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Harnessing chemical ecology to address agricultural pest and pollinator: A review

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Abstract
Insect pests cause serious economic, yield and food safety problems to managed crops worldwide. Compounding these problems, insect pests often vector pathogenic or toxigenic microbes to plants. Previous work has considered plant–insect and plant–microbe interactions separately. Insect chemical ecology (ICE) evolved as a discipline concerned with plant-insect interactions and also with a powerful specialise in intraspecific pheromone-mediated communication. We propose that these aspects of microbial volatile emission may make these compounds ideal to be used in agricultural applications, as they will be more specific or enhance methods currently utilized in insect control or monitoring. Our survey of microbial volatiles in insect–plant interactions suggests that these emissions not only signal host suitability but may indicate a particular time frame for optimal conditions for both insect and microbe. Bees are the most important pollinators, but over 100,000 invertebrates including butterflies, moths, wasps, flies, and beetles and over 1,000 mammals including birds, reptiles and amphibians, act as pollinators. Unfortunately, pollinators are in decline worldwide. Habitat loss, invasive species, parasites, and pesticides are largely to blame. Pheromones and semiochemicals in General, Consist of a Wide range of Organic molecules that could be volatile or non-volatile.

Keywords: Chemical ecology, microbial volatiles, pheromone, pollinators

Introduction
Chemical ecology are often defined because the study of the structure, origin and performance of present that mediate interspecific or intraspecific interactions. Insect chemical ecology (ICE) evolved as a discipline concerned with plant-insect interactions, and also with a strong focus on intra-specifc pheromone mediated Communication.The manipulation of insect behavior and movement is finished by volatile signals. Most studies and applications of volatile signals in agriculture to date focus on signals produced by plants and insects.insect pheromones and the role of chemicals in plant-insect interactions, insect chemical ecology (ICE) has developed into a distinct research discipline being practiced at universities and other research organizations worldwide.The plant insect interactions have revealed that volatile organic compounds often mediate insect movement, aggregation, and host location by herbivores, predators, and parasitoids. The insect microbe interactions may be of particular importance in developing control and monitoring systems in agricultural systems and the semio-chemicals (signaling molecules) mediating interactions between insects and microbes is also accustomed, enhance the effectiveness of monitoring and control (Rhoades 1983) [22]. Their own exploration into the interactions between a spread of crop species and different taxa of insect herbivores, natural enemies, plant-parasitic nematodes, and microbes. A broad range of animal taxa can function as pollinators (Ollerton, 2017) [19]. Like bees (Hymenoptera: Anthophila) are uniquely specialized for pollen transport and account for the majority of pollination services in both wild and cultivated plants, complemented principally by other insect pollinators (Willmer *et al.*, 2017) [28]. Pollinators are animals that mediate the exchange of pollen between flowers, facilitating fruit and seed production in roughly 88 pe cent of flowering plants (Ollerton *et al.*, 2011) [18].

Pollinators and food security
Agriculture in eastern United States is concentrated on many crops that need insect pollination. There's an economic importance of both the crops and therefore, the beneficial insects that support them.

Food security the massive segment of the population living in large cities that depend on imported food and also for the agriculture rural population, so maintaining agricultural productivity is important for the well being of many with in the region. Agriculture with in the Northeast is efficiousand productive, hoping on a combination of growing practices that range from heavy reliance on pesticides to integrated pest management and adopting organic practices. To support this diverse base of food production, innovations are needed that reduce the risks of pesticides in conventional agriculture and enhance the productivity in organic systems.Pollinators are in trouble. These important wildlife move from plant to plant while looking for protein-rich pollen or high-energy nectar to eat. As they go, they are dusted by pollen and move it to the next flower, fertilizing the plant and allowing it to breed and form seeds, berries, fruits, and other plant foods that form the muse of the organic phenomenon chain for other species including humans.We still say “the demand for organic fruit and vegetables continues to grow, and producers are demanding holistic, ecology-based systems. Northeast regional priorities for fruit and vegetable specialty crops are replete with imply research and sustainable practices to scale back the impacts of insect pests and to guard valuable pollinators. This multi-state project seeks to harness innate properties of crops and agroecosystems to deal with pest and pollinator priorities.

