

Native insect flower visitor diversity and feral honeybees on jarrah (*Eucalyptus marginata*) in Kings Park, an urban bushland remnant

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Abstract

This study aims to determine firstly the diversity of native insect visitors to flowers on the mass-flowering canopy tree jarrah (*Eucalyptus marginata*), and secondly the relative abundance of feral honeybees and native insects visiting jarrah flowers. Flower density and nectar production were measured, and observations of animals visiting flowers were made during peak flowering of jarrah in Kings Park. Insects were the most commonly observed floral visitor; 83 species from 63 genera in 38 families across 5 orders were recorded. The overall richness and abundance of insect species visiting jarrah flowers changed through the day. Feral honey bees were by far the most common visitor, accounting for 47 % of observations, and suggesting they are a significant pollinator of jarrah in Kings Park. However, the presence of a number of exclusively nectar- and pollen-feeding native bees and flies, and native anthophilous tiphid wasps and beetles, suggests that the native fauna is still effecting some pollination. The diversity of insects observed visiting jarrah flowers is higher than reported for other eucalypts throughout Australia, and confirms that remnants like Kings Park are significant for the conservation of biodiversity.

Keywords: native insects, feral honeybees, *Eucalyptus marginata*, jarrah flower visitors

Introduction

Remnants of native vegetation in Australian cities are important community assets that form parts of regional conservation networks and provide unique opportunities for recreation and conservation education. However, in many urban bushland reserves the impacts of fragmentation and changed disturbance regimes are transforming community structure and species composition with some species declining in abundance, some species showing no change and others (predominantly exotic species, though not always) increasing in abundance (Kirkpatrick 1988; Recher & Serventy 1991; Dixon *et al.* 1995). Understanding the impacts of changes in species composition on functional interactions such as pollination is vital for organisations vested with the management of urban bushland. In particular, the management of exotic species may be problematic. For example, removal of exotic species may have a net positive effect for native species, no net effect, or a net negative effect if the exotic species is fulfilling a functional role that has been lost. The ecological consequences of removing exotics, therefore, needs to be assessed before implementing a control program. For example, feral honey bees are widespread in Western Australia's urban Kings Park bushland and Dixon *et al.* (1995) recommend the removal of colonies. However,

little is known about the relative abundances of honey bees and native insect pollinators in the bushland. A recent study in Argentine subtropical dry forest observed that the frequency and taxon richness of native flower visitors on mass flowering trees declined with decreasing forest fragment size but frequency of visits by feral honey bees increased in a complementary fashion (Aizen & Feinsinger 1994). It is therefore possible that feral honey bees are now the major insect pollinator in Kings Park bushland and their removal could have a negative effect on seed production in plants which have generalist insect pollinators.

This study aims to determine firstly the diversity of native insect flower visitors on the mass-flowering canopy tree jarrah (*Eucalyptus marginata*) in Kings Park, and secondly the relative abundance of feral honeybees and native animals visiting jarrah flowers. Establishing the diversity and relative abundance of native insect flower visitors will provide vital information for decisions concerning the potential removal of feral honeybee colonies in Kings Park.

Methods

Study Site

The Kings Park bushland is a 267 ha remnant of mixed *Eucalyptus-Banksia-Allocasuarina* woodland located approximately 1 km from the Perth Central Business

District. Jarrah is a dominant canopy species in the woodland. Kings Park is isolated from other native vegetation by urban development to the north and west, and by the Swan River to the south and east. The bushland is highly disturbed and of the 578 plant species recorded, 246 are native, 217 are naturalized aliens, 30 are naturalized and native to other parts of Western Australia and Australia, and 80 are planted but not naturalized (Barrett & Tay 2005). Despite this, the Kings Park bushland has significant conservation values and is an important component of the nature reserve system on the Swan Coastal Plain (Anon. 1981). More recently a planning guide outlining objectives and recommendations for the conservation management in the bushland has been published (Dixon *et al.* 1995). Kings Park bushland is isolated from other native vegetation by urban development to the north and west and by the Swan River to the south and east. Perth has a warm Mediterranean climate characterised by hot dry summers and mild wet winters. The mean monthly maximum air temperature ranges from 31° C in February to 18° C in July; mean annual rainfall is 774 mm of which 80% falls in the winter months between May and September (Bureau of Meteorology 2005).

