The Australian Apiary Industry

Pest and disease management

A report for NUFFIELD AUSTRALIA FARMING SCHOLARS

By Ben Hooper

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Scholar Contact Details
Ben Hooper
PO Box 577
Tintinara SA
5266

Phone: 0407820474
Fax:
Email: hoopsbee@hotmail.com

In submitting this report, the Scholar has agreed to Nuffield Australia publishing this material in its edited form.

Nuffield Australia Contact Details

Nuffield Australia
Telephone: (03) 54800755
Facsimile: (03) 54800233
Mobile: 0412696076
Email: enquiries@nuffield.com.au
PO Box 586 Moama NSW 2731

Foreword

The Australian apiculture industry is relatively small, contributing around $80 million per annum in gross value of production (GVP) (More Than Honey, 2008). The importance of the honeybee to agriculture and horticulture is not realised through its GVP, but through its versatility as a pollinator. The pollination services that managed and feral European Honeybees provide to the 35 most pollination dependent crops is estimated at $3.8 billion per annum (More Than Honey, 2008). In fact CSIRO estimate that every third mouth full food consumed in Australia has been pollinated to some degree by a honeybee.

The rapid global decline in European honey bee populations is having a dramatic effect on cost of production to the apiarists. The knock on effect is being felt by the wider agricultural and horticultural sector, which are reliant on honey bees for their pollinating abilities.

Internationally there are many pest and diseases that can have a serious impact on the productivity of the honeybee. Australia has its share of these pests and disease but uniquely remains free from some of the most serious and debilitating pests and diseases. Across the world *Varroa* mite remains the most debilitating pest to commercial bee keepers. This blood sucking parasitic mite can be a vector for an array of other diseases and has decimated managed colonies and wiped out wild populations the world over. Anderson whom a expert in this field, claims it is simply a matter of time before the mite will make it to our shores.

The purpose of this report is to offer an understanding of new management techniques for the Australian Apicultural industry post an incursion of Varroa mite.

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Acknowledgements

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Thank you to those within the industry who have entertained my ideas and answered my many questions, Thanks for sharing your time and information. Cheers Danny and Des!

To my family, Mum and Dad for all the opportunities, guidance and support; particularly Dad for pushing me to start my own business at such a young age. You have given me everything; I hope we can continue to work to better things.

Finally to my wife for allowing me to spend so much time away at such an early stage in our marriage. I look forward to the expansion of our family very soon!!

Abbreviations

AHB Asian Honey Bee

AHBIC Australian honey bee industry council

CCD Colony collapse disorder

GVP Gross value of Production

SAAA South Australian Apiarist Association

USA United States of America

Contents

Executive Summary

Beekeeping in Australia can be described as somewhat hassle free compared to anywhere else in the world. The industry is very diverse through management techniques due to our varying climate and with those come specific challenges. Nothing, however that cannot be overcome by adequate animal husbandry practices.

Currently the majority of Australian apiarists rely on honey production as the core component of their business structure. The diverse flora found throughout our country supports some of the biggest and best honey crops compared to anywhere in the world. The face of beekeeping will change forever once Varroa destructor is declared endemic in Australia.

Firstly no country in the world has ever successfully eradicated the Varroa mite. An important lesson can be learnt from New Zealand's experience. They are the most recent country to have had an incursion of this exotic pest. Despite all their preparation and time to implement safe guard measures they failed to prevent Varroa moving from the north to the south island.

It is expected that the Varroa mite will wipe out virtually all wild/feral European honeybees and cause significant damage to the managed honeybee industry. This is basically a beekeeper problem but due to the exceptionally high numbers of feral colonies that currently exist within the Australian environment there are significant ramifications for agriculture sectors reliant on honey bees to support production. A decrease in the incidental pollination services they perform coupled with a decrease in supply of managed hive equates direct financial losses due to drop in yield and quality of yield for both the Apiary industry and pollination dependant producers.

The international beekeeping community has virtually thrown everything at this pest. The industries with long production seasons similar to ours have unfortunately become completely reliant on synthetic chemicals to suppress mite numbers long enough to survive the growing season and fulfil lucrative paid pollination contracts. These actions have resulted in strong resistance being developed quickly amongst these parasites against the available modes of action.

This report aims to provoke thought in alternative methods for dealing with exotic pests and diseases as well as some suggest some recommendations as to what can be done to better prepare ourselves for life with Varroa mite. As I see it Australian apiarists cannot afford to replicate the current actions of the international commercial beekeeping community.

Introduction

My involvement in European Honey Bees began like any other child growing up on the land put to work when reaching a suitable age to be of use. Unlike the average farm child's tasks of opening gates, feeding lambs or helping prepare equipment for seeding. I was extracting honey in a space suit, learning a very different animal husbandry skill set along with wondering around scrubby blocks staring at flora.

As a teenager after growing up around bees I was unsure if the apiary game was for me. However, I was fortunate enough to have my father push me to register my own business despite my lack of direction. I thank him for encouraging my independence and teaching me such responsibilities at that time. Since then my appreciation for the insect we work with continues to grow, and with it my passion to see our industry prosper.

The Australian style of beekeeping is unique when compared to many other parts of the world. Australian beekeepers are often described as nomadic, following the honey crops around the country side. There is no exact pattern to follow and seasons are very rarely replicated. This can often make it hard for beekeeping business to plan and fosters individualised management techniques.

