Australian Government
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FAT BEES
SKINNY BEES

-a manual on honey bee nutrition for beekeepers-

A report for the Rural Industries Research and Development Corporation

By Doug Somerville
Livestock Officer (Apiculture)
NSW Department of Primary Industries
Goulburn

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Researcher Contact Details
Doug Somerville
Livestock Officer (Apiculture)
NSW Department of Primary Industries
PO Box 389
GOULBURN NSW 2580

Phone:	02 4828 6619
Fax:	02 4822 3261
Email:	doug.somerville@agric.nsw.gov.au

In submitting this report, the researcher has agreed to RIRDC publishing this material in its edited form.

RIRDC Contact Details
Rural Industries Research and Development Corporation
Level 1, AMA House
42 Macquarie Street
BARTON ACT 2600
PO Box 4776
KINGSTON ACT 2604

Phone:	02 6272 4819
Fax:	02 6272 5877
Email:	rirdc@rirdc.gov.au.
Website: http://www.rirdc.gov.au

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FOREWORD

Honey bee nutrition is very much a developing area of research within the beekeeping industry. Australian researchers have, for a number of decades, significantly added to our knowledge on the subject. Despite this, the bulk of the information is not readily available to the beekeeping industry.

To address this short fall in information, RIRDC has funded a publication that will prove beekeeper friendly, drawing together relevant research on the subject of honey bee nutrition.

There is more information on the chemical composition of Australian honey bee-collected pollens than in any other country. Most of this work was funded by RIRDC or previous funding organisations supported by the beekeeping industry. This information has become difficult to access, thus the amalgamation of the relevant data in Chapter 6 is pleasing.

What makes this publication unique is its relevance to Australian beekeeping. The 44 case studies of beekeepers are of particular interest as they demonstrate what is being practised by commercial beekeepers in their attempt to maintain a viable beekeeping business.

This publication should have a wide readership within all levels of the beekeeping industry. This project was funded from industry revenue which is matched by funds provided by the Australian Government.

This report is an addition to RIRDC's diverse range of over 1200 research publications and forms part of our honeybee R&D program, which aims to improve the productivity and profitability of the Australian beekeeping industry.

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

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Interviewees:

Western Australia: John Davies, Peter Detchon, Harry East, Colin Fleay, Ron Jasper, Rod Pavy, Bob Power, Steve Richards

South Australia: Leigh Duffield, John Fuss, Geoff Smith, Graham Wagenfeller

Tasmania: Ken Jones, Bill Oosting, Col Parker, Ian Stephens, Julian Wolfehagen

Victoria: Kevin and Glen Emmins, Ken Gell, Ian Oakley, Ray Phillips, Craig Scott

New South Wales: Trevor Billett, Rosemary Doherty, Dave Fisher, Wayne Fuller, Warren Jones, Monte Klingner, Dayl Knight, Keith McIlvride, Greg Mulder, Mike Nelson, Harold Saxvik, John and Kieren Sunderland, Fred Taylor, Warren Taylor, Bruce White, Col Wilson

Queensland: Don Keith, Ken Olley, Rod Palmer, David Stevens

New Zealand: John Berry, Wouter Hyink

CONTENTS

Page

EXECUTIVE SUMMARY

The publication, Fat Bees/Skinny Bees, is a manual on honey bee nutrition for beekeepers. It provides information on the known essential chemical requirements of honey bees including the components of nectar and pollen. Pollens with a protein level around 25% or greater have been recognised as excellent quality pollens, those less than 20% have been described as of a poor quality. Australia has had more pollens analysed than any other country, and for the first time all of the profiles of the analysis are presented, representing 183 species. There is some evidence that pollens from the same genus, i.e., closely related plants, exhibit similar nutritional values in regards to pollen chemical composition.

Lack of nectar or stored honey presents the beekeeper with various sets of problems. These scenarios are discussed with the most appropriate course of action. Likewise, lack of pollen or poor quality pollen creates its own set of problems, often exacerbated by the stimulus of a nectar flow. How to recognise the need to provide pollen supplement and the circumstances which may lead a beekeeper to invest in this practice are discussed.

Some facts about honey bee nutrition include; nectar flows stimulate hygienic behaviour; total protein intake is what should be considered, not so much the individual chemical properties of individual pollens; fats in pollen act as strong attractants to foraging bees, although increasing concentrations in pollen limit brood rearing; vitamins are very unstable and deteriorate in stored pollen; principal cause of winter losses is starvation, not cold.

Pollination and queen rearing present their own set of management issues in relation to supplementary feeding and managing nutritional stress. Stimulating colonies in both circumstances with strategic application of supplements can be very beneficial. Lack of fresh pollen has a major negative effect on the rearing of drones.

Means of preparing and feeding sugar and pollen supplements are presented in different chapters. Our knowledge on pollen supplements is limited, but this area has received a great deal of attention. On the other hand, sugar syrup feeding is a commonly practised management tool in many countries including the state of Tasmania, yet not on the Australian mainland.

The information provided in this manual should provide most beekeepers with enough information to seriously consider providing sugar syrup to bees in the future as a means of manipulating bee behaviour. As the costs and returns of beekeeping change, the option of sugar syrup feeding may prove to be an alternative to moving apiaries further afield in search of breeding conditions.

Forty four case studies of beekeepers from every state in Australia and two from New Zealand are provided as examples on what is being practised by commercial beekeepers. They are not necessarily getting it right, but by trial and error, are improving the way they manage bees and ultimately improving the profitability of their beekeeping enterprise.

CHAPTER 1

INTRODUCTION

Honey bees need a range of elements to satisfy their nutritional requirements for normal growth and development. These elements include proteins (amino acids), carbohydrates (sugars), minerals, fats/lipids (fatty acids), vitamins and water.

Honey bees collect three substances — water, nectar and pollen — to satisfy their nutritional requirements. These materials are collected by field bees according to the needs of the colony and the availability of these substances in the field. The quality and quantity of these materials available to field bees does not always match the requirements of the colony. Lack of one or more of these substances will potentially lead to a serious reduction in the population of the colony, reduced longevity of the bees, reduction in drone populations, increased disease susceptibility and ultimately, death of the colony.

A beekeeper's skill is to be able to ascertain the nutritional status of a colony, predict what the floral conditions that are immediately, and in the future, available to it and determine a course of action to ensure his/her goals are achieved. These goals may include building populations prior to a major nectar flow, maintaining populations, or even allowing populations to reduce to a more sustainable level, for instance, during a prolonged drought period or over wintering when often colonies are not foraging to any large extent. Healthy colonies are also a recipe for reducing the disease incidence. Nectar flows, for instance, stimulate hygienic behaviour in the brood nest so dead and dying adults and brood are removed more swiftly than if there was no fresh nectar stimulus.

Nectar flows stimulate hygienic behaviour.

The nutrition status of a colony can be manipulated so as to encourage a greater ratio of foraging bees to collect pollen than nectar. Pollen gathering bees are said to do a better job as far as pollination of crops is concerned. With no fresh nectar available in the field, bees will often be reluctant to forage for pollen. Strategically providing sugar syrup may, under the right circumstances, induce the colony to collect greater volumes of pollen than they would have without the beekeeper's intervention.

A large majority of Australia's honey crop comes from eucalypts.

The specialist beekeeping industry that produces mated queen bees for the export and domestic market has to pay particular attention to nutritional issues. If the availability of pollen in the field is scarce, then one of the first reactions by a colony will be to cease rearing drone brood. Any drone eggs and larvae will be neglected or even eaten by the nurse bees, and the queen will not be stimulated to lay drone eggs. This will potentially create a major problem with inadequate drones of the correct age available when large numbers of virgin queens are ready to mate. Poorly mated queens are said to be superseded earlier than usual and often the queen fails within months without the colony replacing her, eventually equating to the ultimate demise of the colony.

Australia is also a unique country for beekeeping, as a large majority of the national honey crop is harvested from eucalypts. These do not flower on an annual basis and are mainly influenced in their flowering behaviour by seasonal events such as rainfall and drought. Quite a few of our major sources of honey are also considered poor sources of pollen, which creates serious management problems for commercial beekeeping.

Thus, very briefly, this introduction highlights why attention to honey bee nutrition issues is a vital component of successful beekeeping. But it must be remembered that successful beekeeping is governed by a set of golden rules that must all be considered to ensure that attention to one aspect of beekeeping does not equate to neglect in another area.

Keep good records.

In summary, the golden rules are as follows:

1) Regular requeening — requeen any failing queen as necessary.

2) Comb replacement — replace old, dark and damaged combs, particularly in the brood nest.

3) Pest and disease surveillance — regular monitoring of brood.

4) Nutrition management — monitor food intake and stored honey and pollen.

This publication, "Fat Bees/Skinny Bees", sets out to provide the known information on honey bee nutrition that is important for the successful management of problems that may occur in the apiary. There are many gaps in our knowledge of honey bee nutrition, but there is also much we know that works and should be considered by beekeepers in their daily management of honey bees.

A young active queen is essential for a productive hive.

In the process of gathering information on honey bee nutrition, case studies from a number of commercial beekeepers were gathered. They were chosen due to their combined attempts to manage honey bee nutrition issues by supplementary feeding. Various levels of success and failure were achieved by this group and any claims by individuals are pertinent to their own experiences and circumstances. These may or may not translate to your beekeeping enterprise. Even so, it is useful to publish these case studies to hopefully reduce the mistakes and increase your successes in nutritional management of colonies. Australia is also very lucky in having probably the largest set of data on the chemical composition of honey bee-collected pollens in the world. Numerous researchers have analysed pollens over the last 25 years, which allows us to compare the nutritional worth of various sources of pollens. A list of the composition of pollen sources thus far published by various authors is provided in Chapter 6.

As honey bee nutrition is still an evolving science, I encourage you to read this publication, try various practices to overcome nutritional weaknesses identified in your system, and keep good records. Only then will you be able to clearly look back and say what worked and didn't work.

In the process of writing this report on honey bee nutrition, I have picked the brains of many beekeepers, other extension/apiary officers, and bee researchers, including conducting research in my own right. I would be seriously surprised if this publication did not need updating in the not too distant future, as further research is undertaken and beekeepers trial different methods/approaches to overcoming nutritional issues in managing honey bees under a range of circumstances.

NECTAR

Nectar is the primary source of energy in the form of carbohydrates. Nectar initially is principally composed of sucrose with various moisture levels including some enzymes and mineral content. The sucrose is converted by the natural presence and addition by bees of enzymes to levulose (fructose) and dextrose (glucose). At the same time this “ripening process” is occurring, the moisture content of the nectar is reduced to somewhere between 12–21%. Occasionally with very thin nectars in areas that are experiencing high humidity, the moisture content may remain higher than 21%, which will lead to the fermentation of the honey. Once honey is ripe it is capped with beeswax and sealed in the comb.

The levulose/dextrose ratio varies according to the source of the nectar. Honey with higher dextrose levels will tend to candy more rapidly (e.g. canola *[Brassica napus]*), than honey with high levulose levels (e.g. yellow box *[Eucalyptus melliodora]*, Jarrah *[Eucalyptus marginata]*). The impact of honeys with different ratios of these sugars on a honey bee colony is not understood. Fermented honey, on the other hand, is extremely detrimental to the health of the colony. This will lead to the early death of the bees who consume the contaminated honey.

Excess heating of honey in the extraction process is known to reduce or eliminate the enzymes and thus its activity in converting nectar to honey. Combs, when removed from hives, need to contain ripe honey to guard against high moisture content and an incomplete conversion of the sugars.

Whenever field bees are collecting fresh nectar and the temperatures in the field are not excessively hot, the colony will obtain most of its water requirements through the nectar. It is mainly when colonies rely on stored honey for their carbohydrate or the climate is hot and dry, that the ratio of field bees in a colony significantly changes to favour water gathering.

The mineral content of honey is also variable, depending on the floral source and presumably the mineral composition of the soil the plants are growing in. Dark honey has a generally richer mineral profile than light coloured honey. One source of information on the difference between dark and light Australian honeys provides the following data:

Table 1. Comparison of mineral constituents of honey (Petrov 1970) — Mean concentration (mg/kg)

Mineral	Dark honey	Light honey
Ca	227	107
Cu	1	1
K	1241	441
Mg	132	40
Mn	10	1
Na	23	251
P	123	129
Zn	2	3

(Refer to Chapter 6 for key to minerals.)

The mineral content of honey dews has been implicated in health issues of the colony. Most are of European origin and even though honey dew is not a major product of honey bees in Australia, it is worth being aware of. High K and/or P and low Na concentrations were associated with paralysis of adult bees in Germany, and high mineral levels were also implicated in causing dysentery in adult bees.

Beekeepers in temperate Australia occasionally talk about “hot” honey flows. They are not referring to the climatic conditions, but rather the heat generated by the bees in ripening some honey sources. Colonies, particularly in late autumn, are said to perform better on hot honey flows than cold honey flows, going into winter. Red stringybark *(Eucalyptus macrorhyncha)* is said to produce hot honey, whereas mugga ironbark *(Eucalyptus sideroxylon)* produces cold honey. One possibility could be that the enzyme activity in hot honey is more intense than cold honey.

POLLEN

Chemical composition

Pollen is composed of a range of chemical components which are necessary for a honey bee colony's survival and success. The principal compound has arguably been protein, although the ratio between the different amino acids has been demonstrated to be of a major consequence. More recently certain levels of fat, vitamins and minerals have all been implicated as being necessary to satisfy honey bee nutritional demands.

Mixed pollen collection.

Protein

The protein requirements for honey bees have been calculated by a number of researchers with honey bee-collected pollen between 20–25% crude protein being considered the minimum level. The percentage of crude protein of pollen in the mid 20s are far more useful to colonies in allowing them to meet their protein requirements. Even better pollens with crude protein percentages (CP%) in the late 20s and early 30s guard against any imbalance in the amino acids of the pollen or shortage of pollen. What is probably more important is the total protein intake of a colony. When colonies collect very little pollen, whatever its CP% or when the CP% is below 20% whatever the volume collected, the colony will exhibit a protein deficiency by reducing the area of brood being reared.

What is probably more important is the total protein intake of a colony.

It has been demonstrated that the longevity of worker bees is greatly enhanced when they receive a diet of high protein pollen, as compared to diets dominated with pollens with low protein levels. The amount of brood rearing is also reduced when colonies are experiencing a lower protein diet. One Australian researcher indicated that for every 10 grams of protein required by the colony, it was necessary for that colony to consume 48 grams of pollen containing 30% crude protein. If the crude protein levels of pollen available to a colony are reduced to 20%, then the same colony would need to consume 72 grams of pollen to achieve the same performance levels. Thus a colony would need to collect 3 kg of pollen at 20% crude protein to be equal to 2 kg of pollen at 30%, a substantial saving to the colony in foraging activity.

The volume of pollen a colony requires is problematic and depends on the climatic conditions, nectar availability, brood area, and the quality of the pollen being collected. Various attempts at quantifying the volume of pollen consumed by a colony have ranged from 25–55 kg per year. If the crude protein levels of pollens are low then the volume bees collect will need to increase. What the various estimates of annual pollen consumption fail to take into account is the consumption by adult bees in their first two weeks after emergence. The Australian commercial beekeeping calendar is also dramatically different from that of many other continents due mainly to the flowering patterns of many indigenous species. A number of species flower during the winter months ensuring a 12 month production period in many years. For a colony to be productive it must have ample populations of adult bees and sufficient brood emerging to replace deaths of adult bees. Thus the demand of a colony for pollen within the Australian context could be as much as 100 kg per year.

The crude protein (CP) content of pollen is a measure of its nitrogen content multiplied by a factor of 6.25. The measurement of the nitrogen content in pollens is not necessarily uniform between chemists, thus any comparisons of data should take into consideration this variation. Even so, data provided for 61 samples of Paterson's curse pollen indicate that the CP% will consistently fall into a bandwidth which allows some degree of assessment of the value of that species of pollen to honey bees. Many species in the same genus, i.e., white clover *(Trifolium repens)*, balansa clover *(Trifolium balansae)* or coastal banksia *(Banksia integrifolia)*, saw banksia *(Banksia serrata)*, heath-leaved banksia *(Banksia ericifolia)* tend to fall within a given bandwidth. With over 500 species, *Eucalyptus* is one genus that does not tend to behave in this manner, although groups such as the red gums do show strong similarities to each other in CP%.

Given this information beekeepers, if trying to determine the CP level of a certain species from the published data, but unable to locate their chosen species, may instead consider other species within the same genus, i.e., clover, banksias, etc, as a likely scenario for the species they have an interest in.

Amino acids

The proteins are composed of a series of amino acids, 10 of which (threonine, valine, methionine, isoleucine, leucine, phenylalanine, histidine, lysine, arginine and tryptophan) have been identified as being essential for honey bee nutritional requirements (Table 2).

The main limiting amino acid in honey bee-collected pollen is isoleucine.

The amino acids glycine, proline and serine are not essential for growth, but do exert a stimulating effect at sub-optimal growth levels.

Table 2. Essential amino acids for satisfactory honey bee nutrition (deGroot 1953)

Essential amino acids	Bee requirements (g/16 g N)
Threonine	3.0
Valine	4.0
Methionine	1.5
Isoleucine	4.0
Leucine	4.5
Phenylalanine	1.5
Histidine	1.5
Lysine	3.0
Arginine	3.0
Tryptophan	1.0

The levels of amino acids in honey bee-collected pollens have been quoted by many researchers as grams of amino acid/16 grams of nitrogen. This measurement is a ratio of the amino acid to the total nitrogen content in the pollen and not a quantative measurement based on the dry weight of pollen. If the amino acid levels were expressed as a dry weight of the pollen, it is possible that a sample of pollen at 20% CP and a pollen at 25% CP could exhibit the same volume of a particular amino acid. Thus, when a pollen source is said to be low in one or more amino acid, particular attention should be paid to the CP% or total nitrogen content. Pollen with a low CP% and limiting in one or more amino acids is a much greater concern than pollens with high CP% limited in one or more amino acids.

The chemical analysis techniques between laboratories for amino acids may vary. Comparative studies of laboratories have demonstrated serious discrepancies for amino acid levels from the same samples.

The amino acids methionine and cystine have been difficult to extract without breaking down in the process. The tryptophan levels in pollens has not been tested by many researchers, due to the need to conduct separate chemical analysis and the added extra cost to the projects. The main limiting amino acid in bee-collected pollen when reviewing the published data originating from Australia, is isoleucine. This has been at significantly lower levels in the indigenous flora, particularly many of the eucalypts when compared to introduced species. This may only be cause for concern if the pollens in question are limited in their availability and there are no other pollen sources for the field bees to obtain, or the CP% of the pollen is close to or below 20%.

Fat

Fat refers to lipid which is composed of fatty acids, sterols and phospholipids. It is thought that fatty acids are necessary components of the phospholipids which play an important role in the structural integrity and function of cellular membranes of insects. Under normal conditions, any lipid requirements are satisfied by the consumption of pollen. One research trial (1981) indicated that the sterols cholesterol or 24-methylenecholesterol supported brood rearing when included with diet supplements, compared to other diet mixes. They concluded that either cholesterol or 24-methylenecholesterol should be incorporated in dietary studies. However a diet of unsupplemented lactalbumin yeast containing 0.01% indigenous cholesterol, when supplemented with cholesterol (0.1% dry weight) did not increase brood rearing, which led the researchers to believe that 0.01% level must have satisfied the requirements for brood rearing. The cholesterol requirements for brood rearing could have also been satisfied from body reserves within the attendant nurse honey bees.

Fats in pollen act as strong attractants to foraging honey bees.

Other than the need for cholesterol, the dietary needs of honey bees for fats or lipids is unknown. There are two other functions that appear to be possible in explaining the role of fats in pollen. Certain fats in pollen would appear to act as strong attractants to foraging honey bees and a number of fatty acids can exhibit significant antimicrobial activity.

It has been observed that pollens with high lipid levels were preferred by foraging honey bees over those pollens with lower lipid levels. The addition of either whole pollen lipids or the soluble fraction extracted in cold acetone significantly increased the amount of dietary supplement consumed by caged honey bees. The addition of the insoluble fraction, or of an extract of the volatile substance in pollen, led to decreased food consumption. This indicated that the addition of fat to artificial diets may be beneficial or detrimental, depending on the composition and quantity of the individual components of the lipids. The total lipid concentration within a pollen supplement should probably be between 5–8%. Recently Rob Manning in Western Australia provided evidence that various fatty acids restrict brood rearing once they exceed a certain ratio of the food available to the bees. Maximum levels of two fatty acids include linoleic acid 6%, and oleic acid 2%.

Eucalypt pollens have a very low fat level, around 1%.

The role of lipids as phagostimulants (attractants) appears to have merit when examples of pollens with nutrient qualities low in protein but high in fat content are far more attractive to foraging honey bees. Historically, the view has been held that the more attractive pollens have a higher food value for brood rearing, whereas in fact this was not a true indication of the actual nutrient contribution to brood rearing.

Pollen may have a sanitary role in the colony due to the antagonism of certain fatty acids to two major bacterial honey bee brood diseases. One research project reports that a fatty acid compound (linoleic acid) within pollen inhibited the growth of the two bacteria that cause European foulbrood *(Melissococcus pluton)* and American foulbrood *Paenibacillus larvae* subsp. *larvae)*. A number of other fatty acids including capric, lauric, myristic, linoleic, linolenic acids are also known to have antimicrobial properties.

Increasing concentrations of minerals in pollen limit brood rearing.

Very few fatty acid compositions of honey bee-collected pollen have been analysed to determine the levels of these antimicrobial components. The fatty acid composition of six eucalypt species originating from Western Australia indicated significant differences in the linoleic acid and linolenic acid levels. However, the implications for honey bee disease management within apiaries has not been established.

The total fat/lipid content of corbiculum pollen has been reported to range between 0–20%. The genus *Eucalyptus* appears to have very low levels of fat, around 1–2%, when compared to *Brassicas* with levels that range from 6–20%.

Given field observations, it is very likely that increasing fat composition of pollens improves the attractiveness of pollen to foraging honey bees. Thus there are implications to the floral species in question, providing them with a pollination advantage. Research is limited on the absolute fat/lipid requirements of honey bees or on the definitive benefits to honey bees of various fatty acids.

Minerals

Little is known about the mineral requirements of honey bees. Substantial amounts of potassium, phosphate and magnesium are required by all insects, although excessive levels of sodium, sodium chloride, and calcium have been shown to be toxic to honey bees.

Various elements can be found in pollen including potassium, magnesium, calcium, sodium, iron, copper, manganese, zinc, aluminium, cadmium, chromium, lead, nickel and selenium, although many elements are only present as trace amounts. Up to 27 trace elements were reported in pollen and honey bee larvae by one researcher. Pollen is said to normally contain between 2–4% ash on a dry weight basis, or 1–7% of minerals. Honey bees reared on a synthetic diet containing various concentrations of pollen ash reared the greatest amount of brood at 0.5–1% ash levels.

Increased concentrations of minerals in pollens has also been shown to limit brood rearing. Pollens exceeding 2% ash demonstrated a decline in brood rearing and almost ceased when diets contained 8% pollen ash.

Research determining the ideal levels of major and trace elements needed by honey bees has not been carried out due to difficulties in administering the minute levels required to feeds, plus the time and cost involved. Another possible method of determining the levels of minerals required by honey bees is to analyse honey bee-collected pollens to obtain average levels for each element across the same species and between species.

Vitamins

Not a great deal is known about the vitamin requirements of honey bees, although they are essential for all animals. It appears they are not linked to longevity of the adult bee but are intrinsically linked to brood development. The B complex vitamins have been demonstrated to be essential for most insects. Thus there is an assumption that honey bees will follow this pattern. Pollen has been demonstrated as an excellent source of these vitamins. Four B complex vitamins, pantothenic acid, thiamine, riboflavin, and pyridoxin, plus vitamin A and K have been linked to development of the hypopharyngeal glands and brood rearing. Gibberellin acid and inositol have also been implicated in promoting brood development.

Vitamin B complex is essential for most insects.

There is some evidence that bees may be able to synthesise some vitamins such as pantothenic acid, although this may be due to the micro organisms in the honey bee gut.

Many vitamins are not very stable and will deteriorate in stored pollen. This may be one of the factors contributing to the reduced food value of pollen stored for lengthy periods in excess of 12 months.

There is some indication that irradiation of pollen increases the period in which it can be stored.

Many vitamins are not very stable and will deteriorate in stored pollen.

CHAPTER 2

NUTRITION MANAGEMENT

The management of honey bee colonies should always take into consideration the nutrients available to them. Ultimately a beekeeper may manage a colony with the best material, combs, disease free status and genetically selected queen bees, but if the colony does not have access to nectar and pollen, then the system fails. The management of a colony to assist in any nutritional imbalances will vary according to the desired outcomes of the beekeeper. Is the intent to expand populations, hold the population, promote foraging for pollen enhancing pollination or provide the ideal conditions for producing new queen bees? To achieve these aims it may be necessary to manipulate the carbohydrates and/or the pollen or pollen supplements available to the colony.

If the colony does not have access to nectar and pollen, the system fails.

LACK OF NECTAR/HONEY

Honey bees collect nectar and convert this into honey for long term storage. This is their principal carbohydrate source and without it the colony will perish in the short term (within days). Ample available nectar in the field also acts as a stimulus to the colony, encouraging increasing interest by the colony for pollen and an expansion of the areas of brood within the colony.

Lack of nectar and lack of stored honey elicit different responses by the colony. Lack of nectar will cause colonies to become more aggressive in defending their hive. Lack of nectar will see a decline in field bees foraging for pollen. Lack of nectar will also reduce the hygienic behaviour of a colony.

This last point is often not fully appreciated by beekeepers in their day to day management of colonies. A nectar flow or the provision of sugar syrup to a colony will increase the cleaning behaviour, particularly stimulating older bees and generally lead to a reduction in brood diseases. There is no evidence that the brood diseases are eliminated, but their presence and frequency is significantly reduced.

Lack of nectar will reduce the hygienic behaviour of a colony.

The loss of the stimulating impact of nectar will also equate to a reduction in the area of brood being cared for by the colony. The provision of nectar continues to keep the brood area “open” and population replacement at a high or expanding level. This stimulus can be artificially created by the provision of sugar syrup.

Winter requirements

This will vary considerably depending on the size of the population and location (be it warm or cool), brood rearing, if any, and any flowering events occurring in the area of the apiary. The bigger the winter cluster, the more honey will need to be consumed to keep it warm. If a colony is broodless then the cluster temperature will fall from 35°C to 14°C, providing a substantial savings in the honey that would need to be consumed to keep the brood area at the higher temperature. As temperatures continue to fall, the outside of the cluster remains constant at 6–8°C, even if external temperatures are lower. Honey bees are said to use their winter stores most efficiently at 7°C.

The principal cause of the loss of honey bee colonies over winter is not the cold temperatures, but starvation. Estimates of the total amount of honey required by a colony during winter vary from 20–45 kg. These are nearly all North American figures and the higher amounts relate to regions experiencing lengthy snow cover. For temperate zones not experiencing such severe conditions, 20 kg of honey per colony should be ample.

The principle cause of loss of colonies over winter is starvation, not cold.

The most ideal wintering conditions are either ones that offer reasonable breeding conditions, i.e., warm location with temperatures reaching the early 20°C level supported by a light nectar and pollen source, or a cool location with temperatures down to 0°C with no flowering events in progress which would render the colony broodless.

In all cases, choosing an apiary site with a north-east aspect, sheltered from the winds, would be highly beneficial. Wet, shaded locations should be avoided.

An overwintered colony dead from starvation.

A full depth super of honey weighs approximately 30 kg, 10 kg of which is box weight and frames, etc. Thus, one super full of honey should, in most Australian conditions, provide sufficient stored honey for the colony's survival.

Feed dry sugar over winter to avoid stimulating the colony.

One North American example of the survival of colonies based on the honey stored prior to winter dramatically illustrates what a difference an extra few kilograms of stored honey in the autumn will make. Colonies with 32 kg or more honey stored, only suffered an 18% loss rate, as compared to colonies with less than 29.5 kg with a loss rate of 55%.

Although this is an example of extreme winter conditions, the like of which is not experienced in Australia, what it does illustrate is the small margin of stored honey that can have a major impact on the survival of a colony.

Colonies over wintered in any location should be checked at least twice after the beginning of winter, preferably mid winter and at the end of winter. This can be done by simply lifting the hive by the hand grips to ascertain the weight of its contents. Stored honey contributes a considerable weight to the hive and is usually readily assessable by the beekeeper without the need to enter the hive. Breaking open a hive and exposing a colony to the elements will often be extremely detrimental to a cluster of bees or a colony which has started rearing brood after a period of winter hibernation. This interference is thought to promote the levels of Nosema disease in adult bees, which will have a major impact on the rate of population expansion. Also, breaking open a hive to inspect the colony should never be done during cool weather at this time of year, as this will require the colony to consume more honey to bring the brood temperature or cluster back to the desired temperature (35–37°C).

If a colony is deemed to be short on stored honey then frames of honey kept by the beekeeper or dry sugar can be provided to the colony to circumvent starvation. As the weather warms, thick sugar syrup could be used to prevent starvation.

Providing dry sugar in frame feeder.

Sugar syrup feeding should be avoided over winter except in warm sunny locations. A trial in 2003 involving the application of pollen supplement and sugar syrup significantly increased the Nosema levels in adult bees. The hives not fed sugar syrup in the same trial had reduced Nosema levels.

Drought management

Drought can be another set of circumstances that may require supplementary feeding to prevent starvation. In this case, the provision of sugar syrup could be one strategy, although syrup, whatever the concentration, behaves as a stimulus to the colony which may not be a desirable outcome. Dry sugar has been demonstrated to provide the necessary carbohydrate both during winter and drought conditions and is possibly the technique of choice if stimulating the colony is to be avoided.

Colonies will rapidly decline in size if adequate pollen or supplement is not available.

LACK OF POLLEN

Management issues may result from a lack of pollen or the poor quality of the pollen being collected by field bees. Colonies normally consume pollen soon after collection or within one or two months. Thus any short term periods (e.g., 3 to 6 weeks) when pollen is limited in the field, may be made up by the colony consuming previously stored pollen or living off body reserves. Colonies will rapidly decline in size if adequate pollen or a supplement is not available.

Limit the volume of pollen and the area of brood will decrease.

Population management is critically dependent on the quantity and quality of pollen. Limit the volume of pollen and the area of brood being reared by the colony will reduce. Limit the quality of the pollen and the colony requires greater amounts to obtain the nutrients necessary for colony development. If only poor quality pollen is available in limited quantities, then the impact on the colony will be multiplied, reducing significantly the area of brood tendered by nurse bees. Limited quantities of high quality pollen will also reduce the area of brood but not as significantly. Ideally, a beekeeper should seek floral species that produce known high quality pollen in abundance. Not only will this ensure that the maximum area of brood is reared, (restricted by queen fertility and the number of nurse bees), but also the adult bees are longer lived.

Larger populations of field bees with maximum longevity should be the aim of all beekeepers prior to anticipated major nectar flows. A Queensland trial indicated that a colony population of 50,000 bees produced 5.2 kg of honey per day, compared to colonies with a population of 35,000 bees which produced 2.2 kg per day. This trial was conducted on a warm weather honey flow when maximum flight periods would be experienced. In this case an increase in the total population by 40% increased honey production by 90%.

Nosema disease seriously reduces longevity of adult bees.

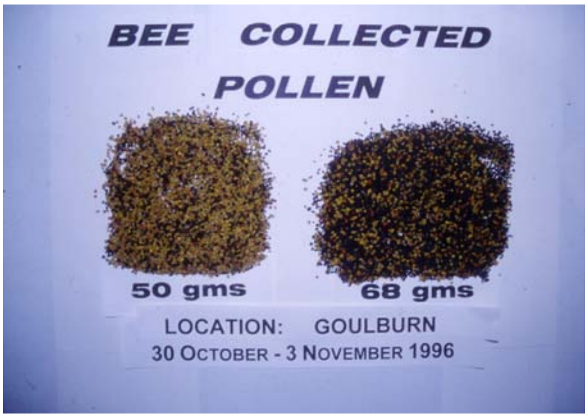
Essentially a beekeeper, in most cases, wishes to build the population of a colony or hold the population, i.e., births exceed deaths or births equal deaths. When Nosema disease is present, the longevity of adult bees is seriously reduced whereby death of field bees exceeds the birth rate. This is often referred to as spring dwindle. Through good breeding conditions (pollen and nectar availability), warm sunny locations and an actively laying queen, this situation can be turned around and the colony can recover. Although the disease-causing organism is the prime cause of the dwindling population, the availability of nectar and ample quality pollen allow the colony to overcome the rapid die-off in field bees by an increase in brood area, resulting in rapid replacement of adult bees.

One experiment published in 1997 indicated the benefit to colonies infected with Nosema, receiving pollen as a supplement. The longevity of adult bees was reduced from 21 days with bees fed pollen and Nosema spores to 14 days with bees fed Nosema spores only. A similar result was achieved when bees were fed a "protein food" as compared to no protein food, both fed Nosema spores. Longevity was reduced from 23 days to 14 days.

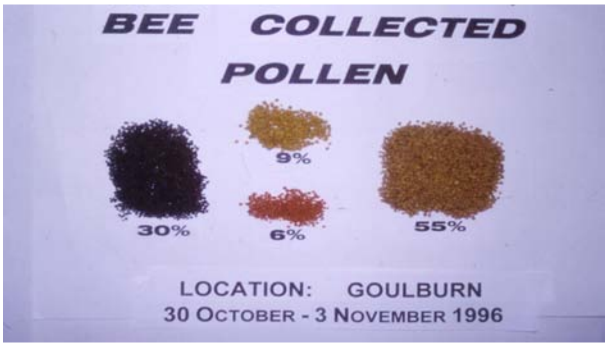
Colonies are, on occasions, exposed to a single pollen source with no other pollens available. In these circumstances the nutrients provided by this pollen source are not supplemented by nutrients from other pollen sources and thus deficiencies or imbalances are more probable but not always the case. The greater the volume of a single source pollen and the higher its CP%, the more likely nutrient deficiencies will be reduced. Low protein pollens that may exhibit deficiencies in one or more amino acids provide conditions whereby the colony's development will be restricted.

The conditions whereby only one pollen source is available probably only occur in 20% of the floral events commercial apiaries are exposed to. In most cases a mixture of pollens from a range of sources is commonplace. It is interesting to note that colonies within the same apiary will gather different ratios of the pollens available.

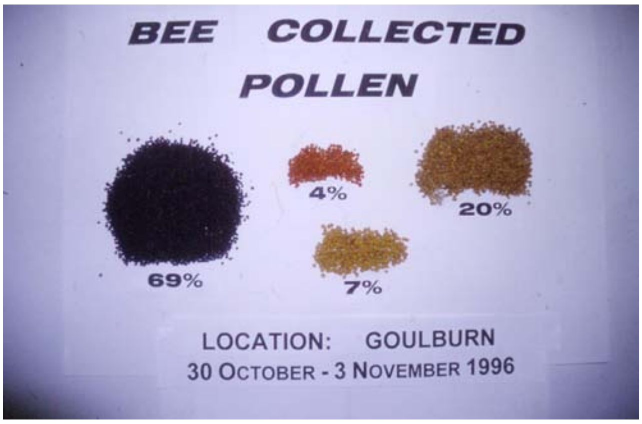
For example, two colonies within one metre of each other in Goulburn both collected pollen from four floral species, yet the ratios of the different species was significantly different.



Left hand sample 30% Paterson's curse pollen; right hand sample 69% Paterson's curse pollen.



The right hand sample has a greater volume of protein due to greater volume & the higher CP content of Paterson's cure pollen component.



Even so this would make little difference to the productivity of each hive. Only when one pollen source is available and that source becomes limited or is deficient in one or more substances required by honey bees, does there become a necessity to provide pollen supplements.

The words supplement and substitute imply subtle, albeit important differences. A pollen supplement implies that pollen is available to the colony in the field, be it either of poor quality or the quantity is restricted. A substitute, on the other hand, suggests that there is no pollen naturally available to a colony and a "complete" substitute is required by the colony to allow brood to be reared.

The greater the number of hives in an apiary, the greater the chance of pollen being limited.

Often the same substance purchased or produced by the beekeeper is used as a pollen supplement or substitute. Very rarely do conditions exist whereby there is absolutely no available pollen in the field, thus in most cases a pollen supplement is used to overcome any shortfall in the field conditions experienced by the colonies. The phrase "complete" substitute is also questionable, for as yet the "complete" dietary requirements for vitamins, minerals and fats for honey bees are not known.

Some would argue that a substitute suggests that no pollen is added to the recipe. There is ample proof that without a percentage of pollen included, sustained brood rearing is not possible. Thus using the word substitute or supplement in relation to pollen added to the recipe used is rather academic.

Providing pollen supplement to a colony becomes necessary whenever the aim is to maintain or increase brood rearing, and pollen available in the field becomes limited, which may occur before or during a nectar/honey flow. The amount and length of time the supplement is made available is dependent on the colony strength, the desired population levels, the attractiveness of the supplement, and the effectiveness of the supplement in achieving the desired goal.

The discussion within this section has focussed on the individual colony's dietary needs. In essence, the stocking rate of a site given the same floral conditions, will significantly impact on the amount of food available to each colony. The greater the number of hives in an apiary, the greater the chance of pollen being limited at some stage during the management of an apiary (e.g., 80–120 hives). A smaller apiary (1–20 hives) located in a town or close to an urban area is unlikely to ever suffer any major pollen shortfall except in extremely exceptional circumstances.

POLLINATION

Three issues are associated with colonies used for pollination and the implications on honey bee nutrition. The first is the use of sugar syrup to stimulate a colony to forage on the target crop. The second is the poor nutrition obtained by honey bees foraging on the pollens of certain crops. The third issue, although not specific to providing colonies for pollination, is the building up of colony populations and maintenance prior to the anticipated flowering dates. This third point is similar to that already discussed with building colonies and maintaining populations prior to anticipated honey flows.

The use of sugar syrup to improve pollination has been trialled by various persons over many years. Sugar syrup has been sprayed on the crop to attract bees to that crop, and it has been fed to the bees by internal and external feeders to stimulate foraging.

Fresh syrup stimulates brood rearing.

Various concentrations of syrup have been applied to crops with mixed results. Some studies suggest that visitation of field bees is increased after the spray, whereas other studies suggest a decrease in field bee visits to flowers. Any activity by the bees caused by the spray application of sugar syrup wears off after a day. This method of attracting field bees to a target crop is unreliable and short term.

Feeding syrup to colonies has proven to be reasonably successful in improving the pollination efficiency of the honey bee colonies on the crop. This can be done by soaking the target crop flowers in prepared syrup then providing the scented syrup to the bees either inside or outside the colony. Feeding syrup outside of the hive increases the number of foraging bees and is probably easier to administer by the beekeeper or grower. The degree to which the response by bees is due to the scent of the flowers or simply the sugar syrup alone has not been quantified.

Trials conducted with internal syrup feeders have shown that this increases the number of pollen gatherers in each colony. This has been a useful method in increasing pollen collection on a number of crops including sweet cherry, faba beans, red clover, kiwifruit, and almonds, although this method has been reported to reduce nectar gathering in the field from brussel sprouts.

Sugar syrup feeding station on lucerne.

Sugar syrup feeding on lucerne.

