The primary melliferous flora and other aspects associated with beekeeping within State forests of New South Wales as determined by surveys of beekeepers

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Summary

The State forests of New South Wales (NSW) are a very important resource for the NSW beekeeping industry. In 1995/96, 3749 occupation permits were issued for bee farming, and this number increased to 3843 in 1997. On average, 100–120 beehives were periodically placed on each occupation permit site, the number and location being determined by the flowering of species which beekeepers regarded as reliable producers of nectar and pollen. Commercial apiaries were also periodically placed adjacent to State forests, allowing the bees to fly to the floral resources of these forests. The fraction of sites located on private property in this way varied from 5% to 57%, depending on the forestry district, with an average of 34%. Thus the actual number of commercial honey bees accessing the State forest floral resources was much higher than occupation permits indicated.

The main floral species of importance for beekeeping within the NSW coastal forests were *Banksia ericifolia*, *Corymbia maculata*, *C. variegata*, *Eucalyptus muelleriana*, *E. paniculata*, *E. siderophloia*, *Lophostemon confertus*, *E. acmenoides* and *E. longifolia*. The ironbark group of eucalypts was a major source of nectar for honey bees throughout the State forests of NSW. The main tablelands species were *E. viminalis* and *E. pauciflora*, although as there are fewer forest districts on the tablelands the frequency of mention across more than one forest district was reduced. The species of importance in the western forests included *C. trachyphloia*, *E. camaldulensis*, *E. crebra*, *E. largiflorens*, *E. microcarpa*, *E. sideroxylon and E. fibrosa*. This paper provides a collective anecdote of the most important nectar- and pollen-producing flora of value to commercial beekeepers within the forests under the management of Forests NSW.

Keywords: honey; nectar; pollen; honey bee forage; beekeeping; forests; *Corymbia*; *Eucalyptus*; *Apis mellifera*; New South Wales; Australia

Introduction

The State forests of New South Wales (NSW) are a very important resource for the NSW beekeeping industry. In 1995/96, 3749 occupation permits were issued for bee farming in NSW State forests (State Forests of NSW 1996); this number rose slightly to 3843 in 1997 (Smith 1999). On average, 70% of the honey obtained by beekeepers comes from eucalypts or closely related species in NSW (Somerville and Moncur 1997). Most of the accessible forested lands of NSW are located in State forests.

Commercial beekeepers in NSW manage, on average, 500 hives of honey bees (*Apis mellifera* L.) each; the range is from 350 to 700 hives. Average annual yield for a skilled operator is 100–120 kg per hive. To achieve this, beehives are transported from one location to the next. Most beekeepers operate within 200 km of their home base for most of the year, with occasional trips outside of this range to particularly good and reliable nectar flows, for over-wintering or to escape drought closer to home. Hives may be shifted 4–6 times annually onto flora producing surplus nectar (Hornitzky *et al*. 1993). Commercial beekeeping is a family-based, labour-intensive rural industry.

Commercial beekeepers require access to an extensive network of floral sources to be able to regularly move hives onto nectar-producing flowering plants. On average, 100–120 hives are located at each site. A commercial beekeeper with 500–600 hives will require 5–6 sites for each floral species.

Many eucalypt species from which nectar is periodically harvested by honey bees flower on a 2–4-y cycle. Beekeepers have observed that some eucalypts have a longer flowering cycle (Somerville 1999). Even though a species is flowering and it has been identified as a useful floral resource for beekeeping purposes, the climatic conditions may not be suitable for nectar secretion. Thus beekeepers may work a particular floral species only every second or third flowering period. Yields from any one species will also vary according to location, climatic factors and strength of the foraging force of the colony (Clemson 1985).

Beekeepers have to continually make careful management decisions in relation to nutritional requirements of their colonies. The colony obtains its carbohydrate from nectar, which the honey bees convert into honey, whereas their protein is derived from pollen which varies considerably in quality. The volume and sugar content of the nectar produced by each species also vary considerably due to a range of factors. Honey bees can identify nectars with higher levels of sugar, and favour their collection (von Frisch 1950).

