A REVIEW OF THE INSECT PESTS OF PULSE CROPS AND STUDIES ON THE BIOLOGY OF THE PEA LEAF ROLLER *Nacoleia vulgalis* GUENCE (PYRALIDAE)

By

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THESIS

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C E R T I F I C A T E

This is to certify that the thesis herewith submitted contains the results of bonafide research work carried out by Shri K.V.Mammen under my supervision. No part of the work embodied in this thesis has been submitted earlier for the award of any degree.

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INTRODUCTION

Pulses play a major role in two important aspects of human welfare, namely nutrition and soil fertility. In human nutrition they serve as a rich and readily available source of protein in man's diet. They also supply essential minerals like calcium and phosphorous. In soil fertility pulses are soil recuperative crops. By virtue of their unique ability to fix atmospheric nitrogen through intermediary micro-organisms which inhabit their root nodules, pulses are of inestimable value in building up soil fertility.

A number of varieties of pulses are grown in India covering an area of about 60 million acres as against 73 million acres under rice and 24 million under wheat, the annual production being to the tune of 12 million tons. In Kerala alone about 1.09 lakh acres are under pulses mainly grown as a mixed crop in coconut plantations and as vegetables in kitchen gardens but the annual production of 17 thousand tons is comparatively low. It would appear that the advantages of these crops are yet to be fully exploited by researchers and agriculturists and in Kerala very little attention has been paid to them as a source of staple food.

Pulse crops are generally susceptible to the attack of a number of insect pests and diseases during all stages of

their growth ie. from the seedling stage to the harvested produce. In general, it may be said that the damage and loss caused by insects is greater than that caused by diseases. A perusal of the literature has shown that in India about 95 species of insects are associated with pulse crops as pests, causing damage in various ways. Thus there are tissue borers boring into stem, terminal shoots, flowers, pods and seeds and damaging the respective parts. There are also quite a good number of sap feeding insects which seriously impair the grwoth of the crops. Different species of beetles and caterpillars damage the leaves. Several of these pests are common to the different pulse crops, while some are specific.

Among the various leaf-feeding insects, a pyralid leaf-folding caterpillar, Nacoleia vulgalis Guen. has been observed to be of major importance in Kerala. In recent years, this pest has been observed to attack various types of pulse crops in the Farm attached to the Agricultural College, Vellayani. Apart from some preliminary observations made by Fletcher (1914) about its occurrence as a pest of some cultivated pulses like lucerne, green gram, black gram and horse gram in the plains of South India, no other information is available on this pest. Being an insect gaining considerable importance as a pest of cultivated pulse crops in Kerala it was considered useful to study the various aspects in the life

history of this pest. With this end in view studies on its biology and behaviour were undertaken and the results of these studies are embodied in the present thesis.

Also a fairly exhaustive review of the work so far done on insect pests of pulses, with special reference to the work done in India is presented.

REVIEW OF LITERATURE ON PESTS OF PULSES IN INDIA

ORDER - LEPIDOPTERA

1. *Heliothis armigera* Hb.

Syn: *Chloridea armigera* - Gram Cutworm (Noctuidae)

Lefroy (1909) recorded this insect as a pest of universal importance and Fletcher (1914) gave a brief account of its life history, food plants and control. Eggs are laid on the tender leaves. Incubation period is about 5 to 7 days. The young caterpillars at first feed on the tender foliage, but as they grow they bore into the pods and feed on the seeds. They remain with the head thrust inside, the rest of the body being outside. Occasionally the larvae turn cannibalistic. The most important food plant of this pest is gram, but the insect feeds also on red gram, ground nut, tomato, maize (cob), tobacco (seed capsules), safflower (capsules), ganja (leaves and capsules), linseed (capsules), lablab (pods) and many other low growing plants. Regarding control, handpicking of the caterpillar was found effective. A pentatomid bug *Andrallus spinidens* was found predaceous on the larva on linseed at Coimbatore. Ballard (1920) found this as a major pest of cotton and gave a list of the alternate host plants.

Chamberline (1926) observed that tobacco and beggar weed *Meibomia* sp. are the preferred food plants. He also

recorded several parasites of this pest and found that parasitisation by Cardiochiles nigriceps Vier. ranges from 50 to 100 percent. A bait consisting of 1 lb. of lead arsenate and 75 lbs. of cornmeal was found effective in controlling this pest. Morgan (1927) observed that neither dusting nor spraying plants gave satisfactory results.

Rao (1928) recorded the caterpillars feeding on other plants like hemp and chillies. Winburn (1932) found a number of natural enemies of this pest, the most important being the egg parasites Trichogramma minutum R., Telenomus heliothidis A., the larval parasite Microplitis croceipes Cress., the predaceous Anthocorid Orius insidiosus S. and the mite Diplogaster acrivora Cobb. Pal (1936) observed that the stem of plants with large diameter and extensive development of woody tissues are slightly attacked by cutworms. Ditman (1943) recommended the dusting of a mixture of 80% cryolite and 20% sulphur at 15 to 50 lbs. per acre for controlling the cutworms. Mitra (1944) noted that the cutworm appears in large numbers in some seasons and causes considerable damage to all pulse crops. He also described the bionomics of the pest. Rao (1956) recorded a new species of Chelonus on the larvae of H.armigera Hb. Monolache (1956) obtained effective control with D.D.T. 5% dust or 20% water wettable powder. Murthi and Varghese (1961) found that Heliothis on redgram can be controlled by one application of Dipterex and D.D.T.

2. Exelastes atomosa W.

Plume moth. (Pterophoridae)

Lefroy (1909) recorded this insect as a pest of pigeon pea in the plains of India during the cold weather and gave a short account of the biology of the pest. Fletcher (1914) observed it infesting pigeon pea and lablab and briefly described its life history. In Bombay and Sholapur this pest was controlled by shaking the infested plants over baskets when the larvae and pupae fell off the leaves (Rep. Proc. II & III Ent. Meeting, Pusa. 1917 & 1919).

In a subsequent paper Fletcher (1920) gave a detailed description of the biology of the pest. The minute eggs are laid at night singly on young pods, flower buds or young leaves. Incubation period is about 3 to 4 days. On hatching the small hairy caterpillar eats into the pods and feeds on the seeds or it bites into the unopened flower buds and attacks the developing anthers. The caterpillar never enters the pod completely. The larval period is about 25 to 30 days. The greenish grey or brown pupa, looks like a larva. Pupal period is about 3 to 7 days, pupation taking place on the plant. Moths fly about in the dusk and rest by day in the lower surface of the leaves. Mating takes place on the same day of emergence of the moth and oviposition occurs next night. Besides pigeon pea the insect attacks kulthi also.

Ayyar (1940) made some observations on the damage caused by this pest. He found that the minute caterpillars on hatching first scrape the surface of the pods and thus gradually cut a hole and thrust their head into it and feed on the seeds from outside. The full grown caterpillars pupate on the surface of the pods or even in the burrow of the infested pod.

3. Maruca testulalis T.

Spotted pod borer (Pyralidae)

This insect commonly known as the spotted pod borer was first described by Hampson (1876). It was first recorded in India by Lefroy (1909), its caterpillar boring into the pods of pulses. Fletcher (1914) noted it as a minor pest of lablab, green gram and red gram and gave a description of the caterpillar and pupa. Dietz (1915) observed that in some cases, the caterpillar in its later stages bores into the stem and when full grown, generally falls to the ground and pupates in soil. Hutson (1919) found it as a pest of Tephrosia candida in Ceylon, Ayyar (1932) on black gram and Dietz (1932) on other pulses like cow pea.

Latta (1940) observed that the caterpillars remaining inside the seeds can be destroyed by fumigation with methyl bromide at 0.5 lbs. per 1000 cu.ft. of space at normal temperatures. Caldwell (1945) gave a detailed account of the bio-

logy and control of the pest. Eggs are laid on or near the flower buds. The young caterpillar enters the bud, open flower or in the pod. It burrows inside the pod and feeds on the seeds. The entrance hole is plugged with faecal matter. The full grown caterpillar is about 2 cm. long, brownish green in colour with brown head and black warts on the body with short hairs. Infested flowers and pods are usually webbed together. Pupation takes place among the debris or near the surface of the ground. Moths shelter among the lower leaves.

Application of a mixture of derris dust containing 1% or more of rotenone or a 3% nicotine dust was recommended by him as control. Spraying of 3 oz. of 20% D.D.T. emulsion in 4 gallons of water or 2% D.D.T. dusting was also found effective (Agric. Pests. N.S.W. 59).

4. Etiella zinckenella Treit.

Spiny pod borer (Pyralidae)

This insect was first described by Hampson (1876). Lefroy (1909) noted it as a pest of cold weather pulses and sunhemp in India while Fletcher (1914) observed that it was a minir pest of horsegram, cowpea, redgram and sunhemp and recorded that pupation takes place outside the pods in white silken cocoon. This pyralid was found attacking Acacia (Robina pseudacasia) and various other wild leguminous plants. (Saratov. Reg. Agric. Expt. Sta. 1925) Rohwer (1925) recorded

a larval parasite Heterospilus etiellae (Braconidae) attacking the caterpillars of the pest.

Larson (1926) observed that some of the larvae, after boring out of the pods, returned and pupate within the pods itself. Flanders (1926) recorded Zatropis tortricidis C. (Chalcidae) as a pupal parasite of the insect. Couturier (1934) observed that in general, only one caterpillar attacks each pod.

For controlling this pest Strong (1936) found that cryolite was effective. Ayyar (1940) found it as a minor pest of horse gram. Cheu (1943) noted that the caterpillar attacking the pods of soybeans, garden peas, several species of crotolaria, lupin (Lupinus angustifolius), pigeon pea and yam bean (Pachyrhizus erosus). De Saeger (1943) reared out Microbracon ettillae from the larvae of E.zinckenella T. Baranyovits (1944) recorded acacia as an alternate host of the pest. Middlekuff (1956) recorded Cephalonomia gallicoli as a larval parasite of E.zinckenella T.

Abdul Nasar and Awadalla (1957) gave a detailed description of the morphology and biology of the pest. Eggs are laid singly or in small groups preferably at the junction of the calyx and the pod and the pod surface. The number of eggs laid per moth varied from 47 to 178 and the incubation period is about 5 to 6 days. After hatching the larva bores

into the green pod, where it feeds on the growing seeds. The point of entrance is closed leaving only a black spot. The larva attacks and eats one seed after another, making rough irregular incisions, but does not enter the seeds. Cannibalism occurs when more than two caterpillars occupy one pod. The larval period is about 10 to 13 days. When full grown they drop to the ground and form cocoons about an inch below the surface of the soil or under dry leaves. Pupal period is about 9 to 20 days. Pairing takes place 24 to 30 hours after emergence and each male fertilize only one female. Ephialtes (Pimpla) roborator F. (Ichneumonidae) attack the larvae of E.zinckenella T.

Larson (1957) observed that attack is less in places where there is sufficient moisture in the field. Popaya (1957) recommended the application of emulsion sprays of 0.2% D.D.T. or 0.08% parathion or suspension of 0.4% D.D.T. or a 5% D.D.T. dust, 3 times at an interval of 8 days.

5. Adisura atkinsoni M.

Pod borer (Noctuidae)

Hampson (1876) described the insect and recorded it as a pest of pulses distributed in Sikkim, Nagas, Karachi, Bombay, Madras and Ceylon. Fletcher (1917) mentioned it infesting the lablab seedlings. Rao (1917) noted this on lablab

and red gram and described the life history and stages in detail. Eggs are laid singly, either on the pods or on the flower buds, attached by a gummy secretion. Incubation period is about 3 days. The caterpillar on hatching bites its way into the pod and feeds on the tender seed. The larval stage has five instars, the larval period being 14 to 15 days. Pupation takes place in an oval, earthern cocoon in the soil; pupal period being 11 days.

Krishnamurthi (1936) observed that some of the caterpillars pupate on the flower spikes. He recommended the spraying of a solution of bleaching powder (1 lb. in 8 gallons of water) on newly opened flowers and young pods as a repellent. Ayyar (1940) recorded it as a pest of lablab and observed that during cold weather, the attack is severe.

This pest appears to have a number of parasites and predators attacking it. Cherian and Kylasam (1941) observed a Braconid, Microbracon lefroyi parasitising the caterpillars. Krishnamurthi and Appanna (1944) and Lal (1947) noted two larval parasites, Bracon hebetor S. and B.brevicornis W. Puttarudriah and Basavanna (1956) recorded a fly Carcelia evolans kockiana Tns. and Ichneumonids Hymenobosmina sp. and Enicospilus sp. parasitising the caterpillars.

6. Lampides (Polyommatus) boeticus L.

Blue butterfly (Lycaenidae)

This insect was first recorded in India by Lefroy (1909). Vuillet (1913) worked out its biology and found that pupation takes place among the fallen leaves and dry weeds or in the soil. Fletcher (1914) described the life history and host plants of the caterpillar. In South India he has recorded it as a serious pest of crotolaria and as a minor pest of pulses. The eggs are laid on the flower buds and pods. On hatching, the pale green caterpillar with roughened skin burrows into the tender pods. Pupation is on leaf, twig or pods. He also recorded this pest as attacking Butea frondosa. Andrews (1918) found it infesting Crotolaria juncea and Cajanus indicus. In Kerala, this pest was recorded by Pillai (1921) on different pulses. Aokiu (1927) observed that pupation may take place among the fallen leaves and dry weeds or in the soil.

Another caterpillar pest belonging to this family Catechrysops onejus F. was recorded by Lefroy (1909) and Fletcher (1914) as a minor pest of red gram, lablab and other pulses.

7. Amsacta albistriga W.

Red hairy caterpillar (Arctiidae)

This insect was first recorded by Lefroy (1909)

as a pest of ground nut. Fletcher (1914) gave a detailed description of this pest. It is generally found in sandy loams on cholam, cumbu, ground nut, pulses, castor etc. and on almost all low growing plants and crops, as a serious pest. The caterpillars are sluggish and pupate in soil. The moths which emerge after the early monsoon showers are sluggish and conspicuous and can be collected by hand. Trenching and putting fresh leaves in the trenches is also recommended. Another species A.moori B. similar in habit as A.albistriga W. was mentioned by him. Mackenna (1917) and Coleman (1922) suggested handpicking of the sluggish adults and caterpillars to control the pest. Kannan (1925) noted that the emergence of the adults is related closely with the rainfall. Chopra (1926) reported that the collection of moths by light traps was found successful in Punjab. Ayyar (1940) described this as a major pest of ground nut and mentioned it as polyphagous in habit, feeding on almost all green vegetation especially pulses and other legumes and other crops like castor, calotropis etc. He has also given a detailed description of the pest. Bindra and Kittur (1957) observed that the caterpillar of A.moori B. is parasitized by a nematode Mermis indica in some districts of Madhya Predesh.

