A number of insect pests attack apple and other trees of horticultural importance causing serious damage and rapid fall in fruit yield and inflicting thereby a heavy financial loss to the horticulture industry in J and K. In view of the devastation due to insect infestation, a general survey of various fruit orchards of Kashmir valley as well as its high altitude areas was conducted from 1982-1984 to assess the incidence and distribution of pests associated with apple and other fruit trees in the region. During such studies, 38 insect pests were collected and, of these, four insect pests namely Archips subsidiaria, Pandemis dryocestae, Boarmia selenaria and Lyonetia clorkella were found to be quite serious, inflicting substantial damage to apple trees in Kashmir. Whereas the former two belong to the family Tortricidae, the third comes under Geometridae and last is included in Lyonetiidae of the order Lepidoptera. Different species of these four genera have been reported by various authors as destructive pests of fruits, vegetables and forest trees from all over the globe (Gilliat, 1930 and 1932; Janjua, 1940; Wheatley, 1963; Abassa, 1972; Kuroko, 1964 and Sekita and Yamada, 1979).

Larvae of Archips subsidiaria and Pandemis dryocestae were found feeding on apple, quince, rose, plum grapes, willow, hawthorn...
and cherry trees. *Boarmia selenaria* larvae cause heavy damage to the foliage of apple, plum, rose, mulberry, beans and maize whereas *L. clerkella* larvae mine into the foliage of apple, quince, cherry, hawthorn and birch causing severe defoliation.

Almost very little work has been done on biology and control measures of these four pests in Kashmir. Therefore studies on their biology and control measures were carried out in the laboratory during present investigation.

**PART - I - BIOLOGY**

1. **ARCHIPS SUBSIDARIA** Meyrick.

The biology of *A. subsidaria* was studied in the laboratory under 23°C ± 1°C temperature and 60-70% relative humidity and the whole life cycle took 78 to 99 days. Preoviposition period was found to be 2-3 days and each female laid 230-260 eggs over an oviposition period of 7-9 days. Eggs were laid in masses during nights. In the field, eggs were normally deposited in protected places of the main tree trunk and its branches. In the laboratory, however, entire oviposition took place on the walls of rearing jars. An egg is oval, flat at base, green in colour
and measures 1.14 mm to 1.17 mm in length and 0.75 mm to 0.78 mm in breadth. The incubation period varied from 8-11 days. The larval stage of *A. subsidaria* consists of five instars as determined on the basis of exuviae. It was further confirmed by the gradual increase in the body length and head capsule width. The body length in I, II, III, IV and V instar larvae averaged 3.12 mm; 4.94 mm; 6.37; 11.70 mm and 17.94 mm whereas corresponding head capsule width was 0.33 mm; 0.49 mm; 0.93 mm; 1.28 mm and 1.58 mm respectively. Each proleg has 9-10 crochets in I instar, 17-18 crochets in II instar, 30-32 crochets in III instar, 40-43 crochets in IV instar and 58-59 crochets in V instar. The total larval period ranged from 29-36 days in the laboratory. First instar lasted for 3-5 days, II instar for 5-6 days, III instar for 5-7 days, IV instar for 7-8 days and V instar for 9-12 days. The larvae prior to pupation pass through the prepuetal stage which lasts for 2-3 days. Mature larvae construct very thin cocoons in tied or rolled leaves. The pupation takes place in rolled leaves or on the floor of rearing jars. Pupae are obtect, cylindrical, tapering posteriorly and measure 8.6 mm to 12.3 mm in length and 2.5 mm to 3.1 mm in breadth. The pupal period lasted for 12-14 days. Male moths of *A. subsidaria* have a longevity of 11.5 days while the female moths lived for only 8 days when fed on 10% sucrose solution in laboratory.
It has two generations in a year and overwinters as young larvae in protected places in Kashmir.

2. **Pandemis Dryoxesta** Meyrick

The whole life cycle of *P. dryoxesta* took 78-109 days under laboratory conditions, i.e. 23°C ± 1.0°C temperature and 60-70% relative humidity. The moths were observed to start mating after 12-24 hours of adult emergence and the oviposition took place during nights. Each female laid 150-220 eggs during its oviposition period of 3-6 days. In the laboratory, entire egg laying took place on the walls of rearing jars.

