

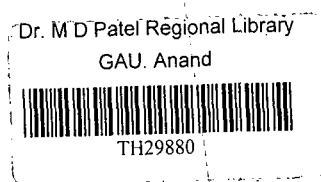
THE BIONOMICS AND CONTROL OF THE
COTTON SEMILOOPER (ANOMIS FLAVA F.)
(NOCTUIDAE : LEPIDOPTERA) ON OKRA
(ABELMOSCHUS ESCULENTUS (L.) MOENCH)

By

Mohan S. Rao

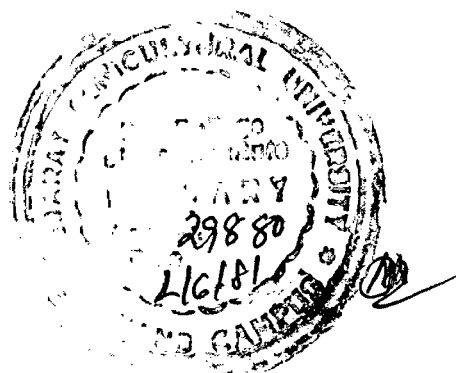
A THESIS
SUBMITTED TO SARDAR PATEL UNIVERSITY
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OF

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IN
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• ANAND (GUJARAT STATE)
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Dr. R.C.Patel,
Hon. Prof. of Entomology,
B. A. College of Agriculture,
Institute of Agriculture,
ANAND.

CERTIFICATE

This is to certify that the thesis entitled
" The bionomics and the control of the cotton semilooper
(Anomis flava F.) on okra (Abelmoschus esculentus (L.)
Moench)", submitted by Shri Mohan S. Rao in partial
fulfilment of the requirements for the Degree of M.Sc.
(Agri.) in Agricultural Entomology embodies results of
research done by him under my guidance and supervision
and no part of it has been submitted for any other degree.

December 25 : 1969.


(R.C. Patel)
Major Professor

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(M.S.Rao)

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INTRODUCTION

The world food problem is not a future threat. We either better our production or face grievous consequences. At the present rate of population growth it is reckoned that by 2000 A.D., there will be four times as many people in the developing countries as are in the developed. The problem becomes all the more acute in developing countries like India, where the crop land per capita is progressively diminishing.

Among the several steps that could be taken to meet the threat, liberal use of vegetables and fruits not only provides substantial energy but also the most needed vitamins and minerals. Their yield in terms of calories per unit area is much higher than that of cereals. Thus, they could be used to supplement rice and wheat, supplies of which are inadequate at present.

Bhinda or okra (Abelmoschus esculentus (L.) Moench) is one such important vegetable. It is cultivated in many parts of the world such as Africa, South America, West Indies, Ceylon and other warm countries. In India, it is

widely grown under varying conditions of soil and climate and is quite popular among all classes of people. While bhinda is grown for its green tender pods, it is also preserved by drying by housewives in Gujarat. These dry preserved pods are used in the off-season when this vegetable is not available or when the price is too high.

Apart from being highly prized as a delicacy in culinary preparation, it has several other uses. Milk yield of dairy cattle increases significantly when green okra pods are included in their ration. The fibres in the bark of the stem are utilized by the villagers for making ropes and the mucilagenous quality of the stem is utilized for the purification of sugarcane juice at the time of preparation of Gur.

As regards food value, bhinda is rich in carbohydrates (one pound of okra pods providing 175 calories of energy) and provides appreciable amount of vitamins A and B. It contains small quantities of mineral elements like Fe, Ca and P. Fresh pods of okra, on an average, contain 89.8 %

..water, 7.4 % carbohydrate, 1.8 % protein, 0.84 % ash and 0.2 % fat. (Francis and Harold, 1950-51). It also possesses medicinal properties and it is known to prevent cough and irritation of the intestine.

In spite of the fact that several advantages can be derived out of different parts of the okra plant beyond using the green pods as a delicious vegetable, its cultivation has been very limited because of low yields consequent to the attack of several diseases and pests. Out of the several pests recorded to occur on okra, jassids (Empoasca spp.), spotted bollworms (Earias spp.) and stemloopers (Anomis and Acontia spp.) are very serious and attack the crop regularly year after year.

Anomis spp. usually occur sporadically but sometimes assume epidemic proportions and under such circumstances it has to be dealt with seriously. Out of 10 species of Anomis recorded in the world, three species namely sabulifera Gn., A. fulvida Gn. and A. flava F. have been recorded to occur in India (Hargreaves, 1948). A. flava F. by far does the most damage and has been recorded to occur

on a wider range of hosts. Although recorded principally as a pest of cotton (sometimes known as the cotton semilooper or green semilooper), its ravages on bhinda cannot go unnoticed. A few observations on some aspects of its biology have been recorded on cotton but up to date no information is available on the nature and intensity of damage, life history, control measures etc. on bhinda. An effort was, therefore, thought necessary to supplement the knowledge in this direction. The studies made on these aspects form the subject matter of this thesis.

REVIEW OF LITERATURE

During the last fifty years, various workers have reported on the different aspects of the cotton semilooper, Anomis flava F. An attempt has been made here to review the literature on the subject.

Taxonomic position

A lot of confusion prevailed between the generic names Cosmophila and Anomis. Tams (1924), after a revision of the Anomis group, sank Cosmophila in the Anomis group and stated that A. flava F. occurs throughout the tropics with the geographical races, C. flava flava F. in the Old World and C. flava fimbriata Steph. in the New World. He recorded the following as synonyms of A. flava.

- 1) Noctua flava Fabr. Syst. Ent. P. 601 (1775)
- 2) N. stigmatizans Fabr. Syst. Ent. P. 601 (1775)
- 3) Cosmophila indica Guen. Noct. ii P. 396 (1852)
- 4) Cirroedia variolosa Walk : List. Lep. Ins. B.M. XI P. 750 (1857).

5) Cirroedia edentata Walk : List. Lep. Ins.

B.M. XI P. 750 (1857).

6) Cosmophila aurantiaca Prittwitz. Stett ent. zeil:

XXVIII P. 277 (1867)

Anomis flava F. is a sporadic pest recorded on plants belonging to the family Malvaceae. It has been found to feed on almost all species of Gossypium and some species of Abelmoschus - particularly Abelmoschus esculentus (L.) Moench. Numerous brief reports on the occurrence of this pest and its hosts have been made by various workers. Since this would entail needless tediousness and space, a list enumerating the author, year of record, hosts and distribution has been compiled as under.

<u>Sr.No.</u>	<u>Author</u>	<u>Host Plants</u>	<u>Distribution</u>
1.	Tryon (1918)	Cotton	Queensland (Australia)
2.	Simmonds (1922)	Cotton	Fiji
3.	Gater (1924)	Cotton, Roselle	Malaya
4.	Pomeroy (1925)	Cotton	Southern Nigeria
5.	Vayssiere and Mimeur (1925)	Cotton, Okra	French, Africa
6.	Jack (1926)	Cotton	Rhodesia

7.	Hancock (1927)	Cotton	Uganda
8.	Frappa (1937)	Cotton	Madagascar
9.	Woo (1935)	Cotton	N. Kiangsu (China)
10.	Henrard (1937)	Cotton	Lisala (Belgium Congo)
11.	Tjoa (1937)	Cotton	Batavia
12.	Box (1937)	Cotton, Okra	Asuansi (Gold Coast)
13.	Pruthi and Isaac (1946)	Cotton, Okra	Delhi
14.	Treh (1946)	Cotton	Surat (Bombay Prov.)
15.	Nanal (1948)	Cotton, Okra, Deccan hemp, <u>Urid</u>	India
16.	Kh (1956)	Cotton	Hyderabad
17.	ptarudriah and meswariah (1956)	Cotton, <u>Bhinda</u> , Deccan hemp, <u>Urid</u> , Shoeflower, <u>Briar</u> , Hollyhock, <u>Silk</u> cotton tree and <u>Bhan bhindi</u>	Mysore
18.	Privastava and Bhatnagar (1963)	Cotton	Rajasthan
19.	Patel et al. (1964)	<u>Bhinda</u>	Gujarat
20.	Sweeney (1964)	Cotton	Nyasaland

Thus, it is a widely distributed pest and has been recorded on cotton from many parts of the world. Though

sporadic in nature, at times it builds up epidemic populations to cause great havoc particularly in the seedling stage of the host.

Pomeroy (1925) noticed the larvae feeding on the leaves and occasionally on the bracts of flowers. In severe cases of infestation, up to 90 % of the leaves are eaten up. (Go, 1935). Nangpal (1948) found the insect eating up the entire leaf leaving only the veins behind. Tender shoots, buds and bolls were also injured particularly in years of heavy rainfall when the pest appeared in epidemic form. Maximum damage was, however, recorded by Khan (1966) when over 1,50,000 acres of cotton in Hyderabad were severely infested. All the parts of the plant were attacked except the bolls. In some cases the level of infestation was as high as 25 to 30 larvae per plant. This was very heavy infestation since 5 to 6 larvae per plant damaged about 20 to 25 % of the flowers. In the same year Puttarudriah reported severe stunting of cotton plant consequent to the voracious eating by the larvae. Jagihallimath (1961) reported that Laxmi cotton was seriously damaged during seedling and early growing stage

of the crop, the peak period of attack being in October. From Rajasthan, Srivastava (1963) reported 15 to 20 % loss in cotton due to the attack of this pest.