The fresh syrup appears to stimulate a colony to increase brood rearing. The increased syrup availability also increases the number of field bees collecting pollen. Even with a larger brood area, once the syrup feeding is stopped the number of pollen gatherers declines. The increased area of brood does not maintain the level of interest in the colony to continue collecting pollen. This point has major ramifications at any stage of the beekeepers' calendar, suggesting that sugar syrup should always be the first consideration when contemplating the need for supplementary feeding.

Rearing queen bees requires a light nectar flow and ample pollen.

Research conducted in NZ indicated that the concentration of the syrup (35–69%) did not appear to matter when 1–3 litres was provided to each colony in mid spring. Feeding in the morning was demonstrated to be more efficient in recruiting more pollen foragers, than feeding in the evening. Feeding one litre every day was also more effective in recruiting pollen foraging bees each day than feeding three litres every three days. Feeding one litre every day or two days was found to produce a similar pollen foraging response.

Sugar syrup feeding as a result of the extensive research conducted by Dr Mark Goodwin in NZ is now common practice in kiwifruit orchards. There was concern by the beekeeping industry that the escalation in the use of sugar syrup would also create major problems with robbing bees. This has not been the case and, on many orchards, the grower feeds the syrup to the bees while the hives are in the orchard.

Poor quality pollens have significant nutritional impacts on the colonies used in crop pollination, usually after they are moved to their next location. Poor quality pollens, or lack of pollen, will reduce the area of brood being reared and potentially reduce the longevity of the field bees. Thus a colony may be nutritionally in a sub-standard condition after servicing a pollination contract.

Some examples of known poor quality pollens come from kiwifruit, lucerne, sunflowers, blueberries and buckwheat. Some of these may not be a problem as they may represent only a fraction of the pollen types being collected by the colony, thus any nutrient deficiencies may be balanced from pollens derived from other species, i.e., weeds growing around orchards.

Lucerne and sunflowers bloom over mid summer and may be the only source of nutrients available to the colony. Sunflower pollen is produced in abundance, although the crude protein levels are rather low, ranging from 13–19%, below the 20% regarded as a minimum protein level.

In both cases the colonies would need to be either provided with supplementary protein or the beekeeper needs to manage these colonies to minimise workloads, such as a major nectar flow straight after coming off either of these crops. Other crops may also exhibit similar issues, particularly when there is only one source of pollen available.

QUEEN REARING

The desired outcome when rearing queen bees is to produce a genetically superior queen that is well mated and long lived. Two factors come together to achieve this aim — they are the careful and rigorous selection of breeding stock, and ensuring the whole process is carried out in the best possible nutritional circumstances.

Selection of stock when breeding queen bees is normally a lengthy, time consuming job which requires extensive record keeping and analysis of data. Occasionally the emphasis in queen rearing is largely placed on stock selection and the nutritional circumstances under which the queens are reared is neglected or given passing consideration.

The ideal conditions for rearing queens are a combination of factors including a light nectar flow with pollen available from multiple sources. Frequently these circumstances don't exist or only partially exist, e.g., limited nectar, but available pollen. If there is a significant long term shortage of fresh pollen in the field, then the queen rearing operation should be moved to an area that has a diversity of pollen sources, or queen rearing should cease.

Lack of pollen reduces the number of drones reared.

Any shortage of nectar in the field is easier for the beekeeper to address by the strategic use of sugar syrup. In a queen rearing operation the aim is to keep a colony stimulated, thus a 40–50% solution is quite adequate. Syrup should be provided to drone mother colonies, queen cell, starting and finishing colonies and, if the need arises, to the nucleus colonies that the virgin queens will mate from. The volume should not be excessive and is best provided in 1–3 litre lots, once to three times per week. In many cases this becomes routine when rearing queens, e.g., each time cells are grafted, the cell finishing colony is provided 1–2 litres of syrup.

Feeding sugar syrup to cell raising colony — note bar of cells in centre.

It is important not to neglect the colonies rearing drones. Providing stimulating quantities of syrup will encourage pollen collection. A steady supply of pollen will stimulate the colony to rear drone larvae and feed adult drones.

If pollen becomes limited in the field, then colonies will neglect drone larvae, drone eggs are eaten by the worker bees and, in extreme cases, the mature drones are ejected from the hive. Ideally a drone honey bee reaches its peak of sexual maturity between 2–4 weeks after emerging from its brood cell. Colonies low in stored pollen do not feed the drones as frequently, and as a consequence they take longer to reach sexual maturity. If continuous queen rearing is planned, then a continuous supply of mature drones will be required. In this case, management of the nutritional status of drone mother colonies becomes critical for the success of rearing quality long lived queen bees that have been satisfactorily mated.

If pollen is not available in sufficient quantities in the field, then it is possible to keep the colony on task, rearing drones by providing previously collected pollen to the drone mother colonies. Even though pollen is expensive to buy or collect, this is a critical part of the process and should not be neglected.

Pollen collection by a colony can be monitored by observation of returning field bees, particularly in the morning when most pollen is collected. Another method of determining the range and volume of pollen a colony is collecting is to place a pollen trap on one or two hives and trap pollen over a few days every one or two weeks. This will not always collect the pollen going into a hive, particularly small loads, but it will give a strong indication as to the diversity and quantities of available pollens being collected.

Another aspect of poor quality pollens besides reduced longevity of worker honey bees is the reduced fertility of drone honey bees. The major impact of a lack of pollen is a reduction in the number of drones being reared.

Providing a litre of sugar syrup to a colony the day before you need to graft larvae into queen cell cups, will ensure the day old larvae are “swimming in jelly”. This makes the transfer process a lot easier and probably helps prevent the larvae drying out during the process.

CHAPTER 3

SUGAR — SUPPLEMENTS

Why feed?, when to feed?, what to feed?, and how to feed sugar? are all legitimate questions to ask when contemplating supplementary feeding of a honey bee colony. White sugar or sucrose is the primary sugar used in Australia as a substitute for a naturally occurring nectar flow. Nectar has a very stimulating effect on a colony and this is not always the aim of providing a supplement.

When to feed is critical to the success of supplementary feeding.

Why the need to feed sugar?, should be the first question. Does the colony need stores for winter or drought? Does the colony need stimulating to maintain an active open brood nest for population maintenance or build up? Does pollen foraging need to be encouraged by syrup feeding in order to improve pollination efficiency or maintain drone rearing?

Dry sugar on inner cover.

When to feed? is critical to the success of supplementary feeding. Feed too late or too early and the response will not produce the desired outcome, also it may prove to be an absolute waste of money and time by the beekeeper.

What to feed? is fairly straight forward when sugar feeding. Dry sugar is the best form of providing sugar without stimulating the colony to any significant extent. Thick syrup (67%) is less stimulative than thinner syrup (50%), thus the beekeeper must decide what the aim is, as this will influence the preparation of the sugar.

How to feed sugar? will also have a major impact on the response. A large amount of syrup fed all at once may have a reducing stimulus effect, compared to slow release of the same amount of syrup over many days. Thus the type of feeder, i.e., open or slow release, of the same volume of syrup will impact on the colony's response.

Bulk sugar syrup.

PREPARATION

White sugar can be purchased in bulk already as a syrup at about 67% sugar, 33% water. This is usually referred to as 67% brix being the units of sugar in solution. Syrup, whether bought pre-mixed or mixed into solution from bags of dry sugar, has a limited shelf life. This is usually dictated by the growth of yeast spores in the syrup. Syrup mixed from dry sugar should be fed to bees within three days, particularly during warm or hot weather. The process of fermentation will increase the warmer the temperature.

Only mix the required amount of syrup for immediate needs.

Commercially available pre-mixed syrup will usually last longer as it has been sterilised in the process of dissolving the sugar into the solution. The same can be achieved by the beekeeper by boiling the syrup for 10–15 minutes before storing it in sterile, clean containers. It is always better to mix or prepare only the amount of syrup that is required for immediate use. Old syrup may look okay, but the rising yeast cell counts will have a significant deleterious effect on adult bees, leading to premature deaths of field bees. Only mix the amount of syrup required for immediate needs and use clean containers.

Use thin syrup when stimulating a colony.

Dry sugar requires no preparation, whereas preparing syrup requires a source of fresh, clean water and vessel to mix the sugar and water. Hot water will dissolve the sugar into solution with less effort than cold water. Ideally the mixing vessel will have a heating element so the syrup can be brought to the boil for 10–15 minutes to eliminate yeast cells.

Syrup can either be mixed thick or thin. Thin syrup may be more desirable if stimulating a colony, whereas thick syrup may be a better choice if the desired aim is to provide stores to a colony prior to winter.

Syrup tank on back of one tonne truck.

One litre of water mixed with one kilogram of dry sugar provides a 50% sucrose solution. One litre of water plus two kilograms of dry sugar provides a 67% sucrose solution. This latter concentration is a supersaturated solution and it is not possible to dissolve any further quantity of sugar into this solution. As a guide to mixing sugar and water, the following table (3) will help estimate the amount of ingredients that need to be organised.

Table 3. To achieve a 50% syrup, mixing equal parts of water and sugar

Water (litres)	Sugar (kg)	Syrup (litres)
1	1	1.575
10	10	15.75
100	100	157.5
2	2	3.15
20	20	31.5
200	200	315

To work out how much sugar and water you need to mix together to achieve a certain quantity of syrup at 50%, divide the amount of syrup required by 1.575 to arrive at the quantity of sugar and volume of water, e.g., 200 litres of syrup is required — divide 200 by 1.575 — you will need to mix 127 litres of water and 127 kilograms of sugar to produce 200 litres of syrup. A quick guide (Table 4) is as follows, to mix a 50% sugar solution.

Table 4. Ingredients required to produce a sugar solution at 50% brix.

Sugar syrup (litres)	Water (litres)	Sugar (kg)
10	6.35	6.35
20	12.7	12.7
50	31.7	31.7
100	63.5	63.5
200	127	127
1000	635	635

To mix a thicker solution (67% brix), then a ratio of one litre of water is added to 2 kg of sugar. This produces 2.26 litres of syrup. The following table (5) provides a quick estimate of the volume of syrup produced with the volume of sugar in kilograms twice that of the water in litres mixed together.

Table 5. To achieve a 67% syrup mixing one part water to two parts sugar.

Water (litres)	Sugar (kg)	Syrup (litres)
1	2	2.26
10	20	22.6
100	200	226
2	4	4.52
20	40	45.2
200	400	452

Syrup tank on back of bee truck (NZ).

To calculate how much sugar and water is required to produce a certain quantity of syrup at 67% brix, divide the desired total amount of syrup by 2.26 to calculate the amount of water required and multiply this figure by two to calculate the amount of sugar required. A quick guide (Table 6) is as follows, to mix a 67% sugar solution.

Table 6. Ingredients required to produce a sugar solution at 67% brix.

Sugar syrup (litres)	Water (litres)	Sugar (kg)
10	4.46	8.9
20	8.85	17.7
50	22.1	44.2
100	44.2	88.4
200	88.4	176.8
1000	442	884

FREQUENCY OF FEEDING SUGAR

This is largely dependent on the desired aim of the exercise. Small amounts (1 or 2 litres) provided once or twice per week will act as a stimulus, whereas 10 litres provided all at once to a single colony will produce a much reduced stimulating effect. Thus, if the beekeeper intends to maximise the stimulating effect of syrup feeding then providing a litre every second day of a 50% sugar syrup should achieve the aim. Preferably a very slow release feeder should be provided so a colony can obtain a continuous supply of syrup, be it at a very low volume. This will produce the ultimate stimulus effect.

If a colony is being prepared for winter and the idea is to get the bees to store as much as possible, then providing colonies 10 litres of 67% sugar syrup will provide the desired outcome. If a colony is on the weaker side and only covers four or five frames, then five litres may be sufficient. It is best to gauge the uptake of the syrup by the colony to determine if further quantities of syrup should be provided. If the syrup is removed from the feeder within two or three days then a follow-up feed within a week should be considered. If the bees cannot consume the syrup within five days, then no more syrup should be provided to a colony.

Frequency also refers to dry sugar feeding, particularly for winter and drought situations. In this case, how often dry sugar should be provided to a colony is on a needs basis. If the colony is low on stored honey or sugar previously provided, then more should be made available while the need continues. If a colony hasn't consumed all the dry sugar by the time the need passes, the residue can be collected by the beekeeper and stored for future use.

Providing 2 or 3 kg of dry sugar to a small colony occupying five frames will last a few months. The weight of the hive can quickly be assessed by lifting the back of the box. If the weight noticeably declines, then more dry sugar can be provided. It is best to regularly check the weight of a hive every four to six weeks through winter by this method and not let the colony completely run out of honey or sugar.

SUGAR FEEDERS

The means by which sugar or syrup is provided to a colony wil vary considerably, and largely depends on the resources available to the beekeeper, their imagination and ingenuity, plus the time and expense they wish to go to. There are many designs and types of feeders and those illustrated in this chapter should not be allowed to limit the imagination.

Drowned bees as a result of retrieving syrup out of a tray feeder.

Frame feeders

Frame feeders are, as the name suggests, feeders designed to take the place of one or more frames, and usually sit to one side of the box. Two common models in Australia are made from different materials. A moulded plastic frame feeder requires two frames to be removed from the box and holds approximately 3 litres of syrup. The wooden frame feeder is made from waterproof masonite and timber. This feeder, in most cases, is made to replace a single frame and holds 2 litres of syrup.

Frame feeder.

Both feeders are open at the top and drowned bees are common if floating material is not placed in them. They can also be filled with dry sugar instead of syrup, if this is a desirable strategy. In this case, if the dry sugar is not eaten by the bees, it can be collected by the beekeeper and reused elsewhere in the future without wastage or spoilage.

Frame feeders are commonly used in queen rearing operations.

Frame feeders are commonly used in queen rearing operations where individual colonies are regularly opened for various reasons. The feeders in this case are often permanently in place. Permanency of frame feeders in the brood box is also common in other countries, particularly in beekeeping operations that specialise in pollination, where syrup feeding to maintain and prepare colonies is required.

The number of holes dictates the rate at which syrup is consumed by the bees.

The major positive impact of frame feeders is that the syrup is close to the warmth of the brood or cluster area and the syrup is readily consumed. The negative, other than drowning bees, is that the syrup is taken up by the bees relatively quickly and thus any stimulation benefit quickly passes. Also, there is a need to remove one or two frames each time the feeders are placed in a hive.

Bottle or tin feeders

Bottle or tin feeders were common in past decades, but their use has lost momentum. Their placement in the hive varies, they can be put inside or outside of the hive body with bees accessing the syrup via a series of small holes. The number of holes

Tin feeder.

Entrance bottle feeder.

dictates the rate at which the syrup can be consumed by the bees. Thus, by reducing the number of holes, the amount of syrup consumed is slowed down. This method provides a stimulation effect over a longer time span.

Bottle feeder placed in hole in lid.

The feeders can be as big as the available container which usually restricts the size of the feeder, as large tins/bottles in excess of 1 or 2 litres are uncommon.

They can also be placed in various positions — in, front, or on top of a hive. A hole cut in the lid will accommodate an inverted tin or, if the hole is a neat fit for a bottle, this can be inverted and placed in the hole. An empty super can be placed on the hive and an inverted tin placed over the frames so the feeder is contained within the hive. The feeder can be placed at the entrance of a hive, usually a bottle or jar inverted into a frame made especially to hold the container in place.

The advantage of clear plastic or glass containers placed on the outside of the hive is that the amount of syrup consumed can be readily monitored. All these types of feeders are designed for individual hive use and release the syrup slowly.

The disadvantage of these feeders is the small amount of syrup available to the colony and the mould that often grows on the inside of the feeder. They require cleaning and sterilising, otherwise any syrup will quickly ferment when the feeder is reused and bee deaths will result.

Bucket feeders

Bucket feeders are essentially the same concept as a bottle or tin feeder. They are normally inverted over a hole in the lid of the hive. The bucket lid is designed with 10 to 20 small holes or a small piece of very fine screen, 5 cm diameter in the middle. Large amounts of syrup can be fed to a colony, restricted only by the size of the bucket. One disadvantage besides the fact they need to be thoroughly cleaned after each time they have been used, is that they are often blown off the hive when they are empty. Some beekeepers have overcome this by placing a brick either in or on the bucket.

Bucket feeder.

Bucket feeder in position.

Absorbent pad under hole for bucket.

Buckets full of syrup.

Tray feeders

Tray feeders have been very common in Tasmania. They sit on top of the frames of the hive and are housed in a shallow hive body, often an ideal or half depth super.
The lid is placed over the top of the super ensuring robbing bees can't get access. The trays can be whatever is available. They have been made from old 60 lb honey tins cut lengthways; more recently, new "kitty litter" trays are used. Tray

Straw in tray feeder to prevent bees drowning.

feeders made completely from timber designed to restrict bee escape are also relatively common.

Floating wooden platform in syrup tray.

These feeders are usually filled by removing the lid of a hive, pouring in the required quantity of syrup, and replacing the lid. As many are open to bees within the hive, drowning can be a major problem. Floating racks or devices are essential to reduce the loss of adult bees, which can be substantial.

Most tray feeders can hold at least 5 litres, but this depends on the evenness of the ground on which the hives are placed. Bees will do a reasonable job at cleaning all the syrup out of the tray, although it is necessary to manually clean the tray after each feed of syrup. As with all feeders that are designed for single hive use, the volume of syrup provided to each colony can be varied according to each colony's requirements.

Styrofoam feeder with centre hole, owned by Hedley Hoskinson, TAS.

Plastic bags

Sugar feeding with plastic bag.

Plastic bags are handy for small quantities of syrup in an emergency. A plastic bag can be filled with syrup, sealed and placed on the top of the frames under the lid cavity. If the lid cavity is too small, then a frame can be removed and the bag placed in this space. Some plastics are very thick and may require punching with a few pin holes. Mostly bees will chew a small hole and start the process themselves. If the plastic bag is left in the hive, bees will continue to chew at the plastic, shredding it and attempting pull it out of the hive.

Open feeders

Open feeders are the equivalent of providing water to stock of any nature. A large container or trough is placed in the open near the apiary. Half 200 litre (44 gal) drums have been used for this purpose. The containers are levelled and filled to the level required. Drowning bees are a major problem and floating materials are essential. Fresh straw has been used quite successfully, but must be replaced after one use. The straw cover must be 20–30 mm thick (1 inch) at least. Over this straw a wire grid to prevent livestock and wildlife from drinking the syrup is important. There are a few reports of cattle and goats dying as a result of drinking sugar syrup provided to bees. If rain is predicted, then the feeder should be protected with a roof preventing the entry of moisture. Water has been known to sit on top of the syrup, making it unattractive to the bees. This will eventually cause the whole batch of syrup to ferment and be wasted.

Drowning bees can be a major problem in open feeders.

The advantage of this system of feeding is the speed at which syrup can be fed to an apiary and the lack of the need for an investment in individual feeders.

The disadvantages are that strong colonies will collect more syrup than weaker colonies. Protection from livestock and moisture is important. Large numbers of drowning bees are common and thus floating materials are vital. There is nothing to stop bees within a few kilometres radius, either feral or managed honey bee colonies, helping themselves to the syrup.

There have been suggestions that it may spread bee diseases, although there is no substantive proof to support these concerns.

One method may suit winter feeding, whereas another may suit spring stimulation.

Other devices

Other devices to feed syrup have included a sheet of plastic pushed down between frames to act as a very crude frame feeder, ice cream containers placed in an empty super acting in a similar fashion to tray feeders and other tray feeders that replace part of the bottom board.

Filling icecream containers with syrup.

Different feeding methods suit varying circumstances and beekeepers' way of doing things. One method may suit winter feeding, whereas another may suit spring stimulation. Each beekeeper needs to experiment with different techniques to adopt those that best suit their operations.
Dry sugar is fed to each hive in an open feeder, either in a tray on top of the frames, within a frame feeder placed on the inner mat, or simply poured down the sides of the frames. Bees will occasionally throw some of the sugar out the front of the hive, although this behaviour rarely exceeds a few days before the bees retrieve the sugar and return it to the hive.

PESTS

The two main problems feeding syrup are robbing bees and ants. It is important when feeding some colonies and not others, that care is taken not to spill syrup. When all colonies are fed, robbing does not appear to be as big a problem.

Take great care not to spill syrup in the apiary.

Ants can be a major problem worrying a colony and all care should be taken to discourage ants from being attracted to an apiary. Again, take great care not to spill syrup in the apiary and only feed enough syrup that can be consumed within one to three days. If ants become a major problem it may be necessary to move the apiary or seek advice on means of controlling them.

SUGAR VERSUS ALTERNATIVES

White sugar is pure sucrose and thus emulates nectar.

Nectar as collected by field bees is principally sucrose, a disaccharide. This is broken into levulose and dextrose, which are monosaccharides, in the process of producing honey. The sugars levulose/ fructose, or dextrose/glucose are interchangeable.

White sugar is pure sucrose and thus emulates nectar. Glucose and fructose were found to be half as attractive to foraging bees as compared to sucrose. Other sugars may or may not be attractive or beneficial to bees. Some sugars are highly toxic.

Readers of North American beekeeping literature will continually come across the term "high fructose corn syrup", or HFCS. Why do beekeepers use HFCS instead of white sugar? The primary reason is the price, with HFCS 30–40% cheaper than white sugar. This is not currently the situation in Australia, thus there is no case to use HFCS in Australia based on any cost savings.

Not all corn syrups are satisfactory to feed to bees.

The production of HFCS starts when starch is separated from the corn kernel. The starch suspension is liquefied in the presence of acid and/or enzymes which initially convert it to a low-dextrose solution. Treatment with further enzymes continue the process of converting the starch to sugars. At any stage, refiners can stop the process. Many corn syrups have high starch contents and can be quite toxic to bees. HFCS has no starch content and is now sold in North America as HFCS 42 or 55. HFCS 42 has 71% solids, of which 42% of the solids are fructose, the rest being higher saccharides. HFCS 55 has 77% solids, of which 55% of these solids are fructose. HFCS 55 has 6% more sugars (solids) than HFCS 42. The latter HFCS 42 is more unstable and will granulate in a third of the time than HFCS 55. If HFCS 42 granulates in the combs, it becomes extremely hard and very difficult for the bees to utilise. The advantage of HFCS 42 is that it is cheaper, but must be utilised soon after its purchase. The higher saccharides in both HFCS offer no caloric value (energy) to honey bees.

Major problems have occurred by using corn syrup due to residue starch, acid or enzymes in the final product. Not all corn syrups are satisfactory to feed to bees and their use should be carefully monitored.

Detrimental sugars

Waste sugar from the manufacture of sweets, etc., can be a very cheap source of sugar for beekeepers. Unfortunately, each batch will vary in the potential contaminates it contains. Flour or starch and salt are two ingredients that may be present and are potentially toxic to bees, particularly as their concentration increases. Thus, using waste sugar should be conducted with caution.

Using waste sugar should be conducted with caution.

Sugars which are poisonous to honey bees even at very low levels include galactose, arabinose, xylose, melibiose, mannose, raffinose, strachyose and lactose. Pectin and many gums are toxic to honey bees. Lactose and galactose occur in milk and milk products, raffinose can be found in some soy bean products.

Hydroxymethyl furfural or HMF is a naturally occurring compound in honey. The levels are considerably lower in lighter coloured honey than darker honey. HMF has been demonstrated to be toxic to honey bees and in one case a sample of eight year old honey fed to bees gave them dysentery similar to effects of poisonous sugars. The HMF levels in extracted honey rise over time, particularly when exposed to heat. This is another good reason for not feeding honey to bees, besides the risk of spreading bee diseases.

HMF has been demonstrated to be toxic to honey bees.

CHAPTER 4

POLLEN SUPPLEMENTS/SUBSTITUTES

WHEN TO FEED

Breeding conditions within Australia vary considerably across the country and from year to year. Providing a pollen supplement or substitute to honey bee colonies may be necessary under a range of circumstances which is not necessarily consistent on an annual basis. There may be significant differences between apiaries working the same species for nectar, with one site providing adequate pollen and another site not. Some circumstances that may require the application of pollen supplements include:

Whenever bee flight is restricted. This is usual during periods of cool weather. It is particularly important in maintaining the continuation in rearing drones when producing queen bees. Any break in pollen availability will provide a signal to the nurse bees to limit or stop the flow of food to developing drone larvae.

Weak colonies may benefit by the ready availability of a supplement as the number of field bees in this scenario are very low as a percentage of the total colony. The majority of bees will be tending brood and carrying out nurse bee duties. For this reason nucleus colonies may be prime candidates for a pollen supplement early in the spring, as flight may also be restricted by cool weather periods.

Pollen deficient honey flows present major management problems for beekeepers. Some classic floral species include yellow box *(Eucalyptus melliodora)*, mugga or red ironbark *(Eucalyptus sideroxylon* or *Eucalyptus tricarpa)*, yellow gum *(Eucalyptus leucoxylon)*, york gum *(Eucalyptus loxophleba),* and napunyah *(Eucalyptus ochropholia)*. These species contribute considerable amounts of honey to the national honey crop, yet the pollen produced by these plants is not collected in any significant quantities sufficient to maintain a healthy populous colony. Without pollens available from other species or the provision of a pollen supplement, honey bee colonies are seriously depleted in population and have been known to perish. There have been examples of hives placed on mugga ironbark honey flows and the beekeeper returning some eight to ten weeks later to find two full boxes of honey and no bees. The colony had completely perished due to no brood rearing as a result of no pollen.

When a pollen source is of doubtful quality, the decline in population may be delayed or subtle. Examples include white box *(Eucalyptus albens)* on the Northern Tablelands of NSW, or mallee in the Goldfields region of WA. Agricultural crops such as lucerne *(Medicago sativa)* and sunflower *(Helianthus annuus)* provide pollen low in protein and deficient in essential amino acids. There are many sources of pollen that are low in protein or deficient in one or more amino acids, yet they do not pose a serious problem in the nutritional management of honey bee colonies. In most cases these pollens are only a fraction of the total pollens being collected by a colony. When a colony is able to collect quantities of pollen from three or more species, any deficiencies in any one species are unlikely to cause any significant problems. The main concern for beekeepers is when a colony has access to only one source of pollen and the nutrients provided by that source are lacking in so far as honey bee nutritional requirements are concerned. In this case the area of brood tended by the nurse bees will reduce and the longevity of adult bees will decline. The provision of pollen supplements during these types of conditions will assist a colony to stay populous and healthy.

POLLEN

Ideally, colonies of honey bees should have access to pollen as collected in the field to satisfy their nutritional requirements. As this is not always possible, the next best course of action is to harvest pollen from incoming field bees by the use of a front or bottom fitting pollen trap. Store the pollen appropriately and feed it back to the colony at a later date when conditions require this to occur.

Pollen should be stored frozen.

Trapping pollen should only occur when the colony has a strong population with ample field bees, and there is an abundance of quality pollen available in the field. These conditions may only occur during rare or infrequent periods in many beekeeping regions within Australia. For this reason, purchasing pollen may be more feasible for use in supplements but will need to be sterilised.

The treatment and storage of pollen will seriously impact on the level of nutrients. Many of the chemical components of pollen including protein, fats and vitamins deteriorate over time. The only substances that remain relatively stable are the minerals and sugars.

Under normal conditions the field bees return to the hive and the pollen pellets are removed by the house bees and packed in cells around the brood area. Further addition of sugars and enzymes creates bee bread through lactic acid fermentation. This tried and true method is very effective at preserving the nutritional value of pollens.

Pollen and honey may contain American Foulbrood or Chalkbrood spores.

Very occasionally, due to an excessive abundance of pollen, honey bees will fill several combs with pollen which restricts the capacity of a colony to rear brood. At other times the queen may fail and the colony continues to collect and store quantities of pollen. In these cases the combs may be removed and stored for feedback to colonies when required in the future. Waxmoth is a major problem in these circumstances and the combs are best stored in a cool room or freezer.

If trapping pollen, then storage is normally either by drying or freezing. Pollens, when first trapped, may range in moisture content from 10–20%. If not properly stored, mould will be a major problem. For ease of transport, drying has become the most preferred method of preserving pollen. Unfortunately this method also reduces the nutrients in the pollen the quickest. Pollen stored for 12 months or more by this method is said to limit brood production. Dry pollen stored for two years or more fails to satisfy the nutrient requirements of brood unless it has been irradiated.

Ideally pollen should be frozen, preferably at -15°C, to retain its nutrient value. Even under these circumstances, after two or three years, the levels of the nutrients will be reduced. Some of the vitamins are said to deteriorate very quickly. Fats will oxidise even at lower temperatures, although the deterioration of protein will be reduced the lower the temperature.

This deterioration in nutrient value will also occur to various degrees with all components considered for use in pollen supplements. Thus, as far as attractiveness and stimulus on brood rearing is concerned, fresh pollen is the most desirable, followed by pollen stored in the freezer, then dried pollen, then recipes containing a portion of pollen. The least attractive pollen supplement to honey bees is one that contains no pollen. These mixtures will not stimulate a colony to rear brood past two brood cycles, when no pollen is available by any other means.

The problem with pollen is that it may contain honey bee pathogens such as American foulbrood *(Paenibacillus larvae* subsp. *larvae)* or Chalkbrood *(Ascophaera apis)*. These diseases are readily transmitted in honey bee-collected pollen and honey. Unless one is 100% certain of the disease status of the colonies from which the pollen is being collected, all pollen should be gamma irradiated before inclusion in any pollen supplement or being fed back to colonies on its own.

The other major drawback with pollen is the cost of collecting and storing it. Honey bee-collected pollen may be up to 10–20 times more expensive per kilogram to purchase than soy flour, a commonly used ingredient in supplements. Thus, to be cost effective in providing pollen supplements, there will be a trade off between increasing the ratio of pollen in any recipe and reducing the cost.

BEE BREAD

One method that can be used to preserve honey bee-collected pollen for longer periods than freezing or drying is to create bee bread. The process involves a type of lactic acid fermentation which renders it more digestible and increases its storage life considerably.

To produce bee bread, fill a container 75–80% of its volume with pollen. The container must be sealable and airtight. To this pollen add a starter culture made from *Lactobacillus xylosus* or Lactobacilli contained in whey. The recipe should be in parts by weight: 10 pollen, 1.5 honey, 2.5 clean water, 0.02 whey or a very small quantity of dried lactic acid bacteria. Leave the container sealed for storage. The process should first take place at temperatures between 28–32°C. After two or three days this temperature should be dropped to 20°C but not below 18°C. After 8–12 days at 20°C the fermentation process should be complete. With the high initial temperatures this will promote the growth of the lactic acid producing bacteria over other yeasts. The desirable bacteria should dominate after two or three days. If done correctly this will preserve its nutrient value and extend its shelf life considerably, said to be almost unlimited.

CHOICE OF INGREDIENTS

Besides honey bee-collected pollen, a range of other substances have been trialled in an effort to fulfil periods of pollen shortage in the field. There is no complete success story whereby any one ingredient or recipe has performed in all circumstances where supplements are provided. Soy flour has been utilised extensively for a number of decades with various degrees of success. Other ingredients that have been trialled include:

Canola flour — has a lower protein level than soy flour and is said not to be attractive to bees.

Sunflower flour — has a lower protein level than soy flour and has a repellent property, whereby bees avoid consuming supplements with this ingredient.

Sorghum flour and triticale flour — are highly attractive to bees but have a very low crude protein content.

There is no complete success story whereby one recipe works in all circumstances.

Brewers yeast, bakers yeast and torula yeast — are all very attractive to honey bees. They vary considerably in their cost and are normally used as a portion of a recipe, primarily to provide vitamin B complex. Even so, all yeast alternatives are high in protein (around 50%). There are many yeast products produced by various companies and given different names. Essentially, yeast is the dry pulverised cells of *Saccharomyces cerevisiae*, a type of fungus. The different yeast products contain varying levels of ash. Care should be taken to keep the ash content of the final pollen supplement as low as possible. Some yeast products have salt levels as high as 12%.

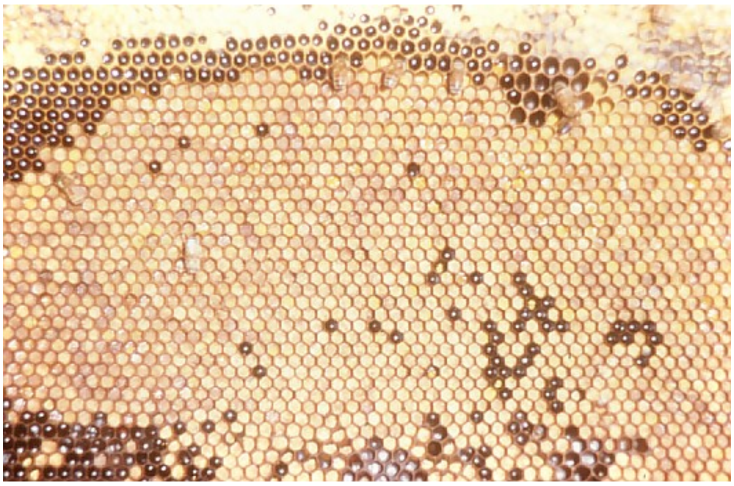
Vitamin, mineral and amino acid supplements — designed for livestock have been added to pollen supplements at various rates, usually between 1–3%. Mineral supplements designed for sheep and cattle have been fed to honey bees, but have shown to be unsatisfactory for adult honey bees. These mixes have been found to be lacking in potassium and contain excessive calcium and sodium.

Various feeding trials indicate that a diet containing 1% ash is probably ideal, although diets containing up to 3% ash will still not seriously impact on brood rearing. Diets with up to 8% ash were shown to seriously reduce brood rearing.

Other substances such as dried egg yolk, skim milk powder, and peanut flour have been included in various recipes, but offer no advantage above those already mentioned.

SOY FLOUR

Soy flour has long been the ingredient of choice in pollen supplements due to its attractiveness to bees, availability, price as compared to other materials and relatively high protein content. It is low in vitamin B complex, thus the reason why yeast is often added to soy flour when producing pollen supplement.



Soy flour stored in comb by bees.
Photo: W Jones

Soy flour has been either fed on its own to bees or used as the prime ingredient in various pollen supplement recipes. Not all soy bean flours are the same. Even the same product may differ between manufacturers. Essentially, solvent extracted soy has a high risk of residues of Hexane, which is toxic to bees. When soy flour is heated during the manufacturing process, proteolytic enzyme inhibitors are destroyed. These chemicals interfere with the digestion of the protein. If excessive heat is used the protein may be denatured. Fresh soy flour is critical, as old flour has been shown to be toxic to bees. Flour should be used within six months and stored in a cool, dry environment. An explanation of the different types of soy flour is as follows.

The information was supplied by Will Tiswell, Hyfeed, Toowomba, Queensland.

Solvent-extracted soy — most common commodity in the world market. By-product of oil extraction. Highest protein level (50%) of the soy flour processes, also one of the cheapest. Major issue with solvent residues potentially toxic to bees.

Expeller processed soy — heated by different means to primarily reduce "anti-nutritional factors". Depending on the amount of heat applied, the protein can be denatured and made unavailable. The oil is removed from the soy bean by physical crushing prior to the heating process. This is the only non-chemical process for high protein soy flour. Nutritionally it has the lowest levels of anti-nutritional factors and is regarded to be superior to solvent extracted process. Protein 50%; oil 6%.

Full fat soy — main processes to produce full fat soy flour include debittered, extruded, expanded or micronised methods. Micronised soy full fat (microwave heat) is the least affected flour by the process and has high anti-nutritional factors. This method does not break open the cell structure so the oil remains trapped in the cell. This method produces the cheapest full fat soy.

Baker's soy flour — is debittered uncooked. Baker's soy flour has the highest levels of anti-nutritional factors. Protein 38%, oil 18%.

By increasing the content of pollen in the mix, consumption by the bees increases.

Expander full fat soy — indicates that the product has had steam heat applied. The process preserves the protein and reduces the levels of anti-nutritional factors. Protein 34%, oil 14%.

Extruded full fat soy — is produced under pressure and is a very oily consistency. It is the most expensive of the three methods used to produce full fat soy flour. The cell structure is broken open and the nutritional contents are readily available. Protein 38%, oil 18%.

Tray of pollen under the lid — majority of pollen removed.

Another problem identifiable with the use of soy flour is its low levels of vitamin B complex. As yeast is relatively rich in vitamin B complex, this is the ingredient of choice added to soy flour to make up for any vitamin deficiency. One experiment described yeast at 20% of the mixture as a satisfactory level to supply vitamin B.

RECIPES

Various combinations of recipes have come and gone through the beekeeping literature over the last 50 years. A few things stay fairly constant. By increasing the content of honey bee-collected pollen in the mix, the greater its attraction and consumption by bees. Without pollen the pharyngeal glands are not stimulated and the nurse bees are not able to fully tend to young larvae. Pollen content of 10–25% is probably going to provide nurse bees with the necessary nutrients to produce brood food and ensure the mixture is attractive to the bees.

Soy flour may be as much as 20–100% of the recipe. If fed dry as a flour, 100% soy may be made available to the bees. If soy is a component of a recipe, then the ratio in the mix will reduce depending on what other ingredients are available.

The primary contribution from yeast is derived from its vitamin B complex content. These vitamins are not abundant in soy flour and may have deteriorated in honey bee-collected pollen that has been dried.

Vitamin, mineral and amino acid additives are manufactured for the various livestock industries and have not been formulated for insects. Additives containing minerals should particularly be utilised with caution. Their use has not been evaluated and, as such, their addition to any recipe is based on speculation that they might be beneficial. As all the other ingredients used in the recipe will contain various levels of minerals, vitamins and amino acids, all the honey bee nutritional requirements for these chemical components are possibly already being met.

The same can be said for the addition of oil to any recipe. Certain fatty acids can be toxic to bees once they exceed a certain level. Knowing what the fatty acids are in the other ingredients is critical before adding further quantities of oil or fat.

To form a pattie, cake or biscuit, sugar, water and honey may be added. High levels of sugar will make the finished product harder as compared to using honey, which makes the mixture softer. Honey will add to the attractiveness of the final supplement, but it should be either gamma irradiated or tested for American foulbrood spores before it is included.

A pollen supplement may be an expensive method of feeding sugar.

A recipe may thus look like this:

Pollen	10–25%
Soy flour	20–100%
Yeast	20–25%
Sugar/honey/water	20–50%

Warning: Frequently bees may consume the mixtures presented to them, not for the nutrients as normally obtained from pollen, but rather for the honey/sugar stimulus. If there is no fresh nectar available to foraging bees or sugar syrup is not being provided to the colony, then it is a dubious exercise to feed pollen supplements. Otherwise a pollen supplement may be an expensive method of feeding sugar.

MAKING/MIXING

Once all the ingredients have been sourced, it is important to store them correctly. Any prepared pollen supplement is best kept in the freezer or fridge until required. Only enough ingredients should be purchased to satisfy the immediate needs of the colonies. Most of the ingredients, except dry sugar, have a limited shelf life of between 6–12 months.

Sourcing the ingredients may present a problem. Flour milling companies don't always have what you want in stock, so forward planning will be necessary. Contact relevant manufacturers at least two months before the supplement is required.

The amount to be fed to a colony is determined by the colony's requirements.

The finer the particle size of the flour, the better. Pollen grains range in size from 15–60 µm. Coarse or large particles are not easily gathered by the bees and are ignored. Flour particle sizes of 500 µm (0.5 mm) or finer are desirable. The closer to pollen grain size the better.

Pollen supplement placed above brood nest.

Mix all ingredients and blend together. Then add the sugar to hot water to aid in its dissolving and add honey if this is desirable. Once this liquid is mixed, add it to the dry mix until the desired consistency is reached. This can be done in a commercial dough mixer used by bakers, a cement mixer, or even the hard way — in the bath tub. One beekeeper modified a commercial sausage maker for the purposes of mixing the ingredients together. The machine had to be especially geared to account for the heavy consistency of the final mix.

