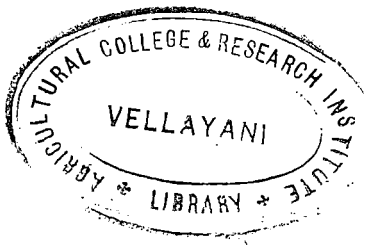
STUDIES ON THE RICE SWARMING CATERPILLAR, *Spodoptera mauritia* BOISDUVAL IN KERALA



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THESIS

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DIVISION OF ENTOMOLOGY

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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 Thomas, B., 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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A C K N O W L E D G E M E N T S

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C O N T E N T S

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INTRODUCTION

INTRODUCTION

Rice is one of the most widely grown food crops of the World and it forms the staple food of about half of the World's population. In India, rice cultivation is concentrated mostly in Assam, West Bengal, Maharashtra, Gujarat, U.P. and Kerala. In Kerala, rice is cultivated over an area of nearly 19 lakh acres and the production falls short of requirements by 50 per cent.

There can be no doubt that the use of high yielding varieties and adoption of better agronomic practices would go a long way in augmenting production of this food crop, but intensive cultivation accentuates the intensity of pest infestation. This is especially so in the case of some of the newly introduced high fertility strains. Unless the major and minor insect pests infesting rice are effectively controlled, increase in yield cannot be attained and maintained.

The rice crop is generally susceptible to infestation by a number of insects throughout the growth period resulting in substantial losses ranging from 10 - 15 per cent.

In Kerala, the rice swarming caterpillar Spodoptera mauritia Boisd., is one of the most serious pests of rice, generally occuring during the ' punja ' season from November to February, over extensive areas of Kuttanad and the ' kole ' areas of Trichur district. The epidemics occur in association with cloudy nights and light drizzles. Generally broad cast

crop of about 2 week's age are relatively more prone to infestation. The larvae feed voraciously on the crop, leaving only the stumps.

The army worm epidemics have been reported from several parts of the state from time to time. Serious infestations were for example recorded from the lift irrigated fields of Alwaye and its suburbs during 1924. Severe outbreaks have been reported during 1944 from several places throughout the erstwhile Travancore State.

Apart from some preliminary observations made by Pillai (1921), Ananthanarayanan and Ayyar (1937) and Joseph (1948), no other information is available on the biology of this pest under Kerala conditions. Being a pest of considerable importance in the State it was considered useful to study the various aspects of the life history of the insect. The present investigations were undertaken to obtain detailed information on its biology and bionomics. Besides this the relative larval preference of several food plants and the variations in colour and behaviour of the larvae when bred singly and under crowded conditions were also studied.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The Rice swarming caterpillar, Spodoptera mauritia Boisduval, has long been known as a serious pest of paddy, occuring sporadically in many parts of the World.

Systematic position: Hampson (1894) who gave a detailed description of the insect included it in the Sub Family Trifinae, under Family Noctuidae. The original description of the adult of Spodoptera mauritia Boisd., as given by Hampson (1894) is as follows:

" Dark grey brown with a rusty tinge, abdomen fuscous. Forewing with the sub basal, antemedial, and post medial double waved lines indistinct; the orbicular small and ochreous; the reniform blackish; the sub marginal line whitish and irregularly waved; a whitish patch is often present between the orbicular and reniform and a dark patch on the central marginal area. Hind wing opalescent and semihyaline white, with a dark marginal line".

Fletcher (1956) recorded the existence of two sub species, namely, Spodoptera mauritia mauritia Boisd., and Spodoptera mauritia - acronyctoides Guence, on the basis of differential characters of the forewing. His description of the adults of the two sub species is as follows:

Male: Palpus and head cinnamon buff irrorate with brownish vinaceous; thorax and crest on first abdominal segment brownish vinaceous irrorate with fuscous; abdomen pale pinkish buff with long, dark grey hairs dorsall

and irrorate with cinnamon buff, and brownish vinaceous ventrally. Fore wing elongate and narrow. Proximad of the antimedial fascia, which is dentate and fuscous black edged proximally with white, the wing is a mixture of snuff brown and vinaceous brown, very lightly irrorate with fuscous and white. In some specimens there are traces of a dentate, fuscous, basal fascia. The medial area posterior of vein Cu2, is similarly coloured between the subcostal vein and Cu2, it is white with an orbicular spot, ringed and centred with fuscous and a large fuscous black reniform, the latter joined to the vinaceous brown costa by an ill defined medial shade. The band between the dentate, white subterminal and the post medial fasciae is vinaceous brown from the costa to vein M2 and then densely suffused with fuscous to just posterior of vein Cu1, the posterior third is white very lightly irrorate with vinaceous brown and the area distad of the subterminal fascia is similarly coloured, except between veins M1 and M3, where there is a small but conspicuous patch of fuscous. The apex of the terminal area is almost pure white. There is a terminal row of fuscous internal spots. Underside glossy, pale pinkish buff; the anterior half is irrorate, with brownish vinaceous and distally lightly suffused with fuscous; reniform and terminal spots fuscous. Hind wing almost hyaline, varying with the light from white to vinaceous; the margins and the veins are suffused with fuscous. Underside similar, but with fuscous suffusion in the costal area only.

Female: Differs from the male in the forewing, lacking the conspicuous white markings of the medial area and the posterior third of the band between the

post medial and subterminal fusciae: those of the area distad of the sub terminal fascia are reduced; instead all are irrorate with fuscous.

Male genitalia: Uncus curved ventrad and tapered to a fine point. Valve with large corema bearing dense deciduous hair tufts; ventral margine shallowly incised just before apex; the part of the valve apicad of the level of the ventral incision is as broad as long. A tapered process arises from mid valve. Vesica with a single cornutus, three fifths as long as the aedeagus; the apical fifth obtusely angled and covered with several small teeth.

Female genitalia: Ostium bursae and ductus bursae sclerotised and of equal length. Posterior three sevenths of bursa copulatrix cylindrical ribbed and partially sclerotised posteriorly; anterior four sevenths globular and ribbed with a single, longitudinal, scobinate signum.

Distribution: Mauritius, Madagascar, Comoro Is; Tanganyika.

Spodoptera mauritia acronyctoides Guence.

Differs from the nominale subspecies in the forewing. In the male the conspicuous white of the medial band is reduced to a small spot between the reniform and the orbicular; that of the terminal area is reduced to a small patch near the apex. In the female the white subterminal fascia is much more slender and the white terminal markings are replaced by fuscous irrorations.

Distribution: Red Sea, India, Burma, China, Hainan, Shanghai, Ceylon,

Malay Peninsula to Australia, Solomon Is; New Hebrides; Fiji, Samoa, Society Is., Austral Is., Marquesus Is., Marshall Is., Hawaiian Is.,.

Imms (1957) included this insect in the lepidopteran Super Family Noctuoidea and Family Noctuidae.

Distribution and host plants: The distribution of this pest in the different parts of the world and its host range are as listed below:

Distribution	Host attacked	Reference
Philippines	Rice	Arce (1919)
		Merino (1920)
		Woodworth (1922)
		Otanes (1925)
		Otanes and Karganilla (1940)
Dutch East Indies	Rice	Van Hall (1919, 1920)
Malaya	Rice	South (1920)
		Corbett (1930)
Ceylon	Rice	Hutson and Jardine (1923)
		Fernando, Weeraverdana and Manickavasagar (1954)
Burma	Rice	Ghosh (1924)
Indo-China	Rice	Commun (1932)
Guam	Rice	Swezey (1940)
Fiji	Rice	Lever (1940)

Distribution	Host attacked	Reference
Philippines	Maize	Merino (1920); Otanes and Kanganilla (1940)
Natal	Maize	Dick (1943)
Natal	Sorghum	Dick (1943)
Queensland	Sugarcane	Jarvis (1922)
Hawai	Sugarcane	Swezey (1926); Swezey and Pemberton (1932); Williams (1936)
Natal	Sugarcane	Dick (1943)
Madagascar	Graminaceous crops	Fletcher (1956)
Mauritius	"	Fletcher (1956)
Comoro Islands	"	Fletcher (1956)
Indo-Australian region	"	Fletcher (1956)
Pacific region	"	Fletcher (1956)
Oahu	Lawn grasses	Tanada and Beardsley (1957)
Honolulu	"	Tanada and Beardsley (1957)
Hawai	Cynodon dactylon	Tanada and Beardsley (1957)
Philippines	Tobacco	Arce (1919)
Mauritius	Tobacco	D' Emmerez, Decharroy D, and Gebert, S. (1921) Corbett (1926)
Philippines	Cabbage and Tomato	Arce (1919)

In India, Spodoptera mauritia was reported as attacking various graminaceous crops. The first record of its occurence in the country was that by Lefroy (1906) who noted it as a pest of rice. Fletcher (1913) recorded it on rice in Madras. In Bengal this pest was reported to occur on rice by Fletcher (1916), Mackenna (1918) and Sharangapani (1929). Ballard (1921) noted it as a serious sporadic pest of paddy in Malabar, causing heavy damage. Pillai (1921) reported serious damage to 'puncha' rice in Travancore caused by this pest. In Mysore this insect was noted as a pest of rice by Iyer (1921) and on rice and ragi by Anstead (1924). Gupta (1926) found it to occur on rice in Assam. Rao (1927, 1929) also found it to occur in Madras. Ayyar and Ananthanarayanan (1936) recorded this pest on rice under 'Kole' cultivation in Malabar, and also mentioned about its occurence on rice, maize, wheat and barley from outside Kerala. Otanes and Kanganilla (1943) reported the pest on potato in Kumaon.

Life history and habits.

Mating, oviposition and fecundity: Observations made in Coimbatore by Ananthanarayanan and Ayyar (1937) showed that copulation usually took place a day after the emergence of moth and that in nature the gravid moths moved to great distances before eggs were laid on a crop of suitable age. They further observed that the pre-oviposition period ranged from 3 to 6 days. Dick (1943) recorded that in Natal the pre-oviposition period was 4 days.

Ayyar and Ananthanarayanan (1935) made some observations on the oviposition and fecundity of the insect. Oviposition usually took place at night. The eggs were laid in masses and covered by a layer of short brownish hairs produced from the abdomen of the female. One moth was able to lay 5 to 6 egg masses, each containing 50 to 500 eggs. A maximum number of 2750 eggs had been recorded as laid by a single female. The largest egg mass collected from the field measured 1½" in length and ¼" in breadth and contained as many as 727 eggs. (Ananthanarayanan and Ayyar 1937). Cherian and Ananthanarayanan (1937) reported that eggs were laid in groups of 15 to 20, while according to Dick (1943) eggs were laid in batches of 100 to 200. Tanada and Beardsley (1958) from Hawaii recorded that the females caged with males during first night after emergence laid an average of 8.6 egg masses per female, each containing on an average 709 eggs.