How do pesticides affect pollinators?

Pesticides can exert sub-lethal and lethal effects on individual pollinators, and therefore the type and extent of those effects vary with exposure level, duration, and route (ingestion, contact, inhalation) the mode of action of the pesticide; interactions between pesticides; the developmental and physiological condition of the pollinator and also the species of pollinator. Moreover, these effects aren't caused only by insecticides specifically designed for insect toxicity; other pesticides, like fungicides and herbicides, also can be toxicologically relevant to pollinators. Furthermore, many adjuvants included in pesticide formulations can synergize active ingredients or maybe possess intrinsic toxicity (Mullin, 2015) [15], with documented effects including impaired learning and memory (Ciarlo *et al.*, 2012) [4] and increased viral titers (Fine *et al.*, 2017) [8]. Published studies of the “inert” ingredients in formulations are quite limited, though, so we'll focus our review on active ingredients. The primary impact of herbicides on pollinators, however, is their negative effect on the availability of flowering plants, reducing pollinators' nutritional resources and potentially exacerbating the impacts of other stressors (Bohnenblust *et al.*, 2016) [2].

Lethal effects: Many pesticides are acutely toxic to bees and result in death. Carbamates, organophosphates, synthetic pyrethroids, and neonicotinoids are highly toxic to bees.

Sublethal effects: Pesticide levels that do not kill bees at significant rates may none the less have effects on performance that inhibit tasks such as olfactory learning, foraging, and reproduction, which affects hive survival.

Synergistic effects: Often pesticides have more toxic effects in combination than alone.

Food availability: Insecticide employed in fields, along rights-of-way and in forests tend to scale back the quantity of flowering plants. This reduces the quantity of food available for native pollinators, making their survival tougher. This has effects throughout the organic phenomenon, as reduced pollination ends up in reduced fruit on which birds and other creatures depend.

The importance of chemical ecology and its advantages

The application of semiochemicals to be used as biopesticides, nonpheromonal insect pest attractants, enhancements or adjuvants for pheromones, biomarkers for detection of disease, and repellents. Focused on insect and plant produced volatile compounds as discussed here, microbial volatiles are on the increase and may even be included in additional symposia. Plant-insect interactions, the role of microbes in mediating a range of biotic interactions may be a growing research field in chemical ecology. Studies within the last decade have delved into complex microbial assemblages, i.e. microbiomes (for instance, bacteria, fungi, endophytes, foral microbes, etc.) that associate and interact with different plant species and their organs (Vorholt, 2012; Hardoim *et al*. 2015; Compant *et al*. 2019) [26, 11, 5]. Fungi volatiles were slightly on top of bacteria volatiles, and virus volatiles associated publications were a far off third. A particular crop or target pest rather than developing management models that cut across a broad range of crops and pests. We propose the reverse, to harness the intellectual breadth of chemical ecology practitioners and to focus their interests on agricultural pests and pollinators.

As the discipline of chemical ecology matures, the knowledge gained in ecological, behavioral and evolutionary studies is translated into practical and applied pest management. Thus, blending fundamental and applied research enhances the likelihood of sustainable pest management and a discount within the quantity of pesticides released into our surroundings. The consequence of not pursuing sustainable, non-pesticidal management of pests may be a continued reliance on insecticides and other pesticides, with potential long and short term adverse effects on the environment for future generations

Future multistate goals

These include collaborative work on:

1. Emerging non-insect pests,
2. Development of recent approaches to breeding that include screening diverse pools of cultivated germplasms for quantitative resistance traits
3. Developing a quantitative framework for understanding the results of patchiness in herbivore attacks in agricultural systems.

Notably, these goals are specific to a specific crop, but seek to check how chemical ecology approaches may be applied to unravel general agricultural problems.