Puttarudriah (1956) observed the females to lay at night as many as 577 pale green eggs mostly on the dorsal surface of the leaf and occasionally on petioles and tender leaves. From Africa, Vayssiere (1925) reported that the eggs hatch out in 3 to 6 days and the larvae begin to feed on the edges of the leaf. Incubation period of the eggs was 3 to 4 days in Hyderabad (Khan, 1956) and 4 to 5 days in Mysor (Puttarudriah, 1956), the eggs being laid singly in irregular pattern. Srivastava (1963) reported the incubation period to be 2 to 4 days in Rajasthan.

Larvae start feeding on the leaves soon after hatching, the larval period being 12 to 16 days in Africa (Vayssiere, 1925), 24 to 25 days in Madagascar (Frappa, 1934) and 9 to 15 days in Rajasthan (Srivastava, 1963). Woo (1939) reported 6 larval instars to occur with an average period of 12 days in the third generation and 34 days in the sixth. Khan (1956)

reported the larval period to be from 15 to 20 days and the light green mature larvae measured from 30 to 35 mm. These larvae had prominent white longitudinal stripes with pale green head. Puttarudriah (1956) is the only worker to have studied this insect in some detail. According to him, there were totally four instars with an occasional fifth one. Under room temperatures during November and December, the larval period occupied 18 to 22 days, the instars from the first to the fifth lasting 6 to 9 days, 1 to 5 days, 2 to 3 days, 6 to 8 days and 6 to 7 days respectively. The measurements on length and breadth of the larvae and the width of the head capsule were also recorded for each instar.

The larvae have been reported to pupate in silken cocoons spun in between the leaf folds (Vayssiere, 1925 ; Woo, 1939; Khan, 1964; Puttarudriah, 1956) and occasionally in the ground (Vayssiere, 1925), about 1 to 1.5 inches deep in an earthen cell (Srivastava, 1956). Simmonds (1922) in Fiji, observed pupae on ripe open cotton bolls. The pupal period has been reported to vary from 5 to 6 days by Frappa (1934), 9 days by Khan (1956) and 8 to 9 days with

the pupae measured 14 mm. in length and 4 mm. in breadth by Puttarudriah (1956). The pupae have been reported to hibernate in folded leaves (Woo, 1935), while Srivastava (1963) observed the pupae of the second generation to hibernate but if the monsoon prolonged, the pupae of the sixth generation hibernated.

The adults are sexually dimorphic (Nangpal, 1948), with males having orange yellow head and thorax irrorated with brown the abdomen being brown dorsally and the females being bright orange yellow. Wings in males were fuscous with white tipped cilia whereas, females had their forewings slightly speckled with red. According to Puttarudriah (1956), adults measured 16 mm. in length and 32 mm. in wing expanse. Female oviposited 4 days after emergence continuing for 8 to 10 days with the maximum number of eggs being laid on the second or third day of oviposition. Sex ratio in laboratory reared insects was found to be 63 males : 37 females. The life period from egg laying to emergence varied from 30 to 33.5 days.

The number generations of A. flava F., have been reported to vary from place to place. In China, Woo (1939) observed 6 generations per year whereas Srivastava (1963) observed a maximum of 3 generations in Rajasthan with the third occurring only if the monsoon is prolonged.

Numero references can be cited on the control of this pest cotton. The mechanical measures recommended in the thies and forties are hand collection (Tjoa, 1937) and drops the larvae in kerosinized water (Nangpal, 1948) and using light traps against the adults (Woo, 1939). The earliest chemical control measure was carried out in China (Anon. 1936) with lead and calcium arsenates. Thereafter several workers have tried lead arsenate (Tjoa, 1937; Nang, 1943) and calcium arsenate (Woo, 1939). Pruthi (194) used zinc arsenate with lime quite effectively. Narany (1955) found BHC and DDT with Toxaphene next, as the most popular insecticides. Passlow (1959) conducted tests on cotton with schedules of 4 and 5 applications an emulsion spray, containing 0.05 % endrin @ 50 to 84 and 60 to 90 gallons per acre and found that the total yields increased considerably. The larval parasites recorded are:

Zenillia cosmophilae by Curran (1938); Apanteles ruficornis Hal., and Zacharops narengae Cushman by Woo (1939) and Carcelia kockiana Tns. and Sturmia macrophallus Bar. by Nangpal (1948). Isyropa sp. parasitised about 60 % of larvae in field (Puttarudriah, 1956). The pupal parasites recorded are Xanthopimpla punctata F. and Brachymeria obscureta Wlk. by Woo (1939). In the laboratory, egg parasite, Trichogramma evanescens minutum Riley and pupal parasite, Tetrastichus ayyari Rohwer were bred on fresh eggs and pupae respectively of A. flava (Puttarudriah, 1956). The natural predators were crows and wasps (Nangpal, 1948).

The literature reviewed above clearly indicates that a good amount of work has been done on certain aspects of this insect as a pest of cotton but no reference is available on it as a pest of bhinda. Bhinda, as shown earlier, is an important vegetable crop particularly in Gujarat. Therefore, it was thought worthwhile to study this pest on bhinda under Gujarat conditions so that suitable control measures could be devised for recommendation to the farmers.

MATERIALS AND METHODS

In order to start the experiments a culture was established by collecting about 75 mature larvae from a bhinda plot in the School Farm of the Institute of Agriculture, Anand during the second week of August, 1968. These larvae were reared in the laboratory in five pint capacity glass jars on fresh leaves of bhinda. The pupae obtained from these larvae were sexed by measuring the distance between the genital slit and the anal slit with the aid of a stereoscopic binocular microscope and an ocular micrometer. The adults emerging from these pupae were paired and held in glass chimneys for the study of longevity and fecundity. For this purpose, a circular piece of urethane foam sheet was cut to fit in a petri dish. The piece was moistened and kept in the petri dish. A piece of square thin plastic sheet approximately measuring 12 cm. x 12 cm. was perforated by pin pricks and kept on the foam sheet. The perforations permitted the flow of moisture from the foam sheet into the glass chimney. In absence of this plastic sheet, the moths often got stuck to the wet urethane sheet and died. The other end of the chimney was closed by a piece

of fine nylon cloth held in place by a rubber band. A piece of cotton-wool swab soaked with 10 % honey solution was kept on the nylon cloth cover to feed the adults. The swab was covered by the polythene cap of a specimen tube to avoid rapid desiccation. The fine nylon cloth permitted good visibility and had the added advantage of not absorbing honey from the swab. The cut ends of the petioles of a few host leaves were wrapped in cotton-wool and a piece of foam sheet was wound tightly around the petioles. It was then squeezed in a specimen tube (7.5 cm. height x 2.5 cm. diameter) filled with water. The foam sheet held the leaves in position without damaging the petioles, prevented spilling of water and prevented the insects from dropping into water. This arrangement kept the leaves fresh and turgid for a longer period of time. Fresh leaves were substituted and the eggs laid were counted everyday until both the individuals of the pair died. While changing the leaves, the glass chimney was covered over by a larger circular iron cage measuring 30 cm. in height and 22 cm. in diameter lined with a muslin or fine nylon cloth with its top opening regulated by a stitched-in string so as to prevent the moths from escaping.

Leaves bearing eggs were transferred to five pint capacity glass jars and the larvae were reared in there up to second or third instar during a period of 4 to 5 days after hatching. They were then transferred to circular galvanised iron sheet cages measuring 35 cm. in diameter and 10 cm. in height containing compact moist soil to a depth of about 4 to 5 cm. These cages were quite spacious with the moist soil maintaining humidity in the cage and absorbing all the extra moisture from the faecal pellets. Since the larvae preferred to stay in darkness, a piece of black cloth was covered over the cage. The cloth was held in place by a circular elastic string held in the groove just below the rim. Excrement and other extraneous material in the cage was swept up daily with a 'T' - shaped brush and fresh leaves were provided. To keep the culture vigorous and growing, strict sanitation was maintained and overcrowding was avoided.

The mature larvae spun their cocoons in folds of leaves and pupated in them. Such leaves containing pupae were transferred to a five pint capacity glass jar containing 5 cm. deep moist soil to maintain humidity and to absorb the

meconium dropped by emerging adults. A very low percentage of pupae developed into adults by this method since the decaying leaves killed many of the pupae. To prevent this mortality, ribbons of plastic sheet about 30 cm. in length and 3 to 5 cm. in width were provided in the circular cage when the larvae were about to pupate. Such strips were wrinkled, coiled and placed in the cage along its periphery. Most of the mature larvae moved towards the periphery of the cage and pupated among such strips. The strips were then transferred to the glass jar for emergence of the adults. This method permitted higher emergence of adults since the larvae could pupate in clean dry plastic strips and the adults could rest on these strips to stretch their wings. The strips could be used over and over after cleaning them. (Plate 3- A). The mouth of the jar was covered by a piece of nylon cloth held in place by a rubber band.

