NOVEL STRATEGIES OF INSECT CONTROL : PHEROMONES

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Introduction

Insecticides are designed to combat the attack of various insect pests that cause harm to man. Properties of an ideal insecticide are that it should preferentially attack the target pest species without harming other living organisms or the environment. The insecticides used by us are, however, far from the ideal. Early insecticides, such as Paris Green (1A) and lead arsenate (1B)were highly toxic to insects as well as for man. On the contrary, synthetic organic compounds, eg. organochlorines (2A) and organophosphates (2B), which came to light in the 19th century had low mammalian toxicity and a wide spectrum of insecticidal activity in addition to their cheap cost of manufacture. Thus, these insecticides became popular and were extensively used. They were the saviours of man against killer diseases like Malaria in the Far East during the second world war. Since coming to recognition in the 19th century, the services they have provided to man in the field of agriculture are remarkable.[1] However, the extensive use of the above insecticides over a long period has left us with enormous problems which have been brought to light now. One major problem is the non-degradable nature of these insecticides. They leave toxic residues such as DDD (2A, X=H, the breakdown product of DDT) in the environment. The levels of contamination by this substance have risen to alarming proportions. Due to long exposure to insecticides and their residues, the insects themselves have developed immunity, demanding more toxic insecticides for their control. Thus, synthetic insecticides have become an unwanted friend of man today though their dominant position is not challenged due to lack of alternatives. This situation has nevertheless led to a radical revision of our concepts of insect control during the past few years.

Novel Approaches

The new term "environmentally safe insecticides" which is in vogue today describes the new trend. The first concept is that of pest management which advocates the suppression of insect populations below the levels of economic injury rather than their destruction with conventional insecticides. Consequently, two possibilities have emerged. A vast amount of insect controlling agents are being sought from plant resources.[2] A well known example, Pyrrethrin (3), obtained from *Chrysanthemum cinerariaefolium* still is one of the highly used plant derived inset controlling agents. Insect antifeedents, repellents of plant origin and microbial insecticides such as *Bacillus thuringiensis* are some of the possibilities under consideration.

Second approach is the use of insects' physiology and behaviour for their own destruction. Identified in the recent years are the insect hormones (4A), hormone mimics (4B), chemosterilents and insect pheromones (5). These novel compounds generally have the high selectivity against target species and minimum toxicity to other living organisms and the environment.

Insect Pheromones

Insects rely on their keen sense of smell to communicate *via* a sophisticated chemical language, using as words, specific volatile compounds ; a phenomenon recognised in early 1960's. Although other modes of communication such as visual, tactile or auditory signals are important for some insect species, olfaction is often the dominant method. The word insect pheromone[3] describes a chemical /s emitted by one member of the species that triggers a response only from individuals of the same species.* The most well known are the sex attractant pheromones. Often the female of the species emits a specific chemical/s to announce her availability to her male counterpart. An aggregation pheromone on the other hand may guide hoards of both sexes of a species to a single site

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* *In the case of sex pheromones, deviations from above have been observed.*

part. An aggregation pheromone on the other hand may guide hoards of both sexes of a species to a single site mass attack on a host plant. Trail pheromones deposited by a foraging ant create a path for other members of that colony to follow towards a food source : an observation we all are aware of. An alarm pheromone is emitted by an insect when it experiences a danger, to alert other members of the colony against possible attack. Nearly 600 pheromones belonging to different species have been identified and among them about 80% fall into the category of sex pheromones.

The fact that specific compounds attract given insects created a practical solution - the basis of insect control by insect pheromones. When an identical chemical message is created for a pest species with synthetic chemicals, members of the same species can be lured into a trap where they could be killed. Thus, the presence of insects in such a pheromone baited trap (Figure I) indicates the presence of that species in that area and the number of insects trapped can be related to population levels present. This is an important information to the farmer. Guided by this information, the spraying of insecticides can be timed at higher levels of pest populations only, for better results, rather than spraying continuously throughout the pest season. Both the cost of insect control and the environmental damage are minimised as a result. Most of the successful applications of this method are from Lepidopteran sex pheromones such as those of Codling moth, Gypsy moth, Boll weevil, Pink boll worm etc.

Mass trapping is another technique which uses the above basis but a large number of traps are deployed to catch insects in order to bring down pest populations below the levels of economic injury. An alternative approach involves the use of pheromones to disrupt communications between males and females by maintaining fairly high concentrations of pheromones in the atmosphere by spraying methods. Due to the large number of artificial chemical messages, the male is unable to locate the female. Thereby mating is prevented. Thus a reduction of mating in that generation results in low levels of pests in the next generation.