Life cycle: Hutson (1920) recorded that under conditions in Ceylon the incubation period ranged between 4 to 5 days. Pillai (1921-1922) observed that in Travancore, egg period lasted 3 to 4 days. In Philippines an egg period of 2 to 4 days was recorded by Otanes (1925). In Madras, Cherian and Ananthanarayanan (1937) found it ranging from 3-5 days while in Travancore Joseph (1948) recorded it as 3 to 4 days. The eggs hatched out into a tiny caterpillar which according to Ananthanarayanan and Ayyar (1937) attained full growth in 21 to 32 days. The larval duration was recorded as one month in Ceylon by Hutson (1920), 14 to 17 days in

Travancore by Pillai (1921), 14 to 23 days in Philippines by Otanes (1925) 25 to 34 days in Natal by Dick (1943), 14 to 17 days in Travancore by Joseph (1948), 28 days in Hawaii by Tanada and Beardsley (1958). The larvae underwent 5 moults in majority of cases but occasionally six and even seven moults were recorded by Ananthanarayanan and Ayyar (1937). Tanada and Beardsley (1958) reported that the larvae selected tender foliage, and when forced to feed on rough foliage took longer time to complete their development.

The full grown caterpillar pupated in the soil, the pupal period being 10 days in Madras according to Ananthanarayanan and Ayyar (1937). It was 2 weeks in Ceylon (Hutson 1920), 6 to 9 days in Travancore (Pillai 1922), 7 to 16 days in Philippines (Otanes 1925) 6 to 10 days in Natal (Dick 1943), 8 to 10 days in Travancore (Joseph 1948) and 11 days in Hawaii (Tenada and Beardsley 1958).

Seasonal incidence: According to Hutson (1920) out breaks of Spodoptera occured in the months of November and December in Ceylon. In Malaya it appeared in August (South 1920). In Philippines Spodoptera was reported to be most numerous during May, June and July, when upland and seed bed rice was planted (Otanes 1925). Corbett (1930) suspected that in Malaya its occurence was influenced by the spell of unusually dry weather conditions. Attack was not severe in the hot and dry regions of Mauritius according to Moutia (1934). Out breaks of Spodoptera on rice in Fiji during February to June were associated with flood conditions (Lever 1940)

Ballard (1921) noted the greatest damage due to Spodoptera mauritia in Malabar when the monsoon was late. Pillai (1921) found it causing serious damage to rice cultivated during 'puncha' season in Travancore. Ramachandra Rao (1921) recorded its occurence in Madras State on first crop rice in May and on the second crop in September - October. In Bengal the attack was noted during the colder months of the year (Sharangapani, 1929).

Studies on the atmospheric conditions congenial for the out break of Spodoptera in Malabar conducted by Ananthanarayanan and Ayyar (1935) revealed that moths suddenly migrated from distant sources when the weather was moist and warm, apparently owing to a specific attraction of the prevailing atmosphere. Most active oviposition took place during such nights, which were preceded by morning temperature of 78-82°F and relative humidity of 78-82 per cent. Oviposition ceased by the end of February when the weather became hot and dry. According to Cherian and Ananthanarayanan (1937) invasion by the moth was often preceded by the gradual cessation of wind followed by calm weather condition.

Natural Enemies: Spodoptera mauritia, is subject to attack by a large number of parasites, predators and a virus disease. Fletcher (1916) reported the occurence of an Ichneumonid parasite in Bengal. Hutson (1920) observed in Ceylon that the natural enemies included parasitic

Hymenoptera, certain species of fungus, and a predatory beetle, Cicindela sexpunctata F. South (1920) reported that in Malaya, immature Spodoptera population was held in check by a tachinid parasite. Ballard (1921) reported that in Malabar, the parasites observed included the tachinids, Actia aegyptia Villen., Pseudogonia cineraceens Rond., Tachina fallax Meig., Cuphocera varia F., and a braconid Chelonia sp. Petch (1925) noted a fungus Spicaria prasina as parasitic on Spodoptera larvae in Ceylon. Swezey (1926) reported from Hawaii, Hymoeter exiguae (Viereck) a hymenopteran parasite on Spodoptera. Ferriere (1930) reported a chalcid, Thosea cervina Wlk., as a natural enemy in Ceylon. Uichanco (1934) from Philippines, mentioned Euplectrus platyhypenae Mow., and Telenomus nawai Asm., as parasites of this pest there. Ananthanarayanan and Ayyar (1937) recorded the ichneumonid Charops dominans Wlk., the braconids Apanteles ruficrus Hal., and Chelonus sp., the eulophid Euplectrus euplexiae Roh., and the tachinids Cuphocera varia F., Sturmia inconspicua Mg., and Tachina fallax Mg., as parasites of Spodoptera mauritia in Madras. Swezey (1940) reported the inchneumonid Echthromorpha conopleura Krieger., as a parasite on the pupae of Spodoptera and the eccilonid Telenomus nawai Asm., as parasitic on the eggs in Hawaii. Sonan (1942) reported from Formosa the occurrence of Euplectrus taiwanus parasitising larvae of Spodoptera there. Tanada and Beardsley (1957) reported that Spodoptera mauritia larvae were found to be infected with a polyhedrosis virus. They also reported (1958) that

the natural enemies in Hawaii included a polyhedrosis virus, the toad Bufo marinus, a scelionid egg parasite of the young larvae, Apanteles marriniventris and the tachinids Chaetogaedia monticola, Achaetoneura archippivora and Blondelia aymisera Coq. Rao (1967, Private communication) found that Spodoptera mauritia was affected by several parasites throughout India. In Assam, Actia sp., Drino sp., and Isomera cinerascens were reared from its pupae. A secondary parasite Syntomosphyrum obscuriceps was also recorded on the pest through an unidentified tachinid. From Kerala, Charops bicolor, Meteorus sp. Pseudoperichaeta orientalis, Strobliomyia aegyptia, and Drino unisetosa, were recorded as larval parasites. Apanteles ruficrus and Charops bicolor, were collected from Madras while no parasites were detected from Mysore. Charops bicolor and Netelia sp. were bred out from pupae obtained from Orissa. In West Bengal Drino unisetosa was reported as larval paresite.

Control: Fletcher (1913) suggested protection of paddy seed beds by surrounding them with narrow steep sided trenches, regular collection of egg masses, spraying and letting in ducks, as effective control measures against Spodoptera infestation. Henry (1917) recommended digging trenches around infested fields, flooding the field and spraying lead chromate. Mackenna (1918) observed that pouring kerosene in the field water in paddy fields and subsequently dislodging the caterpillars were quite effective control measures. Arce (1919) in Philippines advocated

spraying with 1 lb. lead arsenate in 10 gals. of water and sweeping with a net. South (1920) suggested hand picking of caterpillars, while Coco (1921) from Philippines recommended collection of egg masses, application of poisoned bran mash, flooding, ditching and rolling, crop rotation and clean culture. Pillai (1922) suggested the application of lime and ashes in equal proportion or paris green and lime in the ratio of 1:80 when larvae were young, pouring kerosene into the water in rice fields and dragging a heavy pole over the crop, spraying with lead chromate or paris green or sprinkling finely powdered paris green and lime on the crop to control the pest. Edwards (1925) reported that in Mauritius the remedial measures included digging round the base of the plant during the day when the larvae were found 1 or 2" deep in the soil, trapping the caterpillars at night using artificial light and application of a poison bait made by dissolving 1 oz. arsenic and 2 oz. sugar in 1½ gal. water and adding 2½ lbs. bran. The bait was to be applied at 5 lbs per acre. Sweezy (1928) recommended spraying with poisoned molasses. Hao (1929) advocated hand picking, trenching or flooding, and treating the surface with calcium arsenate and lime. Sharangapani (1929) suggested digging trenches treating cracks with kerosene and water 1: 20, and treating the surrounding uninfested rice crop with lead chromate at 1 oz. to 2 gals water. Pemberton (1932) found that dusts containing 5 lbs of white arsenic or 6 lbs of lead arsenate and 30 lbs of finely ground rock phosphate would control Spodoptera on sugarcane provided that the dusting

was repeated at intervals of 2-3 weeks.

Nanta (1933) recommended collection of eggs, ploughing the soil after harvest, flooding and combing the larvae from the plants. Iyer (1933) recommended dusting with calcium arsenate. Smith (1933) suggested ploughing a deep furrow as a barricade against the marching caterpillar, and placing liberal amounts of paris green baits in such furrows. Moutia (1934) found that poisoned baits made of sliced Cactus and sodium fluoride were effective in controlling Spodoptera in Mauritius. Smith and Caldwell (1947) reported from Queensland that DDT 0.1% sprays gave excellent results. Fernando et al (1954) found that aerial spraying with 18% DDT emulsion concentrate diluted with water at 2 pints per 1.5 gals. and sprayed at 2-3 gals. per acre gave complete control of Spodoptera in Ceylon . Joseph (1961) preferred DDT to BHC for the control of Spodoptera caterpillars, in view of the long residual action and comparative good initial action of the former insecticide.

MATERIALS AND METHODS

MATERIALS AND METHODS

Materials

Stages of Spodoptera mauritia: Eggs and caterpillars were collected from the paddy nurseries, raised in the farm attached to the Agricultural College, Vellayani. Adult gravid females also were collected at light in the college hostel and eggs were obtained from them. Eggs collected so were used for both bulk rearing and individual rearings.

Host Plants: For bulk rearing and for studies on the biology of the insect, leaves of paddy plants 1½ - 2 weeks old were used as food material for the caterpillars. The paddy plants required for these were raised in flower pots.

To study the relative preference of the caterpillars for different species of grasses and to study the variations with respect to feeding on different grasses, the following grasses in addition to paddy were used. These were collected from the field.

(1) Eleucine indica

(2) Pseudanthisteria umbellata

(3) Isachne dispar

(4) Cyperus iria

(5) Cyperus rotundus

(6) Fimbristilis miliacea

Glass wares and other articles.

(a) Glass chimneys.

(b) Glass cylinders.

(c) Specimen tubes.

(d) Glass trough.

(e) Cotton pluge. Made by tying a spherical mass of cotton wool in a square piece of muslin cloth, large enough to close the mouth of 8 x 2 cm specimen tubes.

(f) Camel hair brush.

(g) Flower pots.

(h) Muslin cloth for covering the glasswares.

Methods

Mass rearing of Spodoptera mauritia: Bulk rearing was done in circular glass troughs. The caterpillars collected from the field or obtained by hatching of eggs in the laboratory were kept in the glass trough with fresh young paddy plants, the top portion of the trough being closed with muslin cloth kept in position with rubber bands. The troughs were examined daily, cleaned and fresh plants supplied. When the caterpillars had reached the fifth instar stage soil was put in the trough to a height of 2"-3". A circular paper was placed above the soil and the paddy plants and larvae placed on top of the paper. Cleaning could be done by removing the paper. Pupae were collected and kept in separate chimneys.