Jarrah (*Eucalyptus marginata*)

Jarrah is an endemic tree or mallee of southwestern Australia (Abbott & Loneragan 1986) and is the most important hardwood in Western Australia. Jarrah most commonly grows as a tree and is a dominant in forests and woodlands. There has been considerable research on the ecology and silviculture of jarrah (Abbott & Loneragan 1986; Dell *et al.* 1989; Stoneman & Dell 1994; Stoneman *et al.* 1994), but little is known about its reproductive biology and pollination ecology. Information on pollination is limited to mainly opportunistic observations (Brown *et al.* 1997). Currently there are 15 records of ten animal species visiting jarrah flowers; these are four birds (western spinebill, brown honeyeater, new holland honeyeater, purple-crowned lorikeet), one mammal (honey possum), three jewel beetles, an evaniid wasp and a therevid fly (Brown *et al.* 1997).

Jarrah produces bud primordia annually in the axils of new leaves from late summer to early autumn (February – April) (Abbott & Loneragan 1986; Davison & Tay 1989). In many years the new buds are aborted during the winter and spring but in some years they continue to develop and flower in late spring and early summer (September – January) (Abbott & Loneragan 1986; Davison & Tay 1989). Little is known about the factors which favour the retention of buds but flowering has been described as occurring every 4 – 6 years by Abbott & Loneragan (1986) and every 2 – 3 years by Davison & Tay (1989).

Jarrah inflorescences are unbranched, have 7–21 flowers each 15–20 mm in diameter which are borne in the leaf axils near the outside of the canopy. Individual white stamens up to 8 mm long are splayed upwards and outwards from the rim of the hypanthium forming a flat-topped array 15–20 mm in diameter, and exposing a nectar-producing disc. The ovary roof lies about 2 mm below the hypanthium rim; the style is short (8 mm) and emergent with the stigmatic tip projecting 2 mm above

Table 1

Characteristics of the trees used in the study.

Tree	Height (m)	DBH (cm)*	Canopy width (m x m)**
1	8.5	28	8 x 6
2	14.5	50	12 x 9
3	7.2	18, 17	5 x 4
4	14.4	59	12 x 11
5	5.3	8, 8, 8, 10, 5, 6	3 x 3
6	11.2	26	6 x 5
7	18.8	48, 59, 51	18 x 15

* Trees with more than one DBH are multistemmed; ** Canopy width measurements were made at the widest axis and perpendicular to the widest axis

the level of the tops of the stamens when the flower is fully open. Like all other eucalypts jarrah is protandrous with anthers dehiscing before the stigma becomes receptive. As a consequence adjacent flowers within and between inflorescences can be in the male or female phase (House 1997).

The trees used in the study were centrally located within the 270 ha bushland remnant. The trees ranged in height from 5.3 m to 18.8 m and in canopy width from 3 m x 3 m to 18 m x 15 m (Table 1). Flower density (number of flowers in 1 m³ of foliage) was estimated at two points in the lower canopy of five trees.

Nectar measurements were made on flowers from three trees. In each tree at two positions in the lower canopy a cluster of mature flower buds was enclosed with a 1 mm mesh bag to exclude flower visitors. The progress of buds towards flowering was checked daily and approximately 72 hours after anthesis, bagged clusters of flowers were harvested and nectar measured with 2 ml micropipettes on 10 fully opened flowers. The volume of nectar collected from each was often very small and concentrated, and consequently samples for individual trees were combined, and then diluted with 20 ml of de-ionised water for measurement of % sucrose concentration (w/w) with a temperature compensated 0–50% Bellingham & Stanley pocket refractometer. The original concentrations of the nectar samples were calculated from the diluted concentrations with the formula (wt of nectar + wt of water/wt of nectar) x sucrose concentration.

