Wrapping colonies is the final step in preparing bees for winter and serves a number of functions to assist in colony survival over the winter, including:

- Protection from pests
- Ventilation and moisture removal,
- Insulation
- Protection from wind
- Heat attraction

As with most beekeeping equipment, methods and styles of wrapping colonies will vary greatly. However a beekeeper chooses to wrap their bees, they should strive to provide the above-listed functions.

- Entrance reducers, as their name suggests, are intended to reduce the size of the hive entrance at the bottom board. Entrance reducers also assist in protecting the colony from intruders such as mice, and limit wind exposure. It is important that reduced entrances do not become blocked during the winter months by dead bees or other debris.
- Upper entrances, secondary to the main bottom board entrance of the hive, must be provided to overwintering colonies to allow for adequate ventilation. As bees consume food over the winter, moisture is created and must be removed. The provision of a secondary entrance allows air to circulate through the hive, wicking away moisture and preventing it from becoming trapped and chilling the bees. Upper entrances should be provided on the same side of the hive as the main entrance to allow air to circulate rather than pass through the hive body.
- Hive-top insulation (similar to wearing a toque in winter) is intended to prevent heat generated in the hive from rising and escaping out the top. Hive-top insulation can be provided through the addition of any insulating material. Common materials include straw, styrofoam, wood shavings, or newspaper. If using a rim or deep inner cover, placing the hive's queen excluder above the insulation material can help prevent mouse damage.
- Winter wraps – a hive's winter jacket – are intended to wrap around the exterior of the colony to provide a wind break, insulate the colony and trap a layer of warm air around the hive, and attract the sun's warmth. Winter wraps can be made out of many materials with varying R-values including tar paper, cardboard, insulated plastic, styrofoam, or wooden boxes filled with insulation. Winter wraps, regardless of material, should be resistant to environmental conditions, provide adequate insulation and wind protection from the elements, and be dark in colour to attract the sun's warmth. Upper entrance function must also be considered when installing winter wraps.

It is important to remember that the function of winter wraps exists beyond the winter months and snow on the ground. During early spring, when colonies are rearing brood, and stored resources and populations are strained, winter wraps and insulation are particularly important to assist in colony survival. Beekeepers are advised to remove and re-wrap colonies during early spring management until temperatures are consistently above 0 °C.

Beekeepers can anticipate successful overwintering if they manage colonies throughout the beekeeping season while being mindful of the long-term and prepared for fall, properly addressing food stores, pests and diseases, colony health, colony strength and population, and insulation.

For more information, refer to the info sheet Best Management Practices For Ontario Beekeepers In Advance of Winter at *www.ontariobee.com/sites/ontariobee.com/files/document/Best%20Management%20Practices%20for%20Ontario%20Beekeepers%20in%20Advance%20of%20Winter%20-%20en.pdf*

ASK AN EXPERT

HOW SHOULD I MANAGE SWARMS?

BY KELSEY DUCSHARM, TECHNICIAN – TECH-TRANSFER PROGRAM

When a honey bee colony starts to outgrow its hive, it will begin the swarming process. Worker bees will create multiple queen cells that will eventually hatch into new queens. Just before the virgin queens emerge and duke it out for the crown, the existing queen will leave with half of the bees to find a new home. The swarm, as it is now called, will temporarily stop on branches, road signs, cars, or whatever may be available before they settle on a permanent location.

Clusters of buzzing bees tend to be vilified in the media – take the killer bees in Irwin Allen's 1978 horror film *The Swarm*, for example. In reality, swarming honey bees are extremely docile, as they have nothing to defend. Their main priority is finding a new location to settle in before foraging and other hive activities can resume.

Catching swarms in the spring can be a good way to increase the number of colonies you have, but care must be taken when doing so. You won't be at risk of being attacked by a cloud of venomous killer insects, but you will be exposing your bees to the many pests and diseases that might be present in the swarm.

Extreme caution should be taken when catching swarms of unknown origin to ensure you are not introducing disease into your operation – most notably American foulbrood. Caught swarms should be segregated from the other hives in your operation and should be monitored closely for signs of disease.

In your own hives, swarming should be prevented as much as possible. Swarming is a natural process – it's how honey bees proliferate in the wild. However, it is in the beekeeper's best interests to prevent swarming in their colonies because it causes a major loss in production. Half of the bees in a colony are lost through swarming, and it takes a few weeks before a new queen is laying again. This reduces build-up rate as well as foraging capabilities. It can also be an issue for neighbours who end up with unwanted bees in their yard or, worse, building comb in their chimney or siding.

Swarming can be prevented by checking all the brood frames in your hive regularly (every eight to 10 days), especially in late spring. Bees will often build queen cups to be ready for when it is time to swarm. Empty cups are not a concern. Once there are eggs in the queen cups, however, it's time to take action, as the bees are thinking about swarming.

Swarm cell production begins with eggs in queen cups, progresses to volcanoed cells filled with royal jelly, and ends in capped cells. It is best if you can catch swarming at the "egg-in-cup" stage as the bees are more likely to stop trying to swarm if you tear these down and add space for the colony to expand. The farther along you catch the cell, the less likely you will be able to stop the colony from swarming. When checking the frames, shake all the bees off to expose any hidden cells. Any eggs or queen cells found should be removed, but be sure to find the existing queen first so you know you're not too late.

Your bees will definitely grow in numbers throughout the season – so you have to make sure they have adequate room for growth. This can be accomplished by letting them grow out by splitting colonies to increase hive numbers, or up by adding honey supers to existing colonies. Making sure your colonies always have enough room to grow will reduce their tendency to swarm.

Swarms of honey bees are nothing like in the movies – still, they can be risky. They are a nuisance to neighbours, can harbour pests and diseases, and decrease production in the operations they leave behind. Hives should be managed to prevent swarming, and biosecurity guidelines should be followed when introducing swarms into an operation.

"It is best if you can catch swarming at the 'egg-in-cup' stage as the bees are more likely to stop trying to swarm if you tear these down and add space for the colony to expand."

ASK AN EXPERT

WHEN ARE WINTER BEES PRODUCED?

BY MELANIE KEMPERS, TECHNICIAN – TECH-TRANSFER PROGRAM

One of the most interesting aspects of honey bee dynamics is that there is a change between the short-lived summer bees and the long-lived winter bees. Winter bees are characterized by enlarged hypopharyngeal glands and larger, more developed fat bodies. They also have elevated protein, triglyceride, glycogen, and glucose content within their bodies along with a higher dry weight. They sustain the population until spring and begin mid-winter brood rearing to replace themselves with the new population. Winter bees have extended lifespans – more than 100 days (but, on average, less than 250 days) – so that they can perform these important tasks. Without them, a colony would not survive the extended cold periods in a temperate zone – winter bees regulate nest temperature for a long period of time and need to live longer to accomplish this.

Worker bees all develop from fertilized eggs laid by the queen and are fed by other worker bees, so what causes winter bees to be different? Essentially, it's the nutrition they get at a young age and the tasks they perform during their lifetime.

Winter bees receive large amounts of protein at a young age, helping them build up essential resources. Most notably, the difference between winter bees and summer bees is the level of juvenile hormone (JH) and vitellogenin (Vg). JH levels remain lower in winter bees but steadily increase in summer bees as they age. In contrast, levels of Vg are significantly higher in winter bees than summer bees, and are sustained at higher levels throughout their lives.

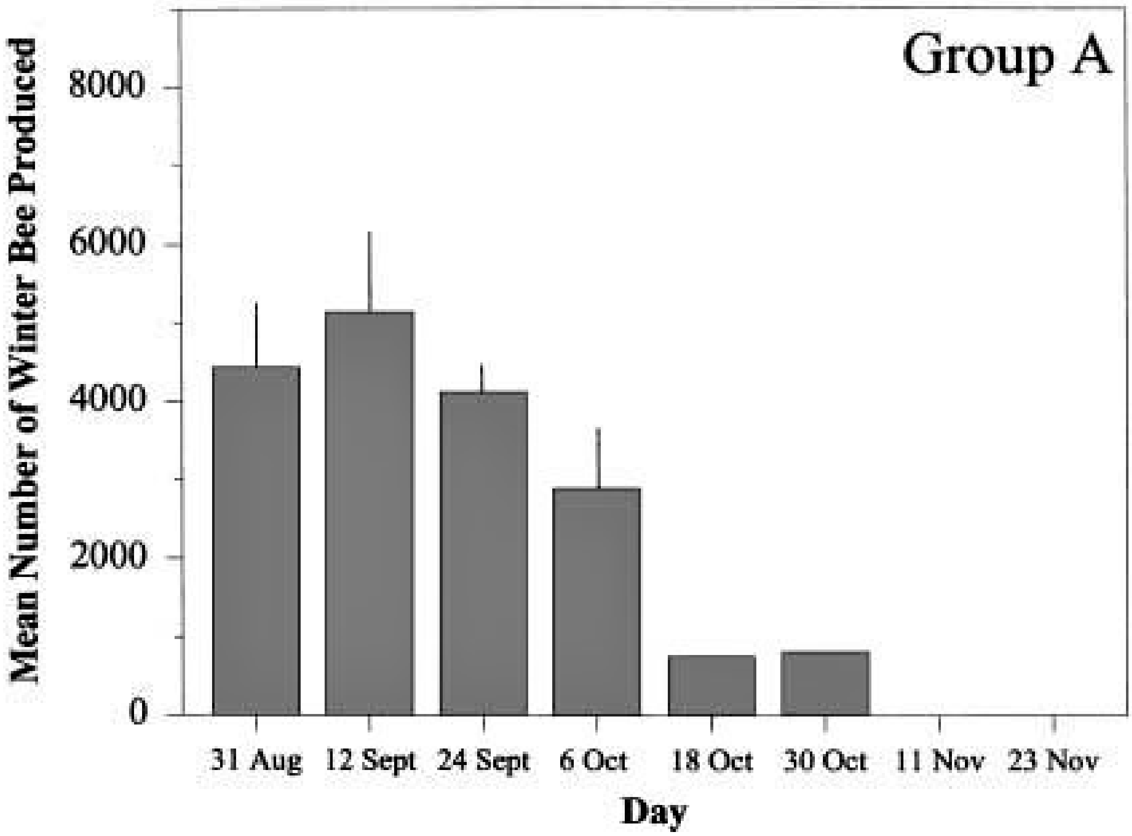
JH controls the development and aging of bees and is highest in active, hard-working foragers. JH helps bees "grow up." Vg, on the other hand, works as an antioxidant to prolong worker bee lifespan and serves as an indicator of immune and overall bee health.

