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A Novel Approach to Minimizing Pesticide Exposure to Bees in Agricultural Ecosystems

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Abstract

Many cropping systems are dependent upon insect pollinators, especially bees. This is especially the case for most fruits and nuts and some vegetables. However, pest management in these crops may require pesticide applications that can lead to exposing bees with the resulting residues. Recently, several farmer cooperatives, universities, and government agencies have developed guidelines to minimize pesticide exposure to bees within the crop environment. Many of these tactics depend upon choosing least toxic alternative pesticides, minimizing pesticide drift, and/or utilizing pest monitoring in combination with action thresholds that result in pesticides only being applied when farmers are threatened with economic loss greater than the cost of the pesticide application. Few tactics are based upon knowledge of bee behavior that may minimize pesticide exposure. One such example is to apply pesticides at night when bees do not forage. I believe that another tactic that has not been discussed is to identify bee "lek" sites and protect them from pesticide contamination. Leks are sites that some bee species aggregate to locally for purposes of mating. Thus, protecting sites that aggregate bee numbers could be an important tool for farmers.

Keywords: Lek mating system; Halictida, Insect ecology; Pollinator; Environment; Bee conservation; Pesticide exposure; Climate change

Introduction

Many insect species have evolved a lek mating system [1]. The definition of a lek is a mating system in which some of the following criteria occur: an absence of male parental care, the existence of a mating site or location (arena) where most matings take place, no male regulated access to resources that might appear in the arena, and the opportunity of females to freely select a mate in the arena. Bradbury [2] observed that some insects do not meet all the criteria of the "classic" lek and that lek criteria should be considered as continuous variables. This results in lekking behavior being a "fuzzier" multi-dimensional space. Insect leks can be categorized as either "substrate-based" or "aerial aggregations". Most bees that lek, exhibit substrate-based lek behavior [3]. However, some social bees have aerial aggregations of drones, an example being the European honeybee [4]. Carpenter bees (*Xylocopa* spp.) use hilltops. Males deposit an attractant pheromone on a local hilltop. Air currents move the pheromone plume downwind where females detect it and follow the plume upwind to the pheromone source and male aggregation where mating takes place [5]. Some bees that aren't characterized by lekking behavior may have males that search for females on floral resource. These floral resources are referred to as rendezvous places [6]. This is the case for several bumble bee species (late summer fall mating), a few social Halictidae (late summer mating) and several *Andrena* spp. (spring mating), especially those *Andrena* that nest in sparse aggregations [6]. It is often the case that the author has observed *Bombus* males spending the night on rendezvous flowers in order to be the first to meet gynes for mating in the morning.

From 1989 to 2018 the author taught an insect ecology course at the University of Maine (Orono, ME, USA). A substantial *Andrena dunningi* Cockerell soil nesting aggregation site was located at the back of the building. This species, Dunning's miner bee, is one of the earliest spring emerging bee species in Maine (Figure 1) and it is a common and important pollinator of Maine wild blueberry [7]. Class research projects over the 30 yr period revealed that *A. dunning* utilized one of two yew (*Taxus* spp.) shrubs as a lekking site. The same shrub, not the other of the two shrubs, was used over the 30 yr period. This shows a long-term fidelity to this one rendezvous (Figure 1). It was not solely mating that occurred on this shrub, however. Ornamental yews in Maine flower and produce pollen in late April, precisely the time that *A. dunningi* takes place. Therefore, this individual shrub was critical for mating and provisioning for the initial brood prior but overlapping also with red maple (*Acer rubrum* L.), willow (*Salix* spp.) and ornamental crocus (*Crocus* spp.) bloom. So, what does lek behavior in bees have to do with agriculture? The rendezvous fidelity that we observed with Dunning's miner bee suggests that these resources in the environment can be fixed and should be a focus of protection for bee conservation. This idea is not entirely new [8], but implementation of it into an agricultural setting is.

Figure 1: Lek rendezvous shrub used by Dunning's miner bee at the University of Maine and location of soil nest aggregation (left), and a Dunning's miner bee adjacent to its nest tumuli and in its nest (right).

Minimizing Bee Exposure through Location of Lekking Sites

Bee decline is a phenomenon with drastic consequences for crop production of many fruits, nuts, and vegetables [9]. Decline is thought to be a result of many factors such as: pesticide exposure, lack of pollen and nectar resources, disease, and climate change [10]. Insecticides commonly used in farming, especially those that are systemic in plants (such as neonicotinoids), have especially been implicated in bee decline [10-12]. Because of the importance of bees to agriculture and their recently documented decline, many guides to reduce pesticide exposure to bees have been produced and made available to both agricultural professionals and farmers. There are too many to cite here, but one that I have cooperated in constructing, is a guide specific for wild blueberry production *Vaccinium angustifolium* Aiton [13]. Almost all of these guides focus on farmer pest management tactics and how pesticide exposure can be minimized by either selecting the least bee toxic pesticide, eliminating flowering weeds in the crop field to be sprayed, minimizing drift on to non-crop areas, using pest monitoring and action thresholds so that pesticides are only applied when risk of crop loss occurs that is equal to or greater than the cost of application, and applying pesticides at night when foraging bees are not in the crop. This last management tactic is based upon knowledge of bee behavior. Only few of the tactics are based upon behavioral knowledge of bees.

