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PRACTICE INSIGHTS

The brown honeyeater (*Lichmera indistincta*) is an effective pollinator in Australian blueberry orchards

Karen C. B. S. Santos[1] | Abby E. Davis[1] | Maurizio Rocchetti[2] | Brad Hocking[2] | Bar Schermeister[2] | Romina Rader[1]

[1]School of Environmental and Rural Science, University of New England, Armidale, New South Wales, Australia
[2]Costa Group Exchange Pty Ltd, Dirty Creek, New South Wales, Australia

Correspondence
Karen C. B. S. Santos
Email: karenbsantos.bio@gmail.com

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Abstract

1. The brown honeyeater (*Lichmera indistincta*) is a common bird species in Australia and is a pollinator of many native plant species but there are no records demonstrating evidence of effective pollination by honeyeaters in commercial cropping systems.
2. We observed *L. indistincta* visiting rabbiteye blueberry flowers at a commercial berry orchard on the Mid North Coast of New South Wales and evaluated their capacity to transfer pollen. We did this by bagging flowers to prevent visitation prior to anthesis; after anthesis, we unbagged the flowers and waited for *L. indistincta* visits. After a single visit, we collected the stigma and mounted it on a slide to evaluate stigmatic pollen load.
3. We observed the birds visiting blueberry flowers and foraging on nectar. We also found that *L. indistincta* deposited similar amounts of pollen to other common insect pollinator species, such as honeybees and stingless bees. As the commercial berry orchard blocks are surrounded by diverse remnant vegetation, we hypothesize that the vegetation is likely providing habitat for these birds.
4. Our results indicate that berry growers with management practices that protect and support remnant vegetation surrounding blueberry orchard blocks may benefit from higher blueberry pollination services by supporting diverse pollinators within fields.

KEYWORDS
agroecosystems, bird pollination, flower visit, pollen deposition, pollination effectiveness

1 | INTRODUCTION

In commercial pollinator-dependent cropping systems, such as apples and berries, insects are the best-known pollinators of crop flowers. The European honey bee, *Apis mellifera* L., is the most commonly managed pollinator globally, as this bee species can easily be transported in hives to pollinate blooming crops. However, alternative pollinators to managed honey bees also exist and are known to provide effective pollination services in commercial crops, including social and solitary bees, flies, bats and birds (Cook et al., 2020; Rader et al., 2020; Tremlett et al., 2020; Witter et al., 2015). With the expansion of pollinator-dependent crops globally, there is an increasing demand for pollination services (Godfray, 2011; Potapov et al., 2021), and diverse flower visitor communities may complement pollination services by honey bees. Multiple taxa can also act as insurance in the event of single species declines as a result of pests, pathogens and other stressors (Goulson et al., 2015).

Birds are excellent pollinators of many plants, with over 920 species of birds pollinating different plant species (Stiles, 1981). Three families of birds in particular are considered flower specialists: Trochilidae (hummingbirds), Nectariniidae (sunbirds) and Meliphagidae (honeyeaters), each of which are found in different biogeographical regions globally (Cronk & Ojeda, 2008). The foraging patterns of flower-feeding birds are different from other pollinators, such as bees. As flower-feeding birds are generally larger than bees but share the same food source for energy (floral nectar), it is likely that the birds would need to visit more flowers than bees to meet their energy needs. This depends on the amount of nectar produced by flowers (Bond & Brown, 1979) as the birds are more likely to visit an even greater number of flowers if the flowers produce small quantities of nectar. This increased flower visitation may result in increased movement between plants, which would enhance the chances of cross-pollination between flowers.

Previous studies have shown birds, including honeyeaters, are effective pollinators, carrying pollen on their beak and/or feathers (Celebrezze & Paton, 2004; Hopper, 1980a, 1980b). In some cases, due to differences in their foraging behaviour, honeyeaters are more effective than honey bees (Celebrezze & Paton, 2004). Some bird species are also known to provide pollination services in some food crops (Gras et al., 2016; Maas et al., 2013). However, to our knowledge, there are no records demonstrating evidence of effective pollination by honeyeaters in commercial cropping systems. For pollinators to be effective, pollen grains of the same plant species need to be deposited on the stigma(s) of receptive flowers for fertilization to occur.