8. Stauropus alternus W.

Crab caterpillar. (Notodontidae)

The first record of this pest in India is by

Lefroy (1909) who found its caterpillar feeding upon the pigeon pea. Fletcher (1914) noted it on several plants like tamarind, tur, Trewia medifolia and tea and gave detailed descriptions of its different stages. The crab caterpillar is found feeding on the leaves. Pupation is in light cocoon spun among the leaves. Rutherford (1914) recorded this pest on tea, cocoa, mango, Albizzia stipulata, Acacia decurrens, Grevillea robusta, roses and other plants and recommended arsenical spray as control. Andrews (1915) found spraying with lead arsenate suitable for controlling the pest on tea.

A detailed study of the life history of this pest was made by Susinathan and Sundaram (1921). Round, flattened, sculptured eggs laid by the female, hatch in about 3 days. There are six instars. The larva is active and when disturbed assumes a spiderlike appearance. The final instar caterpillar is 20-21 mm. long, the larval period being about 30 to 32 days. Pupation takes place in slight cocoon of yellow fibrous silk covered over by leaves. Pupa is dark brown 18 - 19 mm. long and the pupal period is 10 days. Hutson (1922) and Rao (1937) noted this as a serious pest of tea in Ceylon and India respectively, during certain years. A braconid Apanteles stauropi was found parasitising S. alternus W. in Sumatra (Menzil, 1923) and in Ceylon (Gadd, 1942).

9. Eucosma critica M.

Leaf folder. (Eucosmidae)

Syn: Eucelis critica

Lefroy (1909) recorded the caterpillar of this insect attacking red gram. Fletcher (1914) gave a detailed account of the biology of this pest. In upper India the attack is generally noted during March to May and during the winter months it hibernates in the larval stage. Elongate, spherical, creamy white eggs are laid singly or placed in rows on the upper and lower surface of the leaves, on petioles or on the stem, but a groove or depression is always preferred for oviposition. One female lays about 100 eggs, the incubation period being 3 days. The yellowish caterpillar on hatching burrows into the tender shoots and feeds from within if the leaves are in the folded state. If the leaves are unfolded, it begins to gnaw the midrib and the adjecent tissue on the upper surface of the leaf and soon hides itself under a very thin transparent gummy stuff to which dustlike gnawed particles of the leaf remains are attached. As it grows it brings together almost all the top leaves of a shoot or of adjecent shoots and binds them together in a crumpled mass, within which it feeds and lives. Pupation takes place in a thin papery whitish silken cocoon within the crumpled mass of the spun leaves. It may also takes place inside a flower bud or within a few dried petals rolled together or within a seed

pod, in which the caterpillar feeds. Pupal period is about 4 to 6 days. Pupa is yellowish brown in colour with 6 white cremastral hairs at the anal end. The removal of the spun leaves has been recommended as a control measure.

Ayyar (1940) mentioned this insect as a minor pest on red gram.

10. Laspeyresia torodelta M.

Lablab shoot borer. (Eucosmidae)

This insect was first recorded and studied in India by Fletcher (1914) on lablab. He observed that the green caterpillar bores into the growing tip, devouring the tissues of the stem. Brief descriptions of the larval and pupal stages are given. Pupation takes place in the larval furrow and the pupal period is about 10 days. Ayyar (1940) found it as a minor pest of cluster bean and suggested clipping and destroying first affected shoots as a remedial measure. Wright (1948) recorded another species L.nigricana as a pest of pea, the caterpillar feeding within the pods causing considerable damage to the developing seeds and giving to their contents a very unsighty appearance. He has recommended spraying with 0.5% D.D.T. emulsion as a control measure.

11. Sphenarches caffer Zell.

Plume moth (Pterophoridae)

This insect was first described by Lefroy (1909)

who found its life history similar to that of the plume moth, Exelastes atomosa W. Fletcher (1914) gave descriptions of the different stages. Later he (1920) made detailed observations relating to the distribution, life history and food plants. He found it generally feeding on pigeon pea (Cajanus indicus), kulthi (Dolichos lablab) and bottle gourd (Lagenaria vulgalis). Besides these cultivated crops it was found to feed on Averrhoa bilimbi, buds of Luffa sp., petals of Hibiscus mutabilis, Biophytum sensilivum and Mimosa pudica.

Pruthi (1935) reported a Braconid (its name not mentioned) parasitising the caterpillar. Ayyar (1940) mentioned this pest as Bottle gourd plume moth, the spiny caterpillar of which was seen feeding on the foliage of bottle gourd.

12. Laphygma exigua Hb.

Cut worm (Noctuidae)

Syn: Caradrina exigua

Lefroy (1909) noted caterpillars of this insect feeding on young indigo seedlings. Fletcher (1919) gave a brief description of its life history and recorded lucerne, indigo, onions, chillies, gingelly, cow pea, brinjal, raddish and amaranthus as food plants. Chopra (1928) collected it from lucerne and gram, and studied its biology.

Taylor (1931) noted L.exigua Hb. and L.exempta W. as serious pests of cotton and peas, and also found them

attacking maize, tobacco, grape vines, garden beets and wild plants. The young plants were usually attacked. He observed that the female moth lays 8 to 100 white eggs in clusters on the leaves and cover them with down like scales. Incubation period is about 3 to 7 days. Caterpillars on hatching spin a loose web over the cotton leaves, on the lower surface of which they feed, while the upper surface is generally intact. They feed during night and hide in the soil during day time. The full grown larvae make oval earthern cocoons in the soil and pupate inside. The larval stage consists of five instars, the larval period being about 17 to 20 days. Oviposition begins 3 days after emergence. A Tachinid and a Chalcid parasite were recorded as the natural enemies of the pest. Ayyar (1940) found this pest as polyphagous, feeding on several crops. He recommended the application of stomach insecticides like lead arsenate or calcium arsenate as a control measure.

13. Prodenia litura F.

Tobacco caterpillar (Noctuidae)

Lefroy (1909) described this as a polyphagous pest which is widely distributed and commonly destructive to most of the food crops. Fletcher (1914) recorded it on castor, tobacco, maize, tomato, colocasia, agathi, jute, indigo, lucerne, brinjal, cabbage, elephant yam, pear, plantain and grasses; severe damage being noted in tobacco, castor and

agathi. He described the bionomics of the pest in detail. Eggs are laid in clusters on leaves and covered with buff coloured hairs. Incubation period is 3 to 4 days. The caterpillars on hatching start feeding on the leaves. Larval period is about 20 days. Pupation takes place in earthern cocoon, pupal period being 6 days. Hand picking of egg masses and young larvae and trenching around the field to prevent the advancement of the caterpillars were recommended as a control measure.

Andrews (1916) found it as a pest of green manure crops and studied its biology in detail. Endrozo (1918) recommended spraying with 1 lb. paris green in 100 gallons of water or dusting with a mixture of 1 part of paris green with 50 parts of lime to control the caterpillar. He also recorded a parasitic fungus Cordyceps sp. killing the caterpillar of this pest. Fletcher (1919) noted an Elaterid Agrypnus fuscipes and Carabid Broscus punctatus K. the larva of the former and the adult of the latter predaceous on the caterpillar of P.litura F. Jhaveri (1920) and Correia (1920) recorded caterpillars of the pest attacking rice seedlings in North Gujerat and Goa respectively.

Kurup & Joshi (1959) noted this pest on cotton, mulberry, cauliflower, banana and pulses. They found spraying with D.D.T. 50% W.P. at 2 lbs. in 100 gallons of water in the

nursery and 4 lbs. in 100 gallons of water in the field, useful as a control measure.

14. Gracillaria soyella D.

Leaf roller. (Gracillaridae)

Fletcher (1917) observed it as a pest of Cajanus indicus, the caterpillar feeding on leaves. Dutt (1921) described the immature stages of the insect in detail. He noted the insect on tur from November to April. The caterpillar rolls up the apical extremity of the tur leaves and lives within the fold. In severe cases the folded portion of the leaves is skeletonized and dries up. Pupation takes place inside the leaf fold, pupal period being 8 to 9 days. The caterpillars are attacked by a small Chalcid parasite Asympiesiella indica G. Ayyar (1940) recorded the insect as a minor pest of Cajanus indicus.

15. Stomopteryx nertaria M.

Leaf miner (Gelechiidae)

Lefroy (1909) noted it in India on groundnut and Psoralea corylifolia and found the caterpillars mining the leaves. Fletcher (1914) found it infesting redgram and soybean and as a severe pest of groundnut popularly known in Tamil as "Surul puchi" and described the biology of the pest

in detail. Ayyar (1940) suggested the collection of the moths by light traps as a control measure.

Channabasavanna (1956) described in detail the biology and control of this pest. Eggs are laid on tender portions of the plant, hatch in 3 days. On emergence the tiny caterpillar bores into the leaf tissue from the upper surface of the leaf and feeds on the internal contents. The attacked portions of the leaf appear as pale brown patches, seen along the mid rib. After about one week the leaf miner comes out and webs together two or more leaflets and lives under shelter for about 4 days. The full grown caterpillar is green in colour with front and hind ends black. The caterpillar then pupates in a silken cocoon within the folds of the affected and withered leaves on the plant. The moth emerges after 4 days. The entire life cycle is about 3 weeks. Application of B.H.C. 5% and 10% dusts and Folidol 5 c.c. per one gallon of water were found to be effective in controlling this pest.

ORDER - DIPTERA

1. Agromyza obtusa M.

Pod fly (Agromyzidae)

Agromyza phaseoli C.

Stem fly (Agromyzidae)

These flies were first recorded in India by Lefroy (1909) as Tur pod fly and Pea stem fly respectively. Fletcher (1914) called them Red gram agromyza and Cow pea agromyza respectively and made some investigation on their oviposition. Andrews (1914, 1918) worked out the biology of A.obtusa M. and found that eggs were laid in the setting flowers or in very young pods. Scott (1918) mentioned the control followed in Queenzland for A.phaseoli C. ie. by covering the rows of the crop with a thin layer of saw dust 4 days after planting, which should be wetted with kerosine emulsion (1 lb. ordinary soap dissolved in about 2 gallons of boiling water) and a second dressing when the plants are in the second leaf.

Ahmed (1938) studied in detail the biology of A.obtusa M. According to him the female pierces the pericarp with the ovipositor and lays a single egg. When a pod is opened the eggs appear like needles projecting from the walls of the pod. A female lays about 38 to 79 eggs during its

life time. In about 3 days, the eggs hatch and the maggot mines into the seed and forms galleries just below the epidermis of the seed. The maggot feeds deeper into the seed and grows. Larval stage lasting 5 to 6 days. The larva may either pupate in the larval groove inside the seed or very close to a hole made on the pericarp for the adult to escape, pupal period being 8 to 9 days. The adult fly is short lived. Under abundant moisture conditions there may be two broods in a year. An Eulophid was found parasitizing the larval stage of this fly. Later he (1940) described a Chalcid Euderus lividus Ashm. as a larval parasite attacking the maggot. Subsequently he observed that in severe cases the infestation of the seeds may be as high as 60 percent.

Morgan (1938) recommended spraying the upper surface of leaves with nicotine sulphate (1 in 800) plus white oil emulsion (1 in 100) as a control measure. Hely (1947) found 0.05% D.D.T. spraying quite suitable. Braithwait (1957) recommended two sprayings of the above material within a week of germination and subsequently at weekly intervals until flowering. Taylor (1959) observed that spraying with nicotine sulphate and white oil emulsion was quite effective in controlling the infestation. According to Walker (1960) seed dressings with chlorinated hydrocarbons prevent the attack of bean fly for 30 days after emergence.

2. Phytomyza atricornis M.

Pea Leaf Miner (Agromyzidae)

Syn: Phytomyza geniculata

Lefroy (1909) and Fletcher (1914) mentioned this insect as a leaf mining fly under the common name of cruciferous leaf miner. Subsequently it was identified as P.atricornis M. and preliminary observations on its life history given by Ahmed and Gupta (1939). It is known under different common names in various countries according to the plants attacked. In England it is known as Chrysanthimum leaf miner, in New South Wales as Cineraria leaf miner, in Italy and in India as Pea leaf miner. Rahman (1940) recorded it on toria, and sarson, from Lyallpur (Punjab).

Ahmed and Gupta (1941) studied the bionomics of this pest in detail and gave a detailed account of the biology and control of the pest. This pest was found to be polyphagous in nature attacking a number of plants including pea, mustard, toria, cabbage and other cultivated plants. The damage caused to the leaves is partly due to the numerous punctures made by the female for feeding purposes; but chiefly on account of the mining of the larvae into the leaves. The female fly thrusts eggs into the leaf tissues. Upto 329 to 358 eggs are laid by a single female and the incubation period is about 2 days. On hatching, the minute white maggot mines

the leaf feeding on the mesophyll. The larval period is about 5 days, the pupal period being 7 days. The adults are generally observed in December and January. Systematic collection and destruction of infested leaves was recommended as a control measure. A spray containing 1 part nicotine sulphate and 2 parts of soft soap dissolved in 400 parts of water was found effective in controlling the pest. An Eulophid parasite Solenotus sp. was bred from the larval stage of this fly.

ORDER - HEMIPTERA

1. Aphis craccivora Koch.

Pea aphid. (Aphididae)

Syn: A.medicagenis K.

Lefroy (1909) recorded A.rumicis Linn. attacking cow pea and Benincasa cerifera; A.cardui Linn. attacking pigeon pea; A.adusta Zehnt. attacking guar and Chaitophorus maculatus Buckt. attacking lucerne. George (1927), Krishnamurthi (1928) and Ayyar (1932) found A.medicagenis K. (A.craccivora K.) as a pest of pulses. Krishnamurthi gave a brief description of A.medicagenis K. and A.rumicis L.

Rekh (1938) made a record of A.craccivora K. as a pest of cotton in Russia. Caldwell (1945) gave a detailed

description of the bean aphid and its control. The adults and nymphs suck the sap from the undersurface of the tender leaves, growing tips, flower stalk or pods. The leaves of the heavily infested young plants take on a pronounced yellowish hue and growth is greatly retarded. Malformation of the pods may be caused by large colonies feeding on them. The adult is a sluggish greenish black insect found in dense colonies. The colony usually comprises both immature and adult stages. Application of a 3% nicotine dust or of a spray prepared by adding ½ pint of nicotine sulphate to a solution of 2 lbs. of soft soap in 50 gallons of water, was found as an effective control measure. Dusts appeared to be more satisfactory than sprays for treating large plants as more efficient coverage could be obtained.