To maintain a general culture, the adults were released in a 30 cm. x 30 cm. x 30 cm. wooden cage having the top fitted with glass sheet, three sides with plastic sheets and the fourth side by a muslin cloth having a sleeve (Plate 3-B)

The sleeve facilitated cleaning of the cage and changing food and host leaves. The bottom of the cage was covered by a slightly larger plastic sheet on which was placed a square urethane foam sheet of the same dimensions as the bottom of the cage. Branches of the host plants were wrapped with cotton-wool at their cut ends and squeezed into small jars. These were placed inside the cage to stimulate mating and oviposition. A small rectangular piece of urethane foam placed on a slightly larger plastic piece was pierced by a paper pin till the head of the pin tightly held the foam piece. The pointed end of the pin was bent, the urethane foam was soaked in 10 % honey solution and stuck on the walls of the cage to feed the adults. The plastic piece remained between the urethane and plastic side and thus, prevented honey from being smeared on the sides.

To study the incubation period under different humidities and temperatures, eggs laid on the glass chimney, plastic piece covering the sponge and on the nylon cloth were utilized. To control the humidity, the method recommended by Buxton and Mellanby (1934) was adopted as

under : 100 c.c. of each of the concentrated sulphuric acid (A.R. Sp. gr. 1.481) and distilled water gave 183.5 c.c. of stock solution. To prepare different solutions which would maintain different relative humidities from 20 to 90, the following quantities of stock solution and distilled water were mixed.

Relative Humidity %	Stock sol. in c.c.	Water in c.c.	S.G.
20	7.09	1.14	1.486
30	6.86	2.26	1.410
40	5.39	3.06	1.380
50	5.14	4.20	1.330
60	3.74	3.96	1.295
70	3.48	5.10	1.250
80	2.74	6.40	1.190
90	1.61	7.12	1.125

100 % relative humidity was obtained by using only distilled water and 0 % relative humidity by using calcium chloride in the desiccator.

The solution was poured in a crystallising dish measuring 7.5 cm. in diameter x 3.5 cm. in height and kept on the bottom of a desiccator measuring 28 cm. top diameter, 19 cm. bottom diameter and 20 cm. height. The rim of the desiccator and its lid were thoroughly greased to ensure air-tightness. The percentage of hatching of the eggs was calculated by counting the number of eggs that failed to hatch out of the total number of eggs held in the desiccator. For incubation studies under different temperatures, incubators maintained at different temperatures were used.

To study the number and duration of larval instars, freshly hatched larvae were transferred to the host leaves with a fine camel hair brush. The petioles of the leaves were wrapped with cotton-wool, moistened and held in numbered specimen tubes. Measurements on the length and breadth of the larva and the width of the head capsule were recorded daily with the help of stage and ocular micrometers used through a stereoscopic binocular microscope. The tubes were cleaned of excrement and fresh leaves provided

until pupation. The duration of larval, prepupal and pupal periods was recorded. Such studies were also made at constant temperatures in the incubators.

To study the growth index, equal numbers of freshly hatched larvae were reared on different hosts and the duration of larval and prepupal periods and the number of pupae developing on respective hosts were recorded. These pupae were sexed, measured and weighed to determine the effect of diet on the development. The pupae were also held separately to determine the duration of pupal stage. Some of the moths obtained from these sets were killed, set and measured and the remaining adults were paired and released in glass chimneys to test the effect of larval diet on their fecundity and longevity. (Plate 3 - A).

Preference of host leaves for oviposition by the females was determined by releasing uniform numbers of adults in cages prepared in the same manner as for the general culture. Bunches of different host leaves were introduced in the cage and held upright in specimen tubes. 10 % honey solution was provided as food and fresh leaves were substituted daily.

The eggs laid on different host leaves were counted till all the females in a particular cage died and the total number of eggs laid on each host was taken as the criterion to judge the preference of hosts for oviposition.

To test the efficacy of different insecticides, a bhinda plot was divided according to the number of treatments following randomized block design. Infestation being very meagre, five laboratory reared third to fifth instar larvae were released on each plant. Spraying with the various chemicals was carried out after taking a pretreatment count 24 hours after the release. To determine the effect of the insecticides, counts were taken after 24 hours, 48 hours and 7 days from the treatment. The results were analysed statistically to determine the effectiveness.

Line drawings of various stages of the insect were made with the help of camera lucida, and the details were filled in with free hand. Since the temperatures recorded in Fahrenheit are being reported in Centigrade scale, the temperatures appear in fraction and not in full figures.

BIOLOGY OF ANOMIS FLAVA F.

Biology on okra

1. Egg (Plate 1 - A)

(i) Description of the egg

The eggs of A. flava when laid on a flat surface are round, dome-shaped and with flat bottom. The chorion is soft, bearing zigzag verticular ridges and transverse striations which originate from below and converge at the top. When freshly laid, most of the eggs are leaf green in colour which gradually change to pale green. A few were deep blue in colour and such eggs failed to hatch even after a week. The measurements of one hundred eggs revealed that the diameter of the egg varied from 0.539 to 0.616 mm. with an average of 0.591 ± 0.005 mm. Gradually, the greenish content of the fertilized egg concentrates in one portion of the egg so that the rest of the egg appears translucent. After about one or two days, a brown patch develops in this portion indicating the head of the larva which by now is almost developed. Just before eclosion, the fully developed larva can be readily made out when viewed through a microscope. It lies coiled in an 'S' - shaped manner within the egg.

While hatching, the larva cuts open an aperture in the.

chorion and pushes its head out through this aperture. When head and thoracic parts have come out and the abdomen is still in the egg-shell, it swings its head in all directions and slowly wriggles out leaving transparent empty chorion on the leaf. It moves very little soon after eclosion and then begins to feed.

The unfertilized eggs slowly begin to shrink and turn black after a period of 4 to 5 days. There is no definite pattern of egg deposition. They are laid on the lamina, petioles of young and tender leaves, calyxes of bolls in case of cotton, occasionally at the base of flowers in cotton and okra and on the growing tips of young shoots. Majority of the eggs are deposited on the leaves, more so on the ventral surface. The eggs are laid scattered, singly or rarely in groups. They are firmly glued in depressions on the leaf surface and sometimes tucked away partially beneath the veins and veinlets. Occasionally, a female may dump eggs one over the other to form a heap of as many as four to five eggs.

(ii) Incubation period of the eggs

The incubation period of the eggs of A. flava was .

studied at varying laboratory temperatures (from 27.55°C. to 30.73 °C. with an average of 29.14 °C. and from 26.66°C. to 27.77°C. with an average of 27.21°C.) and also in the incubators maintained at 32 ± 1 °C. and 38 ± 1 °C. The eggs laid on dry surfaces such as the glass chimneys, muslin cloth cover and the plastic sheet bottom were held at these temperatures and observations were recorded every morning. The results obtained are summarised in table 1.

Table 1.

Incubation period of eggs of A. flava F.
at different temperatures.

Sr. No.	Period of study	Temp. in °C.	Total No. of eggs		Hatching %	Incubation period in days
			Observed	Hatched		
1.	29.10 to 31.10.69	27.21*	203	171	84.23	2
2.	6.11 to 8.11.69	29.14*	111	79	71.18	2
3.	6.10 to 8.10.69	32 ± 1 **	115	65	56.52	2
4.	6.10. to 8.10.69	38 ± 1 **	232	0	-	-

* Average laboratory temperature.

** Constant temperature.

The results in the above table indicate that at a temperature of 27.21 °C., the hatching percentage was 84.23 % which was the highest among all the sets studied. As the temperature is gradually raised, the hatching percentage begins to decline until at 38 ± 1 °C., no eggs hatched at all. The incubation period, however, did not show any effect of the rising temperature since the observations were recorded at the interval of 24 hours.

(iii) Effect of relative humidity on hatching of eggs

The effect of different relative humidity percentages on the incubation period and hatching percentage of the eggs of A. flava was studied in the laboratory. The eggs laid on the dry surfaces only were held in desiccators which maintained different relative humidities. Observations on the hatching of eggs were recorded daily in the morning. The results are presented in table 2.

Table 2.

Effect of relative humidity on the
incubation and hatching of A. flava F.eggs.