A number of floral resources important for nectar do not produce pollen that is attractive to honey bees. Classic eucalypt examples include *E. paniculata* (grey ironbark), *E. sideroxylon* (mugga

ironbark) and *E. melliodora* (yellow box) (Clemson 1985). Yet other eucalypts provide pollen that is attractive to honey bees but is considered to be of poor quality in relation to honey bee nutritional requirements. Honey bees require pollen with a protein content of at least 20% to maintain breeding, but, for example, *E. albens* (white box), an important nectar source on the Northern Tablelands of NSW, produces a pollen with only 17% protein. This causes significant management problems (Kleinschmidt and Kondos 1976). It is important to have a mix of floral resources within the foraging range of a colony to enable the bees to satisfy their nutritional requirements and minimise any deficiency associated with a single pollen source.

Beekeepers may invest much time in seeking apiary sites. Commercial and semi-commercial beekeepers desire a network of high-quality apiary sites with diverse, reliable nectar- and pollen-producing plants within economic travelling distance of their base. Forests NSW allows beekeepers to place apiaries within public forests, where sites are defined by the availability of locations suitable for hives and with all-weather vehicle access.

The public forests managed by Forests NSW principally for timber harvesting provide ideal facilities. Old log dumps are excellent sites for large numbers of hives. The forests offer a network of such sites, where often more than one species can be worked in different years, in different seasons of the same year, or concurrently.

Materials and methods

Information was collected by a series of surveys of beekeepers with beekeeping occupation permits, recorded at 31 district offices of State Forests of New South Wales (now Forests NSW) between 1990 and 1997. The survey was a collaborative effort of the writers and various district foresters of Forests NSW. The number of beekeepers with permits for each State forest district varied from one (Bombala) to 80 (Batemans Bay).

Names and addresses for all apiary permits for each Forests NSW district were obtained from each district office. For every district a survey form and covering letter was sent to each beekeeper and — in some districts with reduced beekeeping activity — to beekeepers who had had permits in immediate past years. Most responses were by return of the survey form. Key beekeepers with significant numbers of permits were interviewed either in person or by phone to ensure that the responses accounted for most of the permits issued for each district.

The ultimate survey form consisted of two parts. The first section asked the beekeeper to list the floral species of importance in that particular forest district. The questions included:

- species (common or scientific)
- level of importance for honey or pollen — low, medium, high
- expected annual yield (tins) (a tin is an historical measurement used by beekeepers to indicate the yield of honey per hive; it is equivalent to 27 kg)
- period during which buds are carried, and time of year when flowering occurs
- interval (number of years) between nectar flows
- stocking rate (hives per site).

The second section asked more general questions which included:

- information on history of usage
- comments on forestry practices, as they relate to beekeeping activities (likes or dislikes)
- the number of sites the beekeeper uses in _ _ _ _ forestry district
  - the number of sites in State forest
  - the number of sites in private property adjoining State forests
- comments on changed flowering or yielding patterns of forest flora, impacting on honey production
- how these forests fit into the annual calendar of activity
- other comments.

The surveys were conducted over a number of years. An initial pilot survey in 1990 (Nowra State Forests) was simple in design, asking only for information on the floral species of importance to beekeeping. The next group of districts surveyed, using the questions in section one only, included Baradine, Batemans Bay, Central Murray and Queanbeyan/Badja. The Baradine survey, although part of the initial study, was the only district in which the survey design differed substantially from that used in the rest of the State (Stace 1996). The remainder of the forestry districts studied were surveyed during 1996–1997, using the questions from both sections one and two.

The principal reference for botanical names was the Royal Botanic Gardens (Anon. 2004). Nomenclature of *Corymbia* species is the subject of continuing debate; the names used in this paper are as published by the Royal Botanic Gardens.

Results

Survey statistics

The tables summarise the results of 26 reports on beekeeping based on information from the completed surveys. In most cases a 70–80% response was obtained. Due to only occasional usage of some State forest districts by beekeepers, data for some districts were amalgamated with those of adjacent districts. These mergers were Bathurst/Oberon, Eden/Bombala, Queanbeyan/Badja, Tumut/Tumbarumba and Walcha/Gloucester.

State beekeeper analysis

The commercial status of beekeepers can be divided into four categories: 1–39 hives = amateurs; 40–199 hives = part-time; 200–399 hives = full-time (although not a sufficient number in most cases to provide the only source of income) and $\geq$400 hives = full-time. Table 1 shows that amateur and part-time beekeepers occupied <10% of the total number of forestry sites, whereas the group of beekeepers managing the greatest number of hives occupied the greatest number of forest sites, 67%.