Kanakaraj, David (1953) observed this aphid affecting different pulse crops, including field bean (Dolichos lablab), cow pea (Vigna catiang), ground nut (Arachis hypogea) green gram (Phaseolus radiatus), black gram (Phaseolus mungu) lucerne (Medicago sativa) indigofera sp. and a number of leguminous and other crops.

Tanasijevic (1954) recommended spraying 1% parathion at the rate of 18 lbs. per acre. Appart (1954) recommended 0.25% schradan, isolan and parathion spray at the rate of 150 gallons per acre for effective control of the aphids

on ground nut and gave a schedule of application. Barker and Tauber (1954) studied the biilogy and seasonal history of the pest and found that highly succulent plants produced under reduced light and high moisture were condusive to aphid reproduction. Fecundity and plant injury appeared to decrease as the nitrogen level increased.

In Mysore State Appanna (1954) observed Cervaphis schoutedeniae V. on redgram; Aphis rumicis L. on horse gram and Macrosiphum pisi K. on green pea and found spraying with honey oil rosin soap (1 lb. in 3 gallons of water + ½ lb. soap), Rhothane emulsion (1 lb. in 25 gallons of water) and Folidol E. 605 (6 cc. in 2½ gallons of water) effective against those aphids.

Evans (1954) recorded Aphis craccivora K. as a pest of ground nut and as a vector of the Rosette disease. Real (1955) also mentioned this aphid as a vector of the Rosette disease. He observed heavy infestation under wet and humid conditions and also found that close planting of ground nut reduces the infection with rosette disease. The reason for this was found to be due to the reduction in exposure to the sun of crowded plants, which in turn reduced photosynthesis and consequently reduced the fecundity and production of alates. Real also worked out the biology of the aphid and found that the life cycle from egg to adult occupes 8.3 days. The reproductive period averaged 6.7 days, each female producing about

14-70 offsprings during a reproductive period of 43 days. The four nymphal instars averaged about 2, 1.5, 1 and 1 days respectively and reproduction began after a further period of 2.76 days. When both temperature and humidity are high, some individuals reproduce in the second or third nymphal instar.

Anderson (1955) did some experiments with Picrasmin, extract of jamaican quassia (Picrasma excelsa) and found it useful in controlling the aphid. This was mixed with water and applied to the soil around the plants. Mac Leod (1955) observed the fungus Empusa aphidis attacking the aphids Macrosiphum pisum K. in Nova Scotia.

2. Riptortus pedestris Fb.

Riptortus linearis Fb.

Pod sucking bugs (Coreidae)

Lefroy (1909) recorded R.linearis Fb. as a minor pest of leguminous crops and pulses and Fletcher (1914) gave an account of its bionomics and control. About 3 to 8 eggs are laid singly on the plant by one female. Incubation period is about 6 days. The nymphs hide themselves away that they are little noticed. Life history is completed within 21 days. Nymphs and adults are found sucking the sap from the pods of the lablab, cow pea, black gram, green gram and Luffa acutangula Collection of the insects by hand net was recommended as a control measure.

Rutherford (1914) recorded R.pedestris Fb. and R.linearis Fb. as minor pests of tea in Ceylon.

Brittan (1925) found that dusting with calcium cyanide gave good result in controlling R.pedestris Fb. Caldwell (1945) reported Riptortus surripes Fb. from Queensland and described in detail its biology and habit. Sprays of nicotine sulphate - white oil emulsion and derris were found to give a moderate control of the bugs. Macrophamurus basalis W. was observed as an egg parasite.

3. Coptosoma cribraria Fb.

Lablab bug (Pentatomidae)

Syn: Coptosoma cribrarium.

Lefroy (1909) observed the habit of this bug, clustering gregariously on the stem of tender plants of jute and lablab, but it did not appear as a pest. Fletcher (1914) found it feeding on lablab, green gram, cluster beam, agathi (Sesbania grandiflora) and some other leguminous plants. He found the creamy white elongated eggs laid in batches of 35 arranged in two rows. Incubation period was 6 days, life history being completed in about 7 weeks.

Ayyar (1922) recorded it on red gram and avenue trees (Pongania glabra) while Esaki (1926) found it on sugar cane and rice in Formosa. Ayyar (1940) described its habit and life history in detail. Collecting the bugs in hand nets and destroying them in vessels containing water mixed with kerosene was recommended as a control measure.

4. Anoploconemis phasiana F.

Pod bug (Coreidae)

Lefroy (1909) recorded this pest on erithrina and also on shrubs and grasses. Fletcher (1914) noted it on young erithrina trees in hills and also on brinjal, red gram, green gram and cholam. Hand collection of the bugs was recommended as a control measure. Burt (1918) noted this as a minor pest of indigo and Ayyar (1922) found it on red gram, egg plants, cow pea, and the tender shoots of grape vine.

5. Clavigralla gibbosa S.

Clavigralla horrens D.

Pod sucking bugs (Coreidae)

Lefroy (1909) described these two insects as pests of leguminous crops especially on red gram. Fletcher (1914) made a note on the habit of the pest. Adults and the nymphs suck the juice of the unripe seeds from green pods. Collection of eggs and shaking the plants over a vessel of oil and water or over a cloth saturated with oil are recommended as control measures. Caldwell (1945) recommended spraying of nicotine sulphate and white oil emulsion to control these bugs.

The biology and morphology of the pest was described by Rao (1962). The attacked pods show light yellow patches on the surface due to desapping, which is followed by shrivelling and drying of the pods. It has been found that heavy infestation coincides with the pod formation of the gram. An egg parasite Hydronotus forster was also recorded.

ORDER - COLEOPTERA

1. Pulse beetles (Bruchidae)

Lefroy (1909) listed the following species of pulse beetles in India attacking different pulses.

1. Bruchus chinensis Linn.

Syn: Pachymerus chinensis on Pisum sativum, Dolichos lablab, D.biflorus, Cicer arietinum, Cajanus indicus, Ervum lens and Vigna catiang.

2. Bruchus affinis Froll. on imported beans.

3. Bruchus emarginatus Fabs. on Pisum sativum.

4. Bruchus quadrimaculatus Fabs. on Pisum sativum and on beans.

5. Bruchus pisorum Linn. on Pisum sativum.

6. Bruchus analis Fabs. on Vigna catiang.

Chittenden (1898) stated that Bruchus obtectus S. also occurs as a pest of pulses and described the life histories of B.pisorum L., B.obtectus S. and B.quadrimaculatus F.

Fletcher (1914) recorded B.chinensis on red gram and described the biology of the pest. Ghosh (1917) noted that in the case of B.affinis F. infestation takes place in the field, which is carried over to the store. Selection of good seeds by putting them in water and the fumigation of the seeds with naphthaline in air tight vessels are recommended as remedial measures. Later he (1918) found B.chinensis L. on the pods of sesbania also.

Kunhikannan (1919) made some observations on the function of the prothoracic plate in this insect and also described in detail its biology and control. Fumigation of the seeds with CS_2 and HCN in storage and storing the seeds under a layer of several inches of grains of Eleusine coracona (ragi) or Panicum frumentaceum (savai) which are not attacked by these beetles are suggested as control measures. The hymenopterous parasites Bruchocida orientalis C., Bruchobius colemani C and a predaceous mite Pediculoides ventricorsus N. are also recorded. Kasergode (1919) mentioned Bruchus theobromae L. as a pest of red gram.

Zacher (1929) found that B.chinensis L. are able to mate and oviposit without feeding as adults for a long time. Ferreira Lama (1942) recorded a Pteromalid Brochobius laticeps Ashm.an egg parasite of B.chinensis L.

Rahman, Singh and Amarnath (1943) mentioned eleven injurious Bruchids infesting the pulses of which Bruchus phaseoli G., Bruchus caerulens C. and Bruchus maculipyga C. were new records. They described the biology and control of B.analis F. and B.chinensis L. About 95 eggs are laid by the female of B.analis F. in 2 to 12 days, during May to December. They hatch in 3 to 6 days. The newly hatched larva bores directly into the grain by cutting a hole and frass is seen at the entrance hole. The entire larval stage is passed within

the grain, larval period being 8 to 43 days. Pupation takes place below the seed coat and pupal stage is 5 to 36 days. The adult emerges by cutting out a circular hole in the seed coat. The biology of B.chinensis L. is similar to that of B.analis F. Grubs of both these species are parasitised by Bruchobius laticeps A.

Caldwell (1945) described the biology of B.quadrimaculatus F. in detail. As regards control he found that treatment with 8 oz. of paradichlorobenzene and 8 oz. of naphthalene per bag of seeds was sufficient to control the Bruchids. Mixing the seeds with ground dolomite or magnesite at the rate of 4 oz. per bushel of seed was also found effective. Gobind Ram (1945) described the biology of B.analis F. in detail. Krishnamurthi (1950) observed that the infection by most of the Bruchids begins in the field and the seed, with husk alone is preferred, dehusked dhalls being unaffected. Chatterji (1954) also recorded Bruchobius laticeps Ashm. (Chalcidae) as a larval parasite of B.chinensis L.

Ruppel (1956) recommended drying of the seeds thoroughly before storage to prevent damage. Usman (1956) mentioned Collosobruchus chinensis L. from Mysore infesting leguminous seeds. Arora and Pajni (1957) studying the biology of Bruchus analis F. with special reference to its oviposition, showed that the adults pair immediately after emergence. The

eggs are laid singly on the seeds, cemented by means of sticky fluid.

Menon, Beri and Kumar (1960) recorded Collosobruchus maculatus F. and stored seeds of mung (Phaseolus aureus). Mukherjee, Beri, Sharma and Kumar (1960) studied the relative efficacy of different types of jute bags against the infestation of the Bruchids in stored mung and found that the infestation of the seeds stored in jute bags is dependent on the jute cloth used to make the bag.

2. Hypera variabilis Hb.

Lucerne weevil (Curculionidae)

Lefroy (1909) mentioned two species Hypera varians H. and Hypera medicagenis M. feeding on lucerne (Medicago sativa) and senji (Melilotus indica) which are active during the cold season. Hastings and Pepper (1949) recommended the spraying of chlordane 2 lbs. per acre as a preventive measure against Hypera variabilis Hb.

Srivastava (1959) studied the life history of lucerne weevil Hypera variabilis Hb. in detail. The grubs damage the leaves by feeding on the opening buds and the attacked plants become stunted. The adult Beetles also feed on the rind of the stem. Eggs are laid in the stem, the green larvae feed on the leaves. When full grown, it pupates in a fine net like silken cocoon, attached to the plants or in the dried leaves in the ground. Sometimes cocoons are spun in between two leaflets. The adult beetles are oval, light grey in colour with

short white and brown hairs and present a mottled appearance. It is active during winter and hides in crack and crevices during summer.

3. Colobodes dolichotis M.

Root weevil (Curculionidae)

This pest was first described in India by Subramonium (1959) as attacking Dolichos lablab at Coimbatore. The biology and food habits of the weevils were worked out in detail. This was also recorded on redgram and cowpea. It causes huge galls at the lower portions of the stem of red gram. In cowpea the base of the stem is completely riddled by the grubs and irregular galleries are made inside resulting in the formation of gall like swellings. All stages of the weevil are present inside the gall. The adults also feed on the stem tissue. The attacked plants dry up completely and the pest is noted during the flowering and fruiting periods. Eggs are inserted singly into the tissues, generally at the nodes. One female lays about 79 to 319 eggs and the incubation period is about 6 to 7 days. The white grubs on emergence tunnel into the tissues and make galls. Full grown grub is about 8 to 9 mm. long and the larval period is about 59 to 64 days. Pupation takes place inside the cavity at the end of the larval furrow, inside the stem. Total life cycle is about 75 to 81 days. An Eulophid parasite Tetrastichus sp. was recorded as a larval parasite.

Venugopal and Subramonium (1959) recorded this pest on redgram. Injection of chlorosol and chloroform caused total mortality of all the stages inside the stem.

4. Episomus lacerta Fb.

Leaf weevil (Curculionidae)

This weevil was first reported in India by Lefroy (1909) as feeding on the bark of cotton plants. But Fletcher (1914) recorded it from pulses and other low growing plants and he described the life history of the pest. Four to twelve eggs are laid by a female in a leaf fold and the incubation period is about 12 to 14 days. The newly hatched white grubs drop to the ground where they burrow down and probably feed on the root lets of plants. Marshal (1916) also described this weevil feeding on the bark of cotton plants.

Ayyar (1940) described Episomus lacerta Fb. as a specific pest of field beans, defoliating the leaves. Hand picking and spraying of contact insecticides were recommended as a control measure.

5. Ceuthorhynchus asperulus F.

Bud weevil (Curculionidae)

This insect was recorded in India by Fletcher (1914) as feeding on the buds of red gram and described its biology. Eggs are thrust into the young flower buds and a

liquid oozes out through the hole, which dries into a conspicuous red spot. Tiny grub on hatching eats its way to the pollen sacs of the flower and feeds on them. The full grown grub comes outside through a hole and drops to the ground and pupates in the soil. The weevils on emergence, will attack the next crop. Hand collection of the weevils was recommended as a control measure. Ayyar (1940) mentioned it as a minor pest, which breeds inside the tender buds and prevents the pod formation of red gram.

6. Alcides bubo F.

Alcides collaris P.

Legume weevils (Curculionidae)

Lefroy (1909) recorded these weevils attacking Sweet potato and sesbania respectively, while Fletcher (1914) recorded Alcides collaris P. on green gram and other pulses and Alcides bubo F. on sesbania, daincha, indigo and clusterbean. He described the life history of A.collaris. A single egg is deposited in a hole made on the stem and covers it with fibres of the stem. On hatching the grub bores into the stem and a swelling or gall is formed near the point of entry and the grub lives in the gall. The plants may break at these points when wind blows. The grub pupates in a thin, tough brownish cocoon. Total life cycle is about 35 days. Collection and

distribution of the beetles was recommended as a control measure. A small Braconid parasite (name is not given) was also recorded.

Ayyar (1917) observed that Alcides collaris P. is present in the field in all stages throughout the year. Later he (1928) recorded Aphrastobracon alcidiphagus (Braconidae) as a larval parasite of Alcides affaber F. Other species Alcides fabricii F. and Alcides pictus B. were also recorded by him, feeding on the leaves of pulses.

ORDER - THYSANOPTERA

Taeniothrips lefroyi Bangal.

