Australian Government

Rural Industries Research and Development Corporation

RIRDC Completed Projects in 2008 - 2009 and Research in Progress as at June 2009

RIRDC Publication No. 09/103

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HONEYBEE

September 2009
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Foreword

RIRDC produces Research in Progress summaries of continuing projects and those completed during 2008-2009. Our intention is to:

- give stakeholders early access to the results of ongoing and completed work to inform their decisions, and
- inform researchers of results to shape research directions.

The complete report on all Programs is on our website at http://www.rirdc.gov.au

The goal of the Honeybee Program is to improve the productivity, sustainability and profitability of the Australian beekeeping industry through the organisation, funding and management of a research, development and extension program that is both stakeholder- and market-focussed.

Five Year Plan objectives that drive the 2007-2012 R&D Program, together with expected shares of the Program budget are:

1. *Pest and disease protection* – to be prepared for exotic pest and disease incursion before it occurs, to prevent the establishment of exotic pests and diseases of economic significance, and to control endemic pests and diseases that impact on beekeeper profitability. (45%)

2. *Productivity and profitability enhancement to lift beekeeper income* – to encourage a culture of constant improvement in bee husbandry and management, to provide an across-the-board lift to industry productivity and profitability, and to focus productivity improvement on bee genetics, best management practices, beekeeper efficiencies and industry benchmarking. (15%)

3. *Resource access security and knowledge* – to ensure ongoing access to native forests on public lands, to win back a share of native forest access lost in previous resource allocation decisions; to better understand the native floral resource on which the industry depends, and to address the implications of climate change on the Australian apiary industry. (10%)

4. *Pollination research* – to better understand the cost and value of pollination services provided by beekeepers, and to generate industry value through shared learning with crop producers, especially the Australian almond industry. (10%)

5. *Income diversification including new product development* – to provide a major boost to packaged bee sales, and to develop new Australian apiary products which represent secondary niche opportunities. (10%)

6. *Extension, communication and capacity building* – to improve industry performance through the adoption of relevant R&D project outcomes and beekeeper participation in vocational training to educate the public and policy makers on the economic contribution made by the honeybee industry and to build capacity in the Australian honeybee industry by encouraging the next generation of industry leaders and researchers. (10%)

Program budget allocations are flexible and are guided by the Honeybee R&D Advisory Committee.

The Five Year Plan is consistent with RIRDC's aim of maximising the contribution its investments make to the profitability, sustainability and resilience of rural industries and communities.

This report is an addition to RIRDC's diverse range of over 1900 research publications, which are available for viewing, downloading or purchasing online through our website: www.rirdc.gov.au. Purchases can also be made by phoning 1300 634 313.

Peter O'Brien
Managing Director
Rural Industries Research and Development Corporation

Contents

1.1 HONEYBEE PROGRAM – COMPLETED PROJECTS

1.2 HONEYBEE PROGRAM – RESEARCH IN PROGRESS

1.2 HONEYBEE PROGRAM – RESEARCH IN PROGRESS

PROJECT No	PROJECT TITLE	RESEARCHER	PHONE	ORGANISATION	PAGE No
				Agriculture	
PRJ-000643	Development of a pollen substitute meeting the nutritional needs of honeybees	John Black	02 4753 6231	John L Black Consulting	19
PRJ-002916	Hygienic behaviour of the Western Australian bee breeding program	Robert Manning	08 9368 3567	The State of Western Australia represented by the Director General of Agriculture	20
PRJ-002862	A study of *Nosema ceranae* in Australia	Michael Hornitzky	02 4640 6311	New South Wales Department of Industry and Investment for and on behalf of the State of NSW	21
PRJ-000510	Small hive beetle biology providing control options	Nicholas Annand	02 6330 1210	New South Wales Department of Industry and Investment for and on behalf of the State of NSW	22

Completed Projects - Extension, communication and capacity building

Project Title	Honey Industry Survey 2006/07
RIRDC Project No.:	PRJ-000968
Start Date:	1/10/2007
Finish Date:	1/8/2008
Researcher:	Milly Lubulwa
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Objectives	The objective of this project is to generate a consistent set of estimates for the production and financial characteristics of honeybee producers in Australia, in line with the survey done by ABARE in 2001-02.
Background	In March 2008 RIRDC approached ABARE to update the information on the honeybee industry and produce industry benchmarks. It has been five years since the last honeybee industry survey and the information needs to be updated. Also industry benchmarks are needed as guidelines for producers. RIRDC would also like ABARE to improve the estimation of the honeybee industry Gross Value of Production (GVP).
Research	The 2008 Australian honeybee industry survey was designed and the sample selected from a list of apiarists obtained from each state's regulatory body. To be eligible for sample selection, the apiarist must have operated at least 50 hives during the previous year. A sample of around 150 apiarists was selected from a population of 1 702 from around Australia. To select the sample, the population was stratified based on state and the number of hives operated and the sample selected randomly within it. The only exception to this is New South Wales where the state was broken into two regions, north and south. Since the survey was voluntary, additional selections were made in addition to the primary selection to ensure that as close to the sample goal of 150 was realised. Once the sample was selected, information was collected by telephone interviews with supporting financial data being submitted by mail or fax. The Australian Bureau of Statistics (ABS) Business register was also considered as a source of the sample list for the survey. This list uses estimated value of agricultural operations (EVAO), an ABS derived measure of size reflecting all agricultural activity. This list, however, appeared to have an under-coverage of smaller units and a disproportionate number of the beekeepers on the list were classified into the horticultural industry. Therefore, the state registration lists were used in order to derive a sample. The sampling methodology and questionnaire were cleared by the Commonwealth Statistical Clearing House (SCH). This ensured that the survey met the rigorous requirements of the SCH for surveys conducted by the Commonwealth. The data were weighted to produce estimates for the whole industry. Results are presented in a report "Australian Honeybee Industry Survey 2006-07".