Honey bees store Vg in their fat bodies, which act as food storage reservoirs. If worker bees are abundantly fed immediately after emergence, their Vg levels are high. Vg helps bees "stay young." The level of Vg will naturally deplete if a worker bee is busy feeding young bees, using their hypopharyngeal glands to produce brood food. Winter bees maintain higher Vg levels (and, in turn, sustain low JH levels) until the spring, as this task is not needed when no new brood is being produced. This continues until a shift in roles is needed, and there is a trigger to raise brood and forage for pollen.

So how does the colony know to make winter bees? Various triggers have been investigated, such as photoperiod, temperature, and nutritional state. A shortened day length has been shown to increase gathering of nectar and pollen which, in turn, causes increased fatty tissues in workers. This would help protect them against the cold. Huang and Robinson (Huang, Z.-Y. & Robinson, G.E., 1995. Seasonal changes in juvenile hormone titres and rates of biosynthesis in honey bees. *Journal of Comparative Physiology B,* 165, 18–28) demonstrated that sudden, low ambient temperatures induced a drop in JH titres in workers. When bees experience a reduction in JH levels, they undergo the "Benjamin Button" effect – although they don't actually become younger; they just act younger.

Changes in resources may also affect the move into an overwintering state. Honey bees decrease brood rearing when there is a lack of protein (pollen) resources and cease reproduction altogether when there is a dearth. This happens naturally in the fall and is

"WAITING UNTIL MID-SEPTEMBER TO TREAT HIGH MITE LEVELS WILL CAUSE HARM TO WINTER BEES AND REDUCE THE CHANCES OF A COLONY SURVIVING THE WINTER."



likely to play a major role in the changeover to winter bees. Additionally, the lack of brood alone may induce colonies to transition to their wintering state, regardless of photoperiod, temperature, or availability of resources. It could be that all of these factors play a role in the changeover from summer bees to winter bees. Relying on one factor alone could be detrimental – hedging their bets using various triggers could better assist colonies in the successful transition for winter survival.

A Canadian project by Lloyd Harris (Mattila, H.R., J.L. Harris, & G.W. Otis, 2001. Timing of production of winter bees in honey bee colonies. *Insectes Sociaux 48:* 88-93) studied the age structure of bees within colonies in Winnipeg. Heather Mattila analyzed this data to help answer the question of when winter bees emerge.

In the prairies (Winnipeg), the first winter bees emerged on August 31st. Not all of the bees that emerged on this day were winter bees (only 40% were). The production of winter bees increased and more than half (53%) of the total winter bee population had emerged within 12 days. Winter bee production continued throughout the fall brood rearing cycle until the last bees emerged at the end of October. Although this study was conducted in Winnipeg, a similar winter bee production cycle could be extrapolated for Ontario, though perhaps seven to 14 days later.

In this temperate region, the number of bees and brood in a colony increases between spring and summer and decreases between summer and fall. However, the Varroa mite population will steadily increase from spring through fall. The main peak of mite abundance happens after the colony population starts to decline, resulting in an increasing number of mites per bee. Furthermore, it is during this time that bees hatching from this infested brood will become winter bees. A study by van Dooremalen (van Dooremalen, C, et al., 2012. Winter Survival of Individual Honey Bees and Honey Bee Colonies Depends on Level of Varroa destructor Infestation. *PLoS ONE 7(4):* e36285.) found that winter bees produced when there are low levels of Varroa had increased longevity compared to colonies with higher infestation levels.

So why does this matter? The success rate of a honey bee colony in surviving the winter hinges on the health of the winter bees. Stressed, protein-deficient, stunted, infested, or otherwise damaged winter bees will not make it to spring. The damage by Varroa mites plays a major role in winter bee health. It is now known that Varroa not only feed on the bees' haemolymph (or blood) but on their fat bodies as well, which is where their precious Vg is stored.

Ensuring that Varroa levels are low before winter bees are produced is ideal. This means that starting to treat colonies before September is the target timeline. Waiting until mid-September (or later) to treat high mite levels will almost certainly cause harm to winter bees and reduce the chances of a colony surviving the winter.

ASK AN EXPERT

ARE UPPER ENTRANCES AND ENTRANCE REDUCERS NECESSARY FOR WINTER?

BY DANIEL BORGES, TECHNICIAN – TECH-TRANSFER PROGRAM

There is a fair amount of research – and a large amount of debate – on the best ways to successfully overwinter honey bee colonies. This includes discussion on the necessity of using entrance reducers, as well as whether or not the hive should have an upper entrance. These questions are particularly relevant this year, after a winter where many beekeepers lost a higher than usual number of colonies.

Entrance reducers are a good place, to start as their use is a little more straightforward – and less contentious. Entrance reducers come in different shapes and sizes, and are also very easy to make yourself. They are placed in the entrance of the hive to make the opening smaller. Using an entrance reducer has a number of benefits.

First, installing an entrance reducer earlier in the fall can help with colonies being harassed by robbing bees and wasps. The smaller entrance makes it much easier for a colony to defend their hive against intruders. This is particularly helpful if the colony happens to be on the weak side. One thing to keep in mind, though, is that a number of treatments – including formic acid and Thymovar – require that the entrance be open and unobstructed. If using one of these treatments, make sure you wait to put an entrance reducer on until the treatment period is complete.

A second benefit to using an entrance reducer is to help keep mice out of the hive. Once the temperature begins to drop, mice (and other small animals) start looking for somewhere warm to spend the winter. A warm hive is a great location, especially when the clustering bees are no longer guarding the entrance. The mice can damage frames and boxes, and they cause a large amount of stress to the clustering bees during the winter months.

Finally, using an entrance reducer can help reduce the draughts of cold air that enter the hive. While a good flow of fresh air is necessary for the cluster to breathe, too much cold air means that the bees have to work extra hard to stay warm. Working extra hard means that the bees need to consume more honey stores, and this can possibly lead to the colony starving over the winter.

The importance of having an upper entrance over the winter has been the subject of more debate than entrance reducers, and can be a little more contentious. A study by Toomemaa et al. (2013) looked at the water vapour produced by respiring bees over the winter. They found that the amount of water vapour that condenses on the inner roof of the hive was only a tiny fraction (about 2.5%) of what cooled, sank, and condensed on the bottom board. The authors concluded that having an upper entrance is therefore unnecessary, and can lead to large amounts of heat being lost and more honey stores being consumed over the winter. However, it is important to note that the authors also found that the

> "AN UPPER ENTRANCE OVER THE WINTER PREVENTS EXCESS CONDENSATION AND MOISTURE IN THE HIVE, WHICH KEEPS BEES HEALTHIER, ALLOWING THEM TO CONSUME LESS FOOD OVER THE WINTER AND BUILD UP FASTER IN THE SPRING."

water that condensed on the upper parts of the hive (the inner roof and walls) was associated with this small fraction of water vapour, and it had a great impact on how wet and humid the overall hive was.

While it may only be a small amount of water, condensation on the inner roof of the hive can cool and drip on the clustering bees. Wet and cold is a not a good combination, and this dripping can very quickly sap away a colony's heat over the winter. An upper entrance is important to prevent this water vapour from condensing in the hive, even if it is only a small fraction of water compared to the total amount of water a cluster of bees can produce over the winter.

A study by Szabo (1982) looked specifically at overwintering colonies with different types of upper and lower entrances. He found that colonies with a small upper and lower entrance consumed less honey, had larger adult populations in the spring, and had lower levels of Nosema infections in the spring than colonies with only a lower entrance. This was true whether the upper entrance was a notch in a wooden inner cover, or a hole drilled in the front of the brood box.