Responses to survey questions — section 1

Stocking rates

The number of hives per site varied widely, 35–300. The mean number of hives per site was 100–120. Only a few beekeepers

Table 1. The categories of beekeeper issued with beekeeping occupation permits in 31 Forests NSW districts

Statistic	Category of beekeeper			
	Amateur 1–39 hives	Part time 40–199 hives	Full time 200–399 hives	Full time ≥400 hives
Number of beekeepers	20	91	148	393
Fraction of beekeepers (%)	3	14	23	60
Fraction of sites issued to each group (%)	<1	9	23	67

varied the stocking rate to match the capacity of the flora to yield nectar and pollen.

The primary melliferous flora by forestry district

We considered the floral species most frequently mentioned to be most important to beekeepers in each forest district. The three species most frequently named in each district are listed in Table 2; these species number 40 in all. The importance of these species can be attributed to either their abundance in the district or the reliable nature of their yield of nectar and/or pollen.

A number of species were mentioned in reports from more than one district. The South Coast districts were particularly favoured for *C. maculata*, and *E. muelleriana* and *E. longifolia*. The tablelands were favoured for *E. viminalis* and *E. pauciflora*, and the Riverina (southern western) region for *Echium plantagineum*, *Eucalyptus camaldulensis* and *E. largiflorens*. Ironbarks, including *E. sideroxylon, E. fibrosa* and *E. beyeri*, were important in the central and northern areas of the western forests. The Central and North Coast forests were favoured for *E. acmenoides*, *E. paniculata* and *E. siderophloia*. Other important North Coast species included *C. variegata* and *Lophostemon confertus*.

Table 2. The top three melliferous floral species most frequently stated by survey respondents to be of importance to beekeeping in Forests NSW districts. (Walcha/Gloucester district is not included due to the small size of the sample; *E = Eucalyptus*; *C = Corymbia*)

Region and Forests NSW district	Ranking in frequency of mention as important		
	1	2	3
South Coast			
Eden/Bombala	*E. muelleriana* (yellow stringybark)	*E. globoidea* (white stringybark)	*E. longifolia* (woollybutt)
Narooma	*E. muelleriana* (yellow stringybark)	*C. maculata* (spotted gum)	*E. longifolia* (woollybutt)
Batemans Bay	*C. maculata* (spotted gum)	*E. paniculata* (grey ironbark)	*E. saligna* (Sydney blue gum)
Nowra	*Banksia ericifolia* (heath-leaved banksia)	*C. gummifera* (red bloodwood)	*C. maculata*(spotted gum)
Tablelands			
Tumut/Tumbarumba	*E. pauciflora* (snow gum) – equal 1st with	*E. delegatensis* (alpine ash)	*E. viminalis* (manna gum)
Queanbeyan/Badja	*E. pauciflora* (snow gum)	*E. viminalis* (manna gum)	*E. fastigata* (brown barrel)
Bathurst/Oberon	*E. macrorhyncha* (red stringybark)	*E. viminalis* (manna gum)	*Echium vulgare* (Viper's bugloss)
Inverell	*E. melanophloia* (silver leaf ironbark)	*E. albens* (white box)	*E. crebra* (narrow-leaved ironbark)
Western region			
Central Murray	*E. camaldulensis* (river red gum)	*E. largiflorens* (black box)	*Echium plantagineum* (Paterson's curse)
Mildura	*E. largiflorens* (black box)	*E. camaldulensis* (river red gum)	*E. dumosa* or *E. incrassata* (yellow mallee)
Narrandera	*E camaldulensis* (red river gum)	*E. melliodora* (yellow box)	*Echium plantagineum* (Paterson's curse)
Forbes	*E. sideroxylon* (mugga ironbark)	*E. microcarpa* (grey box)	*E. fibrosa* (broad-leaved ironbark)
Dubbo	*E. crebra* (narrow-leaved ironbark)	*E. beyeri* (corky ironbark)	*E. sideroxylon* (mugga ironbark)
Baradine (Pilliga)	*C. trachyphloia* (Pilliga bloodwood)	*E. fibrosa* (broad-leaved ironbark)	*E. crebra* (narrow-leaved ironbark)
Central Coast			
Morisset	*Dillwynia* sp. (eggs and bacon)	*C. gummifera* (red bloodwood)	*C. eximia* (yellow bloodwood)
Bulahdelah	*E. siderophloia, E. paniculata* (grey ironbarks)	*E. acmenoides* (white mahogany)	*C. maculata* (spotted gum)
Taree	*E. siderophloia, E. paniculata* (grey ironbarks)	*E. acmenoides* (white mahogany)	*E. punctata* or *E. propinqua* (grey gum)
Wauchope	*E. siderophloia, E. paniculata* (grey ironbarks)	*E. pilularis* (blackbutt)	*E. acmenoides* (white mahogany)
Kempsey	*E. siderophloia, E. paniculata* (grey ironbarks)	*C. maculata* (spotted gum)	*E. acmenoides* (white mahogany)
North Coast			
Urunga	*E. siderophloia* (grey ironbark)	*E. acmenoides* (white mahogany)	*C. variegata* (spotted gum)
Dorrigo	*Lophostemon confertus* (brush box)	*E. siderophloia* (grey ironbark)	*C. variegata* (spotted gum)
Grafton	*E. siderophloia* (grey ironbark)	*Lophostemon confertus* (brush box)	*C. variegata* (spotted gum)
Casino	*E. siderophloia* (grey ironbark)	*C. variegata* (spotted gum)	*E. tereticornis* (forest red gum)
Urbenville	*E. siderophloia* (grey ironbark)	*Lophostemon confertus* (brush box)	*E. moluccana* (grey box)
Glen Innes	*Lophostemon confertus* (brush box)	*E. siderophloia* (grey ironbark)	*E. andrewsii* (New England blackbutt)