Outcomes	A current overview and analysis of the Australian Honeybee industry derived from the 2008 honeybee survey conducted by ABARE.
Implications	In addition to providing the industry, policy makers and researchers valuable information on honeybee businesses, survey results will be used in the calculation of the economic value of the industry. The report will assist the development of industry policy and planning, providing a factual basis for further development of the honeybee industry.
Publications	Australian Honeybee Industry Survey 2006-07 RIRDC Publication No. 08/170.

Completed Projects - Income diversification, new product development

Project Title	An investigation into the therapeutic properties of honey
RIRDC Project No.:	PRJ-000544
Start Date:	31/7/2004
Finish Date:	30/6/2009
Researcher:	Dee Carter
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Objectives	To conduct an ongoing screen of Australian honeys for therapeutic properties and to build on previous work on the antimicrobial and wound healing properties of honey. To increase the use and acceptance of honey as a therapeutic agent in conventional medicine.
Background	Honey has been used as a medicine throughout history, and it is still used in this way in a number of countries, but it has largely been ignored in Western medicine and is usually dismissed as "alternative" therapy. Underlying this scepticism is the current lack of knowledge of how honey works and what organisms it can effectively kill. Honey is likely to be most useful as a dressing for wounds and skin infections, which are responsible for significant death and disease and cost billions of dollars in treatment every year. The problems caused by these infections are compounded by drug-resistance, which is linked with our excessive use of conventional antibiotics, and this also places a heavy burden on the health care budget. Although honey appears to effectively kill bacteria in wounds, its application in modern medicine has been very restricted as there are limited good scientific studies undertaken in well-recognised institutions. To gain use in Western medicine, more clinical and scientific data from internationally respected institutions are needed. New data will increase demand and sales of Australian honey. It will also boost the image of our honey in the medical and wider community.
Research	The following four lines of investigation were pursued throughout this project 1. Surveying Australian honey produced from a range of nectar sources for antibacterial activity; 2. Determining whether fungi that cause skin and wound diseases are killed by honey; 3. Determining whether bacteria that can live without oxygen and cause deep wound infections are killed by honey, and 4. Investigating whether honey affects microorganisms that live in communities known as biofilms (which are generally highly resistant to antibiotics).
Outcomes	Key findings: 1. Surveying Australian honey for antibacterial activity. Numerous Australian honeys have levels of antibacterial activity that would be useful in treating skin and wound infections. Some plant sources reliably produce medically-active honeys, however they do not always do so, and medical grade honey needs to be tested batch by batch. Certain honeys made from Australian plants of the *Leptospermum* genus

consistently produce antibacterial activity that is not due to the production of hydrogen peroxide (which is the type of activity produced by most other honeys).

The current most widely accepted method for testing the levels of antibacterial activity of honey is reliable, but very sensitive to even minor variations in execution.

2. Determining whether fungi that cause diseases are killed by honey.
Honey prevented growth of the fungus *Candida*, and this effect was due to more than the presence of high sugar.

Honeys with high levels of hydrogen peroxide-type activity were more effective against fungal pathogens than non-peroxide type honeys. There was no relationship between susceptibility to known antifungals and sensitivity to honey.

3. Determining whether bacteria that can live without oxygen and cause deep wound infections are killed by honey.
Honey killed a wide range of bacteria obtained from wounds that could live without oxygen (anaerobes).

This activity was due to more than the high sugar content of honey. There was no relationship between antibiotic susceptibility of these bacteria and their sensitivity to honey.

4. Investigating of the effects of honey on biofilms.
Honey prevented the wound bacteria *P. aeruginosa* and *Staphylococcus* spp. from forming biofilms.

This inhibition occurred at levels well below the amount of honey required to kill the bacterial cells under free-living conditions, indicating it was affecting the biofilm and not simply killing the bacteria.

Implications

This project has shown that there are many Australian honeys with therapeutically beneficial levels of antibacterial activity. We have shown that honey has potent activity against numerous problematic microorganisms, including bacteria and fungi that can resist other drugs, and bacteria growing in biofilms. Further investigations are needed to fully determine how honey works and the full spectrum or microbes that it can inhibit. It is clear that honey is currently under-used as a modern infection control agent, and the honey industry should work to ensure healthcare workers and the general public are aware of its potential as a safe, effective wound-care treatment.

Publications

Publications in peer reviewed journals

Blair, S.E., Cokcetin, N.C., Harry, E.J. and Carter, D.A. (2009). The unusual antibacterial activity of medical-grade *Leptospermum* honey: antibacterial spectrum, resistance and transcriptome analysis. *European Journal of Clinical Microbiology & Infectious Diseases* (in press).