The Nosema infections in this study can be thought of as a proxy for overall colony health and stress. While cold, moist, and humid conditions in the hive do not cause Nosema infections per se, these conditions can cause a lot of stress on the bees – when bees are stressed, they are more susceptible to all kinds of infections, including Nosema. Having an upper entrance over the winter prevents excess condensation and moisture in the hive, which keeps bees healthier, allowing them to consume less food over the winter and build up faster in the spring.

The idea that an upper entrance lets out a large amount of heat is a valid argument. While the upper entrance is necessary to vent excess moisture, it is important that this upper entrance is small to minimize the amount of heat that escapes.

The placement of this upper entrance is also important to prevent excess heat from being lost. The upper entrance should be on the same side of the box as the lower entrance to prevent a cross draft from being created by the cold winter winds. In the study by Szabo (1982), the hives that had an upper entrance on the side of the box (instead of on the front) in addition to a lower entrance in the front performed the worst of all of the hives tested. These colonies consumed the most honey stores, had the smallest adult populations in the spring, and had the highest Nosema infections in the spring. While these hives had an upper and lower entrance, the cross draft that was created caused a large amount of heat to be lost, and a lot of stress on the colony.

Having an upper entrance also serves another function that can be crucial for colonies overwintering in northern climates: a secondary or alternative entrance. It is not uncommon for the lower entrance to become blocked over the course of the winter by dead bees, snow and ice, or both. Having an upper entrance allows bees to leave the hive on warmer days to go on defecation flights when the bottom entrance is blocked. In the case that the lower entrance becomes so blocked that even air can't get in or out, the upper entrance becomes crucial for proper ventilation in order for the colony not to suffocate. It is important that the winter wrap you use also has an upper entrance cut into it for the bees to get in and out. If the wrap has an insulated lining and a hole can't be cut into it, leave part of the wrap untucked from under the outer lid so that the bees still have a way in and out.

Using an entrance reducer and making sure your hive has an upper entrance are two important steps in preparing your hives for winter.

For the best overwintering success, make sure to complete a fall/winter prep checklist. In addition to entrance reducers and an upper entrance, this checklist should include monitoring and treating for Varroa in the fall, feeding colonies so they are nice and stocked for the winter, tipping hives forward slightly so that water does not pool on the bottom board over the winter, using some kind of hive-top insulation, and wrapping hives.

TTP FEATURE

LOW-COST INFRARED THERMAL IMAGING

BY KESLEY DUCSHARM, TECHNICIAN – TECH-TRANSFER PROGRAM

AND LES ECCLES, TECH-TRANSFER PROGRAM LEAD

For beekeepers, the winter months are used to catch up on work that was pushed aside during the last busy bee season, and to prepare for the next. Honey bee colonies are managed in the fall to optimal conditions (fed, treated, wrapped) and left untouched all winter. Overwintering is a blank area in our industry because any management during winter traditionally does more harm than good – so the bees are forgotten until spring checks.

Throughout the winter of 2018, the TTP worked on a project that addressed this gap in knowledge. Infrared thermal imaging cameras were used to monitor honey bee colony strength and mortality during the overwintering period. There were four areas of focus:

1. Early colony mortality detection and diagnosis
2. Effectiveness of winter wraps
3. Indoor overwintering assessments
4. Colony strength assessments to increase the efficiency of a beekeeper's work plan.

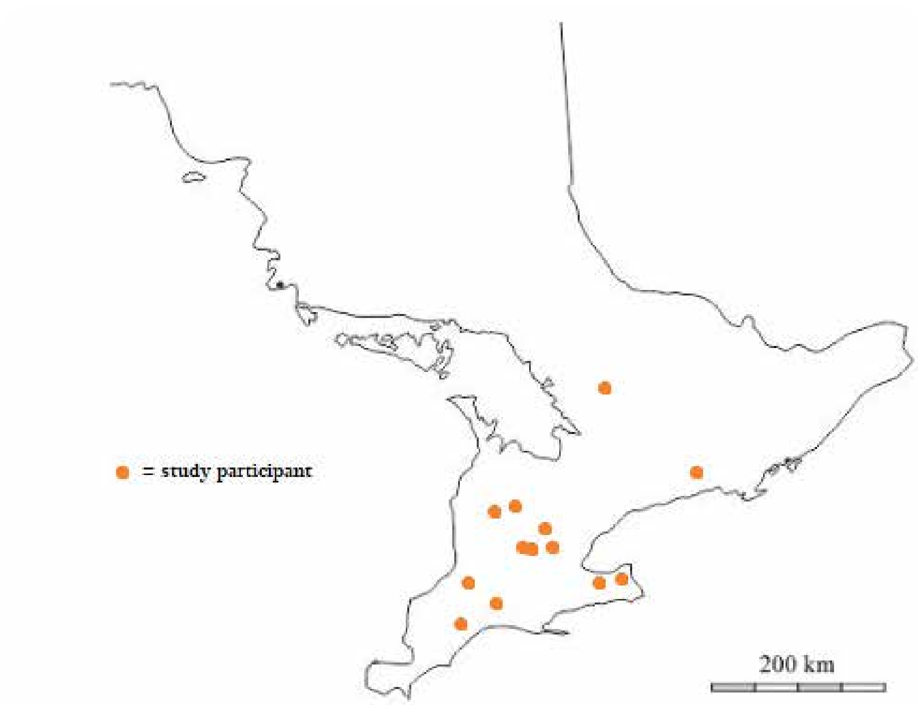
Assessments were performed on overwintering colonies spread across southern Ontario.

Three infrared/thermal imaging cameras were selected for testing: FLIR ONE ($545), FLIR TG165 ($300), and FLIR E6 ($2,700). These cameras were chosen based on previous work published in *Bee Culture* magazine by Dr. Jerry Bromenshenk as well as camera price and specs. The bulk of the work was performed using the mid-range FLIR TG165. This camera is the most accessible as it is sold at department and hardware stores at a lower cost (and was perpetually on sale at Canadian Tire during the course of this project).

Even with a user-friendly interface, wielding these tools required some adaptation and practice by the user given different hive equipment and environmental conditions. The best conditions for using infrared cameras are overcast days or night time to eliminate issues that can cloak target readings. The most accurate readings seemed to be taken from the top entrance of a hive as well as looking down on the inner cover after removing the wrap material and hive top insulation.

MORTALITY DETECTION AND DIAGNOSIS

The practicality of using infrared cameras to observe a yard was high once the user had some practice operating the tool. By using best methods to avoid light/heat interference in the images, and calibrating for specific equipment and environmental conditions, it was possible to easily differentiate between live and dead colonies in a yard. Once accurate methods were practiced, it was possible to quickly walk through a yard to identify dead colonies and focus work on them.



When dead colonies were identified, an in-field diagnosis was performed in order to identify the cause of mortality. The technicians performing the cause-of-mortality diagnoses were more easily able to identify the most likely cause of death because the symptoms were fresh. Attempting to diagnose colonies in spring – weeks or months after their actual demise – can be difficult, if not impossible, on account of decay, hungry vermin, and robbing bees.

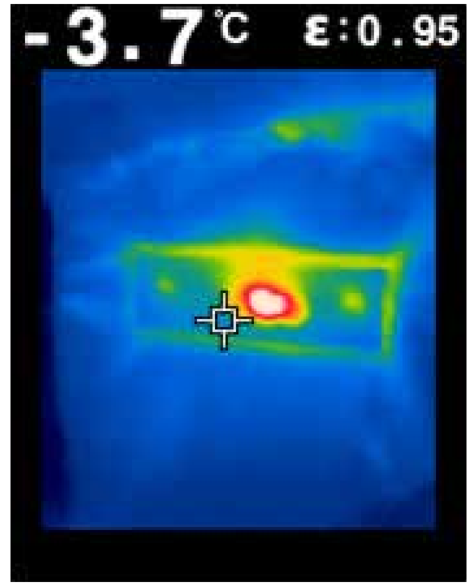
The TTP was able to perform post-mortems on dead-out colonies found throughout the winter. The most common causes of mortality were Varroa mite and queen issues. Colonies that died of Varroa mites tended to die much earlier in the winter than colonies that had queen issues.

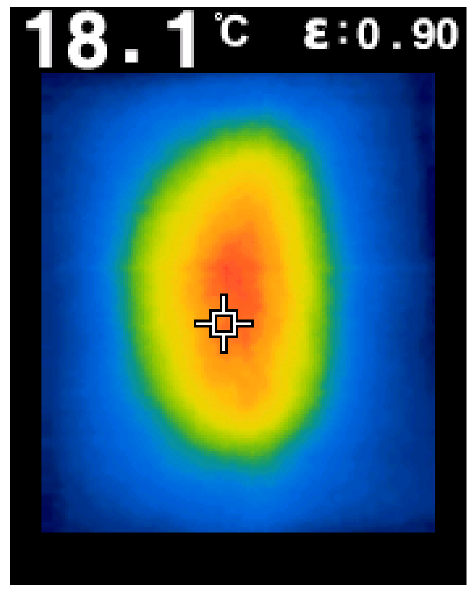
WINTER WRAP PERFORMANCE

The main winter wraps compared were the Western (Inland) wrap and the Wellington wrap. The infrared/thermal imaging showed that the Western wraps allowed the bees to be more loosely clustered and more likely to fly in winter when weather permitted. In theory, this would allow the colony to remove dead bees and go on defecation flights more frequently than with the Wellington wrap. It would also allow them to access food stores during colder temperatures because they would not need to be as tightly clustered.

