INTRODUCTION
Insects are the most abundant form of animal life on earth and they are either useful or harmful to man. However, the harmful insects outnumber the useful ones and cause great economic loss by damaging and destroying agricultural crops, other valuable plants and stored foods. The control of the insect pests of man, domestic animals and food crops is a necessity. The methods used to combat insect pests commonly include the use of chemicals, biological controls, culture practices, mechanical devices, draining and filling (Davidson, 1966; Sathe and Sharma, 1977) and the legislative methods (Davidson, 1966). The chemicals for insect control are classified in various ways. A common method is to group them according to their type of action e.g. stomach poisons and contact poisons (insecticides), fumigants, attractants, repellants and chemosterilants (Davidson, 1966).

The most widely used method of insect control is through insecticides. However, their use has some drawbacks like the potential health hazards of insecticidal residue, the possible hazard to fish, wild life and livestock and the development of insect resistance or tolerance to the insecticides. According to Brown (1971) and Brown and Tal (1971), about 130 species of arthropods of agricultural and veterinary importance have shown resistance to insecticides and 102 species of medical importance, most of which are insects. Davies et al. (1958) and Georgiou (1971) also are of the
same view. According to Davidson (1974), insecticides are still important for control of insects but of more concern is their cost and the organisation required for their efficient application. According to Davidson (1974) problems created by the use of insecticides have induced the idea of genetically manipulated insects to control an insect population i.e. genetic control of insects.

Thus, an obvious alternative to controlling the insect populations by increasing the death rate usually attained by insecticides, is the control by decreasing the birth rate which can be achieved by hampering the reproductive potential of an insect; in other words, by inducing sterility in the insect. Exposure to ionising radiation or to certain chemicals are ways of deliberately sterilising insects and this is known as genetic or autocidal control (Davidson, 1974; Pal and Whitten, 1974). The advantage of the control of insects through sterilisation over the control through killing of insects is explained by Knipling (1960, '62) who made the first study of the characteristics of population decline after the release of irradiated males (1955). Knipling (1960) hypothesised that male sterility had greater impact in reducing insect populations than mortality i.e. the dynamics of a population are more strongly influenced by a sterile male than by a killed counterpart. This hypothesis led to the sterile male technique of insect control (Knipling, 1967). The potential role of sterility in insect control has been
discussed thoroughly by Borkovec, (1966, 1975) and Campion (1972).}

[Until 1958 the only usable method of inducing sterility in insects was by ionising irradiation (La Brecque and Fye, 1978). Unfortunately this procedure produced such serious damage to somatic tissue of many males, primarily the mid gut epithelium, that the viability and sexual competitiveness was hampered to the extent of preventing them from fulfilling their role as the disseminators of sterile sperm. This led to the search for chemicals that could sterilize without causing the same loss of sexuality. Since ionising irradiation induced sterilisation by causing dominant lethal mutations (La Brecque and Fye, 1978), the logical procedure was to discover chemicals that could produce such effects. This was not done until the early years of second world war (Davidson, 1974). Auerbach and Hobson (1947a, b) found that mustard gas produced mutations in Drosophila as well as affected fertility in insects. Rapport (1947) independently found that ethyleneimine was also mutagenic and it was from analogues of this compound — aziridines — that most of the modern insect chemosterilants are derived. Since 1960 interest in the potential of chemosterilants as practical insect control agents increased rapidly and within a few years numerous chemosterilants were identified. Foremost among them are aziridines and their derivatives (La Brecque, 1961, 1967; Knodel, 1962; Chamberlain, 1962; Crystal, 1963; Borkovec,
1966). They have been suggested as an alternative method of sterilisation where γ or X-ray irradiation has been proved too damaging to the species (Klassen et al., 1958). A large number of such chemicals affecting fertility now exist and act in different ways (Borkovec, 1968). However, according to Lachance (1967), all chemicals that induce dominant lethal mutations are chemosterilants but not all chemosterilants can produce dominant lethal mutations or any kind of mutation.