Observations of flower visitors

Detailed observations of flower visitors were made on seven trees over seven days during peak flowering in mid November in 1997. Observations were made on three trees per day, and were restricted to branches up to 5 m from the ground. In each tree at three locations, 2 m³ of canopy was measured with a tape and marked, and the richness and abundance of animals visiting flowers counted for two independent 5 minute intervals (30 minutes total for whole tree). During the first three days of the survey censuses were made at three times of the day: morning (06:00–08:00 hrs), midday (11:00–13:00 hrs) and evening (16:00–18:00 hrs). After three days it became evident that animal activity at flowers was greatest at midday (11:00–13:00 hrs), and subsequent observations were restricted to that period. Sunrise and sunset for the study period were 05:11–05:06 hrs and 18:49–18:58 hrs

respectively. Insects were identified as morpho-species in the field with voucher specimens of each taxon determined at least to family by Dr T Housten and Mr B Hanich (Department of Terrestrial Invertebrates, Museum of Western Australia).

Statistical analyses

Analysis of variance was used to compare the abundance and richness of insects according to the time of day and insect species for the three most common orders: Hymenoptera, Coleoptera and Diptera. Values were transformed prior to analysis using the square root transformation to stabilise variance. The combination of tree and day of measurement was used as a random effect while the time of day and insect species were fixed effects. A Kruskal-Wallis test was used to compare the proportion of bees (total of feral and native honeybees) that were native bees over the three sampling times; morning, midday and afternoon. Values are given as mean ± standard error (sample size).

Results

Flower Density and nectar measurements

The mean flower density was 1334 ± 165 (n=10) flowers m⁻³ of canopy. The mean volume of nectar per flower was 0.64 ± 0.22 ml (n=30), and the mean sucrose concentration of nectar was 55.27 ± 7.81 % (n=30).

Observations of flower visitors

The 3278 observations of insects visiting jarrah flowers found 83 species from 63 genera in 38 families across 5 orders. A list of all insects observed visiting flowers is given in Table 2. Only three observations of birds visiting jarrah flowers were made; these were one red wattlebird (*Anthochaera carunculata*) and two brown honeyeaters (*Lichmera indistincta*). Feral honeybees (*Apis mellifera*) were by far the most common floral visitor accounting for 47% of insect observations (Fig 1). Beetles were seen in 18.6% of observations followed by flies (12.0%), ants (8.8%), native bees (6.4%), wasps (5.5%) and moths and butterflies (1.7%).

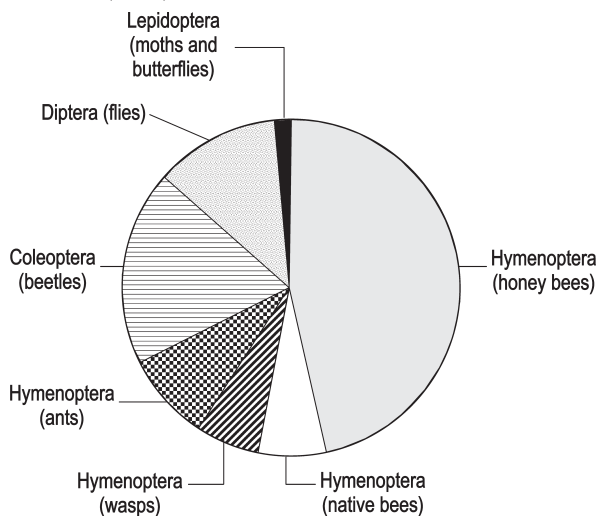


Figure 1. The proportion of all floral visits accounted for by the most abundant insect orders; Hymenoptera, Coleoptera, Diptera and Lepidoptera.