Oviposition studies: For the purpose of obtaining eggs in the laboratory male and female moths were confined in pairs in chimneys and closed at both ends with muslin cloth. The moths were fed with sucrose solution on soaked cotton wool. The eggs laid in masses on the muslin cloth were taken, and kept in specimen tubes for hatching and closed with cotton plugs.

Individual rearing: In individual rearing, specimen tubes and glass chimneys were used. The specimen tube was filled with moist sand to $\frac{3}{4}$th of its height and a paddy seedling was planted in it. The top of the specimen tube was covered with a thin cardboard piece, $1\frac{1}{2}$" x $1\frac{1}{2}$". The specimen tube with the plant was then placed on a white paper and a newly hatched caterpillar placed on the plant. The plant with specimen tube was then covered with the chimney closed at the top with the muslin cloth. The paddy seedlings were changed on alternate days or according to necessity and the stage of development and duration of each instar was noticed. When the larva had completed development, it entered the sand in the specimen tube to pupate.

Studies on adult longevity: For studying the longevity of adults, both fed and unfed moths were confined in chimneys and mortality observed.

Sex ratio: For ascertaining the sex ratio the male and female moths obtained from the bulk rearings in the laboratory were sorted and counted.

Host preference studies: To study the variations in colour, duration and size of the larvae and the moth by feeding on different grasses, the following method was used:

The different grasses were collected from the field and planted in flower pots. Just hatched larvae were liberated on each grass and then covered with glass cylinders closed at the top with muslin cloth. Usually the grasses were changed once in three days. The size and colour of the larvae during the last instar were recorded.

DETAILS OF INVESTIGATION AND RESULTS

Details of Investigation and Results

A. Biological studies on Spodoptera mauritia Boisd.

Life history:

The studies on the life history of the insect were made under laboratory conditions. The details of observations made are given below:

Mating: Emergence of moths generally takes place during night between the hours of 12 midnight and 5 A.M. and mating starts about 24 hours after their emergence. As a rule copulation takes place at night; rarely it may take place during day time also.

Oviposition: Oviposition generally commences 48 hours after emergence, i.e. 24 hours after copulation and takes place at night. The eggs are laid in masses on the tender leaves of the host plants, arranged in longitudinal rows, 2 to 3 layers thick, the rows touching each other. The masses of eggs are covered with buff coloured silken hairs. When caged in chimneys without food plants the moths usually lay eggs on the muslin cloth and even on the sides of the chimneys. The egg masses laid on cloth and sides of chimneys may not be covered with the buff coloured hairs.

Table I gives the number of eggs laid by 10 individual female moths and the durations of their egg laying periods. The egg laying extends for 5 to 6 days. The number of eggs laid varies from 1332 to 2368 with an average of 1899. Maximum number of eggs are laid during the

TABLE I

Number of eggs laid by female moths of S.mauritia

Sl.No. of pairs of moths	Date of emergence	Number of eggs laid on subsequent days							Total No. of eggs
		1st day	2nd day	3rd day	4th day	5th day	6th day	7th day	
1	18-10-66	Nil	718	807	467	212	164	Nil	2368
2	20-10-66	Nil	830	Nil	843	195	65	Nil	1933
3	20-10-66	Nil	796	745	362	144	62	Nil	2109
4	20-10-66	Nil	774	566	46	237	Nil	Nil	1623
5	21-10-66	Nil	528	415	189	114	112	70	1428
6	21-10-66	Nil	892	624	212	385	Nil	Nil	2113
7	21-10-66	Nil	468	649	559	337	Nil	Nil	2013
8	23-10-66	Nil	712	355	265	Nil	Nil	Nil	1332
9	23-10-66	Nil	968	677	228	124	94	Nil	2091
10	23-10-66	Nil	1084	521	205	135	34	Nil	1979
	Average		777	595.4	337.6	209.2	88.5	70	1899

first or second day of oviposition and then the number gradually decreases. The maximum number of eggs laid by a single female moth in a single day is 1084, during the first day of oviposition and the minimum is 34 laid on the fifth day of oviposition by the same moth.

The egg which is cream coloured when laid acquires a brown tinge as development proceeds and become black just before hatching. The eggs hatch on the third day after they are laid. Hatching usually starts by dusk and it may continue during the night.

Larval stages: The first instar larva is a tiny worm like creature pale white with a slight greenish tinge. When observed with naked eye the first instar larva appears as blackish in colour with a prominent head broader than the rest of the body, and deep brownish black in colour. A prothoracic shield, almost of the same colour as head is present. The meso and meta thorax are sub equal in size and pale greenish in colour. The abdomen is broader at the cephalic end and tapers posteriorly towards the caudal end. During this stage the larva exhibits the characteristic movements of a semilooper, though the thoracic legs and prolegs in abdominal segments 3 to 6 and 10 are fully developed. When the eggs are allowed to hatch in glass chimneys the larvae climb up the chimneys and congregate at the top. They descend by means of silken threads on to the paddy leaves or plants supplied. The newly hatched larva does not start feeding immediately. About an hour after hatching it starts feeding by scraping the green matter on the leaves. The caterpillar

becomes greenish yellow in colour with the head and prothoracic shield appearing brownish black. Minute setae are seen throughout the body. Before moulting the caterpillar stops feeding, colour slightly changes to pale yellow and then moults. The first instar stage lasts for 2 to 3 days (Tables II and III).

The second instar caterpillar is pale yellow with a greenish tinge. The body is cylindrical smooth and covered with minute hairs. The prothoracic shield is lighter in colour than in the first instar. The head becomes less conspicuous than in the previous instar, has the size of the thoracic segments and is paler in colour. During this instar white longitudinal lines appear on the body extending from the prothorax to the posterior margin of the 9th abdominal segment. These are five in number disposed one dorsomedially, two sub dorsally on either side and two laterally below the sub dorsal lines on either side. The caterpillar descends by the aid of silken threads in this instar also. During the first day of the second instar it feeds by scraping the green matter of the leaves. But from the second day onwards they begin feeding by nibbling the leaf blade from the margins. Just before moulting the caterpillar becomes sluggish and pale yellow in colour. The duration of the second instar is 2 to 3 days (Tables II and III).

The third instar larva is light green in colour and is stout with head and prothoracic shield prominent and light brown in colour. The body is light green dorsally and laterally and the ventral

surface is pale and smooth. The five white longitudinal lines which originate in the second instar become more marked and deep white in colour, the mid-dorsal and sub-dorsal ones white and narrower and the lateral ones broader. Pale yellowish white lines appear inter-segmentally, which demarcate the body segments. These are more distinct in the abdominal region. The hairs present on the body are less conspicuous than in the previous instars. The larva at this stage feeds by cutting bits of the leaf blade along the leaf margin. The third instar lasts 2 to 3 days (Tables II and III).

The fourth instar caterpillar is stout with the general body colour greenish. The longitudinal lines and the intersegmental lines are prominent. The head is slightly smaller than the thoracic segments and is light brown in colour. Prothoracic shield is also light brown in colour. After the third moult a pinkish brown band appears at the posterior end of the abdomen. Such colouration is noticed at the tip of the prolegs also. These lines start on either side of the body and extend anteriorly along the dorsal border of the lateral white lines. The mid dorsal white line turns pinkish brown. The characteristic pinkish brown band is present prominently. The fourth instar period lasts for 2 to 3 days (Tables II and III).

The fifth instar larva has a stout and cylindrical body. The general body colour is deep greenish dorsally, mottled with white specks, and is olive green ventrally. The mid dorsal pinkish brown line

becomes a little more deeper. The sub dorsal white lines present in the earlier instars become yellowish white bands, extending from the anterior end of the prothorax to the posterior end of the abdomen. The pinkish brown line which made its appearance in the previous instar becomes broader and more prominent. Ventral to the above band is an yellowish green streak. Longitudinal black markings begin to appear sub dorsally during this instar and later assumes a semi circular appearance, broader at the centre and narrowed at the two ends. These markings are present one on each side, lateral to the mid dorsal band from mesothorax to the penultimate abdominal segment. The different stripes present on the body becomes less prominent. The fifth instar stage lasts 2 to 4 days. (Tables II and III)

The sixth instar caterpillar has a stout and cylindrical body which is greyish green dorsally and pale olive green ventrally. Just after the moulting, the larva is 22 to 25 mm in length, but grows to a length of 35 to 38 mm, towards the close of the instar. The colour of the caterpillar varies according to the host plants and also due to crowding. The dorsal surface is greyish green, the colouration being darker towards the anterior end. Along the mid dorsal line there is a dirty white stripe, broad at the centre of the body and gradually tapering towards the anterior and posterior ends of the body. Semilunar black markings are present one on each side along the sub dorsal surface on segments starting from the mesothorax to the penultimate abdominal segment. These markings

are prominent on the abdominal segments 3, 4, 5, 6 and 7. Immediately below the semi lunar markings on either side is an yellowish white band extending from the anterior end of the prothorax to the posterior extremity of the abdomen. This band is found to be made up of two yellowish white bands on either side with a brownish line in the middle. Ventrolaterally on either side of the body there is an yellowish green streak mottled with white spots. In between the ventrolateral and subdorsal lines the body colouration is pale green, tinged with pink and yellow. The larva is a voracious feeder during this stage. This is the final instar and the larva attains its growth. During the final stages of this instar the colour becomes dark brown and the semi lunar markings become prominent. The sixth instar lasts for 4 to 6 days. (Tables II and III)

Towards the close of the sixth instar, the caterpillar stop feeding and enters the soil for pupation. The caterpillar makes an earthern cell. The body shrinks and become soft. The dark colour fades and the body assumes a light grey colour. This is the prepupal stage. The prepupa turns into the pupa inside the earthern cell. The freshly formed pupa is greenish yellow in colour but the colour changes rapidly to light brown and then deep brown and just before emergence of moths become dark brown in colour. In the laboratory rearings it has been observed that pupation takes place on the surface of the soil also. The pupal instar lasts 7 to 10 days.