Bean thrips (Thripidae)

Lefroy (1909) reported two species of thrips (names of which are not mentioned) as destructive to pulse crops, but they were observed only once. Ayyar (1940) mentioned the species Ayyari chaetophora K. and Taeniothrips distalis K. as swarming inside flowers which in severe cases prevent pod formation.

Caldwell (1945) recorded Taeniothrips nigricornis in Queenzland, damaging the flowers and curling up the pods of beans. The infested young plants become distorted and the main stem gets transformed into a broad, flattened stripe like structure, usuallytwisted at the top. Spraying with

nicotine sulphate - white oil sprays or 2 applications of 3% nicotine dust at intervals of 7 to 10 days was found to be successful in controling the thrips.

Haq (1960) found Taeniothrips lefroyi B. as a serious pest of broad bean in Kumaon. Tender leaves, flowers and pods are attacked. The larvae congregate inside the corolla tube and feed on the walls of the ovary and stamens. In severe cases the flowers may be so injured that the development of the pods is arrested and the entire plant may be crippled and stunted. The peak attack of the pest was noted during April. Application of B.H.C. dust to the soil and parathion emulsion 5% in combination with B.H.C. dust proved to be effective in controlling the pest.

ORDER - ACARINA

Red Spider mite

Tetranychus sp. (Tetranychidae)

This small red mite attacks a number of species of pulses in India. Caldwell (1945) recorded Tetranychus urticae K. infesting different pulses viz. french, long, sword and jack beans in Queenzland and noted the nature of

damage of the mite in detail. Infestation is usually confined to the leaves. Both adults and nymphs suck the sap from the undersurface of the leaves, resulting in a faintly, mottled, yellowish appearance of the upper surface of the leaves, while the lower surface is more or less rusetted. Mites are generally noted in places where climatic conditions are warm and humid. Dusting with a mixture containing equal parts of sulphur and hydrated lime was recommended as a control measure. Hucket (1948) found dusting with parathion or toxaphene and spraying with H.E.T.P. or toxaphene effective for controlling infestations. Klostermeyer (1954) recommended dusting and spraying with aramite, which is relatively non-toxic to pollinators and predators.

Wilcox and Howland (1957) recorded two species Tetranychus telarius L. and Tetranychus trodeni attacking lima beans. They found that one or two applications of 0.3 to 0.4 lb. demeton sprays or 0.9 lb. aramite dusting per acre were effective.

Channa Basavanna and Puttarudriah (1958) recorded Stethorus paupereulus W. (Coccinellidae) predaceous on Tetranychus telarius L. which attack various plants in Mysore State. The adults and grubs of the beetle feed on mites.

LIST OF PULSE CROPS IN INDIA

1.	Bengal gram	*Cicer arietinum* L.
2.	Black gram	*Phaseolus mungu* L.
3.	Bakla	*Vicia faba*
4.	Cluster bean	*Cyamopsis psoralioides* DC.
5.	Cow pea	*Vigna catiang* E.
6.	Field bean	*Dolichos lablab* L.
7.	Green gram	*Phasiolus radiatus*
8.	Horse gram	*Dolichos biflorus* L.
9.	Khesari	*Lathyrus sativus*
10.	Lentil	*Lens esculenta*
11.	Lucerne	*Medicago sativa*
12.	Pea	*Pisum sativum*
13.	Red gram	*Cajanus indicus* S.
14.	Sweet pea	*Lathyrus odoratus*
15.	Soy bean	*Glycine hispida*

LIST OF PESTS OF PULSES RECORDED IN INDIA

ORDER - HEMIPTERA

1. Aphis craccivora K.	Aphididae	Major
2. Aphis rumicis L	,,	Minor
3. Aphis cardui L.	,,	,,
4. Aphis adusta Z.	,,	,,
5. Chaitophorus maculatus B.	,,	,,
6. Cervaphis schoutedeniae V.	,,	,,
7. Macrosiphum pisi K.	,,	,,
8. Ceroplastodes cajani M.	Coccidae	,,
9. Lecanium longulum D.	,,	,,
10. Empoasca kerri	Jassidae	,,
11. Anchon pilosum W.	Membracidae	,,
12. Ragmus importunitas D.	Miridae	,,
13. Clavigralla horrens D.	Coreidae	Major
14. Clavigralla gibbosa S.	,,	,,
15. Riptortus pedestris F.	,,	,,
16. Riptortus linearis F.	,,	,,
17. Anoplocnemis phasiana F.	,,	Minor
18. Nezara viridula L.	Pentatomidae	Major
19. Coptosoma cribraria Fb.	,,	,,
20. Coptosoma nazirae At.	,,	Minor
21. Dolycoris indicus S.	,,	,,

ORDER - THYSANOPTERA

22.	Taeniothrips lefroi B.	Thripidae	Minor
23.	Taeniothrips distalis KY.	,,	,,
24.	Ayyari chaetophora K.	,,	,,

24.

ORDER - LEPIDOPTERA

25.	Heliothis armigera Hb.	Noctuidae	Major
26.	Adisura atkinsoni M.	,,	,,
27.	Laphygma exigua Hb.	,,	,,
28.	Laphygma exempta W.	,,	,,
29.	Prodenia litura F.	,,	,,
30.	Amyna octo G.	,,	Minor
31.	Azazia rubricans B.	,,	Major
32.	Agrotis ypsilon R.	,,	Minor
33.	Plusia orichalcea F.	,,	,,
34.	Plusia nigrisigna	,,	,,
35.	Euproctis fraterna M.	Lymantridae	Major
36.	Acherontia styx W.	Sphingidae	,,
37.	Acherontia lachesis	,,	,,
38.	Herse convolvuli L.	,,	,,
39.	Stauropus alternus W.	Notodontidae	,,
40.	Maruca testulalis G.	Pyralidae	,,

41. Nacoleia vulgalis Gn.	Pyralidae	Major
42. Etiella zinckenella T.	,,	,,
43. Lamprosema indicata F.	,,	Minor
44. Exelastes atomosa W.	Pterophoridae	Major
45. Sphenarches caffer Z.	,,	Minor
46. Eucosma critica M.	Eucosmidae	Major
47. Laspeyresia torodelta M	,,	Minor
48. Cosmopteryx mimetis M.	Cosmopterygidae	,,
49. Gracillaria soyella V.D.	Gracillaridae	Major
50. Cyphosticha coerulea M.	,,	Minor
51. Polyommatus boeticus L	Lycaenidae	Major
52. Euchrysops cnejus Fb.	,,	Minor
53. Stomopteryx nertaria M.	Geleohiidae	Major
54. Amsacta albistriga W.	Arctiidae	,,
55. Amsacta moori B.	,,	,,
56. Diacrisa obliqua W.	,,	,,

ORDER - DIPTERA

57. Agromyza obtusa M.	Agromyzidae	Major
58. Agromyza phaseoli C.	,,	,,
59. Phytomyza atricornis M.	,,	,,

ORDER - HYMENOPTERA

60. Megachile anthracina Gm.	Megachilidae	Minor

ORDER - COLEOPTERA

61. Bruchus chinensis L.	Bruchidae	Major
62. Bruchus theobromae L.	,,	,,
63. Bruchus affinis F.	,,	,,
64. Bruchus emarginatus F.	,,	Minor
65. Bruchus quadrimaculatus F.	,,	,,
66. Bruchus pisorum L.	,,	,,
67. Bruchus analis F.	,,	,,
68. Bruchus phaseoli G.	,,	,,
69. Bruchus caerulens C.	,,	,,
70. Bruchus maculipyga C.	,,	,,
71. Collosobruchus chinensis L.	,,	,,
72. Collosobruchus maculatus F.	,,	,,
73. Hypera variabilis Hb.	Curculionidae	Major
74. Hypera medicagenis M.	,,	Minor
75. Colobodes dolichotis M.	,,	,,
76. Episomus lacerta F.	,,	,,
77. Blosyrus inaequalis B.	,,	,,
78. Pachytychius mungonis M.	,,	,,
79. Ceuthorhynchus asperulus F.	,,	,,
80. Myllocerus sp.	,,	,,

81. Alcides collaris P.	Curculionidae	Minor
82. Alcides pictus B.	,,	,,
83. Alcides fabricii F.	,,	,,
84. Alcides bubo F.	,,	,,
85. Apion amplum F.	Apionidae	,,
86. Aulacophora stevensi B.	Chrysomelidae	,,
87. Aulacophora foveicollis F.	,,	,,
88. Aulacophora atripennis F.	,,	,,
89. Sagra nigrita Ol.	,,	,,
90. Platyxria hystrix Fb.	Hispidae	,,
91. Oberea brevis S.	Cerambycidae	,,
92. Sphenoptera perotetti G.	Buprestidae	,,
93. Cantharis setaceae	Cantharidae	,,
94. Mylabris pustulata Th.	Meloidae	,,

ORDER - ACARINA

95. Tetranychus sp.	Tetranychidae	,,

ORIGINAL INVESTIGATIONS

MATERIALS AND METHODS

I. MATERIALS:

1. Stages of Nacoleia vulgalis Gn. required for studies:

Eggs, caterpillars and pupae could be collected from the field from cow pea, black gram, green gram and horse gram growing in the Farm attached to the Agricultural College, Vellayani. The collections were made at frequent intervals and the stages of the insect obtained were used for bulk rearing. The eggs required for the individual rearings were obtained from moths of the bulk rearing.

2. Glassware:

(a) Glass chimneys.

i. Length 30 cm., diameter 15 cm., with perforated tin lids.

ii. Length 24 cm., diameter 10 cm., with perforated tin lids.

iii. Length 15 cm., diameter 5 cm., open at both ends.

(b) Specimen tubes 8 cm. x 2 cm.

3. Cotton wool plugs:

The cotton wool was rolled into small cylinders and covered with a piece of muslin cloth. The top was tied firmly and such plugs were used for closing the specimen tubes.

4. Breeding cages:

Field cages 1.8 m. x 1.2 m. x 0.9 m. in size fitted with wire guaze were used for studies in egg laying under field conditions.

5. Flower pots:

Flower pots 30 x 30 cm. size were used for growing the pulse crops.

6. Host plant seedlings:

Life history studies were made on 1½ to 2 weeks old seedlings of green gram grown in specimen tubes. For egg laying under field conditions, 3 to 4 weeks old seedlings of green gram in pots were used. To find out the relative preference of the insect for different species of pulses, green gram, black gram, horse gram and cow pea were grown in 6 x 6 metre plots in the farm.

7. Host material as food for rearings:

Fresh leaves of pulses were collected daily from the field and used for feeding the caterpillars.

8. Diluted honey:

10% honey was used for feeding the moths.

II. METHODS:

For life history studies the insect was reared in the laboratory both on a bulk scale and individually. Bulk rearing was done in glass hurricane chimneys as follows:

The caterpillars collected from the field or obtained by hatching of eggs in the laboratory were kept in chimneys with fresh leaves of the host plant, the two openings being closed with muslin kept in position with rubber bands. The chimneys were examined daily and cleaned and the old leaves were replaced by fresh leaves. Any prepupae and pupae collected were put in separate chimneys. When the moths emerged they were used for egg laying. Parasitized larvae and cocoons of parasites were separated and kept in specimen tubes for emergence and further studies.

For the purpose of obtaining eggs in the laboratory males and female moths were confined in pairs in large glass chimneys with a seedling of the host. The top of the chimney was closed with a tin lid with small perforations. The seedlings were raised in specimen tubes by sowing one or two seeds of the host plant in the soil contained in the tube. Every day fresh seedlings were supplied for oviposition, till the moths died, or till no more eggs were laid. The eggs thus obtained were allowed to hatch in chimneys.

For studying oviposition under field conditions adult males and females were liberated in insect proof cages in which freshly grown potted plants of green gram were kept and the first instar caterpillars were collected for individual rearing.

In individual rearing specimen tubes open at one end and small glass chimneys open at both ends were used. Two leaves of the host plant were placed in the chimney and one newly hatched caterpillar introduced and the chimney was closed with muslin fixed in position with rubber bands. The leaves were changed daily and the stage of development and duration of each instar was noted.

When the larvae had completed development and moths emerged, they were kept in chimneys and supplied with diluted honey soaked on cotton wool.

For longevity studies, mated and unmated males and females were separately kept in hurricane chimneys and fed on diluted honey. For ascertaining the sex ratio the male and female moths obtained from the bulk rearings in the laboratory were sorted and counted.

In order to find out the relative preference of the insect to different species of pulses, plots 6 x 5 metre were laid out in the field and four species of pulses viz. green gram, black gram, horse gram and cow pea were grown.

All leaf folds containing the caterpillars were collected separately once a week from all the plots and counted and the intensity of attack of different species noted.

Experimental conditions:

The biology of N.vulgalis Gn. was worked out in the laboratory during the period September 1962 to January 1963. The maximum and minimum temperature and humidity during the period were recorded every month and are given in Appendix I.

STUDIES ON THE BIOLOGY OF NACOLEIA VULGALIS Gn.

Systematic position

Order	-	Lepidoptera
Family	-	Pyralidae
Sub Family	-	Pyraustinae
Genus	-	Nacoleia
Species	-	Vulgalis

(Hampson, Fauna. Ind. Moths, IV)

Synonyms:

Phalaena indicata Fab, Ent. Syst. III ii 218 (1794)

Botys vulgalis Guence, Delt & Pyr, p. 202, t6., F.8.

Nacoleia indicata Fb. Fletcher, S.S.I., pp. 433-434; 1914.

I. Life history

These studies were made both in the field and in the laboratory. Following are the details of observations.

i. Mating:

The moths emerge during night and after 24 hours they mate. Mating takes place only during night. In rare instances mating on the same day of emergence has been noticed. During the mating process they remain with their head pointing in opposite directions with their abdominal tips touching each other. The moths remain in copulation for about

10 to 15 minutes during which time they are stationary. When mating is over the male moves away while the female may either remain in the same position for some time or may move away.

ii. Oviposition:

Oviposition commences in a day or two after emergence and generally takes place at night. Flat, scale like eggs are deposited on the tender leaves of host plants usually on the under surface in straight rows of 10 to 15 eggs each. Several such rows are seen side by side. There may be irregular clusters without any arrangement or scattered singly. When laid in groups the eggs are arranged overlapping one another like the scales of a fish (vide Plate III, fig.1). The egg clusters are covered with a slimy secretion of the female moth which when dries up cements the eggs firmly to the substratum.

Table I gives the record of the number of eggs laid by a female moth and the duration of the egg laying period. It will be seen that the number of eggs laid varied from 433 to 688, the average being 542 eggs per female. It is also seen that the female moth lays eggs for 5 to 6 days. The number of eggs laid per day by a female moth varies from 19 to 234.