Table 3. Comments by beekeepers on the primary melliferous flora in State forests of NSW

Species	Level of honey importance	Level of pollen importance	Duration buds carried (mo)	Months when flowering occurs	Interval between flowerings (y)
Banksia ericifolia	*Med–high	High	3–4	May–Aug	1
C. maculata	High	High	18–20	Apr–Sep	4
C. trachyphloia	High	High	3–4	Feb–Apr	2
C. variegata	Med–high	High	20–24	Jan–Mar	3–5
Dillwynia spp.	Low	High	–	Aug–Oct	1
E. acmenoides	Med	Med	8–9	Oct–Dec	1–3
E. camaldulensis	High	High	12	Dec–Jan	2–4
E. crebra	High	Med–high	6–12	Oct–Dec	2–3
E. delegatensis	Med–high	High	12	Jan–Mar	2
E. largiflorens	High	Low–med	12	Jan–Mar	2
E. macrorhyncha	Med–high	High	15–24	Feb–Mar	3–4
E. melanophloia	High	Med	1½–2	Dec–Jan	3–5
E. muelleriana	High	High	18–24	Dec–Mar	3–5
E. paniculata	High	Nil	5–9	Nov–Jan	3–5
E. pauciflora	Med–high	Med–high	9–12	Nov–Feb	2–3
E. siderophloia	High	Nil	6–10	Nov–Jan	1–3
E. sideroxylon	Med–high	Nil	4	Apr–Sep	2–3
Lophostemon confertus	High	Med–high	1½	Dec–Jan	2–4

*Med = medium

Beekeepers response on the floral rewards and flowering phenology of melliferous flora

The relative values for honey and pollen yield, the length of time buds were carried, the time of year of flowering, and the interval between flowering events for the most important species are shown in Table 3. These species are those ranked first, second or third in more than two forest districts in Table 2.

Nearly all species listed in Table 3 had a high or medium-to-high rating for honey. The values for pollen, on the other hand, ranged from nil to high, with only half of the species being highly valued.

Beekeepers observed that the length of time each species was in bud ranged from 1.5 mo to 2 y. The spotted gums (*C. maculata* and *C. variegata*) and two stringybarks (*E. macrorhyncha* and *E. muelleriana*) carried buds for up to 2 y. Five species carried buds for up to a year. The two grey ironbarks *E. paniculata* and *E. siderophloia* carried buds for up to 9–10 mo and five species carried buds for up to 1.5–4 mo.

