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CANADIAN AGRICULTURAL INNOVATION AND REGULATION NETWORK

An ERCA Network

Mailing Address:
Department of Bioresource Policy, Business and Economics
University of Saskatchewan
3D34 - 51 Campus Dr.
Saskatoon, SK
S7N 5A8

Network Lead:
Dr. Richard Gray

General Inquiries:
306-966-4026

Fax: 306-966-8413

Email:
cairn.network@usask.ca

Website:
www.ag-innovation.usask.ca

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Extension of Honey Bee Pest and Disease Innovations to Canadian Beekeepers

Amanda Lenhardt, Ph.D. Candidate,
University of British Columbia

Issue

Canadian honey bee producers continue to face a number of biological, environmental and economic barriers when attempting to meet the demands for pollination of essential food crops and to produce honey in a sustainable fashion. Although no single cause has been directly associated with ongoing decreases in the honey bee population and increasing trends in bee mortality, honey bee diseases such as *American Foulbrood*, and parasites, notably the *Varroa destructor*, have shown to be among the most significant contributing factors. A number of chemical, organic, and integrated pest management treatments are currently undergoing research, testing and application, however effective coordination of these efforts has been slow to emerge. Adoption of effective innovations by Canadian beekeepers is necessary to ensure that the honey bee industry can maintain a sustainable honey bee population.

The purpose of this policy brief is to describe some of those disease and pest management innovations that are currently in the research development and application stages. Also included in this brief is a discussion about the applicability of recent innovations to Canadian honey bee producers and a discussion about extension and coordination issues related to the dissemination of these technologies.

Policy Implications and Conclusions

Canada is one of the few places in the world where honey bee populations are increasing.[i]

Despite a slight rate of increase, the number of beekeepers has been declining and the number of bee colony losses is significantly higher than the long-term average overwintering losses, which typically range from 5-15 percent.[ii] Recent years (2006-2009) have seen significantly higher losses with national mortality averaging between 34-36 percent.[iii] The implications of reduced honey bee populations extend beyond the honey industry, which by 2010 was valued at slightly over CDN $125 million.[iv] Indeed, at risk is the estimated $2 billion pollination service which honey bees provide to a variety of staple crops in Canada including canola, berries and tree fruit.[v] It is widely understood that on-going decreases in both the number of pollination service operators and the size of their honey bee colonies is placing considerable strain on those crops which are highly dependent on pollination.

As such, research which explores the causes of bee mortality and seeks preventative measures to avoid losses is of immediate importance. At present this research is being undertaken by a worldwide network of researchers and significant scientific advances are ongoing. What is unclear is how this research will be adopted by beekeepers, who are typically highly sensitive to additional operating costs because of thin profit margins. The importance of extending accurate information and viable solutions is particularly important for the apicultural industry. Given the migratory nature of bees, partial adoption of a particular innovation may not be effective because the parasites and diseases are likely to spread from non-treated to treated colonies. Widespread adoption is required to ensure that pest and disease extension policies are effective.

Discussion

There are currently a number of innovations in bee disease and parasite prevention and treatment being studied across Canada, as well as worldwide. Many of these innovations may still be in the research stages and are not yet viable for broader distribution to industry, however beekeepers who are facing high mortality rates as well as higher input costs for existing chemical treatments and bee package replacements should be made aware of what innovations may be useful in the maintenance of their operations. With an early awareness of potential solutions to common causes of bee mortality such as *American Foulbrood* and *Varroa destructor* policy makers may begin preparing extension programs in order to disseminate up-to date breakthroughs in these innovations as they come forward. This type of information may benefit those operators who are currently downsizing or exiting the industry due to high loss rates and increased costs (e.g., they may participate in trials on piloted innovations). Keeping beekeepers in the industry is vital to maintaining an adequate honey bee supply for pollination services and honey production. Thus, information which reduces economic risk and increases the feasibility of remaining or even expanding within the industry is likely to have broad reaching positive effects.

Selective Breeding

In order to maximize productivity, mitigate losses or expand production, beekeepers will tend to purchase new queens or bee packages on an annual to bi-annual basis. Some of these queens and bee stocks may be raised by beekeepers themselves or purchased by local breeders, but the majority are imported from California, Hawaii, Australia, New Zealand and Chile. Both migration and trade have, over time, developed a wide array of biological differences among particular bee populations such that a number of sub-species are known to exist with varying physiological and behavioral characteristics.

The biological diversity achieved by the international trade of honey bee populations may have both negative and positive effects. One significant shortcoming of this practice is that the environmental conditions in which foreign bees thrive may diverge significantly from those where they are sold. Hence, the adaptability of those honey bees may be limited. However a positive outcome of international trade is that access to a variety of bee populations has allowed Canadian beekeepers to select breeds based on desired characteristics.

