NOTES ON *LASPEYRESIA GLYCINIVORELLA* MATSUMURA, THE SOY BEAN POD BORER

By

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(With Plate X and a Chart)

INTRODUCTION

The soy bean pod borer (*Laspeyresia glycinivorella* MATSUMURA) is probably the most serious pest of more than seventy species of insects destructive to the soy bean culture of Japan. The larvae injure the seeds of the soy bean prior to harvest. This pest belongs to the Tortricoid genus *Laspeyresia*, family Eucosmidae (Olethreutidae) which contains many species of economic importance in the world. Superficially it resembles in appearance and habits the so-called pea-moth, *Laspeyresia nigricana* STEPHENS, in Europe and in America.

The writer has had this pest under observation at the Hokkaido Agricultural Experiment Station since 1919, during which period many experiments have been conducted along control measures. Although the observations and experiments have not been fully carried out, the writer takes in this opportunity to make a preliminary report. This report deals mostly with investigations carried on at Sapporo, and a more complete report will appear in the future.

At this point, the writer wishes to express his hearty thanks to Prof. Dr. S. MATSUMURA of the Faculty of Agriculture, Hokkaido Imperial University for his kindness in preparing this paper, and to Mr. T. R. GARDNER of U. S. Department of Agriculture for his kindness in going over the manuscript.

HISTORY

The first attention of the soy bean pod borer as of economic importance in Japan is obscure. But the earliest reference to this insect appeared

[Jour. Coll. Agr., Hokkaido Imp. Univ., Vol. XIX, Pt. 5, Sept., 1928.]

in 1898, when MATSUMURA *(8)*[1] issued a report in which he states that the larvae are considered as a serious pest to soy beans in Hokkaido, and described it as a new species under the name of *Grapholitha glycinivorella*. In Honshu, the main Island, injury to soy beans was not noticed until recent years. However, MATSUMURA in the same report recorded it as it occurs on that Island. It is probable that this insect has occurred in Japan for a long time.

In Hokkaido, the increased destructiveness of this pest is largely responsible for the decline in price paid to farmers for dried soy beans. In several localities on Honshu serious injury to soy beans has been reported during the past few years. According to the communication from J. OKADA, entomologist to the Yamaguchi Agricultural Experiment Station, considerable injury to soy beans has been noticed since 1915 in the Yoshiki district of the Yamaguchi Prefecture, especially in 1919 and 1920 when over 85 per cent of the seeds was injured. In his paper published in 1924, SANKO *(14)* states that serious damage occurred in the Shimokumage district of the Kagoshima Prefecture in recent years. In Manchuria damage to soy beans by this pest was noticed as far back as 1908.

In 1906 MATSUMURA *(10)* placed this insect in the genus *Eucosma*, and in 1917, the same author *(11)* changed it to the genus *Laspeyresia*, into which genus the writer believes it really belongs.

DISTRIBUTION

It is difficult to determine the exact distribution of this insect as literature and correspondence is rather vague and indefinite, and even the determinations may not be accurate. However, it is known to be widely distributed in Japan through Hokkaido, Honshu (Hondo), Shikoku, Kyushu and Chosen (Corea), extending so far foreign as South Manchuria. Along the west coast of Karafuto (Saghalien) the immature seeds of soy beans are often injured by some insect, but it is not known whether this is caused by the present species or by *Etiella zinckenella* TREITSCHKE. As far as the writer knows it has not been found in Okinawa (Loo-Choo) and Taiwan (Formosa).

In Hokkaido, it is most common in the west central section, namely in the province of Ishikari and in certain parts of Shiribeshi and Teshio. At present, it is not considered of much economic importance in the province of Nemuro, and also in certain parts of Oshima, Kushiro and Kitami.

1) The numbers in parenthesis refer to corresponding numbers in the bibliography.

On Honshu, Shikoku and Kyushu it is reported as being most serious in the Prefectures of Fukushima, Aichi, Yamaguchi, Fukuoka and Kagoshima.

COMMON NAMES

In Japan this pest is commonly known as "Mame-shinkui-ga" or "Daizu-kyoto-chu" owing to the habit of boring into the soy bean pods. In Hokkaido, it is also known as "Mame-sayamushi", "Mame-shinmushi", "Kuchikakemushi", "Shinkui-mushi", "Saya-mushi", and in the Yamaguchi Prefecture it is called "Saya-doshi". Sometimes it is known as "Aka-mushi" in the Fukushima Prefecture being of a reddish colour of the full-grown larva.

DESCRIPTION

The Adult

(Pl. X figs. 1, 2 & 3)

Head grayish yellow; labial palpi concolorous, moderate, upturned to the middle of front, being longer in the second joint and roughly scaled beneath; antennae simple, rather stout, one-third as long as the forewings, dark brown with thin, whitish or fuliginous annulations; eyes blackish.