Irish, J., Heard, T.A., Carter, D.A. and Blair, S.E. (2008). Antibacterial activity of honey from the Australian stingless bee *Trigona carbonaria*. *International Journal of Antimicrobial Agents* 32:89-98

Irish, J., Carter, D.A., Shokohi, F. and Blair S.E. (2006). Honey has an antifungal effect against *Candida* species. *Medical Mycology* 44: 289-291

Book chapters

In ‘Honey: A modern wound management product’, volume II. (in press).
Blair, S.E. An historical introduction to the medicinal use of honey
Blair, S.E. The antibacterial activity of honey.
Cooper, R. A. and Blair S.E. Challenges in modern wound microbiology and the role for honey.

Reviews

Blair, S. E. and Carter, D.A. (2005). The potential for honey in the management of wound and infection. *Journal of Australian Infection Control* 10(1):24-31

Other publications

Blair, S.E., Irish, J., Carter, D.A. (2006) Honey: the sweet solution to a global emergency? *Syntrophy* 7(9):1, 11-13

Irish, J. and Blair, S.E. (2006). The use of honey in veterinary wound management. Control and Therapy Series, Postgraduate Foundation in Veterinary Science of the University of Sydney

Blair, S.E. (2005). Therapeutic honey. *National Healthcare Journal* Aug:54-58

Blair, S.E. and Irish, J. (2005). Honey vs Superbugs. *Australasian Beekeeper* 107(2):79-83

Completed Projects - Pest and Disease Protection

Project Title	Feasibility study into in-hive fungal bio-control of small hive beetle
RIRDC Project No.:	PRJ-000037
Start Date:	1/7/2007
Finish Date:	24/9/2008
Researcher:	Diana Leemon
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Objectives	To carry out a feasibility study into the fungal bio-control of Small Hive Beetle (SHB) using endemic isolates of the fungi *Metarhizium anisopliae* and *Beauveria bassiana*
Background	The Small Hive Beetle *(Aethina tumida)* is a foreign pest of bee hives that was first reported in Australia in 2002. Larvae of these beetles cause extensive damage to honey frames and combs, stored honey and pollen when they feed, and leave wastes behind. The resulting fermented honey is rejected by honeybees and cannot be marketed by the beekeeper. Heavy infestations may also result in queens ceasing to lay eggs or bees abandoning their hives. Since *A. tumida* was first reported it has spread at a rapid rate and is now regarded as a serious pest of hives in the eastern states of Australia. Chemical control of these pests in hives is limited by the toxicity of chemicals to the bees, unacceptable chemical residues in honey and the possible development of resistance to active ingredients. Therefore it is necessary to look for alternate and novel control strategies. One strategy is to consider fungal biopesticides for the control of *A. tumida.*
Research	Assay systems were developed in laboratory investigations to screen local isolates of *M. anisopliae* and *B. bassiana* against both adult and larval small hive beetles. Some of the *M. anisopliae* originated as infections in dead *A. tumida* adults collected from bee hives. The toxicity of fungal spores to bees when applied as a dry powder was also assessed as was the viability of fungal spores contaminating honey
Outcomes	A number of local isolates of *M. anisopliae* and *B.bassiana* that show good efficacy against adult and larval small hive beetles were identified. The *B. bassiana* isolates were more effective against the adult beetles, while the *M. anisopliae* isolates were more effective against the larval beetles. The susceptibility of beetles to fungal infection did not appear to increase with age. Although isolates of *M. anisopliae* did not kill high numbers of adult beetles there was a trend of lowered production of offspring by surviving beetles that is worthy of further investigation. Spores applied as a dry loose powder to hives were rapidly cleaned up by bees in strong hives. The spores appeared to have a negative effect on the bees in the treated hives, although it was short term. It was also noted that fungal spores contaminating honey lose their viability rapidly.
Implications	A fungal biopesticide for the in hive control of small hive beetles may be feasible. However, further research needs to be conducted with isolates of *B. bassiana* to first develop a formulation and application strategy for adult small hive beetle control, then to test this in hives.

Completed Projects - Pest and Disease Protection

Project Title	Development of treatment options for European foulbrood
RIRDC Project No.:	PRJ-000492
Start Date:	1/1/2006
Finish Date:	23/11/2008
Researcher:	Michael Hornitzky
Organisation:	New South Wales Department of Industry and Investment for and on behalf of the State of NSW
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Objectives	1. To determine the minimum infectious dose of *Melissococcus plutonius* required to initiate European foulbrood (EFB) in artifically-raised honeybee larvae. 2. To determine whether 8 fatty acids (previously demonstrated to inhibit the growth of *M. plutonius*) can protect honey bee larvae from infection with *M. plutonius.* 3. To determine the minimum inhibitory concentration of oxytetracycline to M. plutonius in artifically raised honey bee larvae.
Background	European foulbrood (EFB) was first discovered in Australia in 1977 and since that time has spread to every state except Western Australia. EFB is a major bacterial honeybee disease which causes significant economic losses to the beekeeping industry in Australia and around the world. There are still unanswered questions about EFB and its treatment that need further study. Although OTC has been used to treat EFB for decades, the concentration of OTC in honeybee larvae required to protect them from developing EFB is still unknown. As OTC is the only registered product for the control of EFB, alternative EFB treatments would be useful to develop. Alternative methods for the control of EFB are needed if problems with residues are to be eliminated. In a recent RIRDC funded project DAN 193A: “Fatty acids – an alternative control strategy for honey bee diseases” eight fatty acids were identified as having the potential for use in the treatment of EFB. Testing alternative treatments on honeybee colonies is problematic. Transmitting EFB to colonies is unreliable and is further complicated by the natural hygienic behaviour of bees which eject diseased larvae. A reliable alternative method of producing EFB in larvae raised artificially is required. The development of such an assay would provide the means to test fatty acids, OTC and other yet to be identified candidates for the treatment of EFB.
Research	The key methodology in this study was the development of an assay for the transmission of EFB in honeybee larvae raised in the laboratory. Other methodologies involved the culture and harvesting of *M. plutonius* and *P. alvei* for feeding honeybee larvae, and the determination of the appropriate dose of these organisms to reliably produce EFB, and feeding fatty acids or OTC to young honey bee larvae infected with *M. plutonius* or *M. plutonius* and *P. alvei.*
Outcomes	A robust assay was developd to produce EFB in artificially raised honeybee larvae. The assay involved feeding young larvae with 500,000 *M. plutonius* and 60,000 *P. alvei* organisms.