The imaging also showed that colonies which shared wraps were more likely to share warmth by nearing the walls of the adjacent colony – the area shared seemed to be increased with the use of the Western wrap compared to the Wellington wrap.

In spring – when live colonies were assessed for frames of bees, frames of brood, and frames of honey – there was no statistical difference between colonies overwintered in the Western wrap compared to the Wellington wrap. There was, however, a significant decrease in the mortality rate between the Western wrap at 5% and the Wellington wrap at 23%. This could also account for the lack of significant difference between the two winter wrap types for live colonies in regard to frames of bees, brood, and honey – the more susceptible or weaker Wellington wrap colonies may not have survived and, therefore, were not included in the data; only live colonies were included in the data set for comparison.





> "INFRARED CAMERAS CAN ALLOW A BEEKEEPER TO NON-INVASIVELY CHECK UP ON THEIR COLONIES DURING THE OVERWINTERING PERIOD AND TAKE ACTION TO REDUCE RISK AND INCREASE EFFICIENCY IN THEIR OPERATIONS."

INDOOR OVERWINTERING ASSESSMENTS

Indoor overwintered colonies were observed for overall colony changes and to prepare for management when the colonies were moved outdoors in spring. Although the infrared cameras were able to take images of the colonies in the indoor overwintering room, there was little change in strength or mortality observed that required us to take action. The imaging did provide assurance that the colonies were proceeding well during the winter months.

COLONY STRENGTH ASSESSMENTS

Colonies were measured using the infrared/thermal cameras and a strength grading was marked on the front of the hives in chalk before pulling them out of the indoor overwintering rooms in spring. The purpose of this grading was to allow beekeeping workers to easily identify weak colonies that needed to be managed or united without having to inspect all of the colonies, making spring checks more efficient. These observations were applied to a large overwintering facility in Beamsville, Ontario. The managers of this apiary found it to be an effective management strategy to reduce the amount of time needed to work hundreds of colonies.

CONCLUSION

The overall objectives of this project were to explore an innovative technology to reduce the risk of losing honey bee colonies over the winter; to provide a tool to increase accuracy of winter mortality diagnoses; and to decrease the reaction time to colony health issues during the winter months.

These preliminary results show the potential for incorporating infrared/thermal imaging into beekeeping management strategies. With a little practice, using infrared cameras can allow a beekeeper to non-invasively check up on their colonies during the overwintering period and take action to reduce risk and increase efficiency in their operations. This will allow for more accurate management decisions when considering changes in strategies for overwintering honey bee colonies.

More work will be needed to ensure the results obtained in 2018 are repeatable and to further insights into honey bee overwintering.

Special thanks to the AgriRisk Initiatives program for allowing this project to go forward, and to all the beekeepers who participated.

ASK AN EXPERT

HOW CAN I START MY SEASON OFF RIGHT?

BY KELSEY DUCSHARM, TECHNICIAN – TECH-TRANSFER PROGRAM

This is an exciting time of year for beekeepers. Muscles are all healed up from hauling last fall's honey crop, and spirits are refreshed and ready to get back to the bees. The winter months are usually used by beekeepers to relax a little and prepare for the upcoming season, and that prep time is quickly running out.– but don't panic! There's still time to make sure you have everything you need for a successful beekeeping season.

The best way to make sure you start your season off right is to reflect on last season – make sure you have a solid plan in place that will keep you organized and on top of your goals. So, before the bees start getting ahead of you, take a minute to sit down and ask yourself the following questions:

HOW DID LAST SEASON GO FOR YOU?

It's important to reflect on how your bees (and you) fared last season. Were your bees healthy? Did you have many losses? If so, why? Were you well prepared to handle the challenges your bees threw at you? Did you accomplish everything you set out to do? Taking note of last season will inform you about how you can improve this season. If you made notes throughout the season, go through them. If not, try to remember how things went. See where you ran into issues and how those issues can be prevented this year.

WHAT DO YOU WANT TO ACCOMPLISH THIS YEAR?

Setting goals will help you determine an action plan for the season. How many colonies do you want to run? What sort of production model do you want? What happened last season that you want to have a better handle on this season? Whether personal or professional, setting goals is key to turning your beekeeping into a successful and meaningful endeavour.

HOW WILL YOU ACCOMPLISH ALL OF YOUR GOALS?

Writing out specific tasks that work towards accomplishing your goals will help determine exactly what you need to do this season. Brainstorm the main steps of achieving your goal and be sure you have the means to execute each one before the season starts. For example, if your goal is to increase your colony numbers this year, your main steps are going to be:

1. Gather necessary equipment
2. Paint new equipment
3. Buy nucs or queens
4. Make splits or set up nucs.

You'll want to buy equipment and have it painted before you need it (or make sure you already have proper equipment by doing an inventory of your supplies). Realizing you're missing a critical piece of woodenware halfway through a split never turns out well. Nucs and queens can be difficult to source last minute, so you should be making calls and ordering bees now if you haven't already.

Having the first few steps already out of the way before things start getting busy will really help your season go smoothly. It'll give you much more time to focus on keeping your bees healthy.

Finally, you should consider the timing of these activities. Going back to our example, splits and nucs should be started with enough time for the bees to be able to grow into a strong colony before the fall. Try to consider every step of your goal so you know what's coming and can avoid unnecessary stress and anticipate the issues you may face.

THINK GREEN

While you're thinking about your goals for the year, don't forget to check their viability in the context of your budget.

A new season can feel like a fresh start in beekeeping. Before things really get rolling this year, take the time to sit down and write out a game plan. Knowing what your goals are and having detailed, achievable tasks as stepping stones will allow you to become a more responsible and successful beekeeper. It will also cut down on the stress of being ill-prepared.

Following this same process every year (reflect, plan, achieve) will help you start every season off well so you can continuously build and better your beekeeping operation.

"A SOLID PLAN WILL KEEP YOU ORGANIZED AND ON TOP OF YOUR GOALS."

ASK AN EXPERT

WHAT DO I NEED TO KNOW ABOUT BUYING A NUC?

BY KELSEY DUCSHARM, TECHNICIAN – TECH-TRANSFER PROGRAM

The most common way for beekeepers to purchase honey bees is by buying a nuc (short for nucleus colony). Getting your first nucs of the season can be as exciting as Christmas morning, but unlike what Santa left under the tree, what's inside your nuc box should never be a surprise to you. The following article outlines Ontario standards and regulations for nucs, and how you can stay informed and make sure you're spending your money on a quality product.

ENSURE YOUR SELLER HAS A VALID PERMIT

In Ontario, a permit is required to sell bees, queens, or queen cells. This permit is issued by the OMAFRA apiary program and must be renewed every year. Bee inspectors visit prospective sellers and conduct a field inspection to ensure pest and disease levels are below a certain threshold before their bees are moved around. It is risky to buy bees from someone without a valid Queen and Nuc permit because their bees are harbouring pests and diseases at unknown levels. You want to make sure any bees coming into your operation are healthy and won't pose a biosecurity risk to your other hives – or your neighbours' hives.

To check if your seller has a valid permit, consult the following list: *www.omafra.gov.on.ca/english/food/inspection/bees/info_honeybeequeen.htm*

ENSURE YOU'RE GETTING THE ONTARIO STANDARD

There can be lots of variability in nucs, so knowing what to expect is critical if you want to ensure you're spending money on a quality product. The Ontario Bee Breeders' Association (OBBA) works to support the production of high quality queens and bees in Ontario. The OBBA has set a standard for four-frame nucs. They must include:

1. a queen
2. two frames of brood, ½ to ⅔ capped, with adhering bees
3. one frame of feed with adhering bees
4. one frame of foundation or empty comb
5. extra bees to ensure the brood is kept warm

Even with this standard, there remains a lot of variability between nucs depending on the source. The best thing you can do is have a conversation with your seller and ask questions to clarify what exactly you're paying for, and if the price is fair.

BUY LOCAL STOCK

Buying bees that have been bred to perform well in Ontario will increase their overall health and productivity. Bees can be bred for many traits such as honey production, gentleness, overwintering ability, spring buildup, etc. We are fortunate in Ontario to have access to honey bee stock that has been bred not only for the latter traits but for disease resistance as well.