Eggs are oval, green in colour, flat at base, measuring 1.04 mm to 1.14 mm in length and 0.67 mm to 0.78 mm in breadth. Incubation period was found to be 10-14 days. There are five larval instars in *Pandemis dryoxesta* also. The body length in I, II, III, IV and V instar larvae averaged 2.52 mm; 4.55 mm; 7.54 mm; 15.21 mm and 18.85 mm respectively whereas the corresponding head capsule width was 0.25 mm; 0.44 mm; 0.67 mm; 1.11 mm and 1.48 mm respectively. Each proleg bears 8-11 crotchets in I instar, 14-17 in II, 28-29 in III, 38-42 in IV and 50-52 crotchets in V instar. The total length of larval life of *P. dryoxesta* was observed to be 32-38 days in laboratory. The duration
of immature stages was determined to be 4-5 days for I instar, 8-9 days for II instar, 7-9 days for III instar, 6-9 days for IV instar and 10-11 days for V instar. The larvae prior to pupation pass through prepupal stage which lasts for 1-2 days. In the laboratory, pupation takes place in rolled leaves or on the floor of rearing jars. The pupa is oblong, cylindrical and measures 7.6 mm to 9.3 mm in length and 2.2 and 2.9 mm in breadth and the pupal stage lasted for 10-15 days. Males lived for 14.5 days and females lived for 11 days when fed on 10% sucrose solution.

In Kashmir, *P. dryoxesta* passes two generations in a year and overwinters as young larvae.

3. **BOARMIA SELENARIA** Schiffermuler.

The adults of *B. seilenaria* became sexually mature 12-18 hours after emergence from pupae. Mating took place during first or second night after emergence. Preoviposition period was observed to be of 1.5-2.5 days duration. Eggs are laid singly or in large batches and each female laid an average of 258 eggs, ranging from 196-320, during its 9-13 days of oviposition period. In the laboratory, females usually laid the eggs indiscriminately on the leaves, buds, crevices of twig and floor of rearing jars. The egg is oval,
pale green in colour and measures 1.69 mm to 1.79 mm in length and 1.34 mm to 1.44 mm in breadth. Incubation period for the eggs of _B. selenaria_ was found to last for 9-14 days. There are five larval instars which are differentiated on the basis of their exuviae and size. The body length in I, II, III, IV and V instar larvae averaged 2.34 mm; 6.27 mm; 8.45 mm; 12.22 mm and 20.15 mm respectively whereas the width of head capsule measured 0.33 mm; 0.61 mm; 0.89 mm; 1.22 mm and 2.52 mm respectively. Total larval period ranged from 32-41 days with an average of 36.5 days. The first instar lasted for 5-6 days, II for 6-8 days, III for 5-6 days, IV for 7-8 days and V instar lasted for 9-13 days. When the larva is mature, it stops feeding, shrinks in size, changes its colour and is transformed into prepupal stage which lasts for 1-2 days. In the laboratory, pupation takes place in soil when provided or else on the floor of rearing jars. The pupal stage took 10-14 days and the pupa is obtect, cylindrical, dark brown in colour and narrowing at the posterior end. It measures 10.5 mm to 13.6 mm in length and 4.06 mm to 5.00 mm in breadth. Males of _B. selenaria_ lived for 10-14 days and females for 8-9 days when fed on 10% sucrose solution.

In Kashmir it passed two generations in a year and overwintered as pupae.
4. **LYOMETIA CLERKELLA** Linnaeus

The whole life cycle took 46.5 to 61.5 days in the laboratory at 21 ± 1°C temperature and 50-60%, relative humidity. The preoviposition period was found to be 1.5 to 2.5 days in the laboratory. Each female laid 100-132 eggs over an oviposition period of 4-5 days and entire egg laying took place during night. Eggs are invariably laid singly in the leaf tissue, just below the upper epidermis, from lower side of the leaves. The incubation period was noted to be 8-11 days with an average of 9.5 days. Egg is small, oval, semitransparent and whitish green in colour. It measures 0.32 mm to 0.38 mm in length and 0.22 mm to 0.24 mm in breadth. The larva of *L. clerkella* does not leave its mine before it fully matures. It moult twice in the mine and has three larval instars. First instar is transparent green in colour, lacking abdominal legs and measures 1.51 mm in length and 0.18 mm in breadth. Second instar is also light green in colour, dorsoventrally flattened and measures 2.48 mm in length and 0.29 mm in breadth while the third instar is dark green in colour and measures 4.86 mm in length and 0.55 mm in breadth. The abdominal legs are fully developed in II and III instar larvae. The larval period ranged from 13-16 days. The first instar lasted for 3-4 days while the second instar took 4-5 days and third
Inetar took 6-7 days. When larva is mature it leaves its mine through upper epidermis by cutting it at one end and spins its hammock shaped cocoon usually on the lower side of leaves. In laboratory, the cocoon formation took place in jar corners and it took 25-30 minutes for making a cocoon. Pupae are spindle shaped and yellowish green in colour. Male pupa measures 3.30 mm in length and 0.59 mm in breadth whereas female pupa measures 4.00 mm in length and 0.72 mm in breadth. L. clerkella males lived for 7-8 days and females lived for 5-7 days in the laboratory when fed on 10% sucrose solution.