This nomadic style of beekeeping is mainly due to the type of native flora available to beekeepers. Whilst the Australian native flora can produce excellent quality honey during the warmer months very little is available during the colder winter months, making adequate wintering sites difficult to source. In my region of South Australia we have very mild winters which, means the bees are still actively looking for food to maintain the brood nest. Conversely in many other countries the winters are cold and the honeybee goes into a dormient state. During this dormient state the hive will become 'broodless'(no presence of baby bees) for a period and does not require flowering flora to maintain its health.

The aim of my study scholarship is to explore the cold storage of bee hives as a tool for combating pests and diseases within the Australian apiary industry. The 'brood lessbroodless' state that is induced by cold storage is a potential non-chemical tool in controlling Varroa Mite. The Varroa mite requires brood within the hive to reproduce, if you induce an artificial cold winter, far more severe than experienced here in Australia. A prolonged state of

dormancy will result in a brood less hive thus breaking the life cycle of the parasitic Varroa mite.

Objectives

The objectives of my Nuffield scholarship are:

- To explore international apiary industries pest and disease management techniques.
- To examine winter dormancy / induced hibernation and the effects on Varroa control.
- Study the effects on cost of production for Agriculture as well as the apiary industry
- What will work for the Australian Apiary Industry in terms of Varroa control.

The Australian Apiary industry of today

Australia has around 9600 registered apiarists who collectively manage around 600 000 registered hives (More Than Honey, 2008), producing a total of 30 000 tonnes of honey per annum of which nearly 1/3 is exported (Centre of International Economics, 2005). Nearly 65% of the annual honey crop is produced by 250 businesses; highlighting how small the commercial beekeeping industry is (More Than Honey, 2008).

On average a commercial beekeeper will require 16 000 hectares of native and agricultural flora for foraging from both private and public lands (More Honey, 2008). As very minimal amounts of land are owned by apiarists, there is a high reliance on the good will of land holders to grant access to resources to maintain honey production.

Predominantly income is derived from bulk honey sales with an industry production average of 75kg per hive. However much higher yields are commonly experienced by those who are in more fruitful producing areas as well as those who intensively manage their hives. The other common income source is paid pollination services. This is when a colony is supplied specifically to increase the yield of a crop reliant on pollination (fertilisation by transfer of pollen from the anther to the stigma of a plant) or cross pollination (fertilisation by transfer of pollen from the anthers of one flower to the stigma of another).

Beekeeping is an aging art with secrecy surrounding information as to the success of production and ultimately positive economic return. The average age of a beekeeper is close to 60 years and due to the unusual work skills operations almost always remain within the same family. Until recently the industry has failed to attract suitable and in particularly young entrants to the profession.

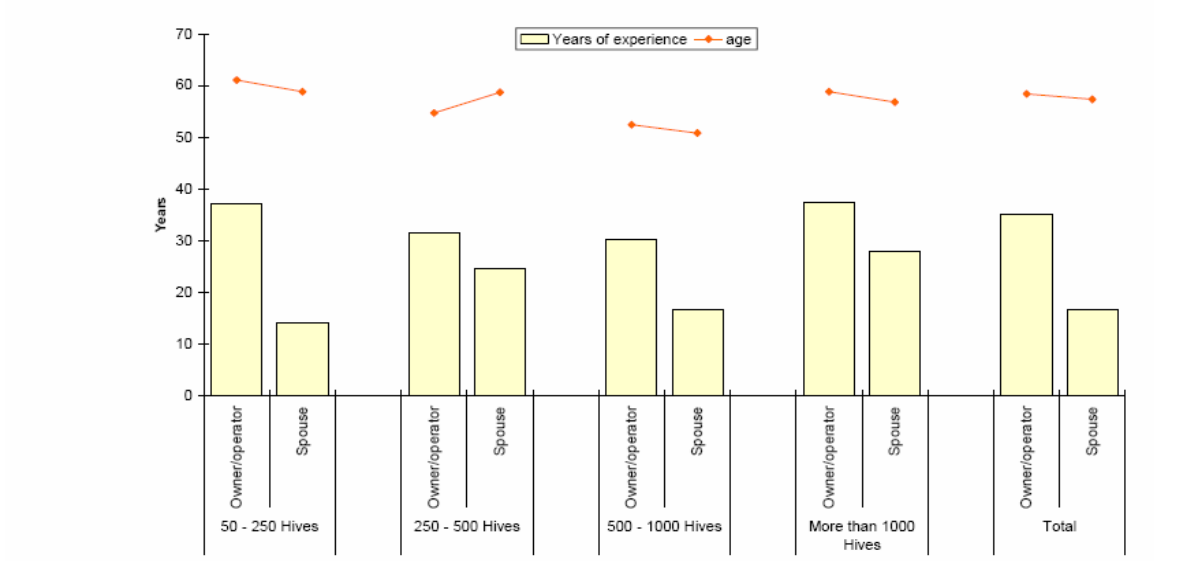

Figure 1: Australian Honeybee Industry Survey 2006-07 Age of beekeeper

Source: RIDIC Publication 2008

"The apiary Industry is one of the most unusual within the Primary industries family, seldom seen, little being known about our activities, our value to the wider community or how or where we operate." (E. Papworth, Australian Bee Journal) This quote from the Victorian Apiarist Association president highlights many of the challenges we face in voicing our plight. It also highlights our failures in self promotion to accurately portray the importance of the industry.