The final dough, if dry enough, can be rolled and cut into dry biscuits or cakes. There is also specialist bakery machinery that will do this if one wants to produce large quantities, otherwise it may be a case of putting the dough in the middle of a table and rolling it out to the desired thickness. A useful thickness is one that will fit under the queen excluder (around 10 mm). If the mixture or dough is more sloppy, then handfuls may be removed and placed between sheets of greaseproof paper. They can also be squashed to the desirable thickness. Another method is to take a bucket of the dough to the apiary and scoop the desired amount into each colony. If the bees don't eat this sloppy dough it can present a major clean up problem for the beekeeper.

FEEDING / PLACEMENT OF SUPPLEMENT

The amount to be fed to each colony will largely be determined by the need for the supplement. Weaker nucleus colonies of three to four frames of bees may only need 100–200 grams every one or two weeks, whereas a strong colony covering 10 to 12 frames may consume 500 grams of supplement every one or two weeks. The consumption rate will be a function of the area of brood to be fed, which is influenced by the amount of nectar/sugar stimulus and the vigour of the queen. Far too often the amount of pollen supplement is restricted by the beekeeper which then leads to a reduced area of brood. A rule of thumb should be that enough supplement is fed to a colony so that it doesn't completely run out before the next visit by the beekeeper or a natural pollen source becomes available.

Open feeding pollen substitute in wheelie bin.
Photo: W Jones

The closer the supplement is placed next to the brood area, the more likely it will be consumed.

The placement of the supplement will have a considerable bearing on the rate of consumption. The closer to the brood area the supplement is, the greater the likelihood that it will be consumed.

There is an alternative view to the reasons why bees consume supplement placed directly above the brood, and that is it's simply in the way. Even so, there is sufficient evidence to suggest that to gain the best acceptance of a supplement, it should be placed directly above the brood, below the queen excluder. This placement is probably more important when the colony is still collecting pollen, be it of a low quality. When a colony is more in need of a total pollen replacement due to no fresh pollen available in the field, then the bees are more likely to seek out pollen supplement wherever it is placed, inside or outside of the hive.

Bulk feeding dry pollen supplement.
Photo: W Jones

Normally, dry mixes are fed in bulk containers within the apiary and the field bees fly to collect it. Straight soy flour is normally provided by this method. While reducing disturbance of the colonies and possibly minimising Nosema disease *(Nosema apis)*, this method favours stronger colonies and is not satisfactory during wet and cold weather. This method is quick, simple and easily monitored, although unwanted attention from feral pigs, livestock, possums, mice, etc. can cause problems. Soy flour provided in this fashion also forms a crust on the surface after a period of days which can prevent the field bees accessing the flour.

Soy flour feeding in empty bee box.

Pests associated with feeding pollen supplements include waxmoth and the small hive beetle. Waxmoth is only a problem when the supplement is unattended by bees or the colony is extremely weak. Under these circumstances it is problematic if in fact a colony is strong enough to warrant the labour and time necessary to keep it alive. The small hive beetle, a recent arrival in Australia, could pose a significant nuisance when feeding pollen supplements. In areas experiencing high humidities (70% plus) and temperatures approximating

Feeding soy flour — note mesh over drum.

30°C, the beetle will thrive. Providing pollen supplements to weak hives may favour the beetle with a readily available food source. In these circumstances, supplementary feeding should be closely monitored and either the amount of supplement be reduced or the adult beetle population controlled.

HISTORY

Over the years there has been a range of pollen supplements manufactured for the Australian beekeeping industry by individuals and companies. The evidence of their success is patchy. The reasons for this are numerous, but probably include the lack of attractiveness of the product, the cost of the product, limited knowledge by beekeepers of where, when and how much to feed to each colony, plus the problem of the manufacturer obtaining fresh ingredients and ensuring ample fresh product was available when required.

Soy flour feeding on mugga ironbark flow.

Given that most of the ingredients have a limited shelf life, yet they have been sold without a use by date. Not all supplements would be used when purchased, probably being kept for 12 months or more. When this “old” supplement is fed to colonies it either produces disappointing results or has a toxic effect on the colony. Either way, this creates a poor image for supplementary feeding and, as such, the practise is often terminated.

One product worthy of mention was produced in SA. Krawaite was the name of a pollen supplement manufactured by Kraft in 1965–1966. It received widespread publicity and was available through Kraft divisions in WA, SA, VIC, NSW and QLD. The supplement was packaged in half pound packs (226 gms), which were designed to be cut open and be placed above the brood combs under the queen excluder and honey super. If the colony required more than one pack at a time, then two or three packs could be placed in the same area of the hive, only opening one pack and letting the bees chew their way into the other packs.

There were a number of trials conducted with the supplement, one of note was for a whole year during 1965. Essentially five hives were the control (no supplement) and five hives were provided Krawaite on a regular basis throughout the year. The weight gain and brood area were measured every 21 days to determine the impact of the treatment. During this 12 month period various flowering and seasonal events occurred that influenced the results. The total honey yield (av./hive) for the treated hives was 759 lbs (344 kg), whereas for the hives not treated the annual yield average was 550 lbs (250 kg). A substantial gain in yield and profitability was obtained in 1965. The calculated economic gain was based on the cost of Krawaite pollen supplement ($3.66/hive) versus the price for honey ($0.08/lb or 18c/kg). Unfortunately, there was no factoring in of the travel to and from the apiary and the labour to provide the supplement every three weeks throughout the year.

Brood rearing also declined in all colonies with and without the supplement in July and early August, this may have been due to winter conditions or Nosema. The results may have also been influenced by the race of bee heading each colony, which were Carniolan. Italian bees would have responded more rapidly to the changes in food supply.

Even though the literature and research published on Krawaite was all very positive, there were some expressions of concern that the supplement was not working in all circumstances. A letter to Keith Doull, a senior researcher at the Waite Agricultural Research Institute in SA from Alan Clemson, the chief apiary officer of the NSW Department of Agriculture, suggests that tests conducted in NSW provided unsatisfactory results.

The detail and nature of these tests are not available, which is often the fate of negative results. Even so, the product Krawaite eventually faded from use in the Australian beekeeping industry, probably due to a number of reasons that can only now be speculated.

CHAPTER 5

ECONOMICS

COST VERSUS BENEFIT

The most important piece of equipment a commercial beekeeper can own is a calculator. Honey prices will forever be driven by what the market wants to pay. There are two ways of increasing the profit margin, either by increasing income or decreasing expenses. Supplementary feeding strategies offer both options.

The most important piece of equipment a commercial beekeeper can own is a calculator.

Normal mainland Australian commercial beekeeping practice involves apiaries being periodically moved to new sites as the floral conditions dictate. When these conditions are not apparent locally (i.e., within 200–300 km), then moves further afield, up to 1000 km, are not uncommon.

There is a major expense in moving apiaries, particularly long distances and into regions unfamiliar to the beekeeper. Expenses include time spent looking for new sites, diesel fuel, and wear on the truck. These moves are usually either as a means of keeping the colonies alive and breeding, or to work a reliable honey flow.

Each beekeeper has their preferred management patterns. Some beekeepers prefer to keep apiaries as close to home as possible to minimise costs, while others prefer to chase major reliable honey flows even if they are a considerable distance from home. The basic rule every commercial beekeeper has is that of maximising worker populations in colonies prior to any anticipated honey flow.

Maximising bee populations is done by seeking breeding conditions, characterised by a light nectar flow supported by a range of nutritious pollens. These conditions can be partly emulated by the beekeeper by providing a light nectar flow stimulus in the form of sugar syrup. Often pollen is available in the field, but the bees are not inclined to collect it.

Maximising populations is done by seeking breeding conditions.

Nectar availability is the main trigger for an expansion of the brood area. An increasing area of brood subsequently stimulates a colony to collect more pollen. By moving hives into areas where pollen is readily available but nectar is replaced or supplemented by sugar syrup, the colony will be stimulated to expand its population. This strategy increases the options for managing commercial honey bees.

Now with the use of sugar syrup, large populations can be built or maintained prior to anticipated major honey flows without the need to move considerable distances to achieve the same goal. Refer back to previous chapters in relation to the different methods of feeding sugar syrup. In summary, providing a small amount of a 50:50 sugar syrup on a continuous basis will maximise the stimulation effect. Providing larger volumes of thicker sugar syrup will significantly reduce the stimulation effect. As the costs of moving apiaries increases as compared to the cost

Nectar availability is the main trigger for an expansion of the brood area.

of sugar, then sugar syrup feeding must be seriously considered as an economically viable alternative.

The economics and advantages of pollen supplements or substitutes are not as clear cut as sugar syrup feeding. Certainly conditions dictate that beekeepers need to manage colonies to avoid serious shortages of pollen or move apiaries onto sites that have a good supply of pollen after they have been exposed to a poor quality pollen for any length of time. Unfortunately it is not always possible to do one or the other. Some major honey flows are characterised by a shortfall of pollen or by poor quality pollen. Traditionally, the preparation before and remedial actions after the flow are the main focus for managing such circumstances.

Pollen supplement is very beneficial in some circumstances.

Providing pollen supplement has not always been successful. Many beekeepers buy or mix pollen supplement and swear that it is beneficial, but there are just as many who state that they had a go at this strategy but it failed. A perfect pollen supplement that works in all circumstances has yet to be developed. Even so, pollen supplements can assist shortfalls of naturally occurring pollen for one or two generations (three to six weeks).

Measuring the impact of the use of pollen supplements is often difficult. Ultimately it could be determined by the area of brood, size of colony or the quantity of honey produced over time. Frequently pollen supplement is provided, in many circumstances, as an insurance by the beekeeper. Many beekeepers interviewed for this publication, stated clearly that they provided pollen supplement to colonies to make themselves feel as if they were looking after their bees!

The other major problems with pollen supplement is the cost of the ingredients and their limited shelf life. Honey bee-collected pollen is a vital component of most recipes, but is also the most expensive. All components will deteriorate over time no matter how well they are stored. If possible, ingredients and prepared pollen supplement should be stored in a cool room or freezer to slow down this deterioration. After 12 months, the use of any pollen supplement or ingredients must be questionable. Sourcing ingredients for pollen supplement can also be difficult, with the same product having different food values and different levels of attractiveness, depending on the manufacturing process.

There is no doubt that pollen supplement is very beneficial in some circumstances, but these conditions change and the cost benefit is not always apparent. In these situations it would be worthwhile carrying out your own research to measure any benefit or gain. This is not difficult to do, and is worth the investment in time to allow better informed decisions next time similar circumstances with shortages of pollen or poor quality pollen occur.

CONTAMINATION

Honey contaminated with sugar or corn syrup can be readily detected by a range of chemical analyses. Honey should, on average, contain 1–3% sucrose or white sugar. Out of 919 samples analysed in the United States, only 19 (2%) contained sucrose over 5%. Of these 19 samples, a significant number originated from lucerne and sweet clover. The honey types that exhibit high sucrose content are known to be deficient in natural invertase and are slow to ripen. All these honeys will reduce in sucrose levels below 5% when stored for a few months at room

Contaminated honey can be readily detected by a range of chemical analysis.

temperature, if they aren't heated excessively in the extraction process. Added sucrose does not tend to invert, is more stable in the extracted honey and is readily detected after a period of storage.

The use of pollen supplements usually does not pose a problem in contaminating extracted honey. A research project conducted in 2004 on mugga ironbark required soy flour, pollen and yeast to be placed in trays under the lid of each hive. In the process of collecting the flour or powder, the bees spread the mix through the honey super. The resultant extracted honey, although from a pure floral source (mugga ironbark), was contaminated to a very low extent with fine soy flour and pollen particles. Some tests measure the content of the protein in honey and use this to determine any contamination with other sugars. In this case the tests suggested contamination of the mugga ironbark honey when this wasn't the case. Other tests had to be conducted to verify the sugar ratios of the honey and check that contamination of unwanted sugars was not the case. To avoid this complication, beekeepers should probably avoid feeding pollen supplement in a powdered form above a honey super during a nectar flow.

Medicating syrup or pollen supplement is not recommended. There are two very good reasons for this practice to be avoided by all beekeepers. Antibiotics used to treat colonies with infections of European Foul Brood (EFB) have been applied to each hive mixed with sugar syrup or dusted over the brood area in a powdered form. Both methods assist the colony in recovering from an infection of EFB, although antibiotics provided in sugar syrup have been demonstrated to more likely be stored within the honey super.

Antibiotic testing of honey is a regular event by honey packers and market regulators. Accurate records should be kept of all antibiotic usage and the first extraction after any treatments should be labelled and the relevant packer notified. The dry or powdered method of treating infected colonies does not eliminate potential contamination, it only reduces it.

Medicating pollen supplement creates another set of problems. By the very nature of the take up of pollen supplement, the medication will be made available over a number of days and at very low levels. This creates an ideal environment for resistant microbes to multiply. Any population of microbes will have strains ranging from those that demonstrate some resistance to ones that are highly susceptible to the antibiotic. Sub-lethal doses of antibiotics may not kill the microbes, demonstrating some resistance and thus the population of bacteria recovers over time, be it now demonstrating a degree of resistance to the antibiotics used.

The doses recommended are set to ensure close to a 100% kill of the microbes targeted. Any less will quickly manifest itself in a resistant population to the antibiotics used. This is the scenario that is currently occurring in many countries where the use of various antibiotics is now failing to control the diseases that it is being used to suppress.

Keeping good records is critical. All agricultural enterprises and food handling businesses are being encouraged to adopt quality assurance procedures. This process has two prongs, adopting industry best practice in all procedures to avoid or eliminate contamination of the food being handled, and ensuring records are kept of the whole process. Whenever supplementary feeding bees in any circumstance, adopt industry best practice and keep good records.

EXPERIMENTAL DESIGN

Basically the formula for carrying out experiments is straight forward. Identify what it is that you wish to measure, measure the variations and record the data, analyse the data and draw conclusions.

In most circumstances the bottom line is how much honey is extracted from each colony over time. This can be done by simply weighing empty supers before they go onto the hive and weighing the full supers as they come off the hive. If time doesn't permit this to happen in the field, then number the hives and supers and record which supers belong to which hive, weighing the full supers back in the extracting room.

Pollen supplement is often provided too little too late.

Not all colonies are equal, even given the same treatments This is primarily due to differences in the queen's response to the food materials provided. Thus there is a need to include a substantial number of colonies in each treatment. If we have an apiary of 100 hives, then keeping 10 hives separate to the rest as controls (no treatment) or to trial a new formula, should be considered the minimum number. If there are 20 hives in the apiary, then only two treatments should be considered. One of these treatments may be doing nothing, i.e., the control.

Frequently when it comes to providing pollen supplement, beekeepers provide too little, too late. Another design may be increasing the amount of supplement per hive, particularly if the supplement is regularly consumed well before the return visits. The period of time after the treatments have been applied must be long enough to measure any significant response, i.e., measuring the amount of honey removed from a colony three or four weeks after any treatments is premature. Brood requires three weeks for each cycle. If the supplement provided to the colony stimulates brood rearing and increases the longevity of adult bees, then the difference between this colony and another colony not treated with supplement may only start to show up within four to six weeks as the shift in populations occur. There is always a delayed reaction in population increase or decrease depending on the brood area expanding or contracting.

A sure sign of a failing queen is when some colonies do not eat the pollen supplement.

Don't provide supplement to the entire apiary and none to another apiary elsewhere. There are often significant location differences between apiaries for a range of reasons. It is best to test supplements within the one apiary, leaving at least 10 colonies untreated as a control. If you are certain that what you are feeding a colony works and you wish to trial another method of feeding or recipe, then it may not be necessary to have non treated colonies. Instead, provide supplement to all the hives in the apiary and provide the new formula to 10 hives. For any supplementary feeding to work best, actively laying queens are critical. It is a sure sign of a failing queen or queenless colony when supplement is not consumed in some hives as compared to others.

Comparative trials with bulk open feeding may be a little more difficult to measure in relation to the response. In this case it would be ideal to provide bulk feed to two apiaries and leave two apiaries unfed. This would require a large number of bee hives, but it would give the results a lot of credibility if the treated and control apiaries were replicated (repeated) twice.

After collecting all this data then it's time to make sense of it. If you have gathered a lot of measurements, then you are beginning to experience what researchers have to go through. Don't waste the data, write a short article on what you did, why you did it, outlining the results and send it to one of the beekeeping newsletters or magazines. This exercise alone will help you tidy up your thoughts on what it means to your management of honey bees in the future.

Collecting adult bees to test for Nosema disease.

Weighing hives to measure weight gain.

A lot of beekeepers "have a go" at various supplements, etc., and lose interest fairly quickly. The following questions need to be asked:

a) Was it enough supplement to meet the requirements of the colony?
b) Was it fed early enough to prevent a decline or promote breeding?
c) Was another factor such as Nosema disease having a major impact on the results?
d) Were the pollen supplement and ingredients fresh?
e) Was the poor response due to old queens or had the colony already weakened substantially?
f) Was the syrup contaminated with yeast or other substances known to reduce the longevity of adult bees?
g) Were the ingredients used in the pollen supplement free of substances known to be toxic to bees?

The bottom line is don't be put off by one failed attempt to trial supplementary feeding. Review what you did, discuss it with others, and consider retrying in different circumstances. The only way to stay in business in the long run is to adapt and change management practices as the circumstances dictate. Adopting supplementary feeding, either pollen supplement or sugar, will enhance the profitability of most beekeeping enterprises in Australia.

CHAPTER 6

POLLEN CHEMICAL COMPOSITION

The following are the known chemical compositions of bee-collected pollens collected in Australia. The data can be used by beekeepers to access the nutritional value of these various sources of pollen.

Honey bee-collected pollens vary significantly in their chemical composition, as they relate to the nutritional requirements of a colony. The species are listed in order of botanical name. A list of botanical and common names is provided at the beginning of the section.

Where there is only one result or figure for a particular species, this should be interpreted with caution. Multiple results, particularly from different sources, give one a reassurance that this is more representative of the species. The variation in chemical composition within the pollens of the one species can be significant, but not usually enough to change the general nutritional contribution of that pollen source to a colony. There are a few exceptions which may occur as a result of incorrect identification of the species or faulty chemical analysis.

There is a strong correlation within a genus, i.e., all clovers (*Trifolium* species) appear to have a CP% around 25%. Thus the beekeeper can use the information from closely related species to arrive at a probable value for species not tested.

INTERPRETATION OF THE COMPOSITION

Crude protein = CP, expressed as a % of the dry matter of the pollen pellet.

CP below 20% is regarded to be of a poor quality and unable to meet honey bee nutritional requirements. CP levels between 20% and 25% are regarded to be of average quality and are a satisfactory food source assuming there are no other limiting chemical components. CP levels above 25% are regarded as good to excellent quality pollens, even though they may be deficient in one or more other chemical components, particularly amino acids. As long as honey bees are able to consume sufficient quantities, they will be able to obtain the nutrients they require.

Mineral disorders occur in livestock, there is no reason to believe this is not the case with honey bees.

Amino acids — Protein is made up of a series of amino acids, 10 of which have been identified as essential to honey bees. The minimum amount of each amino acid has also been calculated as a ratio to the nitrogen content. The amino acids in this text are all expressed as grams/16 grams of nitrogen. The ideal ratios have been identified as follows: threonine 3.0, valine 4.0, methionine 1.5, leucine 4.5, isoleucine 4.0, phenylalanine 2.5, lysine 3.0, histidine 1.5, arginine 3.0, tryptophan 1.0.

If a pollen source has one or more of these amino acids below the ideal ratios, then the colony would need to increase the volume of pollen consumed to maintain the individual amino acid intake. This may not be a problem if the pollens are over 25% CP, there is a mixture of pollens from different floral sources, or the volume of pollen being collected is in abundance. Amino acid deficiencies would be expected when the volume of pollen being collected is limited as a function of the size of the colony and/or the combined CP levels of the pollens being collected approach 20% or below.

Minerals — An interpretation of the value of the mineral contribution from different sources of pollens is not possible, as the quantitive requirements for minerals by honey bees is not known. This information would be worth investigation if the beekeeper observes a problem in the colony which they think is related to nutrition, but cannot be definitely linked to CP levels or specific amino acid deficiencies. Certainly mineral disorders occur in other livestock industries and there is no reason to believe this is not happening in the management of honey bees.

Key to elements: Ca—calcium; Cu—copper; K—potassium; Mg—magnesium; Mn—manganese; Na—sodium; P—phosphorus; Zn—zinc.

Fats/Lipids — Similar to minerals, in as much as the exact requirements by honey bees for fat has not been quantified. What is known is that honey bees do have a need for fat in their diet, and pollens with higher fat contents appear to be highly attractive to foraging honey bees.

KEY TO SOURCE OF DATA IN TABLES

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(h[1]) Kleinschmidt, GJ (1989). *Honey bee body protein management in napunyah (Eucalyptus ochnophloia) country.* Honeybee Research and Development Council. Project No. QAC-4H.

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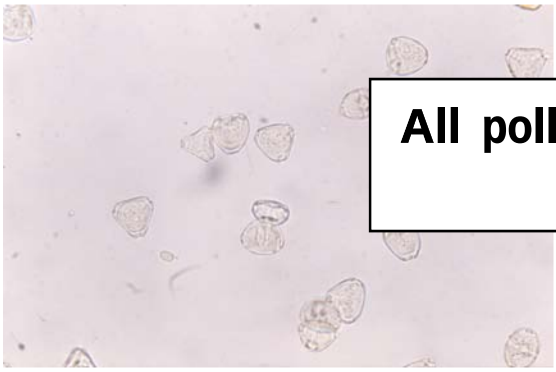
(k) Moncur, JW; Charles, R; Kleinschmidt, G (1993). *Honeybees to increase seed production in E. globulus.* CSIRO Division of Forestry. Australasian Beekeeper. 95(6): 251-254.

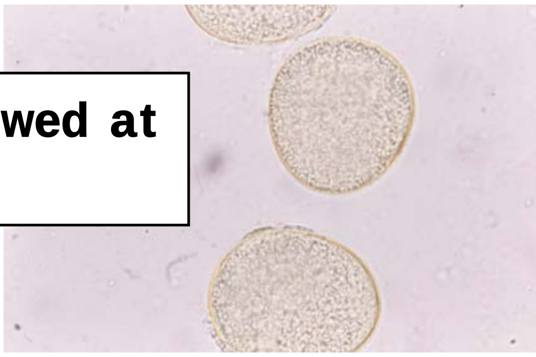
(l) Warhurst, P; Goebel, R (1995). *The Bee Book — beekeeping in the warmer areas of Australia*. Queensland DPI.

(m) Moncur, MW; Somerville, D (1989). *The use of honey bees for pollen transfer and increased pod set in black wattle (Acacia mearnsii)*. ABK. 91(2): 73–89.

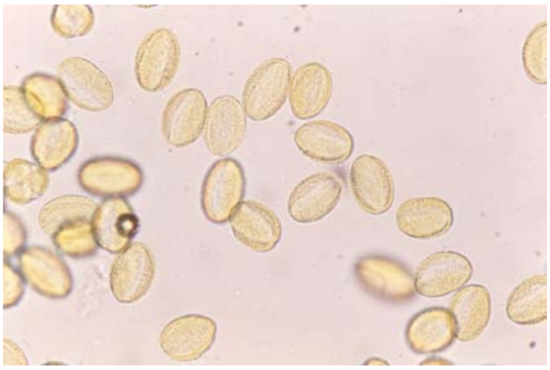
All pollens viewed at 400 x



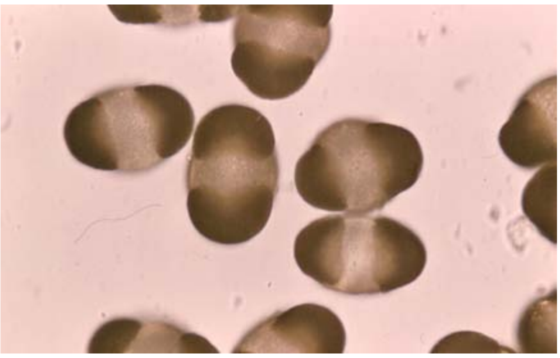
Red stringybark



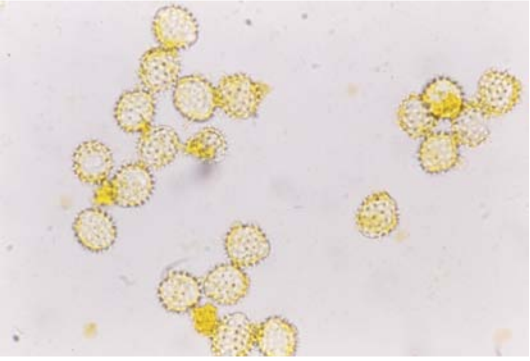
Faba bean



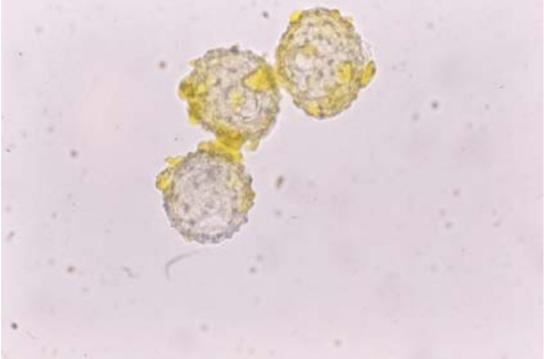
Canola



Radiata pine



Capeweed



Saffron thistle

BOTANICAL NAME	COMMON NAME
Acacia baileyana	Cootamundra wattle
Acacia cambagei	Gidgee
Acacia concurrens	Black wattle
Acacia cunninghamii	Black wattle
Acacia dealbata	Silver wattle
Acacia doratoxylon	Currawong wattle
Acacia implexa	Lightwood Hickory wattle
Acacia ixiophylla	Wattle
Acacia longifolia	Sydney golden wattle
Acacia mearnsii	Black wattle
Acacia melanoxylon	Blackwood
Acacia polybotrya	Western silver wattle
Acacia pyanantha	Golden wattle
Acacia spp.	Wattle
Acacia suaveolens	Sweet scented wattle
Acacia tetragonophylla	Dead finish
Acacia tindaleae	Gold-top wattle
Agerata riparia	Crofton weed
Ageratum houstonianum	Blue billygoat weed
Angophora floribunda	Rough barked apple
Angophora subvelutina	Coastal rough-bark apple
Andredera cordifolia	Madeira vine
Arabidella eremigena	Priddiwalkatji
Arctotheca calendula	Capeweed
Asphodelus fistulosus	Onion weed
Asteraceae spp.	Daisy family
Baccharis halimifolia	Groundsel
Banksia ericifolia	Heath leaved banksia
Banksia ornata	Desert banksia
Banksia serrata	Saw banksia
Brachyscome ciliocarpa	Showy daisy
Brassica napus	Canola
Brassica tournifortii	Wild turnip
Caduus nutans	Nodding thistle
Callistemon pachyphyllus	Wallum bottlebrush
Calotis cuneifolia	Purple burr daisy
Calotis multicaulis	Woolly-headed burr daisy

BOTANICAL NAME	COMMON NAME
Calotis spp.	Burr daisies
Carduus tenuiflorus	Slender thistle
Carthamus lanatus	Saffron thistle
Cassia spp.	Cassia
Cassia eremophila	Desert cassia
Cassia oligophyla	Limestone cassia
Cassinia laevis	Wild rosemary
Casuarina littoralis	Black she oak
Casuarina spp. *(Allocasuarina)*	She-oak
Centaurea solstitialis	Yellow burr
Chondrilla juncea	Skeleton weed
Cirsium vulgare	Spear thistle; Black thistle
Citrus spp.	Citrus
Corymbia calophylla	Red gum
Corymbia gummifera	Red bloodwood
Corymbia maculata	Spotted gum
Corymbia polycarpa	Bloodwood
Corymbia terminalis	Inland bloodwood
Corymbia trachyphloia	Pilliga bloodwood
Curcurbita pepo	Pumpkin
Echium plantangineum	Paterson's curse
Echium vulgare	Viper's bugloss
Eremophila bigoniiflora	Eurah
Eremophila duttonii	Boobialla
Eremophila mitchellii	Budda
Eremophila oppositifolia	Weooka
Eremophila sturtii	Sandalwood
Erodium crinitum	Blue crawfoot
Eucalyptus accedens	Powder bark
Eucalyptus acmenoides	White mahogeny
Eucalyptus albens	White box
Eucalyptus andrewsii	New England blackbutt
Eucalyptus aromaphloia	Scent bark
Eucalyptus blakelyi	Blakely's red gum
Eucalyptus botryoides	Bangalay
Eucalyptus bridgesiana	Apple box
Eucalyptus caliginosa	Broad-leaved stringybark
Eucalyptus camaldulensis	River red gum

BOTANICAL NAME	COMMON NAME
Eucalyptus cephalocarpa	Silver stringybark
Eucalyptus chlorochlada	Pilliga gum
Eucalyptus crebra	Narrow-leaved ironbark
Eucalyptus dealbata	Hill gum
Eucalyptus delegatensis	Alpine ash
Eucalyptus diversicolor	Karri
Eucalyptus dumosa	White mallee
Eucalyptus eugenioides	Thin-leaved stringybark
Eucalyptus fibrosa	Red ironbark
Eucalyptus globoidea	White stringybark
Eucalyptus globulus	Tasmanian blue gum
Eucalyptus goniocalyx	Bundy apple
Eucalyptus gracillis	White mallee
Eucalyptus laevopinea	Silver-topped stringybark
Eucalyptus largiflorens	Black box
Eucalyptus longifolia	Woollybutt
Eucalyptus macrorhyncha	Red stringybark
Eucalyptus mannifera	Brittle gum
Eucalyptus marginata	Jarrah
Eucalyptus melanophloia	Silver-leaved ironbark
Eucalyptus microcarpa	Inland grey box
Eucalyptus muelleriana	Yellow stringybark
Eucalyptus obliqua	Broad-leaved messmate
Eucalyptus ochrophloia	Napunyah
Eucalyptus oleosa	Red mallee
Eucalyptus orgadophila	Mountain coolibah
Eucalyptus ovata	Messmate
Eucalyptus patens	Blackbutt
Eucalyptus pilligaensis	Pilliga box
Eucalyptus pilularis	Blackbutt
Eucalyptus planchoniana	Needlebark stringybark
Eucalyptus polyanthemos	Red box

BOTANICAL NAME	COMMON NAME
Eucalyptus punctata	Grey gum
Eucalyptus robusta	Swamp mahogany
Eucalyptus saligna	Sydney blue gum
Eucalyptus sclerophylla	Scribbly gum
Eucalyptus siderophloia	Grey ironbark
Eucalyptus signata	Scribbly gum
Eucalyptus socialis	Christmas mallee
Eucalyptus spp.	Grey gum
Eucalyptus tereticornis	Forest red gum Blue gum
Eucalyptus umbra	Broad-leaved white mahogany
Eucalyptus viminalis	Manna gum
Eucalyptus wandoo	Wandoo
Fagopyrum esculentum	Buckwheat
Genista spp.	Broom
Gompholobium spp.	Wedge pea
Goodenia cycloptera	Serrated goodenia
Goodenia ovata	Hop goodenia
Gossypium hirsutum	Cotton
Hakea sericea	Silky hakea
Helianthus annuus	Sunflower
Helichrysum leucopsideum	Satin everlasting daisy
Hovea acutifolia	Pointed leaf hovea
Hypochaeris radicata	Flatweed
Lavendula spp.	Lavender
Leptospermum laevigatum	Teatree
Lomandra multiflora	Many flowered mat-rush
Lupinus albus	Lupins
Lupinus angustifolius	Lupins
Macadamia integrifolia	Macadamia
Mantisalca salmantica	Thistle
Medicago sativa	Lucerne
Medicago trunculata	Barrel medic
Melaleuca quinquenervia	Broad-leaved tea tree; Belbowrie
Microlonchus salmanticus	Thistle
Muehlenbeckia cunninghamii	Lignum
Myoporum deserti	Ellangowan
Myoporum montanum	Boobialla
Nymphaea capensis	Water lily

BOTANICAL NAME	COMMON NAME
Olearia elliptica	Sticky daisy bush
Onopordum acanthium	Scotch thistle
Papilionaceae spp.	Dillwynia; Peaflowers
Persea americana	Avocado
Phalaris minor	Canary grass
Phyla nodiflora	Lipia, Matweed, Carpet grass
Pinus radiata	Radiata pine
Pinus spp.	Pine
Plantago lanceolata	Plantain
Prunus dulcis	Almond
Ptilotus	Square-headed foxtail
Pultenaea myrtoides	Bush pea
Pultenaea villosa	Bush pea
Pyrus communis	Pear
Raphanus raphanistrum	Wild radish
Rapistrum rugosum	Turnip weed
Romulea rosea	Onion grass
Rubus ideaus	Raspberry
Rubus fruticosus	Blackberry
Salix discolor	Pussy willow
Salix fragilis	Crack willow
Schinus molle	Peppercorn
Senecio linearifolius	Fireweed groundsel
Senecio madagascariensis	Fireweed
Sida rhombifolia	Sidratusa
Sisymbrium officinale	Hedge mustard
Swainsona galegifolia	Darling pea
Trachymeme spp.	Wild parsnip
Tribulus terrestris	Yellow vine
Trifolium balansae	Balansa clover
Trifolium repens	White clover
Ulex europaeus	Gorse
Vaccinium spp.	Blueberry
Velleia glabrata	Smooth velleic
Vicia faba	Faba bean
Vicia spp.	Vetch
Xanthorrhoea	Grasstree
Zea mays	Maize/corn

Acacia baileyana — Cootamundra wattle

Crude protein %: 28.6 (e)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
e	4.9	5.1	2.1	7	4.3	5.7	7	2.3	5.4	1

Acacia cambagei — Gidgee

Crude protein %: 17.5, 25.3 (i)

Acacia concurrens — Black wattle

Crude protein %: 24.5–29 (l)

Acacia cunninghamii — Black wattle

Crude protein %: 24.5 – 29 (c)

Acacia dealbata — Silver wattle

Crude protein %: 21.4 (d)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
d	4.7	6.1	2	8.7	5	4.2	-	-	10	-

Acacia doratoxylon — Currawong wattle

Crude protein %: 24.9 (a[1])

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	3	4	2.2	5.4	2.9*	3.2	4.7	2.4	6.4	-
* = Below ideal ratio										

Fat/Lipid %: 0.9 (a[1])

Acacia implexa — Hickory wattle

Crude protein %: 25 (c); 23, 27 (b) **Lightwood**

Acacia ixiophylla — Wattle

Crude protein %: 27, 28 (c)

Acacia longifolia — Sydney golden wattle

Crude protein %: 24.6 (a[1])

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	4.5	5.3	2.7	7.5	4.6	4.2	6.2	2	5.5	-

Fat/Lipid %: 1.4 (a[1])

Acacia mearnsii — Black wattle

Crude protein %: 24.2 ± 3.6 (m)

Acacia melanoxylon — Blackwood

Crude protein %: 16.2 (c)

Acacia polybotrya — Western silver wattle

Crude protein %: 26.3 (c)

Acacia pyanantha — Golden wattle

Crude Protein %: 19.9 (d)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
d	3.8	5.4	5	7.3	4.4	2.8	1.1	-	15.8	-

Acacia spp. — Wattle

Crude protein %: 23.8 (a[1])

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	4.6	5.5	2.5	7.3	4.6	4.1	5.4	2.1	7.2	-

Fat/Lipid %: 1.2 (a[1])

Minerals (mg/kg): K–5000; P–3900; S–2000; Ca–670; Mg–950; Na–110; Fe–62; Zn–60; Mn–9; Cu–4 (a[2])

Acacia suaveolens — Sweet scented wattle

Crude protein %: 21.7 (a[1])

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	3.7	4	2.8	6.4	3.4*	3.5	5	1.7	4.7	-
* = Below ideal ratio										

Fat/Lipid %: 2.5 (a[1])

Acacia tetragonophylla — Dead finish

Crude protein %: 13.1, 22.4 (g)

Acacia tindaleae — Gold-top wattle

Crude protein %: 21, 22 (b)

Agerata riparia — Crofton weed

Crude protein %: 9.5, 11.7 (b)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
b	3.2	3.5*	1.5	6.1	3*	3.6	7.4	2.5	5.5	1.2
b	1.8	3.9*	1.6	7.5	3.6*	4.2	7.4	2.6	13.7	-
* = Below ideal ratio										

Ageratum houstonianum — Blue billygoat weed

Crude protein %: 21.1 (c)

Angophora floribunda — Rough-barked apple

Crude protein %: 22.9, 22.3 (a[1])

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	4.5	5.7	2.2	7.9	4.7	4.7	6.1	2.7	7	-
a[1]	4	5.3	2.1	7	4	4.1	5.7	2.6	6.1	-

Fat/Lipid %: 1.1, 1.5 (a[1])

Minerals (mg/kg): K–6200; P–4000; S–2100; Ca–720; Mg–790; Na–77; Fe–71; Zn–97; Mn–42; Cu–16 (a[2])

Angophora subvelutina — Coastal rough-bark apple

Crude protein %: 19, 20 (b)

Anredera cordifolia — Madeira vine

Crude protein %: 23.5 (c)

Arabidella eremigena — Priddiwalkatji

Crude protein %: 19.8, 25.9 (g)

Arctotheca calendula — Capeweed

Crude protein %: 17.3 (a[1]); 16.75 (d); 21 (e)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	4.2	4.3	2.3	5.9	3.7*	3.9	7.6	3.8	3.8	-
d	3.6	4.2	1.4*	6.1	3.2*	2.1*	7.8	2.7	4.2	-
e	4.1	4.7	2.1	6.4	4.2	4.5	6.8	3.5	4.6	1.1
* = Below ideal ratio										

Fat/Lipid %: 3.4 (a[1])

Minerals (mg/kg): K–2600; P–2700; S–1500; Ca–1200; Mg–700; Na–87; Fe–23; Zn–28; Mn–7; Cu–12 (a[1])

Asphodelus fistulosus — Onion weed

Crude protein %: 22.5 (a[1]); 14 (d)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	3.5	4.1	1.8	5.3	3.2*	3.1	3.8	1.6	3.4	-
d	3	18.1	0.8*	8.5	5.9	3.7	-	-	11.4	-
* = Below ideal ratio										

Fat/Lipid %: 4.5 (a[1])

Minerals (mg/kg): K–38000; P–3100; S–1800; Ca–1100; Mg–790; Na–86; Fe–52; Zn–34; Mn–22; Cu–4 (a[2])

Asteraceae spp. — Daisy family

Crude protein %: 14.5–24.5 (l)

Baccharis halimifolia — Groundsel

Crude protein %: 15 (c)

Banksia ericifolia — Heath-leaved banksia

Crude protein %: 28.6 (a[1]); 30.1, 30.3, 30.5, 31.8 (b)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	4.2	4.5	2.7	6.4	3.8*	3.8	6	3	6.6	-
b	4.4	3.9*	1.1*	7.7	3.4*	4.2	7.9	2.9	10.1	-
b	4.5	4.2	2	6.7	3.5*	4.4	7.3	3.2	8.8	-
b	3.7	4.6	1.9	6	4	3.7	6.2	2.4	5.9	2.6
b	3.8	4.5	2.7	5.9	3.8*	3.7	6.2	2.3	5.8	-
* = Below ideal ratio										