The duration of flowering ranged from 2 mo for *E. camaldulensis*, *E. macrorhyncha*, *E. melanophloia* and *Lophostemon confertus* to 6 mo for *C. maculata* and *E. sideroxylon*. Both of the species with the longest flowering period were winter flowering, whereas the species with the shortest flowering periods were primarily summer flowering. Ten (56%) of the species had a 3-mo flowering period.

The interval between flowering events ranged from 1 y, for the shrubs *Banksia ericifolia* and *Dillwynia* spp., to 5 y for *C. variegata*, *E. melanophloia*, *E. muelleriana* and *E. paniculata*. For most species the interval was 2–4 y.

Indicative honey yields by floral species

The honey yields varied significantly between species and within each species. Yields per hive for the species of primary importance are tabulated in Table 4. No honey yields were reported for *Dillwynia* spp. *Banksia ericifolia* and *E. largiflorens* had the lowest average annual honey yield per hive, 20 kg, compared

Table 4. The average and range of honey production from the primary melliferous species in State forests of NSW

Species	Annual honey yield per hive	
	Average (kg)	Range (kg)
B. ericifolia	20	5–40
C. maculata	50	27–103
C. trachyphloia	50	40–100
C. variegata	55	14–216
E. acmenoides	35	14–54
E. camaldulensis	40	27–135
E. crebra	30	15–108
E. delegatensis	40	20–60
E. largiflorens	20	10–30
E. macrorhyncha	50	15–108
E. melanophloia	60	50–135
E. muelleriana	40	10–80
E. paniculata	64	27–104
E. pauciflora	30	20–50
E. siderophloia	75	14–200
E. sideroxylon	30	14–93
L. confertus	80	27–135

to *Lophostemon confertus* with the highest of 80 kg, closely followed by *E. siderophloia* with 75 kg. The average annual honey production for all 16 species was 46 kg per hive. The species with the greatest range in yields were *C. variegata*, 14–216 kg, and *E. melanophloia*, 50–135 kg. The minimum yields ranged from 5 kg to 50 kg, and nine species (50%) had top yields exceeding 100 kg.

Responses to survey questions — section 2

History of usage

The time that beekeepers had periodically used forest sites for their hives varied from the brief duration of those with recently-acquired permits to that of families who have had had access to sites for two generations. Periods of 40 y were mentioned by a number of respondents.

Forestry practices

Responses indicated that beekeeping was generally compatible with forestry management activities, as there was a general acknowledgment that road access and old logging dumps associated with tree harvesting offered beekeepers an excellent road network and suitable apiary locations. The main concern identified by beekeepers was that many tree species required a considerable period of growth before useful quantities of nectar were reliably produced. Even though some eucalypt species flowered as small trees, they were not regarded as reliable sources of nectar and hence honey until more mature. Thus logging of mature stands of important nectar- and pollen-producing species was regarded as detracting from the value of a site for beekeeping purposes.

Bee sites in and adjacent to State forest

The study surveyed beekeepers with beekeeping occupation permits issued by Forests NSW, but it did not necessarily collect information from all beekeepers managing honey bees foraging in State forests. As honey bees are capable of flying 2–4 km in favourable weather, it is possible for apiaries placed on private property or on land in other tenures adjacent to State forests to effectively harvest this nectar and pollen resource. Table 5 indicates the number of apiary sites adjacent to State forests where honey bees would be able to forage on the floral resources within the State forests.

The number of hive sites on private property adjacent to State forests was above 20% of the total number of sites available within and adjacent to State forests in all districts except Dorrigo and Dubbo. Of the total number of sites using State forest flora, 34% were on private property adjacent to rather than in State forests. Three districts — Narrandera, Forbes and Walcha/Gloucester — had a total of 18 Rural Lands Protection Board (Travelling Stock Route) sites adjacent to State forests. No data were collected for five districts as this question was not asked in the early surveys.

Changed patterns of flowering or yield in forest flora

Observed changes in flowering patterns were interpreted in the following way:

- Drought affected flowering regularity by reducing growth and bud formation.
- The age of the trees affected the potential honey production from various sites, older trees being considered more reliable.
- The lack of regular flooding of forests dominated by *E. camaldulensis* in the Riverina reduced growth and bud initiation, thus reducing honey yields from this once-reliable species.
- Fire, either as wildfire or as a deliberate forestry management practice, reduced the value for beekeeping of the areas affected. *Banksia ericifolia*, identified as the most important floral species in the Nowra forestry district, was reported to be of no value for 7 y after a fire, presumably due to the time required for this species to regenerate and mature.