	2. None of the eight fatty acids prevented larvae fed with *M. plutonius* and *P. alvei* from developing EFB. 3. Low concentrations of OTC protected larvae infected with *M. plutonius* and *P. alvei* from developing EFB, confirming its efficacy as a treatment for EFB.
Implications	1. Fatty acids are not an alternative treatment option for EFB. 2. Even when fed at low concentrations OTC is an effective means of treating EFB. 3. The EFB larval assay developed in this study provides a robust methodology for testing potential anti-*M. plutonius* agents.
Publications	Hornitzky, M. & Giersch, T. (2008). Fatty acids do not protect larvae from developing European foulbrood. Proceedings OIE Symposium - Diagnosis and Control of Bee Diseases, Freiburg, Germany 26-28 August.

Completed Projects - Pest and Disease Protection

Project Title	Biological control of chalkbrood by anti-fungal bacterial symbionts of bees
RIRDC Project No.:	PRJ-000571
Start Date:	1/1/2002
Finish Date:	30/11/2008
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Objectives	The nature of the Australian honey bee-bacterial interaction was started through an Honours project done by Margaret Hilton (current project ANU-58A). The aim of this new project is to make a detailed study of the fundamental nature of the important bee-bacterial association in the gut of the honeybee in Australia, and its role in factors such as hive health. The results of this strategic basic research, in studying the nature of honeybee bacteria, will allow us to carry out applied research to determine the feasibility of developing biological control strategies against the important chalkbrood disease.
Background	The Australian apicultural industry is under significant threat from several pests and diseases such as chalkbrood. This report outlines the nature of the bee-bacterial association in the gut of the Australian honeybee, and its role in factors such as hive health, as a first approach to developing a biocontrol method for chalkbrood.
Research	Healthy honeybee colonies from all around Australia had high number of gut bacteria. Honeybee colonies infected with chalkbrood consistently had a significantly lower level of bee gut bacteria. Colonies recovered from chalkbrood had increased gut bacteria, close to normal levels. The screening of colonies from Western Australia that were bred for the "Better Bees Program" to promote hygienic behaviour showed these bees consistently contained significantly higher numbers of gut bacteria compared to bees from normal healthy colonies in WA. This showed that bee gut bacteria are a strong indicator of bee hive health. An ultrastructure study of the bee gut was carried out and the mechanisms involved in suppression of chalkbrood by bee gut bacteria were elucidated. For the first time ever, probiotic feeding experiments showed high numbers of bee gut bacteria could be maintained as long as regular feeding occurred with two very different species of chalkbrood-inhibiting bacteria (*Bacillus* and *Pseudomonas*). This opens the way for probiotic feeding of bacteria to be developed in the future to maintain hive health and in biocontrol of diseases such as chalkbrood.
Outcomes	This study shows the current practise by apiarists of using bees bred to promote hygienic behaviour ("Better Bees Program"), and the use of sugar feeding to enhance recovery of hives from disease, can also be recommended in relation to gut microflora. In both cases this study showed these treatments maximise numbers of bacteria in the bee gut which correlates with healthy hives.
Implications	Industry and policy makers need to aware that ongoing research into the gut bacteria of honeybees is essential if honey production is to be maintained, especially with the significant change in climate predicted. Bee gut bacteria are an essential part of a healthy colony and the

	potential exists to develop new technologies such as probiotics in the future.
Publications	Honours thesis published. PhD thesis being assessed. Five publications in preparation to be submitted to scientific journals.

Completed Projects - Pest and Disease Protection

Project Title	**Evaluation of anti-Varroa boards for increase in honey production**
RIRDC Project No.:	PRJ-003551
Start Date:	20/10/2008
Finish Date:	26/8/2009
Researcher:	Robert Spooner-Hart
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Objectives	To assess whether bottom boards primarily designed to control varroa mite could lead to an increase in honey production and facilitate the production of pollen. To assess whether bottom boards primarily designed to control varroa mite could lead to improved management of small hive beetle. To compare mesh bottom boards and tube bottom boards for their ability to achieve the above desired outcomes. To familiarise Australian beekeepers with use of modified bottom boards. This is important prior to any establishment of varroa mite in Australia, where they are likely to be used for both reduction of mites in-hive, and for monitoring presence of mites, especially in winter.
Background	Modified hive bottom boards have been used for management of the most serious parasite of honeybees, varroa mite. The most common of these have metal mesh bottoms, although a plastic tube design was developed in France in the 1990s. Australia currently does not have varroa mite. However, there is some overseas evidence to suggest that there may be benefits in using the modified bottom boards, even in the absence of varroa mite. Potential suggested benefits may include increased colony honey production and increase in brood production. There has only been limited testing against another bee parasite which does occur in Australia, small hive beetle, and the results are inconclusive.
Research	We compared mesh hive bottom boards and a French-designed tube bottom board with conventional Australian solid bottom boards, for ability to stimulate hive strength and increase honey production early in the season. We also assessed whether modified bottom boards provided any benefits for reducing small hive beetle infestations in hives. This work was targeted at providing useful advice for both commercial and hobby beekeepers in Australia. The investigations were conducted in apiaries in NSW and Victoria during spring and summer, 2008-09. The parameters measured in the different treatments were: • Honeybee flight activity • The area of sealed brood in hives • The area of stored pollen in hives • Honey production by colonies (based on hive weight), and • Incidence of small hive beetle in hives in the NSW site.