Fat/Lipid %: 2.45 (a[1])
Minerals mg/kg: K–6000; P–5300; S–3400; Ca–360; Mg–820; Na–480; Fe–110; Zn–91; Mn–22; Cu–10 (a[2])

Banksia ornata — Desert banksia

Crude protein %: 35.3 (d); 36.9 (e)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
d	4.3	5.2	2	7.1	4.1	4.9	5.6	-	6.7	-
e	3.9	4.7	2	5.6	3.5*	4.3	5.1	2.4	8.6	-
* = Below ideal ratio										

Banksia serrata — Saw banksia

Crude protein %: 33.3 (a[1]); 31.2 (d)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	3.8	4.8	2.3	5.8	3.6*	3.7	5.5	2.4	7.2	-
d	4.1	5.4	2.2	7.6	4.5	5.4	6.5	-	7.7	-
* = Below ideal ratio										

Fat/Lipid %: 1.9 (a[1])

Brachyscome ciliocarpa — Showy daisy

Crude protein %: 18 (g)

Brassica napus — Canola

Crude protein %: 22.8, 26.1, 23.8, 23.6 (a[1]); 23.2, 24.9 (b); 27.1 (e); 10.6 (d)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	4.9	5.1	2.3	7	4.6	43	8.2	2.1	5.1	-
a[1]	5.1	5.6	2.3	7.6	4.5	4	8.5	2.7	4.8	-
a[1]	3.9	5.2	2	6.6	3.8*	3.8	5.6	2.5	6.3	-
a[1]	5	5.5	2.5	7.2	5	4.5	8.3	2.2	5.1	-
b	4.4	3.5*	1.7	6.2	3.9*	4	6.8	2.7	4.6	-
b	4.4	4.7	2.9	6.4	4.3	4	6.7	2.3	4.3	-
e	4.8	5.2	1.9	6.9	4.5	4.3	7.8	2.2	5.2	-
d	5.6	6.8	1.8	8	6.2	5.5	3.2	-	6.2	-

* = Below ideal ratio

Fat/Lipid %: 7.3, 6.9, 1.8, 6.8 (a[1])

Minerals (mg/kg): K–5300, 5400; P–5600, 5300; S–3200, 2900; Ca–1700, 1800; Mg–1400, 1400; Na–30, 31; Fe–25, 30; Zn–36, 30; Mn–42, 30; Cu–7, 6 (a[2])

Brassica tournifortii — Wild turnip

Crude protein %: 18.3 (d)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
d	5.6	7.5	1.4	8.3	5	3.9	5	-	5.6	-

Caduus nutans — Nodding thistle

Crude protein %: 15.1 (a[1])

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	3.8	4.8	2.3	5.7	4.2	3.4	6.1	3.6	3.7	-

Fat/Lipid %: 2.3 (a[1])

Minerals (mg/kg): K–2700; P–2900; S–1500; Ca–1500; Mg–560; Na–28; Fe–48; Zn–21; Mn–9; Cu–9 (a[2])

Callistemon pachyphyllus — Wallum bottlebrush

Crude protein %: 30 (c)

Calotis cuneifolia — Purple burr daisy

Crude protein %: 14.7–31.5 (l)

Calotis multicaulis — Woolly-headed burr daisy

Crude protein %: 19.9 (l)

Calotis spp. — Burr daisies

Crude protein %: 12.4–22.8 (l)

Carduus tenuiflorus — Slender thistle

Crude protein %: 18.1 (d)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
d	4.2	1.7	4.2	7.8	7.3	2.4	5	-	3.3	-

Carthamus lanatus — Saffron thistle

Crude protein %: 18.1 (a[1])

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	4.1	5.7	2.6	6.9	5	4.2	6.8	4.4	4.5	-

Fat/Lipid %: 3.9% (a[1])

Minerals: K–3100; P–3300; S–1800; Ca–1500; Mg–420; Na–42; Fe–38; Zn–40; Mn–7; Cu–11

Cassia spp. — Cassia

Crude protein %: 26.7, 30.5 (h[2])

Cassia eremophila — Desert cassia

Crude protein %: 27.3, 28.6 (i)

Cassia oligophyla — Limestone cassia

Crude protein %: 24.8, 25.7 (i)

Cassinia laevis — Wild rosemary

Crude protein %: 13, 21.6 (c)

Casuarina littoralis — Black she-oak

Crude protein %: 11.5, 12.9, 13.1 (a[1])

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	3.2	3.3*	2.5	5.6	2.7*	2.9	3.5	1.6	5.8	-
a[1]	3.7	4.2	2.3	6.4	3.4*	3.6	4.9	1.9	6.4	-
a[1]	4.2	4.7	2.6	6.1	3.9*	3.4	4.7	1.7	7.1	-
* = Below ideal ratio										

Fat/Lipid %: 3.25, 1.38, 1.15 (a[1])

Minerals (mg/kg): K–3400; P–1400; S–1200; Ca–1100; Mg–230; Na–290; Fe–28; Zn–18; Mn–25; Cu–9 (a[2])

Casuarina spp. *(Allocasuarina)* — She-oak

Crude protein %: 11.3, 13.9, 17.3 (b); 13.6 (c)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
b	3.1	2.5*	1.4	4.9	1.9*	2.9	4.7	2.7	6	-
b	3.3	2.7*	1.9	5.3	2*	3.3	5.3	3.5	5.6	-
b	3.7	3.9*	3.1	5.8	3.4*	3.6	5.6	3.5	6.6	-
* = Below ideal ratio										

Centaurea solstitialis — Yellow burr

Crude protein %: 20.6 (a[1]); 18, 22.4, 26 (b)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	4.2	4.9	2.1	7	4.5	4	6.3	3.7	4.4	-
b	3.4	3.6*	1.5*	5.2	2.9*	3.1	5.9	3	4.9	-
b	4.4	4.1	2.1	6.7	3.3*	4.5	5.5	4.2	5	-
b	3.8	4.4	1.9	6.3	3.9*	3.5	4.3	2.5	4.7	-
* = Below ideal ratio										

Fat/Lipid %: 2.8 (a[1]); 8 (b)

Minerals (mg/kg): K–3400; P–3600; S–2200; Ca–1500; Mg–500; Na–58; Fe–100; Zn–35; Mn–10; Cu–19 (a[2])

Chondrilla juncea — Skeleton weed

Crude protein %: 23.4, 22.2 (a[1])

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	4.7	7.2	3.1	8.2	5.8	5.2	5.9	3	6	-
a[1]	3.7	3.8	3.6	6	3.1*	3.4	5	2.2	4.5	-
* = Below ideal ratio										

Fat/Lipid %: 2.6, 3.4 (a[1])

Minerals (mg/kg): K–2200; P–2100; S–1400; Ca–1100; Mg–250; Na–69; Fe–30; Zn–26; Mn–6; Cu–5 (a[2])

Cirsium vulgare — Spear thistle, Black thistle

Crude protein %: 17.6, 16.1 (a[1]); 31.8 (c); 18.3 (d)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	4.3	5.2	1.2*	6.7	4.7	4	6.1	3.6	3.7	-
a[1]	3.6	5.1	1.9	6.2	4.5	3.5	6.8	3.1	3.9	-
c	3.4	3.6*	2.1	6.4	3.2*	4.1	1.8*	1.4*	3.9	-
d	1.7*	3.4*	1.9	4.6	3.5*	2.6	1*	-	6.5	-
* = Below ideal ratio										

Fat/Lipid %: 2.25, 2.59 (a[1])

Minerals (mg/kg): K–2800; P–3000; S–1600; Ca–1700; Mg–420; Na–31; Fe–39; Zn–26; Mn–11; Cu–15 (a[2])

Citrus spp. — Citrus

Crude protein %: 18.5 (a[1])

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	4.4	5.3	2.1	7.2	4.2	4.3	9.5	2.3	5.2	-

Fat/Lipid %: 3 (a[1])

Corymbia calophylla — (Marri) Red gum

Crude protein %: 26.7 (n = 9) (f); 28 (j)

Fat/Lipid %: 2.02

Minerals (mg/kg): K–5400; P–4200; Ca–600; Mg–900; Fe–124; Zn–79; Na–100; Mn–35; Cu–22; S–3000; Boron–19 (f)

Corymbia gummifera — Red bloodwood

Crude protein %: 26.9 (a[1])

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	4.4	5.4	2.3	7.3	4	4.7	6.6	3.1	7.7	-

Fat/Lipid %: 1.6 (a[1])

Corymbia maculata — Spotted gum

Crude protein %: 24.9, 30.4, 29.5, 28.4, 29.1, 28.7 (a[1]); 33.3 (c); 24.7, 26.8, 27.3, 28.8, 31.4 (b)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	3.8	4.7	2.2	6.7	3.9*	3.9	5.8	2.7	7.7	-
a[1]	3.7	4.7	2	6.3	3.6*	3.8	5.5	2.6	6.6	-
a[1]	4.2	5.2	2.3	7.6	2.9*	4.4	6.4	2.7	8	-
a[1]	4.4	5.4	2.2	8.1	4.1	4.5	6.9	2.9	8.4	-
a[1]	3.8	5	2.3	7.3	3.7*	4	6	2.8	7.1	-
a[1]	4.1	5.2	2.3	7.6	3.8*	4.1	6.2	2.9	7.8	-
b	3.9	4.4	2.2	6.8	3.5*	3.9	6.7	2.4	9.1	1.4
b	4.3	4.8	2.4	7.1	3.6*	5.1	6.8	3	9.5	-
b	4	4.3	2.2	6.9	3.3*	4.4	6.3	2.9	9.2	-
b	4	4.4	2.5	6.9	3.5*	4.3	6.9	5	8.7	-
b	3	4.5	2.9	4.8	3.4*	3.6	4.9	2	7	-
h[2]	4	3.8*	2	5.9	3.7*	4	6.2	2.3	6.7	-
* = Below ideal ratio										

Fat/Lipid %: 1.5, 1.4, 1.1, 1.3, 2, 2 (a[1])

Minerals (mg/kg): K–6200, 6000, 5600, 6500; P–4500, 4800, 4200, 4500; S–2700, 2900, 2800, 2800; Ca–740, 610, 680, 740; Mg–720, 710, 710, 750; Na–91, 130, 97, 96; Fe–51, 45, 45, 49; Zn–90, 77, 58, 85; Mn–110, 79, 63, 100; Cu–40, 42, 42, 39 (a[2])

Corymbia polycarpa — Bloodwood

Crude protein %: 26.5 (h[1])

Corymbia terminalis — Inland bloodwood

Crude protein %: 25.8 (h[1])

Corymbia trachyphloia — Pilliga bloodwood

Crude protein %: 21.8, 22.5, 23.9 (b)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
b	4	4.1	2	7	3.2*	4.2	4.7	2.6	6.7	-
b	3.4	4.6	1.8	6.3	3.9*	3.8	5.6	2.2	6.2	2.6
b	3.4	4.3	2.2	6.2	3.7*	3.7	5.5	2.3	5.8	-

* = Below ideal ratio

Curcurbita pepo — Pumpkin

Crude protein %: 26.4 (c)

Echium plantangineum — Paterson's curse

Crude protein %: 30.9 (1995, n = 28), 34.6 (1996, n = 17), 34.8 (1997, n = 16) (a[1]); 30.8, 33.3 (b); 31.4 (d); 35.2 (e)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1] (n = 28)	4.4	5.6	2.6	7	5.1	4.2	6.9	2.6	5	-
a[1] (n = 17)	4.5	5.2	2.3	6.8	4.4	4.1	6.2	2.6	4.9	-
a[1] (n = 16)	4.5	5.2	2.3	7	4.4	3.9	6.7	2.9	4.9	-
b	4.1	4.1	2.1	5.9	3.5*	3.7	6.8	3.3	5	1.3
b	3.9	4.1	2.5	6	3.6*	3.6	6.2	2.3	4.7	-
d	4	4.5	1.7	6.8	4.3	4	6.5	1.8	4.7	-
e	4.8	5.3	1.9	6.8	4.6	4	6.6	2.4	5.1	1.1

* = Below ideal ratio

Echium vulgare — Viper's bugloss

Crude protein %: 34.9 (a[1])

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	4.7	5.5	2.3	7	4.6	4.3	5.1	2.4	4.9	-

Fat/Lipid %: 4.1 (a[1])

Eremophila bigoniiflora — Eurah

Crude protein %: 26.2 (i)

Eremophila duttonii — Boobialla

Crude protein %: 25.8 (g)

Eremophila mitchellii — Budda

Crude protein %: 24.3, 25.7 (i)

Eremophila oppositifolia — Weooka

Crude protein %: 24.6 (g)

Eremophila sturtii — Sandalwood

Crude protein %: 25.2, 29.6 (i)

Erodium crinitum — Blue crawfoot

Crude protein %: 28.9 (i)

Eucalyptus accedens — Powder bark

Crude protein %: 23.6 (n = 2) (f)

Fat/Lipid %: 1.02

Minerals (mg/kg): K–4200; P–3200; Ca–1000; Mg–0.05; Fe–116.5; Zn–50; Na–200; Mn–33.5; Cu–16.5; S–2600; Boron–11 (f)

Eucalyptus acmenoides — White mahogany

Crude protein %: 24.7, 18.6, 20.5, 20.3 (b)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
b	2.7*	2.8*	1.1*	4.7	2.5*	2.2*	4.7	2.0	5.5	-
b	4.2	4.0	1.9	6.2	3.1*	3.7	5.8	3.2	4.9	-
b	3.9	4.1	2.0	6.2	3.0*	3.9	6.1	3.2	6.1	-
b	3.8	3.4*	2.2	6.4	2.6*	4.1	6.2	3.5	4.7	-

* = Below ideal ratio

Eucalyptus albens — White box

Crude protein %: 22.1, 22.4, 22.5, 23.1 (a[1]); 16.3, 17.7, 17.9, 17.9, 19.2, 19.5, 20.1 (b); 20.6, 24.3 (c)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	3.4	4.3	2.7	6	3.4*	3.4	5.2	2	5.8	-
a[1]	3.8	5.3	2.7	6.9	4.2	3.9	5.4	2.3	6.4	-
a[1]	3.9	4.7	2.6	6.6	3.8*	3.9	4.8	1.7	5.8	-
a[1]	3.9	4.9	2.3	6.5	3.6*	3.8	5.6	2.6	6.8	-
b	3.1	4.8	2.0	7.0	3.7*	4.2	6.7	2.9	7.1	0.9
b	6.8	4.9	1.8	6.8	3.8*	4.1	6.6	2.4	7.1	-
b	3.9	4.8	1.9	6.8	3.7*	4.1	6.7	2.5	7.3	-
b	4	4.4	2	6.5	3.5*	4.4	6.7	3.9	5.9	-
b	3	4.7	2.6	5.7	3.6*	3.7	5.6	1.9	6.4	-
b	3.7	4.8	3.1	5.3	3.7*	3.9	5.3	1.9	6.3	-
b	3.4	4.5	2.7	5.7	3.5*	3.7	5.3	1.9	6.3	-
h[2]	3.5	4.3	2.0	6.1	3.4*	4.1	5.4	1.9	5.8	-
h[2]	3.4	3.4*	2.0	6.3	3.2*	3.9	6.9	2.2	6.1	-
h[2]	4.0	5.5	2.8	6.9	3.3*	4.4	4.0	1.9	5.9	-

* = Below ideal ratio

Fat/Lipid %: 2.5, 2.6, 2.3, 4.2 (a[1])

Minerals (mg/kg): K–4500; P–4700; S–2200; Ca–3100; Mg–740; Na–46; Fe–140; Zn–58; Mn–53; Cu–16

Eucalyptus andrewsii — New England blackbutt

Crude protein %: 21.9, 22.9, 22.1, 20.6, 22.3 (b)

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
b	3.4	4.6	2.4	6.2	4	3.6	5.5	1.8	5.7	-
b	3.3	5.4	2.0	6.7	4.1	4.1	6.8	3.3	7.5	-
b	4.0	4.1	1.9	6.2	3.1*	3.7	5.8	3.2	4.4	-
b	3.4	4.7	1.6	6.3	3.8*	3.8	5.6	2.0	5.3	2.7
b	3.3	3.9*	2.0	5.7	3.2*	3.6	4.8	2.0	5.7	-

* = Below ideal ratio

Eucalyptus aromaphloia — Scent bark

Crude protein %: 28.7 (e)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
e	3.9	5	1.9	6.7	3.8*	5.2	5.4	2.2	7	0.9*

* = Below ideal ratio

Eucalyptus blakelyi — Blakely's red gum

Crude protein %: 28.8 (a[1]); 22.4, 25.1, 26.4 (b); 24.3 (d)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	3.9	5.1	2.3	7.2	3.7*	4.2	6.3	2.1	6.5	-
b	3.5	4.7	1.7	6.2	3.8*	3.8	5.8	2.0	5.8	2.6
b	3.5	4.6	1.5	6.1	3.5*	3.5	5.1	1.8	7.5	-
d	3.1	4.3	2.3	8.1	6.6	3.4	5.3	2.1	4.1	-
* = Below ideal ratio										

Fat/Lipid%: 1.5 (a[1])

Eucalyptus botryoides — Bangalay

Crude protein %: 20.4 (d)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
d	4.2	4.0	2.7	8.0	6.7	15.0	6.7	2.0	4.8	-

Eucalyptus bridgesiana — Apple box

Crude protein %: 23, 22.6, 24.5, 23.5, 24.9 (a[1])

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	3.8	4.8	2.2	7.6	5.1	4.3	6.6	2.4	6.4	-
a[1]	3.6	4.8	2.7	7.3	5	4.2	6.4	2.5	5.9	-
a[1]	3.9	5	2.4	6.9	3.9*	3.9	5.8	2.5	6.1	-
a[1]	3.7	6.1	2.6	6.7	3.9	4	5.2	1.6	5.8	-
a[1]	3.6	6.3	2.2	6.2	3.6	3.7	5.6	2.2	5.4	-
* = Below ideal ratio										

Fat/Lipid %: 1.26, 1.72, 0.77, 0.57, 1.1 (a[1])

Minerals (mg/kg): K–5100, 5000, 5400; P–4100, 4200, 4400; S–2200, 2300, 2400; Ca–1000, 1000, 940; Mg–500, 550, 530; Na–20, 31, 24; Fe–73, 90, 64; Zn–80, 62, 55; Mn–51, 45, 46; Cu–17, 16, 16 (a[2])

Eucalyptus caliginosa — Broad-leaved stringybark

Crude protein %: 22.6, 24.3, 26.1, 26.9, 29.9 (b)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
b	3.9	4.7	1.1*	6.6	3.7*	4.2	5.8	3.0	8.3	-
b	3.6	4.3	1.3*	6.0	3.3*	3.8	5.2	2.8	7.3	-
b	3.4	3.8	1.9	5.7	3*	3.5	5	2	5.9	-
b	3.7	4.2	2.7	6.4	3.2*	3.7	6	4.6	7.9	-
b	3.6	3.5*	1.7	6.5	2.7*	4.0	6.0	2.4	10.2	1.3
* = Below ideal ratio										

Eucalyptus camaldulensis — River red gum

Crude protein %: 22.6, 25.6 (a[1]); 21.9 (d); 26.5 (e); 25.8 (c)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	4	5.5	3	6.9	4.5	3.8	5.9	2.3	6.5	-
a[1]	3.8	5	2.5	6.5	3.6*	3.8	5.5	2.3	6.2	-
d	3.2	5	1.1*	5.4	3.2*	5.9	3.4	1.5	8	-
e	3.6	4.9	1.8	6.4	3.7*	4	5.9	2.2	6	-
h[1]	6.7	4.4	1.4	6.2	3.2*	4.0	-	2.1	7.1	-
* = Below ideal ratio										

Fat/Lipid %: 4.6, 1.3 (a[1])

Minerals (mg/kg): K–5300; P–4700; S–2400; Ca–1000; Mg–740; Na–86; Fe–110; Zn–64; Mn–40; Cu–19 (a[2])

Eucalyptus cephalocarpa — Silver stringybark

Crude protein %: 28.4 (e)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
e	3.6	5.1	1.6	6.4	3.9*	3.4	6.4	2.1	6.4	0.7*
* = Below ideal ratio										

Eucalyptus chlorochlada — Pilliga gum

Crude protein %: 20.8 (b)

Eucalyptus crebra — Narrow-leaved ironbark

Crude protein %: 19.9, 18.6, 16.4 (b)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
b	3.4	4.2	2.1	6.0	3.4*	3.4	6.2	2.0	6.4	-
b	3.6	4.1	2.3	5.8	3.3*	3.5	5.3	2.2	6.5	-
b	3.4	4.3	2.6	5.9	3.7*	3.8	5.9	1.7	6.7	-
* = Below ideal ratio										

Eucalyptus dealbata — Hill gum

Crude protein %: 21.1, 21.6, 24.2 (b); 20.5, 22.1, 26, 26.1 (h^2)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
b	4.1	4.2	1.9	6.4	3.2*	4.3	4.9	2.3	5.8	-
b	3.5	4.7	1.8	6.3	3.7*	3.8	5.8	2.1	6.1	2.6
b	3.5	4.6	1.5	5.7	3.4*	3.2	4.7	1.7	6.6	-
h^2	3.6	3.3*	1.9	4.8	2.9*	7.3	3.7	1.9	5.5	-
h^2	4.8	3.7*	2.3	5.8	3.5*	3.2	8.6	2.4	5.9	-
h^2	2.6	2.6*	1.6	5.1	2.5*	2.9	4.0	1.8	4.9	-
h^2	3.0	2.7	1.8	5.6	2.9*	3.5	4.9	2.0	5.5	-
h^2	3.1	3.0	2.0	5.7	3.0*	3.5	4.8	1.8	5.7	
* = Below ideal ratio										

Eucalyptus delegatensis — Alpine ash

Crude protein %: 23 (a^1)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a^1	3.7	5.8	2.1	7.1	4.9	4.3	6	2.3	6.5	-

Fat/Lipid %: 1.87 (a^1)

Eucalyptus diversicolor — Karri

Crude protein %: 23.4 (n = 4) (f)

Fat/Lipid %: 1.90

Minerals (mg/kg): K–4400; P–4000; Ca–1300; Mg–500; Fe–87.5; Zn–72.8; Na–200; Mn–33.5; Cu–9.2; S–2500; Boron–16 (f)

Eucalyptus dumosa — White mallee

Crude protein %: 22.5, 20.5, 24.8 (a[1]); 24.8 (d)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	3.6	4.9	2.1	6.3	3.5*	3.6	5.7	2.5	7.2	-
a[1]	3.7	4.8	1.9	6.5	3.5*	4.1	5.8	2.8	8.2	-
d	3.1	3.5*	0.9*	6.1	4.1	3.1	5.4	1.8	6	-
* = Below ideal ratio										

Fat/Lipid %: 1.9, 1.4 (a[1])

Eucalyptus eugenioides — Thin-leaved stringybark

Crude protein %: 22.9, 22.1, 23.0 (b)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
b	3.5	4.7	1.7	6.3	3.9*	3.6	6.1	2.1	5.8	2.7
* = Below ideal ratio										

Eucalyptus fibrosa — Red ironbark

Crude protein %: 20.5 (a[1]); 22.6 (h[2])

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	3.4	5.3	2.5	6.6	4.4	3.7	5.6	2.1	6.5	-

Fat/Lipid %: 2.2 (a[1])

Eucalyptus globoidea — White stringybark

Crude protein %: 29.4 (a[1])

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	4	5	2.3	7.3	3.7*	4.2	6.3	2.8	7	-
* = Below ideal ratio										

Fat/Lipid %: 1.2 (a[1])

Eucalyptus globulus — Tasmanian blue gum

Crude protein %: 27.6, 29.6 (k)

Eucalyptus goniocalyx — Bundy apple

Crude protein %: 20.0 (d)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
d	3.5	13.0	1.8	7.3	4.2	2.9	5.8	1.9	6.1	-

Eucalyptus gracilis — White mallee

Crude protein %: 20.0 (d)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
d	4.1	7.5	1.5	8.5	5.8	4.3	8.0	1.9	3.6	-

Eucalyptus laevopinea — Silver-topped stringybark

Crude protein %: 17.3, 19.6

Eucalyptus largiflorens — Black box

Crude protein %: 19.7 (d)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
d	5.8	4.9	1.5	5.0	4.0	3.9	3.5	1.8	3.7	-

Eucalyptus longifolia — Woollybutt

Crude protein %: 24.9, 25.4 (a[1])

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	3.7	4.8	3	6.3	3.8*	3.7	5.8	1.8	6.5	-
a[1]	3.5	4.5	2.4	6.3	3.5*	3.5	5	1.8	6.3	-
* = Below ideal ratio										

Fat/Lipid %: 2.4 (a[1])

Eucalyptus macrorhyncha — Red stringybark

Crude protein %: 24.2, 22.1, 26.9, 26.2 (a[1]); 23.2, 23.4 (b); 23.4 (d); 30.1 (e)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	3.3	4.3	2.2	6.1	3.4*	3.6	5.1	2.1	5.6	-
a[1]	3.5	5.8	2.1	6.9	4.8	3.9	6.2	2.5	5.7	-
a[1]	3.7	5.4	2.1	6.9	3.8*	3.5	6.1	2.3	5.5	-
a[1]	3.9	5.7	2.2	7.3	4	3.7	6.3	2.3	5.6	-
b	3.8	4.0	1.7	5.8	3.2*	3.5	5.6	1.9	5.9	-
b	3.2	4.3	1.8	5.6	3.5*	3.3	5.1	2.0	5.5	-
d	3.1	3.8*	1.9	5	2.9*	2.8	4	1.3*	5.1	-
e	3.3	4.8	1.3*	6	3.6*	3.4	5.4	1.9	6.4	-
* = Below ideal ratio										

Fat/Lipid %: 2.2, 2.6, 1, 0 (a[1])

Minerals (mg/kg): K–5300; P–4400; S–2400; Ca–1100; Mg–550; Na–16; Fe–120; Zn–58; Mn–62; Cu–13 (a[2])

Eucalyptus mannifera — Brittle gum

Crude protein %: 28.1, 24.3 (a[1])

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	3.9	5	2.4	6.6	3.7*	4.2	6.1	2.5	6	-
a[1]	3.6	4.8	2.2	6.2	3.5*	3.7	5.6	2.2	5.6	-
* = Below ideal ratio										

Fat/Lipid %: 1.5, 0.9 (a[1])

Eucalyptus marginata — Jarrah

Crude protein %: 19.7 (n = 5) (f); 21 (j)

Fat/Lipid %: 0.59

Minerals (mg/kg): K–5700; P–3400; Ca–1300; Mg–900; Fe–66.8; Zn–47.8; Na–100; Mn–50.6; Cu–14.8; S–1900; Boron–15.6

Eucalyptus melanophloia — Silver-leaved ironbark

Crude protein %: 19.7, 22.9 (b)

Amino acids:

Reference	**Thr**	**Val**	**Met**	**Leu**	**Iso**	**Phe**	**Lys**	**His**	**Arg**	**Try**
b	3.6	3.8	1.8	6.3	3*	3.8	5.6	2.8	6	1.9
b	3.6	4.4	1.5	5.9	3.3*	3.3	5	1.7	8.3	-
* = Below ideal ratio										

Fat/Lipid %: 1.1% (b)

Eucalyptus microcarpa — Inland grey box

Crude protein %: 23.6 (a[1]); 25 (d); 23.3 (e); 25 (c)

Amino acids:

Reference	**Thr**	**Val**	**Met**	**Leu**	**Iso**	**Phe**	**Lys**	**His**	**Arg**	**Try**
a[1]	3.9	5.1	2.1	6.5	3.8*	3.9	6	2.4	6.4	-
d	3.3	4	1.1*	5.3	3.1*	3.2	5	1.6	4.6	-
e	3.7	5	1.7	6.5	3.8*	3.8	5.1	2.2	5.6	-
* = Below ideal ratio										

Fat/Lipid %: 3 (a[1])

Eucalyptus muelleriana — Yellow stringybark

Crude protein %: 24.8 (d)

Amino acids:

Reference	**Thr**	**Val**	**Met**	**Leu**	**Iso**	**Phe**	**Lys**	**His**	**Arg**	**Try**
d	3.1	4.6	1.0*	4.6	2.5*	6.6	4.0	1.5	5.8	-
* = Below ideal ratio										

Eucalyptus obliqua — Broad-leaved messmate

Crude protein %: 24.3 (d)

Amino acids:

Reference	**Thr**	**Val**	**Met**	**Leu**	**Iso**	**Phe**	**Lys**	**His**	**Arg**	**Try**
d	5.6	4.9	1.5	13.3	7.4	6.0	7.0	1.7	4.8	-

Eucalyptus ochrophloia — Napunyah

Crude protein %: 20.3 (g); 26.4 (h[1])

Amino acids:

Reference	**Thr**	**Val**	**Met**	**Leu**	**Iso**	**Phe**	**Lys**	**His**	**Arg**	**Try**
g	3.8	4.5	2.1	6.7	3.8*	3.9	8.1	2.8	4.9	-
* = Below ideal ratio										

Eucalyptus oleosa — Red mallee

Crude protein %: 18.8 (d)

Amino acids:

Reference	**Thr**	**Val**	**Met**	**Leu**	**Iso**	**Phe**	**Lys**	**His**	**Arg**	**Try**
d	3.6	6.4	1.7	4.3*	3.0*	4.7	3.0	0.6*	5.2	-
* = Below ideal ratio										

Eucalyptus orgadophila — Mountain coolibah

Crude protein %: 27.6, 28.1 (h^2)

Amino acids:

Reference	**Thr**	**Val**	**Met**	**Leu**	**Iso**	**Phe**	**Lys**	**His**	**Arg**	**Try**
h^2	3.1	3.1*	1.8	5.8	3.1*	3.4	5.1	1.9	4.9	-
h^2	3.8	2.3*	1.9	6.3	3.5*	3.5	3.9	1.4*	4.0	-
h^2	2.7*	5.6	2.1	6.4	3.9*	3.6	6.9	2.2	7.7	-
* = Below ideal ratio										

Eucalyptus ovata — Messmate

Crude protein %: 18.1 (d)

Amino acids:

Reference	**Thr**	**Val**	**Met**	**Leu**	**Iso**	**Phe**	**Lys**	**His**	**Arg**	**Try**
d	3.1	5.3	1.0*	6.3	4.1	4.0	5.5	1.5	6.3	-

Eucalyptus patens — Blackbutt

Crude protein %: 26.3 (n = 3) (f)

Fat/Lipid %: 1.35

Minerals (mg/kg): K–6000; P–4000; Ca–700; Mg–800; Fe–102.5; Zn–69.3; Na–200; Mn–36; Cu–19.3; S–2700; Boron–13 (f)

Eucalyptus pilligaensis — Pilliga box

Crude protein %: 16.6 (b)

Amino acids:

Reference	**Thr**	**Val**	**Met**	**Leu**	**Iso**	**Phe**	**Lys**	**His**	**Arg**	**Try**
b	3.6	4	2.4	6	3.1*	3.6	6.2	1.2*	8	-

Eucalyptus pilularis — Blackbutt

Crude protein %: 21.8 (b)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
b	4.1	4.7	2.3	7.2	3.6*	4.9	7.6	6.8	4.3	-
* = Below ideal ratio										

Eucalyptus planchoniana — Needlebark stringybark

Crude protein %: 30.8 (b)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
b	2.2*	2.4*	0.9*	4.1*	2.1*	2.5	4.1	1.8	4.8	-
* = Below ideal ratio										

Eucalyptus polyanthemos — Red box

Crude protein %: 22.4 (a[1])

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	3.8	4.9	2.2	6.4	3.6*	3.7	5.7	2.5	6.2	-
* = Below ideal ratio										

Fat/Lipid %: 3.9 (a[1])

Eucalyptus punctata — Grey gum

Crude protein %: 27.3 (a[1]); 19.8, 20.4, 22.1 (b)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	3.5	4.8	1.7	6	3.5*	3.5	5.4	2.3	5.6	-
b	3.7	4.0	2.3	6.9	2.9*	4.2	5.2	2.7	6.0	-
b	3.5	4.8	1.5	6.0	4.0	3.6	5.0	1.9	6.8	-
b	3.7	4.6	1.0*	5.8	3.9*	3.7	5.2	2.5	7.3	-
* = Below ideal ratio										

Fat/Lipid %: 2 (a[1]); 3.4% (b)

Minerals (mg/kg): K–6000; P–5400; S–3700; Ca–940; Mg–720; Na–340; Fe–520; Zn–120; Mn–46; Cu–30 (a[2])

Eucalytpus robusta — Swamp mahogany

Crude protein %: 22.6 (a[1])

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	3.7	5.1	2.5	6.6	4	4	5.3	1.8	6	-

Fat/Lipid %: 1.4 (a[1])

Minerals (mg/kg): K–4900; P–4300; S–2700; Ca–890; Mg–540; Na–21; Fe–66; Zn–65; Mn–28; Cu–22 (a[2])

Eucalyptus saligna — Sydney blue gum

Crude protein %: 27.6 (a[1])

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	4	5.2	1*	7.3	3.7*	4.1	5.9	2	6.7	-
* = Below ideal ratio										

Fat/Lipid %: 1.5 (a[1])

Minerals (mg/kg): K–5300; P–4700; S–2500; Ca–990; Mg–680; Na–92; Fe–60; Zn–64; Mn–38; Cu–20 (a[2])

Eucalyptus sclerophylla — Scribbly gum

Crude protein %: 29.7 (a[1])

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	4.1	5.2	2.5	6.9	3.9*	4.1	6.1	2.5	7.1	-
* = Below ideal ratio										

Fat/Lipid %: 2.3 (a[1])

Eucalyptus siderophloia — Grey ironbark

Crude protein %: 22.6 (h[2])

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
h[2]	3.9	5.0	1.9	6.1	3.6*	3.6	7.5	1.9	7.3	-
* = Below ideal ratio										

Eucalyptus signata — Scribbly gum

Crude protein %: 29 (b)

Eucalyptus socialis — Christmas mallee

Crude protein %: 26.6 (a[1])

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	3.5	4.5	2	6	3.4*	3.6	5.4	2.5	7.2	-
* = Below ideal ratio										

Fat/Lipid %: 1.8 (a[1])

Eucalyptus spp. — Grey gum

Crude protein %: 24 (c)

Eucalyptus tereticornis — Forest red gum, Blue gum

Crude protein %: 24.2, 26.2, 26.4, 26.5 (h[2])

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
h[2]	6.5	4.7	2	6	3.3*	3.4	6.9	1.8	7.7	-
h[2]	7.8	4.5	2.1	6.3	3.7*	3.5	8.7	2.7	7.2	-
h[2]	6.2	4.7	2	6	3.3*	3.4	6.9	1.8	7.7	-
h[2]	6.8	4.5	2.1	6.3	3.7	3.5	8.7	2.7	7.2	-
b	4.1	4.6	2	6	3.5*	4.1	6.6	2.6	6.2	-
b	3.6	4.2	1.6	5.8	3.1*	4.2	5.6	4.8	6.8	-
b	3.6	4.5	1*	6.2	3.5*	4.2	5.5	2.5	6.1	-
* = Below ideal ratio										

Eucalyptus umbra — Broad-leaved white mahogany

Crude protein %: 18.3 (b)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
b	3.5	4.8	1.9	6.3	3.8*	3.7	6.0	2.1	6.1	-
* = Below ideal ratio										

Eucalyptus viminalis

Manna gum

Crude protein %: 23.7 (a[1]); 21.3 (d)

Amino acids:

Reference	**Thr**	**Val**	**Met**	**Leu**	**Iso**	**Phe**	**Lys**	**His**	**Arg**	**Try**
a[1]	3.8	5.6	2.5	7.1	4.7	3.9	6.2	2.5	5.5	-
d	3	4.2	2.5	6.6	6.2	6.8	5.9	5.2	2.8*	-

* = Below ideal ratio

Fat/Lipid %: 0.5 (a[1])

Minerals (mg/kg): K–4900; P–4400; S–2300; Ca–890; Mg–520; Na–40; Fe–63; Zn–58; Mn–77; Cu–15 (a[2])

Eucalyptus wandoo

Wandoo

Crude protein %: 21.8 (n = 9) (f); 23.1 (n = 2) (f); 23.7 (n = 2) (f)

Fat/Lipid %: 1.3 (f) (n = 13)

Minerals (mg/kg): K–4200; P–3200; Ca–900; Mg–500; Fe–181; Zn–52; Na–300; Mn–26; Cu–15; S–2300; Boron–10 (f)

Fagopyrum esculentum

Buckwheat

Crude protein %: 11.4 (a[1])

Amino acids:

Reference	**Thr**	**Val**	**Met**	**Leu**	**Iso**	**Phe**	**Lys**	**His**	**Arg**	**Try**
a[1]	4.2	5	2	6.8	4.5	3.9	6.9	2.7	4.3	-

Fat/Lipid %: 2.2 (a[1])

Minerals (mg/kg): K–6800; P–4800; S–1100; Ca–1800; Mg–2700; Na–34; Fe–51; Zn–17; Mn–20; Cu–5 (a[2])

Genista spp.

Broom

Crude protein %: 20.6 (d)

Gompholobium spp.

