Journal & Proceedings of the Royal Society of New South Wales, vol. 157, part 2, 2024, pp. 295–297. ISSN 0035-9173/24/020295-03

Thesis abstract

Fly (Diptera) pollination efficiency and reproductive needs within crop agroecosystems

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Abstract of a thesis submitted to the University of New England

Global agricultural crop production has become increasingly pollinator-dependant.[1] Eusocial bee taxa within the family Apidae (e.g., honey bees, bumble bees, stingless bees) are well established, successful crop pollinators globally. In particular, the ubiquity and well established management of the European honey bee (*Apis mellifera* Linn., 1758) has resulted in an overreliance of this pollinator worldwide. As other non-bee insects are also effective pollinators, it has become increasingly important to better understand the capability and life history needs of non-bee pollinator taxa so they can provide alternative, or supplementary, pollination services to managed bees and be supported within the landscape. This will ensure that consistent and reliable pollination services continue to be supplied to agricultural systems. This thesis investigates the pollination effectiveness and reproductive needs of the second most important pollinator taxon behind bees, the flies (Diptera), in pollinator-dependant food crops.

First, I conducted a systematic literature review on the diets and habitat needs of 431 crop flower-visiting fly species found globally and collated the existing information into a database. I was able to document the diets and habitat needs of 242 crop-visiting fly species (24 families and 119 genera) inhabiting all eight global biogeographical regions. I found that these crop-visiting fly species live in 35 different natural habitats and belong to 10 different feeding guilds. The results of this review identified major gaps in our understanding of the life history needs of crop-pollinating flies. In particular, current floral management schemes are largely focused on the resource needs of bees. As flies require other non-floral habitats to complete their life cycles, the diverse life history needs of flies and other non-bee taxa are not currently supported by existing pollinator management practices.

Second, I investigated the identity and efficiency of floral visitors to carrot seed crops. To do this, I conducted floral field surveys and pollen deposition trials across two years (2020–21) within varying environmental conditions in the Riverina region of New South Wales (NSW). I conducted 268 floral visitation surveys and identified 53 different insects (26 families) as floral visitors of seed carrot in temperatures ranging from 10.5 °C to 39.5 °C and in 19.7% to 94.7% relative humidity. Spatial and temporal complementarity was observed across all dominant taxonomic groups (ladybeetles, bees, flies). Wild taxa generally matched managed honey bees in terms of abundance and their capability to transfer pollen between carrot parent lines. Further, wild taxa, not managed European honey bees deployed for pollination services, are providing the bulk

1 Chancellor's Doctoral Research Medal 2024

of pollination services to Australian hybrid seed carrot.

Third, I determined the oviposition and habitat needs of pollinating hoverflies (Syrphidae: *Eristalini*). I did this by deploying 14 portable pools filled with soil and decaying vegetation across four seed carrot sites in the Riverina (NSW) region of Australia. All pools successfully supported the immature stages (eggs and larvae) of hoverflies after 12 to 21 days, and two beneficial species of flies were reared from the pools: *Eristalinus punctulatus* and *Eristalis tenax* (Linn., 1758). Both species were effective pollinators of seed carrot in Chapters Three and Four of this thesis, respectively. These results suggest that deploying portable habitat pools filled with decaying plant materials in agroecosystems may be a successful management intervention to rapidly facilitate hoverfly pollinator reproduction.

Fourth, I assessed the effectiveness of the Australasian endemic golden native dronefly *Eristalinus punctulatus* (Macquart, 1847) at transferring pollen to hybrid seed carrot flowers. While both honey bees and the native drone fly were capable of depositing pollen onto seed carrot floral stigmas, golden native drone flies on average deposited more pollen onto stigmas than European honeybees. I also observed the first recorded event of natural oviposition of this fly species on the Mid North Coast (NSW) region. When observing the oviposition of this fly, I found that they oviposited within discarded raspberry plant root balls at a commercial berry farm. This observation, coupled with their demonstrated pollination effectiveness in seed carrot, suggests that these endemic flies could be supported as potential pollinators by deploying non-floral habitat within agroecosystems.

Finally, I compared the pollination effectiveness and activity patterns of two managed fly pollinators and two managed bee species at commercial raspberry and blackberry farms in two major berry growing regions in Australia: Mid North Coast (NSW) and Northern Tasmania (TAS). All taxa were capable of effectively pollinating raspberry and blackberry after one visit to a flower; however, the quality, weight, and number of pollinated drupelets per fruit varied depending on the taxa tested. In small cages, *E. tenax* and wild taxa pollinated raspberry fruits that weighed significantly more and were of higher quality than fruits harvested from *C. stygia* cages; however, there were no significant differences in the quality, weight, and number of pollinated drupelets in blackberry across all taxa. Further, in a blackberry polytunnel in Tasmania, *E. tenax* flies were significantly more active than European honey bees, and the fruits harvested from the *E. tenax* polytunnel did not differ from fruits visited by honey bees. These results demonstrate that some fly species could be effective supplementary, or alternative, pollinators to managed bees in commercial raspberry and blackberry.

This thesis demonstrates the importance of understanding how wild taxa, like flies and non-*Apis* bees, contribute to pollination service delivery, and how best to support these taxa within agroecosystems. Some flies and other wild taxa can provide significant and effective pollination services to some crops. If supported with foraging and habitat needs, these taxa may be able to provide similar pollination services to the honey bees used within these systems. Identifying wild pollinator taxa and their life history needs, assessing their capability as pollinators in a variety of crop systems,

developing rearing techniques to commercialize effective taxa, and methods to support effective wild and managed pollinator assemblages within agroecosystems, are all important next steps to improve pollination services and yields of pollinator-dependant cropping systems globally.

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