Some of these characteristics, such as bee temperament, may be apparent to the bee breeder; less aggressive bees, for example, are desirable to beekeepers for their relative ease of management. Breeders are able to, by selection, use only those bees with less aggressive temperaments in their breeding operations. As traits are passed down among generations of bee breeds, those desired traits will tend to dominate a particular stock of honey bees.

Unlike temperament, biological traits such as pest and disease resistance may not be immediately evident to bee breeders. Through observation it may be possible to note particularly resistant hives based on their survival rates, however this method is imprecise and does not allow breeders to select for particular disease and pest resistances. Additionally, this process can prove financially prohibitive as the increased demands for labour required to regularly inspect hives to observe these traits may in fact outweigh the economic returns.[vi]

Biomarker Technology

One innovation currently undergoing research which could help reduce the costs and imprecision associated with observational selection of bees for the purposes of selective breeding is that of biomarker technology, particularly in the areas of proteomics and genomics. By sequencing the diversity of protein or genetic expressions among honey bees, researchers have been able to better understand the mechanisms by which selected honey bee populations adapt to particular environmental circumstances as well as diseases and parasites.[vii,viii]

Not only might advances in genetic and proteomic research help our understanding of the biological differentiation among selected bee breeds for particular desirable traits, but these innovations may also serve as a cost effective and reliable manner by which bee breeders could actually test their own bee stocks to determine which are more desirable for distribution based on measurable biological traits. Once these genetic and protein bio-markers have been identified as differentiating among, for instance, honey bees with greater resistance to *Varroa* mites, this innovation may then be converted to an economically viable testing device to be used by bee breeders to selectively breed only the most resistant bees. At present further research is necessary to arrive at a precise and low cost instrument for release, but given the potential benefit that biomarker technology may provide to the beekeeping industry, it is essential that policies are designed to support this research as well as to ensure that beekeepers are made aware of this and similar innovations.

Hygienic Behavior and Selective Breeding

With advances in biomarker technology, it will not only be possible to identify particular disease resistant honey bees, but it may also be possible to determine the biological aspects of what is called hygienic behavior. This term refers to the self removal of diseased or mite affected brood prior to maturity as a disease reduction mechanism. Research is currently trying to determine how this behavioral reaction to threats to the hive may be biologically observed so as to differentiate hygienic from non-hygienic breeds. This hygienic behavior has been observed in response to both *American Foulbrood* as well as to the elimination of *Varroa* mites, in addition to other common causes of honey bee mortality.[ix]

A better understanding of hygienic behavior, coupled with biomarker technology, may make it possible to selectively breed bees which essentially treat their own hives. Although there may be limitations to hygienic behavior, any reduction in the labour and financial resources that beekeepers currently devote to pest and disease treatment would have a significant positive impact on the industry's economic viability.

Local breeding versus imported breeding

Advances in selective breeding, biomarker technology and a better understanding of hygienic behavior may all contribute to the strengthening of an otherwise limited Canadian bee breeding industry. As noted above, the majority of bee packages are imported to Canada which poses adaptability concerns. By encouraging further research in these domestic innovations it may be possible to not only produce locally viable bee stocks, but also to expand the Canadian bee breeding industry. A stronger breeding industry is desirable for the sake of economic growth in the beekeeping industry (many bee breeders also manage their own hives) as well as poses less vulnerability to local stocks from variability and pest and disease shocks that may befall imported honey bee sources.

Integrated Pest Management

In addition to these advances in breeding technologies, the beekeeping industry has made significant strides in the area of integrated pest management (IPM). IPM innovations, which tend to be labour intensive, have contributed to disease and parasite monitoring, prevention and treatment. One such IPM innovation is a screened bottom board which is placed below the hive to trap fallen mites. This inexpensive addition is useful for counting mites to determine economic thresholds. Another innovation is sugar dusting, which involves dusting icing sugar over bee frames as a means of causing mites to lose their grip on hosting bees. This technique causes mites to fall and become trapped below the screen on a sticky substance (petroleum jelly may be used). The screened bottom board prevents these mites from returning to the productive parts of the hive.

Screened bottom boards and sugar dusting are among some of the many IPM techniques currently being used and refined by beekeepers. Of course beekeepers use many of their own variations of these innovations based on their own experiences. Extension services to Canadian beekeepers would benefit significantly from the knowledge that has been accumulated among these user-driven innovations. A survey of effective IPM strategies and their adaptations which are being employed by beekeepers could be used to compile a set of procurable strategies to be made available to all beekeepers so that information could be shared across the industry uniformly rather than through informal networks or regional associations, as it currently does. A number of effective pest and disease prevention and treatment methods exist, but aggregation and standardization of these through policy, followed by extension, would serve to benefit the Canadian beekeeping industry as a whole. This would provide both incentives for current beekeeper to stay in the industry and incentives to encourage new entrants, thus leading to the maintenance of an sustainable Canadian bee population.

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