Sr. No.:	Period of study	Rel. humidity	No. of eggs Observed	Hatching %	Incubation period in days	
:	:	:	:	:	:	
:	:	:	:	:	:	
1.	27.9 to 29.9.69	0	121	18	14.87	2
2.	27.9 to 29.9.69	20	134	76	51.94	2
3.	27.9 to 29.9.69	30	195	146	74.84	2
4.	1.10 to 3.10.69	40	176	136	77.27	2
5.	1.10 to 3.10.69	50	200	169	84.50	2
5.	1.10 to 3.10.69	60	163	154	94.53	2
7.	5.10 to 7.10.69	70	175	155	88.57	2
8.	5.10 to 7.10.69	80	212	175	82.54	2
9.	5.10 to 7.10.69	90	167	141	84.40	2
10.	8.10 to 10.10.69	100	243	182	74.89	2

The results in the above table indicate that the hatching percentage is greatly altered with the changes in relative humidity. At zero per cent relative humidity, only 14.87 % of the eggs hatched out. The hatching percentage increased rapidly to hit the peak (94.53 %) at 60 % relative humidity. Thereafter, with an increase in the relative humidity, a slight decline in the hatching percentage is

noticed until at 100 % relative humidity i.e. saturation point, it came down to 74.89 %. Thus, 60 % relative humidity can be taken as the optimum for the hatching of the eggs. The effect of changing relative humidities on the incubation period of eggs could not show out since the incubation period was recorded at an interval of 24 hours.

2. Larva

(1) Description of larval instars

For the purpose of studying the larval instars and the growth attained in each instar, 45 freshly hatched larvae were reared individually in specimen tubes at an average laboratory temperature of 27.15 °C. Out of these 45 larvae, 40 completed their development of which 32 larvae passed through 5 instars and 8 passed through 6 instars. Since majority of the larvae have passed through 5 instars, the measurements of these larvae have been utilized to describe different larval instars. These measurements are given in table 3 at the end of larval description.

First instar larva (Plate I - B)

The newly hatched larva measured from 1.78 to 2.17 mm. with an average of 1.99 ± 0.02 mm. in length and from 0.13

to 0.19 mm. with an average of 0.15 ± 0.004 mm. in breadth. The head width of the newly hatched larva measured 0.264 mm. It is tiny, cylindrical and almost colourless except for the light brown mandibles. The head bears six black ocelli arranged in semicircular manner on each gena. The head is wider than the body and is light brown in colour. The median epicranial suture is well developed enclosing broad and triangular clypeus between its arms. At the lower end, a transverse suture divides the clypeus into the upper post-clypeus and the lower ante-clypeus. The bi-lobed labrum is attached to the lower edge of the ante-clypeus. The head except the clypeal region is divided by the epicranial suture into two symmetrical halves. Out of sixteen pairs of small and big setae on the head, nine pairs are equally distributed on the symmetrical two halves. The labrum carries four pairs of setae in a transverse row just below the clypeo-labral suture. The size of the setae from the middle of the labrum to the lateral margin increases in ascending order until the outermost setae are very large. The clypeus bears three pairs of setae of which two pairs are situated near the transverse suture and the third lies midway up in

the triangular clypeus. Four pairs of setae are distributed along the ocelli and in between the ocelli and the clypeo-epicranial suture. Two pairs lie on the middle of the epicranial plate of which one pair is proximal to the adfrontals and the other to the second pair of ocelli. The remaining three pairs are distributed in the upper epicranial plate. One of these pairs lies just above the apex of the adfrontals, the second on the vertex and the third lies laterally above the ocelli. Laterally, the head bears four prominent setae situated on the gena in between and around the ocelli.

The armature of the body bears a number of setae, of which the prominent ones are borne on small raised black tubercles. The setal arrangement on the thorax differs markedly from that on the abdomen. On each of the thoracic segments, a transverse row of setae-bearing tubercles forms a semicircular dotted line near the posterior margin of the tergum and extending up to the middle of each pleuron. The prothorax bears a second anterior row of setae overhanging the head and converging on the posterior row mid-laterally.

The integument of the abdomen except that of the last two segments has similar setal arrangement. Each of the terga bears four setae, forming two rows on either side of the mid-dorsal line. The anterior pair is located near the anterior margin and the posterior pair is located near the posterior margin of the tergum. The tubercles bearing the anterior pair of setae on the seventh tergum are much smaller than those of the posterior pair. Each abdominal pleuron except that of the ninth and tenth abdominal segments, bears three prominent setae in triangular fashion. The anterior two are located on either side of the mid-lateral line. Out of these two, the lower seta is closer to the anterior margin of the pleurite and the other slightly above the spiracle. The third lies mid-laterally near the posterior margin. Of the four setae on the ninth tergum, the anterior pair is placed wide apart and outside the rows formed by the setae on the terga. The ninth pleuron carries only two setae on either side of the mid-lateral line and near the posterior margin of the pleuron. The last abdominal segment which ends up into claspers, carries three to four groups of long and tough

setae projecting posteriorly at various angles. Beyond these prominent setae, the tergum also bears small and fragile setae distributed in no particular order.

The ventral surface of the integument bears fewer setae as compared to the dorsal and lateral surfaces. Two inconspicuous setae are present on the abdominal sternites which do not bear prolegs. A few fragile setae are dispersed on the thoracic and abdominal legs in an indefinite fashion.

The freshly hatched larva is colourless, however, a faint white line is seen passing longitudinally through the pleura. Microscopic examination revealed this to be the trachea connecting different spiracles under the integument. There are totally nine pairs of spiracles, one on the prothorax and the remaining eight on the first eight abdominal segments. Of these, the prothoracic and the last abdominal spiracles are quite prominent.

The larva of A. flava is a characteristic semilooper. The first instar larva bears two pairs of prolegs on the fifth and sixth abdominal segments. The last abdominal segment ends up into the third pair of prolegs or claspers. The

plantae of the prolegs bear crochets which occur in an unioordinal mesoseries and are arranged in the shape of a kidney. When the larvae are about to moult, they become inactive and do not feed well. The prothorax becomes slightly swollen with marked change in the body colour. Dorsally, these larvae appear Spinach Green* in colour with white dorsolateral lines on the margin. The remaining portion of the body is Light Green-Yellow.

Second instar larva (Plate 1 - C)

The second instar larva measured from 4.95 to 6.93 mm. with an average of 5.88 ± 0.079 mm. in length and from 0.462 to 0.528 mm. with an average of 0.473 ± 0.004 mm. in width. The head width in this instar measured 0.462 mm. These larvae are light green and move about actively. Soon after moulting, the colour of the head is leaf-green turning to Chalcedony Yellow after some time and finally deepening to Olive-Ochre. The number of setae increases in this instar. An additional seta appears on the mid-lateral line near the posterior margin of each of the thoracic pleura.

- The pleurites of the first six abdominal segments bear 2

* Robert Ridgway (1912). Colour Standards and Colour Nomenclature. Press of A. Hoen & Co., Baltimore, M.D.

additional setae in dorsolateral and ventrolateral positions near their posterior margins. The number and arrangement of setae on the remaining abdominal segments as well as on the head are same as in the first instar. Another differentiating feature is the appearance of rudiments of prolegs in the shape of minute bud-like swellings on the sternum of the fourth abdominal segment. These swellings, however, are visible only through a microscope.

Third instar larva (Plate 1 - D)

The larva in this instar varies from 10.00 to 14.00 mm. with an average of 12.17 ± 0.19 mm. in length and from 0.66 to 1.88 mm. with an average of 0.900 ± 0.02 mm. in breadth. The head width measured from 0.72 to 0.79 mm. with an average of 0.786 ± 0.002 mm. The setae are similarly arranged as that in the second instar. The colour pattern, however, is altered. Four parallel, dotted, white lines traverse the whole body length and extend to the claspers by a sharp bend. The inner two, evenly dotted, dorsolateral lines pass just outside the two rows of tergal setae. The outer two, sparsely dotted lines pass

just below the dorsolateral setae which appear in the second instar. The inner two dorsolateral lines enclose a much wider area of integument which is Dusky Olive-Green in colour. The minute bud-like rudimentary prolegs are distinctly visible and a microscopic examination shows them to bear minute crochets on their plantae.

Fourth instar larva (Plate 1 - E).

The fourth instar larva measured from 15.00 to 21.00 mm. with an average of 17.62 ± 0.38 mm. in length and from 0.99 to 1.84 mm. with an average of 1.465 ± 0.03 mm. in breadth. The head width measured 1.38 mm. The larvae in this instar develop one more white, dotted line along the mid-dorsal line and one line on either side below the anterior lateral seta. The tubercles on the terga and pleura are encircled by thick snow white rings. The thoracic segments appear to bear transverse, white, dotted lines due to the white rings of the closely spaced and numerous setae. The first pair of rudimentary prolegs is now distinctly discernible as pointed fleshy lobes

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reaching up to about one-third the length of the fully developed proleg.

Fifth instar larva (Plate 1 - F)

The larva in the fifth instar measured from 25 to 31 mm. with an average of 28.21 ± 0.048 mm. in length and from 1.80 to 2.60 mm. with an average of 2.37 ± 0.037 mm. in breadth. The head width varied from 2.178 to 2.310 mm. with an average of 2.247 ± 0.036 mm. The larva in this instar is now mature with a well developed body and a proportionately wide head. The appearance of an additional colour strip in this instar distinguishes it quite readily from the previous instars. Laterally, a Pale Viridine Yellow longitudinal strip develops on either side of the body between the upper two white lines. The back of the larva remains Dusky Olive-Green in colour and the remaining parts of the body including the sternum and ventrolateral regions are Calliste Green in colour. The first rudimentary pair of reddish prolegs have reached their maximum length which is about half the length of the second pair. Due to the disparity in their lengths, the fourth abdominal segment appears

slightly depressed, when the larva stretches straight on a leaf and has clasped with its first pair of prolegs. The reddish tinge on the prolegs is due to the reddish brown colour of the crochets which by now are well developed. The measurements of larvae during different instars are given in table 3.