The Ontario Resistant Honey Bee Selection Program (ORHBS) began in 1992 as a breeding program aimed to increase natural pest and disease resistance in honey bees. Since then, many Ontario bee breeders have been selecting for bees with high levels of hygienic behaviour each year with the help of the OBA Tech-Transfer Program. Buying ORHBS bees is a great way to increase biosecurity in your operation, and keep your bees as healthy as possible. To find a list of ORHBS breeders or to read more about the ORHBS program, visit *www.ontariobee.com/ORHBS.*

Buying a nuc can be very exciting, but it can also be nerve-wracking when you're not sure what you're looking for. Make the most of your money by staying informed and purchasing a quality product from a reputable source: make sure your seller has a valid Queen and Nuc permit; have a conversation with your seller about what will be included in the nuc, keeping in mind the OBBA standard; and finally, buy Ontario bred stock, preferably from ORHBS breeders. Following those simple steps, you can be sure you'll be bringing home a healthy, quality nuc.

THE FOLLOWING EXCERPT FROM THE OBBA NUC BUYER'S GUIDE OUTLINES SOME OF THE QUESTIONS YOU SHOULD ASK WHEN BUYING A NUC

1. *Are the brood frames capped?* Two frames of mostly capped brood – versus two frames of eggs and larvae – will make a huge difference to how fast your nuc takes off. A good nuc, when made up by the producer with approximately ½ to ⅔ of the brood capped, should produce surplus honey in an average year if it is established on drawn comb. Be aware that if there is a delay in pick-up or installation, the capped brood may begin to hatch.
2. *How old is the queen? Is the queen Ontario stock or imported?* A nuc will usually have a queen mated the previous summer – ideally the daughter of a queen selected for traits such as hygienic behaviour and honey production, and bred for local conditions. Ask your queen and nuc producer whether they have a formal breeding program established. Many nuc producers will mark their queens with the colour of the year, in order to date the queen and allow for easy queen identification.(2018 queens were marked with red; 2019 queens will be marked with green.)
3. *Is it a spring nuc or a summer nuc?* A spring nuc is available throughout the month of May into early June and will consist of an overwintered queen on her own brood. In this respect, the queen has already proven to be a good layer and has survived her first winter with no problems. A summer nuc is one sold mid-June and later and will generally have a newly mated queen, expect an added cost. Also, find out whether the cost of the shipping box is included in the price as some nuc producers have returnable wooden boxes. possibly boosted with brood from other hives.
4. *What is the cost? Does it include the shipping box?* A spring nuc with capped brood and a queen from selected Ontario breeders participating in the OBA breeding program will demand top price. Would you pay as much for a spring nuc made up of random brood and an imported queen? There may also be a drop in prices for summer nucs which must be helped by the beekeeper through their first summer and winter (along with the associated costs). Although it's possible for your nucs to produce honey their first year, they may not be strong enough to produce a surplus crop until their second summer. You may be able to request extra frames of brood, but expect an added cost. Also, find out whether the cost of the shipping box is included in the price as some nuc producers have returnable wooden boxes.

The complete nuc buyer's guide is available at *www.ontariobee.com/OBBA.*

TTP FEATURE

QUEEN INTRODUCTIONS A TEST OF PATIENCE

BY MELANIE KEMPERS, TECHNICIAN – TECH-TRANSFER PROGRAM

Having healthy, productive, selected, high-quality queens is an important aspect of beekeeping. The queen's genetics control many aspects of a colony's development and behaviour – and ensuring each colony has a functional queen is a main task in beekeeping, whether there are two or 2,000 colonies.

PURCHASING QUALITY QUEENS

Genetic diversity and selective breeding of honey bees impact the sustainability and health of honey bee populations. The adaptations to regional environmental factors – such as climate, vegetation, and prevailing diseases – can all affect the longevity of honey bee colonies. Sourcing local stock is ideal for including genetics that have desirable characteristics produced in the same environment in which the queens will live. The Ontario Resistant Honey Bee Selection (ORHBS) program has a range of dedicated breeders who are raising quality queens in Ontario that are adapted to local environments and selected for desirable traits. Furthermore, queen and nuc producers need to be inspected for tracheal mites, Varroa, and American foulbrood (AFB) to obtain a Queen and Nuc Permit from OMAFRA – this is to ensure that stock being purchased is not spreading any pests or diseases.

WHY REPLACE A QUEEN?

A colony should have their queen replaced if there is a problem with its productivity. A colony that has slow population growth or has a queen that is a drone layer should be re-queened. It is possible that the queen may become non-productive for other reasons, but if she is not performing properly despite optimal conditions, then re-queening is the proper solution. If a colony consistently shows signs of heavy chalkbrood or sacbrood, it might be because the queen has susceptible characteristics. If this is the case, it is a good idea to re-queen. Keep in mind that early in the spring, or when a new queen begins to lay, there may be signs of chalkbrood or sacbrood. As the colony strength increases, these indicators should disappear.

A healthy colony may need re-queening if it's not performing as well as colonies of similar strength in the same yard. Re-queening can also be used to change the colony's genetics: A colony that is trying to swarm a lot may be genetically inclined to do so; a colony that is especially defensive may need a change as well. Young queens can help with overwintering survival and keep population levels high. Ideally, it is recommended that queens be replaced every year or two to maintain functional and productive colonies.

CAGED MATED QUEEN CARE

Purchased queens are provided in queen cages that are plugged with queen candy (icing sugar, syrup, and glycerin mixture) and are accompanied by five or six attendants. Placing the queen in a colony immediately after purchase is ideal.

If immediate queen introduction is not possible, keep the queen and her attendants in the cage. Ensure enough queen candy is provided and spread a drop of water on the mesh of the cage each day. Keep the cage entrances corked or capped so the bees cannot escape. Cover the cages with a piece of paper to minimize stimuli. Avoid mesh-to-mesh contact with other queen cages to avoid conflict. Keep temperature around 18-22°C (room temperature). Maintain proper ventilation and try to introduce the queen into a colony within seven days.

INTRODUCING A MATED QUEEN

Before introduction, the attendants can be removed from the queen cage and the queen marked or clipped, if desired (the colour for 2019 is green). These tasks should be conducted in a well-lit and safe area that is either indoors, in the vehicle, or inside an extra beekeeping veil as the caged queen may be capable of flight and may take off. It is an option to leave the attendants within the cage, however removing and killing the attendants will decrease the chance of introducing pests and diseases. Also, the colony receiving the queen will be less welcoming to the foreign attendants and may inadvertently damage the queen if the workers fight through the mesh of the queen cage. Subsequently, the in-hive bees may reject the new queen if there is turmoil during introduction. So, it's hedging one's bet if attendants are removed before introduction. Not everyone is com-

"Queen and nuc producers need to be inspected for tracheal mites, Varroa, and AFB to obtain a Queen and Nuc Permit from OMAFRA."

fortable doing this, and there is always a risk of the queen escaping during the process, so many new beekeepers will leave the attendants in the cage.

Remember to remove the plug that is blocking the entrance to the queen candy. The cage should be placed in the colony with the candy end facing downwards – this is to ensure the queen will not become coated or drown in runny queen candy if it absorbs moisture from the hive. The queen cage should be placed between frames of brood in the brood chamber or where the bees are clustering. In cold weather, the cage should be placed closer to the middle of the cluster. The queen cage entrance should be filled with enough candy so that the workers take one or two days to release the queen.

If the bees release her too quickly (as when there isn't enough candy), they may act aggressively towards her as her pheromone has not had time to be passed around the hive. Ensure the bees have as much access as possible to the mesh of the queen cage. They need to be able to touch and smell her to become used to her before she is released. The bees will eat away at the candy and, in a few days, release the new queen.

If the colony had previously become queenless (not on purpose), and they are lacking in brood, donating frames of brood from another colony is beneficial. Young bees with brood are more likely to accept a new queen.

If replacing a failing queen, the receiving colony should be queenless for one to two days before the new

> "LEAVING THE COLONY UNDISTURBED FOR A WEEK AFTER INTRODUCING THE QUEEN CAN INCREASE SUCCESS."

queen is introduced. This will allow the failing queen's pheromones to dissipate from the hive. Check all frames inside the hive for wild queen cells, shaking every frame clean of bees to look closely for hidden ones. Drawn comb should be provided so the queen can start laying once she is released.

After seven to 10 days, the colony can be checked to see if the queen is laying eggs. Leaving the colony undisturbed for a week after introducing the queen can increase the success of the introduction and queen acceptance. Any disruptions during this transition period may cause the bees to reject the new queen. If she was not accepted, the bees may have started to build queen cells. Other indications of an unsuccessful queen introduction are agitation, unusual aggressiveness, or a low droning sound produced by the colony when opened.

There have been musings throughout the years indicating that applying substances (like vanilla or pheromones) aide in the acceptance of a foreign queen by covering up the queen's "stress" pheromones. A study by Guzman (1998) showed that the traditional method of simply inserting a queen cage with no substances had the highest rate of queen acceptance, whereas the use of additional substances (vanilla, queen secretions, hexadecane) seemed to decrease the rate of queen acceptance.

FACTORS AFFECTING QUEEN ACCEPTANCE

Researchers have studied various factors that affect the success of queen introductions. Some of these factors include:

i. Condition of the queen to be introduced: mating quality, damage during transport, production of pheromones, queen size and weight
ii. Condition of the receiving bees: age, presence of laying workers, health status (Varroa infestation, viral load)
iii. External conditions: nectar flow, climatic conditions, season of the year.