Campion (1972) and Davidson (1974) have divided the chemosterilants as antimetabolites, alkylating agents, organometals and JH analogues. According to Davidson (1974) most of the dominant lethal producing chemicals are alkylating agents i.e. substances producing carbonium (−CH₂) ions which in living tissue combine with some of the nucleic acids and proteins of the cell. This upsets the genetic code and leads to point mutations and chromosome breakage (Fahmy and Fahmy, 1964). The alkylating agents known so far are tena (tri-(1-aziridinyl) phosphine oxide), metena (tris (2-methyl-1aziridinyl) phosphine oxide), apholate (2, 2, 4, 4, 6, 6 hexakis (1-aziridinyl)-2, 2, 4, 4, 6, 6 hexahydro, 1, 3, 5, 2, 4, 6, tri-azatriphosphorine), tetramine, melamine etc.

Chemosterilants offer a number of advantages over irradiation sterilisation. They are relatively cheap and do not require expensive apparatus for their application. They can be applied in different ways, orally, topically, by
injection, by spraying, dipping or fumigation or by exposure of the insect to treated surfaces. One enormous potential advantage of chemosterilants is the possibility of their use in the field to sterilise wild populations (Davidson, 1974). The great disadvantage of alkylating agents is that their sterilising and mutagenic effects extend to higher animals, including man and that some of them at least are carcinogenic and even phytotoxic (Campion, 1972). Attempts to find safer chemosterilants have resulted in the discovery of non-alkylating analogues of tena and tretamine, viz. nemoa (hexamethyl phosphoramide or tris (dimethylamino) phosphine oxide) and nemei (hexa-methyl melamine).

Genetic methods of controlling insect pests fall under two categories (Pal and Whitten, 1974). These are (1) manipulation of the genetic composition of the pest population and (2) suppression of pest population through induction of high levels of genetic death. Both the categories involve in one or the other way, induction of chromosomal aberrations in a population. The most universally applicable method of causing high levels of genetic death is to introduce a large number of structurally abnormal chromosomes into a population so that the chance is high, that the development of any given embryo will be aborted due to the chromosomal imbalance. Chromosome aberrations can either be induced (by chemical treatment or irradiation) every generation and introduced into the field, such as in the sterile male techniques (Knipling, 1955); or
in various forms of baiting with chemosterilants (Whitten and Morris, 1967), or they can be propagated in the rest population for several generations through inheritance of chromosome rearrangements such as translocations (Serbyskovski, 1940; Cuffins and Hill, 1971; Whitten, 1971) or compound chromosomes (Foster et al., 1972). Dominant lethal mutations are not point mutations but chromosome breakage (Davidson, 1974). However the mutagenic property of alkylating agents was discovered earlier (Auerbach and Hobson, 1947a, b) than their chromosome breaking properties (Kihlman, 1966). Chromosomal aberrations are frequently associated with high sterility and thus may be potentially useful as a method of genetic control.

A review of the literature on the subject shows that work on the effect of chemicals including chemosterilants on sterility, reproduction, induction of mutations etc. is much more elaborate than that on the induction of chromosomal aberrations. Sterilization of various insects by chemicals including chemosterilants has been studied by different workers like Labrecque (1961, '63); Labrecque and coworkers (1965, '66) in houseflies; Knipling (1962); Chamberlain (1962) and Crystal (1963) in screw worm; Borkovec (1962, '75); Borkovec and coworkers (1968a, b, '72); Burden and Smittle (1963); Dame and Ford (1964); Lindquist et al. (1964); Chang and Borkovec (1964, '72); Magasawa and Shirahara (1964a, b, '66); Magasawa and coworkers (1974); Mustafa and Aida (1964);
Young and Cox (1965); Young and Snow (1967); Glancey (1968); Miller (1965); Guye et al. (1965); Eddy et al. (1965); Keiser et al. (1965); Hussein (1966); Haynes et al. (1966); Harries and Froster (1966); Sivahani (1966); Toppozada and Bidefawad (1966); Maeda and Yoshida (1966); Persad and Haidu (1966); Saito (1966); Sakakibara (1966); Solomon (1966); White (1966); Luch and Happinger (1967); Harding (1967); Richardson (1967); Grover and Millai (1967); George and Brown (1967); Hedin et al. (1967); Meifert et al. (1967); Soto and Graves (1967); Flint et al. (1968); Ladd (1968); McLaughlin and Simson (1969); Volcovic and Guron (1968); Hamilton and Hutter (1969); Seifet et al. (1969, 1970); Kaur and Stove (1969); Takayama et al. (1969); Zaker and Smith (1970); Maksakaram (1970); Kadallah and Stafford (1971); Deavers et al. (1971); Narwalkar et al. (1971); Sadhukar et al. (1971 a, b); Pollock (1971); Williams and Kuitert (1971); Demilo et al. (1972); Feliciangeli (1972); Hoffman and Dickerson (1972); Terry et al. (1972); Wolfenbarger et al. (1972); Ansari (1973 a, b, c); Aschenko and Oleschchenko (1973); Flint et al. (1974); Jones (1974); Zakhareva and Lure (1974); Moore and Taft (1975); Geman et al. (1975); Jhan and Auresi (1975); Ahmad (1975); Kududa and Haidu (1976); Maneshari and Jungal (1977); Sneikher et al. (1977); Math et al. (1978) etc.

