Pest management by modifying insect development and behaviour

Allelochemicals

- **Chemicals involved in interspecific communication.**
- **Non nutrient substances- affects behaviour, physiological condition or ecology.**
- **Divided into different categories:**

Category	Releaser	Receiver
Allomone	+	-
Kairomone	-	+
Synomone	+	+
Antimone	-	-
Apneumone	Non living substance	+

Pheromones

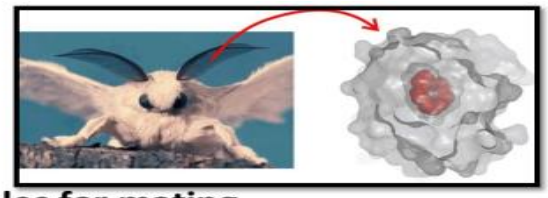
- Greek word- *pherein*- to transfer and *hormone*- to excite.
- Used for intraspecific communication.
- Chemical or a mixture of chemicals *i.e.* released to the exterior by an organism and that causes one or more specific reactions in a receiving organism of the same species.

Types of pheromones

- **Based on the function that they perform**

a. Sex pheromones
b. Aggregation pheromones
c. Alarm pheromones
d. Trial pheromones
e. Host marking pheromones

Sex pheromones



- Produced by the females to attract males for mating.
- Rarely produced by males.
- Produced by eversible glands at the tip of the abdomen and received by sensory sensillae on male antenna.
- Complex physiological process-

Sexual maturity
Environmental stimuli- photoperiod and light intensity

- Volatile, species specific and related only to smaller number of species- depends on distance

Attributes	Sex Pheromones 	Host-Plant Volatiles 
A) Physical		
Specificity	High	Low
Complexity	Low-High	Mostly low
Volatility	Variable	Mostly high
Stability	Often high	Often low
Toxicity	Low (?)	Low (?)
B) IPM		
Target gender	Only one sex	Both sexes
Insect stage	Adults only	Adults and larvae
Background odors	Unimportant	Very important
Compatibility with other control strategies	High	High
Non-target effects	Low	High
Adoption	Wide	Limited

Fig. Differences and similarities between sex pheromones and host-plant volatiles used for behavioral manipulation of insect pests

(Saona and Stelinski, 2008)