TABLE I

Number of eggs laid by female moth of N.vulgalis Gn.

Sl. No.	Date of emergence.	No. of Adults.		No. of Eggs laid							Total No. of eggs.	No. of eggs laid by a female
		Male.	Female	1st day.	2nd day.	3rd day.	4th day.	5th day.	6th day.	7th day.		
1	10-10-'62	2	2	—	125	239	114	163	181	145	967	483
2	10-10-'62	2	2	—	—	200	191	180	145	151	867	433
3	11-10-'62	1	1	—	—	152	158	227	21	130	688	688
4	13-10-'62	1	1	—	—	172	109	194	86	24	585	585
5	15-10-'62	1	1	—	—	216	127	104	47	19	513	513
6	18-10-'62	1	1	—	27	203	164	109	45	16	564	564
7	24-10-'62	1	1	—	—	123	234	117	31	35	526	526
8	30-10-'62	1	1	—	—	28	165	182	97	54	540	540

Average number of eggs laid per female - 542.

The egg which is cream coloured when laid acquires a brownish tinge as development proceeds. The progress of development of the embryo can be observed through the thin egg shell by examining 3 to 4 days old eggs. The eyes, mandibles and other mouth parts being clearly visible. The first instar caterpillar emerges through a longitudinal slit which is laterotorminal in position and the egg shell remains sticking to the leaves even after the emergence of the caterpillar.

Table II and III give the data on the duration of various life stages of the insect as observed in laboratory rearings. It is seen that the incubation period is on an average 4.1 days in October.

iii. Larval stages: (Plate III, figs. 2 to 7)

The eggs hatch during early hours of the day. The pale white newly hatched caterpillars wander in all directions all over the leaf for the first two to three hours. Gradually they come to congregate near the base of the tender leaves on the lower surface in between the veins. Then they start feeding by nibbling at the green tissues of the leaves. In a few hours only the upper epidermis is left intact as papery patches (Plate IV, fig.4). After about a day they disperse on all directions to other leaves and to nearby plants. The caterpillar now fastens two neighbouring leaflets together

with the help of minute white silken threads and constructs a flimsy shelter of silken webbing. It remains in between the two leaflets and feeds voraciously in concealment on the green tissues of the upper leaf for about three days. On the third day, its colour slightly changes to pale yellow and it remains without feeding for sometime and then moults. The first instar stage lasts 3 to 4 days. (Vide Table II and III).

The second instar caterpillar is pale yellow in colour. In the laboratory when they were placed on fresh seedlings they twisted and rolled the terminal portions of the leaflets in the form of small cones, with the help of white, silken threads and remained inside the folds. They are very active and feed voraciously and scraping off the green matter, thus skeletonising the leaves. Just before moulting the caterpillar becomes sluggish. The duration of the second instar is 2 to 3 days (Vide Tables II and III).

The third instar caterpillar is pale green in colour and less active. When placed on fresh plants they were found to roll the leaves or web a number of leaves together by white silken threads. Before making the tubular rolls, the caterpillar selects the proper leaves and after obtaining a firm grip on the leaf surface by postpods and third and fourth abdominal prolegs, brings the edges of the leaves together and fixes them with white silken threads. The webbing is carried

out by moving the head on either side and the edges of the leaves are brought together gradually with the help of mouth parts and thoracic legs. The caterpillar moves backwards gradually as the webbing progresses. Finally it enters the fold and closes the fold from within and lives and feeds from inside. The third instar lasts for 2 to 3 days (Tables II and III).

Fourth instar caterpillars are green in colour, feed voraciously from inside the leaf rolls on the leaf tissues leaving only the main veins. During this stage they can feed on mature leaves also and the leaf rolls are seen filled with the faecal matter. After eating away a portion of one fold, the caterpillar leaves that fold and constructs another. The fourth instar stage lasts for 2 to 3 days (Table II and III).

Fifth instar caterpillar also is an active, voracious feeder like the previous one. When it is full grown and about to pupate, the caterpillar becomes sluggish and moves to the darker places. It rolls a leaf with silken threads and constructs a thin delicate, fluffy whitish cocoon inside the roll. The cocoon is of loose texture so that the outline of the pupating larva or pupa can be made out. On one end of the cocoon the threads are loosely wooven, probably this enables the easy emergence of the moth. The larva stops feeding and remains inside the cocoon quiscent and turns into the prepupa. The body becomes straightened and cylindrical and tapers to a

point posteriorly. The colour of the body on the dorsal side is darken than on the ventral. The dorsal blood vessel can be seen as a hyaline line. The abdominal segments become paler and then turn brown. The fading of colour is noted first at the middle region of each abdominal segment and this is followed in intersegmental membrane also, but there is not much colour change in thoracic segments. The duration of the fifth instar is 4 to 6 days (Table II and III). The caterpillar gets transformed into the pupa.

iv. Pupal stage (Plate III figs. 8 to 10)

Pupation takes place inside the cocoon spun by the final instar caterpillar within the leaf fold. The pupa just after moulting is pale greenish or creamy white in colour. The wing buds appear more greenish. The colour gradually changes to brown and this change is first noticed in the intersegmental regions. Within 1½ to 2 hours, the pupa becomes brown in colour all along the dorsal side, but the ventral side is lighter brown. The pupal period lasts on an average 5.3 days in October-November (vide Table II & III). Then the pupal shell breaks ventrally on each side of the anterior end along oblique lines and the moth emerges.

As the moth creeps out of the pupal case, the wings are folded and wrinkled. Soon the wings become functional and shivering of the wings and the body is noticed during this process. After about 3 hours the moth is capable of flight.

T A B L E II

Life cycle of N.vulgalis Gn. from egg to adult

Date of Egg laying.	Date of hatching.	Date of 1st moult.	Date of 2nd moult.	Date of 3rd moult.	Date of 4th moult.	Date of pupation.	Date of Emergence.	Total period.
5-10-'62	9-10-'62	12-10-'62	14-10-'62	16-10-'62	18-10-'62	23-10-'62	28-10-'62	23 days.
6-10-'62	10-10-'62	13-10-'62	15-10-'62	17-10-'62	20-10-'62	23-10-'62	28-10-'62	22 ,,
6-10-'62	10-10-'62	13-10-'62	15-10-'62	17-10-'62	20-10-'62	24-10-'62	29-10-'62	23 ,,
6-10-'62	10-10-'62	13-10-'62	15-10-'62	18-10-'62	20-10-'62	25-10-'62	30-10-'62	24 ,,
13-10-'62	17-10-'62	20-10-'62	22-10-'62	24-10-'62	27-10-'62	1-11-'62	7-11-'62	25 ,,
13-10-'62	17-10-'62	21-10-'62	23-10-'62	25-10-'62	27-10-'62	2-11-'62	7-11-'62	25 ,,
16-10-'62	21-10-'62	24-10-'62	27-10-'62	29-10-'62	31-10-'62	5-11-'62	10-11-'62	25 ,,
18-10-'62	22-10-'62	25-10-'62	27-10-'62	29-10-'62	31-10-'62	4-11-'62	10-11-'62	23 ,,
19-10-'62	23-10-'62	26-10-'62	28-10-'62	30-10-'62	1-11-'62	4-11-'62	10-11-'62	22 ,,
21-10-'62	25-10-'62	28-10-'62	30-10-'62	1-11-'62	3-11-'62	7-11-'62	12-11-'62	22 ,,

TABLE III

Duration of different stages of N.vulgalis Gn.

Sl. No.	Egg.	I instar.	II instar.	III instar.	IV instar.	V instar	Pupa	Total period.
1	4 days.	3 days.	2 days	2 days	2 days	5 days	5 days	23 days
2	4 ,,	3 ,,	2 ,,	2 ,,	3 ,,	5 ,,	5 ,,	22 ,,
3	4 ,,	3 ,,	2 ,,	2 ,,	3 ,,	4 ,,	5 ,,	23 ,,
4	4 ,,	3 ,,	2 ,,	3 ,,	2 ,,	5 ,,	5 ,,	24 ,,
5	4 ,,	3 ,,	2 ,,	2 ,,	3 ,,	5 ,,	5 ,,	25 ,,
6	4 ,,	4 ,,	2 ,,	2 ,,	2 ,,	6 ,,	5 ,,	25 ,,
7	5 ,,	3 ,,	3 ,,	2 ,,	2 ,,	5 ,,	5 ,,	25 ,,
8	4 ,,	3 ,,	2 ,,	2 ,,	2 ,,	4 ,,	6 ,,	23 ,,
9	4 ,,	3 ,,	2 ,,	2 ,,	2 ,,	3 ,,	6 ,,	22 ,,
10	4 ,,	3 ,,	2 ,,	2 ,,	2 ,,	4 ,,	5 ,,	22 ,,
Total	41 ,,	31 ,,	21 ,,	21 ,,	23 ,,	44 ,,	53 ,,	234 ,,
Average	4.1 ,,	3.1 ,,	2.1 ,,	2.1 ,,	2.3 ,,	4.4 ,,	5.3 ,,	23.4 ,,

v. Life cycle and number of generations in the year:

A perusal of the Tables II and III will show that the total period of life cycle from egg to adult occupies 22 to 25 days in October-November, the average being 23.4 days. As temperature and humidity conditions are fairly uniform throughout the year in Kerala, it is natural to expect that normally, the insect passes through 12 to 15 generations in the year. During the off-period of pulse crops, a few specimens have been noted. Calapagonium muconoides, a cover crop of the rubber and on Moghania macrophylla, a host plant of lac insect, in the nearby plantations.

vi. Longevity of Adults:

These studies were conducted under laboratory conditions, the moths being fed on diluted honey. A perusal of the data in Tables IV to VII shows that unmated males and females lived on an average for 5.6 days and 6 days respectively while mated ones lived for 5.5 days and 7.25 days respectively. From these preliminary observations, it would appear that mating has no influence on longevity of males, while in the case of females, mating tends to lengthen life.

TABLE IV.

Longevity of unmated males of N.vulgalis Gn.

Sl. No.	Date of emergence	date of death	Longecity in days.
1	29-9-'62	3-10-'62	4
2	30-9-'62	8-10-'62	8
3	3-10-'62	8-10-'62	5
4	5-10-'62	10-10-'62	5
5	11-10-'62	16-10-'62	5
6	14-10-'62	19-10-'62	5
7	14-10-'62	20-10-'62	6
8	16-10-'62	23-10-'62	7

Longevity uf unmated male - 5.6 days.

TABLE V.

Longevity of unmated females of N.vulgalis Gn.

Sl. No.	Date of emergence	Date of death	Longevity in days.
1	1-10-'62	6-10-'62	5
2	10-10-'62	13-10-'62	3
3	10-10-'62	16-10-'62	6
4	11-10-'62	18-10-'62	7
5	11-10-'62	18-10-'62	7
6	14-10-'62	21-10-'62	7
7	16-10-'62	23-10-'62	7
8	16-10-'62	22-10-'62	6

Longevity of unmated female - 6 days.

TABLE VI

Longevity of mated males of N.vulgalis Gn.

Sl. No.	Date of emergence	Date of death	Longevity in days
1	9-10-'62	14-10-'62	5
2	9-10-'62	15-10-'62	6
3	10-10-'62	18-10-'62	8
4	10-10-'62	14-10-'62	4
5	10-10-'62	16-10-'62	6
6	11-10-'62	16-10-'62	5
7	15-10-'62	20-10-'62	5
8	30-10-'62	4-11-'62	5

Longevity of mated males - 5.5 days.

TABLE VII

Longevity of mated females of N.vulgalis Gn.

Sl. No.	Date of emergence	Date of death	Longevity in days
1	9-10-'62	16-10-'62	7
2	9-10-'62	17-10-'62	8
3	10-10-'62	15-10-'62	5
4	10-10-'62	18-10-'62	8
5	10-10-'62	18-10-'62	8
6	11-10-'62	18-10-'62	7
7	15-10-'62	23-10-'62	8
8	30-10-'62	6-11-'62	7

Longevity of mated females - 7.25 days.

2. Sex Ratio.

Table VIII gives the observations made on sex ratio of the moths. It is seen that in a population of 75 moths 40% were males and 60% females. Rearing in the laboratory from a single brood of eggs showed that 41% were males and 59% females. Thus a preponderence of females over males is in evidence there being 3 females for every 2 males.

TABLE VIII

Sex ratio of N.vulgalis Gn.

Sl. No.	Number of males emerged.	Number of females emerged	Total number of moths emerged.
1	3	4	7
2	3	5	8
3	4	4	8
4	1	3	4
5	-	2	2
6	6	4	10
7	5	8	13
8	6	9	15
9	1	3	4
10	1	3	4

Sex ratio of male and female - 2:3

3. Food Plants

Fletcher (1914) recorded this insect on lucerne, green gram and black gram. In the present studies it has been found attacking the following crops.

1. Phaseolus mungu L. - Black gram
2. Phaseolus radiatus - Green gram
3. Dolichos biflorus L. - Horse gram
4. Vigna catiang E. - Cow pea
5. Cajanus indicus S. - Red gram
6. Calapagonium muconoides - Cover crop
7. Moghania macrophylla - Lac host

Of these black gram, green gram and horse gram appeared to be the most important host plants. During the crops season, the insect feeds and breeds in large numbers on these plants and then migrates to the cover crop Calapagonium muconoides during the off season. In the case of the three above mentioned pulses, the pest is seen throughout the growth period of the crop. It rarely infests Cajanus indicus and Moghania macrophylla.

4. Relative preference of Nacoleia vulgalis Gn. for different species of host plants

In the fields outside the experimental plots, N.vulgalis Gn. was found to feed and breed on all species of

pulses. However it was noticed that relatively black gram and green gram are infested more heavily than horse gram and cow pea and the infection is more serious in the early stages of the crop than in the later stages. Red gram also appears to be not much preferred by the pest.

Table IX

Relative preference of N.vulgalis Gn. to different pulse crops

Sl. No.	Date of collection.	Number of leaf rolls collected			
		Green gram.	Black gram.	Horse gram.	Cow gram.
1	3-10-62	13	10	8	5
2	10-10-'62	15	17	9	7
3	18-10-'62	11	15	11	9
4	25-10-'62	17	14	8	5
5	2-11-'62	9	11	6	2
6	10-11-'62	12	13	7	1
7	17-11-'62	13	11	7	2
8	26-11-'62	14	15	9	2
9	4-12-'62	10	11	6	-
10	11-12-'62	8	6	5	1
11	20-12-'62	9	7	4	-
12	27-12-'62	6	6	3	-
13	5-1-'63	5	3	2	-
	Total ----	142	139	85	34

Table IX gives the record of leaf rolls collected from the experimental plots to find out the relative preference of the insect to different species of pulses. It is seen that black gram and green gram are infested more heavily than horse gram and cow pea, thus supporting the observations made in the fields.