Outcomes	There was no significant difference between most of the parameters measured at either site. The exception was numbers of small hive beetle, which were in significantly lower numbers in hives fitted with tube bottom boards. However, at this time of the year, the numbers of beetles were generally low, and not at levels for concern in any of the hives in any treatment. These results suggest that, under the Australian conditions tested, there appears to be no advantage in utilising either mesh or tube bottom boards, in the absence of varroa mite and/or small hive beetle. There may be some benefit in using tube bottom boards as part of an integrated management program for small hive beetle.
Implications	Given that there were no conclusive benefits from using either mesh or tube bottom boards (except, possibly, for SHB in the case of tubes) there appears to be no reason for Australian beekeepers to commit to the expense of changing from their current use of solid bottom boards, in the absence of varroa mite. However, in the event that varroa mite does establish in Australia, mesh and/or tube bottom boards may play a useful role in its integrated management. In such circumstances, the data from this project suggest that there will be no detrimental effect to hive development and production if modified bottom boards are used. Further testing is required to confirm whether the limited results obtained here can be replicated under other conditions, especially in the presence of higher small hive beetle populations.

Completed Projects - Pollination research

Project Title	Pollination Five Year R&D Plan
RIRDC Project No.:	PRJ-003330
Start Date:	14/8/2008
Finish Date:	7/6/2012
Researcher:	Michael Clarke
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Objectives	The R&D plan is about investing in research to secure horticulture and agriculture's ongoing access to reliable, consistent quality and cost-effective pollination services, without which many Australian rural industries would not be productive. The plan will deliver R&D for the pollination-dependent industries that is relevant, market-focussed and generates the greatest net benefit for Australia. The proposed research will result in an R&D plan that supports industry in its drive to be productive, sustainable and profitable. The Communication Strategy will be used to improve the awareness of pollination issues and the importance of pollination services, and to garner support for R&D funding.
Background	Pollination services delivered by honeybees are estimated to underpin about 65% of national production of agricultural and horticultural crops. An assessment made in 2003 (using 1999-2000 figures) for 35 major commodities in Australia suggested these services were valued at $1.7 billion per annum. Given that the valuation did not include field crops, the true current value of pollination services is likely to be significantly higher than that estimate. Honeybee activities in Australia, and thus associated pollination-dependent industries, are now threatened by actual and potential incursions of honeybee pests, diseases and competitor species, as well as by newly-recognised impacts of use of systemic insecticides.
Research	The purpose of the Plan is to provide objectives, strategies and performance indicators for R&D investments that will enhance the productivity and profitability of pollination-dependent industries in Australia, in a manner consistent with the vision of the industry alliance body, Pollination Australia. A detailed communication plan is also included to guide adoption and uptake pathways of the Program's investments.
Outcomes	This will be the first stand-alone Pollination Five Year R&D Plan. Pollination-related R&D has previously been supported by RIRDC through the Honeybee Five Year R&D Plan's Objective 7 ('Pollination Research'). The proposed program of Pollination R&D will be supported by investments by other RDCs, agencies, and external contributors in pollination-related research, together with inputs from the Honeybee Program, which comprise statutory levies for honey and queen-bee production, and matching funds from the Australian government.
Implications	It is expected that contributions from HAL and other external contributors will average about $350,000 per year over the next five years.

Publications	The final report will be published by RIRDC as a Five Year R&D Plan for the RIRDC Pollination R&D Program.

Completed Projects - Resource access security and knowledge

Project Title	Forest plantations and honeybees
RIRDC Project No.:	PRJ-000483
Start Date:	1/8/2005
Finish Date:	30/6/2009
Researcher:	Doug Somerville
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Objectives	To evaluate the species of commercial value in the plantation industry to the Australian honeybee industry and estimate the economic contribution of plantations to the honeybee industry.
Background	The area devoted to plantation forestry has increased substantially for several decades, with a significant escalation over the last decade. During this time there has been a movement of government land tenure from that managed for forestry to that managed for national park and conservation-type outcomes. This has had a significant impact on the Australian commercial beekeeping industry due to the loss of useable apiary sites for bee hives. This has occurred due to the restrictive policies placed on beekeeping activities within conserved areas and the loss of access to many sites previously used on a casual basis. The national forest plantation estate has been suggested as a floral resource that may be a future replacement for the loss of traditional sites on government-owned lands. This report sets out the arguments and issues surrounding the discussion of whether forest plantations do or do not represent a valuable contribution to the Australian commercial beekeeping industry.
Research	Research strategies were initially directed at recording as much as possible about the regional distribution of plantations, species grown and age harvested from the literature available. Personnel involved with forest plantation management were contacted to obtain some of the information with strategic visits to plantations. A general request was issued to the Australian beekeeping industry to provide any information as to the utilisation of plantations, indicating frequency of visits, length of stay, and purpose (i.e. honey production, breeding conditions, or safe location to place bee hives between honey flows). A further component of the study was an investigation overseas to ascertain the value of eucalypts to the international beekeeping industry. Presentations on the subject of forest plantations as a floral resource to honeybees were made at two international conferences in 2005 in Europe and India. These occasions were used to discuss with the various participants the circumstances that prevail around the use of planted flora as a floral resource for honeybees.
Outcomes	The study clearly identifies the structure and mechanism of the beekeeping industry and outlines the parameters by which the system operates. The need for commercial beekeepers to have a number of suitable apiary sites on a range of reliable floral species is vital for