Table 3.
Measurements of A. flava larvae.

Sr. No. of :rements :(mm.)	No. of :obser- :vations	Larval instars											
		I	II	III	IV	V	VI	Range	Av.	Range	Av.	Range	Av.
Length	32	1.78 to 2.17	4.95 to 6.93	5.88+0.09	10-14	12.17+0.19	15-21	17.62+0.38	25-31	28.21+0.48			
1. Breadth	32	0.13 to 0.19	0.462- +0.528	0.493 +0.004	0.66-1.88	0.90 +0.02	0.99- 1.84	1.465 +0.03	1.80- 2.60	2.37 +0.034			
Head width	32	0.264 to 0.264	0.462- 0.462	0.462	0.72- 0.79	0.786 +0.002	1.38- 1.38	1.38	2.178- 2.310	2.247 +0.036			
Length	8	1.848- 2.046	5.28- 6.27	5.775 +0.126	8-14	11.63 +0.630	14-19	15.25 +0.605	19-26	23.0 +0.886	29-32	30.63 +0.418	
Breadth	8	0.132- 0.198	0.462- 0.462	0.462	0.66- 0.72	0.858 +0.49	0.858- 1.32	1.18 +0.056	1.65- 2.11	1.97 +0.056	2.44- 2.97	2.706 +0.039	
Head width	8	0.264 0.264	0.396- 0.462	0.454 +0.009	0.726- 0.792	0.776 +0.010	1.12- 1.38	1.27 +0.044	1.71- 1.84	1.76 +0.024	2.31- 2.57	2.34 +0.010	

The results in the table 3 indicate that there was no difference in the size of the first instar larvae in both the cases. However, in succeeding instars, the larvae that passed through 6 instars developed at a slower rate as compared to those which passed through 5 instars. Consequently, these larvae also attained their maturity after a longer period of time. The larvae that completed their development in 5 instars attained on an average 28.21 ± 0.48 mm. in length and 2.37 ± 0.034 mm. in breadth with 2.247 ± 0.036 mm. head width, whereas, the larvae that completed their development in 6 instars attained on an average 30.63 ± 0.418 mm. length and 2.706 ± 0.039 mm. breadth with 2.34 ± 0.010 mm. head width. Thus, the larvae that passed through 6 instars were better developed as compared to those which passed through 5 instars because of more developmental period and an additional instar.

(ii) Nature of damage

The larvae have been reported by various workers to feed on cotton, okra and some other plants belonging to the family Malvaceae. In this area, they have been observed to feed on cotton (Gossypium spp.), okra (Abelmoschus

esculentus (L.) Moench), deccan hemp (Hibiscus cannabinus L.) and shoe-flower (Hibiscus rosa-sinensis L.). Whereas, the infestation usually appears with the onset of monsoon, the peak of infestation is reached in August and September when all the stages of the pest as well as 12 to 15 larvae may be found on a single plant. Feeding by the larvae caused irregular holes in the leaf and at times majority of the leaves are eaten away. The infestation was more serious on okra as compared to that on other crops. Larvae feed voraciously on both tender as well as older leaves and were occasionally observed to feed on the petals of the flowers. No larvae were seen attacking the okra pods. On cotton, the damage was not severe and frequently, the larvae were observed feeding on the calyxes of the bolls. The young larvae move about actively and congregate in small groups nibbling and making small punctures on the leaves while feeding. When disturbed, the larva wriggles, throws out a silken thread and drops away to be suspended by the thread. This characteristic wriggling feature persists in the later instars, however, the tendency to produce a silken thread diminishes until finally the fifth instar larvae do not

throw silk at all. When disturbed, these mature larvae contort and throw their bodies away from the source of disturbance. Normally, they are shy feeders in the day time, camouflaging with leaves or concealing themselves within leaf folds. However, during heavy infestations, mature larvae were found feeding on tender leaves. at the tips of shoots and occasionally on petals of flowers in broad daylight. Presence of the larvae can be detected by large holes eaten in the leaves along with fresh faecal pellets strewn on the upper surface of the leaves below the damaged leaves. The larvae develop solitary attitude as they grow older and not more than 4 or 5 mature larvae are normally observed on a single plant. The larvae prefer shady places to feed in the day time. In cotton, where the branches spread along the ground, the larvae may be seen actively chewing in daylight. In the laboratory, when the food is exhausted, they may even eat away the veins and petioles of the leaves.

(iii) Duration of the larval stage

To study the duration of larval stage and the number of instars that occurred in the larval life, 45 larvae were .

reared individually and observations on the length and breadth of the larvae, width of the head capsule and moulting were recorded everyday. Out of these, only 40 completed their larval development, of which 32 did so in 5 instars and the remaining 8 in 6 instars. The results are summarised in table 4.

Table 4.

Duration of larval instars of A.flava.

Sr. No.	Instars	Duration of instars(in days)			
		32 larvae through 5 instars		8 larvae through 6 instars	
		Range	Average	Range	Average
1.	I	3.00 - 3.00	3.00	3.00 - 3.00	3.00
2.	II	1 - 2	1.81 ± 0.071	1 - 2	1.87 ± 0.13
3.	III	1 - 2	1.90 ± 0.055	1 - 2	1.37 ± 0.19
4.	IV	2.00 - 2.00	2.00	1 - 2	1.62 ± 0.19
5.	V	3.00 - 3.00	3.00	2.00 - 2.00	2.00
6.	VI			2 - 3	2.12 ± 0.120
7.	Pre-pupa	1.00 - 1.00	1.00	1.00 - 1.00	1.00
8.	Total larval life	12 - 13	12.70 ± 0.0836	13 - 13	13
9.	Pupa	6 - 7	6.18 ± 0.07	6 - 7	6.62 ± 0.19
10.	From hatching to emergence of adult	18 - 20	18.90 ± 0.131	19 - 20	19.6 ± 0.435

The results in table 4 indicate that the durations of the first and second instar larvae and the prepupal stages were almost similar in both the cases. However, the larvae that passed through five instars took on an average, some more time to complete the third, fourth and fifth instars than the corresponding instars of the larvae that passed through six instars. Thus, the durations from third to fifth instar are shorter in case of larvae that passed through six instars in order to make up for the duration of an extra sixth instar. Thus, the average larval life in these cases worked out to be 13 days as against 12.70 ± 0.0836 days in case of larvae that passed through five instars. The average pupal period and the period from hatching of the eggs to the emergence of adults are 6.18 ± 0.07 and 18.90 ± 0.131 days respectively in the first case which are shorter by 0.30 and 0.70 days than those in the second case. Thus, the rate of growth is faster in the larvae that passed through five instars and the larvae that are slow in attaining maturity are also slow in development during their pupal period.

3. Prepupa

When the larva is about to pupate, it suspends feeding and looks for a suitable place to spin the cocoon. In the field, mature larvae are found to pupate among the older leaves. After having located a suitable place, the larva commences to prepare a flimsy, silken cocoon by glueing two leaves together or rolling the edge of a leaf. In the laboratory, the larvae formed cocoons in the folds of the black cloth cover, among the plastic strips provided for the purpose and in absence of host leaves, on the surface of the soil by binding the faecal pellets with silk. When the cocoon is ready, the larva becomes short in length and retracts the appendages. The larva in this condition is called prepupa which is a pharate pupa lying inside the old larval cuticle. Its colour differs to some extent from that of the larva. Three Spinach Green narrow strips one along the mid-dorsal line and two on dorso-lateral positions run along the entire length of the body except head. Remaining portion of the dorsal and dorsolateral surfaces are Calliste Green while the ventral surface is Light Viridine Green. The prothoracic and mesothoracic terga have a purplish

hue, while the last abdominal segment is yellowish in colour. The prepupal period, recorded for 40 individuals, was 1 day at an average laboratory temperature of 27.67 °C.

4. Pupa (Plate 2 - H)

(i) Description of pupa

The pupa of A. flava is obtect with a small, pointed vertex and a fan-shaped anal extremity. The fourth, fifth and sixth abdominal segments are free and movable. Ventrally, the wing pads overlap some portion of the abdomen, partially covering the fourth abdominal sternum. The tenth abdominal segment is produced to form a cremaster comprising of four spiny projections of which two are produced by the lateral margins and the other two incurved, pointed hooks by the posterior margin. Four wiry, pale brown crochets with coiled tips, arise from the cremaster and extend posteriorly. One pair arises just outside the incurved hooks and the second pair from the lateral margins just above the outer spiny projections. The cremaster aids the pupa in anchorage within its cocoon and also helps retain the pupal cuticle within the folded leaves. Dehiscence taken place by a fracture which

starts behind the compound eyes at the vertex and extending downwards along the antennae on either side. The pupae when freshly formed are green in colour, gradually turning yellow from the tip of the abdomen upwards and finally become Garnet Brown in colour. On the day prior to emergence, the pupae are Walnut Brown in colour.