Because lekking aggregates bees this behavior can put bees at risk for pesticide exposure. However, knowledge of lekking and the identification of rendezvous locations can be used to minimize pesticide exposure by making sure that these sites are avoided or protected. Operationalizing this tactic will be difficult for several reasons. While the author has observed *Andrena* spp. lekking at rendezvous sites on the edges of wild blueberry fields their discovery was somewhat serendipitous during walks in fields. Also, without farmers being shown lekking sites it will be difficult to train them to hunt for them. In addition, so little is known about lekking or just use of rendezvous sites that we do not know the species compositions of bees that are likely to use such sites in agricultural fields. A third possible obstacle is that we do not know how long the lek sites are active. The author's personal experience at the University of Maine suggests a short tenure in the spring, 7-10 days or so.

So how would a tactic to minimize pesticide exposure based upon lekking be implemented? Identification of lek and/or rendezvous sites by agricultural professionals that work with farmers is the first step. Once these sites are known, they can be visited when active and farmer extension (outreach) meetings can be organized so that a firsthand experience of what these sites look like and the type of habitat that they are found in can be attained by farmers. Subsequently, they can each hint on their own farms for these sites and if found they can call in an agricultural professional to verify its identity. Once identified these sites can be marked and protected. In addition, the sites can be visited annually to determine their constancy ion the environment. One added benefit to getting farmers to look for rendezvous sites is that it will instill a greater understanding of the overall ecology that is the foundation for their farm.

Conclusion

Some bee communities are in decline. Exposure to pesticides is one possible cause of decline. A high likelihood of pesticide ex-

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posure is in intensively managed crops. Minimizing pesticide exposure to bees should be part of all farmer production practices. One of these practices that should receive attention is protection of lek and/or rendezvous sites. The new generation of agricultural ecologists can perhaps make this a reality.

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References

1. Shelly TE, Whittier TS (1997) Lek behavior of insects. In: Mating Systems in Insects and Arachnids (eds. Choe JC, Crespi BJ), Cambridge University Press, NY, pp. 273-293.
2. Bradbury JW (1981) The evolution of leks. In: Natural Selection and Social Behaviour (ed. Alexander RD, Tinkle DW), Chiron Press, NY, pp. 138-169.
3. Alcock J (2013) Sexual selection and the mating behavior of solitary bees. Adv Study Behav 45: 1-48.
4. Loper GM, Taylor Jr OR (1987) Detection and monitoring of honeybee drone congregation areas by radar. Apidol 18(2): 163-172.
5. Alcock J, Smith AP (1987) Hilltopping, leks and female choice in the carpenter bee *Xylocopa* (Neoxylocopa) *varipuncta*. J Zool 211(1): 1-10.
6. Eickwort GC, Ginsberg HS (1980) Foraging and mating behavior in Apoidea. Ann Rev Entomol 25(1): 421-446.
7. Bushmann SL, Drummond FA (2015) Abundance and diversity of wild bees (Hymenoptera: Apoidae) found in lowbush blueberry growing regions of Downeast Maine. Environ. Entomol 44(4): 975-989.
8. Stubbs CS, Drummond FA (Ed.) (2001) Bees and Crop Pollination – Crisis, Crossroads, Conservation. Thomas Say Publ. Entomol. Entomol Soc Am Lanham MD, pp. 156.
9. Allen-Wardell G, Bernhardt P, Bitner R, Burquez A, Buchmann S, et al. (1998) The potential consequences of pollinator decline on the conservation of biodiversity and stability of food crop yields. Conserv Biol 12(1): 8-17.
10. Goulson D, Nicholls E, Botías C, Rotheray EL (2015) Bee declines driven by combined stress from parasites, pesticides, and lack of flowers. Science 347(6229): 1255957.
11. Scott-Dupree CD, Conroy L, Harris CR (2009) Impact of currently used or potentially useful insecticides for canola agroecosystems on *Bombus impatiens* (Hymenoptera: *Apidae*), *Megachile rotundata* (Hymentoptera: *Megachilidae*), and *Osmia lignaria* (Hymenoptera: *Megachilidae*). J Econ Entomol 102(1): 177-182.
12. Van der Sluijs JP, Simon-Delso N, Goulson D, Maxim L, Bonmatin JM, et al. (2013) Neonicotinoids, bee disorders and the sustainability of pollinator services. Curr Opin Environ Sustain 5(3-4): 293-305.
13. Calderwood L, Drummond FA (2019) Bees - IPM tactics to reduce pesticide exposure to honey and native bees. Univ Maine Coop.

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