Exotic pests and disease that pose a threat to our industry

There are many pest and diseases present in the international Apiary community, the most significant of which are the *Varroa destructor* and the *Tropilaelaps Clareae.* The mites are prevalent in most of our neighbouring countries and pose a significant risk to our industry. Evidence from the USA is suggesting that Varroa weakens the immune system of bees, with weakened immune systems the honey bees are more susceptible to common diseases and pathogens. Therefore combining Varroa with existing diseases and pathogens already present in Australia will have severe detrimental economic effects on not only beekeepers but Australian Agriculture in general.

Varroa mite (*Varroa Destructor*) the parasite with the most pronounced economic impact on the beekeeping industry.

Figure 2: Varroa mite honey bee larvae and a finger to demonstrate size.

RIRDC publication 2009

The adult mites feed on the bodily fluids (hemolymph) of young larva prior to its emergence in to the colony. This compromises the bees health through the spread of viruses directly upon penetration or by leaving open wounds. The compromised adult bees are more prone to infections. The European honey bees are almost completely defenseless against these parasite and a significant mite infestation will lead to the death of a honey bee colony.

Tropilaelaps mite (*Tropilaelaps Clareae*), "Tropilaelaps mite is now considered to be more dangerous to *A. mellifera* than the parasitic mite *Varroa destructor* as an emerging threat to world apiculture"(Dr Denis Anderson The Asian mite behaves in a similar fashion to that of the Varroa mite sucking the "blood" out of the young bees.) Due to its relatively recent diagnosis by Dr Denis Anderson there is still a great deal to be understood about this particular parasite. It does need mentioning as significant risk to the economics of Australian beekeeping.

Figure 3: Tropilaelaps Mite collected and identified by Dr Denis Anderson

Source: Ken Walker Museum Victoria

Colony Collapse Disorder, this phrase was adopted in 2007 to badge the phenomenon in which worker bees from a beehive abruptly disappear. In recent years this has caught the attention of the media due to the scale of loses experienced, highlighted in the US with the

rate of attrition rising from 30% to 90% of managed European Honey bee colonies. The exact explanation for these loses has yet to be accurately diagnosed. It is commonly believed that a combination of factors such as the well established Varroa mites and diseases combined with the stress of environmental and management techniques.

The current status on exotic pests and diseases

This report is written on the wide consensus that currently Australia is believed to be free of Varroa Mite. I mention this because the unfortunate reality experienced by many international apiary industries is that upon detection the mites have most likely being established for up to two years.

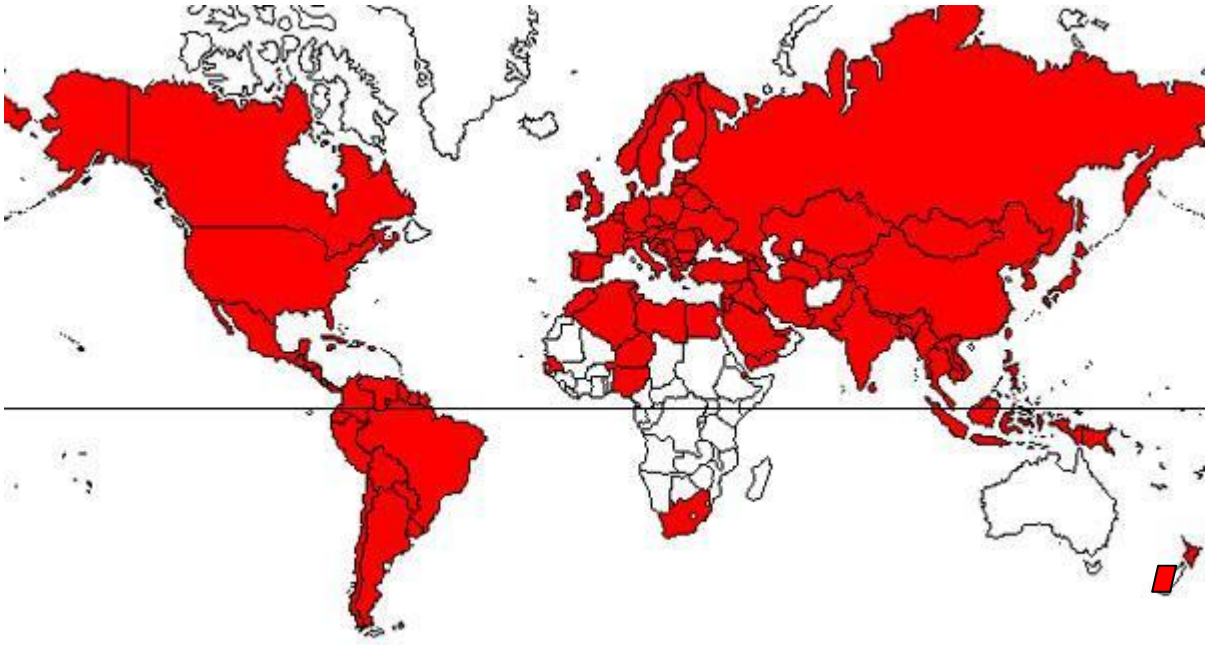

Figure 4: World Distribution of Varroa Mite

Source: Featured Creatures, University of Florida 2010

As an island nation we have fantastic natural boarders which unfortunately will not be enough to protect us. Varroa is currently leaping its way south through Papua New Guinea and the Solomon Islands, if not via land there is also a high risk that this pest could arrive via sea on a swarm of bees externally attached to cargo. While our customs service's do a fantastic job it is impossible to inspect all incoming cargo, as you can see figure 4 the distribution over the world suggests an incursion is imminent.