Thorax grayish yellow or yellowish brown, being darker on the middle; abdomen dark brown with silvery gray scales, at the end rounded in the male, and sharpened in the female; legs dark grayish, with long, concolorous spurs on the middle and hind ones; tarsi darker with narrow, yellowish white annulations.

Forewings normal in form; termen with a slight sinuation below apex; dark brown, obscurely mottled with gray-yellowish or yellow-brownish scales especially on the basal and middle parts; a short but broad, bluish, metallic band further outwardly and near the tornus, adjoining inwardly with a faint ground colour, containing three short, brownish black dots in a transverse row; eight or nine grayish white dashes along the costal edge, which are obscure on the basal two and apical one, and along each dash runs a short, oblique, bluish metallic streak; a thin but distinct, dark brownish terminal line before the fringe which is grayish brown. Hind wings dark brown, a little paler towards the base, with a grayish brown fringe which is darker at the base. Underside of wings uniformly dark brown, with an iridescent sheen, having the concolorous fringe.

Body length: 5 to 6 mm.

Alar expanse: 12 to 14 mm.

The Egg

(Pl. X fig. 4)

The egg is flat and oval in shape, and measures 0.48 mm. in length, 0.35 mm. in width and 0.18 mm. in height. The surface is iridescent, being covered with indistinct fine crinkles. The colour varies with the age of the embryo from milky white to deep yellow.

The Larva

(Pl. X figs. 5, 11 & 12)

The newly hatched larva has a minute, orange yellow body with a dark brown head. After its entrance into the pod, the colour of the body becomes lighter, which continues until the 4th stage, varying from milky white to pale greenish in colour, with a shiny black head, pale blackish brown thoracic shield and anal plate and pale blackish thoracic legs. When full-grown, the larva is about 7.8 mm. varying from 6.0 to 9.5 mm. in length, and of a light yellowish colour. After the feeding has been finished, most of the larvae change to an orange yellow colour, which is uniformly suffused with pink on the upper side. The head is somewhat flat, brown in colour, with long, sparse, concolorous hairs; ocellar area and the tops of trophi blackish; ocelli paler and five in number on each side. The segments of the body show several, regularly arranged, minute tubercles of the ground colour, some minute and short hairs being situated on them. The thoracic shield and anal plate are light yellowish brown. Spiracles small, circular, and yellowish brown. Legs normal, orange yellow, with light brownish claws.

The Pupa

(Pl. X fig. 6)

Within the cocoon, the pupa is somewhat spindle-shaped and in the form of "pupa-obtecta", about 6 mm. in length and 1.8 mm. in width, brown in colour, wing sheath yellowish brown, and suffused with dark brown on the eye sheath. The tip of wing sheath extends to the 4th segment of abdomen; along both edges of each segment of abdomen are arranged fine spines on the dorsum, the spines of the fore edge being longer than those of the hind edge; the last abdominal segment rounded. The spiracles and spines are dark brown. Minute, light brown hairs sparsely cover the body.

The Cocoon

(Pl. X fig. 7)

The cocoon is spindle-shaped, rather thick and composed of a secreted silk. It is usually found in the soil and is covered with soil particles. It measures about 8 mm. in length and 3.5 mm. in width.

LIFE HISTORY AND HABITS

The Adult

Emergence

At Sapporo, emergence of the adult under natural conditions occurs at the end of July and continues throughout August. The maximum occurs about August 11, then decreases for a few days and increases again until it reaches another maximum about August 22, thus giving a double apex curve for emergence. The following table gives emergence data from field breeding cages from 1922 to 1924.

TABLE I

Emergence record of adult moth (1922–1924)

Date of August / Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
1922	–	–	–	2	2	4	1	1	1	4	10	2	1	1	6	1	2	–	–	5	16	15	5	5	5	2	3	–	–	–	–	94
1923	–	–	–	–	–	–	–	–	–	1	5	–	3	8	2	5	–	–	–	–	–	4	3	1	1	–	–	–	–	–	–	33
1924	–	–	–	–	–	–	–	–	–	–	–	1	3	1	1	–	–	1	–	1	–	–	1	–	2	–	–	–	–	–	–	11

Flying moth may suddenly decrease during early September and by the middle of that month none can be found.

Duration of Life

It is almost impossible to determine the length of life of adult in the field, and it is doubtful whether breeding cage experiments give a true estimate of the length of life. The following shows the length of life of 2 females and 3 males confined in a glass tube without food in 1924.

TABLE II

Length of life of moth (1924)

No.	Sex	Date adult emerged	Date of death	Total length of life
1	♂	12/VIII	19/VIII	7
2	♂	13/VIII	19/VIII	6
3	♂	15/VIII	20/VIII	5
4	♀	18/VIII	22/VIII	4
5	♀	19/VIII	24/VIII	5

This was much shorter than expected. The writer estimates from this experiment and field observations that the adult moth lives at least from 7 to 10 days under the natural condition.