EARLY INSECTICIDES

$CU(CH_3COO)_2(AsO_2)_2$

PARIS GREEN (1A)

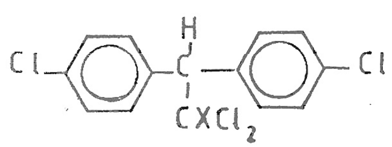
(1864)

$PbHAsO_4$

LEAD ARSANATE (1B)

(1892)

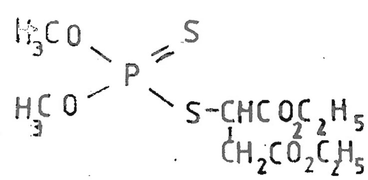
SYNTHETIC ORGANIC CHEMICALS



ORGANO CHLORINES (2A)

X = Cl, DDT (1864)

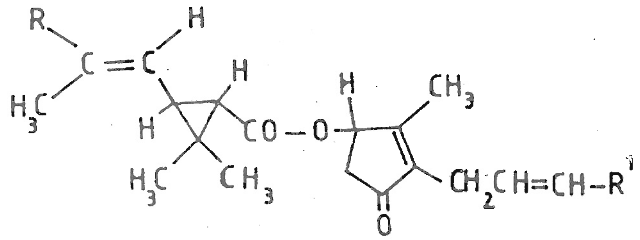
= H, DDD



ORGANO PHOSPHATES (2B)

Malathion (1950)

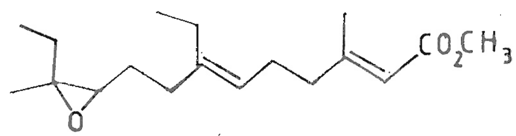
NATURAL PEST CONTROLLING AGENTS



COMPOUND		R^1	R
Pyrethrin	I	$-CH=CH_2$	$-CH_3$
,,	II	$-CH=CH_2$	$-CO_2CH_3$
Cinerin	I	$-CH_3$	$-CH_3$
,,	II	$-CH_3$	$-CO_2CH_3$

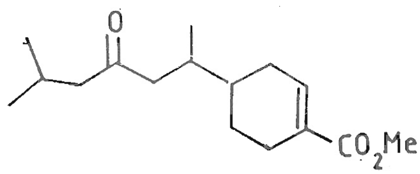
→ Pyrethrin (3)
(1850)

INSECT JUVENILE HORMONES



Cecropia JH (4 A)

JUVENILE HORMONE MIMICS



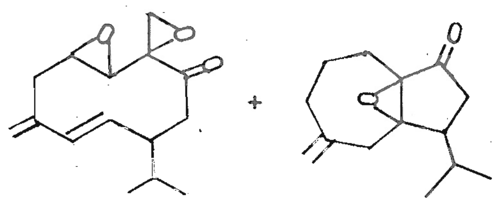
Tuvabione (4 B)

INSECT PHEROMONES (5)

Sex Attractant Pheromones

American Cockroach,
Periplanata americana

(5 A)

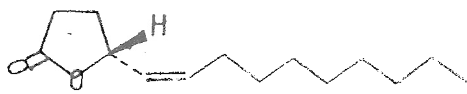


Periplanene - B + A

Japanese beetle,

Papolia japonica

(5B)



Silk worm moth,

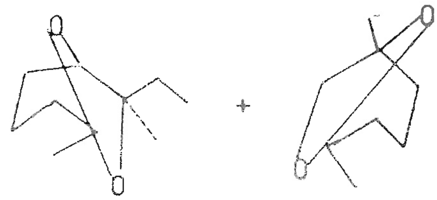
Bombyx mori

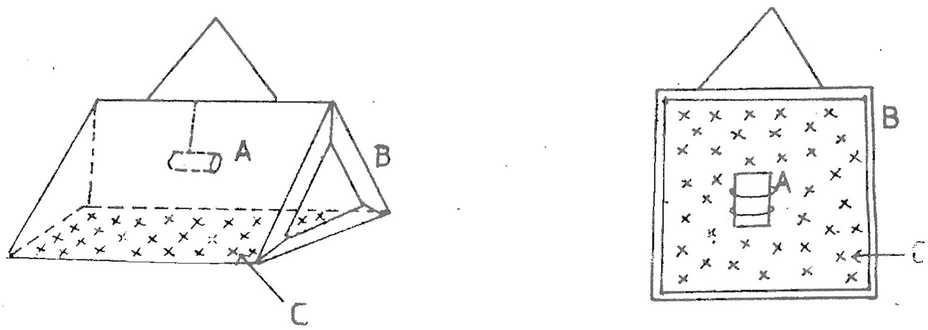
(5C)