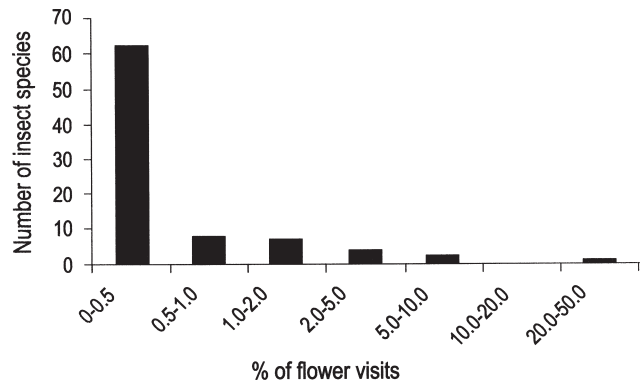


Figure 2. The number of insect species in classes defined by the percentage of floral visits.

The distribution of insect species in classes defined by the number of floral visits is strongly right skewed; 62 species were recorded on fewer than 0.5% of occasions, 8 species on 0.5–1.0% of occasions, 7 species on 1.0–2.0 % of occasions, 4 species on 2.0–5.0 % of occasions, 2 species on 5.0–10.0 % of occasions and 1 species on more than 20% of occasions (Fig 2).

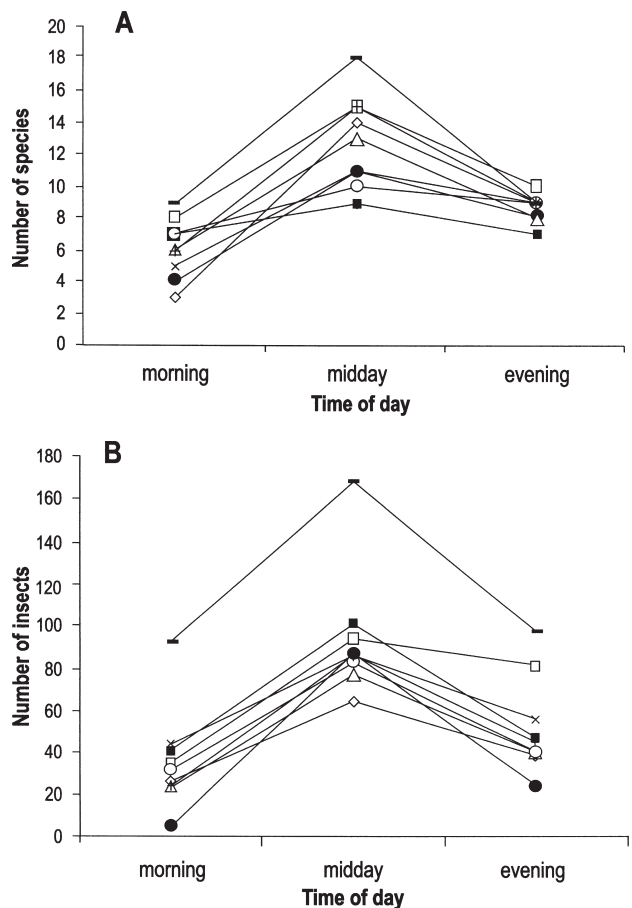


Figure 3. Diurnal data plots showing maximum insect activity at midday in terms of (a) the number of species, and (b) the abundance of insects visiting jarrah flowers. Data are presented for three times of the day; morning (0600–0800 hrs); midday (1100–1300 hrs); and evening (1600–1800 hrs). Observations were made on three trees on each of three days; each symbol represents one tree.

Table 2

Insects observed visiting *Eucalyptus marginata* flowers.