	survival of each beekeeping business. The variability of the floral resource is discussed as it relates to the needs of honeybees under the following headings: the flowering phenology of melliferous flora, the inherent flowering pattern, tree age and flowering frequency, flower bud initiation, frequency of flowering events and distribution of flora. The complexity of managing honeybees on a commercial basis within the Australian context is discussed, as well as the current floral resource constraints which are creating major uncertainty for investment within the Australian beekeeping industry. The international perspective is also covered to ensure the reader has an understanding of the Australian context.
Implications	The findings of this report reiterate the major constraint of the Australian beekeeping industry, namely, that without access to floral resources there can be no commercial beekeeping industry. There is traditionally a major focus by industry and government on issues surrounding the threat of pests and disease, commodity prices and costs of production, but ultimately the availability of a range of suitable floral resources is what will determine the future shape and scope of the Australian beekeeping industry. The beekeeping industry should not be under any illusion that plantation forestry will provide any substantial floral resources for their benefit. The plantation forestry industries could consider some of the issues discussed in this report to make their estate more beekeeping friendly if this is a desired strategy. Government agencies and the beekeeping industry should consider other strategies to increase the volume of melliferous flora within the Australian landscape, particularly the encouragement of planting of nectar- and pollen-producing plants in revegetation projects.

Completed Projects - Resource access security and knowledge

Project Title	Tasmanian floral database
RIRDC Project No.:	PRJ-002933
Start Date:	29/4/2008
Finish Date:	31/1/2009
Researcher:	Mark Leech
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Objectives	To provide a database of floral information of relevance to the Tasmanian apiary industry.
Background	The project was built on the data produced from the 2004 Apiary Census and the 2005 Apiary Industry Profile produced by the FFIC in Tasmania. There remained no nationally available floral database for Tasmania. A new survey was undertaken to identify the knowledge base regarding the extensive tea tree resource and its potential. A user-friendly field guide to the native flora known to be accessed by honeybees has been produced. The field guide is designed to assist beekeepers understand the native flora and help identify any gaps that may exist in floral resource use.
Research	A new survey was undertaken to assess the knowledge of the Tasmanian tea tree resource. Distribution maps of hive site records and accurate species locations were produced to provide an improved understanding of native flora use and opportunities.
Outcomes	A nationally available report on the Tasmanian floral resources accessed by honeybees. An improved understanding of the current knowledge of the tea tree resource and its potential, and a user-friendly field guide to the native flora accessed by honeybees in Tasmania.
Implications	The tea tree survey has identified a lack of knowledge of the resource and its potential. New research opportunities have been identified to improve the understanding of the resource and its potential to add value to the apiary industry in Tasmania. The field guide provides a visual reference that may highlight potential gaps in native flora resource use by the existing honeybee industry.
Publications	Tasmanian Floral Database Field Guide to Native Flora Accessed by Honey Bees in Tasmania

Completed Projects - Income diversification, new product development

Project Title	Investigate the value added potential of the prebiotic components of Australian honeys
RIRDC Project No.:	PRJ-000041
Start Date:	1/7/2007
Finish Date:	1/5/2009
Researcher:	Patricia Conway
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Objectives	The aim of this project is to investigate the prebiotic capacity of Australian honeys and to determine which Australian honeys have the greatest capacity to act as prebiotics to promote benefical bacteria and hence have the potential for imparting health benefits to the consumer. These findings will then be available to promote the sales of honey to the food industry, for both the local and export markets.
Background	The value of Australian honey could be increased with the evidence of health benefits beyond those already demonstrated for topical and antibacterial activity, and that of basic nutrition including the important low glycaemic index. It is apparent that the complex saccharides in honey may promote good intestinal health and well-being by being selectively used by beneficial bacteria in the intestine. This improvement in the composition of the intestinal microbes can provide immune modulation at other sites in the body and therefore honey has the potential to improve and promote health and well-being throughout the body. Honeys from other countries have been shown to promote the growth of beneficial intestinal bacteria. Since the composition of honey varies with the floral species, climate and procedures in use for harvesting and storage, Australian honeys will be unique. Furthermore, different floral varieties of honey have been shown to have different glycaemic index values. It is therefore of interest to investigate the potential of Australian floral varieties of honeys in order to value add and identify valuable natural functional food ingredients using these honeys.
Research	Honeys from each state of Australia were sourced and the physical characteristics of each honey sample recorded. All honey samples were tested for the capacity to promote the growth of pure cultures of known benefical bacteria which are currently used commercially as probiotics. The promotion of growth was quantified and the five honeys which were most efficient for all tested cultures, were selected for further study. The effect of honeys on the growth of pure cultures of known pathogens was also studied. In order to simulate the inclusion of honey in the diet and its effect on indigenous microbes in the intestine, *in vitro* microcosms simulating intestinal conditions were used. Because honey contains both simple sugars and complex sugars, tests were carried out using natural honey as well as honey pretreated to remove the simple sugars. This effectively simulates the absorption of the simple sugars in the small intestine. The prebiotic potential of the honeys has been expressed as the 'prebiotic index' using the results from the microcosm studies.