In Kashmir L. clerkella has four generations in a year and winter is passed in adult stage under protected places.

PART - II CONTROL

(A) CHEMICAL CONTROL

Last instar were selected for testing the efficacy of four insecticides namely: Aldrin, Metasystox, Parathion and Sevin. Aldrin and Metasystox were tested against A. subsidaria and Pandemis dryocusta.; Sevin, Parathion and Metasystox against Boarmia selenaria and Metasystox, Parathion and Sevin were examined against
Lyonetia clerkella. For the first three pests namely A. subsidiaria, P. dryoxesta and B. selanaria, each insecticide was sprayed in its solution form in different concentrations on host plant leaves that were fed to the experimental larvae. The mortality observations were recorded after every 24 hours up to a maximum of 48-72 hours. In case of L. clerkella each leafy twig containing 15 larvae in the mine was used for each experiment in laboratory. After spraying, the mortality was observed after 24, 36 and 72 hours by carefully cutting open the mine to examine thoroughly as to whether the larvae were dead or alive.

The LC 50 values for Aldrin and Metasystox were calculated to be 0.031% and 0.085% respectively while LD 50 values were found to be 0.17 ug and 0.18 ug per larva respectively in case of A. subsidiaria. The results showed that Aldrin is relatively more effective than Metasystox in A. subsidiaria. In P. dryoxesta Metasystox proved slightly better than Aldrin as the LC 50 values were observed to be 0.050% and 0.059% relatively while LD 50 values were calculated to be 0.16 ug and 0.15 ug. The LC 90, LC 100, LD 90 and LD 100 values for two insecticide however show that Aldrin is more toxic than Metasystox to P. dryoxesta. And as such, it may be concluded
that both these insecticides can be successfully used against *P. dryoxesta*. In *Boarmia selenaria* the LC 50 values for Aldrin, Metasystox and Sevin were observed to be 0.088%, 0.11% and 0.14% respectively while the LD 50 values were calculated as 0.40 ug, 0.77 ug and 0.90 ug per larva respectively, thereby suggesting that Aldrin is useful chemical because it has lowest LC 50 and LD 50 values i.e. 0.085% and 0.40 ug than other two insecticides, i.e. Metasystox and Sevin. The LC 50 values for Metasystox, Parathion and Sevin were found to be 0.013%, 0.021% and 0.096% respectively when used against the larvae of *L. clerkella*. Sevin proved to be least effective because of highest LC 50 value whereas Metasystox proved most effective, having lowest LC 50 value i.e. 0.013%, than other two insecticides.

From overall results obtained, Aldrin was found to be better and more useful chemical than Metasystox against *A. subsidiaria, P. dryoxesta* and *B. selenaria* whereas in *L. clerkella* Metasystox proved a more effective insecticide than either Parathion or Sevin.

(B) BIOLOGICAL CONTROL

Eleven parasites (8 hymenopterous and 3 dipterous) were found to parasitise the four lepidopterous pests of...
apple. *Archips subsidiaria* larvae were invaded by five parasites, *P. dryoxesta* and *B. selenaria* were attacked by four each and *L. clerkella* was infested by only three parasites.

The percentage parasitism in *A. subsidiaria* was found more by *Macrocentrus* sp. (27.99) followed by *Apanteles* sp. 1 (16%), *Actia* sp. (8%), *Phytomyptera* sp. (8%) and *Diplazon laetatorius* (2.66%), indicating that *Macrocentrus* sp. and *Apanteles* sp. 1 can be successfully used as biological control agents against *A. subsidiaria*.

In case of *P. dryoxesta* the percentage parasitism was more by *Apanteles* sp. 2 (17.33%) than by *Actia* sp. (12%), *Phytomyptera* sp. (6.66%) and *Diplazon laetatorius* (2%) thereby suggesting that *Apanteles* sp. can be successfully deployed as biological control agent against *P. dryoxesta*.

In *B. selenaria* the degree of parasitism was found more by *Apanteles* sp. 1 (8%) than by *Actia* sp. (11.42%), *Exorista* sp. (5.7%) and *Trissoleus* sp. (2.14%) thereby showing that *Apanteles* sp. 1, can act as an effective biological control agent against *B. selenaria*.

In *Lyonetia clerkella* the degree of parasitisation was only 0.53% by *Copidosoma* sp. followed by *Cirrospilus pictus*. 
(0.35%) and *Tetrastichus* sp. (0.17%) and it is evident that none of the three parasites would prove as suitable biocontrol agents in the control of *L. clerkella*. 