General Behaviour

The moth is rather sluggish in habits, usually resting on the under surface of soy bean leaves during the day and night. At rest the moth folds their wings down touching the body like a roof. The head droops down to a more or less degree. When danger approaches, even in the daytime, they take a quick, irregular flight for a relative short distance and soon disappear from sight. They are most active in the morning from sun-rise to about ten o'clock and in the evening from about four to six o'clock; during which time they appear on the surface of the upper leaves and fly around intermittently in circles in groups of several to several hundreds. In the evenings the swarming may be seen flying around about one-half a meter above the soy bean plants, after which many pairs may be found on the surface of the leaves in copulation. It is quite probable that this swarming has something to do with reproduction.

The moth is easily attracted to artificial lights in the evening, especially by the males. The following table shows the total number attracted to lights on 41 days during August 15 and September 24, 1924. Two light traps used consisted of a "Monarch" 4 candle power and a "D-Lite" 10 candle power, both manufactured by the R. E. DIETZ Co., U. S. A.

These lights were placed in the middle of a soy bean field of about 0.38 hecter.

TABLE III

Experiments with light traps to attract moth (1924)

Number \ Sex	Female	Male	Total
Total number attracted	75	344	419
Percentage of ditto	17.9	82.1	100.0

It is not known what the moth feeds on in the field, but it is supposed that the food comes from the dew on the leaves of the soy bean plants. Experiments show that it seems to be attracted to odorous substances such as molasses. On July 25 and September 24, 1924, experiments were conducted to attract the moth by baits. This consisted of a black, viscid solution made by mixing crude brown sugar (2 lbs.), saké or Japanese wine (ca. 0.9 litre), table acetum or Japanese vinegar (ca. 0.2 litre) and water (ca. 0.4 litre). This mixture was placed in four metal basins each measuring about 0.3 meter in diameter and arranged in a soy bean field of about 0.38 hecter and at a height of about 0.6 meter. The following table shows the number of moth attracted during the above mentioned time.

TABLE IV

Bait experiments to attract moth (1924)

Number \ Sex	Female	Male	Total
Total number attracted	746	318	1064
Percentage of ditto	70.1	29.9	100.0

Mating

Mating occurs in the morning and evening, especially during the evening, the most copulating pairs being found between five and eight o'clock.

Mating seems to be more or less unique. After swarming the male rapidly attempts copulation on the upper surface of the soy bean leaves by placing its body in a direct line with that of the female, but pointing in the opposite direction, the pair often walking about on the leaves. The duration of copulation varies greatly.

Oviposition

Observations in 1923 show that the female oviposits during the day and probably during the evening, but never during the night. Eggs are usually placed on the young bean pods, and occasionally eggs are found on other parts of the plant. They are usually placed singly, but in a few cases two and rarely three were found together. The following table shows position of eggs on soy bean plants under natural conditions in 1921, 1923 and 1924.

TABLE V

Position of eggs on soy bean plants

Year	Date of examination	Number of varieties examined	Number of individuals examined	Condition of plant	Egg-laying places							
					Pod	Calyx	Pod stalk	Petiole (Leaf stalk)	Base of petiole and stipule	Stem	Upper surface of leaf	Under surface of leaf
					%	%	%	%	%	%	%	%
1921	22/VIII	5	5	—	80.5	0.8	0.8	3.1	10.6	3.5	0	0.8
1923	24-25/VIII	8	8	Before podding	—	21.6	2.7	13.5	46.0	5.4	2.7	8.1
	„	10	10	After podding	84.0	1.2	0	4.3	6.2	2.5	1.2	0.6
1924	18/VIII	3	9	Just or after podding	61.3	0.8	0	15.1	10.9	5.0	0.8	6.7
	25/VIII	3	9	After podding	80.7	0.9	0	5.3	5.3	7.0	0	0.9
	5/IX	2	6	„	95.6	0	0	1.5	1.5	1.5	0	0

According to these observations, over 80 per cent of the eggs are placed on the pods. Very few are placed on the base of the petiole and stipule, and it seems that ovipositions on other parts of the plant are not normal. It is quite noticeable that as the pod increases in size, the percentage of ovipositions on the pod increases also.

Females begin to oviposit two or three days after emergence and in one case a female four days after emergence. It is not known how many eggs one female is capable of laying during its lifetime, but it is probable that 100 or more are oviposited. Dissections of field collected females revealed from 25 to 88 eggs per individual.

The Egg

Incubation

The length of the egg stage varies according to temperature, weather conditions and place of oviposition. During the latter part of August and early September it varies from 7 to 9 days, and it is probable that this period is shorter under more favorable conditions.

During incubation, the colour changes of the egg due to the development of the embryo. At first it is a translucent, milky white colour, often with a slight yellowish tinge. In two or three days, it changes to a light yellowish colour with a faint, blood-red, circular patch. As the egg nears the hatching point a small, dark purplish spot, which represents the head and thoracic shields, appears on the circular patch.