Pupae can be sexed by carefully examining the terminal sternites (Plate 2 - H,I). The pupae which are to develop into males, have a slit on the posterior margin of the ninth sternum, representing the genital aperture. The pupae which are to develop into females, have a common aperture representing bursa copulatrix and oviduct on the posterior margin of the eighth sternum. Both the male and female pupae bear the anal slit on the caudal margin of the tenth segment. In males, the distance between the genital and anal apertures varied from 0.264 to 0.330 mm. with an average of 0.290 ± 0.07 mm. In females, the distance between the two respective apertures varied from 0.594 to 0.792 mm. with an average of 0.625 ± 0.10 mm. Thus, the two slits are farther located in females than in males and the sex can easily be determined.

The sex ratio was calculated on the bases of observations

taken on laboratory reared pupae. Out of 520 pupae observed, 248 were males and 272 were females, which gave a ratio of 1 male : 1.09 females.

To determine the length and breadth of pupae, 50 pupae of each sex were measured. The results indicated that the length of pupae to develop into males, varied from 14.11 to 17.10 mm. with an average of 15.95 ± 0.003 mm., whereas, that for the females pupae varied from 13.12 to 16.00 mm. with an average of 14.75 ± 0.002 mm. The breadth varied from 3.82 to 4.55 mm. with an average of 4.092 ± 0.003 mm. ⁱⁿ case of male pupae and from 4.09 to 5.08 mm. with an average of 4.38 ± 0.015 mm. in case of female pupae.

(ii) Duration of pupal period

The duration of the pupal period was studied at constant temperatures as well as at varying room temperatures. The results obtained are given in table 5.

Table 5.

Duration of pupal period of A. flava
at different temperatures.

Sr. No.:	Period of study:	Temp. in °C.:	Total No. of observations:	Pupal period	
				Range :	Average
1.	20.10.69 to 28.10.69	28.02*	33	6-8	6.74 $\pm$ 0.142
2.	24. 8.69 to 31. 8.69	29.17*	40	6-7	6.62 $\pm$ 0.019
3.	22. 8.69 to 1. 9.69	32 $\pm$ 1**	20	5-7	6.05 $\pm$ 0.201
4.	20.10.69 to 28.10.69	37 $\pm$ 1**	70	-	-

* Average laboratory temperature.

** Constant temperature.

The data in the above table indicate that at an average laboratory temperature of 28.02 °C., the pupal period was 6.74 $\pm$ 0.142 days, decreasing to 6.62 $\pm$ 0.019 days at a higher average laboratory temperature of 29.17 °C. When the temperature was further raised to 32 $\pm$ 1 °C., the pupal period further decreased to 6.05 $\pm$ 0.20 days. This shows that the pupal period decreases as the temperature is increased upto a certain extent and vice a versa. At 37 $\pm$ 1°C., there was no emergence at all indicating that it was too high a temperature for emergence.

5. Adult (Plate 2 - M)

(i) Description of the adult

The moths of A. flava are sombre coloured and of medium size. They measured on an average 30.15 mm. when wings expanded and 14.72 mm. in length from head to the tip of abdomen.

The adults are sexually dimorphic as manifested by the antennae and the colour pattern on the wings, specially on the forewings (Plate 2 - K, M). The head when viewed laterally appears triangular in shape. The compound eyes are large and globular, lying laterally. From the narrow portion between the eyes and the vertex, arises a pair of long, slender antennae which are setaceous in the female and bipectinate in the male (Plate 2 - J, L). The labial palpi are 3 segmented and well developed curving upwards in front and above the head (Plate 2 - G). The first two segments of the labial palpi are short and thickened, bearing numerous scales. Both the segments together are more or less equal in length to the third which is slender and pointed with fewer scales. The dorsal surface of the thorax is covered with Antimony Yellow scales dotted with red scales in

the male and covered with only Antimony Yellow scales in females. However, in males, the margin of the thorax bears Olive Brown scales.

Brick red transverse lines divide the forewings of both males and females into different shades of brown. In males, the proximal half of the forewing is Antimony Yellow, speckled with red scales and the distal half is Olive Brown. A wide band of Clove Brown scales separates the two areas. In females, the Antimony Yellow scales occupy the proximal half of the forewing, while remaining half up to the apical margin is covered by Buffy Brown scales. The apical margin of the forewings in both the sexes is lined with a strip of Olive Brown scales. The forewings bear a small white circular spot about one-third away from the base and near the costal margin. In males, however, it is quite distinct due to its dark, well defined periphery. The hindwing bears dull brown scales in the male and straw coloured scales in the female.

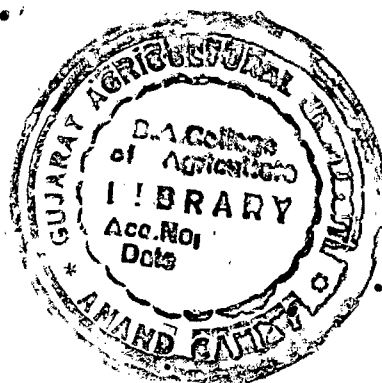
The abdomen of the male is slender but ends up in a broad tip due to tufts of scales, while that of the female is stouter and ends in a pointed tip. The abdominal tergites are clothed with brownish scales in the male and straw coloured

scales in the female.

To determine the variation in size of the male and female moths, 30 individuals of each sex were measured for their length from the head to the tip of the abdomen and breadth when wings expanded. It was found that the average length of males was 14.25 ± 0.22 mm. and that of females was 14.95 ± 0.25 mm. The average breadth of males was 29.5 ± 0.31 mm. as against 30.8 ± 0.29 mm. in case of females. In general, females were slightly longer and broader than males.

(ii) Fecundity and longevity of adults

To determine the pre-oviposition, oviposition and post-oviposition periods and the fecundity and the longevity, adults were studied in different combinations of males and females. For this purpose, a female alone, one female with one male and one female with two males were confined in glass chimneys and were fed with 10 % honey solution. Host leaves were provided and the eggs were counted daily. The results obtained are summarised in table 6.



Pre-oviposition, oviposition, post-oviposition periods, fecundity and longevity of A. flava at 28.21 °C.

M = Male, F = Female

The results presented in table 6 indicate that the pre-oviposition and post-oviposition periods were almost similar when females were caged with either one or two males. The oviposition period was slightly longer when the females were caged with two males. These females laid on an average 407 eggs as against 270.26 eggs laid by females caged with a single male or 158.25 eggs laid by the females caged alone. This is because the females caged with two males each, were certainly fertilized and therefore they fully expressed their fecundity. On the other hand, some females, caged with a single male each, failed to be fertilized and therefore laid as few as 26 eggs. The unfertilized females also laid as few as 14 eggs. The longevity of both the males and females was longer when one female was caged with two males, as compared to that when a single male was caged with a female. The virgin female lived much shorter than either the males or females caged in pairs or more.

(iii) Host preference for oviposition

To test the host most preferred for oviposition, a uniform number of moths were released in the wooden cages, described earlier, and provided with 10 % honey solution. Bunches of the different host leaves were placed inside the

cage as oviposition sites. The food and leaves were changed daily and the number of eggs laid on each host leaf was counted and recorded separately everyday. The results are summarised in table 7.

Table 7.

Host preference for oviposition by
the females of A. flava

Sr. No.:	Host	No. of eggs laid	% of the total
1.	Cotton	2306	48.00
2.	Okra	1275	26.58
3.	Deccan hemp	692	14.52
4.	<u>Urid</u>	523	10.90
Total		4796	100.00

From table 7 it can be seen that the maximum number of eggs were laid on cotton (48.00 %) and the least were laid on urid. Okra which is also an important host was not as preferable as cotton since only 26.58 % of the eggs were laid on this host. Thus, cotton was preferred most for oviposition, with okra, deccan hemp and urid coming next in the order of preference.

6. Duration of life cycle

The larvae studied for the number and durations of instars were reared further up to their adult stage so as to work out the total life cycle from laying of the eggs to the death of the adults. Results from table 4 show that the period from egg laying to emergence of adults varied from 20 to 22 days with an average of 20.90 days. After adding 10.52 days of the adult life to it, the total life cycle from laying of the eggs to the death of the adults at an average laboratory temperature of 28.32 °C., worked out to be 30.52 to 32.52 days with an average of 31.42 ± 0.344 days.

B. Biology on different hosts

(i) Growth of the larvae on different hosts

To find out the most suitable host to rear the larvae in the laboratory, A. flava larvae were reared on different hosts, from first instar until pupation. The suitability of the host was judged on the basis of growth index calculated by dividing the percentage of pupation with the average larval duration. The results obtained are summarised in table 8.

Table 8.
Growth index of A. flava larvae on
different hosts.