The effects of various chemicals including aziridines on longevity, reproduction, egg viability and hatching etc. have been studied by Morgan and Labrecque (1962, 1964);
Kilgore and Painter (1964); Painter and Kilgore (1967); Abasa (1968); Cline (1968) in houseflies; Burden and Smittle (1963); Saxena and Aditya (1969, '71, '74); Rath et al (1975, '76, '77, '78); Tandon (1977); Bhargava et al (1977); Mittal et al (1978); Channani et al (1981); Banerjee and Banaei (1983) in orthoptera and by Cantwell and Henneberry (1963); Hadi (1964); Schwartz (1965); Croigton et al (1966); Hataway (1966); Henneberry and Kishaba (1966); Ladd (1966); Smittle et al (1966); Chang et al (1967); Hedin et al (1967); Jalil and Morrison (1969); Sharma and Hadi (1969); Taber and Borkovec (1969); Turner and Maheswary (1969); Iba and Hirano (1972); Abdel Mageed and Zidan (1973); Landa and Metwally (1973); Sukumar and Saidu (1973, '75, '77); Harwalkar and Kahalkar (1974); Mallik and Galley (1974); Rawat and Sharma (1976); Sharma and Mann (1978) etc. in various other insects.

Mutations and chromosome damage induced by chemicals including aziridines have been reported in animals by Gattanach (1966); and Schling (1968) in mice; Bird (1950); Fahmy and Fahmy (1957); Henneberry et al (1967); Bishop and Lee (1959) and Bertha (1969) in Drosophila and Palmyquist and Lachance (1965); Jenkins (1967); Beavers et al (1971) in other insects.

Cytogenetic effects on insect tissue have been largely ignored by the majority of researchers involved in insect control by chemosterilizing males. However, a few investigators
like Fahmy and Fahmy (1954); Sandler and Hirazumi (1960); Lyon and Meredith (1964); Sai (1964); Sugai and coworkers (1965, '73); Alexander and Glanee (1965); Curtis (1968); Lachance (1968, '69); Pillai and Agrawal (1969); Grover et al. (1971, '72); Whitten (1971 a, b) and Foster et al. (1972); have fortunately contributed significantly to keeping such investigations abreast of other developments.

Chromosomal aberrations in animals induced by different chemicals other than chemosterilants have been studied by Barber (1943) in newts; Hagquist (1948) in frogs and Hsu and Somers (1961); Somers and Hsu (1962); Derris and Whitefield (1967); Mukherjee (1968); Reddy and Rao (1969); Rao et al. (1969); Manna and Das (1972); Roy and Manna (1980); Roy (1982); and Chatterjee (1982) on rats.