Number of Eggs per Pod

Over 80 per cent of the eggs were placed on the pod, but the number per pod varies as shown by the following table.

TABLE VI

The percentage of eggs per pod

Year	Date of examination	Number of varieties examined	Number of individuals examined	Total number of pods examined	Number of eggs per pod							
					0	1	2	3	4	5	6	7
					%	%	%	%	%	%	%	%
1921	22/VIII	5	5	132	38.6	17.4	20.5	10.5	5.3	3.8	1.5	2.3
1923	24-25/VIII	11	11	365	77.0	15.1	4.1	2.2	1.1	0.3	0.3	0
1924	18/VIII	3	9	120	61.7	25.0	9.2	1.7	0.8	0.8	0.8	0
	25/VIII	3	9	192	69.8	19.0	6.8	2.6	1.0	0	0.5	0
	9/IX	2	6	190	78.4	12.1	7.4	1.0	1.0	0	0	0

This shows that one egg per pod is the most common, while the deposition more than one egg per pod diminishes gradually to seven eggs. Compared with the fact that usually not more three larvae are able to exist in one pod, the eggs in excess more than three per pod may be fatal.

The Larva

Habits of the Newly Hatched Larva

Hatching is accomplished by the young larva cutting an irregular opening near one end of the egg. It is quite probable that the young larva does not eat the egg shell.

The young larva is very active and immediately crawls about the hairs on the pod in search of food. When a suitable position has been found, usually near the suture of the young pod, it commences to spin a loose, white, silken covering about itself, which is probably for support in gouging out the pod tissue in preparation for entering the pod. As soon as the gouging is finished the larva proceeds to enter the pod and continues until it reaches a young seed on which it feeds. The following table shows that the larvae prefer entrance through the lower part of the suture than the upper part.

TABLE VII

Entrance point on the pod (1925)

Position / Number	Along upper suture	Along lower suture	Plane of pod
Number examined	94	307	0
Percentage of ditto	23.4	76.6	0

The direction of the silken covering to the suture of the pod has a bearing on the entrance of larvae into the pod as shown by the following table:

TABLE VIII

Direction of silken covering in reference to entrance into pod by newly hatched larvae (1925)

Number \ Position	Right angle	Oblique	Parallel
Number examined	53	148	29
Percentage of ditto	23.0	64.4	12.6

The following table shows that the number of larvae entering one pod never exceeds four, and the majority of pods show only one entrance hole.

TABLE IX

The number of entrance holes per pod (1925)

	Number of pods examined	Number of holes per pod			
		1 hole	2 holes	3 holes	4 holes
Actual number	309	228	70	9	2
Percentage	100.0	73.8	22.7	2.9	0.6

Habits of the Young Larva

The larva remains within the pod until full-grown feeding on the developing seed. By feeding, a single individual is usually confined to a single seed, surrounding tissue throughout larval development, and rarely does the feeding take place on two seeds. The larva during its first and second stages eats into the seed leaving a fine hole as if punctured with a needle. During the third and the following stages it eats out dish-like cavities which soon join together making irregular marks around the seed. The space around the seed is filled in with a dirty coloured excrement and exuviae which are spun together. The larvae are able to stand considerable dryness, and if necessary, they can feed on seeds even as harden towards the maturity.

Habits of the Full-Grown Larva

After larval development is completed, the larva cuts a hole through the surface of the pod and drops to the ground by spinning a silken thread, or crawls down the stem of the plant (Pl. X fig 8). As soon as it reaches the ground, it seeks a suitable place to spin its cocoon. The following table shows that about 75 per cent of the larvae cut exit holes 0.8 to 1.0 mm. in size on the pod close to the suture, especially on the lower side.

TABLE X

Location of exit holes on the pods (1924–1925)

Year	Total number of pods examined	Along the suture of pod			Plane of pod
		Upper side	Lower side	Total	
		%	%	%	%
1924	355	24.10	45.20	69.30	30.70
1925	793	28.60	50.60	79.20	20.80
Average		26.35	47.90	74.25	25.75

The following table shows exit holes per pod indicating the percentage of larvae able to develop in one pod.

TABLE XI

Exit holes per pod (1924–1925)

Year	Total number of pods examined	1 hole per pod	2 holes per pod	3 holes per pod	4 holes per pod
		%	%	%	
1924	325	91.10	8.60	0.30	0
1925	1445	92.10	7.50	0.40	0
Average		91.60	8.05	0.35	0

It is evident from this table the majority of pods contains only one exit hole.

The length of the body of full-grown larvae varies greatly depending upon certain conditions during the larval development. The measurements of 200 larvae varied from 6.0 mm. to 9.5 mm. as shown by the following table.