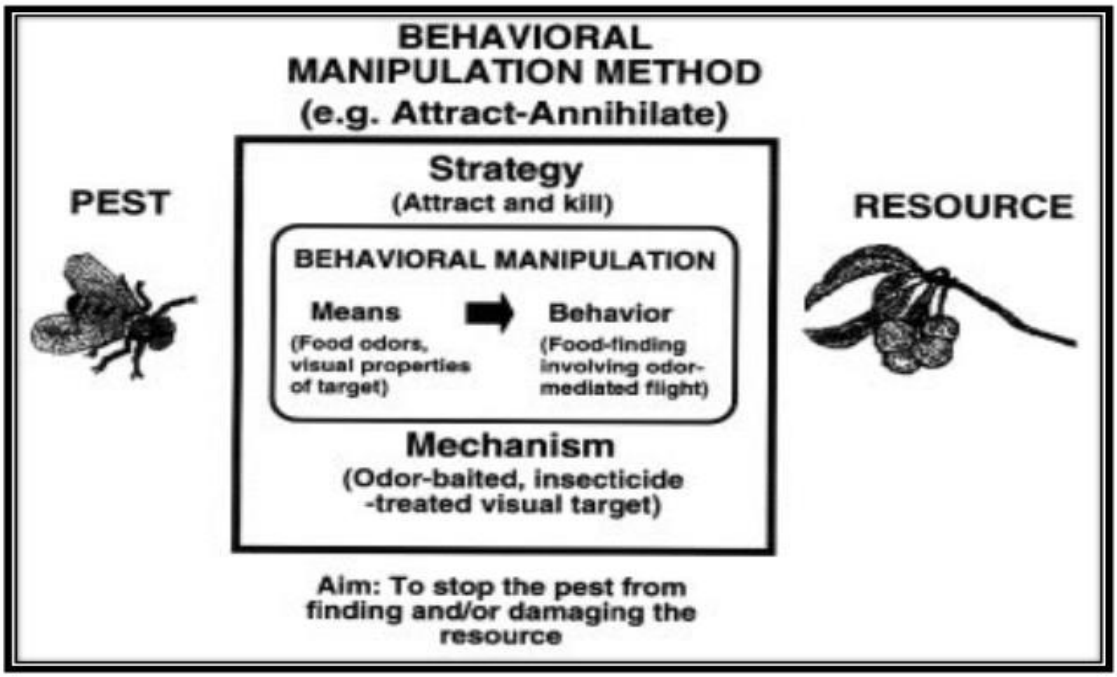


Fig. The behavioural manipulation method concept illustrated using the example of an attract-annihilate method

Aggregation pheromones

- Cause insects to aggregate at food sites, reproductive habitats, hibernation sites ...
- Prominent in some species of beetles like bark beetles, *Ips* spp., *Dendroctonus* spp. - are involved in tree attacks
- Attracts the species of both the sexes and tend to operate over a long range.

Alarm pheromones

- Highly volatile and having low molecular weight.
- Common in social insects- Ants, bees, aphids.
- Occurs in aggregation.
- Function: to raise alert in conspecifics, to raise a defence response and to initiate avoidance.
- Ex: Ants, bees, aphids

Trial pheromones

- Produced by foraging ants, termites and larva of some Lepidopterans.
- Less volatile.
- Used to indicate source of requisites to other members of the colony.

- Ex: Ants- associated with walking.
- Bees- during foraging for making attractive foraging sites and for scent marking of unproductive food sources.
- Bumble bees- to increase efficiency in their use for pollination.

Host marking/ Epidietic/ Spacing pheromones

- Elicit dispersal away from potentially crowded food sources and there by reducing numbers.
- Reduce- intraspecific competitions by disrupting landing, feeding or oviposition of pests on their host plants.
- Results in repelling.
- Ex: Fruit flies – marks the surface on fruits after oviposition.

- Mating deterrent pheromones- House flies and other Diptera.
- Parasitoids - to find their host species.

Strategies for exploitation of pheromones in pest management

- Discovery, isolation and chemical identification of sex pheromone (bombykol) in 1959 - impetus for the exploitation of pheromones in pest management.

- 1970's – for 200 insects
- 1980 - > 2000 insects.

- Pheromones can be exploited in three ways
- A. Monitoring
- B. Mass trapping and
- C. Mating disruption

A. Monitoring

- Highly sensitive means of detecting both the presence and density of pest species.

- Insect infestation can be detected and estimated at a very early stage.

- Can forewarn regarding outbreaks of important pests.

Monitoring helps in

- Detection of pest
- Measurement of pest density
- Assessment of density of natural enemies
- Assessment of pest phenology
- Assessment of effectiveness of mating disruption
- Monitoring of insecticide resistance.
- Decision support

B. Mass trapping

- Catching substantial proportion of a pest population before mating, oviposition or feeding- prevents damage to the crops.
- Effective results with combination of lure and trap.
- Effective for pests which are geographically isolated and at low densities.

- Two approaches:
- 1. Lure and kill
- 2. Lure and infect

1. **Lure and kill:** insect come in contact with the toxicant and get killed.

Ex: Methyl eugenol + malathion – for oriental fruit fly

PBW- 12 traps/ acre

2. **Lure and infect:** combines attractive lure with an entomopathogen.

Also known as auto-dissemination.

Ex: Use of entomopathogenic nematodes, bacteria, fungi and viruses.