Wedge pea

Crude protein %: 29.5 (c)

Goodenia cycloptera

Serrated goodenia

Crude protein %: 16.6, 16.9, 29.8 (g)

Goodenia ovata — Hop goodenia

Crude protein %: 22.8 (d)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
d	3.7	5.1	0.7	5.4	4	2.9	4.4	-	5.8	-

Gossypium hirsutum — Cotton

Crude protein %: 19.4 (b)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
b	3.8	4.4	1.5	6	3.9*	3.8	5.9	2.6	5.8	-
* = Below ideal ratio										

Hakea sericea — Silky hakea

Crude protein %: 18.4 (a[1])

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	4.3	4.8	2	6.6	3.9*	3.8	4.7	2.4	6.4	-
* = Below ideal ratio										

Fat/Lipid %: 2.8 (a[1])

Helianthus annuus — Sunflower

Crude protein %: 13.8, 12.9 (a[1]); 15 (d); 18.5 (c); 17.6 (e)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	4	4.6	2.2	6.6	4.3	3.7	5.8	4.6	3.7	-
a[1]	4.1	4.6	1.8	6.4	4	3.6	6.2	4.8	4	-
d	3.4	4.6	2.3	6.8	4.6	7.1	3.9	-	5.7	-
e	4.2	5	2.3	6.6	4.4	4.6	6.2	4.4	3.7	-

Fat/Lipid %: 1.4, 1.1 (a[1])

Minerals (mg/kg): K–2900; P–2500; S–1600; Ca–1400; Mg–500; Na–46; Fe–40; Zn–37; Mn–12; Cu–10 (a[2])

Helichrysum leucopsideum — Satin everlasting daisy

Crude protein %: 15.8, 16.5 (i)

Hovea acutifolia — Pointed-leaf hovea

Crude protein %: 33 (c)

Hypochaeris radicata — Flatweed

Crude protein %: 15.1, 17, 17.1, 18.2, 17.9, 15.6, 13.6, 15.7, 16.5, 14.1, 17.1, 9.2 (a[1]); 19.1 (b); 15.7 (d); 18.4 (e); 20.4 ± 2 (m)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	3.3	3.4*	2	4.9	3.1*	3.1	7.5	3.8	3.1	-
a[1]	3.7	3.9*	1.8	5.8	3.4*	3.6	8.3	4.3	3.6	-
a[1]	4.1	4.3	2.1	6.1	3.6	4.1	8.9	4.9	3.9	-
a[1]	4.1	4.3	2.1	5.9	3.5*	3.9	7.4	4.4	3.6	-
a[1]	3.8	4.2	2	5.7	3.6*	3.8	7.8	4.2	3.3	-
a[1]	3.1	3*	2.2	5	2.7*	3.1	6.6	3.8	3	-
a[1]	4.2	4.6	2.2	6.2	4.3	3.9	7.8	3.3	3.8	-
a[1]	3.9	4.5	2.1	6	3.8*	3.6	8.2	3.8	3.4	-
a[1]	3.2	3.8*	1.4*	5.6	3.1*	3	8.6	3.1	3.6	-
b	2.8*	3.2*	1.2*	4.8	2.8*	3	6.2	3.1	4.9	-
b	3.8	3.7*	1.6	5.8	3.1*	3.9	7.1	5.1	4	1.6
b	2.6*	1.8*	1.2*	3.7*	1.5*	2.7	4.9	6.3	5	-
b	3.2	2.5*	1.8	4.9	2.2*	3.4	9.7	5.6	2.7	-
d	4.1	4	1.9	7	4.2	3.2	6.4	-	6.6	-
e	3.7	4.3	2	6.1	4	4.6	6.5	3.6	3.9	-
* = Below ideal ratio										

Fat/Lipid %: 5.6, 6.6, 7.4, 8.5, 9.2, 7.4 (a[1]); 10 (b)

Minerals (mg/kg): K–2500, 2300, 2500; P–2100, 2000, 2100; S–1400, 1400, 1400; Ca–1000, 1000, 1000; Mg–260, 220, 260; Na–73, 160, 220; Fe–16, 31, 16; Zn–20, 20, 20; Mn–9, 6, 5; Cu–5, 4, 5 (a[2])

Lavendula spp. — Lavender

Crude protein %: 19.4 (a[1])

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	4.2	4.5	2.2	6	3.6*	4.1	6.4	3.7	4.3	-
* = Below ideal ratio										

Fat/Lipid %: 2.9 (a[1])

Minerals (mg/kg): K–2800; P–2800; S–1800; Ca–1600; Mg–270; Na–89; Fe–14; Zn–16; Mn–15; Cu–11 (a[2])

Leptospermum laevigatum — Teatree

Crude protein %: 14.4 (d)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
d	3.3	4.4	1.3	9	4.5	2.8	2.2	-	5.1	-

Lomandra multiflora — Many-flowered mat-rush

Crude protein %: 33 (c)

Lupinus albus — Lupins

Crude protein %: 32.6 (e); 28 (d)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
e	4	5.1	1.7	6.8	4.5	4	6.1	2.1	4.6	1.1
d	3.9	5.5	1.7	7.4	4.6	4.1	7.3	-	5.6	-

Lupinus angustifolius — Lupins

Crude protein %: 34.7, 33.7 (a[1]); 28 (d)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	4.4	5.4	2.1	8	4.4	4.2	3.3	2.2	4.7	-
a[1]	5	5.7	2.1	8.1	4.9	5.1	7.4	2.8	5.5	-
d	3.9	5.5	1.7	7.4	4.6	4.1	7.3	-	5.6	-

Fat/Lipid %: 3.1, 2.7 (a[1])

Macadamia integrifolia — Macadamia

Crude protein %: 16.3, 19.4, 22.7 (b)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
b	6.3	3.8*	2.2	6.3	3.1*	3.9	6.4	3	5.1	-
b	4.8	5.2	2	7.4	4.1	4.6	7.8	3.3	5	-
b	4	4.4	2	6.5	3.5*	4.4	6.7	3.9	5.9	-
* = Below ideal ratio										

Mantisalca salmantica — Thistle

Crude protein %: 25 (h[2])

Medicago sativa — Lucerne

Crude protein %: 20, 24.1 (b); 19.4 (d)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
b	3.6	4	1.6	5.4	3.1*	3.3	5.5	2.9	5.2	1.4
b	3.3	3.3	1.4	5	2.7*	3.1	5.6	3.2	4.5	1.6
d	3.6	4.7	1.3	8.4	5.7	4.5	6.5	-	4.6	-
* = Below ideal ratio										

Medicago truncculata — Barrel medic

Crude protein %: 14.1% (d)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
d	1.7	3.4	0.4*	4.5	2.8*	2.4	3.2	-	4.1	-
* = Below ideal ratio										

Melaleuca quinquenervia — Broad-leaved tea tree Belbowrie

Crude protein %: 30 (b); 35, 36.8 (c)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
b	2.6	4.4	4.9	5.4	3.4*	3.4	6.7	2.9	11.8	-
b	3	4.7	2.2	5.9	3.6*	3.7	6.3	3.1	9.3	-
* = Below ideal ratio										

Microlonchus salmanticus — ? thistle

Crude protein %: 25 (c)

Muehlenbeckia cunninghamii — Lignum

Crude protein %: 17.7 (i)

Myoporum deserti — Ellangowan

Crude protein %: 21.6, 22.9 (b)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
b	4.3	4.3	1.5	6.5	3.7*	3.7	6.6	4.1	6.4	-
b	3.1	3.9	1.9	6.3	3.8*	4.1	3.7	2.2	5.7	-
* = Below ideal ratio										

Myoporum montanum — Boobialla

Crude protein %: 24.9 (g)

Nymphaea capensis — Water lily

Crude protein %: 30 (c)

Olearia elliptica — Sticky daisy bush

Crude protein %: 9.8 (c)

Onopordum acanthium — Scotch thistle

Crude protein %: 36.4 ± 1.4 (m)

Papilionaceae spp. — Dillwynia Peaflowers

Crude protein %: 19.7, 17.1, 23.3 (a[1]); 14 (b)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	4	5	2.4	6.6	2.7*	3.8	5.7	2.7	7.1	-
a[1]	4.5	5	2.7	7.4	3.7*	4.4	5.7	2.6	4.9	-
a[1]	3.7	4.8	2	6.3	2.7*	3.7	5.6	2.7	7.1	-

* = Below ideal ratio

Fat/Lipid %: 1.7, 1.6, 1.7 (a[1])

Persea americana — Avocado

Crude protein %: 24.4 (e)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
e	4.3	5	1.6	6.9	4	4.1	5.6	2.8	5	1

Phalaris minor — Canary grass

Crude protein %: 10.4 (d)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
d	15.4	11.6	0.2*	7.5	8.9	3.4	-	-	4	-

Phyla nodiflora — Lipia, Matweed Carpet grass

Crude protein %: 25.1 (c)

Pinus radiata — Radiata pine

Crude protein %: 8.9 (d); 9.5 (e)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
d	2*	3.2	0.3*	3.3	3.1*	1.5	1.5	-	3.2	-
e	2.9*	3.8*	1.3*	4.9	2.9*	6	5.4	2*	11.7	0.9*
* = Below ideal ratio										

Pinus spp. — Pine

Crude protein %: 7 (c)

Plantago lanceolata — Plantain

Crude protein %: 17.3 (d)

Prunus dulcis — Almond

Crude protein %: 25.4, 24.8 (a[1]); 23.3, 25.5 (d); 30.7 (e)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	4.5	5.1	2.6	6.4	4.3	3.9	6.5	1.9	5.5	-
a[1]	4.5	4.8	2.4	6.9	4	4.2	5.9	1.8	5.2	-
d	4.7	5.4	1.2*	7.4	4.7	2.6	3.4	-	4.6	-
d	4.7	5.3	0.7*	6.7	4.4	2.3	3.1	-	4.7	-
e	4.5	5.4	2	6.7	4.1	4.9	6	2.1	5.3	1.1
* = Below ideal ratio										

Fat/Lipid %: 2.74, 1.89 (a[1])

Minerals (mg/kg): K–8200; P–4800; S–2500; Ca–990; Mg–670; Na–45; Fe–84; Zn–40; Mn–14; Cu–8 (a[2])

Ptilotus spp. — Square-headed foxtail

Crude protein %: 17.7, 19.9 (i)

Pultenaea myrtoides — Bush pea

Crude protein %: 33 (c)

Pultenaea villosa — Bush pea

Crude protein %: 31 (c)

Pyrus communis — Pear

Crude protein %: 26.2 (a[1])

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	4.4	5.4	2.4	6.9	4.1	4.2	6.4	2.6	4.8	-

Fat/Lipid %: 1.8 (a[1])

Raphanus raphanistrum — Wild radish

Crude protein %: 25.2 (e)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
e	4.2	5	1.9	6.9	4	4	6	2.1	5.8	1.2

Rapistrum rugosum — Turnip weed

Crude protein %: 21.6, 21.8, 22.7, 22.9, 24.6 (a[1]); 25, 29.2 (c); 24.4, 25.3 (b)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	4.7	5.3	2.3	7.1	4.9	4.4	8.5	2.1	5.1	-
a[1]	4.8	4.9	2.6	6.8	4.3	4.2	6.6	2.1	5.1	-
a[1]	4.7	5	2.5	7	4.5	4.3	6.5	1.9	5.6	-
a[1]	4.6	4.8	2.3	7	4.3	4.3	6.8	1.9	4.8	-
a[1]	4.6	4.7	1.9	6.5	3.9*	4.1	7	2.3	4.8	-
b	4.6	4.4	1.7	6.8	3.8	4.1	7.9	2.7	5.9	-
b	4.1	4.6	2.2	6	4.2	3.7	6.2	2.1	5.6	-
* = Below ideal ratio										

Fat/Lipid %: 6.5, 5.9, 5.2, 5.4, 7 (a[1])

Minerals (mg/kg): K–5500; P–4900; S–3200; Ca–1900; Mg–1300; Na–45; Fe–49; Zn–29; Mn–12; Cu–7 (a[2])

Romulea rosea — Onion grass

Crude protein %: 16.8 (d)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
d	4.8	7.4	1.9	9	6.8	4.4	9.6	-	7.9	-

Rubus ideaus — Raspberry

Crude protein %: 21.3 (d)

Rubus fruticosus — Blackberry

Crude protein %: 14.8 (d); 20 (e)

Amino acids:

Reference	**Thr**	**Val**	**Met**	**Leu**	**Iso**	**Phe**	**Lys**	**His**	**Arg**	**Try**
d	3.1	4.8	1.5	6.5	4.1	4.5	8.5	-	7.4	-
e	4.4	5.4	2.3	7.3	4.6	4.6	6.3	2.6	5.2	0.9*
* = Below ideal ratio										

Salix discolor — Pussy willow

Crude protein %: 21.9 (a[1])

Amino acids:

Reference	**Thr**	**Val**	**Met**	**Leu**	**Iso**	**Phe**	**Lys**	**His**	**Arg**	**Try**
a[1]	4.5	5.5	2.5	7.5	4.8	4.4	7.2	2.3	6.3	-

Fat/Lipid %: 3.1 (a[1])

Salix fragilis — Crack willow

Crude protein %: 14.8, 15.1 (a[1])

Amino acids:

Reference	**Thr**	**Val**	**Met**	**Leu**	**Iso**	**Phe**	**Lys**	**His**	**Arg**	**Try**
a[1]	3.4	3.9	2.2	5.6	3.3*	3.3	5.3	1.8	6.6	-
a[1]	3.9	4.5	2.4	6.2	3.9*	3.6	5.9	2	6.8	-
* = Below ideal ratio										

Fat/Lipid %: 1.5, 2.1 (a[1])

Minerals (mg/kg): K–3700; P–4000; S–1400; Ca–1500; Mg–1000; Na–33; Fe–41; Zn–35; Mn–88; Cu–3 (a[2])

Schinus molle — Peppercorn

Crude protein %: 18.1 (d)

Amino acids:

Reference	**Thr**	**Val**	**Met**	**Leu**	**Iso**	**Phe**	**Lys**	**His**	**Arg**	**Try**
d	3.5	4	1.7	8.6	5.6	3.5	6.7	-	8	-
* = Below ideal ratio										

Senecio linearifolius — Fireweed groundsel

Crude protein %: 20.4 (d)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
d	3.5	4.3	0.6	5.1	3.8	5.6	3.1	-	10.4	-
* = Below ideal ratio										

Senecio madagascariensis — Fireweed

Crude protein %: 12.4 (a[1]); 11.8, 12.6, 13.3, 15.2, 17.3 (b)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	4	4.1	2.3	5.8	3.6*	3.4	5.4	3.2	4.4	-
b	4.3	4.2	2.1	6.2	3.5*	4	6.2	4.1	6	-
b	3.5	2.8*	1.5	4.9	2.3*	3.5	6.1	4	5	-
b	3.4	3.3*	1.7	4.9	2.2*	3	6.3	5.1	5.6	-
b	4.4	3.7*	1.2	6	3.2*	3.5	8.4	6.8	6.3	-
b	3.8	3.8*	1.4*	5.7	3.9*	3.4	7.3	3.6	5	-
* = Below ideal ratio										

Fat/Lipid %: 2.41 (a[1])

Sida rhombifolia — Sidratusa

Crude protein %: 16.7, 17.4 (i)

Sisymbrium officinale — Hedge mustard

Crude protein %: 22, 22.3, 22.4 (a[1])

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	5.1	5.3	2.4	7.3	4.9	4.5	8.7	2.3	5.3	-
a[1]	4.2	3.3*	2.8	5.6	3.1*	3.2	5.8	1.8	4.1	-
a[1]	4.7	5.7	2.6	7.2	5.3	4.2	8.1	2.7	5	-
* = Below ideal ratio										

Fat/Lipid %: 5.7, 6.4, 5.4 (a[1])

Minerals (mg/kg): K–5100; P–4700; S–3200; Ca–1900; Mg–1200; Na–53; Fe–42; Zn–41; Mn–21; Cu–5 (a[2])

Swainsona galegifolia — Darling pea

Crude protein %: 17.6 (c)

Trachymeme spp. — Wild parsnip

Crude protein %: 26.1, 28.9 (i)

Tribulus terrestris — Yellow vine

Crude protein %: 13.9, 21 (b)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
b	4.3	4.7	1.5	6.4	4.4	4.1	7.7	2.5	5.4	-
b	3.1	4	2	5.3	3.6*	3	4.9	2.7	4.2	-
* = Below ideal ratio										

Trifolium balansae — Balansa clover

Crude protein %: 23.4, 27.2 (a[1])

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	4.7	5.7	2.4	7.4	5.1	4.4	6	2.4	4.9	-
a[1]	4.6	5.3	2.1	7	4.3	4.4	6.1	2.5	4.6	-
* = Below ideal ratio										

Fat/Lipid %: 2.31, 1.5 (a[1])

Trifolium repens — White clover

Crude protein %: 25.9 (a[1]); 22.5, 22.6, 23.1, 24.9, 25.4 (b); 25.1, 25.6 (d); 24.7 (e)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	4.6	5.3	2.2	7	4.4	4.3	5.9	2.5	4.7	-
b	3.2	2.7*	1.4*	5.1	2.3*	3.3	5.1	2.3	3.5	-
b	3.8	3.1*	1.8	5.9	2.6*	3.6	5.6	4.2	4.6	-
b	3.6	2.9*	1.7	5.5	2.4*	3.4	5.4	4.2	5.1	-
b	3	2.3*	1.5	4.6	1.9*	2.9	4.9	3.9	4.3	-
b	4.3	3.5*	2	6.8	3.1*	4.3	7.6	4.1	3.4	-
d	4.1	4.5	1.5	13.5	5.7	5	2.7*	-	7.3	-
d	4.3	4.6	1.8	13.1	5.7	4.6	2.8*	-	8	-
e	4.3	5.3	2.1	6.9	4.6	4.6	5.5	2.6	4.2	-
* = Below ideal ratio										

Fat/Lipid %: 2.5 (a[1])

Ulex europaeus — Gorse

Crude protein %: 28.4 (a[1]); 16.5 (d)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	4.5	5.1	2.3	7.2	4.4	4.4	6	2.3	4.7	-
d	4.3	10.7	3.2	14.4	2.1*	11.3	2.4*	-	2.6	-
* = Below ideal ratio										

Fat/Lipid %: 2.1 (a[1])

Minerals (mg/kg): K–5700; P–5900; S–2600; Ca–1100; Mg–1100; Na–66; Fe–46; Zn–73; Mn–23; Cu–7 (a[1])

Vaccinium spp. — Blueberry

Crude protein %: 13.9 (a[1])

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	3.8	5.4	2.3	6.7	4.7	3.5	6.4	2	5.6	-

Fat/Lipid %: 2.04 (a[1])

Velleia glabrata — Smooth velleic

Crude protein %: 15.2, 16.8 (g)

Vicia faba — Faba bean

Crude protein %: 24.4 (a[1]); 22.3, 24.1 (a[3])

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	4.6	5.2	2.2	6.7	4.8	4.2	6.2	2.1	5.1	-
a[3]	4.8	5.1	1.8	6.8	4.6	4.3	6.8	2.2	5	-
a[3]	4.8	5.2	1.8	6.9	4.8	4	7.4	2.3	4.8	-

Fat/Lipid %: 1.72 (a[1])

Vicia spp. — Vetch

Crude protein %: 24.1, 24 (a[1])

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	4.6	5.2	2.4	7	4.7	4.4	6.7	2	4.7	-
a[1]	5	5.7	2.4	7.8	5.1	4.8	7.4	2.2	5.2	-

Fat/Lipid %: 1.8, 1.7 (a[1])

Xanthorrhoea — Grasstree

Crude protein %: 20.3 (d)

Zea mays — Maize/corn

Crude protein %: 14.9 (a[1]); 14, 15 (b)

Amino acids:

Reference	Thr	Val	Met	Leu	Iso	Phe	Lys	His	Arg	Try
a[1]	5.1	5.9	1.6	6.8	4.8	3.8	5.6	1.9	4.7	-

Fat/Lipid %: 1.8 (a[1])

Minerals (mg/kg): K–4900; P–3700; S–1800; Ca–580; Mg–740; Na–24; Fe–26; Zn–48; Mn–14; Cu–4 (a[2])

CHAPTER 7

CASE STUDIES

The following information was collected by interviewing individual beekeepers from 1999 to 2004 from all states of Australia and some input from New Zealand beekeepers. The information provided was relevant to them at the time of the interview. Please note, their practices may have been modified or taken on a different direction since the date of the interview. The views expressed by the beekeepers in this section are not necessarily endorsed or supported by the author of this publication.

Western Australia
John Davies, Baldivis; Peter Detchon, Scarborough; Harry East, Morangup; Colin Fleay, Toodyay; Ron Jasper, Hillarys; Rod Pavy, Gidgegannup; Bob Power, Belmont; Steve Richards, Bellvue.

South Australia
Leigh Duffield, Mt Compass; John Fuss, Tintinara; Geoff Smith, Tintinara; Graham Wagenfeller, Keith.

Tasmania
Ken Jones, Sheffield; Bill Oosting, Devonport; Col Parker, Hobart; Ian Stephens, Mole Creek; Julian Wolfehagen, Perth.

Victoria
Kevin & Glen Emmins, Mildura; Ken Gell, Maryborough; Ian Oakley, Carwarp; Ray Phillips, Shepparton; Craig Scott, Echuca.

New South Wales
Trevor Billett, Woodburn; Rosemary Doherty, Mudgee; Dave Fisher, Ulmara; Wayne Fuller, Grafton; Warren Jones, Dubbo; Monte Klingner, Glen Innes; Dayl Knight, Trangie; Keith McIlvride, Thirlmere; Greg Mulder, Hunter Valley; Mike Nelson, Boggabri; Harold Saxvik, Darlington Point; John & Kieren Sunderland, Dubbo; Fred Taylor, Wallabadah; Warren Taylor, Black Springs; Bruce White, Eastern Creek Quarantine Station; Col Wilson, Kurri Kurri.

Queensland
Don Keith, Inglewood; Ken Olley, Clifton; Rod Palmer, Ipswich; David Stevens, Warwick.

New Zealand
John Berry; Wouter Hyink.

John Davies (WA)

Key words: *honey production, pollen combs, pollen deficiencies, pollen supplement*

(Interview: Nov. 2002)

John use to manage four apiaries with a total of 430 to 450 hives. Only recently has his son Stephen joined the business and they have increased the number to 600 across six apiaries. The business is totally focussed on honey production with no other diversification. John believes that this ensures that the total attention of the business is on honey production only, thus maximising returns. He found that in the past, trying to harvest pollen the traps often caused the bees to hang out in hot weather and restricted the movement of bees into and out of the hive. By removing the pollen traps honey production increased and all the pollen collected by bees was now available to the colony.

Nutrition management is achieved by brood comb manipulation. John practices a barrier system for disease management, with one brood box and three supers per unit. At any given time one super is in storage and the colonies are maintained as three deckers. Combs with pollen and brood, in some cases, are lifted above the excluder in spring and again in the autumn on red gum *(Corymbia calophylla)*. Lifting of pollen or brood combs may take place three times during these two periods. This pollen is frequently covered by honey and capped. As the pollen does not dislodge during the extraction process, the stored pollen is returned to the colonies when the supers are returned to the field. By this method, red gum pollen or any other beneficial pollen is often made available to the colony months after it has been collected, thus ironing out any periods when pollen is naturally short. The rate which the stored pollen is consumed depends very strongly on the age of the queen. Young queens respond very quickly, thus the advantage of ensuring that a regular requeening program is followed.

Young queens respond very quickly.

Winter gum *(Eucalyptus wandoo)* honey flows are traditionally hard on bees, but if bees have worked a red gum flow in February/March prior to this then brood and pollen manipulation usually ensures that the colony does not decline significantly on white gum. By the time the bees actually start utilising the freshly collected white gum pollen, after consuming all the stored red gum pollen, the bees are normally being shifted off white gum onto coastal sites to continue breeding. It is imperative to always go to a red gum flow even if there is only a small flowering of the tree. If this is not possible, then the bees can be moved to the banksia or the heath country to maintain breeding.

Supplementation has been trialled a few times with mixed success. One year the bees were moved to the york gum *(Eucalyptus loxophleba)* which has a poor reputation as a pollen source. Dry red gum pollen was provided to the colonies in small amounts, but the bees came back in very poor condition. “Maybe we didn’t feed them anywhere near sufficient amounts”, was one suggestion by John. Then again they may have gone back even further with no pollen supplement.

Some years back a commercially prepared complete pollen supplement, with no pollen in the mix, was provided to each hive while they were on white gum. “While ever they were on white gum, they ate them. The minute we got them onto slightly better pollen, they wouldn’t touch it [the pollen substitute]”. In another year, alternative commercially available pollen supplements, with pollen in the mix, were trialled along with a local recipe. The supplement was being provided to each colony each two or three weeks. Either way, at the end of the feeding exercise, the results weren’t encouraging and the conclusion was made “that we didn’t feed sufficient quantities to really do the job properly”. Even so, it was also noted that the provision of supplements may well have prevented the colonies from going backwards.

John believes that disease management is strongly linked to strong healthy colonies and this is dependent on the nutritional status of the hive.

Beekeepers are getting better at nutritional management but at the same time there is still a lot of guesswork. Areas that require further research include the need to take the guesswork out of nutritional management. He would like to know what the measured response will be if he feeds various diets to his bees, how much should he feed, how often, and the cost benefit of such feeding strategies. “Just seems that people growing crops can get their soil tested and they know how much of this and how much of that to put on. Even the most intensive farming they can monitor everything. These poultry people down the road, they order very slight variations in their feed mix and all this sort of thing, and they’ve got a good handle on that, and if that gives them 1% more eggs laid, or whatever, that’s the sort of fine tuning that they can do… but with beekeeping, you’re just trying to guess those sorts of things.”

Peter Detchon (WA)

Key words: *honey production, pollination, nucleus colonies, pollen supplement, sugar syrup feeders, economics*

(Interview: Nov. 2002)

Peter has varied his beekeeping business, at one time managing 1000 hives. Currently he runs 300 plus hives which are managed for honey production, pollen production, queen rearing and the provision of pollination services. The honey produced by Peter is also packed and retailed at a regular market each weekend. Hives provided for pollination are usually six frame nucleus colonies which are made from full sized colonies as required. Up to 500 nucleus colonies can be provided as per requirements.
Managing bees under a variety of conditions with the necessity to have colonies at a set strength prior to pollination and the need to provide the best possible conditions for rearing queen bees inspired Peter to explore supplementary feeding colonies. Initially this met with mixed success with different strategies for feeding sugar syrup and varying recipes for pollen supplements.

Sugar syrup feeding techniques varied from boardman feeders, using a modified design incorporating milk bottles, plastic bags under the lids and dry sugar poured into the back of the hive. Frame feeders and top feeders all met with mixed success. Syrup was only fed to regular colonies to prevent starvation, where as syrup was supplied to colonies used for queen rearing even when the natural conditions meant that field bees may have been foraging on a light nectar source. Frame feeders were used for queen rearing, these worked well. When colonies were being supplied syrup due to the risk of starvation “an incredible robbing frenzy” could occur and nucleus colonies in some cases under these circumstances were not able to defend themselves. To avoid this situation, feeding was carried out at sunset or after dark.

The concentration of syrup varied according to the intended outcome e.g., to stimulate brood rearing a one part sugar to two parts water mixture was supplied to colonies; when dearth conditions occur the ratio is two parts sugar to one part water. For general feeding and wax comb building a one sugar to one water syrup was supplied to the bees.

Currently most of the syrup feeding is aimed at the six frame nucleus colonies that are made up for pollination. The hive is made up of five combs with a frame feeder that holds two litres of syrup. When the colonies are first put together the feeder is filled to capacity and the colony is supplied a pollen supplement made to

Peter's recipe. Depending on the crop, additional feeds are delivered during the pollination period, particularly when the crop is enclosed by bird or hail netting.

As Peter also sells his supplement the exact recipe has not been made available. Even so, it does currently contain "soy lite oil" as this oil has high levels of linoleic acid and oleic acids both believed to be beneficial to honeybees. This oil is also reasonably easy to obtain from most supermarkets. Some of the other ingredients include sugar, soy flour, torula yeast, a vitamin/mineral additive and bee collected pollen. The pollen is gamma irradiated before it is utilised in the supplement and is mixed at a rate of 10% of the total recipe.

Sourcing fresh ingredients such as soy flour and torula yeast can be difficult.

The ingredients are mixed with a commercial dough mixer into a soft consistency and stored frozen until required. A handful of the dough is removed and placed on the top of the frames in the brood box. Placing the dough to one side of the colony or on top of the queen excluder was found to be unsatisfactory. Another difficulty encountered is sourcing fresh ingredients such as a soy flour and torula yeast as and when they are required. It is important that the dough remains soft while in the colony as Peter suggests if it goes hard it is a "disaster". It is particularly important that the soy flour is not enzyme active, since the protease inhibitors in this flour inhibit protein digestion in the larvae and result in short lived bees with impaired hypopharyngeal glands.

Nucleus colonies are made up from larger colonies at the end of the red gum *(Corymbia calophylla)* honey flow which finishes in March/April. Often there is no other significant nectar or pollen source between April and spring but the nucleus colonies can still be built up in strength by the use of supplements. This is not economical for all occasions, historically this management strategy would not pay for honey production alone. The nucleus colonies are initially supplied 100 to 150 grams of pollen supplement and as they grow in population the amount of supplement increases to a point where the colony may be consuming up to a kilogram per week. Maintenance feeding is completely different from encouraging colonies to breed and expand in population.

Peter traps his own pollen for use in the supplement preferring red gum pollen but regards jarrah *(Eucalyptus marginata)* pollen as also quite good. All the collected pollen is gamma irradiated to prevent the transfer of bee pathogens. As the economics of beekeeping changes, Peter sees the opportunity for the revisiting of supplementary feeding management strategies.

Harry East (WA)

Key words: *honey production, pollen feedback*

(Interview: Nov. 2002)

Harry previously managed 700 hives, but is in the process of scaling back in preparation for retirement and now manages 400 hives. Even so, his aim is to produce more honey and pollen per hive with fewer numbers and, as a consequence, still strives to maintain a good profit from the business.

Normally, production of 200 kg of honey per hive is achieved annually, with 5–10 kg of jarrah and red gum pollen harvested from each hive depending on the season. The pollen is an opportunistic complement of the business and it is only trapped when there are large surpluses available. Income from pollen @ $8 per kg wet can contribute a significant amount to the annual income. A pollination service is provided but only on a small scale. Generally, this can be very time consuming and unrewarding, so this business has not been actively pursued.

Apiaries are wintered in the central coastal heathlands, where the spring flowering provides ample pollen and stimulating nectar to build strong high protein colonies ready for the summer eucalypt honey flows further south. Apiaries are generally moved six to 12 times per year depending on conditions and floral prospects. Winter/spring: coastal heathlands, banksia, hakea, dryandra, bottlebrush, acacia, capeweed *(Arctotheca calendula)*, canola *(Brassica napus)*; Late spring: farmlands, paterson's curse *(Echium plantagineum)*, flooded gum *(E. rudis)*, york gum *(E. loxophleba)*; Summer: forest area, wandoo *(E. wandoo)*, jarrah *(E. marginata)*, blackbutt *(E. patens)*, red gum *(Corymbia calophylla)*, or Goldfields area mallee; Late summer/autumn: farm and forest, late red gum and winter wandoo; Autumn: pastoral area york gum—acacia pollen or heathland, banksia, white bell.

> **The choice of floral resources has declined over time.**

Since the droughts in the 1970s when dry seasons became an issue, Harry had periodically practised supplementary feeding colonies. As time marches on the choice of floral resources to choose from has declined, thus the need to look a lot harder at supplementary feeding of pollen and at times sugar syrup has become necessary. Nectar is not generally considered lacking, but quality pollen is. Pollen is rarely in short supply in WA but at times the quality can be of concern in the management of colonies. Feedback pollen is dried and ground before being gamma irradiated and is normally red gum or blackbutt. Nothing is added to the pollen when feeding to each colony. This pollen supplement is provided only to maintain brood rearing and not to stimulate the expansion of the colony.

As apiaries are often over 300 km from home, the method of feeding has to be simple and easy. Two people can easily provide pollen to every colony in a load within half an hour by lifting the migratory lids and placing approximately 100–150 gm of dry pollen under the cover. This feeding can be done on normal trips to remove honey or when providing water. Originally Harry made up patties using honey, water and pollen to make a paste consistency mixture, which was too sticky or too dry. It was always very difficult to measure and administer to each hive, also if not used quickly tended to grow mould.

Chalkbrood *(Ascosphaera apis)* is causing major problems in WA as it has only been established for a few years. Harry believes that the high quality pollens his bees have access to have helped to keep American foulbrood *(Paenibacillus larvae* subsp. *larvae)* at a low incidence, but has not helped to control chalkbrood. When trapping pollen, hives that succumb to chalkbrood are particularly noticeable with large numbers of mummies in the pollen draw. Some pollens seem to have a suppressing effect on chalkbrood.

> **Some pollens seem to have a suppressing effect on chalkbrood.**

Previously collected pollen is fed to colonies after they leave the red gum in April to work the york gum in the pastoral areas. York gum can provide prolific honey production but has notoriously poor quality and quantity pollen for honey bee dietary requirements. There can be a six week period where there is very little pollen available to the colonies and this is the period when red gum and blackbutt pollen is fed under the lid on each trip to service or water hives. Three weeks after rain under these conditions, acacia pollen becomes available and the brood area quickly increases as a result. The other circumstances when pollen is provided to colonies, is if there has been no early rain in autumn, creating another shortage of pollen in the heathlands.

To avoid production losses, supplementary feeding has to commence well before the population declines in the hives, judgement can be based on previous experience and knowledge of the area. "It would also be helpful if you were able to take some bees and incoming pollen and have both tested for protein levels to give you a quick guide to what is going on at present in the colony and help you decide when you should supplementary feed pollen."

Harry would like to see research into finding a simple and quick method or technique to determine the protein level of bees within the apiary so supplementary protein can be provided to prevent population and protein declines. "You can look at them physically and you can say well you think they are alright, but you don't quite know, you can tell bees that are really undernourished because they get quite small (skinny) and they don't look healthy. When you reach what you might consider a borderline case, it is very difficult to tell by eyeballing them."

There has been a 30 year decline in annual rainfall in WA, thus the honey and pollen production can often be patchy and erratic. Given this fact, the key to maintaining a profitable business in beekeeping is to always keep an eye on the nutritional status of your bees, know what is offering ahead for potential honey and pollen flows and, as insurance, carry stocks of irradiated feedback pollen or have access to it.

Look after your bees, and they will look after you in return.

Look after your bees and they will look after you.

Colin Fleay (WA)

Key words: *honey production, pollen collection, pollen deficiencies, pollen supplement*

(Interview: Nov. 2002)

Colin manages five loads of 80 colonies (400 hives) mainly for honey production, although they all have pollen traps which are only activated when conditions suit. He aims at having strong bee colonies ready prior to honey flows and not after they have started. He regards this as the key in being successful as a commercial beekeeper. "Its like a horse race, you train the horse for the race, you've got to have him fit as a fiddle for the minute that the barrier cracks. The first day your honey's there in the field you want your hives in tip top condition."

Regular autumn re-queening is a major component to his management as well as supplementary feeding. This ensures that the colony is headed by a young queen coming into the spring and can go immediately to work. Supplementary feeding irons out the big population troughs coupled with young queens. It's easier to pick a colony population up from 25,000–30,000 to 50,000–80,000, more so than a colony that has a population of 10,000. The smaller populations will take an extra couple of brood cycles to achieve the same population.

Last year (2001) he extracted 261 x 200 litre drums of honey and collected 8 tonnes of pollen. To help achieve this, supplementary feeding was practised particularly during some nectar flows. On white gum *(Eucalyptus wandoo)*, the bees always go backwards, so Colin concluded that supplementary feeding was required.

Pure pollen is fed back to the bees after it has been gamma irradiated in the eastern states to prevent the transmission of bee diseases. The pollen is crushed and dried for storage. To determine whether bees require pollen, a handful is placed on the inner cover; if the bees start removing the pollen within 5 minutes all colonies are then given a supplement of abut 50 grams of pollen per week. Even when a pollen source is available in the field, bees will still remove the pollen from the inner cover and store it around the brood. The 50 grams at first didn't seem to be having any impact so the rate was increased to 100 grams often only feeding every two weeks depending on how often the apiaries were visited and how busy things were.

When Colin concludes that the pollen being collected by the field bees is nutritionally deficient he will activate all his pollen traps and prevent a large portion of this being available for the brood. Instead he supplies the colony with red gum *(Corymbia calophylla)*, sand plain (a pollen mix of many species) and acacia pollen which he regards as excellent pollens for bees to rear brood with.

The bottom fitted pollen traps are more preferable as they are "not in the way" compared to front fitting pollen traps. When activated they are emptied every week. If ants bother the bees sometimes activating the pollen trap draws attention away from the bees to the pollen collection tray which has helped prevent the ants from annoying the bees.

Feeding pollen to hives is a great way of determining if you have a dud queen. If the pollen is not being removed then the queen inevitably needs to be replaced. Sometimes dry sugar is also fed to the colony in the same fashion as the pollen. As long as they have access to fresh water they seem to consume this without any problems. Feeding either sugar or pollen can take as little as 40 minutes for 80 hives. Supplementary feeding is either done to keep the colonies alive or prepare them for the next expected honey flow. "Look at your prospects and determine when your next flow is going to start then begin feeding 8 to 9 weeks beforehand if necessary". "What you've got to get your head around is that you're not a honey producer, you're not a pollen producer, you're not a pollinator, you're a bee grower. To grow bees you've got to have healthy bees".

Colin is also sure that dietary stress accounts for 90% of disease problems within the colony. He also emphasised that autumn re-queening was a major factor in keeping colonies strong in population and being able to manage bees successfully to obtain honey flows in early spring.

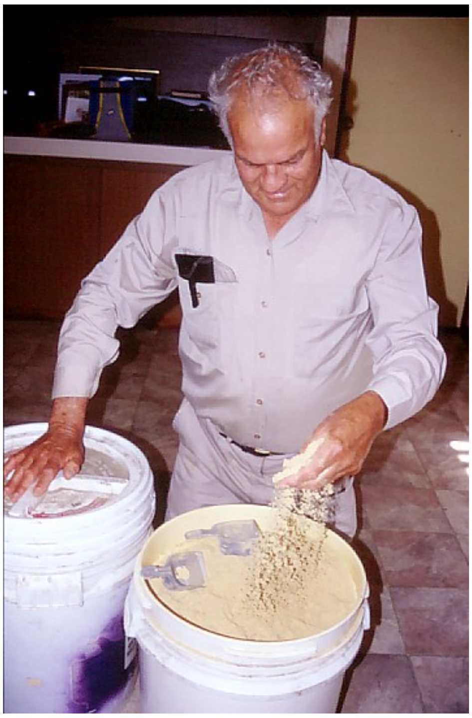
Ron Jasper (WA)

Key words: *honey production, pollen trapping, feeding pollen*

(Interview: Nov. 2002)

Ron manages 300 hives on a full-time basis for honey production. He has pollen traps attached to 100 hives (one load) for the purpose of harvesting pollen to feed back to colonies at a later date. The total harvest of pollen is between 150 and 200 kilograms per year from three floral species; jarrah (*Eucalyptus marginata*), red gum (*Corymbia calophylla*), and blackbutt (*Eucalyptus patens*). The pollen is stored in a freezer at -20°C and once trapping has been completed the pollen is transported to Sydney to be gamma irradiated. Prior to transporting to Sydney, the pollen can be powdered to save space in the container, although Ron has found the pollen forms a hard crust in the storage containers and is then difficult to remove on its return. He prefers to leave the pollen in pellet form.

The formula used in his pollen supplement is 1 part pollen, 1 part torula yeast and 1 part granulated white sugar, by weight. The ingredients are dry mixed and the pollen pellets break up into a fine powder in the mixing process. This mixture is fed back to colonies the following winter after it has been collected, starting early June, through July, August and sometimes in November. Approximately 100 grams of the formula is placed under the lid of a double hive every few weeks. The success of the formula and the need by the bees for the supplement is gauged by the rate of consumption. Once bees actively collect pollen in the field, supplementary feeding stops.



Hand mixing pollen supplement.

Initially, Ron began supplementary feeding by purchasing commercially available pollen patties. He found that bees would not always consume the whole pattie and that often the remaining pattie would go hard and become difficult for the bees to consume. He felt that this was a waste of money and began producing his own supplement.

The method by which the supplement was applied to each colony also changed. Initially, the top box was removed and the pattie was placed on the top bars of the bottom box, under the queen excluder. This broke the cluster of bees in winter, made the bees cranky and created a lot of work in feeding the patties. The next method trialled was to drop a pattie between the frames of the top box, the patties in this case weren't always consumed and at times would create a mess to be later removed. Eventually Ron came to his current decision to provide the pollen supplement under the lid.

If moisture is a problem in the hive the supplement is placed in a small plastic bag with one end open. The plastic bag then protects the dry supplement from the condensation in the cavity of the lid and allows the bees to freely access the supplement. This usually takes 3 to 4 days to remove the entire supplement provided.

One interesting observation Ron had about winter white gum or wandoo *(Eucalyptus wandoo)* was this species seems to impact on the colony populations when in flower. The pollen is thought to be deficient in one or more dietary components necessary to meet honey bee nutritional requirements and as such, populations tend to decline.

Rod Pavy (WA)

Key words: *trapping pollen, pollination, pollen supplementation, sugar syrup*

(Interview: Nov. 2002)

Currently Rod manages 300 hives distributed between three apiaries. In the past he managed up to 700 hives but most of these were for pollen collection with an average of 10 kg annually harvested from each colony.