Outcomes	This study demonstrates that Australian honeys possess prebiotic potential, based on observations that the growth of beneficial bacteria such as lactobacilli and bifidobacteria was promoted when honey was added as the sole carhohydrate source. Since honey is a mix of complex and simple sugars, and the simple sugars are rapidly absorbed by the body when honey is ingested, it was important to examine if the complex sugars in honey could also promote the beneficial bacteria. It was shown that the complex sugars in honey also promoted the growth of the beneficial bacteria. In order to simulate the situation in the body, microcosms were set up in the laboratory to simulate the intestinal environment. When natural honeys were added to these microcosms, it was shown that the beneficial bacteria were enhanced and the less desirable were reduced in number, and that the complex sugars in the honeys contributed to the enhancement. It was therefore concluded that the Australian honeys have prebiotic potential, and that the effect varied for the different floral species.
Implications	The evidence that Australian honeys have prebiotic potential will open an exclusive market opportunity for Australian honeys. Currently, honey competes with sugar in the food industry. Sugar is rapidly absorbed in the small intestine and provides no benefit to the intestinal microbes and gut health. In contrast, honey contains simple sugars as well as more complex sugars which are not degraded by host enzymes, and which reach the large intestine where they are fermented by the benefical indigenous microbes for the benefit of the health and well-being of the body. This type of complex sugar functions as a prebiotic, whereas the simple sugars cannot. While on-going studies will provide *in vivo* evidence of the prebiotic capacity of honey, the results to date provide conclusive evidence that when the complex sugars in honey are delivered to intestinal microbes, a beneficial profile of microbes can develop. This profile is consistent with that observed when health benefits are noted in clinical studies. This finding makes it possible to develop healthier beverages and confectionary based on honey rather than sucrose.

Research in Progress - Productivity and profitability enhancement to lift beekeeper income

Project Title	Testing pollen substitutes that meet the nutritional needs of honeybees
RIRDC Project No.:	PRJ-000472
Start Date:	11/1/2006
Finish Date:	2/1/2010
Researcher:	Robert Manning
Organisation:	The State of Western Australia represented by the Director General of Agriculture
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Objectives	To test ingredients and feedstuffs developed by John Black Consulting (RIRDC Project JLB-4A) for honeybee preference and palatability. To test the final substitute feeds in cage experiments for their effect on honeybee longevity.
Current Progress	In an earlier experiment, 27 oils were tested in low-fat pollen to determine their palatability to honeybees and relative preference. Three oils were chosen to be included in the next round of tests using proteins and protein isolates derived from egg, milk, pea, soyabean, whey, lupin, blood meal and micro-algae at 2 and 5% concentration. The second round of experiments using proteins is still in progress. Part One of the experiment, which involved testing in hives of diets of egg white, egg white and whole egg powder, blood meal, lupin and whey, and soyabean protein extract has been completed. Part Two of the experiment will test diets of micro-algae and whey, whey, soyabean and egg white, egg, micellar milk and pea, and milk protein and pea and is due for completion in June 2009.

Research in Progress - Productivity and profitability enhancement to lift beekeeper income

Project Title	Development of a pollen substitute meeting the nutritional needs of honeybees
RIRDC Project No.:	PRJ-000643
Start Date:	1/7/2006
Finish Date:	30/11/2009
Researcher:	John Black
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Objectives	Develop specifications for an effective pollen substitute that is attractive, meets the requirements of honeybee colonies and is as economically viable as possible.
Current Progress	Successful artificial pollen must meet three essential criteria. Firstly, it must be attractive to foraging bees. Furthermore, it must provide all nutrients essential for a rapidly growing colony, other than energy, including amino acids, fatty acids, minerals, vitamins and hormone precursors. Finally, it must not include toxic substances such as starch and oligosaccharides. Previous pollen substitutes have been manufactured ad hoc from a range of ingredients and not met these criteria. They have been partially successful only because they contained bee-collected pollen. The complete nutrient requirements for viable honeybee colonies were developed in a previous RIRDC project (JLB-2A). Twenty nine lipid-based or other materials have been evaluated for their attractiveness to honeybees by measuring the amount consumed as compared to an artificial pollen patty, and by the number of bees congregated on patties when the materials were included at 2% concentration. Consumption of the patties containing linseed oil, coconut oil and Bundaberg rum was significantly higher than those with red gum pollen. Lavender, fish and sage oils were the least attractive materials examined. The most attractive oils are next to be included in artificial pollen consumption experiments that will examine the suitability of fifteen different protein sources from eggs, milk, blood, lupins, soybeans, canola and micro-algae while separately meeting other mineral, vitamin and essential nutrient requirements. This latter experiment was due to be completed by November 2008. However, because of quarantine issues in Western Australia, commencement of this cage experiment has been delayed and did not commence until mid-2009.