Condition of the queen: The quality of the queen being introduced can affect her acceptance. If a queen is damaged during transportation, or is unhealthy in any way, the receiving bees may reject her. A queen's pheromones are key to her attractiveness, so if she is stressed, sick, or damaged, the bees will sense this. Some research has shown that queen age can affect her acceptance as well. Queens aged 28 days or older had higher levels of acceptance in one study. It was hypothesized that queens who had time to lay eggs and fully mature were more desirable with ideal pheromones. Similarly, the size of a mated queen has been shown to translate to her quality – a queen with a larger abdomen and thorax correlates to a well-mated, productive queen. Heavier queens were more attractive to the workers than the lighter ones.

Bees in the receiving colony: The bees within the colony need to be ready to accept a new queen. If there is a lingering presence of an old queen, or the colony has laying workers, the bees will not be as receptive. Being queenless for a few days will help prepare the bees for the introduction. A study conducted by Szabo (1977) showed that workers up to seven days old accepted an introduced queen more readily than workers aged 14 to 21 days old. Interestingly, workers 14 days old were more aggressive to introduced queens than those who were 21 days old. Ensuring there are young bees present in abundance in the hive will help with acceptance. The health status of the bees will also affect how readily they accept an introduction. If the Varroa infestation rate is high, if the population is weak, or if the bees are malnourished, the introduction may fail. If the bees within the receiving colony are naturally aggressive, or of a different race than the introduced queen, the introduction may also fail. Colonies accept sister or daughter queens more readily.

photo Natalie Ann Comeau

External conditions: Weather can play a role in the success of queen introductions. When food provisions are ample and there is a good nectar flow, acceptance rates are higher. A study by DeGrandi-Hoffman et al. (2007) in Arizona showed that queen introductions were more successful in the fall, so seasonality may play a role.

DEALING WITH A FAILED INTRODUCTION

If the receiving bees decide to reject a new queen, a few techniques will help with a follow-up queen introduction. Feed the receiving colony sugar syrup if there isn't a good nectar flow. Provide a few frames of brood and young bees from a productive colony so that a good portion of young bees are present.

And introduce a queen who could be a distant relative of the original queen.

Remove the attendants from the queen cage. Introduce a queen who is healthy and undamaged. Do not disturb the colony during the acceptance stage (seven days). Ensure there is plenty of queen candy in the cage to prevent the bees from getting access to the queen too quickly.

If the problem is laying workers, simply introducing a new queen may not work. Placing a nuc in the laying worker colony may override the in-hive bees and their commitment to the laying workers. Otherwise, a drone-laying colony can be shaken out, the hive body removed from the current spot in the beeyard, and the bees left to join another colony in the yard.

For an interesting read, a study by Robinson in 1984, "Worker and Queen Honey Bee Behavior during Foreign Queen Introduction," discusses how it is usually just a few bees who incite "balling" behaviour on a queen cage during introduction. The study states that many bees inside a "ball" are not actually acting aggressively, but are in fact tending to the queen in the cage. It cites how queens will stand up against the few aggressive bees (by kicking them) and can overcome the resistance to eventually be accepted by the rest of the colony.

ASK AN EXPERT

WHAT DO I DO IF I FIND BROOD IN MY HONEY SUPER?

BY MELANIE KEMPERS, TECHNICIAN – TECH-TRANSFER PROGRAM

As the season progresses and the queen continues to lay eggs for population maintenance, space within the hive will be in great demand. Adding supers provides the bees with the necessary room needed to store the surplus honey they are bringing back to the hive, but it may also be attractive to a queen needing space to lay eggs. If the brood nest is maintained and frames in the brood chamber are all available for the queen, it should provide enough space for her – but sometimes she can still wander.

A FEW POINTS TO CONSIDER

Are queen excluders being used?

If so, it's likely that the queen excluder used for the hive in question is malfunctioning. It could be malfunctioning for a few reasons, one being that the spacing between the bars/grid has changed and now a queen can fit her thorax through to enter the honey super. Another reason could be that the queen excluder has shifted and left gaps at the edges of the box. A third could be that the cheaper, less reliable queen excluders don't always lay flat or maintain their shape very well, and comb can perhaps hold it up above the top bars making a gap.

If the queen excluder looks intact and has no deformities, other reasons may come into play. Perhaps, on the last inspection, the queen was on the queen excluder and ended up on the "wrong side" when the hive was put back together. It could also be that the brood frame the queen was on was laid against the honey super and the queen ran in during your last inspection. Always keep on eye on both sides of the queen excluder when doing inspections.

In any of the above cases, finding the queen and placing her back in the bottommost box of the hive is key.

"If the brood nest is maintained and frames in the brood chamber are all available for the queen, it should provide enough space for her."

Check the queen excluder for any gaps, breaks, or deformities and replace if necessary. Allow the brood to hatch out of the honey super frames and the bees will clean them up and use them for honey again. This will not spoil or damage the honey being produced.

If you find this issue when you are trying to escape the bees in order to remove the honey super, you'll need to wait until the brood has hatched as the bees will not leave their brood. Regular inspections of the hive and honey supers is key to finding this situation before you're ready to harvest.

Finally, if you end up finding brood in the supers at the honey house/place of extraction, then those frames should be collected into empty boxes and given back to a colony – within 24 hours of removal, and placed over a queen excluder if you wish to preserve the frames as honey super frames – so the brood can emerge or be cleaned out by the bees.

If there is young brood (eggs, young larvae) on both sides of the queen excluder, your hive may be housing two queens.
Is there a top entrance in the inner cover/super above the queen excluder? If so, a recently mated queen could have returned to the top half of this hive and started laying eggs. Remove or close off any top entrances/holes once honey supers are added above the queen excluder to prevent this from happening.

If queen excluders are not being used, then brood in your supers is inevitable.
It can depend on how many brood boxes are being used, as doubles may provide an invisible barrier to the supers if the tops of the frames in the second box are all honey and not attractive for laying eggs. But queens will still travel past this point from time to time. Using single brood boxes with no queen excluders will almost definitely mean brood in the honey supers.

Is it drone brood?
If so, then the issue could be a laying worker or a drone laying queen (or you are using drone cell sized foundation). If it is a drone-laying queen, the best option is to locate and replace her – introduce a new queen into the brood box and let the drone brood in the super emerge. If no queen can be found, then it may be drone-laying workers – fixing this is always difficult. If a queen is present in the brood box, shake the bees out of the supers in front of the hive entrance and force them to march back in. This can re-set the worker bees' mindset and reacquaint them with the queen's pheromones – and hopefully stop the laying of eggs by workers. Sometimes the hive population increases so quickly that the queen's pheromones become diluted amongst the workers. If the pheromone level drops, the workers may feel the need to lay eggs even if a queen is present. So, if there is a queen and worker brood in the brood box, but drone brood in your supers, laying workers may have felt the need to lay eggs because the pheromone levels dropped. Signs that a queen is in the brood box are: seeing the queen; or, seeing eggs that are just one per cell and at the bottom of the cell (not on the side walls).

If you don't have a queen in any of the boxes, then the hive has gone queenless and introducing a new queen with two-to-three frames of healthy worker brood and baby bees can help rectify the issue.

In the end, realizing that hive inspections are important – even in the middle of summer – is key. We sometimes get into the habit of adding supers and going on our merry way, but the need to check out frames, in both the supers and the brood chambers is still an important task at this time of year. Also, it's beekeeping, no nothing is absolute.

Escaping (or removing) the bees from the honey supers can be accomplished by placing an escape board between the honey super and brood chamber. The board has a one-way portal which allows the bees to exit the super but not return. Be sure to close any upper entrances in the supers as well.

ASK AN EXPERT

WHAT ARE BROOD CAPPINGS MADE OF, AND HOW DO THEY DIFFER FROM HONEY CAPPINGS?

BY DANIEL BORGES, TECHNICIAN – TECH-TRANSFER PROGRAM

One of the best parts about teaching the introductory beekeeping workshops is that first trip out to the bee yard with the students. It is an exciting moment, and often the first time that many of them are in a hive. In addition to showing them how to work a hive and the different honey bee castes, an important part of that first bee yard session is to show the students the difference between capped honey and capped brood. This often elicits the interesting question of what the difference is between the two types of cappings, and what they are made of.

The simple answer to the question is wax. However, the composition of the wax is different with brood cappings compared to honey cappings. Before we get into the differences, though, let's start with wax and where it comes from in the first place.

Beeswax is produced by worker bees from four pairs of wax glands on the underside of their abdomen. Wax production starts a few days after the worker bee emerges from her cell, but the glands are not fully developed and at their peak until the worker is about nine to 12 days old.

The production of wax is very costly – worker bees have to consume about seven to eight pounds of honey to produce just one pound of wax. As a result, wax production starts to wane once bees begin outside tasks like foraging. The glands atrophy and stop producing wax at this time because the extra resources are needed to fuel the flight muscles instead.

When wax production is at its peak, worker bees of the right age help to build and repair the nest. The wax is secreted from the glands as thin, translucent flakes. The workers use a wax spike, found on the middle pair of legs, to pull the wax flakes out. They then chew the wax with their mandibles, adding saliva to it and manipulating it to build the comb.

