CHAPTER I
GENERAL INTRODUCTION
The armyworm *Mythimna* (*Pseudalatia*) *separata* (Walker) belonging to the Order Lepidoptera and Family Noctuidae is a major pest on many agricultural crops viz., jowar, maize, wheat and paddy. Besides barley, millet, oats, turnips, beans, rye and tobacco also serve as alternate secondary host plants (Grist and Lever, 1969). It is a notorious agricultural pest in India (Fletcher, 1917) and other Asian countries, USSR, Australia, New Zealand and Pacific Islands (communicated by Commonwealth Institute of Entomology, London). Its infestation appears epidemically both in kharif and rabi seasons in India (Kalode et al., 1972) on jowar and maize (Bindra and Rathore, 1965, Kundu and Premkishore, 1971, Neelgund and Mathad, 1972) on wheat (Bindra and Rathore, 1965, Sarup et al., 1969; Sandhu, 1974) and paddy (Grist and Lever, 1969; Sarup et al., 1969; Kalode et al., 1972). The larval stage of the armyworm being nocturnal, it feeds voraciously at night on the green foliage of sorghum leaving behind only the bare midrib of the leaves. But during the daytime it hides in the whorls of the plants to avoid the high intensity of light. Its damage to wheat is by defoliation (Sarup et al., 1969) and to paddy, by cutting the base of earhead of panicles leading to heavy loss in agricultural yield (Krishnaiah et al., 1980). Its devastation to paddy crops has led to great economic loss in the yield, and therefore, is regarded as a major paddy pest of importance in Madhya Pradesh, Orissa and Uttar Pradesh (Katiyar and Patel, 1969, Kulshreshta et al., 1970, Satpathy,
1978) and as a major wheat pest in the states of North India (Bindra and Rathore, 1965; Sarup et al., 1969; Bindra and Singh, 1973, Verma and Khurana, 1973). The armyworm infestation prevails from July to November reaching its peak density during August (Kulkarni et al., 1974). In recent years, it is reported that the devastation on sorghum and maize was to the tune of 40-60% in 1986-’87 (Anonymous, 1987), 36-76% in 1987-’88 (Anonymous, 1988) and 32-68% in 1988-’89 (Anonymous, 1989). Consequently, it has caused heavy loss in yield and hence deserves the serious attention for its control. Its outbreaks are generally associated with the prolonged drought or dry weather, followed by heavy rains (Laurent, 1915, Ghosh, 1924; Smith and Caldwell, 1948, Butani, 1955; Puttarudraiah and Usman, 1957). The long distance migration of adult armyworms (Oku and Koyama, 1976), and disruption of the delicate balance with their natural enemies, may be other reasons for the armyworm outbreaks.

The pest management would only be effective by keeping a check on the growth of pest population and maintaining the same to a level below the economic loss. Despite various agents currently used, the practice of synthetic organic insecticides and biological agents viz., viruses, bacteria, parasites and predators have assumed varied importance. The efficacy of either agent is time tested considering its merits and demerits. In fact, synthetic insecticides undoubtedly offer immediate control of the pest. The development of...
resistance and pest resurgence have become great impediments in the widely accepted insecticidal control method. But the insecticidal residues, their dissipation in the ecosystem, non-specificity, non-biodegradability of certain insecticidal compounds, high cost of production etc., discourage the use of insecticides. Despite the above-mentioned demerits the pyrethroid compounds like fenvalerate are presently gaining wide acceptance as potential insecticide due to their unique properties like selective toxicity, increased permeability through cuticle, and low mammalian toxicity (Casida et al., 1983). Further, pyrethroids similar to DDT and other organophosphorous insecticides are known to act on the central nervous system (CNS) to cause knock-down effect (Narahashi, 1976). The insecticides greatly alter body functions apparently mediated through the hormones (Samaranayaka, 1974). The studies on <i>S. littoralis</i> showed the effect of chlordimeform on larval and post-larval stages leading to increased mortality, abnormal pattern of egg laying and lower fecundity (Salvisberg et al., 1980). But the sublethal concentrations of permethrin, fenvalerate and carbaryl caused the latent toxicity and deformed wings in the adults of <i>P. xylostella</i> (Kumar and Chapman, 1984). Lomte and Patil (1988) have demonstrated that the stress would result due to malathion, endosulfan, carbaryl and copper sulphate in <i>M. separata</i>. This led in hormonal imbalance through cyto-architectural changes in the ventral neurosecretory cells.
Thus it is pertinent to mention that the secretion of neurohormones during physiological stress or excitations would greatly modify the body functions. The studies on *Mythimna convecta* and *Persectinia ewingii* have shown that relatively pyrethroid compounds are more toxic than DDT (Goodyer, 1982). Pyrethroids having -CN-functional group also known to affect the respiratory rate in spider mite (Mckee and Knowleds, 1984). Fenvalerate [(RS)- α,α-cyano-3-phenoxybenzyl-2-(4 chlorophenyl)-2-methyl butyrate], a -CN- containing synthetic analogue might also affect the respiratory rate besides nerve poisoning.