TABLE II

Life history of S.mauritia showing dates of oviposition, hatching, moults, pupation and emergence as adult

Sl. No.	Egg laying	Hatching	1st moult	2nd moult	3rd moult	4th moult	5th moult	Pupation	Emergence
1	20-10-66	23-10-66	26-10-66	28-10-66	30-10-66	1-11-66	3-11-66	9-11-66	17-11-66
2	"	"	"	"	"	1-11-66	3-11-66	9-11-66	17-11-66
3	"	"	"	"	"	2-11-66	4-11-66	9-11-66	18-11-66
4	"	"	"	"	"	2-11-66	4-11-66	9-11-66	19-11-66
5	7-11-66	10-11-66	12-11-66	14-11-66	16-11-66	18-11-66	21-11-66	25-11-66	3-12-66
6	"	"	"	"	"	"	"	26-11-66	4-12-66
7	"	"	"	"	"	"	22-11-66	28-11-66	5-12-66
8	"	"	"	"	"	"	21-11-66	26-11-66	5-12-66
9	1-1-67	4-1-67	7-1-67	9-1-67	11-1-67	13-1-67	15-1-67	21-1-67	29-1-67
10	"	"	"	10-1-67	12-1-67	14-1-67	16-1-67	21-1-67	30-1-67

TABLE III

Duration of different stages of S.mauritia in days

Sl. No.	Egg period	1st instar	2nd instar	3rd instar	4th instar	5th instar	6th instar	Pupal period	Total life cycle
1	3	3	2	2	2	2	6	8	28
2	3	3	2	2	2	2	6	8	28
3	3	3	2	2	3	2	5	9	29
4	3	3	2	2	3	2	5	10	30
5	3	2	2	2	2	3	4	8	26
6	3	2	2	2	2	3	5	8	27
7	3	2	2	2	2	4	6	7	28
8	3	2	2	2	2	3	5	9	28
9	3	3	2	2	2	2	6	8	28
10	3	3	3	2	2	2	5	9	29
Average	3	2.6	2.1	2	2.2	2.5	5.3	8.4	28.1

The process of moulting as observed in the fifth stage larva

The caterpillar becomes inactive and lies closely pressed to the leaf surface. The posterior part of the larva is fixed to the leaf surface by the anal prolegs. The cuticle starts separating from the anterior region of the prothorax. The wriggling movements of the larva aids the loosening of the old cuticle from the body and the larva slowly wriggles forward leaving the cuticle behind. As soon as the cuticle is cast off, the old head shield is thrown forwards. The thrown off old cuticle remain as a shrunken grey material on leaf. The newly formed head is pale yellow which deepens to a greenish yellow and within ¾ to 1 hour attains the normal pale brown colour.

Life cycle and number of generations in the year

A perusal of Tables II and III will reveal that the total period of life cycle from egg to adult occupies 26 to 30 days with an average of 28.1 days. During off periods when paddy crop is not in the field the insect is found to thrive on weeds on the bunds. So normally twelve generations in an year can be expected.

Longevity of Adults: (Tables IV to XI)

Results of laboratory studies on the longevity of the adult moths are given in tables IV to XI. The average survival periods of the mated and unmated moths under fed and unfed conditions are seen to be as

TABLE IV

Longevity of mated male of S.mauritia fed on sugar solution

Sl. No.	Date of emergence	Date of death	Longevity in days
1	19-11-66	27-11-66	8
2	22-11-66	30-11-66	8
3	23-11-66	28-11-66	5
4	23-11-66	30-11-66	7
5	23-11-66	1-12-66	8
6	23-11-66	2-12-66	9
7	23-11-66	2-12-66	9
8	24-11-66	2-12-66	8
9	24-11-66	3-12-66	9
10	24-11-66	3-12-66	9
Average			8

TABLE V

Longevity of mated female of S.mauritia fed on sugar solution

Sl. No.	Date of emergence	Date of death	Longevity in days
1	19-11-66	1-12-66	12
2	22-11-66	1-12-66	9
3	22-11-66	2-12-66	10
4	23-11-66	28-11-66	5
5	23-11-66	30-11-66	7
6	23-11-66	30-11-66	7
7	23-11-66	30-11-66	7
8	24-11-66	2-12-66	8
9	24-11-66	2-12-66	8
10	24-11-66	2-12-66	8
Average			8.1

TABLE VI

Longevity of unmated male of S.mauritia fed on the sugar solution

Sl. No.	Date of emergence	Date of death	Longevity in days
1	23-11-66	28-11-66	5
2	23-11-66	28-11-66	5
3	23-11-66	29-11-66	6
4	23-11-66	29-11-66	6
5	23-11-66	29-11-66	6
6	23-11-66	30-11-66	7
7	23-11-66	30-11-66	7
8	23-11-66	1-12-66	8
9	25-11-66	1-12-66	6
10	25-11-66	2-12-66	7
Average			6.3

TABLE VII

Longevity of unmated female of S.mauritia fed on the sugar solution

Sl. No.	Date of emergence	Date of death	Longevity in days
1	23-11-66	29-11-66	6
2	23-11-66	29-11-66	6
3	23-11-66	30-11-66	7
4	23-11-66	1-12-66	8
5	23-11-66	2-12-66	9
6	25-11-66	1-12-66	6
7	25-11-66	2-12-66	7
8	27-11-66	2-12-66	5
9	27-11-66	3-12-66	6
10	27-11-66	3-12-66	6
Average			6.6

TABLE VIII

Longevity of unfed mated male of S.mauritia

Sl. No.	Date of emergence	Date of death	Longevity in days
1	26-2-67	1-3-67	3
2	26-2-67	1-3-67	3
3	26-2-67	1-3-67	3
4	26-2-67	1-3-67	3
5	3-3-67	5-3-67	2
6	3-3-67	5-3-67	2
7	3-3-67	6-3-67	3
8	3-3-67	6-3-67	3
9	3-3-67	6-3-67	3
10	3-3-67	6-3-67	3
Average			2.8

TABLE IX

Longevity of unfed mated female of S.mauritia

Sl. No.	Date of emergence	Date of death	Longevity in days
1	26-2-67	3-3-67	5
2	3-3-67	5-3-67	2
3	3-3-67	7-3-67	4
4	3-3-67	7-3-67	4
5	3-3-67	7-3-67	4
6	3-3-67	7-3-67	4
7	3-3-67	7-3-67	4
8	3-3-67	7-3-67	4
9	5-3-67	7-3-67	4
10	5-3-67	7-3-67	4
Average			3.9

TABLE X

Longevity of unfed unmated male of S.mauritia

Sl. No.	Date of emergence	Date of death	Longevity in days
1	28-2-67	2-3-67	2
2	28-2-67	3-3-67	3
3	28-2-67	3-3-67	3
4	28-2-67	2-3-67	2
5	28-2-67	2-3-67	2
6	28-2-67	2-3-67	2
7	28-2-67	2-3-67	2
8	28-2-67	3-3-67	3
9	28-2-67	3-3-67	3
10	28-2-67	3-3-67	3
Average			2.5

TABLE XI

Longevity of unfed unmated female of S.mauritia

Sl. No.	Date of emergence	Date of death	Longevity in days
1	28-2-67	3-3-67	3
2	28-2-67	2-3-67	2
3	28-2-67	2-3-67	2
4	28-2-67	2-3-67	2
5	28-2-67	2-3-67	2
6	28-2-67	3-3-67	3
7	28-2-67	3-3-67	3
8	28-2-67	3-3-67	3
9	28-2-67	3-3-67	3
10	28-2-67	3-3-67	3
Average			2.6

follows:

	Mated male	Mated female	Unmated male	Unmated female
Fed	8.0	8.1	6.3	6.6
Unfed	2.8	3.9	2.5	2.6

It may be observed that mating gives the insect a longer spell of life.

Sex ratio:

Tables XII gives the observations made on sex ratio of the moths. In a population of 101 moths 52 were males and 49 females. In another population of 132 moths 75 were females and 57 males. Considering both the population there is a pre-ponderence of females over males the ratio being 1.2 females to 1.1 males.

Survival potential of caterpillars.

High percentage of natural mortality is observed in the first instar caterpillars, the percentage varying from 30 to 40. After the first instar upto the 5th instar the mortality is low. During the 5th instar 10 to 15 per cent mortality is observed, due to some disease. Due to this the caterpillars become inactive, do not feed, and the colour turns to light pink. Afterwards the body becomes blacker and hang from the leaves. The body wall is intact but if touched the body wall breaks and the inner contents come out as a black viscous liquid. It is suspected to be a bacterial disease.

TABLE XII

Sex ratio of S.mauritia

Date of emergence	No. of males	No. of females	Total number emerged
18-10-66	4	21	25
19-10-66	13	21	34
20-10-66	27	6	33
21-10-66	8	1	9
17-11-66	-	3	3
18-11-66	1	4	5
19-11-66	2	7	9
20-11-66	8	7	15
21-11-66	2	5	7
22-11-66	8	9	17
23-11-66	10	5	15
24-11-66	12	23	35
25-11-66	10	8	18
26-11-66	2	4	6
27-11-66	2	-	2
Total	109	124	233

B. Description of Stages.

Egg (Plate I, Fig. 1a, 1b)

Eggs are globular, slightly flattened at the poles, cream coloured with surface rugose. When viewed under the microscope the chorion surface appears reticulate all over. The egg measures 0.45 mm in diameter. Chorion is shining and transluscent and is longitudinally ribbed.

First instar caterpillar (Plate 1, Fig.2)

On emergence the caterpillar measures 1.1 mm in length and grows to 2.2 mm in length. Body is roughly cylindrical, slightly flattened at the ventral side and tapering caudally. Segmentation is distinct.

Head: 0.37 mm in width, is deep brownish black, broader than rest of the body. Labrum with 6 setae 2 minute and less conspicuous and the other four conspicuous; the minute setae located posterior to the bottom of the anterior notch, one on either side; of the other 4, one each on the anterior lateral boarder, and the rest nearer to the smaller setae, towards its left side. Clypeus beare 6 setae, in 2 rows, an anterior 4 setae, and a posterior 2 setae; the anterior row situated close to the anterior margin. Each parietal area with 7 setae each, one dorsal to the antenna, three surrounding the lateral ocelli and the rest on the

dorsolateral area. Two small setae on the adfrontals, one on either side.

Prothorax: The prothoracic shield bears an anterior row of 3 large setae, one on the median line and the other 2, on either side. A few very minute setae present towards the posterior border of the shield. Lateral to the shield are 4 setae each on either side, irregularly distributed. Legs well developed, spiracles present.

Mesothorax and metathorax: A row of 10 setae of uniform size arranged on the dorsal and lateral regions and two prominent setae, one on either side, just above the base of the thoracic legs. Legs well developed.

Abdomen: Consists of 10 segments, the first 8 segments carrying the 8 pairs of spiracles. Segments 3 to 6 and 10 carries the 5 pairs of prolegs.

1st to 8th abdominal segments: 10 setae of varying size present distributed irregularly, dorsally and laterally on each segment.

9th abdominal segment: 8 setae arranged in a row four each on either side of the median line.

10th abdominal segment: Dorsally is present a sclerotised shield like plate carrying 4 setae in a row, two setae each on either side of the median line.

Second instar caterpillar (Plate 1, Fig.3)

The caterpillar soon after the first moult measures 2.7 mm in length. The head measures 0.42 mm in breadth.

Head: It is as broad as the thorax and is paler in colour than in the first instar. Number and arrangement of setae as in 1st instar.