TABLE XII

Variation of body lengths of full-grown larvae

Class(mm.)	6.0-6.4	6.5-6.9	7.0-7.4	7.5-7.9	8.0-8.4	8.5-8.9	9.0-9.4	9.5-9.9
Frequency	9	19	38	**50**	46	30	7	1
Percentage	4.5	9.5	19.0	**25.0**	23.0	15.0	3.5	0.5

This data give a curve which shows an excellent example of the unimodal type nearly symmetrical on both sides, the mode being 7.75 mm., the mean 7.82 mm. and the median 7.84 mm.

It takes about four days for the larva to spin its cocoon which consists of fine silken threads and particles of soil.

Moulting and Approximate Length of Larval Stage

It is not definitely known how long it takes for the larval development, but some observations show that it takes about one month under ordinary temperature, and a little longer during cool weather. Examinations of the exuviae in the pods and also measurements of the width of head show that there are four moults making five instars. Measurements of the head of the five instars are as follows:

TABLE XIII

Measurements of the width of head of the five larval instars

Instar / Measurement in mm.	I	II	III	VI	V
Average	0.141	0.284	0.448	0.684	1.073

The pupa

After the cocoon is completed, the larva enters the quiescent stage and its body becomes thicker and more fatty. The body changes to a uniform orange buff colour, with a shiny clay coloured head. It remains in this pre-pupal stage over winter and until the middle of the following July. Soon after this the pre-pupa sheds its skin and changes into a yellowish brown pupa.

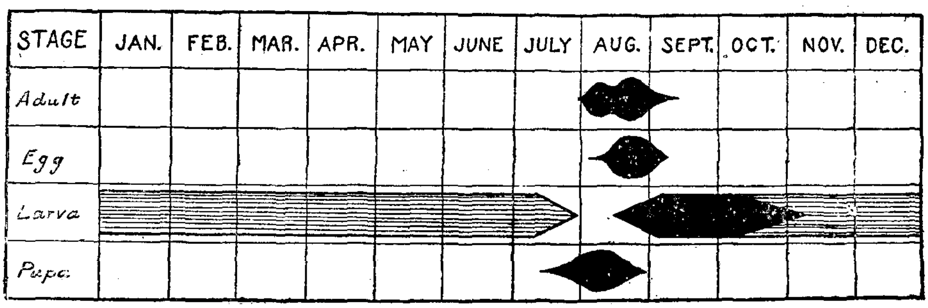
The length of the pupal stage is not definitely known, but in 1924 one pupa was observed in a pot under out-door condition. This pupated August 1 and emerged August 12. It is gathered from this fact that the pupal stage lasts from 10 days to 2 weeks in natural condition.

Seasonal History

The soy bean pod borer has only one generation per year. The adult appears from the latter part of July to early September. Eggs are deposited from early August to early September. The larval period extends from the middle of August to early November after which it remains all winter and spring in the pre-pupal stage, changing to the pupal stage in the middle of July, and continuing until the latter part of August. The following chart shows the life cycle in Hokkaido.

CHART I

Life-cycle of Laspeyresia glycinivorella in Hokkaido



As far as is known, there is only one generation per year in all parts of Japan, but the stages are more advanced in the southern parts. OKADA of the Yamaguchi Agricultural Experiment Station communicated to the writer that he had found the full-grown larvae during the latter part of July. This is about a month earlier than those under Hokkaido conditions which are due to the great difference in temperature.

Food Plants

Experiments show that this insect may live only on the soy bean, (*Glycine hispida* MAXIM.). In 1924, ovipositions were secured on some closely related species of the Leguminosae to see if the pest would develop on them. These experiments were conducted on the Adzuki bean (*Phaseolus angularis* WIGHT.), the kindney bean (*Phaseolus vulgaris* L.), the horse bean (*Vicia Faba* L.) and on peas (*Pisum sativum* L.). Results of these experiments were negative.

INJURY AND ECONOMIC IMPORTANCE

Character of Injury

The larvae destroy seeds of the soy bean by eating and hollowing out the interior, often consuming as much as half the seed (Pl. X fig. 9). This destroys the value of the seeds and greatly reduces the weight and yield. The infested pod always contains a mass of frass held together by a loosely spun web (Pl. X fig. 10). The surface of injured part of seed is usually in the same colour with the embryo, but sometimes it is darkened by certain saprophytic fungi.

In the first stage, it is almost impossible to detect infested pods, except by opening a pod or using a hand lens as the newly hatched larvae make such small entrance holes. However, when near to the harvest the infested pods may easily be discriminated from the healthy ones by an existence of exit holes on the surface of the pod (Pl. X fig. 8).

In the west central section of Hokkaido and certain localities in Honshu where the infestation is the heaviest, there is over 80 per cent damage to the soy bean crops. Although it is lower in other localities, it is difficult to estimate the damage due to climatic conditions and the various varieties of soy beans planted.

Other Species liable to be mistaken for *L. glycinivorella*

In addition to this pest soy bean seeds are attacked by the following insects in Japan:

Lepidoptera.