Lessons can be learnt from the recent incursion of the Asian bee ((AB) exotic pest) in Cairn's which penetrated the boarder by nesting in the mast of an imported yacht. After detection,

governments in conjunction with industry began an eradication programme. Four years on, after extensive efforts and outstanding progress by Queensland department of primary industry, local volunteers and the apiary industry, a decision to cease funding has been made. Instead of trying to eradicate the AB the government has opted for a containment program.

This decision not only has immediate financial impacts on commercial exports of live queens and packaged bees. It will also have long term ramification for public health as well as a public nuisance practically within urbanised areas. The cost of which is estimated to reach over $25 million per annum (Terry Ryan, RIRDC Publication, Estimating the potential public cost of the Asian Honeybee incursion). One of the most significant factors is that the Asian bee is also a host for Varroa mite. As these bees geographically spread, our ability to detect new incursion diminishes.

There is a great deal that can be learnt from this unfortunate incursion, for the first time in many years like a breath of fresh air the industry tried to muscle together. Of particularly success was the beekeepers involvement in the game of politics. Maintaining this intensity as well as successfully demonstrating the support of Agriculture will be paramount in plight against future incursions of exotic pest affecting our industry.

Early detection is key to the success of an eradication attempt of any pest or disease, there is a program called Bee Force which is an initiative of pollination Australia. The program is aiming to utilise volunteer hobbyist beekeepers close to the Port of Melbourne to aid in surveillance and data collection. “Where hoping this pilot program will prove to be an efficient and cost effective early detection system, catching Varroa mites and other pest before they can spread too far and become established.” Gerald Martin, Chairman Pollination Australia.

This is a simplistic program that not only is cost effective but promotes the sharing of information, educating the public as to our plight will be crucial. The message is simple but beneficial for the entire agriculture as it creates awareness as to the importance of production at a grass roots level. Each state association should be pressing to implement similar programs around their reciprocal water ports.

Life with Varro mite

When an incursion of Varroa mite takes place, like the AHB incursion as a category 1 exotic pest an eradication attempt would take place, however the difference is that we will be dealing with destruction of domesticated of managed colonies not feral swarms of zero financial relevance to an individual as was the case with the AHB. This will create operational challenges due to significant emotional and financial effects for those contained in the original restricted area.

Comparison can be drawn to problems experienced by other countries as to how devastating this parasite will be to Australian apiarists. The short term effect (5 to 10 years) after Varroa has been declared endemic is undoubtable going to be the most challenging for the industry. Overseas experience indicates that we will see around 25% reduction of managed hives. Due to the average age of operators in the industry reaching retirement, I believe we will see a larger number of operators leave the industry rather than re training to mange Varroa.

"Hope for the best case scenario but expect and plan for the worst", (Martin, personal communications). The worst case scenario would be an incursion of mites with a high degree of resistance to the only synthetic chemical registered for use as is the situation in the USA.

The USA experience

25 % immediate reduction in managed hives between its arrival in US in 1987 till 1995 coupled with the virtual elimination of feral population. The number of managed hives has since fallen by half in the last 20 years due to a number of reasons like loss of habitat and resources due to monoculture. The decline was hastened by the spread of Varroa; and in the last two years, losses are at unprecedented levels due to the Colony Collapse Disorder (CCD). The largest apiarist in the US, Adee Apiarists lost 40000 of his 70000 hives in 2008 due to CCD (peers comm). That's 2 of every 3 hives in South Australia.

Commercial beekeepers have cornered themselves into a dire position, due to their reliance on synthetic chemical to control Varroa Mite. I observed actions that were completely foreign whilst we are using the same insect their management technique is artificial. Lucrative pollination contracts have made honey merely a bi product of the honey bee in the USA. They are artificially fed protein and sucrose supplement for most of the summer as well as a number of chemical treatments to maintain health just long enough to pollinate select crops. These treatments are administered in many ways as seen in figures 4 and 5.


Figure 5 & 6: Dish washing cloth used to treat hives with Varroa mites

Source: Ben Hooper

This is common practice to see a synthetic chemical administered to such a crude way. This is a house hold dish washing cloth soaked in insecticide and laid over the brood nest of a bee hive. 'Alarm bells ringing', this undoubtable creates residue within the wax and honey. Some of these bee frames used in the USA will only last 4-5 years, due to the fact the queens can no longer function normally on these frames. The large operators do what they need to keep hives alive the honey is not so important as they have access to pollination dependant crops are paying up to $200 US per hive for a 4 week period (Australian Beekeeper 2010).

Australian example of pollination dependant crops

The Australian almond industry is the example used to high light the impact on polloination dependant crops. It has undergone rapid expansion since 2001 and on a percentage basis, is the fastest growing almond industry in the world. Total Australian almond acreage increased six-fold over the past nine years: 4,595 hectares (11,352 acres) in 2000 to more than 27,678 hectares (68,394 acres) in 2009. Of the almond acreage currently planted, approximately one quarter of Australian almond plantings have reached full maturity (eight years and older) and one third of total Australian almond plantings are non-bearing (less than three years).