Blattodea	Coleoptera	Diptera	Hymenoptera	Lepidoptera	Neroptera
Blattellidae	Buprestidae	Bibionidae	Apidae	Lepidoptera gen sp	Mantispidae
<i>Ellipsidion</i> sp	<i>Castiarina rufipennis</i>	<i>Biblio imitator</i>	<i>Apis mellifera</i>	Lycaenidae	Mantispidae gen sp
<i>Ellipsidion</i> sp	Carabidae	Bombyliidae	<i>Exoneura</i> sp	<i>Nacaduba biocellata</i>	
	Scopodes sp	<i>Composia tendens</i>	<i>Thyreus warooneensis</i>	Nymphalidae	
	Cleridae	Calliphoridae	Bethylidae	<i>Geitoneura klugii</i>	
	<i>Eleale aulicodes</i>	<i>Calliphora</i> sp	Bethylidae gen sp	<i>Vanessa kershawi</i>	
	<i>Eleale reichei</i>	Calliphoridae gen sp	Braconidae		
	<i>Eleale</i> sp	Chloropidae	Braconidae gen sp		
	<i>Lenidia</i> sp	Chloropidae gen sp	Colletidae		
	<i>Phlogistomorpha</i> sp	Chloropidae gen sp	<i>Euryglossina (Euryglossina) perpusilla</i>		
	<i>Zenithicola</i> sp	Conopidae	<i>Hylaeus (Euprosopis) violaceus</i>		
	Coccinellidae	Conopidae gen sp	<i>Hylaeus (Prosopistemon) quadratus</i>		
	<i>Coccinella transversalis</i>	Muscidae	<i>Hylaeus (Prosopistemon) sp nov. A28</i>		
	<i>Menochilus quadripagiatus</i>	Muscidae gen sp	<i>Hylaeus (Prosopistemon) sp nov. A216</i>		
	Curculionidae	Muscidae gen sp	<i>Hylaeus (Rhodohylaeus) proximus</i>		
	<i>Meriphus</i> sp	Muscidae gen sp	<i>Hylaeus (Rhodohylaeus) rufipes</i>		
	Dermestidae	<i>Musca vetustissima</i>	<i>Leoproctus (Leoproctus) sp</i>		
	<i>Anthrenocerus</i> sp	Mycetophilidae	<i>Pachyprosopsis (Pachyprosopula) purnongensis</i>		
	<i>Neanthrenus</i> sp	Mycetophilidae gen sp	Evaniidae		
	<i>Trogoderma</i> sp	Nemestrinidae	Evaniidae gen sp		
	Mordellidae	<i>Trichopthalma</i> sp	Formicidae		
	<i>Austromordella</i> sp	Sarcophagidae	<i>Camponotus</i> sp		
	<i>Mordellistena</i> sp	Sarcophagidae gen sp	<i>Dolichoderus</i> sp		
	Rhipiphoridae	Sepsidae	<i>Iridomyrmex</i> sp		
	<i>Evaniocera</i> sp	Sepsidae gen sp	<i>Myrmecia</i> sp		
	Scarabaeidae	Syrphidae	<i>Polytrachis</i> sp		
	<i>Automolius</i> sp	Syrphidae gen sp	Formicidae gen sp		
	Tenebrionidae	<i>Xanthogramma</i> sp	Formicidae gen sp		
	<i>Chromomoea</i> sp	Therevidae	Gasteruptionidae		
		Therevidae gen sp	<i>Gasteruption</i> sp		
			<i>Gasteruption</i> sp		
			<i>Gasteruption</i> sp		
			Halictidae		
			<i>Homalictus dotatus</i>		
			<i>Lasioglossum (Chilalictus) castor</i>		
			<i>Lasioglossum (Chilalictus) sp</i>		
			<i>Lasioglossum (Parapspecodes) sp</i>		
			<i>Noma flavoviridis</i> complex		
			Ichneumonidae		
			Ichneumonidae gen sp		
			Megachilidae		
			<i>Chalicodoma (Hackeriopsis) sp</i>		
			<i>Chalicodoma (Hackeriopsis) sp</i>		
			<i>Megachile (Mitchellapis) fabricator</i>		
			Pompilidae		
			Pompilidae gen sp		
			Tiphidae		
			Tiphidae gen sp1		
			Tiphidae gen sp2		
			Tiphidae gen sp3		
			Tiphidae gen sp4		

Diurnal patterns of flower visitors

The number of species and abundance of insects visiting jarrah flowers changed through the day and was lowest in the morning (06:00–08:00 hrs), and highest in the middle of the day (11:00–13:00 hrs). This trend was consistently observed on all trees on all days (Fig 3). However, changes in the number of species and number of insects visiting flowers through the day were different across the three most abundant insect orders, with the interaction between the time of day and insect order being highly significant ($F = 3.60$, d.f. = 4, $P = 0.014$ for number of species, $F = 4.37$, d.f. = 4, $P = 0.006$ for number of insects). Hymenoptera species number and abundance were significantly lower in the morning and significantly higher at midday compared to the evening; Coleoptera species number and abundance were significantly higher at midday than in the evening or in the morning; Diptera species number and abundance did not change significantly through the day (Fig 4).

