GENERAL CONSIDERATIONS

The use of pesticides in general and insecticides in particular has been the target for considerable criticism, specially since the publication of "Silentspring" by Rachel Carson in 1962. The extensive use of pesticides by the affluent nations of the world has not only created serious problems related to pest control but this also threatens human welfare and jeopardises his environment. In the past few years, research aimed at establishing alternative means of pest control has received increased attention. One of the most promising of these is the use of naturally occurring organic compounds that influence insect chemosensory behaviour as attractants, repellents, stimulants, deterrents etc. Wood *et al.* (1970) has speculated that the chemicals of insect orgin (both larvae and adults) may fit into any of these categories, and has mentioned that their action is most commonly associated with some link in the chain of behaviour leading to feeding or oviposition.

The tobacco beetle, *Lasioderma serricorne* (F.) is a world wide common destructive pest for not only cured tobacco leaves but also various other stored dried food stuffs. The dearth of available proper control methods prompted the present investigation on some aspects of controlling the pest by deploying certain conspecific organismic products or other biological agents.

The work reported in this thesis mainly comprises of two parts. The first one deals with the possible use of any conspecific organismic products for the alteration of behaviour - attraction/repulsion and/or oviposition and the 2nd one deals with the control of this pest by utilizing - Tribolium castaneum (Hbst.) as a predator.

USE OF CONSPECIFIC ORGANISMIC PRODUCTS AS CONTROLLING AGENT:-

As a first step in this direction, it was thought desirable to know whether any stage of the beetle secrete any chemical substance(s) in the medium where they thrive. Observations on this aspect are presented in Chapter - 1. A medium is called "conditioned" when a species of insect inhabited that medium for some time. The conditioning depends on the number of individuals as well as the duration of occupation (Ghent, 1963 and Mondal, 1983). A medium which is thus conditioned involves at least three factors (i) depletion of the nutritive value of the medium (ii) accumulation of exuviae, dead animals and similar debris (iii) and finally and most markedly accumulation of any secretion given off by the insect and taken up by the medium (Ghent, 1963 and Sokoloff, 1972). The attraction of larvae and adult females to the media conditioned by different larval instars (specially 3rd and 4th instars) indicated some secretions from these instars, which may be aggregative in nature. The attraction of different larval instars and adult females (Chapter - 1) to the male-conditioned medium also proved that the males too, secrete

some chemical(s)/pheromone(s), which also is aggregative in nature. The literature on T. castaneum pertaining to the attraction of its larvae and adults to the male-conditioned medium (Suzuki and Sugawara, 1979; Suzuki, 1980 and Mondal, 1985) suggested that it was due to aggregation pheromone. It appears from the male body-wash experiments (Chapter-3) that the chemical(s) secreted by the L. serricorne males are rather different from the usual aggregation pheromone(s) secreted in other insects, as it does not attract individuals of the same sex. Moreover it was also observed to possess an oviposition deterring influence on conspecific female beetles. The female conditioned medium was found to be avoided by the females and late instar larvae (Chapter - 1).

The experimental results with the different conditioned media reported in Chapter - 1 have provided sufficient indications that some pheromonal chemicals are secreted by the larvae and adults (both males and females), which could be put to beneficial use, after gathering necessary further information, towards the management of this pest species.

In majority of known cases in which the insects respond to chemical cues to avoid resource overcrowding involve reactions to pheromones emanating from occupied oviposition sites (Prokopy et al., 1984). The first convincing demonstration in insects of a chemical stimulus having this effect appears to be the work of Salt (1937) on the chalcid parasitoid. Trichogramma

evanescens which oviposit into a variety of Lepidopteran eggs. After first demonstrating in 1934 that T.evanescens adults were able to discriminate between the parasitized and unparasitized eggs of its host (Sitotroga cerealella), Salt proved in 1937 that this discriminating ability arose from the fact that parasitized hosts had been marked with a pheromone, while the females oviposited. Since the discovery of Salt, numerous other cases of pheromone-marking of oviposition sites have been reported (Prokopy, 1972; Prokopy et al., 1978 and Prokopy et al., 1982). Such pheromones or chemicals are known to play important role in the oviposition behaviour of growing number of insects (Prokopy, 1981 a and b and Prokopy et al., 1984).

The female insects may release some kind of pheromonal substances either associated with the integumentary or exocrine glands or with eggs laid. Behan and Schoonhoven (1978) demonstrated that in most case, the deterrent effect is mainly governed by a pheromone-like emanation associated in some way with the eggs. Most of the reports available on the oviposition deterring pheromone (ODP) indicated its secretion by the female insects either during or after oviposition (Yoshida, 1961; Umeya, 1966; Oshima et al.; 1973; Wasserman, 1981; Szentesi, 1981; Giga and Smith, 1985 and Sakai et al., 1986). The literature pertaining to the secretion of ODP by the male insects are also available (Oshima et al., 1973; Shaaya, 1981 and Szentesi, 1981).