Prothorax: An anterior row of 4 setae, 2 on either side of the median line and a posterior row of 4 small setae. On either side of the shield are 4 setae each, one situated just above the base of the leg, middorsal to the spiracle and the other two anterior to the spiracles and closely approximated.

Meso and metathorax: 10 setae are arranged in a row towards the posterior border.

1st to 8th abdominal segments: Each segment with 2 setae, close to the anterior border, one on either side of the mid-dorsal line. On either side of the segment are 5 setae each, two arranged ventral to the spiracle, on behind it and the other two dorsal to it.

9th segment: As in 1st instar.

10th segment: As in 1st instar.

Third instar caterpillar (Plate 1,Fig.4):

The larva measures 5 to 7 mm in length and 1.5 to 2 mm wide across the thorax. Body light green dorsally and laterally and pale and smooth ventrally. Head measures 0.63 mm and is light brown; coronal suture is distinct, adfrontal sutures indistinct. Number and arrangement of setae as in previous instars.

Prothorax: The number and arrangement of setae on the shield as in second instar. The lateral area contains 6 setae each, in groups of 2 each, 2 arranged anterior to the spiracles, 2 dorsal to the spiracles and the other two anteroventral in position to the spiracles.

Meso and metathorax: The dorsal area with 12 setae arranged near the posterior border in a row, those at the two ends being on prominent tubercles; two smaller setae each on either side, one anterior and the other posterior to the marginal conspicuous setae.

1st to 8th abdominal segments: In line with the spiracles is a row of 4 setae on each segment two each on either side of the mid dorsal line. Another row of 4 setae present posterior to the spiracles, arranged as above. Lateral to the spiracle on each side is a transverse row of setae.

9th abdominal segment: As in 2nd instar

10th abdominal segment: As in 2nd instar

Fourth instar caterpillar (Plate 1, Fig.5)

It is stout built with the body cylindrical and smooth and measures 9 to 12 mm in length and 2mm in width.

Head: Smaller than the rest of the body and measures 0.95 mm in breadth; pale brown with greenish tinge. Fronto clypeal area cream coloured; epicranial suture well developed. Clypeus has 4 setae in two rows of two each, one behind the other near the anterior border. Labrum with

2 long setae on the antero lateral margins, one on either side, a smaller seta a little posterior to the larger seta on each side. 6 smaller setae present surrounding the notch. The parietal area has 12 setae on each side. Adfrontals without setae.

The arrangement and number of setae on the thoracic and abdominal segments are as in third instar.

Fifth instar caterpillar (Plate 1, Fig.6):

Stout built measuring 15 to 17 mm in length and 3 mm in breadth across the thorax.

Head: Pale brown measures 1.43 mm in breadth. Arrangement and number of setae as in fourth instar.

Prothorax: Prothoracic shield bears 8 setae in 2 rows of 4 each, the anterior row situated near the anterior margin, and the posterior row near the posterior margin, setae in the posterior row being shorter than those in the anterior row; a pair of setae present on raised tubercles anterior to each spiracle, of which the dorsal one is longer than the ventral one; a pair of small setae on either side between spiracle and prothoracic shield; two setae each on either side just above the legs. Meso and metathorax: A seta each on the antero lateral angles of tergum; a row of 8 setae, 4 each on either side of the mid dorsal line in the middle of the tergal plate; one seta each posteriorly on the lateral margin; a long seta towards the base of the legs on each side; a minute

seta in between the anterio lateral seta of the tergum and the seta at the base of the leg.

1st to 9th abdominal segments: The arrangement and number of setae as in fourth instar.

10th abdominal segment: 8 setae arranged in two rows of 4 each, the setae longer than those on other segments.

Sixth instar caterpillar (Plate 1, Fig. 7a, 7b):

This is the final instar caterpillar; stout cylindrical and measures 35 to 38 mm in length and 5 to 6 mm across the middle of the thorax; general colour greyish green.

Head: (Plate II, Fig. I) 2.2 to 2.5 mm in breadth; pale brown with the dorsal aspects of the parietal region with a deeper colouration; fronto clypeal region cream coloured with a greenish tinge; epicranial suture well developed. Frons represented by narrow adfrontals. Clypeus triangular extending dorsally reducing the area of frons. Adfrontal area without any setae. Clypeus with 4 setae, two each on either side of the median line. Labrum has 2 long setae on anterior margin, one on either side; one seta each on either side on lateral margin, with another inner to it; six small setae surround the notch. Parietal area with 11 setae each, of which three are around the antenna; six ocelli present on the anterior margin on either side, 5 behind the antenna, and one laterad to the base of the antenna. Antenna 3 segmented, basal segment broad,

second one long and cylindrical with a sensory seta at the tip, and the third segment considerably small and placed distally on the second segment towards the outer margin.

Thorax: Prothorax is the smallest and metathorax the largest. Three pairs of thoracic legs well developed.

Prothorax (Plate II Fig.2) Shorter in length than the meso and metathorax, slightly broader than head. The first pair of spiracles are placed on the posterio lateral angle. Prothoracic shield carries anteriorly a transverse row of 4 long setae near the anterior margin and a row of 4 smaller setae posteriorly. Anterior to the spiracles, on the lateral margin of the tergum on either side is a pair of setae, in a line with the anterior row of larger setae on the shield; anterior of these thin and hairy and the posterior long and on raised tubercle. In between the spiracle and the prothoracic shield, in line with the posterior row of setae on either side, is a pair of setae. Pleural region bears just above the base of the thoracic leg a pair of setae.

Thoracic legs are well developed, femur tibia and tarsus being well differentiated, the tarsus terminating in a single claw like pretarsue which is toothed at the base. Coxal sclerites represented by a raised area at the base of the femur and trochanter by a band of sclerotised area at the base of the femur distal to the coxa; a row of 6 setae present on the coxal region, a pair of setae on the ventral side of femur, and a row of 6 setae on the femur towards its distal extremity; a few minute setae on the tarsal region.

Mesothorax (Plate II,Fig.3): Broader and longer than prothorax. Anterio dorsal region with two setae each on either side near the lateral margin; a transverse row of 8 setae dorsally in the middle; in front and in between the two extreme setae is present a thin hair like seta on each side; a single long seta on the pleural region just above the base of the leg. Thoracic legs well developed with setae arranged as in prothoracic leg.

Metathorax (Plate II, Fig.3): Larger than the preceding two thoracic segments; similar to mesothorax in other details.

Abdomen: Cylindrical, 10 segmented, the last three segments tapering posteriorly. Segments 1 to 8 bear the 8 pairs of spiracles, and segments 3,4,5, 6 and 10, the prolegs.

1st, 2nd and 7th abdominal segments (Plate II, Fig.4): Larger than the metathorax: a row of four setae dorsally in level with the spiracles two each on either side of the median line; a row of 4 setae posterior to the spiracles; 3 long setae and one small seta each on the pleural region.

3rd, 4th 5th and 6th abdominal segments (Plate II, Fig.5): Resembles 1st and 2nd segments; but pleural area with 2 setae each and additionally with a pair of prolegs each. Prolegs stout; planta a circular lobe and crochets numbering 17 to 20 arranged in a semi circle, the arrangement being uniserial and uniordinal.

8th abdominal segment: Smaller in size than the preceding segment, the last pair of spiracles situated on this segment are conspicuously larger than the rest of them. Rest as in segment 1.

9th abdominal segment: (Plate II, Fig.6): Smaller in size than the preceding segment. An anterior row of 2 setae near the anterior margin one on either side; a posterior row of 4 setae, 2 on each side, one arranged dorsally and one laterally, all arising from prominent tubercles; 2 setae each arising from raised tubercle laterally.

10th abdominal segment (Plate II, Fig.7): The last and smallest of the abdominal segments, bears the last pair of prolegs. 8 setae in two rows of 4 each, anteriorly and posteriorly on the selerotised shield, the setae being longer than the rest. Prolegs well developed and stouter than those present on the other segments.

Pupa (Plate 1, Fig. 8a, b, c): Elongate, sub fusiform, rounded at the cephalic end and pointed towards the caudal end. Body more or less cylindrical anteriorly upto the fifth abdominal segment, and tapers posteriorly there after. General body colour pale brown with a greenish ting in the beginning, wing buds appearing more greenish; gradually the pupa assumes a dark brown colour. Measures 16.5 mm in length and 5 mm in breadth. Head small and rounded, compound eyes distinctly clear, labrum semi circular with the ventral and lateral margins black in colour. Labial palpi broad at the base and pointed towards the tip. Maxillary palpi long and about twice as long as labial palpi, enclosing the latter. Galea long and reaching upto the middle of the fourth abdominal segment mid ventrally. Abdomen with ten segments, the inter-segmental lines clear except those between 8th and 9th and 9th and 10th segment

which are vaguely marked. The inter segmental lines between the 4th, 5th 6th and 7th segments form deep grooves around the body. Segments below wing pads movable. Cremaster represented by two black spines. Thoracic region with a single pair of spiracles situated at the postero lateral angles of the prothorax. Abdominal spiracles 7 pairs, situated on segments 2 to 8. Spiracles on segments 2 to 7 uniform, elliptical with elevated margins and darker in colour, those on 8th segment vestigial.

C. Biology of S.mauritia in relation to different species of host plants

These studies were made with the following species of plants which grow as weeds in the paddy lands and in the garden lands in both of which places the insect breeds.

i) Pseudanthisteria umbellata

ii) Isachne dispar

iii) Cyperus iria

iv) Fimbristilis miliacea

v) Eleusine indica

vi) Cyperus rotundus

Following are the details of the observations made on paddy and different alternate host plants.

Paddy

The larvae feed and grow very well on tender leaves of paddy. But the young larvae die if they are fed on paddy leaves which are more than a month old. Grown up caterpillars feed also on older leaves but the growth is retarded and the larval period is prolonged by 2 to 3 days. When bred on tender foliage alone the larval stage extends from 17 to 19 days while the pupal period ranges from 7 to 10 days (vide Table XIII). Details on the colouration and measurements of the larvae are given earlier.

TABLE XIII

Biology of S.mauritia on paddy (Above one month old plants)

Sl. No.	Date of egg	Date of hatching	Date of pupation	Date of emergence	Egg period	Larval period	Pupal period
1	23-10-66	26-10-66	15-11-66	22-11-66	3	20	7
2	"	"	15-11-66	22-11-66	"	20	7
3	"	"	16-11-66	21-11-66	"	21	7
4	"	"	16-11-66	23-11-66	"	21	7
5	"	"	16-11-66	23-11-66	"	21	7
6	"	"	15-11-66	23-11-66	"	20	8
7	"	"	16-11-66	23-11-66	"	21	6
8	"	"	14-11-66	22-11-66	"	19	8
9	"	"	15-11-66	23-11-66	"	20	8
10	"	"	16-11-66	23-11-66	"	21	7

Pseudanthisteria umbellata

This weed which is found commonly along bunds in paddy fields, is an alternate host for Spodoptera. In the absence of paddy the caterpillars were found to thrive well on these plants.