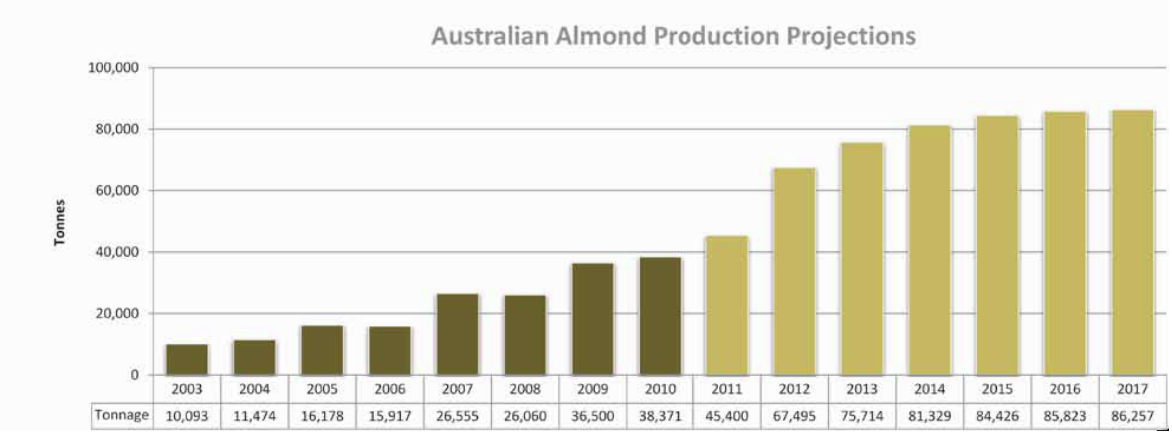

Figure 7: Projection for Almond yield showing its reliance on the honey bee

Source: Australian Almond statics 2010 report

In 2010, Australia produced 38,371 tonnes of kernel: 4% of world almonds, with major world producer being California (85%). It is forecast that Australia will more than double its production in the next 5 years as new planting mature into production as in figure 7. A projected harvest of over 85,000 tonnes will make the Australian Almond industry the second largest in the world.

Given that the Australian almond industry is fully dependent on honey bee pollination services, the current almond acreage is and will continue to place pressure on beehive supplies and pollination services, currently requiring up to 7.5 beehives/ha.

Australia has four main growing regions that spread from Adelaide along the River Murray to the Riverina with some small plantings in Western Australia (WA) as in figure 8.

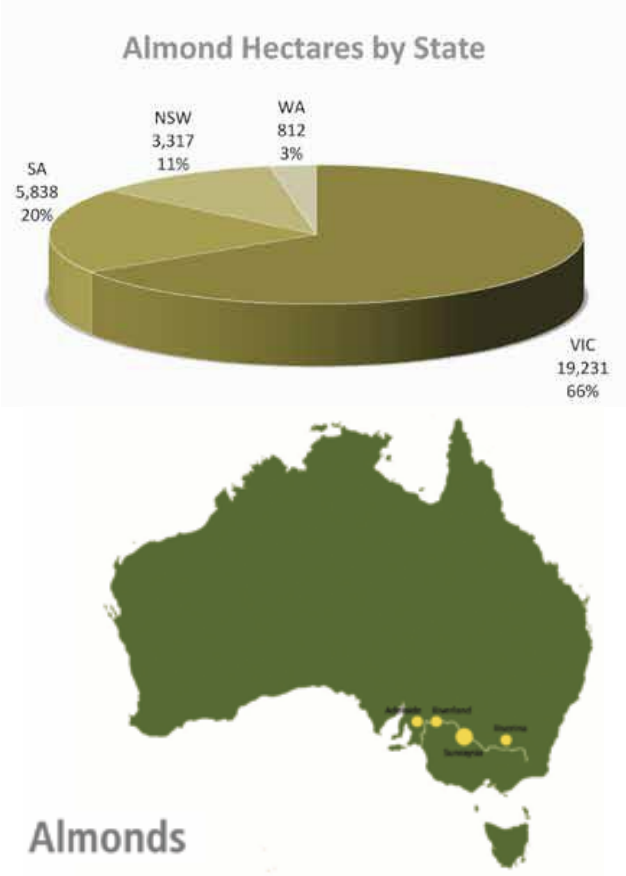

Figure 8: Distribution and demand for bee hives

Source: Australian Almond statics 2010 report

The dilemma

Once in full production (over 8 years) the Australian almond growers will require 220,000 hives during its one month flowering period in August every year. There are currently 600,000 registered hives in Australia, taking into consideration that the WA and TAS boarders are closed to bees and bee related products that leaves 550 000 of which 300 000 are owned by commercial operators. Of these they then need to be of a pollinating standard after a prolonged wintering period. Whilst we have just enough bees to service the industry if we imposed the USA experience of Varroa and CCD which further reduces available hives by 25%, we are left with a server supply and demand issue.

Almond pollination creates a cesspit for disease, as the apiary industry converges all at the same time in the same place from all available corners of our country. This means that if we have Varroa for 2 years before detection, the rapid spread is inevitable and almost impossible to contain without server financial losses incurred.