Etiella zinckenella TREITSCHKE	(Pyralidae)
Maruca testulalis GEYER	(,,)
Cydia phaseoli MATSUMURA	(Eucosmidae)
Chloridea dipsacea LINNÉ	(Noctuidae)
Pyrrhia umbra HUFNAGEL	(,,)

Barathra brassicae LINNÉ (Noctuidae)

Diptera.

Asfonderia sp. (Itonididae)

The injury caused by *Etiella zinckenella* is similar to that of *Laspeyresia glycinivorella* but differs in that the exit holes are larger. The size and coloration of the larvae and adults varies also. The larvae of *Maruca testulalis* as well as *Cydia phaseoli* spin their nests outwardly on the pods and often the larvae feed on the seeds through the pod tissue. However, this injury is rare. The larvae of *Chloridea dipsacea* and *Pyrrhia umbra* and often *Barathra brassicae* make very large holes through the pod and they feed on the seeds usually consuming the whole, leaving a smooth surface on the eaten portion. The injury caused by these pests is easy to distinguish. In the Yamanashi and Gifu Prefectures, *Asfonderia* sp. causes a considerable damage in the larval stage by retarding the development of seeds and causing thinner pods. Pupation takes place within the pod, and before emergence the pupa forces half its body through the pod. Consequently the character of injury by this midge is quite different from that of the soy bean pod borer.

NATURAL ENEMIES

The natural enemies to *L. glycinivorella* seem to be rather few in number. Up to the present, we have been failed to find out any egg parasite. In Hokkaido, two species of Ichneumon-flies, *Epiurus hakonensis* ASHMAED[1] and *E. glycinivorellae* UCHIDA (Msc.)[2], parasitic on the larvae of the soy bean pod borer, have found by the writer, and the effects of these parasites on the check of the borer, are quite remarkable in some cases. The former parasite was reported by NAWA *(12)* as a notable parasite on the pear borer *Nephopteryx pirivorella* MATSUMURA and was also noticed by UCHIDA to be a parasite on *Malacosoma neustria testacea* MOTSCHULSKY and *Pygaera anastomosis* LINNÉ, but has been unrecorded that it is a parasite on the soy bean pod borer. The second parasite, *E. glycinivorellae*, is much smaller than the former, and only known to occur in Hokkaido. According to UCHIDA, the species attacks also the apple borer *Argyresthia conjugella* ZELLER in the same district. These two parasites are abundant in some localities in September and October and have at least two generations in one year. In the fall, we could often find the nearly full-grown

1) & 2) These were determined by Dr. T. UCHIDA.

larvae of these parasites in the pods affected by the soy bean pod borer. These full-grown larvae are apparently similar to each other, being fusiform in shape, always curved, yellowish white in colour, sometimes with a pinkish tinge and lacking any marking. The cocoons which are formed by these parasites are white, turning to brown in the later, cylindrical, up to 12 mm. in length and 4 mm. in width. After the over-wintering, the adult emerges from the pupa at the end of April or early half of May.

The Asilid fly *Asilus atripes* LOEW was observed by the writer to be predaceous on the adult, and some other members of the family may possibly prey upon the moth in a similar manner. The ant *Lasius (Chthonolasius) umbratus* NYLANDER subspecies *mixtus* NYLANDER[1] was observed destroying the full-grown larvae which enter the soil in experimental cages in the fall of 1923. It is probable that birds, spiders, ground beetles, etc. destroy this pest to a certain degree in the various stages, although the writer has no positive evidence to prove this fact.

Two parasitic fungi were also found. During August, the adults can be found dead on the leaves of the soy bean plant killed by a species of *Entomophthora*[2], and during the midsummer cocoons containing dead pupae can be found covered with a white fungus of *Isaria* sp.[3]

CONTROL MEASURES

It is rather difficult to control this pest on soy beans due to the wide area of plantings and the small profit derived from this crop as compared with other crops such as fruits. Two methods of control are employed, direct and indirect, and these are discussed as follows:

Direct Methods

Physical or Mechanical Methods

Collecting. Owing to the fact that the moths swarm in great numbers during the mating season, the collection of them with nets at this time is one of the most effective methods.

In badly infested fields the crop should be cut early, and the plants should be placed on a hard ground or mats. The full-grown larvae leaving the plants are not able to find a suitable place to spin their cocoons, and can be easily collected and destroyed.

1) This was determined by Mr. C. TERANISHI.

2) & 3) These were determined by Dr. I. TANAKA.

Chemical Methods

T r a p s. The use of bait traps, although only practical to a certain degree in small fields, are too expensive as a means of control in large fields.

S p r a y i n g. Spraying is effective during only the short period between the hatching of the egg and the entrance of the young larvae into pod. From 1922 to 1924 summer spraying experiments were carried on with stomach and contact poisons. Of 14 kinds of sprays used, copper soap solution with pyrethrum powder, naphtha pyrethrum emulsion and nicotine-sulphate soap solution as contact poisons, and lead arsenate solution as a stomach poison proved the most effective. However, sprayings with arsenical compounds have a tendency to wither and burn the leaves of the beans. Practically, spraying may be limited in small fields.