In a good year it is possible to harvest 12 kg of pollen per hive, although if colonies were kept strong in doubles and managed well, it would probably be possible to harvest even more pollen. The main pollen sources include jarrah *(Eucalyptus marginata)*, blackbutt *(Eucalyptus patens)*, red gum *(Corymbia calophylla)* and perhaps winter wandoo *(Eucalyptus wandoo)*.

In a good year it is possible to harvest 12 kg of pollen per hive.

Colonies are maintained in single hive bodies with front mounted detachable type pollen traps which are in place most of the time. They can be a bit of a problem during very hot weather as the bees tend to gather at the entrance compared to bottom mounted traps where this doesn't seem to be a problem. Perhaps this is due to the bigger trapping plate in the bottom traps. Pollen is collected from the traps on a weekly basis and returned to the factory to be dried and cleaned.

Red gum pollen stimulates the bees more than any other source of pollen.

At one stage Rod focused equally on honey production and pollen collection indicating that this enterprise mix was slightly more profitable but with considerable more work in removing honey supers and extracting combs. Colonies are now only managed for pollen production and some are provided for pollination of fruit trees under netting.

An eight frame single hive is provided for pollination of plums. These colonies are regularly provided supplements, both pollen supplements and sugar syrup. Flowering starts fairly early beginning 1st August for four to five weeks. Before supplementary feeding was practiced a colony with five to six frames of brood and bees while under the netting would decline to one to two frames of bees with a very small patch perhaps 75 mm across of brood. With supplementary feeding he has been able to minimise the decline of the colonies and they now come away from the pollination service with two to three frames of brood and bees.

A 50:50 ratio of sugar to water is provided in open feeders. Four or five buckets are placed in the orchard and about 10 litres is placed in each bucket three times during the five week pollination period for the 20 hives. They fly for the syrup and it appears to work fairly well. A 100 gram pattie or straight pollen in recent years is provided to each colony just prior to the bees being placed in the orchard.

Patties were made from a variety of substances depending on the availability of ingredients with 15% pollen in the mix. They were made into 100 gram 10 x 10 cm squares approximately 1 cm thick. These would be placed near the brood area of the colony and replaced every 2 weeks. Pollen supplementation only took place for maximum periods of six weeks before naturally collected pollen became available.

The mixture was prepared in a cement mixer. The pollen used in bee feed was always sent to Sydney NSW for gamma irradiation to ensure that it was not a cause for concern in spreading bee diseases. The pollen pellets are crushed, dried and placed in 20 kg drums for transport. Only a fraction of the pollen collected by Rod is utilised for bee feed, much of it is sold on the export market for human consumption. A particularly attractive source of pollen to honey bees is red gum. This pollen always stimulates the bees more than any other source. Bees on red gum in the autumn always come through the winter in good condition.

Apico WA pollen trap — all metal.

In recent years only pollen is provided to each colony, placed on the inner mat. Prior to the use of pollen, only half a cup of dry mixed supplement was provided to colonies. Unfortunately the response was poor and absconding of colonies occurred although it wasn't clear whether this was due to the ingredients in the supplements provided or some other reason, at the time the colonies were on york gum *(Eucalyptus loxophleba)*.

Sugar syrup feeding was not normally practiced except in the colonies provided for pollination. But one year was an exception when stored honey and the area of brood were both receding. Pollen supplement and sugar syrup was provided to each colony. Plastic bags containing 1 to 1½ litres of two parts sugar to one part water were provided every week for three to four weeks. The plastic bags were placed under the lids with a few pin holes to start the bees feeding. There was no noticeable improvement in the brood area of colonies although they were all kept alive.

Bob Power (WA)

Key words: *honey production, vinegar, drought*

(Interview: Nov. 2002)

Bob has been keeping bees for 37 years and is currently managing 70 to 100 colonies. In the past he has managed up to 400 colonies. Hives are mainly for honey production, although every hive is equipped with a pollen trap. Blackbutt *(Eucalyptus patens)* and red gum *(Corymbia calophylla)* pollen is trapped for sale or feed back to bees, but this is not an activity Bob relishes. He has designed his own traps which do not have any wood components. They fit at the front of a hive and hold about one kilogram of pollen when full. For disease control they are soaked in chlorine solution periodically when not in use. The traps are designed to keep the pollen clean of chalkbrood mummies and dead bees. During a flowering event they need to be emptied every second or third day, with up to 8 kg of pollen per flowering event harvested.

If pollen supplement is not consumed within a few days, it's worth inspecting the colony to see why.

Bob Power's pollen traps.

This pollen is either stored for his own use or sold, although Bob believes the wholesale price offered for pollen is low and that he loses 10% of a honey flow due to the large number of bees foraging for pollen. Some of the pollen collected is gamma irradiated and kept to provide a supplement to bees at a later date.

Bob makes up 2 kg of supplement at a time which consists of 300 grams of brewers yeast, 450 grams of soy flour, 250 grams of irradiated pollen, and 400 grams of caster or icing sugar, a teaspoon of vitamin C. Reverse osmosis water is used to obtain the right texture. Bob also adds an additional brew to the mix which is known as "Golden Treat" and he keeps the amount of ingredients of the mix to himself as it has been derived from the ingredients of "Golden Treat" which comes in from Canada and is sold for $90 in WA for a 500 ml bottle. Bob reckons it costs him 50 cents for the same size bottle which does not have the preservatives that the imported bottle has. It is made up fresh each time it is required. The soy flour/meal used in the poultry trade seems to work better than the other sources of soy flour. The icing sugar is made from normal caster sugar by Bob, whereas it does not contain any corn flour which could be hard on the bees. Bob always experiments with new recipes on feeding practices and has changed the recipe since the interview.

Supplementary feeding is largely practiced during drought periods, when approximately 100 grams of the mixture is placed between the excluder and brood frames every fortnight until the bees start collecting nectar. Feeding pollen supplement in this manner is great for detecting hives with problems. If it is not consumed within a few days then it is worth investigating to see why. It will either be queenless, a failing queen or a hive with American Foulbrood. It is noted that the patties can be an attraction to wax moth if they are not consumed by the colony while in the hive.

Linoleic acid feeder.

An idea of feeding linoleic acid to hives was developed from conversations with the late Syd Murdoch, a beekeeper who was always trying new approaches to old problems. The aim was to try a different approach to AFB control, unfortunately this has not been successful. A mixture of 75 ml of linoleic acid, 70 ml of home made “Golden Treat” and 2.250 kg of icing sugar, 780 grams of irradiated honey which is sufficient for 50 tubes. The tubes hold about 150 ml; they are 19 mm square with 4 x 7 mm holes drilled in the length of the tube. Each tube has removable plastic plugs at either end for cleaning. The measurements of the ingredients must be exact, particularly the linoleic acid which will kill the queens above 75 ml. One tube is placed between brood frames and is replaced after 10 days with another. Only 2 tubes are given to a hive. Bob gives the tubes at the end of the summer flow coming into winter and before the spring. He strongly suggests this practice be left alone by the faint hearted.

Another problem disease, Chalkbrood, has been handled with more success, with the application of 4% apple cider vinegar which can be purchased from a supermarket for those who only have a few hives. Bulk supplies can be purchased at a lower cost. It is heated to hive temperature and a half cup is simply sprinkled over the brood or it can be also sprinkled over the honey super and it will run down into the brood box. Bob uses a 5 litre plastic garden watering can and guesses the half cup her hive. Nucs can also be treated using a quarter cup. He has been doing this practice for some years. He also makes up batches of 200 litres of cider vinegar from windfall apples to a proof of 10 to 15%. It is

Drum hive with fixed pollen trap.

watered down to 4% with chlorine free water. Using any other form of vinegar will kill queens and most of the colony and you will end up with a sticky mess on the floor of the hive, according to Bob, as he suggests he made this mistake whilst experimenting some years back. It is also noted that the vinegar is around the 4%.

Steve Richards (WA)

Key words: *sideline beekeeper, honey production, pollen trapping*

(Interview: Nov. 2002)

Steve manages between 50 and 80 hives, as a sideline to full time employment, managing them for honey production only. He has trapped pollen but found this to be labour intensive and did not fit in well with full time employment. He also found that when pollen traps were on the hives the bees were at times slow to build up and generally they slowed the traffic of bees too and from the colony reducing their honey production levels.

Winter white gum *(Eucalyptus wandoo)* honey flows are hard on bees due to the poor quality pollen available from this species. To overcome this problem, pollen supplements have been provided to each colony on the top of the frames. Steve only provides one 200 gram pattie to each colony, believing it is better not to overdo the feeding; just enough to give them a kick along as they usually have stored red gum *(Corymbia calophylla)* pollen in the combs when they are moved onto the white gum.

As Chalkbrood *(Ascosphaera apis)* has caused some problems, a sugar solution containing raspberry juice has successfully been applied to colonies to help them overcome this disease. For every 2 kg of sugar mixed with 2 litres of water, a cup of raspberry juice is added. This solution is placed in plastic lunch bags, pin pricked and provided to each colony on a weekly basis for about a month.

Leigh Duffield (SA)

Key words: *pollen supplement, sugar syrup, wintering*

(Interview: Jul. 1999)

Leigh has been keeping bees for 20 years and he currently manages 500 hives. For the last five years he has been experimenting with supplementary feeding protein supplements. In his initial trials he suggests he killed more bees than he benefited by feeding early recipes of pollen supplement. In all mixes he has avoided incorporating honey and/or pollen due to the inherit risk of spreading bee diseases.

Avoid incorporating honey and/or pollen due to the risk of spreading bee diseases.

Sugar syrup is occasionally fed in winter if the bees are “light on” for stored honey. The period of concern is from the last week in May until the first week in July. In some years bees are moved onto winter flowering banksia *(Banksia ornata)* where they can obtain some nectar, although the bees sometimes have “no guts” if the nectar is too thin. The syrup is provided in one litre plastic bags placed under the lid with a thick syrup; 60% sugar, 40% water by volume. Sugar is fed once a week for two or three weeks. If they haven’t responded to this, then the hive is left to its own devices. This syrup feeding has been necessary three out of five years. If the syrup doesn’t stimulate “the queen to start laying, it is pointless giving her pollen supplements”.

On the other hand, pollen supplements have been fed from the second week of January until the end of February every year for five years. The aim is to maintain bees on the lucerne blossom to provide a professional paid pollination service. The bees do not store much in the way of honey, only a box (20 kg) of honey is obtained in about two out of five years. Bees coming off red gum *(Eucalyptus camaldulensis)* generally don't need the supplements, the benefits are derived from fairly average bees going into lucerne supported by protein supplementary feeding. The queens tend to continue to lay right through the flowering event when pollen supplement is available. The patties are placed on top of the excluder over the brood nest. The supplement works best when bees have access to some natural pollen in the field.

When Leigh started to "play around" with mixing supplements, malt was one of the main ingredients with brewer's yeast. The mix is now marketed to other beekeepers as BLD bee feed. Bees only consume the mixture when they require the supplementary protein, otherwise they tend to ignore it. About 100 grams of feed will be eaten in about five days. If patties are not consumed, the hive is inspected for queen problems or possible brood disease infections. The BLD protein supplement, even though it is commercially available continues to be developed and improved.

John Fuss (SA)

Key words: *pollination, sugar syrup, starvation, dry sugar, protein supplement*

(Interview: Jul. 1999)

John has been beekeeping for 35 years and as at 1999 managed 300 hives. He has been supplementary feeding bees sugar for about 10 years when required.

For three or four years sugar syrup was provided to lift the bees before almond *(Prunus dulcis)* flowering and over the period when the bees were on almond blossom. Half a litre was provided once a week in pie dishes placed on the top frames under the lid. "I wouldn't have a clue if it did them any good, we thought it did, we were trying to give the bees a bit of a lift to make them work better for the almond grower." The practice ceased when John no longer provided an almond pollination service.

Dry sugar feeding is used to keep colonies alive.

Dry sugar feeding is now practiced as a means of keeping colonies alive. The year 1998 was one of the worst years for honey production as experienced by John, and as a consequence a lot of dry sugar was fed to his bees. In most years sugar is not necessary. Dry sugar feeding was started on 26 June, then as follows: 30 June; 10, 17, 22 July; 4, 8, 13 and 21 August. 350 g of sugar was poured along the back of the frames in the brood box. "The bees take it all up pretty well", sometimes "they chuck it out the front, but they'll bring it back in." John believes that dry feeding sugar also helps to control nosema disease *(Nosema apis)*. "It also cuts out a lot of condensation in the hive in winter months. I don't know whether they use the moisture within the hive to dilute the sugar and this gets rid of the condensation or whether they work on the sugar which creates the warmth in the hive which reduces the humidity in the hive." In this case the adult bees covered three to seven frames in the brood box.

Sugar and pollen supplement is used in preference to moving bees further afield.

Sugar and pollen supplementation is used in preference to moving bees further afield. Hives are extracted on site, they are only moved three times a year, enough queens are purchased to re-queen every hive each year, although not all hives are annually re-queened. John stated that he would spend more money on queens than he would on fuel, all sites being within an hour's drive of his home.

"Too many guys switch on their ignition on their truck before they switch on their calculators.

The pollen supplement used in the last six years consists of 15 kg of sugar, 9 litres of hot water, 18 kilos of soy flour and 4½ litres of malt. More recently a "bit" of cottonseed oil has been included. The patties are mixed in a dough mixer. The recipe makes about 220 patties. No honey or pollen is added to the recipe due to the risks of transferring bee diseases. One year John tried to feed the mixture without water in a dry form to the bees with little success – "They won't eat it, it's got to be mixed up into a pattie." John is still not sure he has the formula right, "Some hives won't eat it whereas other hives will eat every skerrick." He has compared his recipe with commercially available pollen supplements and found no difference. If the pattie is not eaten, they become dry and hard in the hive, in storage they go mouldy. Ideally patties should have a consistency similar to plasticine. Patties need to be placed right over the brood nest for the bees to eat the supplement.

"Bees collect a lot of lucerne *(Medicago sativa)* pollen in the summer and they do well on it. But at the end of the flowering period when pollen is no longer available and there is no other pollen available this is when the real problem starts with lucerne. Bees end up using their own body protein to rear that last cycle of brood and that's what causes the collapse", this is why John uses pollen supplements.

Bees are fed on a "need" basis. Protein supplements have been used in three out of five years to overcome pollen shortages. Price is important as he stated that if he had to pay the price of commercially made pollen supplement he doesn't think that it would be a viable proposition. Even so, John is not certain that the whole pollen supplement exercise has been worthwhile. He would like to see research on the palatability of supplements and what makes one mix more attractive to bees than another, as well as a study into the economic benefit of feeding patties. Research of this kind would be of significant interest. Supplementary feeding has to be a serious alternative to current beekeeping practices. "Too many guys switch on their ignition on their truck before they switch on their calculators."

Geoff Smith (SA)

Key words: *lucerne, protein supplement, maintain population*

(Interview: Jul. 1999)

Geoff began beekeeping in 1971 with 150 hives and increased this to 800 by 1979. He has used supplements for the last five years to improve the management of colonies, particularly to ensure that he has "good bees" for the almond *(Prunus dulcis)* pollination and prevent bees going "flat" on lucerne *(Medicago sativa)* blossom. Bees that work lucerne were always "flat" afterwards, with a two to three month break before the banksia *(Banksia ornata)*. Supplementary feeding was adopted to ensure bees maintained a reasonable brood nest for this period. Lack of protein or associated elements was deemed to be the problem.

The best improvement in the supplement was the inclusion of pollen.

The initial mixtures were a combination of soy flour, sugar and malt extract. This evolved into a mixture that contained pollen and honey, leaving out the malt extract. Mineral supplements were tried but Geoff didn't think they improved the supplement. He believes that "the best improvement in the supplement was the inclusion of pollen". A batch of supplement contains 6 kg of soy flour, 3 kg of sugar, 3 kg of pollen, 3 kg of honey and about 2 litres of water. The ingredients are mixed in a 20 kg dough mixer. The 2 kg of sugar and 2 litres of hot water are added first until dissolved, the honey is then added and left until its all dissolved. The soy flour and pollen is added "until you get a consistency that can be rolled out with a rolling pin and not stick to it". The dough is rolled then cut into 7.5 by 10 cm patties. The pollen is gamma irradiated before inclusion in the mix. A drum of honey "of a type bees do well on, like stringybark or even canola" is kept for the purpose. A sample of honey is sent to test for AFB spores before it is incorporated into the supplement.

Pollen supplement on its own does not stimulate brood rearing, but it does maintain brood rearing.

Patties are placed above the brood nest after bees have been working lucerne. Hives that are down in bee numbers are given preference in feeding. The "supplements are never a substitute for real fair dinkum pollen", but they are useful. Supplementary feeding usually occurs over the April–May period between lucerne and the start of banksia flowering. Over this period, six to eight patties could be fed to a weak hive. Patties are sometimes fed to colonies every week for those needing the extra supplement.

When putting the first pattie in the hive, a cup of sugar syrup (50:50) is splashed over the bees and pattie to stimulate the colony. The syrup acts as a starter, with the hive said to "warm up quickly". The ultimate aim is to maintain good bees for almond pollination. A colony with three to four frames of brood can maintain this strength and brood area by feeding patties. The pollen supplement on its own does not stimulate brood rearing, but it does maintain brood rearing. "Some pollens really turn the bees on and cause massive expansion of the brood nest. Turnip *(Rapistrum rugosum)* pollen is such a pollen; if you could find the magic factor in this pollen you could make a mint." The addition of pollen and honey to the recipe has made the supplement far more attractive to bees. The fear of spreading bee diseases is easily managed with irradiating pollen and testing honey.

Graham Wagenfeller (SA)

Key words: *queen breeding, pollen supplements, mixing supplement, EFB, sugar syrup*

(Interview: Jul. 1999)

Graham has been a commercial beekeeper for about 30 years. Graham and his son, Troy manage 950 hives and operate within a radius of 200 km of Keith. Apiaries are moved usually six times each year. About 500 to 600 queens are replaced annually, with 200 to 300 nucs maintained to rear queens and top up failing colonies. Queens are not replaced if they are "doing the right thing".

Graham has been making his own patties for over seven years and regards them as a tool to help bees breed and expand. "You can't get honey without bees". He has no doubts that the incidence of EFB through his apiary's is a lot lower than his counter-parts in Victoria due to his practice of feeding pollen supplements. A 500 gram pollen supplement is also fed to queen raising colonies, with 20 cells to a bar. Feeding pollen supplement to colonies was also beneficial in providing bees for pollination of almonds, "they would fly a lot better and a lot earlier than bees that had not been fed patties."

The formula for the pollen supplement has stayed basically the same with one-third sugar/honey, one-third soy flour and one-third brewers yeast. Vitamin C is added at a rate of 500 grams per mixed batch. Low fat milk powder is also added to the mix at 4% of the total amount. Each batch contains about seven hundred 500 gram patties.

In 1998 cotton seed oil was mixed for the first time at a rate of 4% of the total mix with poor results. The supplement was unattractive to bees and most of the supplement was thrown out of the hive by the bees. A soy flour with a bigger granule size than previously used may have also contributed to the problem. The mix required a lot more water than normal, with about 6½ litres of water extra in the mix, being a bigger granule the mix took longer to "take up".

The patties are dusted with soy flour so they don't stick together.

Graham is an ex-baker so is familiar with some of the tricks of the trade. He uses a "2 bag dough mixer" to prepare the supplement. This is run for about an hour then left for one hour before starting the mixer again, this ensures that all the ingredients are "taken up" in the mix. Once the recipe is well mixed the dough is rolled with an old pastry roller and cut into squares of 500 grams to make a pattie with a shallow cut down the middle to enable the patties to be broken in half. The patties are dusted with soy flour so they don't stick together. The patties are stored in cardboard boxes with grease proof paper between every six layers and used either straight away or within a few months.

Enough supplement can be mixed in about three hours to feed 1500 hives. A 500 gram pattie is placed on the queen excluder above the brood nest every 10 days or as required. Every 10 days is desirable when building colonies for pollination or a specific honey flow. The pollen supplement works best when there is a natural source of pollen available in the field, the fresh pollen supplement then acts as a top-up to meet the bulk of the colony's nutritional requirements. Patties on their own without pollen collected by field bees "does not work for the bees".

Putting patties in hives is very time consuming, although the cost of making them can be kept down by doing it yourself. Graham indicated that in his opinion there is "no profit in buying patties". The cost to Graham for self-made patties for ingredients was between 70 cents to $1.00 per 500 gram pattie. A fresh pollen source was always considered a better choice. Graham has some **warnings** for beekeepers who may contemplate obtaining the machinery to mix their own patties. A 200 loaf dough mixer would be ideal for such purposes, but these machines are very dangerous and capable of "pulling your arm off quick". Use of these machines especially 'single arm' mixers should be used with **extreme caution**.

Graham has tried sugar feeding and thought the exercise was very beneficial although it's a long time since he has done so.

A reasonable honey crop was obtained after the bees were built up using sugar syrup, this was done during a year when many other beekeepers in the district failed to extract honey over the same period.

A fresh pollen source was always considered a better choice.

The syrup was fed in plastic bags, two frames were removed to place the bags in the hive body. A litre of sugar syrup was fed every week and, combined with an adequate pollen source, the bees did extremely well. The bees were said to be "terrible" and were brought up to a "good 3-decker hive".

The exercise hasn't been repeated as the conditions have not warranted the activity, but "It's a thing if your in trouble, you know it works".

Ken Jones (TAS)

Key words: *sugar syrup, spring build- up, honey production*

(Interview: Jun. 2002)

Ken and his family are based in Sheffield, in the northern regions of Tasmania, managing 1,400 (Ken only recently sold his business to John Birchenough). The main honey crop is obtained from leatherwood *(Eucryphia lucida* and *Eucryphia milliganii)*, which contributes about 70% of the annual honey yield. Leatherwood flowers from early January and lasts, depending on the area, for about six weeks. The colonies are moved back around Sheffield in May, June and July, and the condition of the colony is checked from July onwards. The aim is to build colonies into large populations by December to obtain a honey crop from clover *(Trifolium repens)* and blackberries *(Rubus fruticosus)* before moving to leatherwood.

Sugar feeding starts in earnest in August and may extend to December.

Sugar feeding starts in earnest in August and may extend to December. Hives low in stored honey are fed first and as colonies deplete their stored honey they progressively are provided sugar feeders. Each time, a colony is fed it is provided between 5 to 8 litres per hive. Syrup feeding becomes quite intensive through November and over December, with up to 7 litres provided every fortnight. This compares to August when one feed of syrup may last for 2 months. Feeding syrup is done very much on a "needs" basis and even a "per hive" requirement. The concentration of sugar syrup is very heavy at between 60%–65%.

The consumption of sugar per colony is also a factor of the breed of the bee. The strains of bees that have been the dominant genetic material in the apiaries over the last 15 years are hungrier and build up faster than previous breeds of bees. The quicker response from feeding allows for the colony to build into larger populations to work honey flows, but it is also a cost in extra sugar syrup. Each year the business may use 20–24 tonnes of sugar, buying in such large amounts or container loads enables the price per kilogram to be kept manageable.

Ken will only recommend white sugar.

Ken sources the cheapest sugar available, which in 2000 and 2001 was raw sugar. In 2001 some serious problems developed and many bees did not touch the syrup in their feeders. The reason remains unexplained but has meant that in future Ken will only recommend white sugar to remove any possible negative influences raw sugar may create.

In 2001 open feeding was trialed with encouraging results. The main disadvantage is when poor weather is experienced with early feeding. Light or starving hives may not be able to fly and literally starve to death, whereas top individual feeders may have saved these colonies. The compromise may be to feed syrup in individual feeders in August – September and provide open feeders as an option in October – November when the weather begins to become more reliable. Sugar is mixed using cold water in a large vat and transported to the bees in a palletcon on the back of a truck. Buckets are used to fill the top feeders on each hive.

Queens are reared under the best available conditions.

Combs with pollen are sometimes kept aside during the extraction process to feed back to colonies in September on certain sites where a shortage of pollen is experienced. Commercially available pollen supplements have been trialled but no significant response was noticed when they were made available to individual colonies. Ken hasn't discounted their use in future but would like to see more evidence of the benefits of using them. Several hundred queen bees are reared each year as replacements for the production hives, although, as a rule, they are not supplementary fed either pollen supplement or sugar syrup.

The preference is to choose the best areas where natural nectar and pollen sources are not limiting to ensure the queens are reared under the best available conditions, believing that natural conditions will always be better than the artificial.

Bill Oosting (TAS)

Key words: *spring build, sugar syrup, open feeding*

(Interview: Jun. 2002)

Bill manages about 1,500 hives with 80% of his annual crop derived from leatherwood *(Eucryphia lucida* and *Eucryphia milliganii)* on the west coast of Tasmania from January to March. The farming areas in the northern part of the State are utilised to build bees up in population with a significant amount of management input between September and November. Blackberry *(Rubus fruticosus)* and clover *(Trifolium repens)* can provide worthwhile honey crops from December to early January. Sugar feeding is a regular spring and autumn event with the provision of sugar syrup a necessity to stimulate colonies to increase populations prior to the main honey flows.

In the past, sugar syrup was provided to each colony in individual top feeders made from Styrofoam. Feeders were filled every fortnight with a 50:50 sugar water syrup. This used to be the main labour requiring job in the spring.

In the last 12 years the syrup has been provided to colonies in open communal feeders. This has provided a significant saving in time, which has meant that more individual work to each hive is able to be carried out. This can be undertaken at the same time, as the bees work the open containers of syrup with no deleterious impact on the bees or beekeeper. During this time Bill has not observed any increased problems with bee diseases in his operation.

A 200 litre drum of 50:50 sugar syrup is placed in each apiary and refilled every two weeks. This provides each hive within an apiary of 35 to 40 hives with approximately 5 litres of syrup. This procedure is continued from September to November. The open drums have straw on top of the syrup so the field bees don't drown, the drums are also covered so as livestock do not have access to the syrup.

It is important to protect the syrup from livestock as a goat, plus a cow and calf have died as a result of drinking the syrup in the past. A cover is bent over the top of the container with a 50–75 mm gap to allow bee access. The cover also prevents rain from entering the feeder. The open feeder has not created any robbing problems within the apiaries. One year Bill tried brown sugar but found that the bees obtained a bad case of dysentery, as a result only white sugar is used.

Sugar is bought by the container load with ten pallets of sugar per container. Each pallet contains 1.2 tonne of sugar. Each year Bill uses 20–30 tonnes of sugar and these volumes allow for some negotiation on price. Mixing is done with cold water, with the pallet of sugar poured into a vat. The syrup is then pumped into a palletcon on the truck and driven to the apiaries where it is gravity fed into the drums on site.

Col Parker (TAS)

Key words: *pollination, pollen supplement*

(Interview: Jun. 2002)

Col used to manage approximately 450 hives, but reduced this to 200 in recent years in preparation for retirement. All 450 hives were used for pollination often until the end of January when they would be moved onto leatherwood *(Eucryphia lucida* and *Eucryphia milliganii)*. Two-thirds of his income was derived from leatherwood honey, as compared to one-third from pollination service fees. Pollination was a drawn-out process, starting with strawberries *(Fragaria* spp.*)* in atmospherically regulated tents in March 2002, progressing to cherries *(Prunus avium)*, apples *(Malus domestica)*, other small fruits including raspberries *(Rubus idaeus)*, field strawberries and other berry fruits.

The addition of protein supplement kept the colony breeding.

Pollen supplementation occurred from March onwards, with patties placed in hives while on strawberries. This was the only time supplementation was practiced, with a 200 gram pattie placed in each hive every three weeks while the colonies were enclosed in the horticultural greenhouses. These hives appeared to survive well on the limited natural nectar and pollen derived from the strawberry flowers. The hives were changed over at three months. The addition of the protein supplement kept the colony breeding and achieved the goal of maintaining adequate field bees while in the enclosures.

Col started feeding supplements under these circumstances nine years ago and began with a dry mix composed of pollen, yeast and sugar, all in equal portions. The pollen was obtained from Western Australia and was gamma irradiated. This all became very “messy”. Thus, when the opportunity to purchase pre-made supplements became available, Col substituted making his own mixes to purchasing the ready to use pattie. For five years these pre-made supplements have been fed to bees while in the strawberry enclosures with continuing favourable results.

When Col was mixing his own pollen supplements he made the observation that when one pollen source was used in his recipe, the bees did not do so well, compared to a mixture of pollens. In some cases bees would decline in numbers when they only had access to pollen from a single floral species and, in extreme cases, the queen stopped laying.

The dry recipe mixed by Col was placed in old margarine lids under the lid of each hive. Some hives readily removed the supplement, but others would be a lot slower. Even with the pre-made supplements currently in use the rate of consumption varies a lot between colonies. When the consumption of the protein supplement was slow this prompted a response to check on the productivity of the queen and determine if she needed replacing.

Col only fed sugar to bees once, preferring to keep back spring, disease-free honey obtained from working pollination contracts, to feed to bees after all the leatherwood honey had been removed and extracted.

Col Parker — strawberry pollination.

Ian Stephens (TAS)

Key words: *sugar syrup*

(Interview: Jun. 2002)

The Stephens family manage 1900 hives. The business started in 1914, with Ian's father, and continues today with the assistance of Ian and Shirley's sons, Ken, Ewan and Neal. Sugar has always been fed to the bees, "raw" sugar being the preferred choice as it is cheaper than white sugar. In 1960 and again in 2001 the sugar syrups exhibited heavy yeast fermentation. The mixture "frothed up in the bucket, half froth, half syrup. Needless to say, the bees did not do well on this syrup on these occasions and in some cases the bees did not touch the syrup. Other than on these two occasions, the use of raw sugar has been satisfactory in other years. A typical year would involve the feeding of sugar syrup from August to December and then again in April.

Note: The specifications for Manildra Group Raw Sugar as at March 2002 as used by the Stephens'.

Sucrose 99%, reducing sugars 0.3%, ash 0.3%. This compares with: refined sugar, manufacturer's grade sucrose 99.85%, reducing sugars 0.04% and ash 0.03%.

The difference in the specifications for raw sugar and refined sugar only apply to 1% of the total mass, yet the raw sugar has 10 times the reducing sugars and ash levels of refined sugar.

Whether this is of concern or relates to the problems described is not known.

The first sugar feeding occurs in late August when there are flowering weeds and other herbaceous plants available to provide pollen. Management strategies are designed to maximise hive populations by the beginning of December, mid-December at the latest. From then on the main activity is directed at harvesting honey. This is sourced from clover *(Trifolium repens)* and blackberry *(Rubus fruticosus)* from the end of December until half-way through January. The hives are then transported to the leatherwood *(Eucryphia lucida, Eucryphia milliganii)* sites where two thirds of the annual 150 kg/hive honey crop is obtained. On a good year leatherwood will continue to produce well into March. The bees are then packed down for winter, which takes about three weeks. The west coast becomes very cold, even experiencing snow. The colonies over-winter better in the snow country.

Each has its own sugar feeder. This is a top feeder approximately 7½ cm in height. The feeder is separated with a section that holds 5 litres and another, which holds 2½ litres. The feeder is placed on a hive with the section to be filled to the back of the hive. Sugar is mixed up a pallet (1½ tonnes) at a time to a solids level of 58% brix, this is diluted to 55% when a few crystals are left by bees in the feeders. The higher concentrated sugar syrup is more preferable for winter feeding preparation.

The aim is to maximise hive populations by December.

Five litres per hive per two week period is an average feeding regime. Each colony normally consumes two-thirds of a 20 kg bag (13 kg) of sugar over the 12 months. Hives with 3½ frames or more of stored honey are not fed, hives with two frames of honey are given a light feed of syrup, and everything else is fed generously. Hives with huge populations of bees but with no stored honey are given 7½ litres.

The sugar is mixed in a large tank, the water is brought to the boil and the sugar is added. This is then pumped onto a truck into stainless steel square drums. The syrup is decanted on site from a tap into buckets to feed each hive. Pump hoses were found to be too messy whereas buckets are easy to clean. When feeding syrup in spring, the stores in each hive are determined and only enough is fed to last two weeks, repeating the exercise every 14 days.

Julian Wolfehagen (TAS)

Key words: *protein supplement, sugar syrup, winter stores*

(Interview: Jun. 2002)

Julian manages 1000 to 1200 hives, including the packing and marketing of honey. Based at Perth, Julian works the northern areas of Tasmania through the spring then moves hives across to the west coast in January. Leatherwood *(Eucryphia lucida, Eucryphia milliganii)* contributes 60 to 70% of the annual honey harvest, thus being the main focus for colony population build-up and management. The season starts in early spring with crack willow *(Salix fragilis)* as the first significant pollen and nectar source, followed by capeweed *(Arctotheca calendula)*. Blackwood *(Acacia melanoxylon)* can also be significant in certain areas. Blackberries (*Rubus fruticosus)* are the first surplus honey stored by the colonies usually around mid-December. The average honey crop is 94–95 kg.

Pollen supplementation has been used as a management tool only in the past few years, particularly where there is a lack of capeweed in the early to mid-spring period. Two 200 gram purchased pollen patties, fed two weeks apart, seems to provide a satisfactory response at this stage. Julian had experimented with his own "concoctions" but "didn't really know what he was doing." He was, however, more confident that the pollen supplements available commercially were more effective than those that he made up himself many years ago.

The sugar is mixed in a large vat holding 1500 litres. The syrup is then pumped into a tank on the back of a small utility truck to transport to the various apiaries. Approximately 7 tonnes of sugar is used on average in the entire business over a 12-month period.

Sugar feeding starts in August, only to replace the honey eaten over winter. Only 5% of the colonies normally require feeding in August with a heavy syrup. It is not the intention at this early stage to promote brood rearing. Initially the concentration of syrup is two parts sugar to one part water, with up to 15 litres provided per colony. This heavy syrup feeding is continued through September. Lighter syrup is provided from October to the end of November. All syrup is provided in individual feeders with a capacity of 15 litres.

Julian has tried open feeding or bulk feeding in the past, but wasn't convinced that it was as targeted as it could be. There were losses of field bees in attempts to collect the syrup. The hives also varied in the quantity of syrup that each colony collected and it was felt that the closeness of the foraging activity may be a "good place for disease to be transferred between bees from different colonies."

Julian has modified his beekeeping operation, opting for full-depth boxes with manley supers, which are considerably larger combs than the regularly used "ideal" box depth in use throughout much of Tasmania. He has found as a result of this transition that each colony overwinters "extremely well and only in isolated cases do colonies require syrup towards the end of winter."

Kevin & Glen Emmins (VIC)

Key Words: *pollination, pollen supplement, sugar syrup, EFB, white malt vinegar, autumn management*

(Interview: Jul. 1999)

Brothers Kevin and Glen Emmis are second generation beekeepers, managing 1,300 hives. They have been in the bee business for over 30 years and for the last

10 years they have been practicing supplementary feeding colonies either pollen supplement in the form of patties or sugar syrup. They essentially began supplementary feeding to ensure they had "good" bees for pollination of almonds *(Amygdalus communis)* in mid-August, and to control European foulbrood disease (EFB) *(Melissococcus pluton)*.

Sugar is mixed at a ratio of 1½ : 2 parts water. If the bees are a bit light on for stores then the syrup can be more concentrated. One litre of white malt vinegar is added to 15 litres of sugar syrup. Various vinegars were tried but it was found that white malt vinegar worked the best to clean up EFB. Each hive is only fed one cup of medicated syrup by pouring the mixture over the brood combs. In "real bad cases you may need to treat the colony with this syrup/malt mix every 2 or 3 days until the disease symptoms clean up". It may take up to 3 weeks to completely clean up a hive infected with EFB. The sugar syrup also stimulates the hive. Vinegar is not always added, as Kevin believes that treating a colony too late in the autumn promotes nosema disease *(Nosema apis)*. This medicated syrup is usually fed in the early autumn period. Straight unmedicated syrup is supplied to colonies during the first week of July as queens start laying during the middle of June. Oxytetracycline is sometimes added in the early syrup mixtures. Sugar feeding will normally extend to September.

To supply "good" bees for almond pollination in early August and considering bees normally "go out of brood" by the middle of April and start laying again in mid-June it was necessary to consider pollen supplementary feeding to "get some guts into the almond bees". Kevin and Glen started by making their own patties and found that patties made with sugar were not as successful as patties made with honey. They gave up making their own very quickly due to the high costs and time required, favouring the purchase of commercially made patties from other suppliers.

Patties are placed in each colony in early March before the colonies "go out of brood". This encourages the bees to store the patties in and around the brood combs, especially if the colonies are experiencing a poor pollen flow as this will stimulate the colony to continue rearing brood. Two x 200 g patties are fed below the queen excluder over the brood nest or between the brood frames. If the patties are placed above the excluder or on the top bars of the super the bees won't readily eat the pattie and it also becomes very hard. Patties are placed in each colony every fortnight from early March until the end of April. When queens start laying in mid-June the stored pollen supplement is consumed by the colony.

Working grey box *(Eucalyptus microcarpa)* in autumn is possible with the use of pollen supplement and also providing good bees for pollination of almonds for late winter. Generally grey box is considered "hard" on bees. Patties are placed in hives as they are moved onto grey box in early March, the last patties are fed in the first week of April.

Almonds are the only paid pollination Glen and Kevin participate in during the year. Otherwise their operation is focused on honey production. They indicated that they may "lose a bit of honey in the autumn" due to the preparation for almonds, also they may miss out on an early spring honey flow 2 out of 5 years. The attraction is the income from almond pollination is every year.

Grey box is considered "hard" on bees.

Ken Gell (VIC)

Key Words: *honey producer, sugar syrup, drought strategy*

(Interview: Aug. 2002)

Ken with his father manages 1,200 colonies based at Maryborough in Victoria. Ken's father went on a study trip some 15 years ago and brought back an idea for sugar feeding from Canada which he thought had potential. The concept was for sugar syrup to be sprayed into the empty cells of combs then placed back in the hive. Sugar syrup is held in a sump and pumped under pressure by a 3½ hp motor through a filter into a series of nozzles producing a fine spray, the spray is applied to both sides of the comb simultaneously.

Ken demonstrating machine built to spray syrup into combs.

The sump holds approx 90 litres with an option to attach a 200 litre drum using a float valve mechanism to keep the sump full. This method of feeding bees has only been used once when very dry conditions and no honey prospects at that time necessitated the need. The bees where very light in early spring, two frames of syrup were given to each hive containing about 3 litres. As the frames were filled on site it was found that the noise of the machine and the open syrup very much excited the bees. It was felt as a result that if this method of feeding bees was to be used again that the combs would be filled in the shed then transported to the apiaries. As there would be a danger of the syrup shaking out in transit, this method would have to be carefully monitored although Ken commented that he was surprised how well the syrup stays in the combs.

Close-up of machine used to spray syrup into combs.

Another method of feeding sugar was trialled a few years back during a dry spell over summer when the colonies did not have access to stored honey. Waste sugar was obtained from a sweet manufacturer and fed dry to each colony. Approximately 800 grams of sugar was placed on the inner mat of each hive every 2 weeks. The bees readily consumed this waste sugar, although once a nectar flow began they ceased consumption of the sugar. As a drought feeding strategy Ken prefers this method to the combs filled with sugar syrup method as it is much easier to do.

Ian Oakley (VIC)

Key Words: *honey production, pollination, pollen supplement*

(Interview: Jun. 2002)

Ian manages approximately 2,000 hives for honey production and provides a professional pollination service. He shifts his apiaries within 500 km of Carwarp. Supplementary feeding is a strategy used to overcome shortfalls in poor quality pollens, lack of pollen, droughts and as a means of stimulating colonies for pollination and pre-honey flow conditions.