Recommended pheromone traps for mass trapping of pests

Crop	Pest	No. of traps (per ha)
Rice	Yellow stem borer	5
Sorghum	Stem borer	-
Groundnut	*Spodoptera* and *Helicoverpa*	10
	Leaf miner	25
Sugarcane	borers	10
Cotton	Bollworms and *Spodoptera*	5
Pigeon pea	*Helicoverpa*	5
Brinjal	Shoot and fruit borer	10
Okra	*Earias* spp.	10
Cabbage, cauliflower	*Spodoptera* and DBM	10

C. Mating disruption

- **Confusion or decoy method.**
- **To permeate the air with sex pheromones.**
- **Insects entering the area cannot locate mates emitting natural pheromone because synthetic pheromone permeates the whole environment.**
- **Cause a reduction of reproductive rates and achieve crop protection without use of insecticides.**

Control of yellow stem borer by mating disruption with a PVC resin formulation

- **Pheromone – Z9-16:ALD, Z11-16:ALD and Z13-18:ALD = 1:10:1**
- **Selibate CS Strips – 4.1%**

Mating disruption using PB Rope L: for pink bollworm management in cotton

Dosage: 200 per ha

Insect growth regulators(IGR's)

- **Synthetic compounds possessing the activities of juvenile and moulting hormone of insects are called as IGR's/ JH mimics/ JH analogues/ Juvenoids.**
- **Retard the development of pest species particularly inducing effects from sterility to death.**
- **Effective only on immature insects.**

Invention of paper factor

- Discovered by Slama and Williams, 1967

- In *Pyrrhocoris apterous*
- Paper towel was developed from Balsam fir tree

- Mimic the JH- kills the insects without reaching to adult stage

Affects the insects in different ways

1. Antimetamorphic effect
2. Larvicidal effect
3. Ovicidal effect
4. Diapause disrupting effect
5. Embryogenesis inhibiting effect

Chitin synthesis inhibitors

- Chemicals which interferes with the biosynthesis and deposition of chitin.
- Acts on chitin synthase.
- Acts as stomach poisons and kills insects at the time of moulting and also suppress the fecundity and exhibit ovicidal and contact activity.
- Causes improper attachment of the new cuticle during moulting and produces a cuticle that lacks some of the layers.
- Larvae die from rupture of the new malformed cuticle, starvation desiccation and predation.
- Benzyl phenyl urea analogues - affects the larval stage.

Practical IGR's found in market

1. Methoprene (Altosid)- Homopterans and Dipterans
2. Kinoprene (Enstar-IGR)- mosquitoes, flies
3. Hydroprene (Altozar)- Lepidopterans, coleopterans, Homopterans and for few stored pests
4. Pyriproxifen (Admiral)- flies, beetles, midges and mosquitoes.
5. Diflubenzuron (Dimilin)- flies, midges and mosquitoes.

Other chitin synthesis inhibitors

- **Diflubenzuron (Dimilin)** - used in cotton, soybean, citrus, vegetables and also medical pests (mosquitoes).

- **Lufenuron (Match)** - lepidoptera and coleoptera on cotton, corn and vegetables.

- **Buprofezin (Applaud)** - produces weakened exoskeleton in moulting immatures both insecticides and acaricides. Used against hemipterans in rice.

- **Novaluron (Rimon)** - used for whiteflies on tomato and lepidopterans.

Anti-juvenile hormones

- Tested plant extracts for antagonistic activity of JH.
- Discovered anti JH activity from bedding plant, *Ageratum houstonianum.*
- Identified 2 compounds- Precocene I and Precocene-II.
- As they induce precocious form of metamorphosis and their chemical structure.
- Induce premature metamorphosis.
- Lethal activation within the corpora allata, thus destroying the glands.
- Azadirachtin- liquid and dust formulations from neem seeds- disrupts molting process.