The larvae were found to feed and grow well on this host plant. Both tender and mature leaves of this weed are relished by the larvae, though the preference is found always for the tender leaves. The larval period extends from 17 to 19 days and the pupal period 7 to 9 days (Vide Table XIV).

TABLE XIV

Biology of S.mauritia on Pseudanthisteria umbellata

Sl. No.	Date of egg	Date of hatching	Date of pupation	Date of emergence	Egg period	Larval period	Pupal period
1	23-3-67	26-3-67	12-4-67	20-4-67	3	17	8
2	,,	,,	13-4-67	20-4-67	3	18	7
3	,,	,,	12-4-67	21-4-67	3	17	9
4	,,	,,	13-4-67	20-4-67	3	18	7
5	,,	,,	13-4-67	21-4-67	3	18	8
6	,,	,,	14-4-67	21-4-67	3	19	7
7	,,	,,	13-4-67	21-4-67	3	18	8
8	,,	,,	13-4-67	21-4-67	3	18	8
9	,,	,,	14-4-67	21-4-67	3	19	7
10	,,	,,	12-4-67	21-4-67	3	17	9

The full grown larva measures 35 to 37.5 mm in length and 5 to 6 mm in breadth. The general body colour of the grown up caterpillar is greyish brown and the mid dorsal band is pale brownish and indistinguishable. The semilunar markings are deep blackish and prominent. The lateral region is light brown with the different bands coalescing. The ventro lateral line is yellowish brown while the ventral region is greyish brown. In a successive generation the duration

of the immature stages were observed to be 3 days for egg stage, 17 to 19 days for the larval phase and 7 to 9 days for the pupal period.

Isachne dispar

This is a common wet land weed with stout stems and leaves of hard texture. When fed on the leaves of this plant the total larval period ranges from 18 to 20 days and the pupal period 7 to 9 days (Vide Table XV).

TABLE XV

Biology of S.mauritia on Isachne dispar

Sl. No.	Date of egg	Date of hatching	Date of pupation	Date of emergence	Egg period	Larval period	Pupal period
1	24-3-67	27-3-67	14-4-67	23-4-67	3	18	9
2	,,	,,	14-4-67	22-4-67	3	18	8
3	,,	,,	15-4-67	22-4-67	3	19	7
4	,,	,,	14-4-67	22-4-67	3	18	8
5	,,	,,	15-4-67	23-4-67	3	19	8
6	,,	,,	16-4-67	23-4-67	3	20	7
7	,,	,,	15-4-67	23-4-67	3	19	8
8	,,	,,	15-4-67	24-4-67	3	19	9
9	,,	,,	16-4-67	24-4-67	3	20	8
10	,,	,,	16-4-67	23-4-67	3	20	7

The full grown larva measures 32.5 to 35 mm long and 5 mm broad. The general body colour is light pinkish brown with yellowish tinge. The dorsal area is pinkish brown along the mid dorsal line and this area is not distinguishable from the surrounding region. Semi lunar markings are black in colour. Sub dorsal area is pinkish yellow, while the lateral area above spiracles has a brownish yellow colouration with a pinkish shade and the rest of the lateral area is pinkish yellow. Ventral region is greenish white. In the succeeding generation the egg period was 3 days, larval period 18 to 21 days and pupal period 7 to 9 days.

Cyperus iria

This weed is very common in the paddy lands. Though fleshy the leaves are of hard consistency.

The first instar larva do not cherish the foliage, while the full grown larvae feed voraciously on the fresh leaves. The larval period lasts 18 to 20 days and the pupal period 7 to 9 days (Vide Table XVI).

TABLE XVI

Biology of S.mauritia on Cyperus iria

Sl. No.	Date of egg	Date of hatching	Date of pupation	Date of emergence	Egg period	Larval period	Pupal period
1	25-3-67	28-3-67	15-4-67	23-4-67	3	18	8
2	,,	,,	15-4-67	24-4-67	3	18	9
3	,,	,,	16-4-67	23-4-67	3	19	7
4	,,	,,	16-4-67	24-4-67	3	19	8
5	,,	,,	16-4-67	24-4-67	3	19	8
6	,,	,,	15-4-67	24-4-67	3	18	8
7	,,	,,	15-4-67	23-4-67	3	18	8
8	,,	,,	17-4-67	24-4-67	3	20	7
9	,,	,,	15-4-67	23-4-67	3	18	8
10	,,	,,	17-4-67	24-4-67	3	20	7

The general body colour of the last instar larva is light reddish brown with a prominent light pinkish mid dorsal band, delimited on either side by narrow black lines. The semilunar markings are distinct with dark black lustre. Sub dorsal area pinkish brown. The lateroventral region is concolorous with the sub dorsal area. The full grown larva measures 35 to 37.5 mm in length and 4.5 to 5 mm in width.

Fimbristilis miliacea

Cage rearings indicated that this common wet land weed is unsuitable as food for Spodoptera larvae. Heavy mortality occurs among the first instar larvae, and those which survived subsequently died without completing the larval period.

Eleusine indica

This graminaceous garden land weed occurs commonly in the vegetable garden. The fleshy leaves do not exhibit hardiness even when fully mature. The larvae cherish the plants very much and grow vigorously. The larval period occupies about 16 to 18 days while the pupal period ranges from 6 to 8 days. (Vide Table XVII).

TABLE XVII

Biology of S.mauritia on Eleusine indica

Sl. No.	Date of egg	Date of hatching	Date of pupation	Date of emergence	Egg period	Larval period	Pupal period
1	24-3-67	27-3-67	12-4-67	20-4-67	3	16	8
2	"	"	12-4-67	19-4-67	3	16	7
3	"	"	13-4-67	20-4-67	3	17	7
4	"	"	12-4-67	20-4-67	3	16	8
5	"	"	14-4-67	21-4-67	3	18	7
6	"	"	14-4-67	20-4-67	3	18	6
7	"	"	14-4-67	20-4-67	3	18	6
8	"	"	12-4-67	19-4-67	3	16	7
9	"	"	13-4-67	20-4-67	3	17	7
10	"	"	13-4-67	21-4-67	3	17	8

The full grown caterpillar measures 38 to 40 mm long and 5 to 6 mm broad. Fully grown caterpillar is blackish brown in colour. The mid dorsal band which is faintly light brown can hardly be distinguished from the general dorsal colouration. The semi lunar markings are quite prominent with deep black colouration. The sub dorsal area and the lateral area are light brownish, while the ventral area is greenish brown.

Cyperus rotundus

The leaves of this common garden land weed have almost the same texture as in Cyperus iris. The larval period extends 18 to 20 days and pupal period 7 to 9 days. (Vide Table XVIII).

TABLE XVIII

Biology of S.mauritia on Cyperus rotundus

Sl. No.	Date of egg	Date of hatching	Date of pupation	Date of emergence	Egg period	Larval period	Pupal period
1	25-3-67	28-3-67	16-4-67	24-4-67	3	19	8
2	"	"	16-4-67	24-4-67	3	19	8
3	"	"	15-4-67	24-4-67	3	18	9
4	"	"	16-4-67	23-4-67	3	19	7
5	"	"	15-4-67	23-4-67	3	18	8
6	"	"	15-4-67	24-4-67	3	18	9
7	"	"	17-4-67	24-4-67	3	20	7
8	"	"	17-4-67	24-4-67	3	20	7
9	"	"	16-4-67	23-4-67	3	19	7
10	"	"	15-4-67	24-4-67	3	18	9

The full grown caterpillar is deep greenish brown with a mid dorsal light pinkish band. The semilunar markings are light black. The sub dorsal area is yellowish green. The lateral region is greenish yellow dorsally and pinkish yellow ventrally. The ventral area is light greenish yellow. The full grown larva measures 30 to 32.5 mm in length and 4 to 4.5 mm in breadth.

D. Effect of crowding on the larval behaviour and colouration of S.mauritia

To study the behaviour pattern, and colour variation of Spodoptera larvae when bred singly and under crowded condition this experiment was conducted. When reared singly the caterpillars are lethargic in habit. The first instar larva is pale yellowish green and the second instar larva is yellowish green. The third instar larva becomes stout and assumes a light green colouration with the longitudinal and transverse markings yellowish white. During the fourth instar the caterpillar becomes till stouter and the characteristic pinkish brown band makes its appearance and the general colour of the larva is greenish. The fifth instar larva is deep greenish with black semilunar markings on the dorsal side of the body segments. The pinkish brown band becomes broader, yellowish white bands appear immediately below the semilunar markings, and yellowish green band ventro laterally. The sixth instar caterpillar is also olive green with pink suffusion and has all the markings found on the

fifth instar larva. Towards the latter half of the sixth instar the body colour changes to greyish green.

In the case of caterpillars grown under crowded condition, the colouration and markings of the larvae upto the third instar resemble those found in larvae grown individually. A marked colour variation is observed in the fourth instar larva. In this case, the colour is greyish green with the characteristic pinkish brown band. The greyish green colour deepens progressively to deep grey colour. During the fifth instar the colour deepens further. The semi lunar markings though black is less prominent in the greyish brown background colour of the body. The sub dorsal and ventro lateral bands make their appearance but these are less pronounced from the general colouration; the different bands with varying shades merge and become diffused. In the sixth instar the colour becomes greyish brown and the larvae become still stouter. The larvae are very active with swift movements and feed voraciously.

DISCUSSION

DISCUSSION

The moth of Spodoptera mauritia emerges from their pupae during night and mates 24 hours after the emergence. This observation is in confirmity with that of Ananthanarayanan & Ayyar (1937). Egg laying commences in the night following the night of mating i.e., after a gestation period of 24 hours and a pre-oviposition period of 2 days. But according to Ananthanarayanan & Ayyar (1937) the pre-oviposition period lasts for 3 to 6 days.

The egg laying period of the female moth has been seen to cover 5 to 6 days in the present studies when the moths are fed with sugar solution. The maximum number of eggs (Renge 528 to 1084 and average 777) are laid on the day next to that of mating. This number decreases gradually on successive days it being 70 on the last day. The female moth has well developed mouth parts and feeds readily in the laboratory on sugar or honey solution. So evidently, it feeds in the field also and the egg laying period may last for 5 to 6 days and even more.

A female moth has the capacity to lay from 1332 to 2368 eggs, the average being 1899. The maximum recorded by Ananthanarayanan & Ayyar (1937) is 2750 eggs per female moth. Tanada and Beardsley (1958) reported that in Hawaii the average number of eggs per group is 709 and the average number of such groups laid by a female is 8.6; the average number of eggs laid per female thus works out to 6097. This will show the high level

of fecundity the insect is able to reach. It also seems possible that the number of eggs in a mass may depend upon the number of eggs it is able to lay in one sitting (in one night) which as has been seen already, decreases from the first day of oviposition.