5. Nature and extent of damage

The pest is seasonal in occurrence and outbreak as observed in Vellayani fields usually occur during September to January, although the pest may be present in the field throughout the year. Usually the attack starts early in the season. During the early stages caterpillars feed in groups on the green matter at the lower base of the leaves, leaving the upper epidermis intact and the infected portions look like white papery patches. In the seedling stages the damage seriously affected the health and vigour of the plants. In the later stages the caterpillars web the leaves together. They roll the individual leaves or web together a number of leaves by white silken threads and feed from inside the folds (Plate II A.)

The young caterpillars feed only on the green matter of the leaves as a result of which the leaves gradually dry up. The grown up caterpillars feed on the whole leaf tissues excepting the veins and so the attacked leaves in these

cases appear skeletonised. In these ways, a caterpillar is able to damage and destroy several leaves on a plant. As a result of this the plants become weakened and yield is reduced considerably. Attack by this pest is easily detected by the presence of webbed and folded leaves.

6. Status as a pest

Fletcher (1914) mentioned Nacoleia vulgalis Gn. as a minor pest of pulses in the plains of South India. In recent years this has been observed in Kerala (especially at Vellayani) as a very common pest of cultivated pulses. Very often the damage caused is serious, especially in the case of young crops. Young plants if attacked may get killed or remain stunted. The attack may continue upto the later stages of the crop except in the case of cow pea, where it is seldom serious. On the whole N.vulgalis Gn. can be considered as an important pest of pulses, if not a major one.

7. Natural enemies

During the rearing of caterpillars collected from the field, the following larval parasites were obtained from parasitic larvae. viz. Cardiochiles fulvus Cam., Xanthopimpla punctator L. and a Tachnid fly (unidentified)

1. Cardiochiles fulvus Cam.

Fam. Braconidae (Plate IV. fig.2).

This is an endoparasite which appeare to attack the later stage caterpillars. The parasitized larva becomes sluggish, gets reduced in size and assumes a pale white colour. It constructs a pupal cocoon and rests inside as prepupa. After three days the parasitic grubs emerge from the host prepupa, killing the latter in the process. Three or four grubs develop within a single host caterpillar. On emergence from the host, the parasitic grubs spin white, silken barrel shaped cocoons, inside the host cocoon. The cocoon of the parasite measures 3 mm. in length. The adult wasp emerges in 4 or 5 days after cocoon formation.

The adult female parasite is yellowish brown in colour with dark abdomen. It measures 5 mm. long and 1 cm. broad across the stretched wings. Head small round and with black eyes. Antennae dark, filiform inserted in between the eyes. The wings smokey, stigma prominent with an yellow area adjacent to the stigma, towards the base of the wing. Hind legs are longer and the tarsal segments are black in colour. Abdomen elongated and oval, the greatest width being across the second segment. Ovipositor as long as the abdomen. This parasite was collected during the period of October to December.

11. Xanthopimpla punctator L.

Fam. Ichneumonidae (Plate IV. fig.3)

This is an endoparasite attacking the later instar caterpillars. Only one specimen was obtained during the period of investigation in November. The parasitized larva appears reduced in size. It then gets transformed into a pupa, which is smaller than the normal pupa. The adult wasp emerged from the host pupa after four days.

The adult is a stout built wasp about 1 cm. long and 1.5 cm. across the stretched wings. General colour of the body yellow. Head yellowish brown, with prominent black eyes. Antennae long and filiform and yellowish brown, and inserted in between the eyes. The coxae of the legs are swollen, hind legs being longer than the forelegs. A black spot at the proximal end of hind tibia. Two black dots on the metathorax on either side of the mid dorsal line. Wings are membraneous, stigma black and clear. Abdomen long and club shaped with a narrow pedicel and spindle shaped gaster. Nine segments of the abdomen are clear. On either side of the mid dorsal line on each of the first, third, fourth, fifth, sixth and seventh segments two prominent black dots are present. Dark spots on the fourth and sixth segments are not so clear. Ovipositor as long as abdomen.

iii. Tachinid Fly (Unidentified) (Plate IV, fig.1).

This is an endoparasitic fly which also appears to attack the later instar larva, probably a grown up caterpillar. The development of the parasite takes place inside the host pupa. One or two small, barrel shaped, parasitic puparia are seen in each host pupa. Instead of the moth emerging from the pupa, the parasitic flies emerge from the attacked host pupa.

The adult flies are medium sized, well built and sombre coloured, having the size of a house fly and measures about 7 mm. long. This parasite was collected in abundance during the months of January and February.

8. Description of stages

1. Egg. (Plate III, fig.1.)

Eggs are flat, cream coloured, arranged like the scales of fish; they are covered with a slimy secretion secreted by the female moth, which dries up and cements the eggs firmly to the leaves. Eggs are oval and slightly tapering towards the microphylar pole. Surface rugose. When viewed under the microscope the egg appears reticulated all over the chorion leaving a hyaline margin all around and a slight deep coloured thickening in the centre. The egg measures approximately 0.6 mm. in length and 0.45 mm. in bredth. Chorion thick, leathery and translucent; surface is thrown into longitudinal folds conspicuous in the centre.

ii. First instar caterpillar (Plate III, fig.2)

On emergence the caterpillar measures 1.3 mm. to 1.8 mm. in length; cylindrical and gradually tapering posteriorly. General body colour pale white. Segmentation distinct, first six abdominal segments being darker than the rest. Head and body covered with minute hairs arising singly from tubercles.

Head small, pale brown, 0.2 mm. in width; broader than the rest of the body. Epicranium and frons light brown with the ocellar region deep brown; sutures deep and prominent, adfrontal sutures indistinct. Mouth parts pale brown. Antennae lighter coloured. Ocelli four in number seen as small round dark spots laterally on each side of the frons. Prothorax pale yellowish; broader than head, with two small black reniform spots situated dorsolaterally at the anterior end of the segment on either side. Thoracic legs are five segmented with a single brown claw and covered with small minute setae. Prolegs with circular base, slender elongated planta; crochets arranged in triordinal uniseries. Thoracic legs and prolegs are concolorous with the body. Short, white, silky setae distributed sparsely on body and borne on small tubercles which are unicolorous with the body. Spiracles indistinct.

iii. Second instar caterpillar (Plate III, fig.3)

Immediately after moulting the caterpillar measures 2.5 to 5.5 mm. in length and is pale yellow with a green tinge. It is subfusiform and cylindrical, gradually tapering posteriorly. All the segments well differentiated. The digestive tract as seen from the dorsal aspect, appears as a green band.

Head yellowish, relatively smaller than the rest of the body; 0.4 mm. in width. Arrangement of ocelli and setae of the head same as in the previous instar.

Thoracic segments pale yellow. Prothorax smaller than the meso and metathorax; darker in shade. Two dark spots seen on either side as in first instar. Thoracic legs, slender, with single terminal brown claws.

Abdominal segments well defined; first six segments of nearly the same width; the rest of the segments taper posteriorly. The penultimate segment and the anal segment appear translucent. Prolegs with cylindrical planta and circular black base and bears 13 to 14 yellowish brown crochets.

Head and body covered sparsely with minute silvery white setae on raised tubercles; the setae at the anal segments being longer. Spiracles with dark rims; appear prominent. Rest of the characters are similar to those of the previous instar.

iv. Third instar caterpillar (Plate III, fig.4)

Newly moulted caterpillar measures 6 to 7 mm. in length, cylindrical tapering posteriorly; pale green in colour. Head brown, measures 0.6 mm. in width. Epicranium and frons dark brown. Epicranial sutures deep and prominent, light black in colour; adrontal sutures indistinct. Mouth parts brown. Antennae and maxillae yellowish brown; the ocelli being more prominent than in the previous instar.

Thoracic segments yellowish brown. The black dots on the prothoracic shield oblong and darker than in the previous instar. Two raised semicircular chitinisations present near the posterior margin of the tergal plate of the prothorax on either side of the mid dorsal line. Meso and metathorax shorter and wider than prothorax.

Abdominal segments shorter but wider than the thoracic segments; gradually becoming narrower posteriorly. Prolegs yellowish green with black base; bears 19 to 20 yellowish brown crochets arranged in triordinal uniseries.

Head and body covered with minute white silken setae on raised tubercles which are unicolorous with the body. Setae at the anal tip long and stout. Rest as in previous instar.

v. Fourth instar caterpillar (Plate III, fig.5).

The caterpillar measures 9 mm. in length; greenish in colour. Dorsal surface deeper coloured than the ventral side. Head reddish brown; measures 0.8 mm. in width. Epicranium and frons yellowish brown with the ocellar areas deep brown. Epicranial suture deep black and prominent, adfrontal sutures indistinct. The ocelli more prominent than in the previous instar and surrounded by minute setae.

Thoracic segments yellowish brown. Prothorax is the same width as head; broader than long, deeper coloured than the meso and metathorax. The black spots oval and more prominent. The semicircular chitinisations of the tergal plate appear more pronounced. Meso and metathorax longer and broader than prothorax and broader than long. Pro and mesothoracic legs shorter than the metathoracic legs.

Abdominal segments green in colour, except the last two segments which are translucent. Prolegs yellowish green with a black base and bears 20 to 25 yellowish brown crochets arranged in triordinal uniseries. Body sparsely covered with silvery white setae on tubercles which are unicolorous with the body. The anal segments provided with long stiff setae. Spiracles are round, with raised edges ringed with black. Rest of the characters similar to thos of the previous instar.

vi. Fifth instar caterpillar (Plate III, Fig.6)

The full grown caterpillar measures 1.5 cm. in length, green in colour with a yellowish tinge. Dorsal side deeper coloured than the ventral. Body cylindrical subfusiform; the segments well marked by constrictions in between the segments. The general integumental surface coarsely pitted.

Head. (Plate V, fig.1)

1.4 mm. broad. Epicranium and frons light brown with the ocellar areas deep brown, epicranial sutures deep, black and prominent; adfrontal sutures indistinct. Two small, silken setae borne on tubercles at the upper end of the adfrontal area on either side of the epicranial suture at the point of branching; four long setae on the vertex of the epicranium and four to six minute setae on either side of the epicranium. Two small setae on the frontal area and two on the clypeal area in front of the head. Four ocelli arranged in a semicircle, antero-laterally on each side of the epicranium with four or five long setae around them. Antennae three segmented, basal segment short, broader than long, median segment stout and cylindrical; the terminal segment long and tapering with two or three short and one long silvery apical seta. Mouth parts deep brown in colour. Labrum covered with minute hairs.

Thorax:

Consists of three segments bearing three pairs of legs. Yellowish brown in colour; less broader than abdominal segments.

Prothorax: (Plate V, fig.2)

Shorter in length than the meso and metathorax; as broad as head and broader than long. Prothoracic shield yellowish brown. A longitudinal dumbel shaped black spot present dorso-laterally on each side. Transverse row of setae present dorsally consisting of six setae, three on either side of the middorsal line. A raised pinnaculum like area bearing a horse-shoe shaped brownish chitinisation present along the posterior margin, on either side dorsally. Lateral to prothoracic shield on each side is a pair of setae situated anteriorly and the prothoracic spiracle posteriorly. A pair of setae located lateral to the base of the prothoracic leg. Ventrally at the base of the legs is situated a pair of small setae and another pair posterior to the base of the legs.

Mesothorax:

Broader and longer than prothorax, slightly broader than long. Anteriorly, on either side of the middorsal line are two pairs of setae arranged in a transverse line. Posterior to this, two setae are borne on tubercles in a

line dorsolaterally; another seta is situated postero-laterally on a tubercle. Lateral to the base of the mesothoracic leg is a long seta on a tubercle and around the base of the leg are situated four small setae. Ventrally, in between the base of the two legs and posterior to them are two pinnacula bearing one seta each.

Metathorax: (Plate V , fig.3)

Size, shape and setal arrangement similar to those of mesothorax. Legs light brown; longer than pro and mesothoracic legs; five segmented, basal segment broader than long, somewhat conical in shape and with four short minute hairs all around. Second and third segments of legs cylindrical, fourth segment longer than the first three segments, tapers distally and encircled by five minute hairs; last segment short, slender, tapering and tipped with an yellowish brown claw.

Abdomen:

Cylindrical, subfusiform, consists of ten segments, tapering towards the posterior end. Green in colour; dorsal side being deeper coloured than ventral. All segments distinctly constricted.

First segment: (Plate V, fig.4)

Slightly larger than the metathorax and broader than long. Two transverse rows of setae dorsally, the ante-

rior row with two setae on either side of the middorsal line and the posterior one with a single seta on either side, close to middorsal line. Spiracle situated dorsolaterally in a line with the anterior row of setae. Laterally, three setae on a broad pinnaculum just below the spiracle. Posterior to this and roughly in line with the posterior row of dorsal setae is a seta on either side. Ventrolaterally on each side is a pinnaculum anteriorly bearing two setae and one seta posteriorly.

Second segment:

Longer and broader than the first and broader than long. Arrangement of setae on the dorsal side similar to the previous segment. Laterally two setae just below the spiracle and another pair posterior to it in the middle of the lateral plate. Three setae on a pinnaculum latero-ventrally at the anterior end. Ventrally, one seta on a tubercle in the middle of the ventral plate.

Segments 3, 4, 5 and 6: (Plate V , fig.5)

Bigger in size than the first two abdominal segments. All the four segments are similar in form and arrangement of setae. Broader than long; bear four pairs of prolegs. Setal arrangement on dorsal side similar to that of the first two segments. Laterally, below the spiracle are two small setae carried on a pinnaculum. Another seta just above the base of the proleg on a tubercle. Around the base of the proleg are four small setae. Prolegs yellowish green with conical base and a

slender and conical plants with a black base. 28 to 30 yellowish brown crochets arranged in triordinal uniseries.(Fig.8) Prolegs clothed with 12 to 14 minute setae.

Seventh segment:

Slightly smaller than the sixth segment and longer than broad. Setal arrangement on the dorsal side similar to that of the first segment. Laterally two setae just below the spiracle on tubercles; another seta at the posterior end in the middle, and two setae lateroventrally in the middle. Ventrally two setae at the middle of the sternal plate.

Eighth segment:

Smaller than seventh segment, tapering posteriorly. Broader than long. A deep transverse furrow present dorsally. Arrangement of setae on the dorsal side as in the first segment. Laterally two setae just below the spiracle and another seta below that lateroventrally. Two setae are situated at the middle of the ventral plate.