The relative proportion of native bees to feral honeybees changed significantly through the day ($H = 9.59$, d.f. = 2, $P = 0.009$) due to the fact that no native bees were observed during the mornings. Overall, the proportions of insects of the different orders observed at different times of the day were as follows. In the morning feral honeybees accounted for 45.7% of observations, flies (23.3%), ants (18.9%) and beetles (12.2%); in contrast native bees, wasps, moths and butterflies were never observed during the morning. In the middle of the day

feral honeybees accounted for 49.3% of observations, beetles (20%), ants (11.7%), flies (10%), native bees (4%), wasps (3.2%) and moths and butterflies (1.8%). In the evening feral honeybees accounted for 41% of observations, flies (23.5%), ants (25.3%), beetles (7.6%), native bees (2%) and wasps (0.6%).

Discussion

Jarrah is a generalist mass-flowering eucalypt and it attracts a diverse array of floral visitors including birds, mammals and insects. Prior to this study there were only 15 records by ten animal species visiting jarrah flowers; these were western spinebill, brown honeyeater, new holland honeyeater, purple-crowned lorikeet, honey possum, three jewel beetles, an evaniid wasp and a therevid fly (Brown *et al.* 1997). The results of this study substantially expand the list of insect visitors, with insects being the most commonly observed group.

The low number of vertebrates observed visiting jarrah flowers may be attributable to a number of site-specific factors and the proximity of the observer to flowers. Firstly, vertebrate visitors such as purple-crowned lorikeets (*Glossopsitta porphyrocephala*) and honey possums (*Tarsipes rostratus*) are locally extinct in Kings Park (Recher & Serventy 1991; Dixon *et al.* 1995). Secondly, during the study there were abundant alternative nectar resources which may not always be available when jarrah is flowering. In 1996 a fire burnt 30% of the Kings Park bushland, and as a consequence the post-fire opportunist *Anigozanthos manglesii* was flowering. In addition, the grass tree *Xanthorrhoea preissii* was flowering across the entire bushland which is evidently a rare event (Baird 1977). Honeyeaters were observed on both species. It is possible that in years when this concurrent flowering does not occur, birds may be more commonly observed on jarrah flowers. Finally, the close proximity of the observer to flowers whilst not affecting insect visitation rates may have displaced birds.

Despite the potential influences of site and methods, jarrah's floral nectar characteristics provide further evidence that the species is commonly insect-pollinated. The concentration and volume of nectar affect the type of animals foraging on flowers (Proctor *et al.* 1996). Insect-pollinated flowers typically produce relatively lower volumes of nectar with high concentrations of sugar (>50%). In contrast, bird-pollinated flowers produce relatively larger volumes of nectar with low concentrations of sugar (15–25%). The volume of nectar produced by jarrah flowers (0.64 ml) is considerably less than that reported for the large red-flowered bird-pollinated species *E. macrocarpa* (82.0 ml; Collins & Briffa 1982; *E. rhodantha* (mean \pm SE = 21.21 \pm 39.54 μ l; McNee 1995, and *E. caesia* subsp *caesia* (109.6 \pm 34.3 μ l) and *E. caesia* subsp *magna* (298.4 \pm 103.2 μ l) (Hopper & Wyatt unpublished observations). Furthermore, nectar concentration of jarrah flowers (55.3%) was higher than that reported for large red-flowered bird-pollinated species, *E. macrocarpa* (12%, Collins & Briffa 1982), *E. rhodantha* (22–37%, McNee 1995), and *E. caesia* subsp *caesia* (12–24%), and *E. caesia* subsp *magna* (12%) (Hopper & Wyatt unpublished observations). Considerable caution needs to be applied to the above interpretation as nectar volumes and concentrations