Experiments were, therefore, undertaken to check whether any pheromone(s)/chemical(s) are associated with the eggs, males or females of L. serricorne, which could alter the behavioural traits such as attraction/repulsion and/or oviposition of the pest species. The salient features of the results of this investigation are highlighted as under:

The oviposition response of the adult females and the responsiveness (attraction/repulsion) of the different larval instars and that of adult males and females to the egg-washes prepared with different solvents are presented in Chapter - 2. The reduction of egg laying in the tobacco leaf-discs treated with egg washes demonstrated the association of an oviposition deterring chemical/pheromone with the eggs, which was in agreement with the reports of egg-associated oviposition deterring pheromone in many other insect pests (R. cerasi, Katsoyannos, 1975; Rhagoletis species, Prokopy, 1975; Prokopy et al., 1976; A. fraterculus, Prokopy et al., 1982; Agromyza frontella, Mcneil and Quiring, 1983; C. maculatus and C. rhodesianus, Giga and Smith, 1985 and C. maculatus, Messina et al., 1987). The L.serricorne egg-associated ODP may provide a new agent for controlling this pest species. The literature relevent to the oviposition deterring function of the male and female secretions (Yoshida, 1961; Umeya, 1966; Oshima et al., 1973; Wasserman, 1981; Szentesi, 1981; Shaaya, 1981; Giga and Smith, 1985; Messina and Renwick, 1985a; Sakai et al., 1986 and Messina

et al., 1987) revealed that, though general oviposition deterring pheromones are secreted from both the sexes; those from the females play the major role. The reduction of oviposition by both the males and females L.serricorne body-washes (Chapters 3 and 4) also demonstrate similar property. A very high ovipostion deterring influence of hexane and methanol female body washes (Chapter - 4) clearly proved its suitability for application as a potent oviposition deterrent. With reference to larval behaviour; it was observed that the larvae were deterred by the egg-washes, which demonstrated that a potent larval deterrent may be obtained by washing the eggs. However, this aspect deserves further detail and confirmatory experiments.

The literature pertaining attraction of the larvae to the male and female secreted pheromone(s)/chemical(s) is scanty. Scrutiny of data on L. serricorne larvae and adults responding to different male and female body-washes (Chapters 3 and 4) revealed that the larvae(especially the early instars) were attracted to the secretions of their adults. From the above results, it is clear that both the male and female beetles secrete some chemical(s)/ pheromone(s), which can profitably be used, especially those from females, as oviposition deterrent for the females and at the same time as baits to attract the larvae (early instars) into suitable traps, from where they can easily be suitably disposed. The present findings are similar to those reported by Mondal (1985), wherein he has

stated that the medium conditioned by T. castaneum males or females for short periods are attractive to its larvae. Additionally he has also shown that such media conditioned over a longer period were deterrent in effect. During the course of present investigation it was noted that the late instar larvae were deterred by the male and female body washes. The reasons behind such deterrence may be that the larvae of this stage avoid overcrowding and preferring unoccupied areas for pupation after sensing the areas marked by chemicals present in hexane body-washes.

The literature concerning pheromonal secretions of the L. serricorne (Burkholder, 1970; Coffelt and Burkholder, 1972; Chuman et al., 1979 a and b; Levinson et al., 1981; Levinson et al., 1983; Chuman et al., 1985 and Levinson et al., 1986) amply proved that female beetles secrete a sex pheromone. There are, however, no reports of any other secretions from the males. The oviposition deterrence and aggregation/dispersal of larval instars due to both the male and female body washes (Chapters 3 and 4) clearly demonstrated that chemical(s)/pheromone(s) having some other effects are also secreted by both the male and female beetles.

In regard to the suitability of the solvents for preparation of maximally effective body-washes of females, it was noted that the highest oviposition deterrent (93.31%) influence was obtainable with methanolic female body-wash, but the solvent itself was found to reduce deposition of

eggs to a noticeable extent. The second highest oviposition deterrence (82.02%) was observed with the hexane body-wash and that too, with very negligible effect due to the solvent itself. On this background it was thought desirable to undertake further detailed work with hexane female body-wash with respect to the oviposition deterring function. Hence, a dosimetric study of oviposition deterring activity of the female body-wash in hexane was undertaken. As was evident, there was linear relationship within the range of 5 to 10 FE, 15 to 25 FE and 30 to 50 FE between the dose-levels and oviposition deterring activity (Chapter - 5). Lowest dose 5 FE (female equivalents) led to 51.94% deterrence. At the highest dose of 50 FE full inhibition of oviposition was not achieved (92.86% deterrence was recorded). This might have been due to experimental errors. On the other hand, females may not find enough suitable crevices in the control samples alone. Another important factor might have been the limited space (9 cm diameter "choice dish") into which the pheromone diffusion could lead to oviposition perforce on "treated" samples. Perhaps a better control of oviposition may be obtained by employing such preparation under open laboratory or storage conditions, where stimulation of dispersion (Klijstra and Schoonhoven, 1987) will be possible.