Host plants:	No. of : :larvae: :obse- : :rved :	Larval period in days: :Range : :	Average (av.)	Pupae obtained: : No. : :	% (n)	Growth: :index : ($\frac{n}{av}$)
Okra	85	11-15	12.70 $\pm$ 1.433	81	95.29	7.50
Cotton	96	12-16	13.66 $\pm$ 0.011	89	92.12	6.74
Deccan hemp	85	12-15	13.08 $\pm$ 0.403	81	95.29	7.29
Shoe-flower	54	13-17	15.36 $\pm$ 0.169	49	90.07	5.86

The results in the above table indicate that okra was the best ~~host~~ among all the host plants tried. The order of preference of other hosts is deccan hemp, cotton and shoe-flower.

During the study, it was observed that the larvae fed voraciously on okra, cotton and deccan hemp and sparingly on shoe-flower. The average larval period was around 13 days on okra and deccan hemp and it was the longest i.e. 15 days on shoe-flower. Considering the growth index, okra and deccan hemp are the most suitable plants to rear the larvae in the laboratory.

(ii) Development of pupae from larvae reared on different hosts

To determine the differences in development of the pupae obtained from larvae reared on different hosts, weight,

length and breadth of pupae were recorded. The results obtained are summarised in table 9.

Table 2.

• Measurements of pupae when larvae are reared on different hosts.

Sr. No.:	Host	Sex	No. of: Av. wt.:	Length (mm.)		Breadth (mm.)	
:	:	:	: obse-: per :	:	:	:	:
:	:	:	: rva-: pupa :	Range :	Average :	Range :	Average :
:	:	:	: tions: (mg.) :	:	:	:	:
1.	Cotton	M	47	14.0-16.8	15.3 ± 0.054	3.96-4.62	4.17 ± 0.095
			158				
		F	42	14.1-17.2	15.6 ± 0.063	4.20-4.95	4.30 ± 0.018
2.	Okra	M	39	13.9-16.9	15.1 ± 0.044	3.82-4.48	4.15 ± 0.003
			154				
		F	39	14.1-17.1	15.5 ± 0.054	4.09-4.75	4.15 ± 0.015
3.	Deccan hemp	M	43	13.23-17.13	15.15 ± 0.016	3.69-4.42	4.01 ± 0.043
			148				
		F	39	13.6-17.00	15.00 ± 0.017	3.82-4.48	4.08 ± 0.020
4.	Shoe-flower	M	17	12.42-15.80	13.00 ± 0.028	3.36-3.63	3.45 ± 0.022
			122				
		F	32	12.65-15.12	13.05 ± 0.020	3.30-3.69	3.12 ± 0.025

• M = Male, F = Female

The results in table 9 indicate wide disparity in the development of pupae on different hosts. The pupae obtained from larvae reared on cotton leaves were heaviest and better developed than those obtained on other hosts. Okra and deccan hemp were also good hosts and the pupae obtained from the larvae reared on these hosts were comparable. The pupae obtained from larvae reared on shoe-flower leaves were very poorly developed, as seen from their lighter weight and smaller size. The female pupae were generally better developed than the male pupae.

(iii) Effect of larval diet on longevity and fecundity of adults.

Pairs of male and female moths obtained from larvae reared on different hosts were held separately in glass chimneys and fed with 10 % honey solution. The longevity of males and females, pre-oviposition, oviposition and post-oviposition periods of females and the number of eggs laid by these females were recorded. The results obtained are summarised in table 10.

Table 10.

Longevity and fecundity of A. flava when the larvae are reared on different hosts.

Sr. No.:	Hosts	No. of observations	Duration in days				No. of eggs laid					
			Longevity : : (Av.)	Pre-oviposition : : Range	Oviposition : : Av.	Post-oviposition : : Range	Av.	Range				
1.	Okra	10	15.60	19.8	1-4	2.2	9-14	12.6	1-8	4.80	359-687	520
2.	Cotton	10	17.20	19.4	2-3	2.4	13-17	14.4	1-5	2.60	312-706	517
3.	Deccan hemp	9	18.00	18.00	2-2	2.0	12-15	14.0	1-3	2.00	295-845	488
4.	Shoe-flower	10	18.40	22.00	2-3	2.8	11-16	12.2	4-11	7.20	286-823	

The results in table 10 indicate that the pre-oviposition and post-oviposition periods were maximum, and the oviposition period the minimum, when the larvae were reared on shoe-flower. This reflected on its egg laying capacity which was the poorest i.e. 469 eggs per female. However, when the oviposition periods were longer with shorter pre-oviposition and post-oviposition periods, the egg laying capacity was better expressed as seen in case of the larvae reared on cotton, okra and deccan hemp. Among the three favourable hosts, okra was the best since the females obtained from larvae reared on this host laid on an average 520 eggs.

The longevity of adults was the highest (18.4 days for males and 22.0 days for females) when larvae were reared on shoe-flower. However, the longevity in this case did not influence the fecundity to any extent. The other larval diets did not appreciably influence the longevity of the adults.

CONTROL MEASURES

Various workers have attempted to control A. flava on cotton during the past five decades. No reports were traceable on the control of this pest on okra. In this region, no efforts have been made to control the pest either on cotton or okra. With a view to evolve suitable and economical remedial measures for recommendation to the cultivators of this tract, the present investigations was taken up with some of the recent insecticides to control this pest.

The insecticidal trial was conducted in an okra plot of the Plant Breeding Farm, Institute of Agriculture, Anand, during the year 1968-69. The crop was grown in rows 100 cm. apart and 48 cm. between the plants. The following insecticides were tested at the rate of 750 litres per hectare:

1. Carbaryl - 0.15 % from Carbavin 50 % w/w.
2. DDT - 0.25 % from DDT 50 % w/w.
3. Endosulfan - 0.10 % from Thiodan 35 E.C.
4. Dimethoate - 0.03 % from Rogor 30 E.C.
5. Malathion - 0.75 % from Malathion 50 E.C.
6. Control - (Water sprayed)

The treatments were replicated four times in a randomized block design with 45 sq. metres plot size. The natural infestation level being very low, five laboratory reared larvae of the third to fifth instars were released on each plant and a pre-treatment count was taken 24 hours after releasing the larvae. Spraying with various insecticides was carried out and counts were taken after 24 hours, 48 hours and 7 days. All the leaves of plants in the net plot area were thoroughly examined to count the larvae. Statistical analysis of the data was carried out by transforming the percentage kill to inverse sine transformation and the mean percentage control figures for various treatments were worked out by retransformation of the mean inverse sine values. The results obtained are summarised in table 11.

Table 11.

Mean per cent kill (after angular transformation)
of A. flava with different insecticides.*

Treatment	: % kill after : 24 hours	: % kill after : 48 hours
Malathion	94.70	99.79
Thiodan	99.55	100.00
DDT	99.46	100.00
Ro'gor	96.70	100.00
Carbaryl	100.00	100.00
Control	85.30	79.78
C.D. @ 5 %	8.62	14.60
C.V. %	6.05	4.42

* No infestation was found in control after 7 days.

It is evident from the results presented in table 11 that spraying with any of the above insecticides significantly controls the pest. However, Carbaryl 0.15 % gave 100 % control of the pest in 24 hours and maintained the effectiveness throughout. Thiodan 0.10 %, DDT 0.25 % and Rogor 0.03 % gave 100 % control 48 hours after the treatment. Thus, the effectiveness of insecticides was in the order of Carbaryl, Thiodan, DDT, Rogor and Malathion, all applied in the form of sprays. All the insecticides may be recommended for the control of cotton semilooper on okra.

SUMMARY AND CONCLUSIONS

Anomis flava has been reported to feed principally on cotton and okra and other plants such as deccan hemp, urid, shoe-flower, briar, hollyhock, silk cotton tree and bhan bhindi etc.

The greenish round eggs are laid singly mostly on the host leaves. The eggs measured on an average 0.591 ± 0.005 mm. in diameter and hatched out in 2 days. 60 % relative humidity was optimum, giving 94.53 % hatching of the eggs.

Larvae normally moult 4 times and occasionally 5 times during an average larval period of 12.70 ± 0.08 days. The mature larvae measured on an average 28.21 ± 0.04 mm. in length and 2.37 ± 0.03 mm. in breadth.

The larvae pupate by preparing flimsy silken cocoons among leaves or on dry surfaces such as plastic strips provided in the cage. The average length and breadth of the pupa was 15.95 ± 0.003 mm. and 4.092 ± 0.003 mm. respectively. and the average pupal period was 6.74 ± 0.14 days at an average laboratory temperature of 28.02°C . The distance between the genital and anal apertures was more in females.

The adults are sexually dimorphic as manifested by the bipectimate antennae with Clove Brown and Olive Brown forewings in males and setaceous antennae with Buff Brown forewings in females. They measured on an average 14.95 ± 0.25 mm. long and 30.8 ± 0.23 mm. broad with wings expanded. Females lived for a shorter period, laying on an average 370.26 eggs. At an average laboratory temperature of $28.21^{\circ}\text{C}.$, the average pre-oviposition, oviposition and post-oviposition periods were 1.44, 7.68 and 1.00 days respectively. The average duration of life cycle from egg to the death of adults, was 31.42 ± 0.34 days at an average laboratory temperature of $28.32^{\circ}\text{C}.$ Cotton was the most preferred host for oviposition.