The brown honeyeater (*Lichmera indistincta* Vigors and Horsfield 1827) is a widespread native bird found in Australia (Slater, 1974) with a long beak and brush-tipped tongue adapted for nectar feeding (Fleischer et al., 2008). This species is thought to feed almost entirely on nectar, with little of its time (approximately 1%) spent feeding on insects (Halse, 1978). It is already known as a pollinator of a number of native and exotic plant species (Collins & Spice, 1986; van der Kroft et al., 2019). Here, we investigate the effectiveness of *L. indistincta* as a potential pollinator of blueberry (*Vaccinium virgatum*, rabbiteye) orchards on the Mid North Coast of New South Wales, to answer the following questions:

1. Is *L. indistincta* an effective pollinator of blueberry flowers?
2. How does *L. indistincta* perform relative to other common insect pollinators in pollinating blueberry flowers?

2 | MATERIALS AND METHODS

Blueberry flowers are urn-shaped with a small corolla opening and produce pollen as well as large amounts of nectar with a high per-flower sugar yield (Bożek, 2021). In Australia, rabbiteye blueberry flowers between late August and October and is partially self-incompatible, achieving better fruit set when flowers are visited by pollinators able to promote cross-pollination (Kendall et al., 2020).

In 2020, while conducting pollination experiments in rabbiteye blueberry on the Mid North coast of New South Wales, Australia, we observed *L. indistincta* visiting the flowers to feed on nectar (Figure 1). Our observations of the foraging behaviour of this bird in blueberry fields were conducted over the blueberry flowering season over 22 days (approximately 85 h of fieldwork), including early mornings and late afternoons. We then conducted experimental trials to test if *L. indistincta* were effective blueberry flower pollinators and to compare pollen deposition relative to insect visitors. To do this, we used organza bags to enclose blueberry flowers in bud (e.g. not yet receptive to pollen) and exclude all pollinator taxa from visiting the bagged flowers. Open flowers were unbagged early in the morning (i.e. 7 a.m.), just before the honeyeaters started visiting the block. We then observed with binoculars from a distance until a *L. indistincta* individual visited the flower. Immediately after a flower

FIGURE 1 Brown honeyeater (*Lichmera indistincta*) visiting rabbiteye blueberry (*Vaccinium virgatum*) flowers.

received one visit, we removed the stigma and mounted it on a slide with fuchsin gelatine as per standard pollination methods for insects (Jones, 2012). In the laboratory, we counted the number of blueberry pollen present on the slides.

3 | RESULTS AND DISCUSSION

We collected 12 blueberry stigmas in total, each visited once by a *L. indistincta* individual, over 3 days. The number of pollen grains was counted per sample with a total of 135 pollen grains across all slides (mean 11 ± SE 1 grains per stigma). This is similar to the average number of pollen grains deposited by insect pollinator taxa in our previous work following the same methods. In our previous work, we found honey bees depositing 12 ± 1 pollen grains on blueberry stigmas ($n = 25$ stigmas), stingless bees 18 ± 2 ($n = 25$ stigmas) and carpenter bees 10 ± 2 ($n = 17$ stigmas; Figure 2). The number of pollen grains deposited onto stigmas by *L. indistincta* is thus sufficient for blueberry fruit set (Dogterom et al., 2000).