The entire nest starts off being made of just wax when it is first built. However, over time, other materials are added to the wax. One of these materials is propolis. In addition to using it as a glue to stick hive components down and seal cracks, bees also use propolis as a disinfectant in the hive. The plant resins that make up propolis are loaded with antimicrobial and antiviral phytochemicals. Worker bees line the cells with a thin layer of propolis to help prevent the spread of disease. This is particularly true in brood cells where larvae are being reared. Over time, propolis becomes mixed with the wax, making it a component of the nest as well.

The other major component of the nest is silk. Each time a larva is ready to pupate, it spins a cocoon out of silk within its cell, covering the cell walls with a thin layer of silk fibres. This pre-pupal stage is also the time when the larva's digestive system is finally fully developed (before this point, the digestive system is essentially a blind-ended tube, and the larva is unable to defecate). The pre-pupa defecates for the first time at this point, and its faeces, as well as a number of other substances secreted from the digestive system, are applied to and mixed with the silk. Some of these substances are believed to help protect and harden the silk, but researchers do not know the exact function of each of the substances for sure. When the adult bee emerges, this silk casing is left behind and subsequent generations of larvae add more layers of silk to the walls. This silk gets mixed with the wax as well, and acts a major structural component of the nest, strengthening the comb.

These additional materials, especially silk, are what contribute to the difference between brood and honey cappings. Honey cappings are primarily made of beeswax. Because their function is to seal and preserve the ripe honey, these cells are capped with a thicker layer of wax. The wax is fresh, and honey cappings tend to be lighter in colour as they are composed of just wax. Their composition does not change over time, as cells used for storing honey do not contain significant amounts of propolis, and they are generally not used for rearing larvae.

Brood cappings start off as just wax as well. Cells containing older larvae are capped over with wax, but it is a very thin, breathable layer of wax. Once the cell is capped, the larva/pre-pupa then spins its cocoon, adding a layer of silk to the underside of the thin wax capping. So a brood capping is a thin layer of wax on top of a thin layer of hardened silk. In a mature colony, however, the composition of the wax layer changes over time. When an adult bee is emerging, she needs to chew through the capping. The remnants of this capping are

“Over time, brood cells and cappings tend to get darker in colour, as they are made of recycled wax that contains silk, propolis, and other materials.”

placed on the sides and rim of the cell. When the cell is cleaned out, these used cappings – composed of a mix of wax, silk, propolis, and other trace materials – get chewed up and recycled by the nurse bees who use them to cap other brood cells. Over time, brood cells and cappings tend to get darker in colour, as they are made of recycled wax that contains silk, propolis, and other materials.

In addition to being an interesting fact about bee biology and nest construction, this information also has some practical use for beekeepers. Because brood comb tends to darken over time as it starts to incorporate more propolis, shed pupal cocoons, and other materials, the colour of the wax on a frame can help signal when it is getting older and in need of being culled.

Old wax can harbour pest and disease spores, and also accumulates pesticides and other environmental and in-hive toxins. Regularly culling older frames is an important part of any integrated pest management program and helps prevent the spread of pests and diseases as well as reducing levels of chemical contaminants in the hive.

A great time to cull a few older frames from a hive is in the spring, as the colony will just be starting to build up and many frames may not be covered in brood yet. If an older frame that is a candidate to be culled does have brood on it, it can be moved to the outer edges of the hive. The brood will emerge, and the queen won't lay eggs in these outer frames right away, making it easier to cull and replace them.

photos Natalie Ann Comeau

TTP FEATURE

THE SCIENCE BEHIND BREEDING FOR RESISTANCE TO VARROA

BY DANIEL BORGES, TECHNICIAN – TECH-TRANSFER PROGRAM

Parasitism by the Varroa mite continues to be the biggest issue facing the beekeeping industry. Most of the talk around integrated pest management (IPM) in beekeeping focuses on ways of controlling populations of this parasite through cultural and chemical means. The ultimate goal, however, is to breed bees that are resistant to Varroa mites, so that fewer (or no) chemicals are needed for its control. Breeding disease-resistant bees is the primary focus of many breeding programs, including the Ontario Resistant Honey Bee Selection (ORHBS) program.

With so much importance placed on breeding for Varroa resistance, there is an equal focus placed on scientific research into Varroa-resistant bee populations and the traits that may be responsible for this resistance. The eastern honey bee (*Apis cerana*) and Africanized bees (*A. mellifera scutellata*) are both considered to be resistant to Varroa mites. They are able to coexist with the mites, maintaining their levels below damaging thresholds. While the full suite of physiological and behavioural mechanisms that are responsible for this resistance are still not fully understood, a number of promising candidates have been found. The most prominent of these include grooming behaviour, hygienic behaviour, Varroa-sensitive hygiene (VSH), and suppression of mite reproduction (SMR).

These same behaviours have been identified in different populations of the European honey bee. While these populations are not considered completely resistant, these behaviours have been shown to help suppress mite population growth, and are ideal candidates to be assessed and incorporated into breeding programs. This article will go over these different traits, including the current understanding of how they work, as well as lab and field assays that can possibly be used to measure them.

Grooming behaviour is a good place to start, as it is a little more straightforward than the other behaviours. Grooming behaviour involves adult worker bees physically removing mites from their bodies using one or more of their legs, as well as their mandibles. This is known as autogrooming. Worker bees may also recruit their sisters to help groom mites off as well. When one worker bee grooms another, it is called allogrooming. While most bees will groom themselves, the speed and intensity at which they perform this behaviour varies greatly from individual to individual. More intense grooming continues for a longer time, and generally involves more pairs of legs. Not surprisingly, more intense grooming is more successful at dislodging mites (Guzman-Novoa *et al.*, 2012).

Both *A. cerana* and Africanized bees groom more than European honey bees. This is believed to be one of the behaviours that grants resistance to Varroa mites in these bee populations. In Africanized bees in particular, grooming behaviour is believed to be one of the main factors contributing to resistance. While grooming behaviour is also observed in European honey bees at different levels, measuring it can be difficult. Most studies examine differences in grooming behaviour by collecting fallen mites on sticky boards, carefully removing them, and examining them under a microscope for damage. Besides being very time-consuming, this method of measuring grooming behaviour can be problematic. For one, mites may become damaged from things other than grooming behaviour. Hygienic bees can damage mites when they are removing infested brood (more on that later), and different pests and predators may damage mites after they have fallen onto the sticky board. In addition, grooming bees may remove mites without actually causing any damage, meaning that these mites won't be measured as having been "groomed off." Nonetheless, measuring grooming behaviour in this manner has had promising results. A number of studies have found strong correlations between colonies that have high numbers of injured mites on sticky boards, and low overall mite infestations (Arechavaleta-Velasco and Guzman-Novoa, 2001; Guzman-Novoa *et al.*, 2012).

The study by Guzman-Novoa *et al.* (2012) was a particularly notable one, because it made the important link between grooming behaviour in the lab, damaged mites on a sticky board, and overall colony mite infestation. The researchers took individual bees from colonies with high numbers of injured mites and colonies with low numbers of injured mites, and tested them in the lab for grooming behaviour. This was

"While the full suite of physiological and behavioural mechanisms responsible for this resistance are still not fully understood, a number of promising candidates have been found."

done by placing a mite on the workers and observing the intensity at which they groomed. Bees from colonies with higher numbers of damaged mites performed more intense grooming – faster, involving more legs – and were more successful at removing mites. What was even more important was the implication of this research in terms of its application in the field. While the high-grooming and low-grooming bees came from colonies with high numbers and low numbers of damaged mites, respectively, these high and low groups were not actually divided based on the number of damaged mites collected. Instead, the high and low groups were created based on the relative mite growth over the season – a much easier, and less time-consuming, method than collecting and analysing individual mites. A sticky board count was used to analyse mite drop in the spring, and then again later in the summer. Colonies with the lowest relative mite growth throughout the season were placed in the low-mite population (LMP) group, while the colonies that showed the highest relative mite growth throughout the season were placed in the high-mite population (HMP) group. The researchers showed that the LMP colonies had higher numbers of injured mites on the sticky boards and also performed more intense, more successful grooming when measured in the lab. The biggest factor contributing to the low mite growth over the season in this study (as well as the study by Arechavaleta-Velasco and Guzman-Novoa, 2001) was found to be grooming behaviour. As a result, beekeepers and bee breeders can use relative mite growth throughout the season as a proxy for measuring grooming behaviour, allowing them to more easily select and breed from colonies that perform high amounts of this behaviour.

Things get a little bit more complicated when it comes to the other behaviours. While hygienic behaviour, VSH, and SMR are all distinct behaviours, there are also very strong links between them, particularly between VSH and SMR. In general, hygienic behaviour refers to the ability of worker bees to detect diseased and dead brood under the cappings, and then uncap and remove this brood from the hive. Varroa-sensitive hygiene refers specifically to hygienic behaviour where brood infested with Varroa mites is uncapped and removed from the hive. We will come back to SMR later, as it is a (seemingly) different mechanism of resistance.