The same kind of work in insects, mostly grasshoppers, has been done by Sambiar (1955); Gupta and Diakaran (1960); Sharma and Sharma (1960); Rao (1960); Ray Chaudhuri (1961); Manna and coworkers (1964 a, b); 1965 a, b; 1966 a, b; '67, '68, '70, '71 a, b; '72); Dasgai and coworkers (1966, '71); Lobbecke (1967); Wilson (1967); Jain (1967); Herichova (1968); Markowitz and George (1969); Muller et al. (1971); Bhunya and coworkers (1971, '73 a, b; '74); Parida (1972, '73); Abdul Kahiman and Rajasekharasetty (1972, '73); Saha (1973, '78, '79, '80, '81); Saha and Chatterjee (1973, '74); Saha and Khudabaksh (1974, a, b, c); Saha and Chattopadhyay (1978, '79); Saha and Sircar (1980); Pati and Bhunya (1973);
Chromosomal aberrations induced by chemosterilants have been reported by Chang and Lequin (1967); Chang and Klassen (1968) in human cells and Sram et al. (1970) Sturelid (1971); Manna and Das (1973, '76a, b; '77); Das and Manna (1974, '75); Tariq's (1976); Banerjee and Manna (1982); and Gill and coworkers (1982) in rats and mice.

Chromosomal aberrations induced by chemosterilants in insects has been reported by a few workers like Hsi (1964); Nathanayake et al. (1967); Todano and Kitzmiller (1969); Klassen et al. (1969); Bishop and Williams (1973); Grover and Pillai (1973); Mazzini (1975); Pandey (1982, '83); Pandey and Banerjee (in press).

Observations on effect of chlorinated hydrocarbons and other pesticides on reproduction, chromosomes or their mutagenecity is very scanty. These have been reported by a few workers only like Bones and Ham (1969); Reddy and Reddy (1974); Matveeva et al. (1974); Zetter and Locato (1974); Clark (1975); Mishra (1980); Bhunya and Jas (1976); and Hao (1977).
Evidences cited above clearly indicate that the effect of various chemicals including chemosterilants on reproduction, induction of sterility and mutation etc. has been enormously worked out in insects as well as vertebrates, specially mice. Cytogenetic studies, particularly chromosomal aberrations induced by chemicals is quite scanty. Similarly, effect of chlorinated hydrocarbons on induction of mutation and sterility has been studied by a few workers, but again, observations on their effects on chromosomes are almost negligible as far as the author is aware of.

Thus a survey of the entire literature relevant to the subject as given above as well as the fact that chromosomal aberrations induced by radiation or chemicals are frequently associated with high sterility which may be potentially useful as a method of genetic control as has been stated above, point to the necessity of critical observations on the induction of chromosomal anomalies in some insect pests. As chemosterilants and chlorinated hydrocarbons have been worked out only by a few workers as far as their effects on chromosomes is concerned, these chemicals have been chosen for the study. Moreover, the literature cited clearly indicates that most of the work which has been done on this aspect is on grasshoppers and very little on insect pests like Callosobruchus chinensis, Larius faba and Pyderococ similia. It was therefore thought worth while to investigate the induction of chromosomal aberrations by chemosterilants in
In the adult stadium of an insect gametogenesis is a continuous process in both sexes for the duration of their reproductive life span. Also, the reproductive cells are in a constant stage of proliferation unlike the majority of somatic cells where little or no development occurs following adult eclosion, except for enlargement or improved function. Moreover, spermatogenesis is a more steadier process than oogenesis where different stages of division may not be clearly visible during the development of oocytes. Keeping all the above in view it was decided to proceed with the study of testicular (spermatocyte) chromosomes in detail although at some stages somatic tissue has also been studied. It is also known that sterility can be induced by many methods of applications of the chemosterilant against stadia that have reproductive organs, whether these organs are primitive or highly advanced (LaBrecque and Fye, 1978). In the present investigations, therefore, different stadia of insects have been treated with different suitable methods like feeding, dipping, topical application, fumigation or injection in microlitre doses.
The chromosomal aberrations produced by chemosterilants or chlorinated hydrocarbons may be attributed to the damage in the gonads or their abnormal or malignant growth as the germ cells become affected. To observe the extent of this damage and abnormality, the gonad (testis) has been also studied histologically, particularly at those doses of the chemicals where the chromosomal aberrations have been more frequent.