How the forests relate to beekeepers' calendar of activities

The frequency with which forests were used by beekeepers varied according to the distances beekeepers travelled and the reliability

Table 5. Number of apiary sites (and proportions as a percentage) in and adjacent to State forests, by districts: responses from beekeepers

Region and Forests NSW district	State forest sites	Private property sites
South Coast		
Eden/Bombala	33 (57%)	25 (43%)
Narooma	209 (78%)	60 (22%)
Batemans Bay	No data	No data
Nowra	No data	No data
Tablelands		
Tumut/Tumbarumba	117 (54%)	98 (46%)
Queanbeyan/Badja	No data	No data
Bathurst/Oberon	58 (57%)	43 (43%)
Inverell	78 (58%)	59 (42%)
Western region		
Central Murray	No data	No data
Mildura	51 (62%)	31 (38%)
Narrandera	77 (58%)	46 (34%) + 11 RLPB
Forbes	63 (45%)	71 (51%) + 5 RLPB
Dubbo	130 (85%)	22 (15%)
Baradine (Pilliga)	No data	No data
Central Coast		
Morisset	20 (65%)	11 (35%)
Bulahdelah	50 (77%)	15 (23%)
Taree	42 (60%)	28 (40%)
Wauchope	90 (64%)	50 (26%)
Kempsey	109 (67%)	54 (33%)
Walcha/Gloucester	35 (43%)	48 (57%) + 2 RLPB
North Coast		
Urunga	90 (72%)	35 (28%)
Dorrigo	74 (95%)	4 (5%)
Grafton	346 (66%)	180 (34%)
Casino	233 (57%)	176 (43%)
Urbenville	48 (75%)	16 (25%)
Glen Innes	167 (77%)	50 (23%)

RLPB — Rural Lands Protection Board (travelling stock reserves)

of the flora as a source for nectar and pollen. Thus responses varied considerably — some sites were used only every 3–4 y, whereas other sites were used for 2–3 floral species within the one year. The closer the forest to the beekeeper's base, the greater the frequency of the visits by the beekeeper. Forests further from the beekeeper's base tended to be visited only for major flowering events when there was a high probability that the species of interest would yield a significant volume of nectar and possibly pollen.

Discussion

Survey statistics and beekeeper analysis

The rate of response to the questionnaires is considered excellent, given that a 25–35% return in such studies is commonplace. The high rate of return confers credibility on the data collected. The high proportion (67%) of occupation permits held by large-scale commercial beekeepers indicates the importance of this sector in beekeeping activities within State forests, while amateur or part-time beekeepers account for only 10% of the permits.

Responses to survey questions — section 1

The primary melliferous flora by forestry district

The frequency with which respondents named species as being important for nectar or honey production within Forests NSW districts, in combination with the number of sites accessed for each species, was used to identify the species most important to beekeepers in each district. Species having a wide distribution and reliable flowering may appear in the reports from more than one district, thus building up a picture of the flora of regional importance.

Species of importance on the South Coast of NSW included *C. maculata*, *E. muelleriana* and *E. longifolia*. The most important Central Coast species included *E. acmenoidies* and *E. siderophloia*, while the most important species on the North Coast included the latter two species together with *C. variegata* and *L. confertus*. The tablelands forests were not as extensively used by beekeepers as coastal forests. It is not possible to provide a clear indication of the species of value throughout these areas, although *E. viminalis* and *E. pauciflora* were mentioned in more than one district.

The western regions of NSW are characterised by either large river systems prone to periodic flooding, or extensive areas experiencing long periods of dry weather. Forests mainly occur along the river systems and on ridges with skeletal soils and on poor sandy soils which historically have been of little or no value for grazing, and thus have escaped the clearing associated with early agricultural practice. The species of primary importance along the western river systems was *E. camaldulensis*, while in the drier locations key species were the ironbarks *E. beyeri*, *E. crebra*, *E. fibrosa* and *E. sideroxylon* and the boxes *E. melliodora* and *E. largiflorens*.