Research in Progress - Productivity and profitability enhancement to lift beekeeper income

Project Title	Hygienic behaviour of the Western Australian bee breeding program
RIRDC Project No.:	PRJ-002916
Start Date:	1/7/2008
Finish Date:	30/8/2009
Researcher:	Robert Manning
Organisation:	The State of Western Australia represented by the Director General of Agriculture
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Objectives	To genetically improve the hygienic behaviour of honey bees, decrease problems of bee diseases, and increase hive productivity. To identify hygienic behavioural traits in established breeding lines, and use that information to breed hygienic lines by controlled open mating (on Rottnest Island) and instrumental insemination. To improve the hygienic quality of queen bees; provide disease resistant stock to the Australian industry, and boost productivity of the hive through cleaner brood combs.
Current Progress	The field component of the research was completed in December 2008. Cells in the photographs taken of both types of larval-killing techniques (pin-prick and freezing of brood) were counted and the results of the tests recorded. Statistical analyses have not yet been completed, but informal assessment of results indicates a wide variation in the hygienic behaviour of WA lines of honeybees originating from the former Department of Agriculture program, now know as the Better Bees Program. Tests of bee lines outside the breeding program show less hygienic behaviour by comparison. There are a small number of stand-out honeybee lines that should be used as a central nucleus for further development of a hygienic honeybee lineage.

Research in Progress - Pest and Disease Protection

Project Title	**A study of Nosema ceranae in Australia**
RIRDC Project No.:	PRJ-002862
Start Date:	30/6/2008
Finish Date:	301/2011
Researcher:	Michael Hornitzky
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Objectives	1. Develop a real-time PCR methodology for the more efficient and cheaper detection of *Nosema ceranae* and *Nosema apis.* 2. Monitor the incidence of *N. ceranae* in honeybees in apiaries in eastern Australia. 3. Determine the pathogenicity of *N. ceranae* compared to that of *N. apis.* 4. Determine production losses caused by *N. ceranae.*
Current Progress	DNA extraction using the MagMAX – 96 Total RNA Isolation system and Sybrgreen Real time (RT) PCR has been demonstrated to be an efficient protocol for the detection of *Nosema apis* and *Nosema ceranae.* This methodology has been adopted for the processing of adult bee samples. Monitoring to determine the incidence of *N. ceranae* in honeybees in apiaries in eastern Australia has commenced. Twenty hives per apiary and one apiary per beekeeper are being monitored. To date *N. ceranae* has been detected in all apiaries tested indicating that *N. ceranae* is commonly found in the eastern states of Australia. The prevalence of *N. ceranae* varies from apiary to apiary. As few as 1/20 hives per apiary and as many as 20/20 hives per apiary have been found to be infected with *N. ceranae.* In one apiary in NSW 8 hives were infected with *N. apis* and 20 hives were infected with *N. ceranae* in the summer sampling. However, in the autumn sampling of this apiary no hives were detected with *N. apis* and all 20 hives were infected with *N. ceranae* suggesting that *N. ceranae* is replacing *N. apis.* Examination of single bees from hives to determine the dynamics of nosema infection in the hive unit is about to begin.

Research in Progress - Pest and Disease Protection

Project Title	Small hive beetle biology providing control options
RIRDC Project No.:	PRJ-000510
Start Date:	1/6/2006
Finish Date:	1/2/2010
Researcher:	Nicholas Annand
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Objectives	1. To determine optimal temperature, humidity and air movement thresholds to prevent small hive beetle (SHB) damage to stored honey supers (fulls and stickies) and assess what techniques/appliances could be used practically in the sheds of beekeepers. 2. To determine if weak hives and queen-less hives are more attractive and more susceptible to SHB damage than strong healthy hives. 3. To identify the usual daily movements of SHB in and out of managed beehives during each season of the year. 4. To find the number of SHB in the immediate vicinity (ground surrounding and under the hive) of a bee hive compared to the SHB inside the hive for each season of the year. 5. To identify ways of cleaning combs that have been 'slimed' as a result of SHB larval damage causing honey fermentation.
Current Progress	1. Trial technique has been developed. Mature SHB, fed a protein diet for 2 days, are introduced into desiccators, with food and oviposition sites. After 24 hours eggs are counted, then returned to the same conditions to hatch, and percentage hatching is recorded. Trial work is ongoing. 2. Field trial work is complete. Photos of frames still require analysis for brood/pollen/honey areas. Results to date suggest SHB numbers are highest in strong colonies and lowest in weak colonies. No colonies totally collapsed. Some queenless colonies had few bees and SHB larvae were in these hives. 3. All surveillance footage has been recorded with about 25% still requiring review. SHB movements need to be corelated to corresponding weather data. Most SHB movements occurred around dusk during the warmer months. 4. All trial work completed and data collected. SHB numbers, and the proportion of SHB outside the hives rose during the warmer months of the year. 5. Trial work continues to see the bees acceptance of "cleaned" frames for honey storage in the hive this spring. No noticable difference between washing techniques was observed with the bees acceptance and recovery of SHB 'slimed' frames. All data still requires statistical analsyis.

HONEYBEE

RIRDC Publication No. 09/103

The goal of the Honeybee Program is to improve the productivity, sustainability and profitability of the Australian beekeeping industry through the organisation, funding and management of a research, development and extension program that is both stakeholder- and market-focussed.

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