The floral species that cause the most problems with poor quality and or quantities of pollen include lucerne *(Medicago sativa)*, grey box *(Eucalyptus microcarpa)*, black box *(Eucalyptus largiflorens)*, and yellow mallee *(Eucalyptus incrassata)*. Grey box is not worked very often possibly every 10 years or so, black box is worked on a more regular basis from February through to the end of winter in some years.

Soy flour has proven difficult to source on a regular basis.

To overcome the shortage of pollen or the poor quality of some pollens, supplements were trialled 10 to 12 years ago. The formulation and circumstances under which the supplement is now used evolved over this time. For the last five years Ian has been supplying protein supplements to five other beekeepers. The basic ingredients of the supplement have been soy flour and torula yeast. For the first six years this was mixed with sugar syrup to make patties but they set “like rock” and the bees “wasted heaps”. All along he felt that the bees needed something to overcome the nutrient shortfall from the pollens available, yet in the early days only limited success was achieved.

The current recipe for about a quarter of a tonne is as follows: 80 to 90 kg of soy flour; 5–6 buckets (20 litre buckets) of honey; 12½ kg of torula yeast; and ½ kg KelatoVIT® (a vitamin and mineral supplement). The mix varies as Ian likes to achieve an even consistency of the supplement to enable him to pump the mix into endless plastic tubing. The ingredients are placed in a large dough mixer with a bowl 1.2 m across. The flour is placed in the bowl first to reduce the problem of honey sticking to the side of the bowl.

Once thoroughly mixed the dough is placed in a sealed chamber and compressed air is pumped into the chamber to 100 psi. The mixture is forced out of an outlet into endless plastic tubing. Once the mixture is completely forced out of the chamber the end is heat-sealed. The tubes are stored in a cool dark area of the shed and have occasionally been used up to 9 months after being made. Ian cannot see any difference with mixtures that have been stored for long periods, indicating that the bees readily consumed the patties.

At the beginning of the season in late winter, 250 gram patties are provided to each colony in later winter. As there is little or no brood present it takes a while for the bees to start consuming the pollen supplement. As the area of brood increases, further patties of up to 500 grams are provided to the colonies. This depends on the availability of natural pollen, the condition of the bees and the floral source being worked by the bees. Normally only one pattie is given to each hive every three weeks. A crop such as lucerne, only flowers for four weeks, thus one pattie fed to each colony while on this crop, has proven to be adequate.

The endless plastic tubing full of supplement is cut in four 15 cm lengths then slit length ways. With the plastic still attached, the pattie is placed in the middle of the hive. If the bees are not in the second box then the pattie is placed directly above the brood and bees on the queen excluder. The plastic is left on as it is felt this helps to stop it from drying out. It also assists in the spring when there can be excess amounts of condensation in the hive and the plastic acts like a “rain coat”.

If the pattie is placed away from the cluster of bees, there may be supplement left over. Placement of the pattie in the hive can be very critical. Whether bees benefit or not from protein supplements really needs to be proven by research trials, although Ian believes that the fact that bees consume the pattie provides evidence that the bees must want it. One major problem in making patties has been the difficulty of obtaining ingredients. Soy flour has proven to be difficult to source on a regular basis.

Sugar feeding is used to stimulate the bees in preparation for pollination and to improve their performance while on this crop. Syrup is supplied in open feeders with about 20% sugar. This provides stimulation to the colony while on almonds, red clover and lucerne. Ian believes that he is achieving a higher rate of pollination using this technique. Twenty litre buckets are turned upside down on lids from open top drums and placed throughout the crop. The idea is that bees fly to the crop in search of the syrup. Hopefully about 11 am the syrup runs out and the bees switch over to pollen gathering. On one property 10 buckets were placed on a 60-acre crop of red clover. The density of hives for the crop was 2.2 per ha. Subsequent to the sugar feeding strategy yields obtained by the farmer were unsatisfactory. Since the use of syrup, yields have improved. When colonies have been short on stored honey, open 200 litre drums were placed near the apiaries with syrup. Many bees drowned in their attempt to retrieve the syrup. Various means to prevent this are being considered including the use of straw placed on top of the syrup. About 160 colonies were provided with 800 litres of syrup in August 2001 "which lifted their condition."

Bees have also been fed syrup while on almonds in early august by "giving them a cup full of syrup every day for about seven days". The result was encouraging as it "stimulated the hive". The sugar is obtained from wherever the best deal can be sort including juice factories, cordial factories or direct from sugar companies. Waste sugar is available at times, even so "if you want cheap sugar you have to do a bit of work to get it, you can pay anywhere from 30-70 cents, its worth spending half a day on the phone".

Ray Phillips (VIC)

Key Words: *honey production, pollination, queen breeding, syrup, patties*

(Interview: Aug. 2002)

Ray is a commercial beekeeper based in the Goulburn Valley—Shepparton area of Victoria, moving bees throughout northern Victoria and southern NSW. His enterprise mix is honey production 75%, pollination 25%.

The use of sugar feeding has been low-key and only as a means of producing well-fed queen cells when queen rearing to produce replacement stock for his own business. Sugar syrup is fed a few litres at a time to cell building colonies. Ray feels that a better quality queen cell is produced by feeding sugar syrup, rather than relying on stored honey only.

A better quality queen cell is produced by feeding sugar syrup.

On the other hand, Ray has been feeding patties for the last 10 years, to strategically overcome poor nutrition on autumn floral conditions and as a jump-start in spring prior to pollination work. The colonies used to be "flattened a lot in the autumn working grey box *(Eucalyptus microcarpa)* and ironbark *(Eucalyptus tricarpa)*". About two-thirds the way through the flowering of these species, patties are provided to bees over the brood nest above the queen excluder. These species are not worked past May as it is cooling off too much and the colonies have difficulty in controlling the moisture in the hive. By mid-July patties are again provided to each colony, preparing colonies for spring pollination contracts. This may be earlier in future years in preparation for early almond pollination contracts. The idea is that old overwintered bees are replaced well before the colony is made to pollinate almonds or for honey production on canola *(Brassica napus)*. Once bees are placed on canola their strength improves markedly as a result of the earlier pollen supplements.

Patties weigh 100 to 150 grams and are fed every fortnight. The bees consume the pattie faster the warmer the weather, within 4 to 5 days in warm locations. The ingredients are: two-thirds soy flour, one-third torula yeast. Added to this is 15% irradiated bee collected pollen with KelatoVIT® (a vitamin mineral supplement for livestock). This is mixed into a dough using "sugar syrup to make a reasonably moist pattie that is not too firm". The mix is rolled flat and cut into biscuits, a light dusting of flour over the finished pattie allows them to be stacked into suitable containers without them sticking together. Ray estimates that the current recipe costs about $1.30 to $1.40 per kilo for ingredients.

How does Ray know his patties work? In the past he has tried feeding some hives and not others in each apiary and is convinced that the difference in the response from fed hives is worthwhile. In previous years, when bees were moved onto canola, field bee numbers would drop by 40–50%. This is not the case with colonies fed pollen supplement well before the move. The bottom line for Ray is that he "wouldn't ever go back to the system of never feeding patties to [his] bees through the winter period".

Craig Scott (VIC)

Key Words: *honey producer, pollination, pollen supplement*

(Interview: Mar. 2002)

Craig is a commercial beekeeper based at Echuca on the Murray River in Victoria. He manages 600 hives and 50 nucs for honey production and the provision of paid pollination services. His operational range is within five hours drive of Echuca. Averaging 90 kg per hive (honey yields) in recent years (considered to be poor years), he also pollinates almonds, early flowering plums at the end of winter, late flowering plums, apricots in early spring and apples, pears, nashi pears, cherries in mid spring, pumpkins and zucchinis in early summer.

Supplementary pollen feeding has been an important management strategy for many years. This has involved feeding 400–500 gram patties each week starting at the end of June until the bees are shifted into almonds. The pollen supplement boost early in the season appears to increase the brood area 5 to 10 fold in 4 weeks. Pollen supplements are not feed again until the autumn conditions dictate the necessity due to poor quality or quantities of pollen available while bees are working a nectar source. Normally the floral species that require this support are grey box (*Eucalyptus microcarpa*), ironbark *(Eucalyptus. sideroxylon*), and yellow mallee (*Eucalyptus dumosa*). Patties are fed every time honey is removed from the colony under these circumstances.

Craig makes his own patties the hard way—by throwing all the ingredients into a bath and mixing it all by hand. His recipe is one third pollen with two thirds soy flour with enough 1:1 sugar syrup to make a soft sticky dough. He added other ingredients in his earlier forays into producing patties but believes that one third pollen provides the necessary balance to remain an attractive supplement to bees.

Trevor Billett (NSW)

Key Words: *overwintering, pollen supplements*

(Interview: Feb. 2004)

Trevor manages 800 12-frame, two queen hives supported by 500 nucleus colonies, rearing all his own queens. Honey production is the main focus, although some paid pollination services are provided to blueberry and kiwifruit growers. The operational range is within 300 km of Woodburn. Supplementary feeding became an issue about 1994 when Trevor lost access to his traditional wintering sites when National Parks management excluded him from using these sites.

The supplement is mixed as required which assures freshness of each batch.

Pollen supplements have been provided to colonies ever since over the winter period. A total of 600 grams of supplement is split in two and placed either side of the brood nest above the queen excluder every month. The supplement is mixed as required which assures the freshness of each batch and because Trevor does not have a cool room to store mixed supplement for an extended time.

The recipe has changed over the last ten years, starting with a fairly conventional mix comprised of torula yeast, soy flour and pollen. Later a vitamin and mineral supplement was added which Trevor believes improved the supplement. Supplement without pollen as an ingredient has been trialled but “was just a total failure”. The colony would respond with the first two patties, but from then on they went downhill.

Yeast has now been eliminated from the recipe as there was no perceived benefit from this ingredient. Now the recipe is 30% pollen, 70% soy flour, with a bit of cottonseed oil and honey (preferably mangrove *[Avicennia marina]* or privet *[Ligustrum* spp.*]* in origin) to hold the pattie together. They are mixed in two commercial dough mixers into a stiff consistency, then cut into suitable size blocks to place in the hive. Sourcing soy flour at times has proven to be a problem, once a batch of chemically extracted soy was purchased and the bees just didn’t want to eat it. A reliable supplier of soy flour is important for this reason.

Providing pollen supplement appears to stimulate the colony and encourages field bees to gather pollen which wasn’t apparent before they were fed. If they are not provided a pattie then the pollen foraging activity is not observed. A 600 gram pattie split in two will maintain a brood area covering four frames, about the size of a dinner plate. If nothing is supplied to the colony then it will go broodless over the May/June period. By providing the supplement there appears to be no problem with “muck disorder”, an occasional problem noticed on the north coast and thought to be caused by a mineral deficiency or toxicity.

Nucleus colonies are a problem to overwinter. They are usually built up on a light nectar and pollen flow from weeds around the cane farms prior to winter, they are then moved to the coast and given a pattie each. As long as they have plenty of stored honey, they over winter in reasonable condition. Pollen supplements have not been able to stimulate the colonies to cause any population build, the main response has been to maintain colonies through winter.

Supplement without pollen was just a total failure.

Supplementary feeding colonies associated with rearing queens is not practised in favour of only raising queens when conditions are deemed favourable. Due to the diverse and reasonably reliable range of flora within Trevor’s operational range, he has not found it necessary to provide sugar syrup.

Rosemary Doherty (NSW)

Key words: *honey production, pollen supplements*

(Interview: 2000)

Rosemary and Irwin Doherty manage 600–700 hives, primarily for honey production, based on the outskirts of Mudgee. They occasionally travel to south west QLD for winter flowering napunyah *(Eucalyptus ochrophloia)*. They have had two separate experiences with pollen supplements.

On both occasions they were working a napunyah honey flow at Thargomindah, south west QLD. The first trial was in 1995. They fed 75% of their hives and left 25% unfed. This was done by missing every fourth hive in each apiary.

All hives were numbered and a record of the number of supers removed from each hive was recorded. The results showed no difference in honey production between colonies provided supplement and those that were not. At the time it was a particularly good napunyah year, with a lot of natural pollen available. The supplement provided did not contain pollen and was a commercially available product.

In 1999, 700 hives were transported to Thargomindah in QLD for the napunyah, from Mudgee at the end of April. Five loads of bees were supplied pollen supplements, with only one control apiary (no supplement supplied). Each load had approximately 120 hives. It had been quite dry at Thargomindah and although there was a reasonable budding of napunyah, it was assessed to be a poor pollen year, particularly if no rain occurred while the bees were working napunyah. A tonne of a popular commercial bee feed which did contain pollen was purchased.

All hives were given pollen supplement and the trial was limited to a single load of 120 hives. This load was selected at random but turned out to be the strongest load. Although this napunyah flow was predicted by many to be a less than average year, because of the lack of pollen, it actually turned out overall to be an average flow according to most beekeepers.

All hives were requeened late summer. From January to April all hives were on a St barnaby's thistle *(Centaurea solstitialis)* honey flow, which yielded good pollen and an average honey crop.

In the selected apiary for the trial, 75% of the colonies were fed a single feed consisting of a 500 gram pattie. The following table is a summary of the results. The number of honey supers removed from each colony was recorded.

Honey supers removed during the flowering of napunyah (units In supers of honey)

	Hives supplied pollen supplement	***Hives not supplied pollen supplement***
11.5.99	89	29
5.6.99	120	41
3.7.99	76	25
28.7.99	97	35
Honey supers	**383**	**130**
Average	4.30	4.49

The hives were moved to a bimble box *(Eucalyptus populnea)* flow at Bourke NSW on the 21.8.99. Further measurements were taken with an average of 2.38 supers for hives supplied with supplement compared to 2.67 supers for colonies not supplied any supplement. The results did not produce any significant differences between those colonies supplied pollen supplement and those that weren't. The rest of the loads at Thargomindah were all provided pollen supplement.

We could have spent $4500 on a holiday than feed the bees supplement.

All apiaries remained at the same population strength throughout the measurement period. As there were no control hives in these remaining apiaries, it was not possible to ascertain if the whole exercise was financially beneficial with an expense outlay of $4500 not including labour and time costs. In order for supplementary feeding to be of benefit one would expect to recoup actual cost plus. Evidence for this was not clearly provided by the results.

Given the particular year with a low availability of pollen and the average budding of napunyah, the amount of honey harvested proved to be better than most beekeepers had predicted. “Therefore without a trial, using controls, would we have credited the unexpected good results with having provided pollen supplement to the hives? “This trial could not be seen as conclusive nor strictly scientific, but surely some difference should have been seen. Our personal conclusion is that we could have spent $4500 on a good holiday rather than doing this trial.”

Dave Fisher (NSW)

Key Words: *honey production, queen rearing, sugar syrup, drought feeding, soy flour*

(Interview: Feb. 2004)

Dave manages 300 hives for honey production (having recently sold 270 hives) and between 500–600 nucleus colonies for the purpose of producing queen bees for sale. He is based at Ulmara, south of Woodburn on the north coast of NSW. Supplementary feeding mainly sugar syrup has been practiced by Dave for 20 years, primarily when rearing queen bees.

Cell raising colonies are provided with 50:50 syrup every day by splashing syrup over the combs. A 700 ml jar is placed on the other colonies in the queen rearing apiary which normally takes the bees about two hours to remove. The syrup is usually thinner and is probably only 25% sugar. The idea is for the colonies to be stimulated and not provide any volume that could be stored.

Syrup is supplied to honey producing hives in the apiaries, mainly to keep them going during drought. Bricks are stacked in a two metre square pattern with a tarpaulin spread over the bricks. Gravel is placed in the tarpaulin and 200 litres of syrup is placed into the improvised feed trough. The trough is constructed in the middle of the apiary comprised of 90 hives so as to encourage the majority of the syrup to be collected by his own bees and not feral colonies located further away. The syrup usually takes only two hours to be cleaned up by the bees. This procedure is carried out daily while bees require the syrup.

When first introducing sugar syrup to the apiary in this fashion, a little is splashed at the entrance of each colony to let the bees know of its existence. The method described has been used for a month in the spring to help bees through a drought period. They responded so well that some wax building was observed. This bulk feeding never incited the bees to rob or become aggressive.

Nucleus colonies are managed differently. When they are low on stored honey they are provided a frame of honey kept for such purposes. If no combs of honey are available then the whole comb is removed from the nucleus colony and soaked in sugar syrup until all the cells are filled, and then placed back in the nucleus colony.

Water soluble iodine is sometimes added to syrup to prevent Nosema infections in the colony. Very ripe bananas are placed in the hive to help the colony control chalkbrood, these bananas are often gone in a day.

Dave has used pollen supplement in the past; initially a pattie was made, but proved to be too hard. When the supplement ingredients are mixed into a slurry the bees appear to do better. Now Dave simply provides a 25 kg bag of soy flour to an apiary of 90 hives when he deems them to be short on pollen. After a couple of days it can get a crust on the surface of the flour and the bees will leave it alone. Once the crust is broken and stirred up, the bees will resume collecting the flour.

If cell builders are short of pollen, then a recipe of 40% pollen, the rest soy flour, plus a vitamin additive designed for horses. This is mixed into a soft putty consistency and about 100 grams is placed in the cell raising colonies every time grafted queen cells are introduced.

Wayne Fuller (NSW)

Key words: *honey production, open feeding syrup, protein supplement*

(Interview: Feb. 2004)

Wayne operates a mixture of 12 frames (2 queen), 10 frame and 8 frame hives totalling approximately 2,000 colonies within an 80 kilometre radius of his base at Grafton, travelling to Lismore in early summer for macadamia pollination. The primary purpose for placing bees on macadamia is not to pollinate the crop but for the bees to access the many flowering weeds that grow amongst the macadamia orchards. This is not a paid pollination service as the hives are placed in lots of 100 hives in orchards that have consistently produced good breeding conditions. Supplementary feeding as a management strategy began 10 years ago to keep colonies breeding or keep them alive.

Sugar feeding has become a major part of the business.

Sugar feeding has more recently become a major part of the business. With honey prices hovering around $4 kilogram wholesale the sums add up. In the winter of 2003 $130,000 worth of honey was extracted from the bees when this would largely be left on the colonies for winter stores and the cost of the sugar syrup used was approximately $10,000, this does not include labour and feeder costs. During a major bushfire period in December/January 2003/2004, 600 hives were moved four times to escape fires during the middle of the day. As a result the population was run down, so sugar syrup and pollen supplement was supplied which greatly assisted in their recovery. Nucleus colonies are occasionally supplied with two litre bottles of syrup placed in a hole in the lid of the box, which stimulates the new queen to lay and increases the morale of the colony.

Open feeding is preferred for the larger colonies and this is currently carried out by providing plastic cattle troughs with a drip feeding system. The trough is attached to a drum of syrup with a slow dripper into the trough. The trough fills up overnight with enough syrup for the bees to access until 11.00 am when most of the syrup has been removed. An apiary of 100 weak colonies may only consume 100 litres of syrup, whereas stronger colonies may require 200 litres to satisfy their demands. The dripper can be adjusted accordingly. A little syrup available every day seems to keep the colonies in better shape and stimulates breeding and making the bees fly "gives the bees a morale uplift". Some significant problems have occurred which include various animals accessing the syrup. Keeping cattle, possums, rats and other animals away from the syrup has required some thought. A black mould tends to grow on the feeder and storage tanks which may be toxic to the bees. After several days of feeding a lot of dead bees around the apiary and feeder are observed. White styrienne floaties and, more recently, shade cloth have been placed in the trough to prevent bees from drowning, however both seem to harbour the black mould problem. A major problem on public lands is the theft and vandalism of the troughs and storage tanks by persons unknown.

Providing sugar syrup has also backfired when bees were stimulated for three months through the winter in anticipation of an early ironbark flow which didn't eventuate. The colonies were very strong and massive swarming occurred, so all the investment did not provide the desired outcome.

The sugar is normally bought in syrup form and fed to bees at the strength purchased (68% brix) to prevent starvation. When stimulation and breeding is desired the syrup is diluted to 50% brix. Normally once syrup is provided to a colony this stimulates pollen foraging behaviour which surprisingly they find most of the year.

Open feeding is preferred for the larger colonies

Open feeding of sugar syrup also appears to stimulate the colony more so than internal feeding, the risk of spreading disease by this method is not apparent although Wayne is careful not to place apiaries when feeding syrup in areas where the bacterial disease AFB has been known to be a problem. He has noticed that bees will fly a few kilometres to access the syrup in the troughs and as such places them within the immediate area of the apiary to be fed. He has not experienced any significant robbing issues or the bees being particularly aggressive as a result of this practice.

Pollen supplement is provided to colonies in the form of a protein cake, purchased ready made. This is provided pretty well every January, four weekly intervals to maintain breeding until they no longer need them, which varies from year to year. Some colonies will consume the protein cake within two weeks while other colonies won't touch them and other colonies toss the supplement out the front of the hive. The colonies that do consume the pollen supplement seem to respond quite well. Approximately 100 grams of the supplement is placed between the frames in the brood box on the outside of the cluster. At this stage Wayne does not see a lot of difference between apiaries fed patties, compared to apiaries not fed patties, so it's probably only a practise against possible problems.

Warren Jones (NSW)

Key words: *pollination, pollen supplement, sugar syrup open feeding, feral pigs*

(Interview: Sep. 2002)

Warren with his son Bryn manage between 600–1,000 colonies, primarily for the purposes of pollination. Over 60% of their beekeeping income is derived from the provision of a professional pollination service with the remainder from honey, honey comb and wax production. Between 1,500–2,000 pollination services being provided per annum ranging from small cages to large cage and screened enclosures. Pollination units range from 4 frame to 6, 8 and 10 frame hives. Mainly *Brassica* and onion parent seed work. Field crops serviced include sunflower, melons, grapes, citrus, cotton, lucerne and canola. When available, ground flora and eucalypts are used to build up colonies, otherwise supplementary feeding is practised to maintain populations and encourage brood production.

Supplementary feeding of bees is a necessity as colonies must be in a suitable condition to satisfactorily carry out their role as efficient pollinators and to cover the whole crop or cage units. Sugar syrup and pollen supplements are both used when necessary at any time of year to stimulate colonies either to maintain populations or increase populations prior to a pollination event. The type of supplement pattie or syrup used depends on the knowledge of what the crop being pollinated has to offer , either in nectar and/or pollen.

Supplementary feeding of bees is a necessity.

The quantity of sugar supplied to colonies varies from year to year depending on the availability of nectar in the field. Up to 5½ tonnes of sugar is used in most years. Four 25 kg bags are mixed to fill a 200 litre container of syrup. The 200 litre container then has 6–8 cm of straw placed on the top to help stop the bees drowning. Usually 400 litres will be provided to each apiary of 120 hives. This is done by either bulk outside feeders when no other apiaries are in the area, or the syrup is pumped into the combs. A hose with a shower rose is used to enable the syrup to enter the empty combs. Bulk syrup is also provided in containers in supers or special feeders placed in the pollination cages or units. Open feeding saves a lot of time. Robbing is not a problem and it is possible to inspect the colonies to perform various management tasks as long as the syrup is placed at least 200 metres away from the apiary.

Unless there is nectar or syrup available, they will not eat the patties.

Quite often nectar is not a limiting factor, and pollen supplementation becomes the major consideration. Continued feeding of pollen supplement for more than a 6–12 week period without naturally occurring pollen available in the field or high percentage of natural pollen in the pattie will markedly reduce the longevity of the field bees. Pollen supplement is provided as a pattie or a powder. Pollen supplementation is considered as soon as the amount of pollen gathered by field bees diminishes and there is little or no pollen stored around the brood area.

The recipe for a batch of pollen supplement is as follows: 50 kg soy flour (full fat), 40 kg sugar, 10 kg torula yeast (to be added if pollen not available), 200 g salt, 1 litre cottonseed oil, 10 kg pollen (20 kg if yeast not added), and 20 litres warm water. This is mixed in a large tractor-mounted cement mixer. Place 20 litres of warm water in the mixer, add salt, cottonseed oil, then add pollen followed by the soy flour and sugar which has been pre-mixed, a little at a time until the dough is fully mixed. The dough is removed and rolled flat with a rolling pin between sheets of greaseproof paper large enough to cover a large area of the brood combs. The patties, which are approximately 450 grams, are placed over the top bars of the brood nest under the queen excluder or placed between the frames.

Bees will not consume the patties once the weather turns very cold, but will resume consumption as it warms up. Unless there is nectar available or sugar syrup supplied, they will not consume the patties. If not consumed in a couple of weeks the pattie will eventually go hard and brittle during dry weather. With the availability of nectar or moisture in the hive, the pattie will soften again. If the pattie is not consumed quickly, mould growth and spoiling of the pattie may occur.

Cottonseed oil was selected and it is believed that the uriaric acid content is reasonably high and this chemical may assist the hive to control chalkbrood as well as reduce other moulds within the hive.

The recipe is varied from time to time, depending on the availability of ingredients and the amount of material on hand at the time. The pollen used in the recipe is trapped by Warren. One load of 120 hives has pollen traps which are activated when a suitable pollen source is available. For example this may be canola *(Brassica napus)*, Paterson's curse *(Echium plantagineum)*, or wild turnip *(Brassica tournefortii)* depending on the year. Up to a tonne of pollen is trapped each year and stored in a freezer until required. The pollen traps are modified and have one mesh removed so some pollen is allowed into the hive. The traps are left on full time. During droughts they are removed.

Open feeding wherever feral pigs are around is a problem.

Open feeding wherever feral pigs are around is a problem. They can cause major damage to colonies by pushing hives over and destroying combs. It is extremely important to be very tidy around apiaries in these circumstances and not spill or leave food ingredients wherever pigs may gain access. Open or bulk feeding in areas where feral pigs frequent is not a problem if precautions are taken to place the feeders out of their reach. Straight soy flour is provided in an open feeder, the field bees readily collect the flour and return it to their hives. The container should protect the soy flour from the weather (wind and rain).

A powdered pollen supplement is provided to colonies while they are on lucerne pollination, as lucerne pollen has proven to be inadequate in meeting honey bee nutritional requirements. Approximately 200–400 grams of previously collected pollen from another suitable floral source is provided to each hive along the back of the frames. A natural pollen source is always more preferable than supplementary feeding, even if the source is of known poor quality such as oak pollen *(Allocasuarina* and *Casuarina* spp.). In these circumstances bees should be supplied with a pollen supplement as the combination of natural pollen and supplement is better than supplement alone for the bees.

A natural pollen source is always preferable than supplementary feeding.

Cockroaches can build up in numbers if bees do not consumer the supplement in a reasonable time during warm weather. The small hive beetle *(Aethina tumida)* is expected to have a significant impact on the methods of supplementary feeding particularly influencing the placement and amount of pollen supplement during warm weather.

Monte Klingner (NSW)

Key Words: *honey production, pollen supplement, sugar feeding*

(Interview: Feb. 2004)

Monte and son Craig manage 2000 colonies operating from Glen Innes on the northern tablelands of NSW. Their operational range is from central Queensland to the Victorian border with regular winter migration to napunyah *(Eucalyptus ochropholia)* in the Queensland channel country. Over a five to 10 year period, an average of 60% of their annual honey crop would be obtained from the northern tablelands of NSW.

Feeding pollen supplement, we ended up with 300 drums of honey when normally the colonies should be dead.

Supplementary feeding as a management strategy was put into practice two years ago after bees were moved onto napunyah. They had a good start on the tablelands with a late stringybark flow which kept the bees in good condition prior to the move. Once the bees were moved onto napunyah they were fed a pollen supplement every two weeks when the honey supers were removed. One thousand hives could be fed in a day with a good handful of a paste consistency supplement placed on the queen excluder. As the region had only experienced 40 mm of rain in the last 18 months natural pollen was scarce. This regular feeding was able to maintain the colonies during a period when no pollen was available in the field and they ended up with 300 drums of honey, when normally in the same circumstances most colonies would have perished.

Initially the mixture which contains soy flour, yeast, sugar, pollen, pollard, oil, vitamin additive and salt, was made too dry. This was varied to produce a peanut butter consistency supplement which would normally be consumed by good doubles within five to six days. If the mixture was made too thin they would consume it too fast and run out before the next feed in a fortnight. The mixture was stored by the bees in the cells around the brood nest which probably ensured continued supply for the brood once the supplement was consumed and before the next feeding. The recipe underwent a few minor changes with rice pollard used instead of wheat pollard due to its higher oil content. The amount of pollen added to the mix has also been increased.

The following year the hives were again migrated to napunyah and fed supplement but no honey was obtained as the budding was light and the blossom did not yield any nectar. Despite lack of nectar the bees provided with supplement were in good shape to move onto canola *(Brassica napus)* in early spring. Later in the summer the colonies had been moved onto yellow box *(Eucalyptus melliodora)* and again pollen in the field became scarce. The colonies were provided supplement twice, three weeks apart to help them to continue breeding under these circumstances. The supplement must be placed close to the brood area to ensure it is consumed by the bees.

As a result of this recent management strategy of providing pollen supplement to colonies under a range of circumstances the Klingners had a purpose built machine to mix up all the ingredients to produce a suitable pattie of a desirable consistency. The machine is a modified meat mixer specially geared for the purpose. All the dry ingredients are first mixed in a cement mixer and then once thoroughly mixed, placed in the meat mixer when honey and sugar syrup is added.

Sugar feeding has been tried with some success, particularly preparing colonies for the migration to napunyah. Buckets were a problem as they required extensive cleaning, thus top feeders are in the process of being trialled. Sugar syrup feeding is seen as a method of reducing the amount of travelling required to maintain bees particularly when conditions are poor for nectar. Feeding individual colonies needs to be quick to reduce the potential of inciting bees to rob.

Due to experience and investment in machinery and equipment, supplementary feeding has become a main tool in the management of the Klingners 2,000 colony.

Dayl Knight (NSW)

Key words: *drought, pollen supplements, open feeders, sugar syrup*

(Interview: Sep. 2002)

Dayl manages 400 hives, 300 of which are in full production with 100 replacements. He mainly focuses on honey production and sells bees for packages, operating within a 300 km radius of Trangie. He started supplementary feeding over a decade ago with the primary aim to keep the colonies alive during a “very bad drought”, and to “get a few extra frames of brood going into winter”. This was, until recently, focused on pollen supplements and only in the last two years has sugar feeding been trialled.

Batches of waste sugar were very inconsistent.

His experiences feeding different diets to bees are varied and extensive. At one stage Dayl worked in a local feed mill which gave him access to a range of potential ingredients with which to experiment with, including meat meal, fish meal, coconut meal, linseed meal, canola meal, soy flour, skim milk, bran, pollard and yeast. According to Dayl none of these on their own worked “particularly well”, and in some cases, such as fish and meat meal, the bees absconded from the hives. A handful of each material was placed in the back of single hives to see whether it was acceptable to the bees. In Dayl's words, "just because the protein levels are good that doesn't necessarily mean that it's a good protein source for bees."

Bees were attracted to soy flour. This was provided in open feeders mixed dry with waste manufacturing sugar. The mixture was placed in 200 litre drums on their side in the apiary. Bees would work the supplement provided, gathering up the flour only when temperatures were warm enough to do so. The waste manufacturing sugar, even though it was obtained for next to no cost, proved not such a good source of sugar for the bees, often containing artificial sweeteners or other substances which were not the best for the bees. Batches of the waste sugar were very inconsistent in their attractiveness to bees and as such, plain white sugar is now used.

The feeding of supplements does more to make the beekeeper feel good.

The straight soy flour didn't seem to boost populations but did appear to maintain the populations. Recently Dayl has gone "right away from soya flour feeding completely as it didn't seem a worthwhile exercise." A few observations worth noting when open bulk feeding; the flour needs to be fine and for some reason bees were a lot more interested in collecting the supplement after a shower of rain.

Two to three years ago Dayl searched for a more satisfactory solution to supplementary feeding his bees and trialled a recipe originating from New Zealand. A pattie provided to each hive is now the preferred method of feeding a supplement. The composition is a mixture of torula yeast, lactalbumin (90% protein) and sugar. Colonies with failing or old queens were very slow to take up the food. It was also noted that the rate of consumption was influenced by the amount of nectar stimulus available in the field. This was the primary reason for including sugar syrup feeding as part of the supplementation in recent years.

Five hundred gram patties are fed underneath the queen excluder next to the brood area every three weeks. At this stage this management strategy has only been used in early spring to help the colonies recover populations after being harvested for adult bees for packages.

Dayl found that when the colony was actively collecting pollen in the field they tended to consume the pattie supplied to them and store the collected pollen. Cotton seed oil and a vitamin/mineral supplement have been tried in various pattie recipes but no discernible difference or response was noted, thus their use in patties was discontinued. Dayl believes that quite often the feeding of supplements does more to make the beekeeper feel good than benefiting the bees.

Sugar syrup is provided in inverted buckets over a hole in the lid, with 5 to 10 litres provided to each hive depending on the strength of the colony. A colony with three frames of brood going into winter will consume the pattie before they consume all the syrup. This can take up to four weeks. The syrup concentration is 150 kg of sugar mixed with water to produce 200 litres of syrup. The amount of sugar syrup available to each hive was regulated by the number of holes in the bucket. The slower the release rate the better the response to the sugar syrup by the colony in increasing or maintaining the area of brood within the colony as long as it did not ferment in the bucket. Various sugar/carbohydrate sources were trialled including molasses, treacle, brown sugar, white sugar, golden syrup and raw sugar. Bees weren't interested at all in molasses or treacle, and showed the best response to white sugar.

Keith McIlvride (NSW)

Key words: *queen breeding, sugar syrup, pollen feeding*

(Interview: Sep. 2002)
Now retired, Keith spent many years dabbling in the art of breeding and producing queen bees in the Thirlmere area, south west of Sydney. During this time, regular supplementation of sugar syrup and pollen was practiced to overcome limiting supplies of nectar and pollen while maintaining a queen rearing and breeding business.

Sugar feeding was constant in the form of syrup. The syrup was provided in frame feeders, which held 2 litres of syrup. Each feeder was the approximate size of a full depth frame and each cell building colony had a frame feeder permanently in place. Occasionally frame feeders were placed in the full depth nucleus colonies that were used to mate the virgin queens, although frames of honey were used in preference to feed nucleus colonies when available.

Once ants have found the feeder, they don't leave the feeder or colony alone.

The frame feeders in the cell builders were refilled twice a week, with a 50:50 sugar solution, reducing the concentration to 30:70 sugar/water solution as the season progressed and temperatures increased. At the beginning of the season in early spring the heavier syrup was provided, even then the bees were slow to remove the syrup taking up to three days. Once the bees began removing the syrup they would remove all the syrup overnight. If a 30:70 syrup was provided early in the season the bees wouldn't be interested even after 3 days. The heavier or more concentrated the syrup, the more likely the bees would store the syrup. There appeared to be no difference in feeding syrup every day or every 3 days. Top feeders were tried but were found to be unsatisfactory due to ant problems. Once the ants found the syrup in the top feeders they never left the feeder and colony alone, this was never a problem with frame feeders. Sugar syrup was mixed in an old washing machine, one 25 kg bag at a time, which was an efficient method of mixing the quantities of syrup required.

The naturally available pollen in the area was supplemented on a regular basis with WA red gum (*Corymbia calophylla*) pollen. This was purchased direct from Western Australia, and gamma irradiated to ensure that it was not the cause of any disease or infection within the apiary. Supplementary pollen was provided extensively to the cell building colonies. The pollen was placed in a little tray that sat on top of the frame feeder. This container held 30 grams of pollen and was refilled every second day. The combination of supplementary pollen and sugar syrup ensured the cell building colonies produced large, well shaped queen cells. There was always unused royal jelly left over in the base of the cell after it had hatched which is considered a good sign as it indicated that the queen larvae has had access to ample food.

Greg Mulder (NSW)

Key words: *queen breeding, pollen supplement, sugar syrup*

(Interview: Nov. 2000)

Greg operates 1200 to 1300 nucleus colonies producing 10–12,000 queens per year. Queen bees are produced mainly for the Australian market, although some have been exported when the price is attractive. The geographic location of the operation allows bee's access to a variety of floral species, including eucalypt forests. The coastal heath and banksia county is also a short distance from his base and is utilised regularly, particularly during the winter months, although, due to urban development, half of those wintering sites have been lost in recent years. The orchard areas are utilised extensively in spring with various herbaceous pasture, weeds, etc., providing a stimulating nectar source with a mixed pollen supply.

The drone mother colonies and cell raising colonies are prepared by stimulating with sugar syrup.

The first graft of larvae doesn't begin until early September. The drone mother colonies and cell raising colonies are prepared in July by stimulating with sugar syrup. Depending on the conditions and size of the colony, some of the larger colonies may be fed twice a week, two litres each feed. The nucleus colonies are either 3 or 4 frames of bees, on full depth combs with a 2 litre frame sugar syrup feeder. Pollen patties are provided to colonies from July, right through the spring period until the colonies do not find them attractive due to the abundance of naturally occurring pollens.

Commercial pollen supplement is purchased and sugar is obtained as a syrup in a 1000 litre container. In the field the syrup is carried on the back of a utility truck in 25 litre containers and poured into frame feeders using a watering can. The colonies may go for a couple of months over the season not requiring any syrup although in some years when nectar is short, sugar syrup is fed right through the season.

Pollen supplements are provided as required. Generally, pollen is not a problem, although colonies are often given patties at the end of the season in March/April and then again at the end of July early August and the start of September.

The larger hives used as drone mother colonies, queen cell raisers, etc., have a 3 litre plastic frame feeder permanently in place. These colonies can be fed 3 or 4 times per week, usually only 1½ litres each time, although if there is a need, more syrup can be given in each feed. Greg's aim is to ensure his bees have access to as much variation in pollen sources as possible but with the strategic use of pollen supplements and ample supply of sugar syrup ensure the colonies are not stressed nutritionally to maintain the conditions under which he produces queen bees.

Greg pouring syrup into frame feeder — 2 way nucleus box.

Mike Nelson (NSW)

Key Words: *white box, pollen supplement*

(Interview: Feb. 2004)

Mike and his son John manage 1300 hives, working within a 300 kilometre radius of Boggabri on the northern slopes of NSW. White box *(Eucalyptus albens)* nectar flows are considered the bread and butter of the operation, as the floral resource is very close to home base and it reliably yields copious quantities of nectar. Unfortunately white box honey flows have a reputation for "knocking" a colony around due to the deficiencies either in quality or quantity of pollen gathered from this species. Experience has taught Mike that his bees do a lot better when they are provided a pollen supplement when working a white box nectar flow through the winter and early spring.

White box honey flows have a reputation for "knocking" a colony.

A comparison between two years, 1993 (no pollen supplement), and 1997 (pollen supplement), both considered "good white box years" indicates a significant financial advantage in using pollen supplement. In 1993 61,800 kg of white box honey was extracted from 1,100 hives (56 kg per hive), whereas in 1997 when 840 kg of pollen supplement was fed to 1,200 hives at a cost of $5,040, a total of 115,624 kg of white box honey was extracted (96 kg per hive). In both circumstances Mike is confident that the quality of the colonies was good going onto the white box coming off stringybark or bloodwood flowering events, thus he is convinced that supplementary feeding pays dividends on white box honey flows. He has also used pollen supplements on ironbark during November and December due to the lack of available pollen in the field.

It is important to have a strong populous colony prior to the white box

When Mike first started experimenting with pollen supplement, he produced patties comprised of soy flour, yeast and honey but they proved too difficult to handle due to their sticky consistency. About 500 gram cricket ball size amounts were provided to each hive. This proved too much of a nuisance after a few years and Mike now prefers to buy pollen supplement already made into a dry biscuit form. No mess and a definite convenience being able to order more supplement as required. About 100 grams is fed to each colony each fortnight from May until the end of October. It is important to have strong populous colonies prior to the white box flowering, as it is not productive to provide supplement if the colony is weak in population.