Ninth segment: (Plate V, fig.6)

Short, narrow, broader than long. Arrangement of dorsal setae similar to preceeding segments. Laterally in line with the anterior row two setae and ventrally two short setae in the middle of the sternal plate.

Tenth segment: (Plate V, fig.7)

Short, conical in shape, tapering to the tip, bearing the prolegs or anal claspers ventrally. A transverse row of four long stiff setae arranged in a semicircle in the middle of the tergum. Posterior to this is a long seta on

either side of the mid dorsal line and two similar setae at the extreme tip. Ventrally, the bases of the two legs are close together with a median triangular sclerite in between anteriorly. A seta on tubercle in the inner side of the base of each leg. Spiracle oblong, with raised yellowish brown rim.

TABLE X

Biometrical date of different instars of N.vulgalis Gn.

Sl. No.	Particulars	I Instar	II Instar	III Instar	IV Instar	V Instar
1.	Length of the caterpillar	1.55 mm.	3.00 mm.	6.50 mm.	9.00 mm.	1.50 mm.
2.	Width of the head shield	0.20 mm.	0.40 mm.	0.60 mm.	0.80 mm.	1.40 mm.
3.	Width of thoracic segment (Mesothorax)	0.20 mm.	0.40 mm.	0.53 mm.	0.98 mm.	15.00 mm.
4.	Width of Abdominal segment (5th)	0.25 mm.	0.45 mm.	0.60 mm.	10.00 mm.	20.00 mm.
5.	Length of hairs on head	0.06 mm.	0.20 mm.	0.23 mm.	0.30 mm.	0.53 mm.
6.	Length of hairs on thorax	0.12 mm.	0.20 mm.	0.40 mm.	0.75 mm.	0.98 mm.
7.	Length of hairs on abdomen	0.15 mm.	0.20 mm.	0.40 mm.	0.75 mm.	1.35 mm.
8.	Length of hairs on anal segment	0.23 mm.	0.30 mm.	0.53 mm.	0.90 mm.	1.50 mm.

Prepupa: (Plate III, Fig.7)

Body cylindrical, shortened, tapering to a point posteriorly; measures 1.2 to 1.3 cm. long. General body colour greenish white, thoracic segemets green; dorsal side deeply darker than the ventral. Colour fading at the middle of the abdominal segments. Head reddish brown, retracted into the prothorax, placed vertically, mouthparts grouped together and directed backwards. Prothorax much contracted, meso and metathorax bigger in size than prothorax and distended. Tergal plate of mesothorax extending posteriorly into a blunt cone covering the anterior end of metathoracic tergum. Brown, wavy transverse lines on the terga. Thoracic legs distended and directed forward. First two abdominal segments much contracted and narrowed; proceeding four segments greatly distended and enlarged in size. Colour of the segments changed to creamy white. Prolegs much contracted and retracted into the distended sternal plates, except the black base which is conspicuous; legs are directed backwards. Seventh and eighth segments reduced in size, tapering posteriorly. Ninth and tenth segments much contracted, end in a conical spine like process at the top. Long, silvery white anal setae at the tip.

vii. Pupa. (Plate III, figs. 8 to 10)

Length 1.1 cm. breadth 3 mm. across the wing covers over the third abdominal segment. Elongate, cylindrical in shape but slightly broader at the third abdominal segment, round at cephalic end and tapering gradually to a point at

caudal end. General body colour light brown at first, later on becoming dark brown, particularly on the dorsal side. Head small and round, compound eyes distinctly clear. Two minute silky hairs present on the vertex. Maxillary palpi about twice as long as the labial palpi and completely enclose the latter. Wing covers extend beyond the middle of the fourth abdominal segment where they are conjointly rounded in a broad arc, on the vertral side. Tip of the wing cover deep brown. Intersegmental lines between the fourth, fifth, sixth and seventh abdominal segments form deep grooves around the body. Groove between sixth and seventh abdominal segments more deep, the rest of the abdominal segments are movable at this region. Eighth, ninth and tenth segments movable. Spiracles on abdominal segments two to eight. First seven pairs raised, uniform and elliptical with elevated margins and dark in colour. Spiracles on eighth segment linear with margins not elevate. Ninth and tenth abdominal segments taper to a spinelike process. Cremaster represented by nine small brown hooked setae at the apex of the tenth segment.

One transverse row of minute silky setae, arising on small tubercles in the middle of each abdominal segment. First two segments having two setae each; the third and fourth with four setae each dorsally; the rest have eight setae each all round. The tubercles are conspicuous, shiny and unicolorous with the body.

viii. Adult. (Plates I and II)

Original description of the adult of Nacoleia vulgalis Guence. from Hampson's Fanna of British India, Moth's Vol.IV is as follows.

"Antennae of male without tuft of scales at middle. Fulvous yellow, abdomen ringed with white, wings suffused with fuscous except the costa of forewing. Forewing with obliquely curved antemedial blackline, a speck in cell and discocellular spot, the post medial line arising from a black spot on the costa, nearly straight to vein 2, then retracted to a lower angle of cell and slightly angled to vein I. Hind wing with discocellular spot, the postmedial line bent outwards between veins 5 and 2, then retracted to lower angle of cell, both wings with marginal blackline and line at base of cilia, which are fuscous on forewing, white on hindwing. Some specimens have hardly any suffusion".

The adult has been carefully examined and a brief description is given below. General body colour yellowish brown. The female is slightly bigger than the male measuring 1 cm. in length and 2 cm. broad across the stretched wings and the male 0.9 cm. length and 1.8 cm. broad.

Head:

Broadly globular and slightly flat dorsoventrally with eyes subglobular and black; yellowish brown in between

eyes and on vertex. Antennae yellowish brown, long, filiform with 56 segments in both sexes; scape, the largest of the antennal segment more than twice in length than the pedicel, subglobular in shape and covered with yellowish scales; pedicel half as broad as scape, broader than long and short. Flagellar segments alike in both the sexes; along the inner side, the segments are drawn out into thin flat wing-like process which are longer in the basal segments, the whole giving a slightly serrated appearance to the antenna. Flagellar segments taper distally, the basal segments shorter than the distal segments. Each segment carries a number of thin walled, nearly transparent hairs along the inner border, and a sensory cone at the distal inner corner. The last segment bears three sense cones at its tip. Outer side of the segments covered with yellowish hairs.

Thorax:

Clothed with yellowish brown hairs. Legs yellowish, prothoracic legs smaller without tibial spurs, meso and metathoracic legs with two terminal pair and one middle pair of spurs.

Wings yellowish brown on the upper side, smoky brown on the lower side. Forewings with costa deep yellow in colour; two oblique wavy line and a large spot in between.

Hindwing with two oblique black lines which are continuous with those in the forewing, a row of close black spots along the outermargin of both wings. Above the base of the forewings tufts of yellowish brown hairs on either side directed backwards, ending above the second abdominal segment.

Abdomen:

Abdomen yellowish brown, with pale white lines intersegmentally, clothed with yellowish brown scales. Elongated, conical in male with pointed tip; in female broader with anal tuft of yellowish hairs.

S U M M A R Y

Literature on the insect pests of the important pulse crops, with special reference to the work done in India has been reviewed.

The biology and bionomics of the pea leaf roller Nacoleia vulgalis Gn. (Pyralidae) have been worked out in detail. The moths mate a day after emergence. The female moth lays creamy yellow, oval, scale like eggs during night in rows, generally on tender leaves. On an average, about 542 eggs are laid by one female. Incubation period is 4 days. Larval period lasts 13 to 15 days, the larva undergoing five instars. Durations of the different instars are 3 to 4, 2 to 3, 2 to 3, 2 to 3 and 4 to 6 days respectively. The first instar caterpillars nibble and feed on the green matter on the undersurface at the base of the leaves and the later stage caterpillars web the leaves together and feed from inside skeletonising the leaves. The final instar caterpillar constructs a fluffy white silken cocoon and pupates inside. Pupal period lasts 5 to 6 days. Unmated males and females survive on an average for 5.6 and 6 days respectively, while the mated moths survive for 5.5 and 7.25 days respectively. An extension of the life span is indicated in the case of mated

females. There is a preponderance of females in the ratio of 3:2.

The immature stages have been fully described.

The pest is more abundant in the field during August to February. Damage to the host plant is caused by the webbing together and feeding on leaves which finally dry up. Attack by the caterpillars results in the weakening of the plants. The pest has been recorded on black gram, green gram, horse gram, red gram, cowpea, Calapagonium muconoides and Moghania macrophylla in Vellayani.

The Braconid, Cardiochiles fulvus Cam., the Ichneumonid, Xanthopimpla punctator L. and an unidentified species of Tachinid fly have been recorded as larval parasites of Nacoleia vulgalis Gn.

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*Original not seen.

APPENDIX - I

RECORD OF TEMPERATURE & HUMIDITY

(August 1962 to April 1963)

MONTH	WEEK	TEMPERATURE		HUMIDITY	
		Maximum	Minimum	Maximum	Minimum
AUGUST	1	86	79	91	81
	2	86	79	91	86
	3	86	80	91	74
	4	86	79	91	81
SEPTEMBER	1	86	76	91	89
	2	89	79	91	79
	3	86	79	91	89
	4	86	79	91	89
OCTOBER	1	87	76	90	89
	2	86	78	90	89
	3	84	78	90	89
	4	86	78	91	79

MONTH	WEEK	TEMPERATURE		HUMIDITY	
		maximum	Minimum	Maximum	Minimum
NOVEMBER	1	84	78	91	87
	2	88	78	91	85
	3	90	82	92	82
	4	86	80	90	85
DECEMBER	1	84	80	95	89
	2	86	80	95	85
	3	86	80	91	89
	4	86	80	95	85
JANUARY	1	86	80	90	85
	2	84	78	90	79
	3	86	78	90	85
	4	84	78	89	79
FEBRUARY	1	86	78	89	79
	2	86	78	89	79
	3	86	78	90	85
	4	86	78	90	84

MONTH	WEEK	TEMPERATURE		HUMIDITY	
		Maximum	Minimum	Maximum	Minimum
MARCH	1	86	78	90	79
	2	86	78	94	79
	3	88	78	91	85
	4	88	78	90	85
APRIL	1	88	78	96	85
	2	86	78	96	85
	3	86	78	96	85
	4	88	78	95	90

ILLUSTRATIONS

PLATE I

Nacoleia vulgalis Gn. Adult male

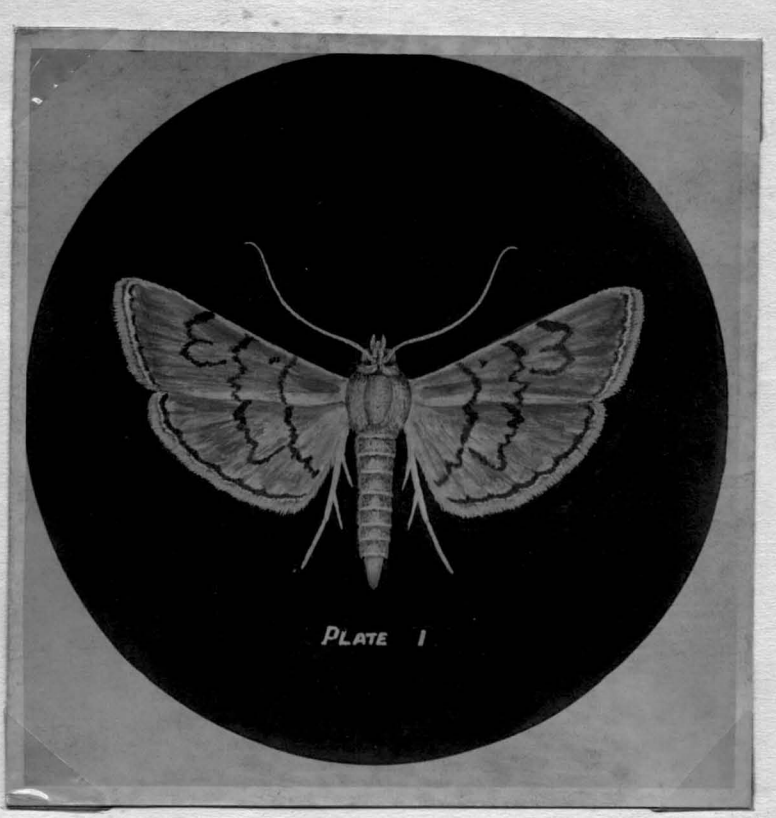


PLATE I

PLATE II

Nacoleia vulgalis Gn. Adult female

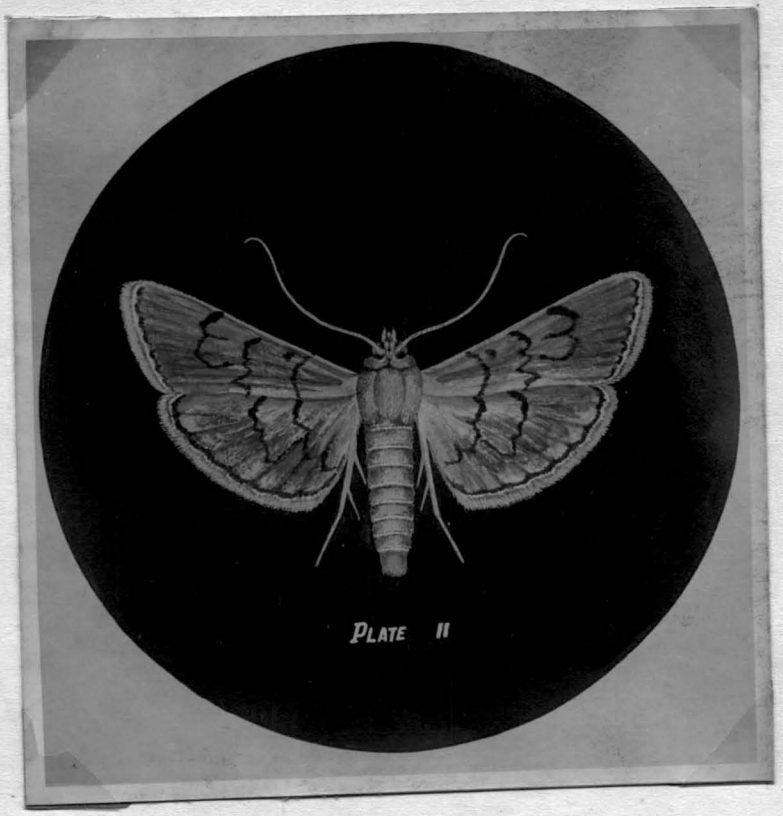


PLATE II

PLATE II A.