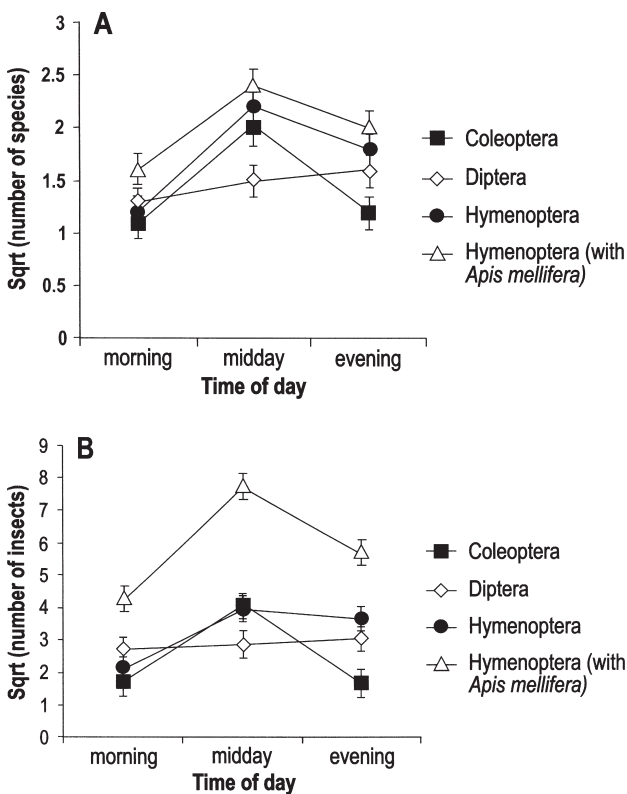


Figure 4. The (a) mean number of insect species, and (b) mean abundance of insects visiting jarrah flowers in each of the three most abundant orders Coleoptera, Diptera and Hymenoptera for three times of the day; morning (0600–0800 hrs); midday (1100–1300 hrs); and evening (1600–1800 hrs). Data were square root transformed to stabilise variances. Error bars are \pm S.E.

measured in this study maybe lower and higher respectively than those normally encountered by the animals (the nectar initially secreted in bagged flowers had up to 3 days for water to evaporate). Nevertheless the floral reward offered by jarrah flowers is considerably less than that recorded for red-flowered bird-pollinated species. A similar pattern was evident in the nectar production data recorded by Paton & Ford (1977) for the small-flowered generalist *E. gracilis* compared with the larger-flowered *E. cosmophylla* and *E. leucoxydon*.

The diverse array of insects observed visiting jarrah flowers (83 species from 65 genera in 39 families) is considerably higher than that reported by a very limited number of other studies. Ireland & Griffin (1988) observed 41 insect species from 29 families in 4 orders visiting *E. muelleriana* flowers in open forest in Victoria, and Hawkeswood (1989) observed 11 insect species in 5 genera from 4 families in 2 orders on *E. foecunda* and *E. cylindrifolia* flowers in mallee woodland in Western Australia. The number of insect species observed on jarrah flowers is also higher than that reported for related shrub and tree species in the family Myrtaceae. Hawkeswood (1981) observed 13 species of insect from 12 genera in 4 families visiting the tree *Angophora woodsiana* flowers in open forest in Queensland. O'Brien & Calder (1993) recorded 23 genera in 15 families from three orders visiting flowers on the shrubs *Leptospermum myrsinoides* and *L. continentale* in coastal heath and open woodland in Victoria. It is highly likely that the number of insect flower visitors to jarrah over its widespread distribution exceeds that recorded in Kings Park.