Impacts

Impacts will still be seen in several areas for instance, we are increasing our understanding of the way to manipulate mixtures of crop cultivars and other sorts of plant diversity to affect the behavior of pests, beneficial’s and natural enemies to extend crop yield. Active research is geared toward discovering new plant natural products which will reduce pests and increase beneficial’s for instance, plants with anti-pathogenic properties are being investigated as the simplest way to shield pollinating bees from parasites, and wildflower strips are being designed to extend pollinator health. The effect of insecticides, fungicides and herbicides within the agroecosystem will still be tested to get which chemicals are both effective and safe for non-target organisms.

Strategies to save pollinators

Bees are the most important pollinators, but over 100,000 invertebrates-including butterflies, moths, wasps, flies, and beetles-and over 1,000 mammals, birds, reptiles and amphibians, act as pollinators. Unfortunately, pollinators are in decline worldwide. Habitat loss, invasive species, parasites, and pesticides are largely to blame. There are different ways, which can directly help pollinators and support National Wildlife Federation's efforts to protect and restore these critically important wildlife species.

Plant Natives

Native plants co-evolved with the native wildlife of our region. Native plants form the foundation of habitat for pollinators by providing them with pollen and nectar for food, cover from the elements and predators, and places where their young can grow. The best way to attract beautiful butterflies, busy bees, speedy hummingbirds and other pollinators are to plant native plants *viz. Antennarianeglecta*, *Eupatorium altissimum* etc.

Gives bees nesting place

Not all bees board hives like honey bees do. In fact, 70% of all the 20,000 species of bees nest underground. but we will still provide them some artificial structures or hives to measure and thrive, as depicted within the image here, within the image is that the beehive for the solitary bees.

Avoid pesticides

Bees are our most significant pollinators, and that they are insects. So are butterflies just like the monarch. Using insecticides will kill these insects. Herbicides will kill important native plants like milkweed that pollinators depend upon as a food source and an area to boost young.

Recent studies have led to the invention that nectar inhabiting microbes change the composition of VOCs in host plant flowers and consequently influence the foraging behavior and survival of visiting insects like herbivores, pollinators, and natural enemies (Beck and Vannette 2017; Rering *et al*. 2018; Klaps *et al.* 2020) [1, 21, 13]. for instance, nectar inoculated by the yeasts, *Metschnikowia gruessii*, and *M. reukaufi*, attracts the parasitoid *Aphidius ervi* (Hymenoptera: Braconidae) via the assembly of volatile compounds (Sobhy *et al*. 2018) [24].

Semiochemical

Semiochemicals derived from *semeion* (in *Greek*) meaning signal, can be defined as chemicals emitted by living organisms (plants, insects, etc.) that induce a behavioral or a physiological response in other individuals. These compounds can be classified in two groups considering whether they act as intraspecific (pheromones) or interspecific (allelochemicals) mediators. Allelochemicals includes Allomones (emitting species benefits), Kairomones (receptor species benefits) and Synomones (both species benefit). However, a single chemical signal May Act as Both as Pheromone and allelochemical.

Plant–insect interactions, like the plant emitted kairomone pear ester, ethyl (2E, 4Z)-2,4-decadienoate, that attract male and feminine adult codling moths. for instance, in laboratory and field bioassays, several species of wasp within the genus Cotesia were found to be drawn to cabbage plants (*Brassica oleracea var. alba* L.) damaged by larvae of the diamondback moth (*Plutella xylostella Linnaeus*) and cabbage white butterfly (*Pieris rapae* L. *Pieridae*) (Poelman *et al.* 2009; Girling *et al.* 2011) [20, 10]. The potential for the exploitation of volatile compounds from basic to applied research, more studies are needed to decipher in-depth the concept of blends and their meaning for insect behaviors. Furthermore, future research also must specialise in the effectiveness of the recruited natural enemies (i.e. predators and parasitoids) in controlling specific insect pests, still because the concentrations and active distances of emitted volatile blends. There are different types of pheromones according to the response they induce on the perceiving individuals. The most common are presented hereafter (Brossut, 1997; Cork, 2004) [3, 6] Semiochemicals provide additional control options to conventional pesticides (El-Shafe and Faleiro 2017; Mauchline *et al.* 2018) [7, 14].