A p p l y i n g S o i l I n s e c t i c i d e s. In 1922 and 1923, application of insecticides in the prepared plots of soil after the harvest was tried with potassium cyanide solution, sodium arsenite solution, lime-nitrogen (calcium cyanamide) and carbon bisulphide with the idea of killing the larvae or larvae in newly spun cocoons. These plots along with control plots were examined in the following year, but no noticeable differences were observed.

Biological Control

As has been already mentioned, several species of natural enemies have been observed which do some good, but no effort in using these in biological control has been attempted.

Indirect Methods

Cultural Methods

F a l l P l o w i n g. This pest may to a certain degree be controlled by the fall plowing.

R o t a t i o n. Rotation of crops is probably effective as a control measure, but no definite experiment along this line has been carried on.

P l a n t i n g i n A l t e r n a t i n g w i t h C e r e a l s. When the soy bean is planted in several alternate rows with barley, wheat or Indian corn, the sowing of soy bean is usually delayed from the ordinary period, and the beans develop much more slowly. This is a protective measure as no pod has formed on the plants for the young larvae to attack. It has also been noted that Indian corn, because of its height, obstructs the flight of the moth to a certain degree, thereby, eliminating a much wider spread of egg laying.

Selection of Varieties. The damage caused by this pest differs a great deal in varieties of soy beans. This resistance or susceptibility is due either to the physiological or physico-chemical properties of different varieties. From the physiological viewpoint there is a wide difference in time of pod production in varieties, some of which produce pods too early or too late to be attacked by the larvae. From the physico-chemical viewpoint there is a great difference in density of pod hairs, hardness of pod tissue, composition of plant body, etc. in the different varieties, some of which are not suitable to the larvae. We have found in Hokkaido some strains of the so-called "Hadaka-Daidzu" or "Kenashi-Daidzu" varieties are injured very little by this pest. However, these are inferior varieties and they may be improved by more careful breeding.

Change of Sowing Period. The soy bean may be planted early or late so as to escape pod injury, but in some varieties, early and late planting materially lessens the yield in localities. So then, when we change the sowing period with a view to avoid the infestation, it should be necessary to consider the period locally with each variety in comparing the yield and the amount of infestation.

SUMMARY

1. *Laspeyresia glycinivorella* MATSUMURA is one of the most serious pests of soy bean culture in Japan. In Japan, it occurs widely on the islands of Hokkaido, Honshu, Shikoku and Kyushu, and in Chosen, while in Karafuto its occurrence is uncertain. It also occurs in South Manchuria.

2. It attacks the seeds prior to harvest, and in severe infestations over 80 per cent of the seeds are destroyed.

3. There is only one generation per year, and over-wintering takes place in the pre-pupal stage within its cocoon in the soil. In Hokkaido, pupation takes place at the middle of July and continues till August. Adult appears at the end of July and continue to early September. Eggs are deposited from early August to early September. The larval period is from the middle of August to early November. About one month is required for the development of the larvae, this period being spent in the pods. After the larvae are full developed, they enter the soil and spin cocoons for hibernation.

4. The moth is rather sluggish in habits. It is most active in the morning and evening, especially during the evening when intermittent swarming and mating take place. Males are more easily attracted to light than the females, while the latter are more easily attracted to baits.

5. Eggs are usually placed singly on the pods, but they may be found also on the petioles, stipules, etc.

6. One egg per pod is the most common, but occasionally as high seven have been found.

7. The newly hatched larvae are active and crawl about the pod in search of a suitable entrance point along the suture. When this has been found the larvae spin a small, loose, white silken covering for support, enter the pods in search of seeds on which they feed. The larvae do not eat their egg shells.

8. A pod that has been injured is determined by the exit holes of the full-grown larvae. Over 90 per cent of injured pods contain only one exit hole, but occasionally two and sometimes three holes are found.

9. The soy bean is the only known plant attacked.

10. There are about seven species of injurious insects on the seeds of soy beans. However, these can be easily distinguished from *L. glycinivorella* by the type of injury and an examination of the species.

11. Two species of parasitic Hymenoptera, two or more species of predaceous insects, and two parasitic fungi are known to be of some value as natural enemies.

12. The following methods of control are recommended:
(a) selection of resistant varieties of soy beans, (b) change of sowing period, (c) planting in several alternating rows with cereals, (d) collection of adults in evening during the swarming, (e) use of bait traps during the adult season and summer spraying with contact poisons in a certain extent, and (f) the fall plowing or rational rotation of crops.

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EXPLANATION OF PLATE X

Fig. 1. Adults of *L. glycinivorella*. Dorsal view with wings spread.
a. Greatly enlarged. b. Nearly natural size.

