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INNOVATIVE VIEWPOINT

Agroecosystems

Observations of nectarivorous birds and potential biological control agents in berry orchards

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Abstract

We observed the brown honeyeater, *Lichmera indistincta*, visiting blueberry orchards in eastern Australia. *L. indistincta* is considered to be a nectarivorous bird, feeding almost entirely on nectar. However, we report observations of this species as both a nectarivore and insectivore in blueberry crops and as an insectivore in raspberry crops. Brown honeyeaters may be acting as biological control agents when feeding on leaf-roller caterpillars (Lepidoptera: Tortricidae) in blueberry orchards and on brown blowflies (*Calliphora stygia*) in raspberry orchards. Although most blueberry growing regions use managed honey bees as the main pollinator, more studies on the complex tritrophic interactions occurring in these crops are needed to better understand the costs and benefits of different farm management practices upon alternative pollinators.

KEYWORDS
agroecosystems, bird pollination, blueberry, dual ecosystem services, honeyeaters, tritrophic interactions

With significant declines in wild pollinators over the last decade (Goulson, 2019; Potts et al., 2010), alternatives to support pollination services and efforts to increase the diversity of pollinators in agroecosystems have become the focus of many agri-environment schemes (Gemmill-Herren, 2016; Williams & Lonsdorf, 2018). In mass-flowering pollinator-dependent crops, flowering periods for each cultivar are often short, and large numbers of pollinators are needed to provide pollination services in a short period of time. In all major berry-growing regions of Australia, honey bees (*Apis mellifera* L.) are the dominant pollinators of blueberries, at times comprising up to 94.5% of floral insect visitors (Goodman & Clayton-Greene, 1988). However, with the increasing cost of bee hive rentals and the impacts from parasites and pathogens threatening bee health (Drummond et al., 2021; Reilly et al., 2020), service provision by a range of different taxa is a less risky strategy.

Managed and unmanaged insects can provide pollination services in blueberry orchards (Isaacs & Kirk, 2010). In Australia, honey bees are the main pollinators; however, native stingless bees (*Tetragonula carbonaria*) and other native bees such as carpenter bees (*Xylocopa* spp.) and red-nesting bees (*Exoneura* spp.) are also recognized as efficient blueberry pollinators (Kendall et al., 2020). Bumblebees (*Bombus* spp.) also pollinate blueberry flowers, but they are not present on mainland Australia, only on the island state of Tasmania (Kingston et al., 2002). In addition to bees, flies have also been recorded as blueberry pollinators (Cook, Deyl, et al., 2020; Cook, Voss, et al., 2020). A large number of flies, however, are not often seen

visiting blueberry flowers under field conditions (Goodman & Clayton-Greene, 1988; Kendall et al., 2020).

The abundant clusters of bell-shaped blueberry flowers produce large amounts of nectar with high per-flower sugar yield (Bożek, 2021), which can make flowers very attractive to nectar feeders. However, while there is evidence of birds pollinating other plant species in the family Ericaceae (Georgian et al., 2015; Turner et al., 2012) and assessments of wild bird densities in vegetation bordering blueberry fields (Smith et al., 2021), there is no evidence in the literature of birds pollinating blueberry flowers. In fact, most growers are concerned that birds are pests, as some species consume and/or damage blueberries and other fruit crops (Anderson et al., 2013; Avery et al., 1991). Blueberry is an introduced cultivated crop that is not native to Australia, and therefore, it is unlikely that there is an evolutionary relationship between native birds and this plant species. However, many relationships result from the interactions between native species and introduced species (Mooney & Cleland, 2001). For example, although blueberry flowers have poricidal anthers (i.e., the pollen is released through pores) that are thought to require "buzz" pollination for pollen release (Michener, 1962), other pollinators incapable of buzz pollination, such as honey bees and stingless bees, are also efficient blueberry pollinators (Kendall et al., 2021).

In 2020, while recording insect taxa visiting "Rabbiteye" blueberry flowers (*Vaccinium virgatum*) on the north coast of New South Wales, Australia, we observed *Lichmera indistincta* feeding on blueberry nectar (Figure 1a; Appendix S1: Figure S1) in the morning and feeding on leaf-roller caterpillars from blueberry fruits on an adjacent blueberry block (*Vaccinium corymbosum* interspecific hybrid) in the afternoon (Figure 1b). These leaf-roller caterpillars (Lepidoptera: Tortricidae) are serious pests of blueberry plants, as their feeding activity damages the vegetative growth, flowers, and fruits (Figure 1c; Appendix S1: Figure S2). This behavior was observed multiple times by different *L. indistincta* individuals each morning and afternoon. The birds would concentrate their visits in "Rabbiteye" blueberry blocks in the morning, where we observed up to 11 different individuals in the same block at the same time. By the afternoon, some individuals would move to adjacent fruiting blocks and continually fly over the "Southern highbush" blueberry bushes until eventually landing on branches to feed on caterpillars or pausing to call from the tallest of blueberry branches. We suspect the males were singing to defend their territory, as observed by Coate (2003). We did not observe *L. indistincta* feeding on blueberry fruits while in the "Southern highbush" blocks, they only appeared to eat the caterpillars, and a review of honeyeaters foraging behavior found no records of this species feeding on fruits (Pyke, 1980).