The incubation period lasts for 3 days. This is shorter than the 2 to 4 days reported by Pillai (1922) in Travancore and 3 to 5 days reported by Cherian & Ananthanarayanan (1937).

The larval period occupies 17 to 19 days on an average. This observation is fairly in agreement with those reported by Pillai (1922) from Travancore, and Otanes (1925) from Philippines. In Ceylon the larval period is reported to last for a month (Hutson, 1920) while in Madras it lasts for 21 to 32 days (Ananthanarayanan & Ayyar, 1937).

The pupal period observed in the present investigation is 7 to 10 days, which period is more or less constant in all previous observations also.

There appears to be three factors which govern the longevity of moths. They are sex, mating and food. The females are longer lived than males, the mated moths, both male and female, survive for longer periods than unmated ones and the fed moths have longer duration of life than the unfed moths. Thus the maximum life period is found for the mated, fed, female (8.1 days) and the minimum for unmated, unfed, male (2.5 days).

The chaetotaxy of the larvae which is its main morphological feature is fundamentally the same in all the instars excepting for slight variations in the number and arrangement of the setae in the head and the three thoracic segments in the different instars.

Table XIX gives the effect of being reared on different host plants, on the larval duration of S. mauritia and the larval colouration.

TABLE XIX

Effect of different host plants on the larval and pupal duration and larval colouration of S. mauritia

Sl. No.	Host	Larval period in days.	Pupal period in days.	Larval colouration
1	Paddy	17-19	7-10	Greyish green
2	Pseudanthisteria umbellata	17-19	7-9	Greyish brown
3	Isachne dispar	18-21	7-9	Light pinkish brown
4	Cyperus iria	18-20	7-9	Light reddish brown
5	Eleusine indica	16-18	6-8	Blackish brown
6	Cyperus rotundus	18-20	7-9	Greenish brown

It can be seen that there is only slight variation in the larval period when grown on the different host plants, those bred on Isachne dispar Cyperus iria., and Cyperus rotundus taking slightly more time for the larval duration than those bred on others. The lowest duration of 16 to 18

days is observed in the larvae bred on Eleusine indica . The pupal period als is seen to be lowest when bred on this host plant.

When the larvae are grown on tender paddy plants, the larval duration is 17 to 19 days, but when the later stages are forced to feed on the foliage of grown up plants the larval period is extended to 19 to 21 days. This effect has been observed among larvae fed on leaves of Eleusine indica; the larvae pupated on the 16th day when the leaves are of young plants and on the 18th day when the leaves are from mature plants. This clearly indicates that the tenderness or otherwise of the foliage influences duration of immature stages. Tanada & Beardsley (1958) has reported that the larvae left to themselves selected tender foliage for their food and that if forced to feed on mature leaves they took longer time to complete the development.

Colour variations are also noticed in the larvae when fed on the different host plants.

The larvae grown individually are lethargic and less active while those reared under crowded conditions are very active. The colour of the larvae grown individually is deep green with the different colour bands on the body prominent; only towards the latter half of sixth instar, do the larvae develop a greyish colouration. But the larvae bred under crowded condition acquire a greyish brown colouration during the fourth instar, and this colour continues till pupation. A certain amount of gradation in colour is noticed among larvae grown individually and under crowded conditions.

SUMMARY

SUMMARY

Literature on the distribution, host range, biology, seasonal incidence, natural enemies and control of rice swarming caterpillar, Spodoptera mauritia has been reviewed.

The biology and bionomics of the rice swarming caterpillar, Spodoptera mauritia Boisd., have been worked out. Moth emerges at night, mates 24 hours after and lays eggs again after 24 hours. Oviposition period is 5 to 6 days. The eggs are laid in masses and covered with buff coloured hairs. Number of eggs laid per female moth ranges between 1332 to 2368 eggs with an average of 1899. The egg period is 3 days. The first instar caterpillars feed by scraping off the green matter. From the latter half of the second instar, the larva feeds by nibbling the leaf portions along the sides of the leaves. The caterpillar attains a size of 35 to 38 mm in length and 5 to 6 mm in breadth in the final instar (sixth instar). The instars 1, 2, 3, 4, 5 and 6 occupy on an average 2.6, 2.1, 2, 2.2, 2.5 and 5.3 days respectively. The total larval duration lasts 17 to 19 days. Full grown larva pupates in the soil, in an earthen cell. Pupal period is 7 to 10 days with an average of 8.4 days. Mated female moths survive on an average for 8.1 days and 3.9 days, under fed and unfed conditions respectively, while the mated males survive on an average for a period of 8.0 and 2.8 days respectively. Unmated females under fed and unfed conditions lived on an average for 6.6 and 2.6 days respectively, while unmated males lived on an average for 6.3 and 2.5 days respectively. The mated and fed

moths (both male and female) lived for longer period. There is a preponderance of females in the ratio 1.2 females to 1.1 males.

The different immature stages have been fully described.

Studies on the larval duration and colour on the following wet land and garden land weeds in addition to paddy have been worked out.

(1) Pseudanthisteria umbellata

(2) Isachne dispar

(3) Cyperus iria

(4) Fimbristilis miliacea

(5) Eleusine indica

(6) Cyperus rotundus

Slight variations in the larval duration are noticed. It is seen that this extension in larval period is related with the roughness of the foliage. In paddy and Eleusine indica the larvae fed on tender leaves pupate a little earlier than those fed on mature leaves. The larval colouration differs when bred on the different host plants.

Studies on the effect of rearing under crowded conditions have revealed that the larvae grown under crowded condition attain darker colouration and are more active than those reared individually.

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APPENDIX I

Record of Temperature and Humidity

(October 1966 to April 1967)

Month	Week	Temperature		Humidity	
		Maximum	Minimum	Maximum	Minimum
October	1	86	74	90	89
	2	86	74	90	86
	3	86	76	90	89
	4	88	76	90	83
	5	88	76	90	86
November	1	86	76	91	86
	2	88	74	95	86
	3	88	76	90	86
	4	88	76	90	86
	5	88	78	90	86
December	1	88	76	90	86
	2	88	76	90	86
	3	88	76	90	86
	4	88	74	90	86
	5	88	74	91	86
January 1967	1	88	74	91	86
	2	88	78	90	86
	3	88	78	90	83
	4	88	78	83	80
	5	88	78	86	83
February	1	88	76	86	80
	2	90	74	86	80
	3	90	74	87	83
	4	90	74	86	83

Month	Week	Temperature		Humidity	
		Maximum	Minimum	Maximum	Minimum
March	1	90	76	90	83
	2	90	76	86	83
	3	90	76	87	83
	4	88	76	90	83
	5	90	78	83	83
April	1	90	76	86	83
	2	90	76	90	84
	3	90	78	88	86
	4	90	78	86	83
	5	90	78	91	83

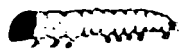
ILLUSTRATIONS

PLATE I

Spodoptera mauritia Boisd. — Immature stages

Figure	1a	Spodoptera	mauritia	Boisd.	Egg mass
,,	1b	,,	,,	,,	Egg
,,	2	,,	,,	,,	First instar caterpillar
,,	3	,,	,,	,,	Second instar caterpillar
,,	4	,,	,,	,,	Third ,, ,,
,,	5	,,	,,	,,	Fourth ,, ,,
,,	6	,,	,,	,,	Fifth ,, ,,
,,	7a	,,	,,	,,	Sixth instar caterpillar (Lateral view)
,,	7b	,,	,,	,,	Sixth instar caterpillar (Dorsal view)
,,	8a	,,	,,	,,	Pupa: Lateral view
,,	8b	,,	,,	,,	Pupa: Dorsal view
,,	8c	,,	,,	,,	Pupa: Ventral view

1.a.



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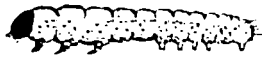

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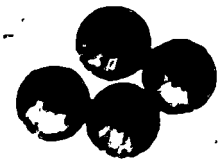
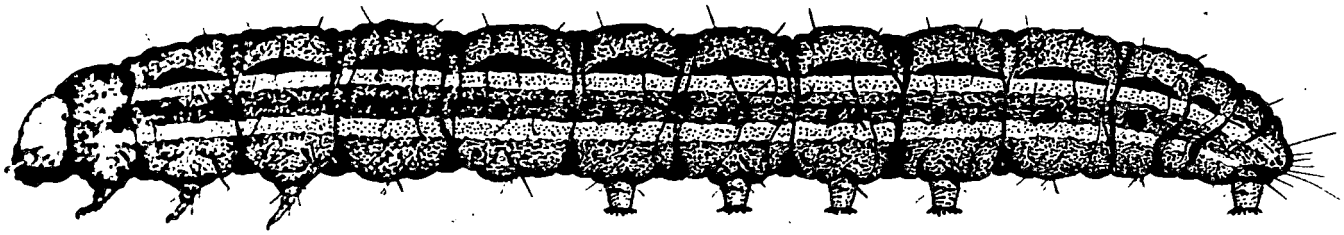


1.b

1 mm .4.

1 mm .5.

1 mm .6.



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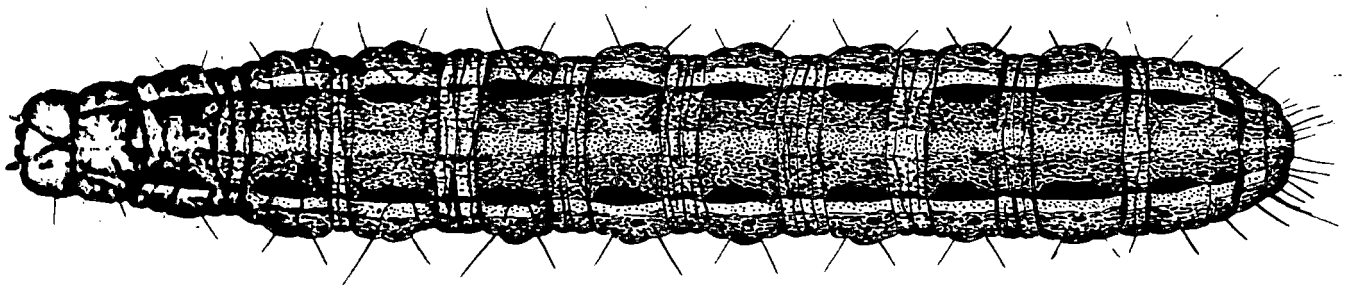
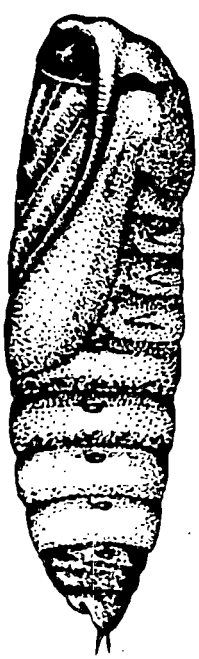


2 mm .7.b.