Fig. 2. Ditto. Dorsal view with folded wings.
a. Greatly enlarged. b. Natural size.

Fig. 3. Ditto. Side view. Natural size.

Fig. 4. Egg of *L. glycinivorella*. Greatly enlarged.

Fig. 5. Full-grown larva of *L. glycinivorella*. Side view.
a. Greatly enlarged. b. Nearly natural size.

Fig. 6. Pupa of *L. glycinivorella*. Side view greatly enlarged.

Fig. 7. Cocoons of *L. glycinivorella*, of which two with pupae out of them. Nearly natural size.

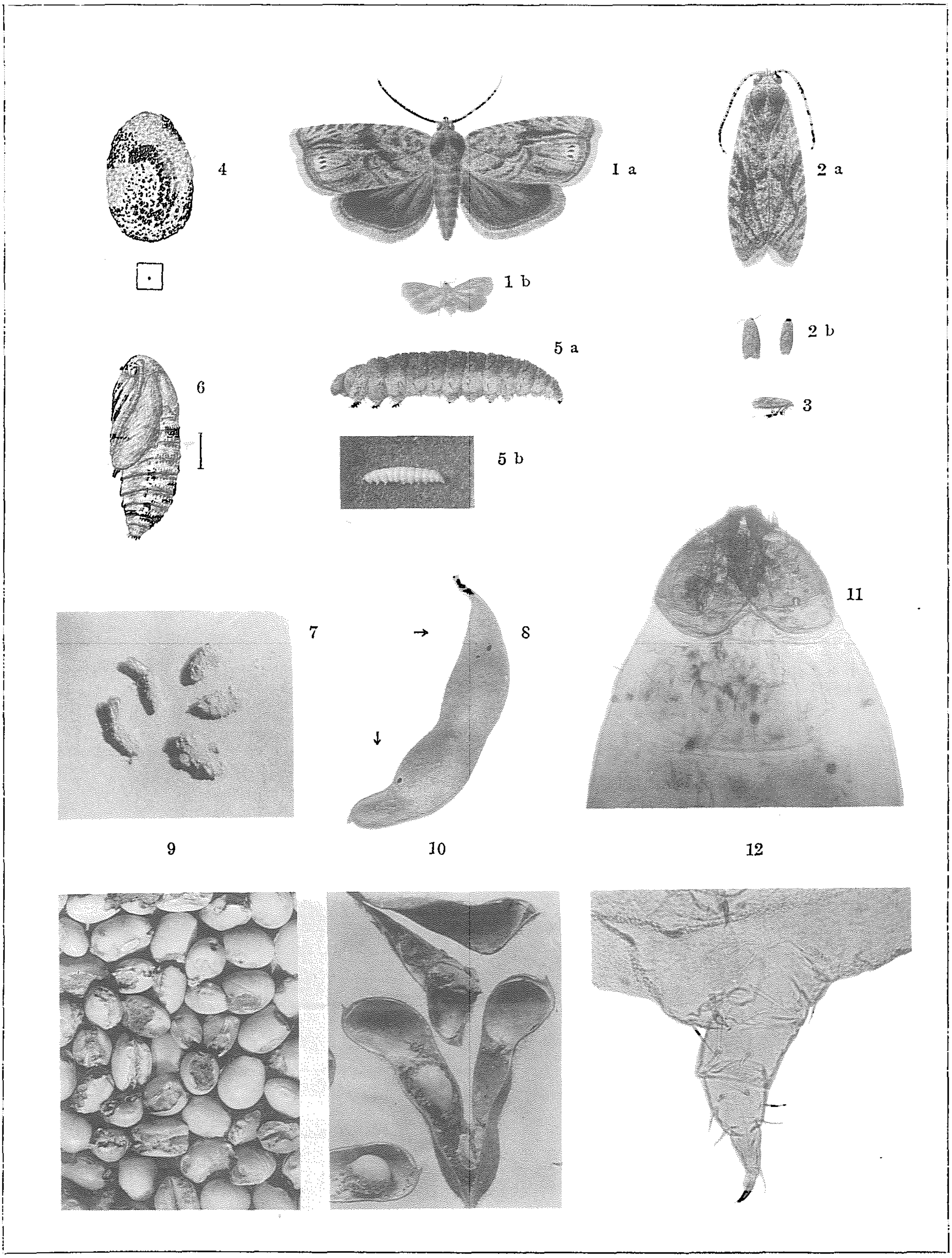
Fig. 8. Exit holes of the full-grown larvae of *L. glycinivorella* on pod. Natural size.

Fig. 9. Infested seeds by *L. glycinivorella*. Natural size.

Fig. 10. Infested pods by *L. glycinivorella*. Natural size.

Fig. 11. Head and first thoracic segment of the full-grown larva of *L. glycinivorella*. Dorsal view greatly enlarged.

Fig. 12. Thoracic leg of ditto. Greatly enlarged.



S. KUWAYAMA photo et del.