When to feed is critical to the success of supplementary feeding.

Young queens and good sized colonies prior to the white box flowering are vital to obtain a surplus of white box honey. "More beekeepers kill bees on white box than white box kills bees", according to Mike, indicating that beekeepers can do a lot to alleviate the risks of working this nectar source. As well as providing pollen supplement, placing apiaries so they are protected from cool southerly winds on well drained soils facing the west are just a few important points. Not interfering with colonies when the weather is poor is vital, painting the lids brown to act as solar panels to assist the colony to keep the hive cavity warm also appears to help. Normally if bees haven't eaten the pollen supplement provided then the colony is queenless. The attraction with white box is that the nectar flow is reliable, the trick is knowing how to manage the situation to maximise honey production.

Harold Saxvik (NSW)

Key words: *pollination, pollen patties, open feeding, pollen supplement*

(Interview: May 2004)

Harold manages between 1500 and 2000 hives based at Darlington Point in the Riverina. His enterprise mix is 50% pollination, 50% honey, occasionally travelling into Victoria after the red stringybark *(Eucalyptus macrorhyncha)* in autumn. Crops pollinated include sunflowers, seed canola, pumpkins, prunes, faba beans, almonds and whatever else that is occasionally grown that requires pollinating.

Supplementary feeding has been trialled in one form or another over the last 10 years, with initially patties being placed on top of the queen excluder in every hive. This required every hive to be opened in the middle of winter which was very labour intensive and very likely to increase the Nosema levels in the adult bees. Open feeding is now the preference as it is quicker and easier to perform and each colony forages for what their requirements are.

Harold inspecting seed set in crop.

Open ended 200 litre drums are placed off the ground in the forks of trees away from livestock, tilted slightly forward so the bees can kick any bigger particles out of the drum. This also prevents a crust forming on top of the mix which can stop or slow down the access of the bees to the supplement. A typical mix would be a 20 kg bag of soy flour, 10 kg of caster sugar and 3 kg of inactive dry yeast. This supplementary feeding is normally only practiced in winter every 10 days to stimulate the colony to rear brood in preparation for almond pollination at the end of July/early August.

Some sources of soy flour are not as attractive to bees.

Some sources of soy flour are not as attractive to the bees, which creates problems in stimulating the bees. Once foraging starts on the supplement by the field bees, the queen usually starts to lay within four or five days even though it is fairly cold and frosty overnight. The system works well as the aim is to have hatching bees in the last week of July, first week of August, when they are moved onto almonds. Old bees tend to die quickly at this time of year and the colony can decline in population. With the young bees hatching, replacing the older bees, the colony performs quite well and come off the almonds in excellent condition. Harold "believes for pollination you've got to have young bees hatching. They've got more guts in cold weather".

When colonies are strong in population Harold is hesitant to stimulate the bees too much, as significant swarming problems can be the result once they are moved onto canola. He is always looking for new bee feeds to try. Currently his thoughts are that a dry pollen added to his mix may be better for the bees.

John and Kieren Sunderland (NSW)

Key words: *honey production, sugar syrup, pollen supplement, bulk feeding pollen supplement*

(Interview: Sep. 2002)

The Sunderlands manage 800 hives, travelling up to 700 km from their home to work nectar and pollen sources within the western division of NSW. Their primary enterprise is honey production, and supplementary feeding is practiced only on occasions as required. Sugar syrup feeding has only been trialled twice, on both occasions to stimulate the colonies to increase the brood being reared, thereby increasing the population in the late winter and early spring period. On the first occasion sugar syrup was provided to each hive in two 3 litre buckets per hive. The buckets were placed lid down, over the frames, which allowed bees to remove the syrup without drowning. On the second occasion, sugar syrup was provided to colonies prior to canola flowering when the colonies were very low on stored honey. A tray was placed under each lid holding about 200 to 300 mls. These were filled three times before nectar became available from the canola blossom.

Keiren with dough mixer for mixing pollen supplement.

Pollen supplements have been used on quite a number of occasions. Initially pollen patties were favoured, with individual 500 gram patties made for each colony. Later, bulk dry feeding the supplement in the apiary was practiced successfully. The original formula comprised of irradiated honey and pollen, soy flour and brewer's yeast. The pollen was purchased from Western Australia. Only enough soy flour for their current needs is purchased as they have found that the flour has a limited shelf life.

The ingredients were placed in a commercial dough mixer, producing 15 kg from each batch. The dough was removed, rolled and cut into blocks. They were then usually taken straight to the bees or stored in a freezer. Each pattie weighed ½ kg. The rate of consumption varied over time. Usually the first pattie provided to the colonies was consumed slowly and in some cases took up to eight weeks. Stored pollen in the brood combs would slow the consumption of the pattie.

The Sunderlands believe they have a better response from colonies by feeding pollen supplement outside the hive as compared to the patties which were placed in each hive, and it's a lot simpler than making patties. The mixture for outside feeding was essentially comprised of soy flour and torula yeast. The bees would readily collect this supplement and return it to their hives. The dry mixture was placed in an empty bee box elevated in the fork of a tree away from feral pigs. Each apiary of 100 hives was provided with 15 kg of the supplement. This usually took about a fortnight for the bees to remove. The size of the particle in the bulk feeder is important as "they can't utilise the heavier stuff." If they can't move this larger sized particle out of the way, a crust forms on the mixture which precludes bee access.

Pollen supplementation is usually practiced in late winter and early spring to provide a stimulus for the colonies to increase breeding and expand populations. They are not totally convinced that the supplementary feeding is working in all cases but it's more of a '"just in case it might work—just in case they need it" scenario. The bulk feeding has a few problems when other apiaries not belonging to the Sunderlands are nearby. They have found that apiaries even two kilometres flying distance and during western winter conditions will collect their pollen supplement.

Soy flour has a limited shelf life.

Fred Taylor (NSW)

Key Words: *honey production, pollen supplement*

(Interview: Feb. 2004)

Fred, with his son Tony, manage 1,100 colonies (hives and nucleus) in the northern tablelands of NSW based in Wallabadah. Fifty to 80 loads of bees are moved each year, depending on the prospects, with a range from Cootamundra in the south to Barcoola and Chinchilla in Queensland. The most profitable honey flows are on their doorstep with white box *(Eucalyptus albens)* one of the big ones.

Fred was inspired to trial supplementary feeding in the management of his bees after a trip to the USA in 1981. He was surprised with the American beekeeper's reaction to the comments about Australian beekeepers not feeding supplements. On his return he started strategic feeding of sugar syrup and pollen supplement based on a US recipe.

The most profitable honey flows are on your doorstep.

The recipe consists of sugar, water, yeast, vitamin additive, oil, pollen, soy flour and salt. This is mixed into a paste and fed immediately to the bees. Most of the pollen is collected by Fred who has 100 pollen traps for the purpose. Whenever bees are performing well and there is deemed to be a surplus of pollen available to the colonies, the traps are placed on the hives. The collected pollen is dried and gamma irradiated before storing it for future use.

The pollen supplement is provided whenever there is only a low quality pollen available to the colonies or there is very little available. White box is a perfect example for pollen supplement to be provided to bees. Each time honey is taken off the hives a handful of supplement is placed on the excluder and the super placed back on top of the hive. Up to a couple of tonnes a year of supplement is used in the business. Fred believes that the cost and effort is well justified, given the benefit of keeping bees breeding and in good condition. Pollens worthy of consideration to trap include the stringybarks, apple and turnip *(Rapistrum rugosum)*.

Sugar syrup is provided to bees whenever they need to be kept breeding.

Sugar syrup is provided to the bees whenever they need to be kept breeding. This is placed internally by spraying approximately two litres of syrup straight into the combs on site at 60% sugar solution. The sugar is purchased in syrup form and keeps quite well over winter, but has a short shelf life in summer. Syrup is only provided to stimulate the colony, without supplying enough for the bees to store.

Fred breeds most of his replacement queens and regards supplementary feeding as cheap insurance. Supplement is provided to all drone mother and cell raising colonies on a continuous basis. Even if the bees don't need it, Fred regards the cost as a small price to pay to ensure they are providing ideal conditions for queen rearing. When there's absolutely no fresh pollen available in the field queen rearing ceases.

Warren Taylor (NSW)

Key words: *packages, queen bee production, syrup*

(Interview: Feb. 2000)

Based on the central tablelands of NSW, Warren operates between 6,000 and 8,000 hives with a diversified operation focussing on live bee exports (packages), queen bee production, and honey production. Autumn is the major period for the sale of package bees, with preparation beginning for this market in mid summer. The queen rearing operation begins in earnest in early spring and finishes in the autumn after all the package orders have been filled. All three facets of the business have a strong export orientation with all package bees exported. From 10,000 to 15,000 packages have been produced in some years by buying bees from other beekeepers and shaking bees from the company's apiaries. To ensure that bees are kept in the best possible condition for package bee production and rearing queen bees it has been necessary to feed sugar syrup depending on the season.

Shaking bees into packages for export.

Queen rearing operation: This requires good supplies of both pollen and stimulating nectar supplies from spring through to autumn, whenever queens are being produced. Queens are mated in mini nucleus colonies and small plastic bags holding just under one litre of 67% sugar syrup are provided to each nucleus colony when new queen cells about to hatch are placed in each nucleus whenever fresh nectar is in short supply. These plastic bags are cleaned up in about 10 days by the nucleus colonies.

Purchased liquid sugar is marginally cheaper than mixing your own.

The cell raising colonies are fed sugar syrup continuously through the queen bee production season. Even when a colony becomes congested with capped honey, one or more frames are removed and the syrup continues to be available in the hive contained in a frame feeder. This ensures the continued stimulation of the colony and maximise the number of queen cells started by the queen rearing colonies, guaranteeing that the cells are well fed during their development.

Package bees: Sugar feeding to stimulate colonies for package bee production is a major management tool. There is no fixed rule as to when and how much syrup to feed to each colony, as this is dependent on the condition of the bees, the floral and climatic conditions on their current apiary sites and the potential floral resources elsewhere in the state. With 50 loads of bees, it is a major job in shifting and finding sufficient suitable floral resources. Feeding sugar syrup also helps the colony overcome chalkbrood.

"Our best year for packages was in a drought year in the early '90s where we fed sugar for almost three months. We had our highest yield with an average of over two packages per colony. Traditionally we shake one or one and a half packages per colony. That year, in the middle of a drought, we averaged over two, directly due to feeding sugar syrup. We continuously fed using buckets.

"We now use division board feeders, but bucket feeding is probably the best way to do it. Unfortunately, when you thin the syrup down to stimulate the colony, the light solution creates all sorts of yeast problems in the bucket. Unless you add a bit of acidic acid to the syrup, you've got to be prepared to wash the buckets every time they come off the hive.

"We always feed when there's a bit of a low in the season, generally in the mountains (January) when it's hot and dry. The brood nest reduces from seven frames to five, so we give them a feed for three weeks to try and keep that brood nest open.

"The last five years we've had dry January's and we've just had no alternative but to feed. Not all loads, some loads will be flying a bit of blue flower *(Echium vulgare)* or something that keeps them stimulated. We may feed 10, 15 or 20 litres most years.

"We buy all our sugar in liquid form at 67% sugar concentration, and we break that down to a 50% sugar:water ratio. We can't get consistency with mixing our own sugar syrup and liquid sugar is marginally cheaper without the cost of mixing your own. The syrup can be purchased in any quantity. We use 3,000 litre bulk tanks.

"It's very difficult to shake bees on a honey flow and they're hot bees to put on a plane, they've got their guts full of honey. It's better to have cold bees in the mountains, sugar fed, as they don't generate anywhere near the amount of heat for shipping on sugar than they do on honey. We have a sticky mess if we try and shake bees on a honey flow.

"There are times when we have 40 to 50 loads from March/April going into winter needing stores and it's more economical to load them on semis and send them to Bourke for goo bush *(Micromyrtus ciliata)* than to feed them here.

If we've only got a few litres to feed for winter stores, it probably pays to leave them here and put a few thousand dollars worth of sugar in them. We never have pollen problems in the mountains, around these forests.

"The problem is not enough nectar to stimulate the colony. There's always dandelions and little bits of clover through the pines, particularly where they thin pines out. The thinned out pines protect those plants even in the real hot, dry time when the paddocks are all brown. I can only remember once in my lifetime we moved out of here because we didn't have pollen.

"We rarely get honey. One year in ten we might get a couple of supers of clover, if the rainfall's right, a little bit of apple tree *(Eucalyptus bridgesiana),* brown barrell *(E. fastigata)* and gum *(E. viminalis)*, but the other attraction is that because there's no honey crops we don't have any other commercial beekeepers in here sitting on top of us.

"In relation to protein, I don't think we have the same problem in building packages that the American's do in raising spring packages. Usually we don't have a major pollen shortage in summer and often we're coming off Paterson's curse *(Echium plantagineum)* with the brood nests plugged with pollen, so if you put a sugar feeder on they'll convert that pollen straight into a big brood nest. Certainly, for the beekeepers supplying bees to us, liquid feeding of sugar has a benefit producing package bees. The advantage of shaking packages is they don't have a spring swarming problem and they don't need to leave a solid box of honey on the hives over winter. So they get paid for the package, they've solved their spring swarming problem and they're probably a box of honey better off. "

Bruce White (NSW)

Key words: *quarantine station, nucleus colonies, sugar feeding, pollen supplement*

(Interview: Apr. 2004)

Bruce, as part of his duties as a Technical Specialist for NSW Agriculture, manages the queen bee importation facility at Eastern Creek Quarantine Station in Western Sydney. The facility was built in the late 70's as a result of a Commonwealth Parliamentary enquiry into the needs of Australia's quarantine service.

The beekeeping industry at that time put up a case to import queen bees into a secure facility on two grounds. Firstly to have access to genetic stock from overseas for the domestic beekeeping industry, but with freedom of risk in relation to the importation of exotic pests and diseases. The second reason was to enable overseas trading partners to send their best stock to Australia so it could be multiplied and exported at the beginning of their production seasons when they may not be able to achieve the same outcome due to climatic constraints.

Pure pollen is very attractive to bees.

The facility is comprised of 12 flight cages which may house two nucleus colonies in each cage. Thus far the maximum number of queens held in the cages have been 12, although an average number is about six.

The original concept was for breeding stock to be imported in our spring, successfully introduced into the flight cages and grafting material to be removed after the prescribed quarantine period, until such a time when the queens were no longer required, which would be expected to be autumn when the imported queens would be killed and properly disposed of. Even so, queens have been overwintered successfully in the flight cages.

The shortest time frame for keeping queens in flight cages is normally three months. The queens are normally held in four-frame nucleus colonies with frames of brood and honey placed in the nucleus colony as required from an apiary outside of the building, located on the quarantine station.

Syrup feeding during winter substantially increases mortality.

As it is the owners of the imported queens decision on what should be given to each colony holding the imported queen, a variety of material has been provided including powdered pollen, pollen patties, sugar syrup and dry sugar.

Depending on the strength of the colony and the honey stored, the colony may be able to sustain itself for two and a half months without any additional inputs. Once a colony starts to decline in strength, frames of sealed brood and/or bees are placed in the colony every second week to ensure a good balance of age in the resident bees.

If the colony needs boosting in the winter period, then a handful of adult bees are shaken at the entrance of the nucleus colony. Brood in the middle of winter can increase mortality because the adult bees expend more energy feeding the brood and keeping it warm.

When stimulating a colony over spring and summer prior to grafting larvae for queen cell production, a 500 gram jar of 50:50 sugar water is placed on the top of the hive. Normally the nucleus colonies will take a week to remove the contents (this is provided every week when grafting material is required by the importer). During winter 100 grams of dry sugar is placed on top of the frames on a plastic lid which reduces any stimulation.

Pollen supplement has been provided by queen bee importers in a variety of different forms, including commercially available supplements, owners recipe to bee collected pollen. Supplements, when placed on the top of the frames are consumed very slowly and with indifference by the colony. When a supplement is placed between the frames in the brood area, the bees usually consume all the pattie.

Pure bee collected pollen is usually very attractive and more attractive to bees than supplements containing other substances other than pollen. When pollen is placed under the lid of a nucleus colony the colony will consume it all in most circumstances, except in the middle of winter when they completely ignore the powdered pollen provided.

Often the brood is lacking in royal jelly, particularly earlier in the season. By mixing 100 grams of pollen into a 50:50 sugar water syrup and providing it to the nucleus colonies in the 500 gram jars, the brood has noticeably more brood food or jelly around each larvae, making the job of grafting easier and presumably assisting the colony to build in population quicker and hold the population.

Feeding sugar syrup during winter substantially increases mortality within the colony, which is easily determined by the volume of dead bees in the cage. Feeding dry sugar substantially reduces mortality within the colony during the winter period.

Col Wilson (NSW)

Key words: *queen bees, sugar syrup, nucleus colonies, pollen supplement*

(Interview: May 2004)

Col is a queen bee breeder, based inland from Newcastle producing production queen bees and breeder queen bees. This is the region where Col grew up and he sees no need to move as most of the year good breeding conditions in the form of pollen and a light nectar flow are available either on the coast or just inland. His beekeeping operation has been mainly based on the production of queen bees for the domestic market and, for the last 15 years, exports have been significant.

At times, mainly in winter, colonies are provided supplements as and when required. All four frame full depth nucleus colonies have a half depth frame feeder permanently in place. The frame is half feeder and half comb which holds approximately a litre of syrup.

Syrup is provided to the nucleus colonies through the year as required which is not often except at the start of July when all nucleus colonies are inspected. All are provided a 50:50 sugar syrup plus pollen supplement to stimulate the colonies and start the queen laying. Three feeds of syrup are usually provided to the nucleus colonies over a three week period after which the colony is well stimulated and able to gather nectar in the field or live off the stored syrup.

The pollen supplement Col uses is mixed himself in a large industrial pastry mixer with a 60 litre bowl. The mixture contains at least 30% pollen with the remainder of the mix soy flour, irradiated honey and a little bit of pollard. The mixture is rolled into sausage shapes and placed between two frames right next to the brood chamber. This is only provided in early spring as most of the year natural pollen is readily available.

Cell builder colonies are always stimulated with 30% sugar syrup throughout the production season. A full depth frame feeder is permanently in place above the queen excluder which holds in excess of two litres and a bottle feeder is fitted to the front of the hive. These are replenished with syrup whenever the cell builders are manipulated.

Cell builders are always stimulated with sugar syrup.

Most of the time the drone mother colonies will have ample natural pollen and access to a light nectar flow. If drone populations diminish due to conditions then Col chooses to cease rearing queens. By doing this, he has disappointed some customers in the past, but he feels that by adopting this approach he is doing the right thing by them in the long run by only providing quality mated queens.

Don Keith (QLD)

Key Words: *honey production, dry sugar, pollen supplement*

(Interview: Feb. 2004)

Don manages 1,600 honey producing hives and 800 nucleus colonies based at Inglewood in Queensland, operating within 500 kilometres most of the time. Pollen is frequently a scarce resource through the year combined with extended dry periods. Often nectar flows are not supported by pollen that is attractive to the bees, creating significant nutritional management issues. As such, pollen supplemented with sugar feeding have become commonplace in the annual management of colonies to prevent populations from declining.
Dry sugar is supplied to nucleus colonies at 4 week intervals to help them survive the winter. A chock is placed under the front of the hive so sugar cannot roll out the entrance, and about half a kilogram is poured down the back and sides of the frames. It is important to feed them before they reach starvation point as they won't be interested in dry sugar by this stage. Production hives are fed about 1 kilogram during nectar dearth's to stimulate pollen collection.

Feeding dry sugar may not stimulate breeding as well as syrup, however, it requires little extra equipment and many hives can be fed in a short time. An increase in the number of bees foraging for pollen can be observed after sugar is fed if suitable conditions exist.

When the bees are first supplied with dry sugar they sometimes throw some of it out the entrance, which can be lost to ants, although this behaviour doesn't last. Meat ants are not such a big problem, they will help themselves to any spilt dry sugar or sugar discarded by the colony but usually colonies of bees are not too worried by meat ants. Black ants on the other hand are a major problem worrying colonies, stealing sugar and honey. Sometimes the only answer to this problem is to move the apiary to a new location.

Liquid sugar has been trialled with plastic bags for each colony but was found to be too labour intensive. Bulk feeding in chicken feeders was also trialled but the stronger colonies collected a disproportionate amount of syrup and the feral colonies in the area also had a free feed. Don also expressed concern over the possibility of spreading bee disease with this method due to the communal nature of the feeding trough.

As pollen was seen as a limiting nutritional factor in managing bees in the Inglewood region, a lot of interest was given to a 'new' product produced in the 1960s by Kraft in conjunction with the Waite Institute in South Australia called Krawaite. Krayeast, a major component of Krawaite, was available in Brisbane and was mixed with skim milk powder, honey and made into patties. It was not successful but in hindsight it may have been fed too late when colonies had nutritionally gone past the point of no return.

After trying a number of pollen supplements with little success, Don decided to gear himself up to trap pollen from his own hives in times of pollen abundance, store the pollen and feed it back to his colonies later in the year as required. Initially the pollen was fed back to colonies under the lid, but only strong colonies removed this satisfactorily. With weaker colonies condensation in the lid would spoil the pollen before the colony had a chance to remove it. The pollen was then placed on a piece of newspaper on top of the brood frames, but a string of droughts with little to no opportunity to trap pollen in the spring occurred over a number of years which stopped the pollen collection and feed back strategy.

Initially when feeding pollen back to colonies, half a kilogram was provided every two or three weeks. The stored pollen was often soon exhausted and other substitutes were added in an attempt to extend the stored pollen including soy flour and torula yeast. The bees would eat these mixes but with no pollen in the mix and after the second feed (2nd round of brood) the brood area would rapidly decline when no pollen was available in the field.

Supplementary feeding strong colonies worked okay, but weak colonies required good natural breeding conditions to recover. Due to the regularity of drought and convenience Don now buys pollen supplement from another beekeeper. The supplement comes in a biscuit form and is easily fed to colonies by slipping approximately half a kilogram between the frames above the queen excluder every three or four weeks. This is now a regular practice particularly during the autumn period when many of the honey flows in the area are pollen deficient. With the honey in the pollen biscuit Don believes they maintain their attractiveness to the bees, keeping colonies breeding for four to six weeks longer than they would have if the pollen biscuit was not provided. Don indicated that you can "waste a lot of money on supplements" and "can't claim that they have produced enormous amounts of honey because of using supplements", but some supplementary feeding is thought beneficial and at this stage dry sugar through winter and pollen biscuits in autumn will remain a regular practice until something better comes along.

Ken Olley (QLD)

Key Words: *honey production, queen rearing, nosema, pollen supplement, sugar syrup*

(Interview: Feb. 2004)

Ken manages a large beekeeping concern comprised of 3,000 hives, in conjunction with 5,000 nucleus colonies, based at Clifton on the Darling Downs in Queensland. He has been beekeeping since 1948 and has tried an array of management styles and practises in his effort to seek the most profitable enterprise model. Now the movement of apiaries is significantly reduced in favour of managing colonies in the SE Queensland region, obtaining honey flows that may not be rapid, but the cost of shifting apiaries is reduced.

There are three issues to managing honey bee colonies in SE Queensland, as Ken sees it. The first is the difficulty of building up colony populations and maintaining these populations for nectar flows. The second is the inherent problems of working bees on nectar flows that are essentially poor yielders of pollen, both in quality and quantity. The third is to be able to minimise the impact of Nosema disease on adult bee populations, often combined with poor nutrition.

Nosema management can be alleviated by a few simple management strategies beginning with minimising the manipulation of colonies, keeping a box of honey on the hive, and placing apiaries in warm locations. This can be a problem if working eucalypt nectar flows, particularly during cooler weather, such as blue-top ironbark *(Eucalyptus fibrosa* subsp. *nubla)* and narrow-leaved ironbark *(E. crebra)*. Attempts to maintain bee populations have been counter-productive due to Nosema infections wiping out the older bees in the colony. Combined with poor quality or a shortage of pollen, the colony quickly decreases from three boxes of bees to one which is no longer capable of foraging for a surplus honey crop.

To help overcome the poor nutritional conditions that prevail at various times of the year, a range of practises have been trialled including initially the use of a product called 'Krawaite', developed and produced by Kraft Food Products and the SA Waite Institute driven by Keith Doull. The product was like marmite or vegemite in consistency. Ken had a lot of success with this product but eventually the beekeeping industry lost interest and it was no longer available.

Ken, on returning from a trip to the USA in 1967, brought back the idea of providing other substances to colonies in the hope to overcome the poor nutrition his colonies suffered at various times in the year. Initially a mixture of torula yeast, skim milk powder and soy flour was provided to the colonies. A whole host of other ingredients were added and subtracted over time, but the ideal dry mix was never achieved. In Ken's words he had "experimented too much, spending a lot of time with the livestock industry people getting the best advice on various mixtures, some worked, most didn't". Soy flour was often the base of the various recipes trialled, but the results were often "very disappointing". Other ingredients including torula yeast and brewers yeast also proved disappointing. Ken has "tried so many mixtures without the success that one would expect; if you can't get an instant response by the extra feeding of the larvae, you haven't got it".

Sugar feeding has proven to be the most effective means of stimulating bees. Liquid sugar is the only way to feed sugar, as dry sugar doesn't stimulate the bees. With a 50:50 mixture, some syrup will be stored, whereas a 60% water: 40% sugar mix will be consumed by the bees but will not be stored. One of the most useful means of feeding syrup is by 10 litre plastic buckets with a 50 mm hole cut in the lid and a 70–80 mesh screen glued over the hole. The bucket is filled with syrup and inverted over a hole in the lid of the hive. A rock is then placed on top of the bucket. The bees usually take two days to remove the syrup, depending on the strength of the colony. This method is labour-intensive and it's not unusual to find buckets blown off the hive once empty.

Sugar feeding has proven to be the most effective means of stimulating bees.

Open feeding 200 L drums has also been tried, with disappointing results. The drum had bags draped over the syrup but the "fighting between the bees was unbelievable, causing the death of many field bees".

Feeding syrup to nucleus colonies was not considered, due to the logistics. Instead, a candy paste was provided to all nucleus colonies during periods of drought. The candy was made by mixing fine white sugar powder and a little irradiated honey. The honey was kept to a minimum so as not to promote robbing. A handful of this mix was placed in the nucleus colonies every 7 to 10 days.

Now a syrup which includes high heat skim milk powder plus oscillated yeast is provided to colonies in a thin plastic bag which may hold 500 mls — Ken calls this his magic mix. This is provided to drone mother hives, cell building colonies and other colonies in the queen rearing yard that require stimulation. The bag easily fits between the existing frames, negating the need to remove frames or produce a host of specialised feeders.

In relation to another serious problem that has been reported in SE Queensland and on the North Coast of NSW, is that of "muck disorder", which is called many things by beekeepers. Ken prefers to refer to it as "watery brood syndrome". Even so, his method of dealing with this problem is to provide fresh chlorinated drinking water for the bees, this he says could be the answer to the problem.

At the end of the interview with Ken, given he has trialled more substances than most beekeepers in Australia in his attempt to manage the nutritional shortages that occur from time to time, he said that "in all my life I've tried to get nutrition right and I believe that I am yet to come up with the answer".

Rod Palmer (QLD)

Key Words: *pollen cakes, Napunyah, queen bees, sugar syrup*

(Interview: Feb. 2004)

The idea of supplementary feeding bees started in the late 70's for Rod when he managed 1,000 colonies and conducted a small queen rearing business in conjunction with his brother, based in Ipswich, Queensland. Originally, colonies involved in the queen rearing side of the business were provided a slurry containing sugar syrup and pollen. This slurry was placed in frame feeders within the hive. In 1981 they migrated all the honey gathering hives to the napunyah country. From then to 1993 the conditions each winter were nutritionally favourable and bees continued to breed well on the pollen available in the field. But, in 1993 onwards, a series of dry years was experienced with no pollen available in the field and the bee populations subsequently suffered. At this point Rod started to dabble with various supplement recipes including feeding straight soy flour, providing it to bees in a sort of "gooey mess", but in the end after a lot of experimentation, a soy, yeast, pollen combination was found to be the most useful recipe.

Bees were reluctant to consume cakes without pollen.

It took a few years to then develop the cake or biscuit that he now uses and sells to other beekeepers. In the early trials, some cakes were made without pollen and trialled against cakes with pollen—bees were reluctant to consume cakes without pollen and would normally take 20% longer to consume. The cakes also contain honey and sugar which is thought to act as a preservative and ensure the attractiveness of the supplement. The honey and pollen in the supplement cakes is gamma irradiated to ensure that no bee pathogens are transmitted. Availability of soy flour became a problem at one stage, so Rod now produces his own flour to ensure a consistent product. All the cakes are made with machinery that Rod himself has constructed. With the cakes so dry and with a thickness of approximately 10 mm, they are easily slipped between combs in each hive. Rod normally recommends that the cakes are placed between the frames in the honey super over the queen excluder.

More supplement was provided if the size of queen cells became smaller.

Large quantities of his cakes were provided to his honey hives while they were on napunyah. Four cakes were provided to each colony whenever the honey was removed (one cake equals 100 grams). If the cakes were not consumed then this would be cause to investigate the brood nest to ascertain the status of the queen. Invariably there would be a problem of some kind and at this time of year (winter), the lack of removal of the cakes was the only trigger to inspect the brood. Pollen supplement cakes were fed consistently for five months at a time, with very little field pollen support, the colonies would survive in reasonable condition. Feeding supplement did not stop once the bees were moved out of the channel country, cakes were continuously provided until a natural pollen source was readily collected by field bees.

In 1998 the honey production side of the business was down sized due to the loss of Rod's brother in a traffic accident. The production of approximately 4,000 to 5,000 queen bees per year and pollen cakes for other beekeepers in all states was now the focus of the business. Pollen supplement cakes are provided on a weekly basis to all the colonies utilised in the queen rearing yard, whether they need it or not. Invariably the bees eat this 100 gram cake. Four colonies in the yard are permanently set up with pollen traps. These are activated for two days each week to assess the volume and variety of pollen in the field. Based on this measurement, further pollen supplement cakes may be provided to all colonies including nucleus colonies. If 400 or 500 grams of pollen was being trapped in all four colonies, then they would receive one pollen supplement cake in each hive. But, if the total collection was 100 grams, then the hives would each receive one and a half cakes or more. The amount of pollen either in the field or supplement provided had a direct bearing on the size of the queen cells. More supplement was provided if the size of queen cells became smaller.

Sugar syrup is provided to the queen rearing apiary on a regular basis, as pollen and pollen supplement cakes are only half the equation. The colonies must have syrup if there is no nectar available in the field if they are to continue breeding and rear queen cells. Two, two litre frame feeders are placed permanently in each queen cell feeder which are filled once a week with thick syrup. Mixing thick syrup requires very hot water to dissolve the crystals. Bees tend to breed a little better when the mixture is thinner which is the syrup consistency provided to all colonies via an external feeder. Four purpose made boxes which hold 40 litres each are placed in the apiary. A total of 160 litres of syrup would disappear in a day. This was done every four weeks when ripe queen cells are placed in the 150 to 200 mating nucleus colonies. The feeders are the same size as a ten frame box, which made it easier to load onto the truck and move with the rest of the equipment. The feeders have a floating device which prevents drowning of the foraging bees. Feeding feral bees is not a big issue, neither is the risk of disease, as bees face the same risk when visiting flowers or common watering sites. A lid is placed over the feeder to prevent the entry of rain. Possums are a problem occasionally accessing the syrup.

The production of pollen supplement cakes is a major part of Rod's business, with markets in every state. When asked what feedback does he get from his regular customers, the answer according to Rod is curious—indicating that "they don't really know what it does for the bees, but they're not game not to feed them".

Rod suggests that storing his pollen supplement cakes is satisfactory for 12 months as long as they are not exposed to heat. If stored in a cool room or freezer, then two years should hold their nutrient value. But, as Rod warns "you must remember that cakes are a food product and the higher the temperature, the more detrimental the effect it has on the protein level of the cakes".

David Stevens (QLD)

Key words: *honey production, pollen cakes*

(Interview: Feb. 2004)

David manages between 800 and 1000 hives strictly for honey production, based in Warwick, Queensland. His operational range is quite extensive, from 400 km north, 800–1,000 km west, and 1,000 km to the south well, into NSW.

> **Pollen supplements are certainly not the answer to everything, but they're a help.**

Western Queensland in the winter is always worked, whenever napunyah *(E. ochrophloia)* is in flower. Unfortunately there have been some years when colonies are seriously weakened as a result of a lack of pollen, and bees have needed to be moved, even when ample nectar is still available in the field. Some autumn honey flows around the Darling Downs are avoided as they also have the reputation of reducing the adult bee population and failing to provide suitable pollen to stimulate an increase in the population. Given these two scenarios, the possibility of providing pollen supplements to colonies to maintain populations was explored approximately 10 years ago.

Initially a dry mix comprised of torula yeast, soy flour and pollen was provided to the bees, but it was a bit of mucking around and the bees used to waste a lot of the feed by throwing it out of the hive. It was also very time consuming to feed each hive and mix the ingredients.

Purchased protein cakes are now used extensively due to the ease with which they are applied to the hive. Three or four (100 g) cakes are placed between the frames of a super, above the queen excluder every time a super is removed, which may be every two weeks. As a result of the regular feeding of colonies under these circumstances, the colonies haven't stopped rearing brood which is the normal reaction to the conditions that prevail.

To build colonies up, it is still hard to beat natural pollen and light nectar conditions, with wild turnip *(Rapistrum rugosum)* or spotted gum *(Corymbia henryi* or *C. variegata)* being the preferred option for this management activity in the winter/spring.

Pollen supplements are "certainly not the answer to everything, but they're a help".

John Berry (NZ)

Key Words: *pollination, sugar syrup*

(Interview: Jul. 2004)

John manages 1000 hives, based in the North Island of New Zealand. Half are moved onto apple pollination each spring, then back to sites around his base for summer honey flows. The other half stay put all year. The size of an apiary varies from 8 to 48, with an average of 24 hives. The average honey crop for the year is 45 kg which is fairly good for New Zealand.

The brood area is contained in two boxes with no excluder. A three frame plastic feeder is permanently in place in the second box. This feeder has a capacity of 5 kg of honey or 8 litres of syrup.

When all hives in the apiary are provided some syrup, this minimises robbing behaviour.

The hives are first inspected for stored honey in mid August and fed honey saved from the previous summer. The subsequent feedings are sugar syrup. This occurs every 10 days if the weather is poor or the colonies are particularly hungry. If not feeding, intervals are up to three weeks apart.

Each hive is provided with eight litres of 67% brix syrup up to the 10^{th} November. The last feed may be half this amount if the honey flow is anticipated. In very poor weather feeding can occasionally continue well into December.

When feeding syrup, all hives in the apiary are provided some syrup as this seems to minimise robbing behaviour between colonies. Robbing has never been a significant issue, possibly as a result of this practice.

Dry sugar has been fed to colonies, either on sheets of paper under the lid or on the bottom board in emergencies. Heavy syrup is preferred, particularly compared to thin syrup, as this reduces stimulation, the syrup lasts longer and is slower to ferment, taking up to two weeks. A good hive should be able to consume all the syrup in the frame feeders within 24 hours.

Syrup is purchased in bulk 900 litre cardboard drums with plastic liners. If the prices are low at any time during the year, John will forward contract up to 20 tonnes, with usually a year to pick it up.

The syrup is poured into a 1400 litre tank on the back of a light truck. Hives are filled by a long hose with a petrol handle. A 12 volt diaphragm compressor keeps the pressure in the tank at about 18 lbs, with a release valve fitted. This compressor is left on most of the day.

Feeder permanently in place — John Berry's apiary, NZ.

Hives are fed in the autumn, particularly if they have experienced drought conditions. Large autumn bee populations are often dominated by old bees. By feeding syrup this stimulates the colony to produce another round of brood prior to winter, ensuring that there is a good population of young bees in spring.

John has tried feeding pollen substitute, but with little success. The need for pollen substitute is not great. In some years hives are sometimes moved in early spring to a better pollen source, then moved back to the summer honey flow. The substitutes John has used have "either set like bricks or dribble through the frames and the bees kick them out the entrance". Thus, pollen substitution has not been successful or, for that matter, the necessity is not strong.

Wouter Hyink (NZ)

Key Words: *sugar syrup, kiwifruit pollination, nucleus colonies, nosema*

(Interview: Jul. 2004)

Wouter manages approximately 800 colonies in the North Island of New Zealand. The business focus is multi-strand, providing colonies for kiwifruit and avocado pollination, honey production, propolis collection and package bees.

There is normally adequate pollen available in the field for bees and this is not considered a significant problem, although there has been a decline in pollen availability in the last few years. Significant pollen sources include gorse *(Ulex europaeus)* and willow *(Salix* spp.) in August/September, followed by pasture pollens in October. As agricultural practises become more intense, gorse populations have had increased pressure with widespread use of herbicides, and willows are being replaced in favour of casuarinas for horticultural windbreaks. Wouter predicts that pollen shortage will be a growing problem for beekeepers in the North Island of New Zealand.

Supplementary sugar syrup feeding is regularly conducted when necessary in spring. Early August hives are checked for stored honey. Syrup is provided to colonies with little or no honey stores. From the start of September all hives are fed three litres every two up to three weeks. The sucrose syrup is bought pre-mixed at 67% brix. The 9000 litres of syrup used is a mixture of eight tonnes of sugar and 4000 litres of water.

Every hive has an internal frame feeder permanently in place in the brood box. This feeder holds five litres and is the equivalent of replacing two frames. Even so, eight brood frames are located in each brood box. When colonies are moved to pollination, a second additional feeder is placed in the super. This is removed after the pollination contract has been completed.

The syrup is provided to stimulate the colony to breed and expand in population. Syrup feeding during kiwifruit pollination is practiced to encourage the colony to collect kiwifruit pollen. This stimulation leads to a better fruit set in the crop, thus the supplementation is regarded as a service to the grower.

Sucrose syrup is sometimes partly converted to fructose and glucose by adding 40 or 50 grams of oxalic hydrate crystals to 800 litres of sugar. The mixture is heated to 95°C to assist the hydrolysing process. This is done in an open top milk vat, with a screen covering it to prevent robbing. Prolonged heating will darken the syrup and is avoided. The inversion rate is probably only 40% to 50%, but Wouter is convinced that it makes a huge difference to the ease with which bees remove the syrup and store it. He hypothesises that bees cannot use sucrose syrup as a direct energy source and have to first convert it to fructose and glucose to utilise it as an energy source.

Over the last few seasons Wouter has wintered 50 polystyrene mating nucs which had been fed inverted syrup. These nucs are little top bar hives with 4 combs, approximately 100 mm by 80 mm (about 2,500 cells for the whole colony). In previous years, before inverting the sugar, larger nucs would struggle to overwinter.

This conversion places some stress on a bee and probably relates to higher Nosema levels in the colony. He has noticed that small colonies that he would expect to die in early spring will respond to the converted syrup and not be a victim to Nosema, whereas sucrose syrup will finish the smaller colonies off.

The converted syrup crystallises quicker than sucrose syrup. Fermentation can be a problem in warm weather and syrup should be fed out within 7 to 10 days. If the syrup does start to ferment, then it is reheated to kill any yeast before feeding it to colonies.

CHAPTER 8

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