Okra was found to be the most suitable host for rearing the insect in the laboratory since the larvae developed quite satisfactorily to yield well-developed pupae and these adults laid maximum number of eggs.

Insecticidal trials conducted to control A. flava showed that Carbaryl 0.15 %, Endosulfan 0.10 %, DDT 0.25 % and Dimethoate 0.03 % were significantly effective to control the pest when used @ 750 litres per hectare. Carbaryl gave 100 % control within 24 hours.

As it is safe and has a good residual effect, it
can be recommended for control of Anomis after some more
field trials.

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PLATE 1

A : Egg of Amorin flava

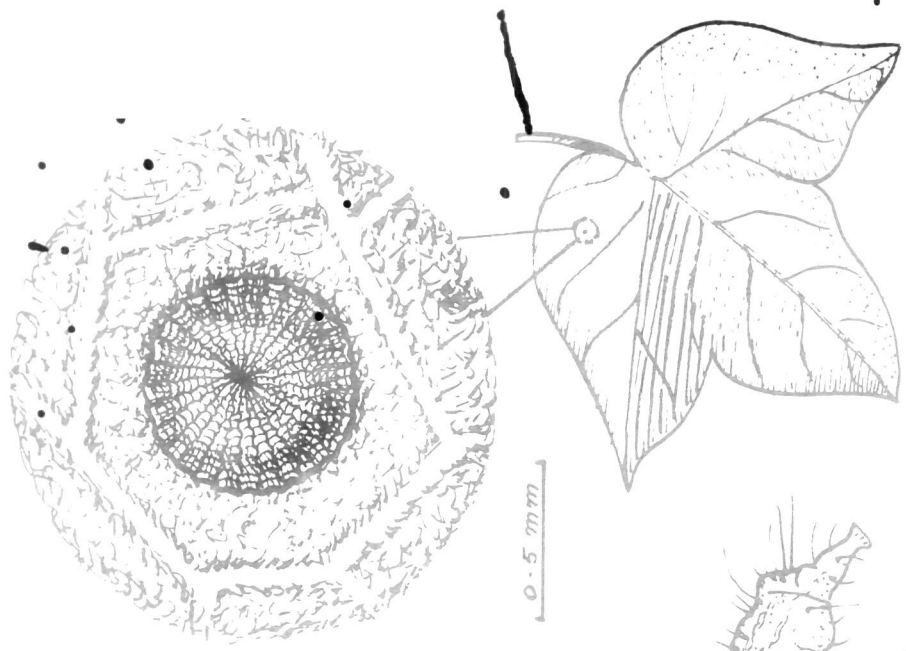
B : First instar larva

C : Second instar larva

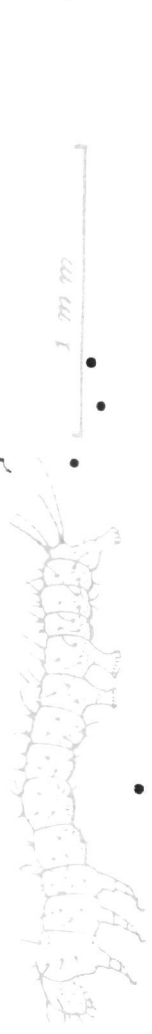
D : Third instar larva

E : Fourth instar larva

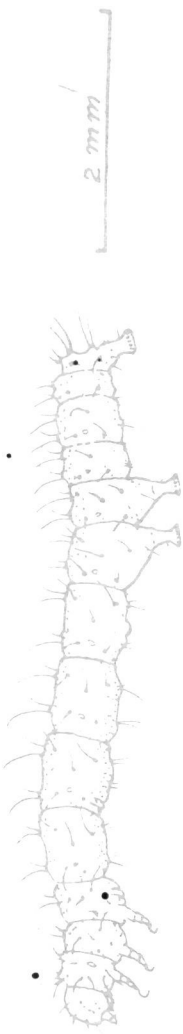
F : Fifth instar larva



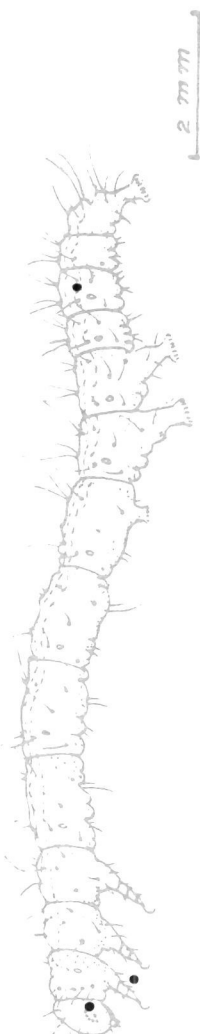
A



B



C



D



E



F

PLATE-1

PLATE 2

- G : side view of Apodis flavus head (male)
showing labial palpi
- H : Male pupa, ventral aspect
- I : Terminal segments of female pupa, ventral aspect
- J : Antenna of female
- K : Wings of female
- L : Antenna of male
- M : Adult male

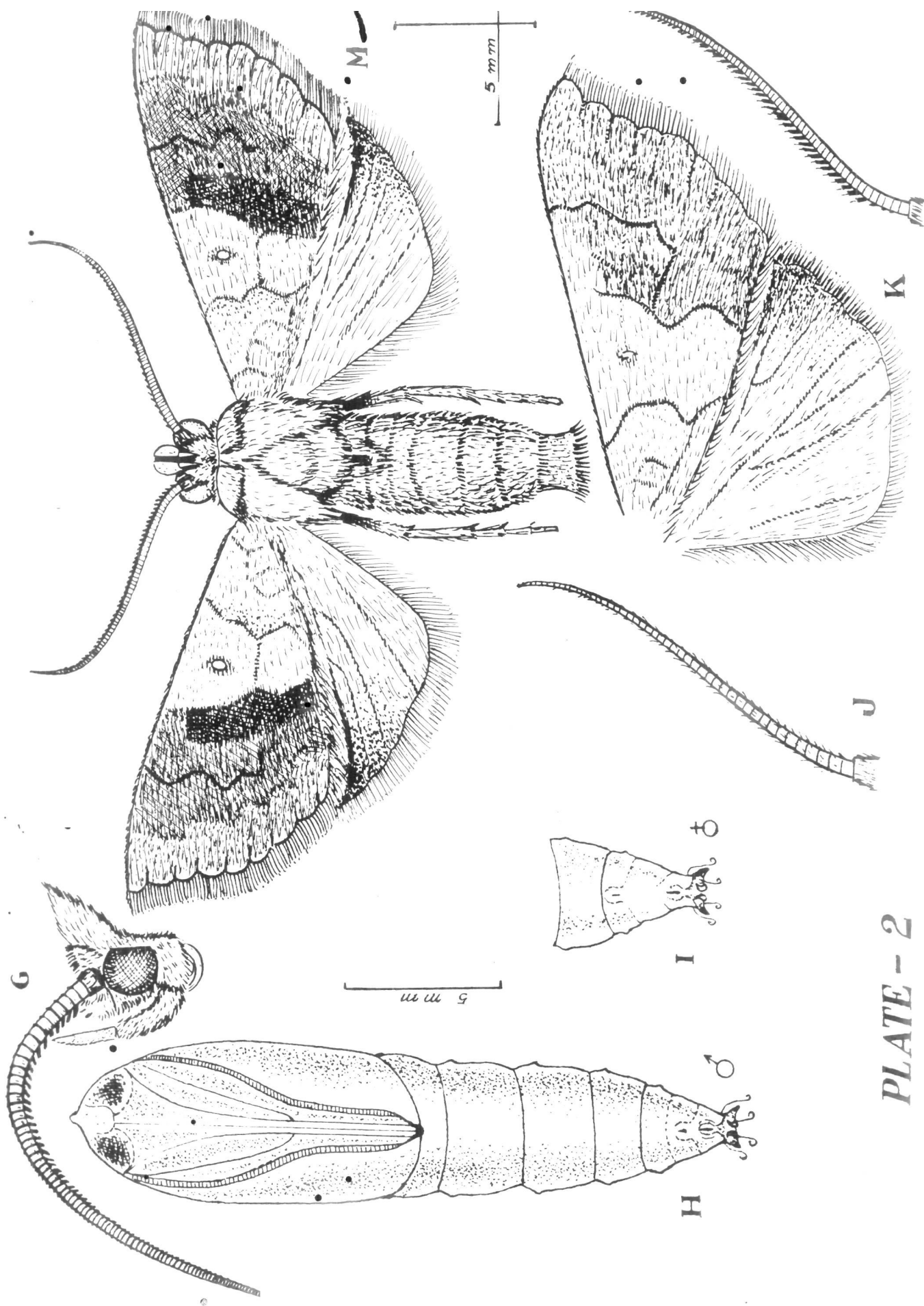


PLATE - 2

PLATE 3

A : Jar for emergence of Anolis flavus

netts and cylinders holding ovipositing females.

B : Rearing cage for adults