The persistence of the oviposition deterring pheromonal property is of particular importance. Observations on persistence of the hexane female L. serricorne

body-wash are presented in Chapter - 6. The relevent literatures on persistence of oviposition deterring pheromonal activity shows that it may vary from a few minutes to few weeks (Katsoyannos; 1975; Prokopy et al., 1981 a and b; Schoonhoven et al., 1981; Prokopy et al., 1984 and Averill and Prokopy, 1987 a and b). The oviposition deterring activity of the hexane female L. serricorne wash was found to possess a high degree of persistence, some activity (about 26%) remaining even after 25 days. The different aspects of which are discussed in Chapter - 6.

That the female L. serricorne body is a rich source of the oviposition deterring pheromone and that the insect releases it only gradually was evident from the results with upto ten successive hexane female body-washes (Chapter-7). All the successive washes tested were found to be highly deterrent to the ovipositing females. It was noticed that the second wash was more effective than the first one. This might have been, in all probability, due to contaminants (excreta, etc.) in the first wash. Upto 7th wash, the activity was found to be more than 50% but thereafter it started to reduce, yet about 19% deterrence was evident with the 10th (last) wash.

It is evident from the pertinent literature on the perception of oviposition deterring pheromone in insects, that besides antennae some other organs i.e. tarsal hairs, maxillary and labial palpi, abdominal hairs etc. are responsible for the perception of oviposition deterring

pheromone (Ma and Schoonhoven, 1973; Katsoyannos, 1975; Mitchell, 1975; Bentley *et al.*, 1976; Behan and Schoonhoven, 1978; Prokopy *et al.*, 1982; Crajnar and Prokopy, 1982; Klijnstra, 1985; Klijnstra and Roessingh, 1986 and Messina *et al.*, 1987). The perception varies in different species of beetles. Ablation of antennae in *L. serricorne* proved that this organ is one of the principal sites of perception of oviposition deterring pheromone(s)/chemical(s) in this pest species (Chapter - 8).

During the course of work on separation of possible components by TLC methods, it became evident that the hexane female body-wash was having six different fractions (Chapter - 9). It was noted from separate bioassays of the six fractions that fraction No.6 was highly effective (60% deterrence). Fraction 1 and 2 also showed accountable oviposition deterring activity. These primarily deterrent functions of 1, 2 & 6 - fractions and the various combinations thereof in respect of oviposition deterrence were discussed in Chapter 9. Further, it was obvious that basically the oviposition deterrent was similar to sex pheromone of this beetle, as borne by earlier reports on sex-pheromone (Burkholder, 1970; Coffelt and Burkholder, 1972; Chuman *et al*, 1979 a and b; Levinson *et al.*, 1981; Levinson *et al.*, 1983 Chuman *et al.*, 1985 and Levinson *et al.*, 1986). It may, therefore, be suggested that the sex pheromone of the beetle, *L. serricorne* (F.) either as such or in its highly active fraction No.6 (serricorone) alone may be used as a potent oviposition deterrent agent

for the conspecific females. This new functional role of the sex pheromone of L. serricorne is an important and interesting addition and may provide new thinking among the entomologists to develop a safer biologically effective control measure for this pest. Finally, it may also be expected a similar case may exist in case of female-originated pheromones of other insect pests (both household and field) which is worthy of trial.

USE OF TRIBOLIUM CASTANEUM AS PREDATOR:-

A casual observation during the course of L.serricorne culture development was that an accidental entry of Tribolium castaneum (Hbst.) to the culture led to total destruction of the former. As early as in 1926, Chapman demonstrated cannibalistic tendency of T. castaneum. A report on egg cannibalism by Sonleitner (1961) stated that it is a spacific behavioural trait and not due to accidental egg eating. The pertaining literature on the general cannibalistic behaviour of T. castaneum (Rich, 1956; Park et al., 1965; Mertz, 1969 and Jacob and Mohan, 1973) prompted an investigation on the inter-specific relation between various stages of T. castaneum and L. serricorne in mixed cultures. It was interesting to note that the T.castaneum larvae and adults readily predate on L. serricorne eggs, larvae and pupae (Chapter - 10). In the light of present experimental results it is suggested that unmated or sterile female T. castaneum can be employed for the control of L. serricorne infestation in the stores of tobacco and spices

with no probability of increase in predator population or botheration of a secondary infestation.