As the results list only the species of most importance for beekeeping, the full value of the various forests to beekeepers has not been ascertained. Individual beekeepers are likely to know of many minor floral species that would be of significant benefit to honey bees from time to time.

Response by beekeepers on the floral rewards and flowering phenology of melliferous flora

All the primary species identified in the study were given a high or medium-high rating for honey, based on their importance as significant producers of nectar. In contrast, some of these species were of little value for pollen (Table 3).

Beekeepers regarded the ironbarks, including *E. paniculata* and *E. siderophloia* on the coast and those species already mentioned in the western districts, as very important sources of nectar in nearly all regions of NSW. Where pollen is absent, particularly in the ironbarks, beekeepers offset the potential resulting nutritional deficiency by use of artificial pollen supplements, or by ensuring colonies have access to a flowering event that produces surplus pollen prior to the ironbark flowering, or by choosing sites with other species flowering at the same time as the ironbarks, which can provide the pollen necessary to satisfy honey bee nutritional requirements. For example, beekeepers on the North Coast favoured *E. siderophloia* from which honey bees did not collect any pollen. Although not highly regarded for honey production, *E. acmenoides* flowered during a similar period in the same forests and was valued as a source of pollen. The combination ensured that the colonies continued to breed and remain in a healthy state (Clemson 1985).

Although an adequate supply of nutritious pollen is required for a honey bee colony to survive and maintain a population capable of harvesting surplus nectar (Kleinschmidt and Kondos 1976, 1977), it seems to have been regarded as a secondary factor among species of primary importance. Pollen must, however, be considered as important as nectar in the profitable management of honey bee colonies.

References by beekeepers to grey ironbark were assigned to either *E. paniculata* or *E. siderophloia* according to geographic location. *Eucalyptus paniculata* occurs on the South Coast, whereas *E. siderophloia* has a distribution from the Hawkesbury River to the Queensland border. Both have the same flowering period, November to January, but the interval between flowering events differs — the North Coast species flowers more frequently than the South Coast one. This difference may be influenced by rainfall.

The reported duration of the period for which buds were carried by each species prior to flowering is a reflection of the dates of periodic observation by the beekeepers rather than an indication of the exact time of bud initiation. Many of the melliferous species mentioned in responses to the survey are forest trees which form buds high in the canopy where they are difficult to observe until they attain significant size. Species which carry buds for longer periods allow beekeepers more time to plan and undertake the preparation of colonies for these flowering events. Although beekeepers might anticipate the flowering of species with briefer budding periods, any preparations made as a consequence would rely to some extent on predictions.

The surveys indicated that flowering periods do not always occur on a regular 3–4 y cycle, e.g. there may be regular flowering events every second year for 8–10 y, then drought or some other factor may interrupt the flowering cycle and the species may not initiate buds for 3–4 y.

Indicative honey yield by floral species

The information collected provides an indication of the volume of nectar the various species could produce if conditions were favourable. The expected yields of honey reported by beekeepers possibly reflected the better years in which these floral resources were used. The ranges of honey yield per hive for the various species provide evidence that beekeepers should not rely on the flora identified to consistently produce large surpluses of nectar. Future studies should seek to identify for each species the circumstances that favour higher nectar production. Beekeepers may be able to indicate which years produced larger crops of honey from various species, and there may be correlation between yield and rainfall over time. The two species that produced the greatest average honey yield per hive, *E. siderophloia* and *L. confertus*, grow on the North Coast of NSW where the highest annual rainfall in the State occurs, suggesting that available moisture may be related to ultimate honey production.

Response to survey questions – section 2

History of usage

Beekeeping in NSW State forest is not a recent phenomenon. The use of some apiary sites over two generations by the families of some respondents would have provided opportunity to acquire significant knowledge of the flora around these sites and its value for beekeeping under varying circumstances. Although perhaps not completely scientifically accurate, this may be the only information available on the flowering characteristics of many melliferous species.

Forestry practices

Beekeepers indicated that they use State forests to the extent they do because of the extensive, well-maintained road network and the availability of small cleared areas located at intervals along these roads that are suitable for the placement of hives. Many of these roads exist primarily for log extraction associated with the harvesting of mature trees which beekeepers indicated were more reliable sources of nectar than young growth. The volume of nectar and duration of its availability from species of differing ages is another topic for future research.