IPM the only way forward

Integrated pest management (IPM) is the integrated approach of management to solve ecological problems when applied in agriculture. The main goal is to utilize a suite of tools including the strategic use of pesticides to reduce the economical impact of pests. This approach will be paramount to Australian beekeepers if we are going to maintain any sense of normality in the way we operate.

It is apparent to me that we cannot replicate the actions of the US and unfortunately our neighbours in New Zealand. Our current plan of attack is to implement similar strategies to those of NZ. As an observer it seems it took the US around 20 years of synthetic chemical use to create strong resistance, a raw observation would suggest it has only taken NZ 10 years to find themselves in a similar position.

Throughout out my travels the Canadian beekeepers seemingly had the best Varroa management practices. The first was their appreciation that mites were always going to be present in their hives and they needed to manage their population rather than kill them all. This was done by testing mite numbers in the hive to see what action of treatment should be used. This was a different approach to the US, who used systematic treatments of synthetic chemicals of the same mode of action with the aim to inflict a maximum kill. Establishing an economic threshold which is widely considered 3000 mites per colony (Delphane & Hood 1997) will be important for selecting what action should be taken. The figure of 3000 mites per colony is not universal and must be derived regionally due to specific climatic conditions coupled the localised disease pressures.

The test used is referred to as a hand shake alcohol test, it is simple and cost effective and the results whilst not 100% accurate, are a very good indication as to what is going on within the hive. The test samples about 300 adult bees collected in a double jar, which are then covered in pure alcohol. The jar is lightly shaken for 30 seconds, during which time Varroa mites fall from the adult bees into the other side of the double jar for counting. After establishing mite populations a mode of action is then selected, generally one of the treatments from figure 9.

Varro Treatment			
Trade Name	Chemical Name	Effectiveness	Comments
Apistan	Fluvalinate	95% +	185 times stronger than bayvarol / leaves residue in wax / cannot be used on honey flow
Bayvarol	Flumethrin	95% +	Leaves residues (less than Apistan) in wax

Apivar	Amitraz	95% + ?	Limited shelf life / residues in wax and honey
Api-Life-Var	Thymol	40–95%	Leaves residues / taints honey
Apiguard	Thymol	20–95%	Leaves residues / taints honey
Thymol	Thymol	40–95%	Crystal form / taints honey
Formic acid	Formic acid	25–95%	Residues / Personal safety gear a must / taints honey
Oxalic acid	Oxalic acid	40–60%	Will kill brood / PPE is a must
Food grade mineral oil	Mineral oil	0 ? %	Possible to blow your hive to bits / PPE is a must
Screen bottom boards	Non-chemical	5–30%	Work best in combination with other chemical treatments. Cannot control Varroa numbers sufficiently to reduce the number of chemical treatments
Cull drone comb	Non-chemical	0–90%	Dependent on system to remove and destroy all drone brood on a regular basis. Time consuming

Figure 9: Available actions against Varroa Mite

Source: Doug Sommerville (2007)

Breeding is one key to the future success of our industry, trials are currently underway to test our genetic stock overseas. I hope that the industry will stick with its current consensus that breeding for hygienic behaviour from our own stock that flourishes in our environment is the way to go. The alternative is importing genetics with the possibility of bringing new pathogens with a bee that may not handle our environmental conditions.

There is no one solution fits all answer, however we will all need to be on the same page. As bulk honey producers Australian beekeepers need to adopt a minimal chemical use approach to managing Varroa. This is because we don't have alternative sources of income like the USA producers and their almond pollination or the Canadians and their Hybrid canola seed production or the New Zealanders and their Kiwi Fruit pollination. Aussie producers will still have to rely on bulk honey as the main source of income which means less time in summer to use chemicals to treat Varroa Mites, as they need to be applied off of a honey flow.

Strategic, time sensitive treatments off of honey flows would avoid any residue issues. This increases cost of production first through loss of income from not working a honey flow and secondly treating the hives. The common strips used inside a beehive cost $2, multiple strips are used each treatment and usually treatments are conducted 2-3 times a year. Consistent testing with the hand shake alcohol method and the repetitive practice of drone harvesting during spring and summer will minimise our reliance on these synthetic chemical strip treatments, whilst also being a cheaper option.

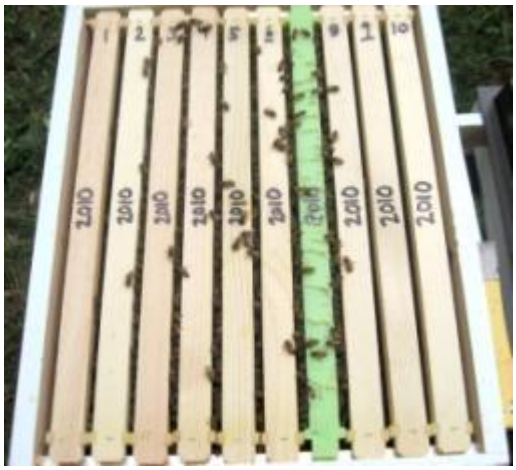


Figure 10 & 11: Specific drone breeding comb

Source: Beemaster.com

Inserting a specific comb for harvesting as above and then freezing the comb to kill the parasites allows the comb to be reused. Accurate timing of the harvest is paramount, 70 hours after the capping of the cell by the bees the Varroa mite will lay its first egg and then every 25 -30 hours after that, normally around 6 in total for a drone cell (Anderson & Trueman 2000). Optimum time to harvest is after the majority of cells are caped but before the drones emerge. Depending on the type of comb selected (new/old) for preparation time and then adequate laying time followed by natural growth until capping somewhere between 15 – 23 days would be a suitable time period as can be seen in figure 12 with hatching of a drone after 24 days from an egg.