Advantages

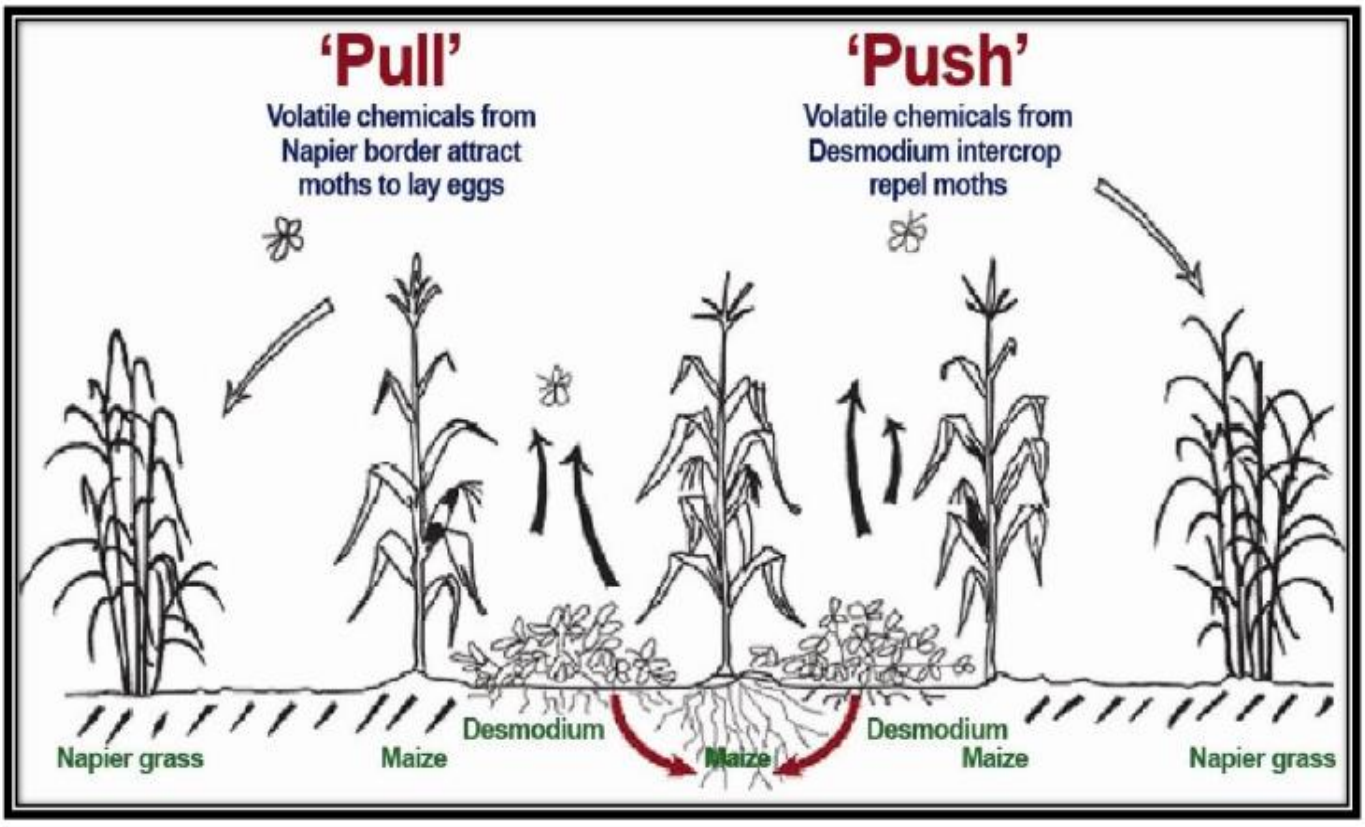
- Effective in minute quantities and hence are economical
- Highly species specific; so non-target organisms are spared
- Affects more than one aspect of insect development and hence effective against insects which are resistant to insecticides.
- Highly biodegradable- non polluting, eco-friendly.
- Non-toxic to plants and animals.
- Suitable for insects which are living in concealed environments.

Disadvantages

- They have a narrow physiological windows; hence cannot be applied at all times.
- Effective only for last larval instars and hence stages will continue to feed.
- Slow mode of action
- Chances of resistance development
- Few are unstable in environment
- High cost of chemicals

Push-Pull Strategy or Stimulo-deterrent diversion

- A strategy where a host-plant attractant(s) and a repellent(s) are used in combination.
- Tested using a repellent intercrop and an attractant "trap" plant.
- Insects are repelled by volatiles emitted from the intercrop (push) and simultaneously attracted by volatiles from the trap plant (pull).
- The most successful work on push-pull to date has been conducted in Africa to control stem borers in maize and sorghum (Cook *et al.*, 2007).
- Works not only by decreasing stem borer damage to maize, but also by enhancing the efficacy of natural enemies.