Hygienic behaviour has been studied extensively, and has been shown to be an incredibly important mechanism for resistance to brood diseases such as American foulbrood, chalkbrood, and sacbrood (Spivak and Gilliam, 1998a, b). Its link to Varroa resistance, however, is much more controversial. Hygienic behaviour is believed to be one of the main factors contributing to Varroa resistance in *A. cerana*. While hygienic behaviour is observed at various levels in Africanized and European honey bees, very few studies have found a

> "The study was a particularly notable one because it made the important link between grooming behaviour in the lab, damaged mites on a sticky board, and overall colony mite infestation."

link between high levels of hygienic behaviour and increased resistance to Varroa. One of the notable studies that did find a link was done by Dr. Marla Spivak (reviewed in Spivak and Gilliam, 1998b). The study found a correlation between removal of brood that was artificially infested with mites, and removal of freeze-killed brood (the most common method used to assess and measure hygienic behaviour). However, an important finding of this study was that this relationship was really only robust when comparing freeze-killed brood removal and brood artificially infested with two or more mites per cell; when only one mite was added to each cell, the removal by hygienic bees did not correlate very strongly with removal of freeze-killed brood.

More recent studies, such as the one by Harris *et al.* (2012), may provide an explanation for Dr. Spivak's findings, and why hygienic behaviour and VSH appear to be distinct behaviours. Our current understanding of hygienic behaviour is that it involves a number of different genes, takes place in distinct uncapping and removing steps that may be performed by different bees, and that worker bees differ in their sensitivity to the olfactory cues that trigger hygienic behaviour (and, therefore, the speed and efficiency with which they perform this behaviour). What Harris *et al.* (2012) found was that VSH bees do not seem to be reacting to cues released by dead or diseased brood. Instead, they are reacting to some cue associated specifically with Varroa reproduction – whether that is the Varroa nymphs themselves, their faeces, or some other related cue. With regard to Dr. Spivak's findings, the hygienic behaviour associated with infestations of two or more mites per cell was likely due to the workers sensing the damage to the pupae, similar to what they would smell with brood that is infected with diseases such as AFB, chalkbrood, and sacbrood. The finding that this correlation with freeze-killed brood removal more or less disappeared when it was only one mite infesting each cell was likely a result of the damage cues being too low to be picked up by most of the hygienic bees. This is important, and has been a critique of these findings by Dr. Spivak, because cells infested with two or more foundress mites are not very common unless colonies are very heavily infested. At the very least, removal of Varroa mites by hygienic bees only when infestations are incredibly high is not a reliable trait to select for when breeding for Varroa resistance. It is also likely the reason why many other studies that compared populations of bees with high and low Varroa infestations found that hygienic behaviour did not contribute to the differences in mite levels, despite there being large variation in the levels of hygienic behaviour between colonies (Harbo and Hoopingarner, 1997; Arechavaleta-Velasco and Guzman-Novoa, 2001; Emsen *et al.*, 2012; Leclercq *et al.*, 2018).

Based on the findings by Harris *et al.* (2012), hygienic behaviour and VSH are related, but distinct, behaviours. Hygienic bees detect and remove brood based on cues associated with dead or dying larvae and pupae; VSH bees remove pupae infested with Varroa mites based on cues associated with mite reproduction. This latter finding is the thread that links VSH and the final behaviour: suppression of mite reproduction. SMR refers to the phenomenon of uncapping older brood cells and finding foundress mites that, for whatever reason, did not produce any viable offspring, whether they produced only a male, or no offspring at all. Colonies that have high levels of SMR are those where a large percentage of the infested brood is found to be infested with infertile mites. Early research on SMR attempted to find a physiological mechanism whereby brood could cause infertility in mites. However, studies like the one by Harbo and Hoopingarner (1997) seemed to point to the effect being caused by the workers and not the brood. The researchers divided test colonies into two groups based on whether there were high levels of SMR found, or low levels of SMR. A mite-infested brood frame was then placed into the test colonies, left for a number of days, and then removed and examined for the level of SMR. The authors found high levels of infertile mites in the high SMR test colonies, regardless of whether the infested brood frame came from that colony itself, or whether it came from a low SMR colony. On the other hand, when a frame of infested brood from the high SMR colony was placed in a colony selected for low levels of SMR, the levels of infertile mites found were very low. The authors concluded that there was only a small SMR effect caused by the brood, and that the workers themselves seemed to be causing the SMR.

Fast-forward 15 years, to the study by Harris *et al.* (2012) again, and a slightly modified mechanism was discovered. The researchers' findings that VSH bees were responding to cues associated with mite reproduction led them to an even more important discovery – the VSH bees were not causing SMR, they were selectively removing fertile mites. VSH bees are known to uncap and then recap large numbers of cells – in some hives, more than 90% of capped brood cells examined were found to have been uncapped and then recapped. Bees that exhibit high levels of VSH appear to uncap cells, and then selectively remove pupae that are infested by reproductive mites. The bees can differentiate between reproductive and infertile mites, and recap cells containing infertile mites. In this way, VSH bees are not causing SMR, they are simply removing large numbers of reproductive mites, leaving behind mostly (and therefore, a higher proportion of) infertile mites.

The bad news is that VSH and the resultant SMR are difficult and time-consuming traits to measure. With both, hundreds of brood cells have to be uncapped per colony to assess whether the behaviour is occurring, and at what level. With VSH testing, brood frames are either artificially infested with a known level of mites and then introduced into the test colony, or a naturally infested frame with a known level of mites is introduced into the test colony. The frame is left in the test colony for a certain amount of days, then removed (and often frozen). Hundreds of cells are then uncapped to determine the percentage of infested brood that was removed, or the relative decrease in the infestation level due to VSH. This is often done in addition to analysing the percentage of cells that show signs of having been uncapped and then recapped, as high levels of this behaviour are associated with high levels of VSH. Testing for SMR is done in the same way, but cells that are found infested with Varroa are analysed for offspring to determine if the mite was reproductive or infertile. Testing for SMR is often even more time-consuming than VSH testing. This is because VSH bees cause SMR by selectively removing most of the fertile mites, meaning that an even larger number of cells need to be uncapped in order to get a large enough sample size of infested cells to reliably calculate the percentage of SMR.

It is worth noting as an aside that while VSH and SMR are very closely linked, in that VSH causes SMR, there is at least a small SMR effect caused by the brood itself that requires further research. While Harbo and Hoopingarner (1997) found that the largest SMR effect was caused by the workers, there was a small brood effect. When the frame of infested brood from the high SMR colony was placed in a colony selected for low levels of SMR, the levels of infertile mites found were very low, but they were slightly higher than when the frame of infested brood came from the low SMR colony itself. Harris *et al.* (2012), however, suggest that most of this brood effect might still actually be related to VSH behaviour. They suggest that some cells with reproductive mites are accidentally recapped by VSH bees. In the process of uncapping and recapping, the VSH bees may damage the developing offspring, causing them to be infertile in subsequent infestation attempts (in this case, even if the infested frame is then moved to a low SMR colony). This goes hand-in-hand with findings that the number of unmated mites increases over time in VSH colonies, possibly due to the uncapping and recapping damaging or killing the male mite, leading to the female offspring being unmated. Nonetheless, there is still a possible SMR effect caused by the brood, one which is often associated or compared with brood attractiveness to mites. A few studies have shown that Africanized brood, in particular, is less attractive to Varroa mites than brood from European honey bees (Corrêa-Marques and De Jong, 1998). In addition, other studies have found differences in the ratio of mites infesting the brood compared to mites on adult bees (Emsen *et al.*, 2012). Differences in this ratio can be caused by many things, including differences in brood attractiveness, grooming behaviour, or VSH, but it is an important finding. As Harbo and Harris (1999) point out in their review article, differences in the brood infestation to adult infestation ratio relate to differences in the length of the Varroa reproductive cycle. When a large proportion of the mites are found in the brood, the reproductive cycle is short, and mite reproduction is high. On the other hand, when a large proportion of the mites are found on the adult bees, the reproductive cycle is longer, and mite reproduction is low.

All of this information is crucial when designing a breeding program around Varroa mite resistance – it also highlights the importance of having a dynamic program that can respond to advances in our understanding of honey bee genetics and mechanisms of resistance. A perfect example is the ORHBS breeding program. While it started as a breeding program in the early 1990s for tracheal mite resistance, the ORHBS program has evolved over time with the industry and our understanding of pests and diseases. Hygienic testing with freeze-killed brood assays was incorporated into the ORHBS program to help combat brood diseases, and also because of its promise to help with Varroa resistance. With our new understanding of the role of grooming behaviour, VSH, and SMR in Varroa resistance, new selection tools are necessary to continue to improve breeding programs such as the ORHBS program. Tech-Transfer is currently working on a grooming behaviour project with the University of Guelph, as well as a VSH and SMR project with Laval University. It is our hope that research projects like these will help discover and refine reliable and efficient ways to assess these behaviours in the field, so that bee breeders around the province can incorporate them into their breeding programs.

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Worker Bee

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