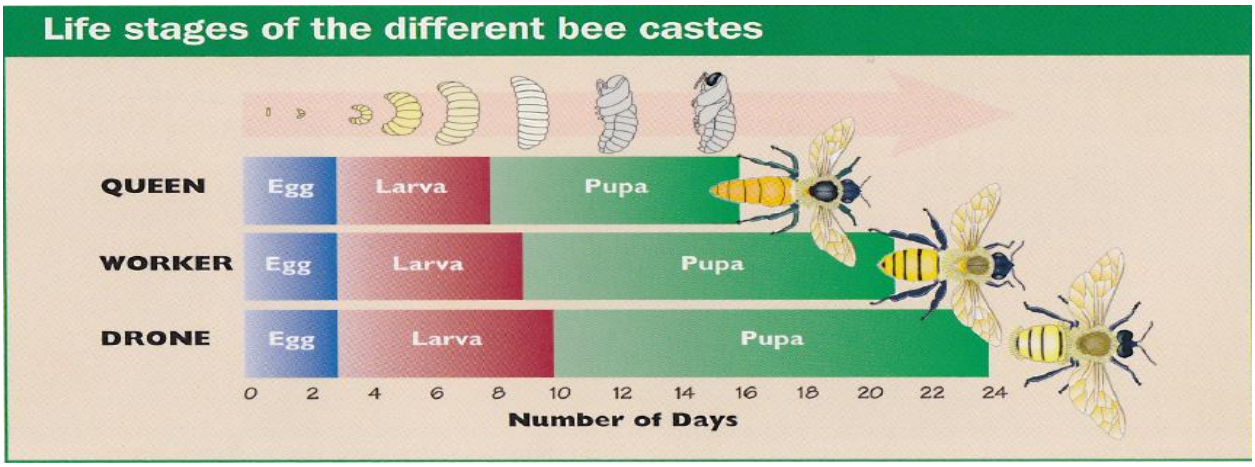

Figure 12: Growth stages of the 3 bee castes

Source: The Story of Honey 2006

Cold Storage

Cold storage is a technique used in the northern hemisphere to house bee hives in a climatically controlled environment. The northern hemisphere naturally experiences colder winters than most areas of Australia and in particularly my state, South Australia. The European Honey bee that we use, as the name suggests originates in Europe, has the ability to withstand extremely cold periods of weather.

I observed beekeepers in North America housing up to 5000 hives in a single shed as in figures 11 and 12. They were doing this for two reasons the first of which was to have all their hives centrally located for logistical purposes and secondly to optimise the life of the bees. In

a normal situation in the outside environment the hives would be exposed to heavy wind, rain and snow all of which a healthy beehive can withstand to some extent. However consistent changes in temperature and weather events have effects on the bees behaviour and activities within the hive.

Figure 13 & 14: large cold storage facility shed with inside view

Source : Ben Hooper

Housing colonies at a consistent temperature of 4 degrees centigrade controlled the bees at a dormant state. This precise temperature allows the bees to cluster together to share their warmth and feed on stored food within the hive. That is all this temperature will promote it stops the bees breeding which would consume stored resources of pollen and honey along with shortening the life expectancy of the adult bees.

The American beekeepers used cold storage for consistency, a tool they could rely on to maximise the number of hives they would have for pollination after their winter. They are able to house these hives for a period of 4-5 months without touching them with 5-8% mortality rate.

Adapting this Technique for Australian use

There are three main reasons for considering cold storage as a tool for the Australian beekeeping industry. The first of which is to reduce the industry's reliance on natural resources. Due to winters being milder than those in the northern hemisphere our bees remain far more active. They continue to fly for flora resources in temperatures warmer than 13-14 degrees. This is fine if Mother Nature has been kind enough to promote plants to flower and the beekeeper is able to access the few select areas and plants that flower and provide adequate nutrition during our wintering period.

Many of these areas are within national parks and have very restricted access by paid permit only. These sites often stay with a beekeeper for a life time, this coupled with natural and prescribed fires means that sufficient sites are a finite resource. A recent decision by the Queensland government to deny access for beekeeper to national parks by the year 2024 means that they are going to have to explore non traditional methods of wintering bee hives. If this policy is steadfast using an induced state of dormancy via climate control is one way around this.

Most significantly the use of cold storage to induce hibernation has potential to aid in the fight against Varroa mite. The concept behind it is to break the bee's brood (baby bees) cycle, with the absence of brood the mites have no ability to reproduce. In an IPM program this is an important process for reducing the use of synthetic treatment to eliminate the parasites. The American experience doesn't note this as a key contribution in their fight against Varroa. However the science is clear that in an average temperate climate, mite populations can increase 12 fold in colonies having brood half of the year and 800 fold in colonies with brood year round (James D. Ellis University Florida). It seems logical to me that we need a brood break when we are not naturally producing honey during winter.