Even though fire was mentioned as a potentially damaging event, interrupting the flowering cycle of the various species, it is likely that a managed low-intensity fire would have less impact than a high-intensity fire that seriously interrupted the growth and flowering of trees for many years. The main comments on fire concerned *Banksia ericifolia*. This species regenerates very readily after fire and can be said to be well adapted to such events. Even so, regular fire events, even of low intensity, were observed to have a significant impact on availability of nectar and pollen over time. Perhaps purpose-lit fires in the floral community in which this species grows could be managed with regard to the flowering of this species. This consideration could also benefit many indigenous nectarivorous fauna and invertebrates known to be attracted to this species when in flower.

Bee sites in and adjacent to State forests

The number of sites from which bees could have access to flora in State forest varied significantly from district to district. This variation would be expected to depend on the size of the individual forests and their accessibility from private property. The proportion of private property sites adjacent to State forests was greater on the tablelands and western forested lands (except Dubbo) than on the coastal forests, reflecting the relative ease of access to, and the smaller size of, 'island' forests in inland NSW. There could have been many beekeepers who chose to use private property adjacent to State forests for the purpose of accessing the flora within the State forests who were not contacted for the surveys. The value of State forests to the NSW beekeeping industry is likely to be greater than permit numbers and our results indicate.

Changed flowering or yielding patterns of forest flora

The factors that trigger bud initiation, flowering periodicity and eventually nectar and pollen yields of individual species are still not clear. Given the extensive knowledge of melliferous flora possessed by beekeepers, there is opportunity to record flowering patterns and possibly to identify factors influencing these patterns. Drought is likely to affect the phenology of any plant, but is beyond the influence of local forest management or State policy. The age distribution of the floral species was said to have a prolonged impact on the ability of a species to flower and yield nectar. Age distribution is a factor that could potentially be influenced at a local forest management level. This possibility requires further investigation, since some species might over time contribute more to the economy through their yield of harvestable nectar than when removed as logs. Some of the slower-growing species, particularly the ironbarks such as *E. sideroxylon*, should be considered candidates for such studies. Thinning of regrowth forests, which allows the remaining trees to have increased access to soil moisture and nutrients, may benefit beekeepers by enabling trees to mature more rapidly and flower more often and/or yield greater volumes of nectar.

Diminished frequency and reliability of flowering of *E. camaldulensis* was attributed to a lack of regular flooding. This attribution may be confounded by other factors such as rising salinity or increasing insect pressure on the remaining trees. Whatever the cause, sufficient comments were received for this observation to be of concern, as the general health of the whole *E. camaldulensis* forest type may be compromised if flowering and subsequent seed production is affected over a wide area of western NSW.

How the forests relate to the beekeeping calendar of activity

It was apparent that access to flora within State forests is important to beekeepers during certain times of the year, with year-to-year variation depending on the choice of flowering events within each beekeeper's operational range. The forests are mainly used for the harvest of surplus nectar rather than to stimulate honey bee colonies to expand populations.

By seeking floral conditions that provide pollen attractive to honey bees and a light nectar flow, beekeepers can enhance breeding conditions prior to the flowering of major nectar-yielding species. These conditions are very important in the management of commercial honey bees, although no immediate income is derived from the resulting population expansion.

Beekeepers responding to our surveys may have under-valued the forests by focusing on the direct economic return derived from honey extraction rather than on the potential of the forests to provide conditions necessary to sustain the colonies' ability to produce these honey crops.

Conclusion

The *Eucalyptus* and *Corymbia* species within State forests should be considered of significant economic importance to beekeeping interests. Individual floral species, particularly those in the ironbark group of eucalypts, provide large surpluses of nectar on a periodic basis.

Given that bees can fly considerable distances, if further studies of the melliferous flora of any land tenure by beekeeper survey are contemplated, consideration should be given to including beekeepers who place apiaries on the border of the land tenure in question.

Research should be considered to identify the factors affecting flowering frequency and nectar secretion, particularly of the floral species that have been identified in this study as being major producers of nectar. Such studies may be relevant to interest groups other than beekeepers, such as those seeking knowledge of seasonal movements of flying-foxes.

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