Most of the 39 insect families observed visiting jarrah flowers have been described as visiting flowers in other eucalypt species (Ashton 1975; Bond & Brown 1979; Hawkeswood 1981; Ireland & Griffin 1988; House 1997), or in other Myrtaceae (Hopper 1980, Hawkeswood 1981b; O'Brien & Calder 1993), or other Australian plant taxa (Armstrong 1979). Most of the insects visiting jarrah flowers are potential pollinators, with the exception of two families Carabidae (Coleoptera) and Mantispidae (Neuroptera) which are predominantly predacious and were therefore unlikely to be exploiting floral resources. This is because, firstly, the small open cup-shaped jarrah flower has no petals but presents a ring of stamens that act as a support for nectar and pollen feeding insects. As a consequence, most insects visiting the flower must come into contact with anthers and probably stigmas. Secondly, all eucalypts studied to date are protandrous and have a mixed mating system that combines outcrossing and inbreeding in varied proportions. Allozyme-based estimates of the rate of outcrossing (t ; 0 = complete selfing, 1 = complete outcrossing) range from 0.44 to 0.96 (Potts & Wiltshire 1997). To date no self-incompatible species have been found, and as a consequence insects need only move the relatively short distance between flowers which are in the male phase to flowers which are in the female phase within the same inflorescence to effect pollination (House 1997).

Although the number of insect species observed visiting jarrah flowers in Kings Park was high, many species were recorded infrequently, and honeybees accounted for nearly 50% of observations. Honeybees

have been recorded foraging on flowers of a number of other *Eucalyptus* species (Ashton 1975, Bond & Brown 1979, Ireland & Griffin 1984, McNee 1995, Paton 1996) and over 200 other Australian plant genera (Paton 1996). Generally, knowledge of the use of floral resources by vertebrates far exceeds our knowledge for invertebrates and as a consequence there are few studies describing the diversity of insects sharing a floral resource with honeybees (Hawkeswood 1981a,b; Bernhardt *et al.* 1984; Ireland & Griffin 1984; Kenrick *et al.* 1987; Ettershank & Ettershank 1993; O'Brien & Calder 1993; Paton 1996). As in the present study, where counts and collections of insects on flowers have been made elsewhere, it has been found that honeybees account for half or more of all flower visits (Paton 1996). In Kings Park it is likely that most of the honey bees belong to feral colonies that occur in the bushland (Dixon *et al.* 1995).

There are no published studies of the proportion of floral resources consumed by native insects and honeybees but Paton (1996) concluded that the potential for competitive interactions is considerable and that the proportion of resources consumed by honeybees is similar to or higher than the proportion of visits honeybees make to flowers. Paton (1996) argued that, firstly, in temperate locations honeybees begin foraging one to two hours earlier than native insects and therefore have more or less exclusive use of the flowers at times when nectar and pollen availability are highest; and secondly, as honeybees are larger than most of the native insects visiting flowers they usually remove more nectar or pollen during each visit.

The results of this study show that honey bees are sharing the floral resource with a similar number of native insects at all times of the day; the proportion of flower visits by feral honey bees and native insects was similar regardless of the sampling time. However, the species composition of native insect flower visitors was not constant through the day; native bees, wasps, moths and butterflies were not observed during the early morning but were observed at midday. Clearly, feral honey bees are utilising nectar and pollen resources earlier in the day than these groups of native insect species but not others (ants, beetles and flies). Of course the impact of feral honeybees on native insect floral visitors will depend on the availability of floral resources. If floral resources are not limiting then honeybees will have no impact on native insect flower visitors. Unfortunately, little is known about the temporal availability of floral resources in Kings Park and this is an important area for further study.

Finally, decisions about removal of feral honeybee colonies require an understanding of the role of honeybees as pollinators, and nectar and pollen consumers for species across the entire community. Honeybees may or may not play a role in pollination when frequently visiting flowers. Critical experiments are needed to resolve their role as pollinators (Paton 1996). Jarrah has simple cup shaped flowers open to many potential pollinators. More complex flowers in the Kings Park bushland such as those of native orchids and peas may be affected by honeybees in quite different ways to jarrah. Community level studies are therefore an area for further research.

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