Finally it creates a climate controlled environment for temperature sensitive treatments. There are two commonly used acids for extermination of Varroa mites Formic and Oxalic acid, both of which become lethal to bees at certain temperatures. For most of our Australian summer these would not be applicable because our climate is too warm. The device shown in figure 13 controls four hand treatment tools as shown in figure 14 which mean a great deal of hives can be treated quickly however Kevin Nixon apiarist and designer of this device stated clearly that the organic treatments should not be used in temperatures more than 15^{o}C.


Figure 15 &16: Fumigation device designed by Kevin Nixon beekeeper (previous president of Alberta Beekeeping Association, Canada) that I visited

Source: Ben Hooper

The concept of cold storage is simple and while some of the structures that were used were elaborate some operators were utilising second hand potato stores which made the process far more cost effective. The most significant difference in replicating this process in Australia is that we would have to use cooling systems to achieve the constant temperature of 4^{o}c. In the US and Canada beekeepers were forcing the outside ambient air through the sheds with water sprinkler systems much like an evaporative cooling system. This would work for certain periods of our winter but would almost certainly need refrigeration boost as a backup.

A cold store with refrigeration that would house 1000 hives could be established for Australian $70,000 - $80,000. This value is derived by establishing a Bondor^{TM} insulated panel cool room inside an existing shed and a refrigerated system to cool to 4^{o}C, based on weather conditions at Tintinara South Australia, as in Figure 15.

Based on 40 year average temperate upper south east	
April	**21.7^{o}C**
May	**18.3^{o}C**
June	**15.6^{o}C**
July	**14.9^{o}C**
August	**16.0^{o}C**

Figure 17: 40 year average temperature for the reciprocating months

Source: Bureau of Meteorology

There are also existing structures that could be utilised here in Australia most significantly are some of the large storage units situated along the River Murray in the Riverland region which are perfectly positioned to coincide with almond pollination. Due to recent pressures on this area many of these facilities are out of action or seldom used.

Recommendations

IPM is the only long term strategy that will work for the Australia apiary industry. It is clear to me, as bulk honey producers; we cannot repetitively use synthetic chemicals. While I appreciate the effects of the chemicals in managing parasite levels and note that we will have to use them in the short term. This however must be limited with controlled rotation of active ingredients to minimise resistance.

At the moment we have time on our side; the organic treatments are tools that need to be explored in our environment. Trials can be undertaken without the presence of Varroa mite to formulate a best practice manual for apiarists. It is essential we have a diverse range of weapons against this parasite rather than relying on synthetic chemical like most other countries have.

A prolonged brood break will be essential in naturally suppressing mite populations. This is due to the fact that in an average temperate climate, mite populations can increase 12 fold in colonies having brood half of the year and 800 fold in colonies with brood year round (James D. Ellis University Florida). The areas in Australia that promote bees to breed the year around will have to find a way to stop this. Cold storage is certainly a way to induce a state of dormancy while reducing our reliance on Natural resources and providing a climate controlled environment for temperature sensitive treatment of Varroa Mites.

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Plain English Compendium Summary

Project Title:	
Nuffield Australia Project No.:	1011
Scholar:	Ben Hooper
Organisation:	B A Hooper
Phone:	0407820474
Fax:	0887 572392
Email:	hoopsbee@hotmial.com
Objectives	To investigate pest and disease management in the apiary industry with a focus on cold storage.
Background	The rapid global decline in European honey bee populations is having a dramatic effect on cost of production to the apiarists. The knock on effect is being felt by the wider agricultural and horticultural sector, which are reliant on honey bees for their pollinating abilities. Internationally there are many pest and diseases that can have a serious impact on the productivity of the honeybee in Australia. Currently and uniquely Australia remains free from some of the most serious and debilitating pests and diseases. Across the world *Varroa* mite remains the most debilitating pest to commercial beekeepers. This blood sucking parasitic mite can be a vector for an array of other diseases and has decimated managed colonies and wiped out wild populations the world over. Anderson whom a expert in this field, claims it is simply a matter of time before the mite will make it to our shores.
Research	Several Apiary industries were visited to see how they were dealing with Varroa mites in general including China and the UK, with the concentration of my studies conducted in USA and Canada where bee hive were intensively housed in storage for periods 4-5 months.
Outcomes	IPM is the only long term strategy that will work for the Australia apiary industry. It is clear to me, as bulk honey producers; we cannot repetitively use synthetic chemicals. While I appreciate the effects of the chemicals in managing parasite levels and note that we will have to use them in the short term. This however must be limited with controlled rotation of active ingredients to minimise resistance. At the moment we have time on our side; the organic treatments are tools that need to be explored in our environment. Trials can be undertaken without the presence of Varroa mite to formulate a best practice manual for apiarists. It is essential we have a diverse range of weapons against this parasite rather than relying on synthetic chemical like most other countries have. A prolonged brood break will be essential in naturally suppressing mite populations. This is due to the fact that in an average temperate climate, mite populations can increase 12 fold in colonies having brood half of the year and 800 fold in colonies with brood year round (James D. Ellis University Florida). The areas in Australia that promote bees to breed the year around will have to find a way to stop this. Cold storage is certainly a way to induce a state of dormancy while reducing our reliance on Natural resources and providing a climate controlled environment for temperature sensitive treatment of Varroa Mites.
Implications	The Australian Apiary industry is currently the only commercial beekeeping country left in the world without Varroa mites. Currently the industry has not taken full advantage of the time we have had as a great deal needs to be done before we are hampered with this debilitating parasite.