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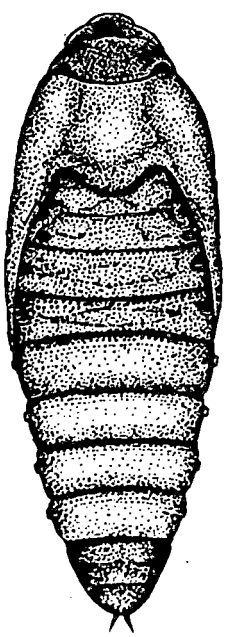
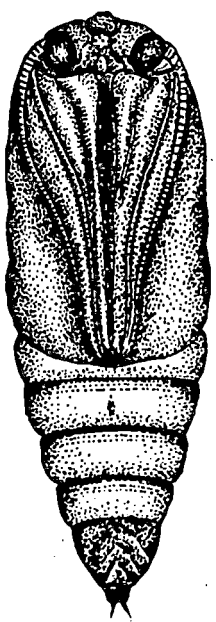


8.b

1 mm



8.c

P L A T E II

Spodoptera mauritia Boisd: Arrangement of setae on sixth instar caterpillar.

Figure 1. Head

Figure 2. Prothorax

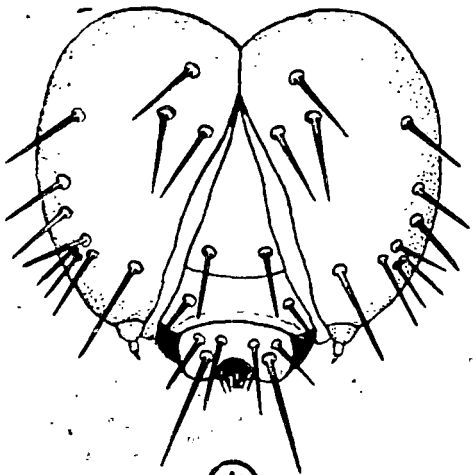
Figure 3. Meso thorax

Figure 4. First abdominal segment.

Figure 5. Third abdominal segment.

Figure 6. Ninth abdominal segment.

Figure 7. Tenth abdominal segment.



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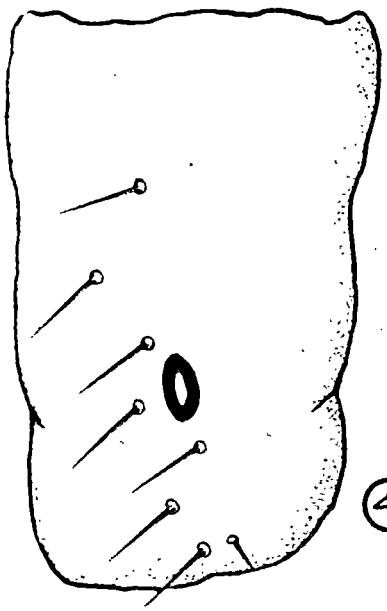

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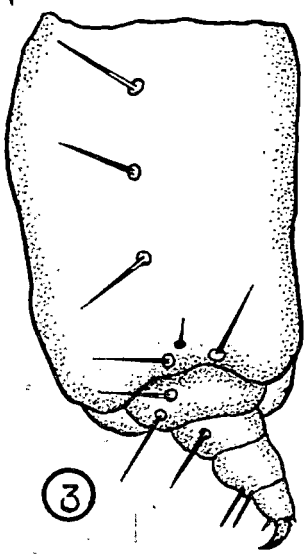

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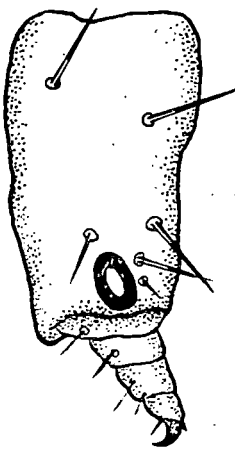

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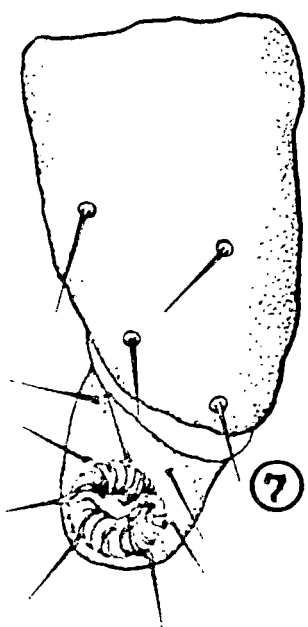

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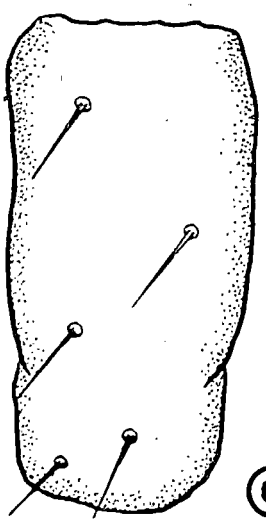

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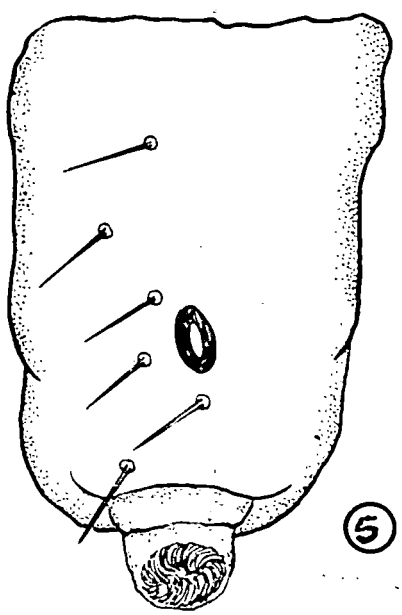
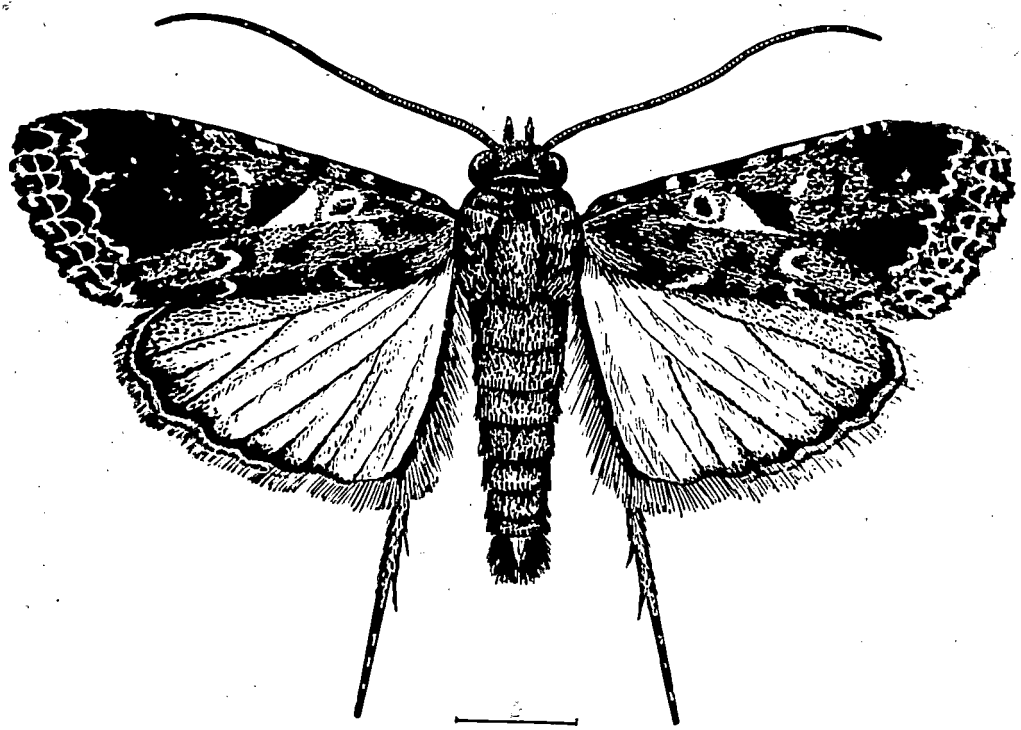


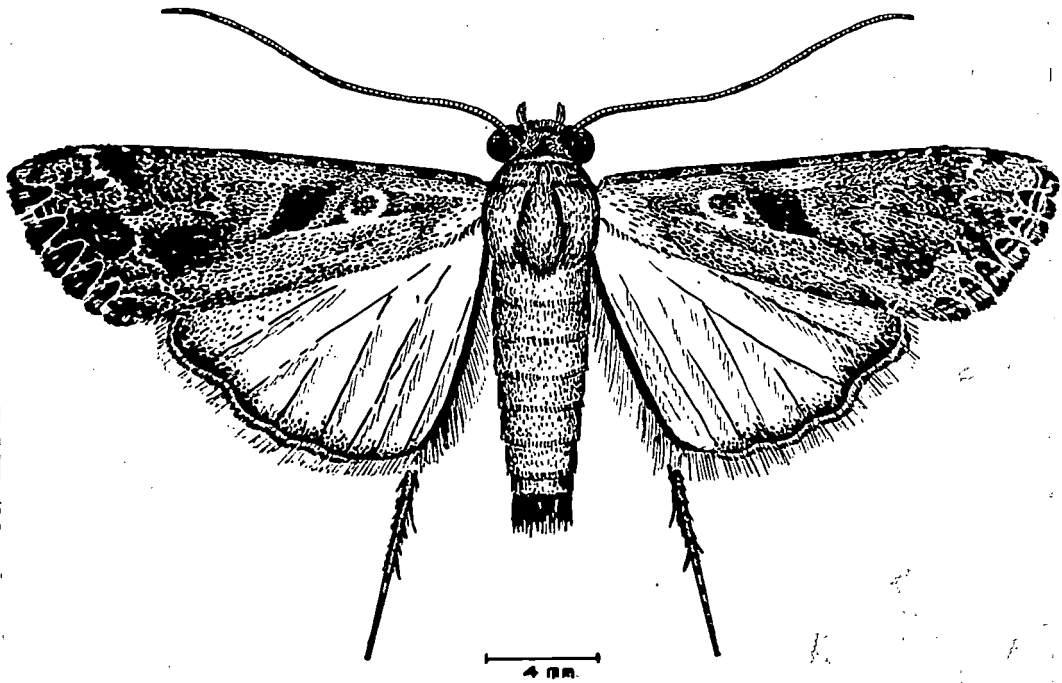
5

P L A T E III

A. *Spodoptera mauritia* Boisd. Male moth

B. *Spodoptera mauritia* Boisd. Female moth


4 mm


4 mm