Leaf rolls formed by caterpillars of

N. vulgalis Gn. on green gram

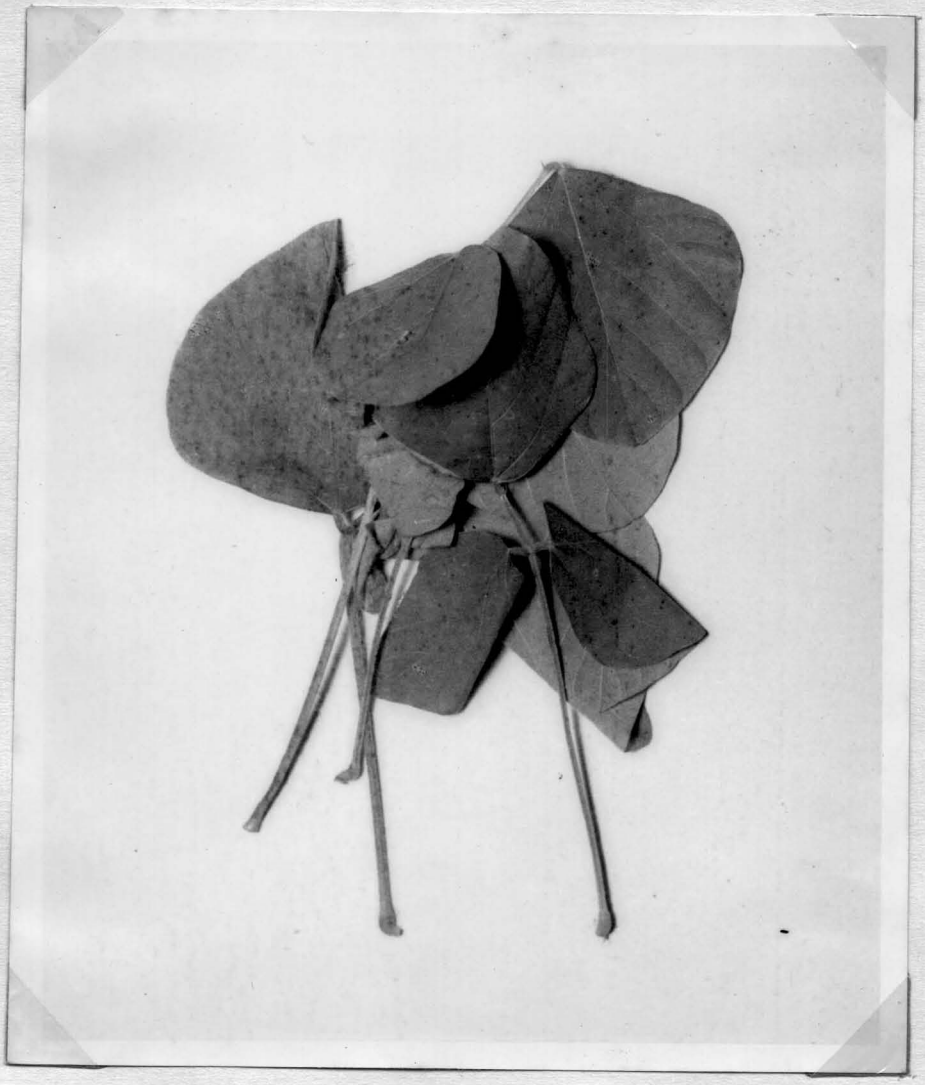


PLATE III.

The immature stages of *N.vulgalis* Gn.

Fig. 1. Cluster of eggs

Fig. 2. First instar caterpillar

Fig. 3. Second instar caterpillar

Fig. 4. Third instar caterpillar

Fig. 5. Fourth instar caterpillar

Fig. 6. Fifth instar caterpillar

Fig. 7. Prepupa

Fig. 8. Pupa: Dorsal view

Fig. 9. Pupa: Lateral view

Fig. 10. Pupa: Ventral view

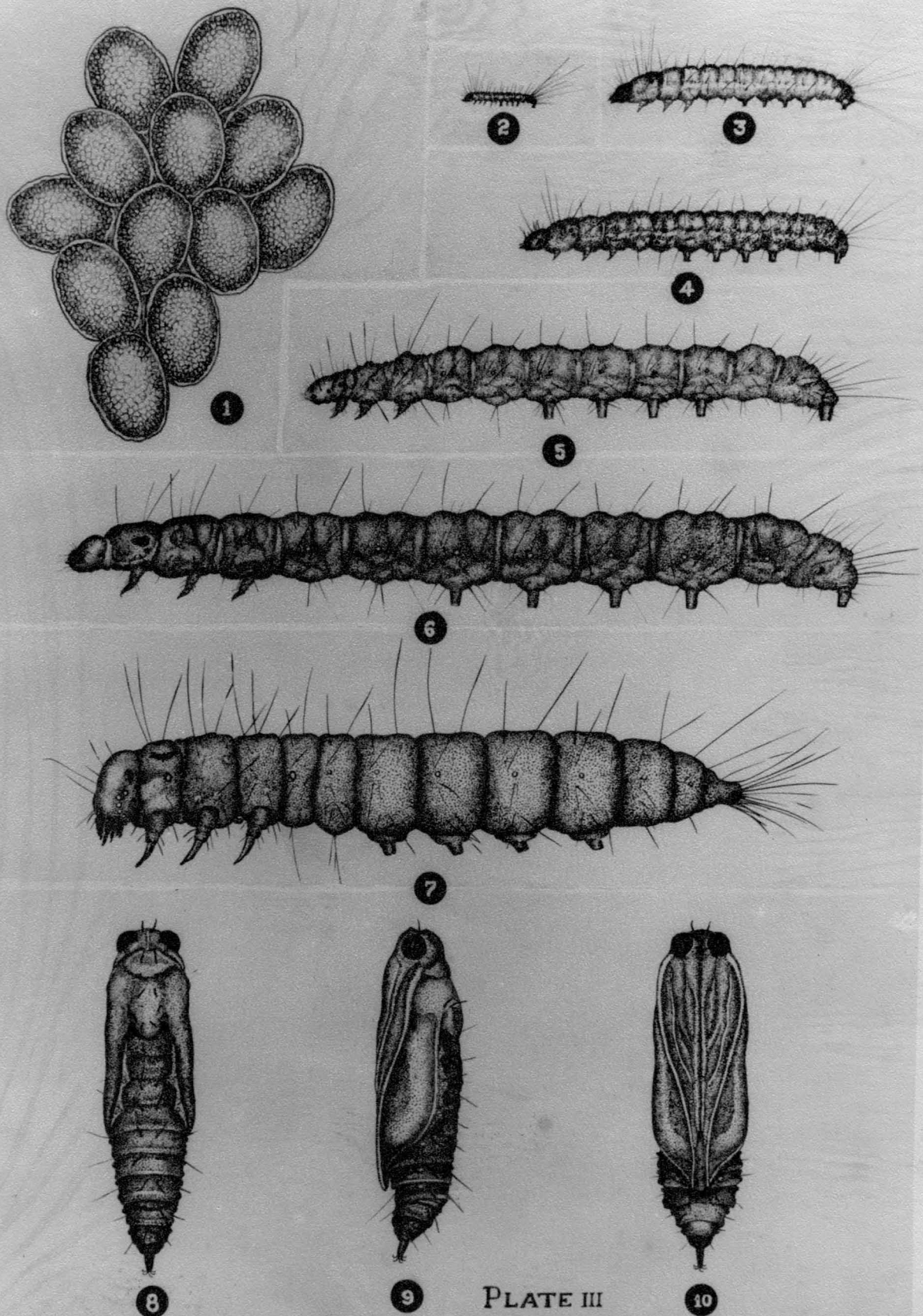


PLATE III

PLATE IV

1. Tachinid fly (Unidentified) parasitic on caterpillar of *N.vulgalis* Gn.

2. *Cardiochiles fulvus* Cam. (Braconidae) parasitic on caterpillar of *N.vulgalis* Gn.

3. *Xanthopimpla punctator* L. (Ichneumonidae) parasitic on caterpillar of *N.vulgalis* Gn.

4. Nature of damage caused by the first caterpillar of *N.vulgalis* Gn.

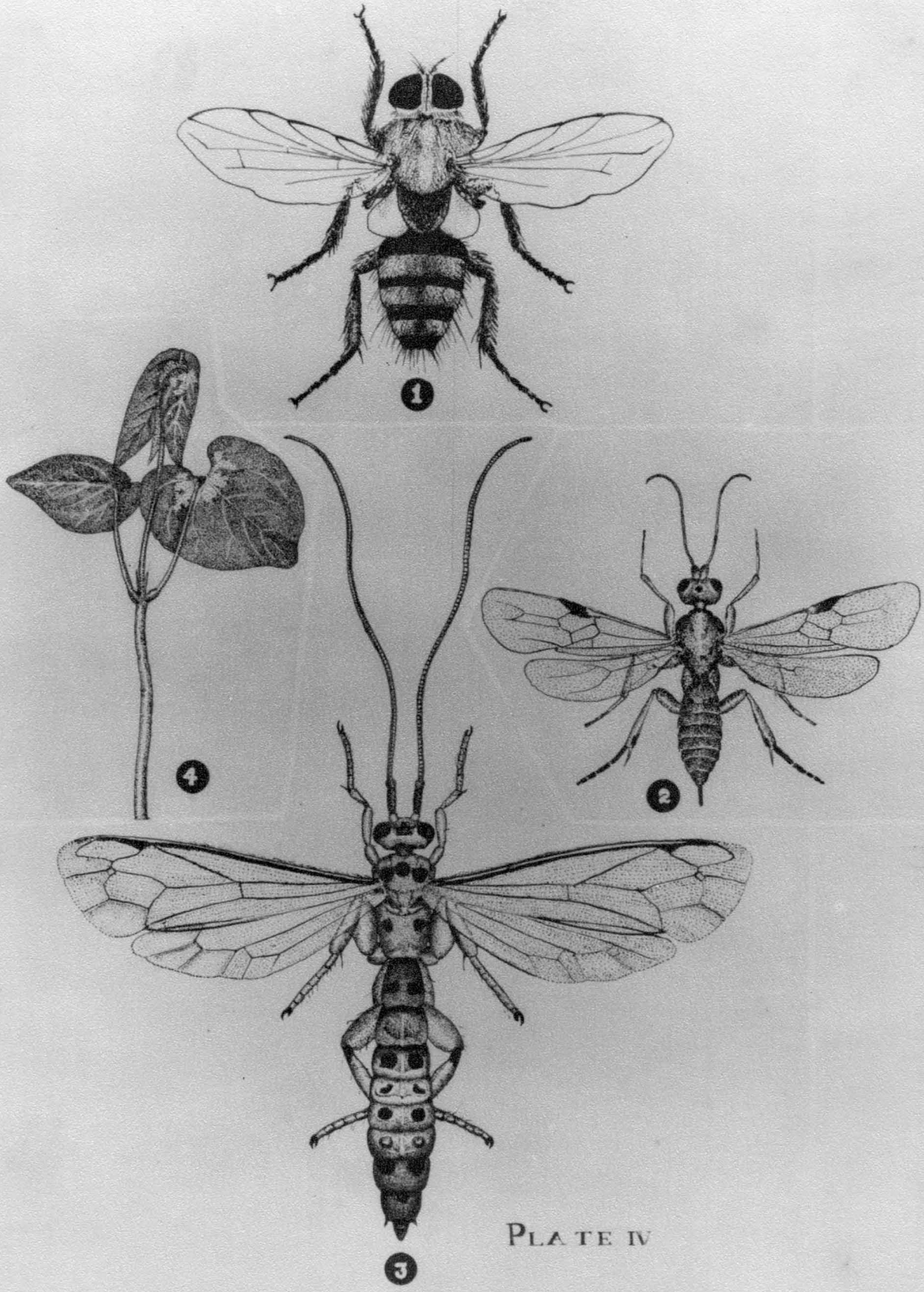
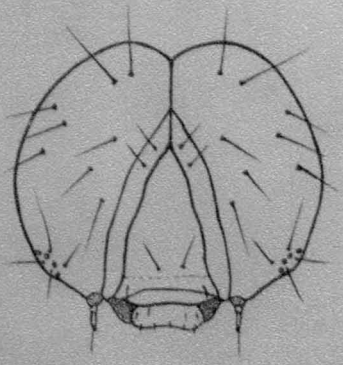


PLATE IV

PLATE V

Arrangement of setae on the fifth instar caterpillar of *N.vulgalis* Gn.

1. Head
2. Prothorax
3. Meso thorax
4. First abdominal segment
5. Third abdominal segment
6. Ninth abdominal segment
7. Tenth abdominal segment
8. Arrangement of crochets



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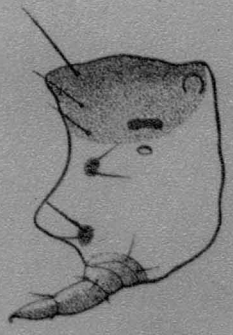

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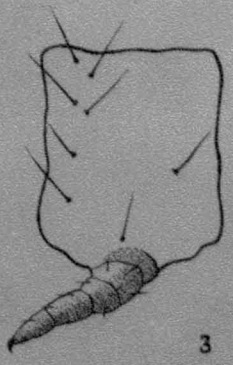

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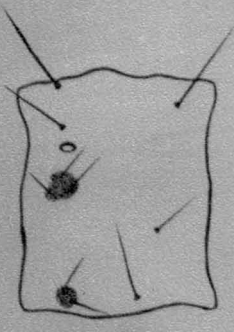

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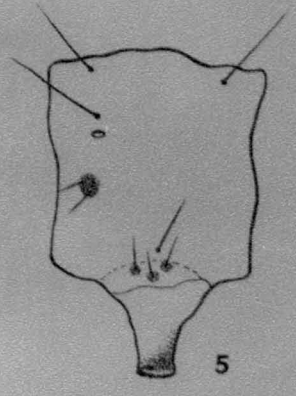

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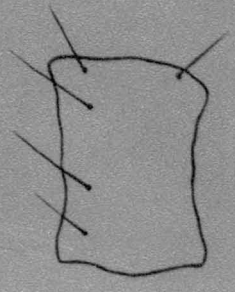

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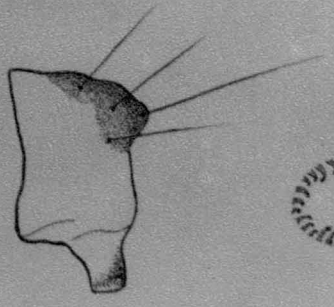

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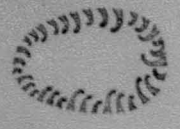

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PLATE V