In 2016, the scarlet honeyeater (*Myzomela sanguinolenta*) was also observed multiple times visiting blueberry flowers in the same area (Figure 2a–d). Similarly to the brown honeyeater, the scarlet honeyeater also feeds mainly on nectar and occasionally on insects (Pyke, 1980), but we did not see this species eating caterpillars. We also observed silvereyes (*Zosterops lateralis*) visiting blueberry flowers in the morning to feed on nectar (Figure 2e,f). While there are records that this species feeds on different insects, including caterpillars (Moeed, 1979), this species is also considered a bird pest as it damages many fruit crops, including blueberry, when feeding on fruits (Bomford & Sinclair, 2002). Moreover, honeyeaters have a long, curved beak, and silvereyes have a sharp, pointed beak, but both honeyeaters and silvereyes have a long, brush-tipped tongue adapted for nectar feeding (Cooper, 1974), which may facilitate nectar extraction from blueberry flowers even though blueberry flowers have a small corolla opening.

We also recorded *L. indistincta* predating upon brown blowflies, *Calliphora stygia*, in experimental trials in the spring of 2021. The brown blowfly was one of two fly

FIGURE 1 (a) Brown honeyeater, *Lichmera indistincta*, visiting blueberry flowers, and (b) feeding on caterpillars in blueberry orchards on 26 October 2020. (c) Caterpillar feeding on blueberry fruit, photo taken on 25 October 2020. All photos were taken in Dirty Creek, New South Wales, Australia. Photo credit: Karen C. B. S. Santos.

FIGURE 2 (a–d) Scarlet honeyeater (*Myzomela sanguinolenta*) male and female visiting blueberry flowers to feed on nectar in September 2016, and (e, f) silvereye (*Zosterops lateralis*) on 15 October 2020. All photos were taken in Dirty Creek, New South Wales, Australia. Photo credit: (a–d) Maurizio Rocchetti and (e, f) Karen C. B. S. Santos.

species tested, the other being the syrphid fly, *Eristalis tenax*, as potential pollinators of raspberry. Flies were placed in four cages (200 flies per cage) covering budding raspberry (*Rubus ideaus*) blocks (Table 1). Within 1 h of the release of blowflies in cages, we observed the honeyeater *L. indistincta* perched on top of one cage, pecking out the flies through the holes in the cage netting. On the fourth day, one *L. indistincta* bird was found inside one of the cages and had eaten all blow flies inside (Figure 3). Over a 10-day period (68 h in total on the farm), we recorded 60 instances of birds predating upon blowflies within cages. In the same period, we did not observe any birds predating upon honeybees or the other fly species in cages being tested for raspberry pollination

TABLE 1 Number of instances insectivorous or nectarivorous birds were seen perched on cages containing brown blowflies, *Calliphoria stygia*, within one raspberry block of a commercial berry farm in Dirty Creek, New South Wales, Australia, between 6 and 16 June 2021.

Days since the release of flies inside cages	No. observational hours daily	Australian magpie, *Gymnorhina tibicen*	Blue-faced honeyeater, *Entomyzon cyanotis*	Brown honeyeater, *Lichmera indistincta*	Noisy miner, *Manorina melanocephala*	Total no. bird individuals seen
0	8	0	0	1	0	1
1	7	0	0	1	3	4
2	7	2	0	0	0	2
3	8	2	0	0	0	2
4	3	0	0	1	0	1
5	8	11	1	2	3	17
6	4	1	1	2	1	5
7	6	3	2	2	0	7
8	6	5	2	0	1	8
9	7	2	1	1	2	6
10	4	2	1	1	3	7
	68	28	8	11	13	60

Note: The number of observational hours spent on the farm varied daily depending on the weather. Observations were not collected while raining or in temperatures below 10°C.

FIGURE 3 Brown honeyeater, *Lichmera indistincta*, was observed entering netted cages covering raspberry plants to feed on *Calliphora stygia* brown blowflies. Photo taken on 10 June 2021 in Dirty Creek, New South Wales, Australia. Photo credit: Abby E. Davis.

efficacy, the syrphid *E. tenax*. We observed three other insectivorous and nectarivorous bird species also eating blowflies in cages (Table 1).

In many agroecosystems, such as blueberry and raspberry orchards, birds are not considered to be potential pollinators. In fact, many farms use protective covers

such as plastic polytunnels, woven hail, or bird netting to enhance blueberry growing conditions and reduce potential hail or bird damage (Kendall et al., 2021). The blocks where we observed these interactions were in one of the few open blocks that are not covered by protective nets on the farm (Appendix S1: Figure S3). While insectivorous and frugivorous birds can damage blueberry cropping systems by feeding on fruits or beneficial insects (e.g., pollinators) within fields, birds that are primarily nectarivorous, such as the brown honeyeater, are unlikely to cause the same damage. Nectarivorous birds have small gizzards (muscular stomachs that break down food), thus making it difficult to digest the chitinous exoskeleton of insects (Richardson & Wooller, 1986). However, insects are an essential part of nectarivorous birds' diet since nectar is generally low in crude protein, amino acids, vitamins, and minerals that birds require for growth and reproduction (Gartrell, 2000). Therefore, these birds often prey upon insects high in protein but low in chitin, such as caterpillars, crickets, and flies.

Our observations show that there are complex tritrophic interactions between plants, their pests, and pollinators. This evidence calls for new research testing different management practices in farm areas, that consider alternative pollinators and their foraging activity, as well as the costs and benefits associated with their behaviour. Honeyeaters seem to be a potential pollinator for blueberry flowers as well as a pest control agent, providing dual ecosystem services. Yet, pollination services by this species in blueberry fields needs to be more formally tested and confirmed. If honeyeaters are excluded from fields due to bird-proof netting, this may result in greater pollination needs and more fruit damage by unwanted insects. Future work is needed to focus on the role of tritrophic interactions and how they impact crop yield and the delivery of other ecosystem services provided by biodiversity in agroecosystems.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

Data (Santos et al., 2023) are available from Figshare: https://doi.org/10.6084/m9.figshare.21877929.v1.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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