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Role of Insect Pheromones in Integrated Pest Management

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SUMMARY

Pheromones' are compounds emitted into the environment by a species member that triggers a specific response in other members of the same species. Karlson and Luscher invented the name "pheromone" in 1959. Alarm pheromones, food trail pheromones, sex pheromones and many more pheromones influence insect behavior and physiology. Pheromones are volatile compounds that serve as a chemical way of communication. Many species pheromones have been found and are being synthesized for use in insect pest management programmes, which could result in a significant reduction in chemical treatments, with significant economic and qualitative benefits. Insect pheromones can thus be used successfully in pest management programmes.

INTRODUCTION

Pheromones are defined as "substances released into the environment by a member of a species that elicits a specific response in members of the same species". Pheromones travel slowly, are not depleted rapidly and have a long range of effectiveness. Pheromones are chemicals secreted into the environment by a particular organism that evoke a specific reaction in another member of the same species. Pheromones are volatile in nature and aid in insect communication. Pheromones are exocrine in nature, hence why they were formerly referred to as ectohormones. Karlson and Butenandt, two German scientists, isolated and identified the first pheromone, a sex attractant from silkworm (Bombykol) moths, and they coined the term "pheromone" in 1959. This word comes from two Greek words: "human" means "to carry" and "pherin" means "to excite." They coined the term pheromone. The main ways of exploiting pheromones in pest control are monitoring, mating disruption and mass trapping.

Types of Pheromones :

Based on the responses elicited pheromones can be classified into 2 groups

Primer pheromones :

- They trigger off a chain of physiological changes in the recipient without any immediate change in the behavior.
- They act through gustatory (taste) sensilla.
- e.g. Caste determination and reproduction in social insects like ants, bees, wasps, and termites are mediated by primer pheromones.
- These pheromones are not of much practical value in IPM.

Releaser pheromones :

These pheromones produce an immediate change in the behavior of the recipient. Releaser pheromones may be further subdivided based on their biological activity into,

- Sex pheromones
- Aggregation pheromones
- Alarm pheromones
- Trail pheromones
- Signal Pheromone
- Territorial Pheromone:

Releaser pheromones act through olfactory (smell) sensilla and directly act on the central nervous system of the recipient and modify their behavior. They can be successfully used in pest management programmes.

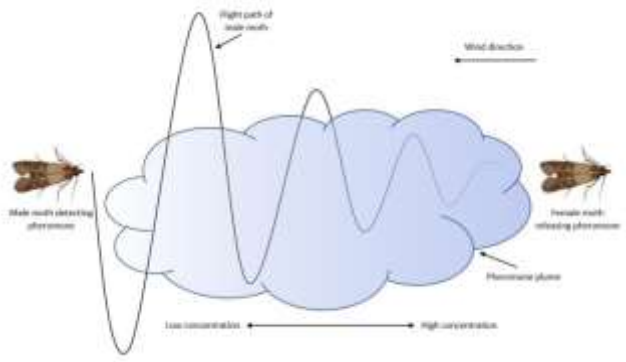
Sex Pheromone :

- These mediate interaction between sexes of the same species and are mainly produced by females to attract males. Commonly released by females.

- The first characterization of a sex pheromone was reported in the silk moth *Bombyx mori* L. (Lepidoptera : Bombycidae) (Butenandt *et al.*, 1959).
- Gossyplure HF (Albany International) was the first registered pheromone product granted by the Environmental Protection Agency (EPA) in February 1978. It was used for the suppression of pink bollworm.
- They are not-toxic to living organisms, most known pheromones being derived from fatty acids, terpenes, amino acids, simple aromatic derivatives, hydrocarbons and several other chemical families.
- Traps containing sex pheromones are used by farmers to detect and monitor insect populations in orchards.
- Aphrodisiacs are substances that aid in courtship of the insects after the two sexes are brought together. In many cases males produce aphrodisiacs.
- Some examples of female sex pheromone showed below in Table.

Sex pheromone and their sources :

Pheromone	Name of the Insects
Bombykol	Silk moth
Gyplure	Gypsy moth
Gossyplure	Pink bollworm
Looplure	Cabbage looper
Helilure	Gram pod borer
Queen substances	Honey bee queen

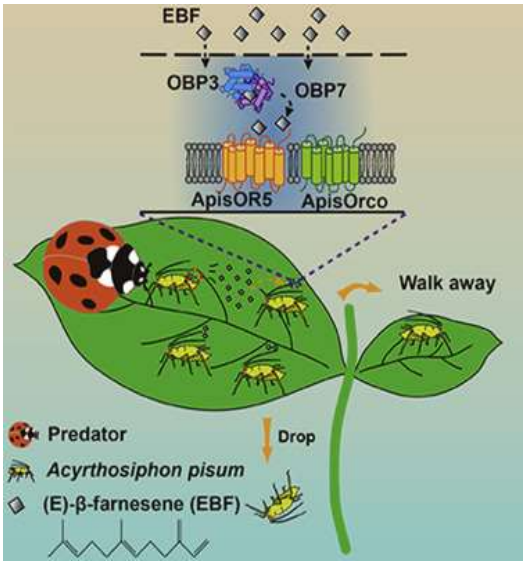


Aggregation Pheromone:

- Attract individuals of both sexes at food sites and reproductive habitats.
- Aggregation pheromones function in mate selection, overcoming host resistance by mass attack and defense against predators.
- Male-produced sex attractants have been called aggregation pheromones, because they usually result in the arrival of both sexes at a calling site and increase the density of conspecifics surrounding the pheromone source.
- Aggregation pheromones have been found in members of the Coleoptera, Diptera, Hemiptera, Dictyoptera and Orthoptera.
- Aggregation pheromones are among the most ecologically selective pest suppression methods. They are non**t**oxic and effective at very low concentrations. For example, the hemiterpene 3-methylbut-3-en-1-ol has been shown to be the aggregation pheromone for two beetle pests, *Polygraphus rufipennis* Kirby (Coleoptera: Curculionidae) and *Lasconotus intricatus* Kraus (Coleoptera: Zopheridae).