While collecting insect pollinator data over 22 days, *L. indistincta* was not observed being aggressive to other bird species or eating insect pollinators. These observations differ from Woinarski (1984), who observed honeyeaters attacking small birds, such as pardalotes in different forest and woodland habitats in Victoria, Australia. However,

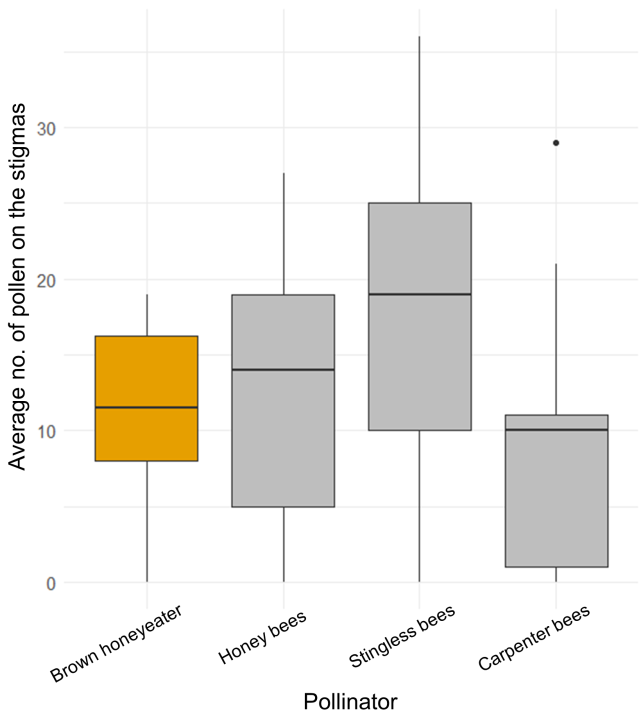

FIGURE 2 Pollen deposited on blueberry stigmas by the brown honeyeater (*Lichmera indistincta*), honey bees (*Apis mellifera*), stingless bees (*Tetragonula carbonaria*), and carpenter bees (*Xylocopa* sp.) after a single visit to the flower. The length of the box corresponds to the interquartile range, the horizontal clear line in the box represents the mean value and the bars represent the standard deviation (SD).

in that study, the pattern of attacks was seasonal, with a higher frequency of honeyeater aggressive behaviour in winter and spring. Winter and spring are often associated with a low average number of *Eucalyptus* flowers (most species peak bloom is in summer), and spring coincides with the commencement of honeyeater breeding, hence the authors suggest these two circumstances could have contributed to their observations of honeyeater behaviour (Woinarski, 1984).

Honey bees are the most abundant pollinators of blueberry in the region (Hall et al., 2020), with both wild unmanaged and managed commercial hives deployed on farms for pollination (average density of managed hives across farms is 6 hives/ha). In our observations, we noticed that *L. indistincta* did not tend to visit flowers with honeybees foraging on them, which could suggest that the birds may not be competing with the honeybee for floral resources, but foraging activity, volume of nectar production per blueberry plant and nectar consumption by *L. indistincta* and honey bees need to be assessed to confirm this observation (Dupont et al., 2004). Nonetheless, these observations suggest that the presence of *L. indistincta* is likely to support rather than detract from existing pollination services within the berry plots, since these birds are also effectively depositing pollen onto blueberry stigmas.

Honeyeaters may visit a higher number of flowers compared to honey bees. Data collected by Hopper (1980a, 1980b) found that honeybees visited 6 flowers per foraging bout (in ±73 s), in contrast to honeyeaters which visited at least 137 flowers (in ±172 s). We observed some individuals of *L. indistincta* visiting a few flowers from a single blueberry plant, but then moving rapidly to other plants, rather than concentrating all the visits in one single blueberry plant. However, we did not collect data on frequency of visits or number of visited flowers per bout. Similarly, Ramsay (2006) observed higher proportions of movement by honeyeaters to distant trees of *Banksia menziesii* rather than on the same tree. This foraging behaviour, combined with our results demonstrate these birds are effective pollinators, likely contributing to the cross-pollination of blueberry plants.