Sex pheromones are generally produced by females of a species to attract males of the same species for mating. Some exceptions exist where male butterflies (*Bicyclus anynana*) produce Sex pheromones to seduce females during the courtship (Nieberding *et al.* 2008) [17]. Sex pheromones consist of individual molecules or a specific blend of compounds in a given ratio. The most studied and used in IPM, Sex pheromones are that emitted by Lepidoptera.As an example, the application of sex pheromones as mating disruptors and lures successfully reduced swede midge in Brassicaceae (Hillbur *et al.* 2005; Samietz *et al*. 2012) [12, 23].

Aggregation pheromones are released by one gender of a species to draw in individuals (both sexes) of the identical species to use a particular resource (food, appropriate mating site, etc.). they're mainly emitted by Coleopterous species. Aggregation pheromones of bark beetles (order; Coleoptera) are frequently utilized in trap-out methods (Gillette and Munson 2007) [9].

Alarm pheromones alert conspecifics just in case of threats. Generally, the response behavior leads to the dispersion of congeners. These pheromones, characteristic of social or gregarious insects, occur in some important insect pests including Aphididae and Thripidae. This class of pheromones has potential in IPM (Verheggen *et al.* 2010) [25]. as an example, field application of the aphid alarm pheromone (E)-β-farnesene (Eβf) recruited parasitoids and predators of aphids (Vosteen *et al.* 2016) [27].

Trail pheromones are present in social colonies to point the trail to be followed when some scout insects locate food resources. Walking insects, like ants, typically produce these pheromones.

Host marking pheromones reduce the competition between members of the identical species prefer it is observed in parasitoids that mark a number within which they need laid an egg.In their use in pest management, pheromones are reliably used as monitoring tools in biodiversity conservation. This has been demonstrated using sex pheromones of the Saproxylic beetles, which successfully help to watch the beetles in both managed and natural forest ecosystems (Musa *et al.* 2013) [16].

Properties of Semiochemical Pheromones and semiochemicals generally, include a good range of organic molecules that might be volatile or non-volatile. Non-volatile semiochemicals include cuticular hydrocarbons, acting in mate recognition or cannibalism regulation of several insect species. Wilson *et al.* (1963) [29] suggested that the volatile pheromones naturally exploited in insect communication have between 5 and 20 atoms of carbon with molecular weights starting from 80 to 300. Those having a relative molecular mass above 300 aren't sufficiently volatile to permit communication at long distances. Cork (2004) [6], within the Pheromone manual, cites the most important pheromones identified in moths and butterflies per their chemical classes.The biosynthesis of such semiochemical molecules is supposed to come from the food. They are generally synthesized *de novo* by excreting cells. The biosynthesis of sexual pheromones is well known in Lepidoptera and Diptera. In both cases, the pheromones consist of long carbon chains (alcohols, aldehydes, and acetates for Lepidoptera; hydrocarbons having high molecular weight for Diptera) derived from the metabolism of fatty acids (Brossut, 1997) [3].

The efficiency of semiochemical substances in chemical communication depends on various physical properties including chemical nature, volatility, solubility and lifelong of the molecules within the environment. a vital abiotic factor controlling the effectiveness of the pheromones is that the temperature which increases the diffusion of the molecules within the air. the soundness of those volatile compounds also affects the efficiency of IPM. These molecules are present and are generally environmentally friendly. Additionally, in IPM strategies the compounds are generally used at concentrations near those found in nature and, because of their high volatility, they will act at long distances and dissipate rapidly. the danger to human health and therefore the environment is additionally reduced compared to pesticides. For of thesem reasons, semiochemicals are compounds of doubtless high interest in IPM.

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