Alarm Pheromone:

- Alerts members of the same species to the presence of a menace.
- It is considered to be the second most common pheromone produced by insects, after sex pheromones.
- Some examples are sesquiterpene (E)- β-farnesene (EBF), germacrene A, and α-pinene which were shown to be the main components of the alarm pheromone of several important aphid species (Vandermoten *et al*., 2012). For example, *Vespula squamosa* use alarm pheromones to alert others to a threat (Landoldt *et al*., 1999).
- In *Polistes exclamans*, alarm pheromones are also used as an alert to incoming predators (Post *et al*., 1984).
- Chemical nature of the some of the alarm pheromones are terpenes (Aphid), aldehydes (Hemiptera) and formic acid (ants).



Trail Pheromone:

Social insects commonly use trail pheromones. For example, ants mark their paths with pheromones consisting of volatile hydrocarbons. Certain ants lay down an initial trail of pheromones as they return to the nest with food. This trail attracts other ants and serves as a guide. As long as the food source remains available, visiting ants will continuously renew the pheromone trail. The pheromone requires continuous renewal because it evaporates quickly. When the food supply begins to dwindle, the trail-making ceases (Robinson *et al*., 2008). The pheromone trail of ants can be seen as communicating cloud providing each single ant with information (Fladerer *et al*., 2019).

Signal Pheromone:

Signal pheromones cause short term changes, such as the neurotransmitter release that activates a response. For instance, GnRH molecule functions as a neurotransmitter in rats to elicit lordosis behavior (Kohl *et al*., 2001).

Territorial Pheromone :

- Laid down in the environment, territorial pheromones mark the boundaries and identity of an organism's territory.
- In cats and dogs, these hormones are present in the urine, which they deposit on landmarks serving to mark the perimeter of the claimed territory.
- In social seabirds, the preen gland is used to mark nests, nuptial gifts, and territory boundaries with behavior formerly described as 'displacement activity.

Role of Pheromone in Integrated Pest Management :

Various strategies exist depending on the goals and scopes to achieve. Some of them are described hereafter (Stephanie Heuskin *et al*., 2011).

1. Monitoring :

- Simple, cheap, and widely used tools for monitoring different insect pests.
- To detect the presence of invasive pests.
- To estimate the relative density of a pest population at a specific site and
- To indicate the first emergence or peak flight activity of a pest species in a given area.
- The appropriate control actions (e.g., local insecticide treatment) can then be carried out.

2. Mass Trapping :

- Trapping with pheromone lures is a mechanical control action that consists in removing large number of pests in an area after monitoring step.
- The traps can be used simultaneously with a killing substance ("lure and kill" strategy) which has the benefit of not being in direct contact with the crop.
- This technique is also useful in stored-product pest control.
- Recently, this technique has been an effective management tactic for controlling the Japanese beetle, *Popillia japonica* (Coleoptera : Scarabaeidae).

3. Mating disruption :

- Mating disruption is a strategy which uses species-specific sex pheromones that affect mating behavior by releasing huge amounts of synthetic pheromones into the atmosphere.
- The technique of mating disruption by using species-specific sex pheromones in large quantity is principally applied to control moth populations in orchards.
- In moth, females generally release sex pheromones to attract males, at relatively long distances (several kilometers), for reproduction.
- Mating disruption consists in affecting the behavior of males in their search of a female for mating by releasing high quantities of synthetic female pheromones in the atmosphere.
- When the population of moth is too large, mating disruption can be associated with targeted pesticides at local and punctual applications.

4. Push-pull strategy :

- Also called stimulo-deterrent diversion, push-pull strategy is a more recent approach than the other described IPM practices.
- It consists in a combination of repellent and attractive stimuli modifying the behavior of insect pests and/or of their natural enemies.
- The insects are deterred or repelled away from the crops (push strategy). They are simultaneously attracted by lures (pull strategy) and concentrated in other areas where they are trapped or killed in a controlled manner.
- This strategy requires a clear understanding of the pest biology, chemical ecology, and of the interactions with hosts, conspecifics, and natural enemies.

5. Biological control :

- Biological control of the insect pests is defined as "the use of living organisms (insects or pathogens) to suppress pest populations, making them less damaging than they would otherwise be."
- Insect natural enemies, also called beneficial insects, can be classified in two classes: predators and parasitoids.
- A new concept consists in attracting local beneficial insects on crops by means of kairomonal substances for the biological control of aphids with their parasitoid wasps (*Aphidius ervi* Haliday) (Hymenoptera: Braconidae) and their hoverflies predators (*Episyrphus balteatus* De Geer) (Diptera: Syrphidae).

CONCLUSION

The use of pheromones could result in a significant reduction in chemical treatments, with significant economic and qualitative benefits. Pheromones and other behavior modifying semiochemicals are now used in many pest management programmes and are predicted to play a major role in future high-tech crop protection. Pheromones and all semiochemicals in general, will play a larger role in future integrated pest management programmes than they do now. Pheromone use is an environmentally friendly and cost-effective IPM practice.

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