Attractants

- Chemicals which elicit oriented movements by insects towards their source.
- Also called as Food lures

Important food lures includes

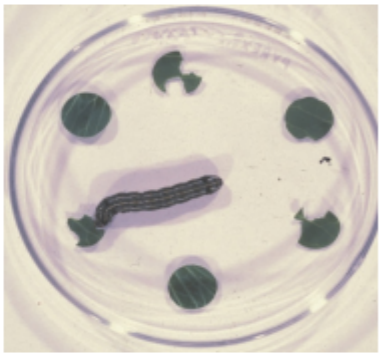
Sl. No.	Lure	Insect
1	Sugar + Molasses	House fly
2	Geraniol	Japanese beetle
3	Trimed lure	Mediterranean fruit fly
4	Melon fruit fly	Cue lure
5	Methyl eugenol	Oriental fruit fly
6	Sinigrin	Cabbage butterfly
7	Cinnamaldehyde	Spotted cucumber beetle

Antifeedants

- Chemicals which inhibit feeding when present in a place where insects in its absence would feed.

OR

- Chemical compound which prevent feeding of insect or animal on a treated material without necessarily killing or repelling.

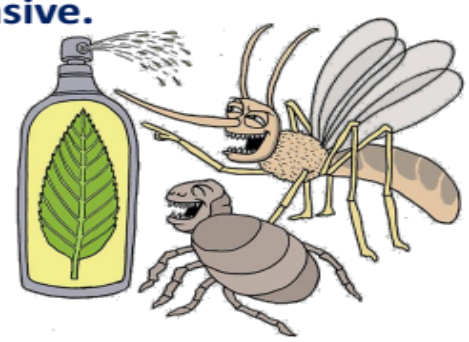


- 1st antifeedant – Zinc salt of Dimethyl dithiocarbonic acid against rodents and trees- to prevent feeding on bark of trees.

Sl. No.	Antifeedant	Target insects
1	Azadirachtin	Desert locust and other insects
2	Baygon	Cotton boll weevil
3	Brestan	Cut worms and potato tuber moth larvae
4	Chlorinated triphenyl methane and triphenyl sulfonium salts	Phytophagous insects
5	Organotins	Grasshoppers, Agrotis sp.
6	Phlorizin	Myzus persicae
7	Pyrethrum	Glossina sp.
8	Solanine	Potato leaf hopper
9	Thiocarbamates and phenyl carbamates	Beetles
10	Triazines	Cockroaches and beetles

Repellents

- Chemicals that cause insects to orient their movements away from a source.
- Allied materials that do not cause movement away but do prevent feeding or oviposition by insects- deterrents.
- Repellents- volatile chemicals- activity in the vapour phase.
- Plants- unattractive, unpalatable or offensive.



List of important synthetic repellents

Sl. No.	Repellents	Insect
1	Benzyl benzoate	Mites
2	Bordeaux mixture	Foliage feeders
3	Creosote	Chinch bugs
4	Diacetyl pthalate	Cattle fleas
5	Dimetyl pthalate	Mosquitoes
6	N, N, diethyl m-toulamide (DEET)	Mosquitoes, fleas, flies
7	Naphtalene balls	Cloth moths
8	N-butylacetanilide	Ticks, fleas
9	Pentachlorophenol	Termites
10	Pine tar oil	Screw worm flies

Advantages

- Low toxicity-safe to humans, plants and domestic animals.
- Protects the desired plants and insects are not killed.
- Resistance development- low.

Disadvantages

- The need to completely cover all susceptible surfaces with repeated applications
- Possibility of increasing infestations on near by untreated surfaces.