The presence and availability of arthropods do not seem to influence the abundance or distribution of honeyeaters, but the number of flowers and nectar volumes have a significant effect (Collins et al., 1984). Most of the vegetation surrounding the commercial berry orchard where we observed these birds comprised native Australian flowering trees, such as *Banksia* (Proteaceae) and *Eucalyptus* (Myrtaceae) species, as well as shrubs. *L. indistincta* normally build their nests below 2 m height mainly on shrubs but also among the foliage and twigs of a variety of mangroves and trees (Franklin & Noske, 2000). Honeyeaters visit a range of plant species known to be common floral resources in their diets, mainly from the families Myrtaceae and Proteaceae, and the genera *Banksia* and *Eucalyptus* (Bond & Brown, 1979; Halse, 1978; Hopper, 1980a, 1980b, 1981; Paton & Ford, 1977; Ramsay, 2006). Supporting these native flowering plant species, among other nectar-rich plants will likely attract these birds to agroecosystems.

Pollination is a vital ecosystem service provided by a diversity of animals to both crop and wild plants. The current decline in pollinator insect communities (Potts et al., 2010; Van Der Sluijs, 2020) means that supporting a diverse range of pollinators, including birds, is crucial, especially since some bird species can both increase crop yield and act as pest control agents (Chain-Guadarrama et al., 2019; Gras et al., 2016; Maas et al., 2013). Although *L. indistincta* is one of the most widespread honeyeater species in areas of granite rocks in Australia (Hopper, 1981), it also occupies diverse habitats such as woodlands, coastal and inland scrubs, *Eucalyptus* savannas, rain forests, mangroves and urban areas (Franklin & Noske, 2000; Slater, 1974; Trainor, 2005; Woinarski, 1984). Further research is needed to evaluate, at broader scales, the occurrence and consistency of flower-visitation by this species in croplands.

Other studies have demonstrated that wild pollinator abundance (including hummingbirds) was positively related to an increase in forest cover and negatively related to hedgerow and grassland cover adjacent to blueberry fields in South America (Ramírez-Mejía et al., 2023). While adjacent vegetation can help birds to find places for nesting and provide them with additional food resources, increasing vegetation diversity surrounding orchards may be a challenge as it can also attract different species of frugivore birds (MacDonald & Johnson, 1995) that could potentially damage fruits. Knowledge of the common bird species present in the area, their preferred habitat and food sources, as well as the time of ripening of plants within the orchard and the adjacent vegetation would ensure informed management of this issue (Tracey et al., 2007). Many birds are attracted to nectar-producing plants and will preferentially feed on these plants rather than on fruit crops (Tracey et al., 2007). Therefore, different native shrubs and trees of varying heights and phenologies are recommended for conservation and may reduce the numbers of birds feeding on fruit crops.

A large number of farms along the Mid North Coast region of Australia use bird netting to reduce the damage on the fruits caused by birds (Anderson et al., 2013). On the farm where we performed this study, other blueberry varieties are also grown (e.g. evergreen blueberry), and some blocks adjacent to where we conducted our observations, were already in fruit. However, over the 22-day period of observations and data collection for this study, we did not observe *L. indistincta* feeding on blueberry fruits in the uncovered orchard blocks. More research is thus needed to quantify the cost and benefits of the presence of *L. indistincta* and other nectarivorous birds in blueberry orchards. These studies should evaluate the relationship between bird abundance, foraging behaviour, fruit yield and quality through exclusion experiments (Stewart & Craig, 1989) and compare areas with and without the presence of *L. indistincta*. This research will then better inform the costs and benefits of encouraging honeyeater pollination in commercial blueberry orchards (Celebrezze & Paton, 2004; Kendall et al., 2020).

AUTHOR CONTRIBUTIONS

Karen C. B. S. Santos and Romina Rader conceived the ideas for the manuscript. Karen C. B. S. Santos collect, analysed the data, and wrote the first draft with support from Romina Rader and Abby E. Davis. All co-authors contributed critically to the drafts and gave final approval for publication.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

PEER REVIEW

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DATA AVAILABILITY STATEMENT

Data available from the Figshare data repository https://doi.org/10.6084/m9.figshare.21664160.v3 (Santos et al., 2022).

ORCID

Karen C. B. S. Santos https://orcid.org/0000-0002-6834-1704
Abby E. Davis https://orcid.org/0000-0002-0942-8439
Romina Rader https://orcid.org/0000-0001-9056-9118

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