Considering the demerits in chemical insecticidal control the search for alternative tool for pest control was probed by utilising the natural enemies of the pest viz, parasites, predators, bacteria, viruses etc. Much knowledge has been accumulated on biological control of pests during the recent years. The control of pests through parasites and predators has received wide acceptance in case of certain insects. But the broad based specificity and longer incubation period would cast the short sighted benefits. Therefore, this method of control will work out until other better, effective and confirmed, long term control method would attract the attention. The armyworm has a range of many parasites (belonging to the orders Hymenoptera and Diptera) infecting the larval stage. Some parasites are as follows: *Apanteles ruficornis* (Pradhan, 1971; Sharma et al., 1982), *Disophryes*
albipilosellus (Anonymous, 1981), Exorista xanthopsnis (Sharma et al., 1982), Metopius sp. (Sharma et al., 1982), Palexorista solemnis and Palexorista sp (Sharma et al., 1982) and Rosar sp (Anonymous, 1982). Surprisingly, a flagellate Herpetomonas infects both larval and adult stages of the armyworm (Malone et al., 1985).

It is well documented that the insect pathogenic viruses cause natural epizootics in insect populations. The significant mortality due to nuclear polyhedral virus (NPV) in Lymantna dispar (Glasser and Chapman, 1913, Koyama and Katagiri, 1959) offer typical example. The baculoviruses and granulosis viruses (GV) infect and multiply in the target tissues of the host insects. They are effective against the specific hosts. Moreover, relatively their low cost of production, easy application methods and least ecological hazards have promoted the general acceptance of these viruses as potential biocides (Summers and Smith, 1975; Tinsley, 1975; WHO, 1973, Tinsley and Harrap, 1978). Whitlock (1977) demonstrated clearly in Heliothis armigera the failure to develop resistance against NPV and GV over 22 consecutive generations. However, the longer incubation period of pathogenesis may impede in the short term control of the pests. But pathogens are potentially capable to change their genetic constitutions and thereby offer counter tolerance to the host responses (Burges, 1971). Thus the NPV presents a
unique and additional advantage for viral control of
M. (P) separata (Neelgund, 1977)

Amongst the viruses described in insects NPVs alone account as much as 41% (Ignoffo, year not mentioned) Neelgund and Mathad (1972) reported for the first time the occurrence of nuclear polyhedrosis virus in M. (P.) separata Later investigations on NPV during the preceding decades have enriched our knowledge in using them intelligently as potential biological pesticide (Thompson and Steinhaus, 1950, Steinhaus, 1954; Tanada, 1959, Hall, 1963, Mathad, 1973; Mathad and Neelgund, 1973) It is predicted that the NPV is quite efficient in replacing the chemical insecticide (Bird, 1955, Tanada and Reiner, 1962) and safe to man and other animals (Heimpel, 1971, Ignoffo, 1973) It is reported that the armyworm M. (P) separata also suffers from nuclear polyhedrosis (Neelgund and Mathad, 1972) The NPV of the armyworm is a multiple embedded type of DNA virus belonging to the genus Baculovirus These viruses are obligate pathogens propagating only through the living tissues of their host insects but unhazardous to non-target pests

The various aspects of the work on NPV of the armyworm is being extensively conducted in our laboratory since 1972 Some of these important and relevant aspects conducted here are cited as follows

Neelgund (1975) made a systemic study of the armyworm with reference to its detailed life history An artificial
diet was devised for mass rearing the insects in laboratory. The studies showed that the susceptibility was directly proportional to the viral concentration but inversely proportional to the larval age. The NPV demonstrated the transovum and transovarian transmission, besides it was also infective to both the pupal and adult stages. The laboratory investigations corroborated with the small scale field trial results which confirmed that the armyworms could be effectively controlled by its own nuclear polyhedrosis.

Some interesting investigations were made by Vijayakumar (1979) to test the toxicity/pathogenicity on albino rats (in accordance with WHO/FAO 1973 Guidelines). The experiments were involved of acute-oral toxicity/pathogenicity, chronic-oral toxicity/pathogenicity, dermal allergenicity, eye irritation test, effect of gastric juice on the virulence of NPV and stability of albino rat passed NPV. It revealed that NPV was safe to albino rats.

Studies undertaken by Manjunath (1980) were to understand the influence of environmental factors on NPV infectivity of pure and crude NPV exposed to sunlight, infectivity of pure NPV irradiated by UV light from a mercury lamp, the influence of certain materials on the stability of NPV exposed sunlight, temperature tolerance and thermal activation of pure NPV and stability of crude NPV in soil. The results revealed that the tolerance to temperature was retained even at temperature prevailing in temperate and tropical regions.
crude virus retained its stability despite its preservation for 72 weeks in black soil.

Dhaduti (1981) conducted experiments on the safety tests of NPV of the armyworm *M. separata* on beneficial insects like mulberry silkworm *Bombyx mori*, eri silkworm *Philosemia ricini*, tassar silkworm *Antheraea mylitta* and honey bees *Apis Cerana indica*. Curiously enough the NPV was found to be quite safe to all these beneficial insects.