Aggregation Pheromones

Western pine beetle,

Dendroctonus brevicomis





A delta trap **A vertical board trap**

A = Pheromone Dispenser B = Plastic body

C = Sticky Surface

PHEROMONE BAITED TRAPS

Figure I

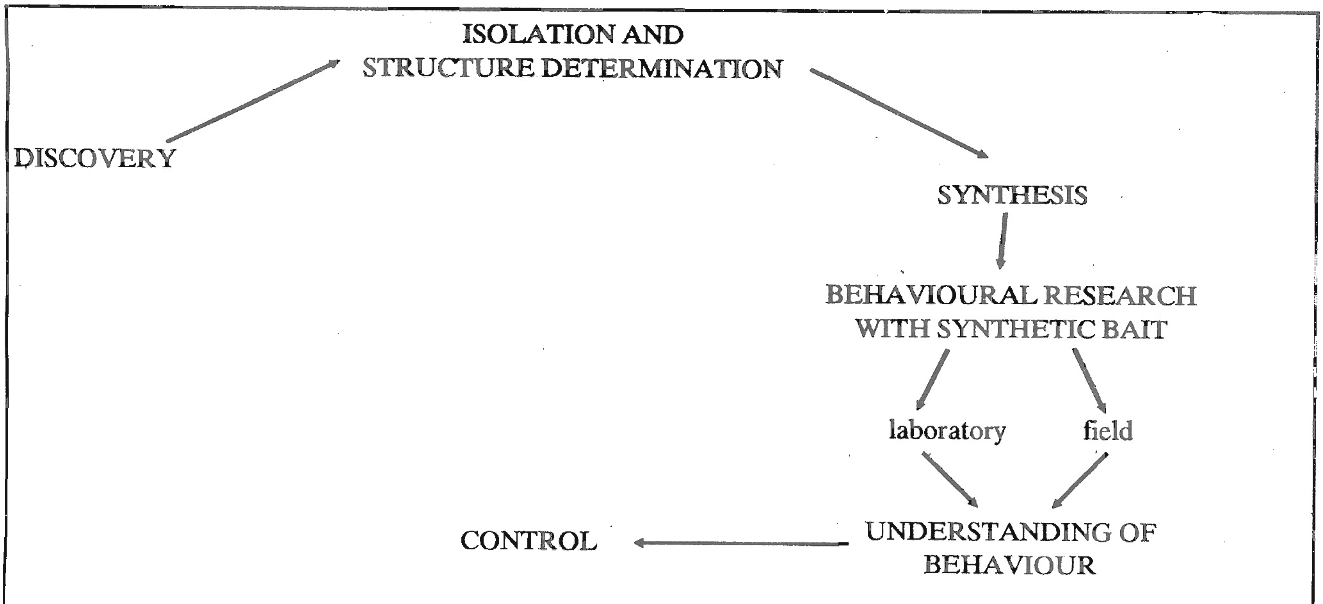


Figure II

The successful use of pheromones depends on several steps taken before its application. Figure II describes these steps. It is clear that the success depends largely on the correct formulation of the synthetic equivalent of the true pheromone. Although pheromones emitted by insects are sometimes as low as nanogram quantities, owing to advanced methods of isolation and structure determination techniques, correct identification of the natural pheromone has been made possible. Gas Liquid Chromatography, Electro antennography, FT Nuclear Magnetic Resonance spectroscopy and FT Infra red spectroscopy are some of the useful techniques that have been developed. In the case of multi component mixtures the correct proportion of each component is evaluated by sophisticated analytical techniques such as capillary Gas Liquid Chromatography. Subsequently, the synthetic equivalent of the natural pheromone is produced by various synthetic procedures. Reproduction of the correct isomer in high purity is a key factor in success. For example, the Silk worm moth, *Bombyx mori* uses only (10E, 12Z) - hexadececadienol (5C) as its sex pheromone out of the four possible isomers while the male the Japanese beetle, *Popillia japonica* responds to its synthetic pheromone only if traps are baited with the furanone (5B) in 99.95% optical purity. Once the synthetic equivalent is available the bait is prepared by absorbing a predetermined dose onto dispensers such as rubber septa/polythene vials etc. which release the pheromone for over a period as long as 3-4 weeks. This bait is incorporated in a suitable trap where sticky gum/water/insecticide would act as the killer of the trapped insects. The correct dose of the pheromone, trap design, the position in which it is hung and the trap height are important parameters in a successful application.

In conclusion, pheromones are not panacea and much research remains to be done in the area of field use of pheromones. Although pheromones have brought many benefits to farmers in the developed countries, as it is often the case, the impact they have made on the poorer countries is still rather limited.

References

1. Cremlyn, R. Pesticides, Preparation and mode of action, John Wiely & Sons, 1978.

2. Chemicals controlling insect behaviour, Ed. M. Berosa, Academic Press, New York, 1970.

3. Jacobson, M. Insect sex pheromones, Academic Press, New York, 1972.