Savanurmath (1982) demonstrated that the simultaneous and sequential treatments of NPV with chemical insecticides (like endosulfan, fenitrothion and fenvalerate) at certain concentrations produced synergistic action. The results indicated a greater value in understanding their incorporation in the integrated control of armyworm *M. separata*.

The investigations on histopathological and biochemical studies in the late instar armyworm infected with NPV were undertaken by Shreesam (1985). The experiments were also involved to understand the combined action of NPV with endosulfan and NPV with fenitrothion. The results indicated that the fat body, tracheal matrix, hypodermis, hemolymph and hypodermal glands were the principal tissues of NPV multiplication. Besides other tissues such as Malpighian tubules, cerebral complex and thoracic ganglion also showed secondary infection. The epithelial linings of the foregut, midgut and hindgut and gonads were also not spared from infection, but not extensively. The glycogen, neutral lipid...
and phospholipid were decreased, whereas the insoluble and soluble proteins increased during the advanced stage of nuclear polyhedrosis. It is a common observation that the virus invasion into the host leads to impairment in food intake capacity of insects. Moreover, the susceptibility of the larvae of *M. (P.)* separata to NPV infection inversely varies with the age (Neelgund and Mathad, 1974). Therefore, to achieve the effective pest control the virus applications have to be made inevitably at an early stage in the infestation (Daoust, 1974). The altered physiopathology of insects utilize proteins, carbohydrates and lipids differently during nuclear polyhedrosis for the formation of viral inclusion bodies, and growth and development of the host insects (Rajmohan and Jayraj, 1976, Shreesam, 1985). Naturally the host metabolites serve as the structural components and as energy sources for the viral multiplication. Since polyhedron coat of the virus inclusion bodies is made of 95% protein (Bergold and Friedrich-Frieska, 1947), the protein metabolism of the armyworm gets suitably modified to meet the requisites of the viral multiplication in the host tissues. It is quite essential to understand the variations in host physiology to determine the stress or critical period which enables for proper integration of different control methods. The altered pathology due to NPV in various insects have shown delayed larval period, lower fecundity, low percentage of pupation and adult emergence, decreased egg hatchability, decreased body
weights of different stages and structural abnormalities such as shrunken body, decolourisation of cuticle and wing deformities (Neelgund, 1977, Vail and Hall, 1969; Whitlock, 1977). It is quite apparent that these morphological deformities would stem from altered functional changes of the different target tissues like fat body, hemolymph etc., as observed in the insects (Pawar and Ramkrishnan, 1977, Narayanan et al., 1979, Shieronsris et al., 1979).

The larval-pupal and pupal-adult metamorphosis interrupts viral multiplication and results in the significant pupal mortalities as observed in Galleria mellonella (Stairs, 1965). And studies on S. littoralis depicted the decreased fecundity and per cent egg hatchability and many structural abnormalities (Klein and Podoler, 1978). The larval-pupal and pupal-adult metamorphic processes involved many biochemical changes followed by structural and functional changes in the insects. So it is intended to observe the persistent effect of NPV in pupa and adult stages following the larval infection.

The biochemical studies in M. (P.) separata were conducted in the late instar larvae (Shreesam, 1985) as in other insects. It was indicated that the physiological responses were directly related to the viral or insecticidal concentration but inversely varied with the larval age. The maturation immunity or the resistance also influence the physiological stress or critical periods in the metabolism which appear as
pronounced effects of NPV pathogenicity or insecticidal toxicity more in the young susceptible larval stages. So the studies were intended on the third instar armyworm larvae. Eventually, the changes in perchloric acid precipitable (PCA) proteins, glycogen and total lipids of the primary tissues of infection indicated the general depletion during the NPV infection (Ingalhalli, 1987). Moreover, much of the knowledge at hand was concentrated mainly on the major metabolic centers such as fat body and hemolymph. But the profile of variation in proteins, carbohydrates and lipids during the nuclear polyhedrosis or fenvalerate toxicity would invoke the probable physiological / metabolic weak-links. Ultimately, the survivability of the insect depends upon the interaction of the diverse factors viz., metabolic changes with respect to proteins, carbohydrates and lipids in the metabolic centers, functional status of the afflicted tissues, detoxification processes, development of resistance against the insecticides and viruses etc., in the whole body of the insects.

Therefore, the present investigations were intended to concentrate on the comparative study of variation of proteins, carbohydrates and lipids due to fenvalerate toxicity and NPV pathogenicity during larval test period and pursue their effects on the surviving pupal and adult stages. The concentrations were as follows:

a. Fenvalerate at sublethal LC10 and LC25 concentrations, and at LC50 lethal concentrations, and
b. NPV at sublethal LC_{10} and LC_{25} concentrations, and at LC_{50} lethal concentrations

The studies also involved the understanding of possible relation between the body weight changes and variations in the metabolites caused by NPV pathogenicity and fenvalerate toxicity. The results obtained in the afore-mentioned investigations were analysed and discussed in the light of the available literature.