MR. F. C. BISHOPP: That depends on the stage of development. We find it is necessary for the grubs to be almost ready to emerge normally in order to transform. Ordinarily it is not necessary to destroy any of those squeezed out, with the exception of those which have taken on the brown or black color, which is indicative of the time being ripe for them to drop out.

MR. R. C. TREHERNE: Do either of these species occur on horses?

MR. F. C. BISHOPP: We have found Hypoderma larvae to a certain extent in the backs of horses. We consider the horse of little importance in connection with possible eradicative or control work. It is an abnormal host. That is also true of a good many other animals.

Mr. E. G. KELLY: How do you mix the treatment?

MR. F. C. BISHOPP: One part of iodoform to five of vaseline. As I mentioned in another paper, we have found certain washes are effective and we have hopes of developing them. Derris in soapy water has been found to kill almost one hundred per cent. with a single application, applied with a brush to the backs of the animals. I might say also that the British Board of Agriculture is advocating the use of a tobacco decoction on the backs of cattle.

MR. C. E. PETCH: Have you noticed any effect that wet springs have on the prevalence of the grubs?

MR. F. C. BISHOPP: Wet springs are always unfavorable to them. That comes about in two ways, we think, first, due to the ill effect on the pupae, and the second due to the effect on the flies when they want to deposit their eggs. Most egg laying occurs in the sunshine and if you have continued cool cloudy weather it results in the destruction of the adults before they have a chance to deposit. Nearly always the next year following a rainy, cool spring, you find a lower percentage of infestation.

PRESIDENT GEORGE A. DEAN: The next paper is by N. F. Howard.

THE MEXICAN BEAN BEETLE IN THE SOUTHEASTERN U. S.

By NEALE F. HOWARD, *Specialist in charge, Research Work on Mexican Bean Beetle, Bureau of Entomology*[1] *in cooperation with the Alabama Experiment Station, Alabama Polytechnic Institute.*

The Mexican bean beetle (*Epilachna corrupta* Muls.) is rapidly assuming a prominent place among the foremost injurious insects of the United States. It has demontrated its importance not only in actual

[1]Progress report prepared December 15, 1921 at Birmingham, Ala., with the assistance of Messrs. L. L. English, J. R. Douglass and others, Bureau of Entomology. Some data published in the Quarterly Bulletin of the State Plant Board of Florida, October, 1921, pp. 15—24, are not included.

money damage, but also in its capacity for destruction wherever it has become established, and in its tremendous capability for rapid spread. In the Birmingham district of northern Alabama early in the summer of 1921, the bean crop was destroyed in almost every case. When garden bean foliage became scarce, serious damage was sometimes done to cowpeas, and soy beans were occasionally injured. A number of new cultivated and wild food plants have been discovered, and the species is now permanently established in the Southeast. Since it thrives on the important forage and cover crops, cowpeas and soy beans, its potential importance to the general farmer is immense.

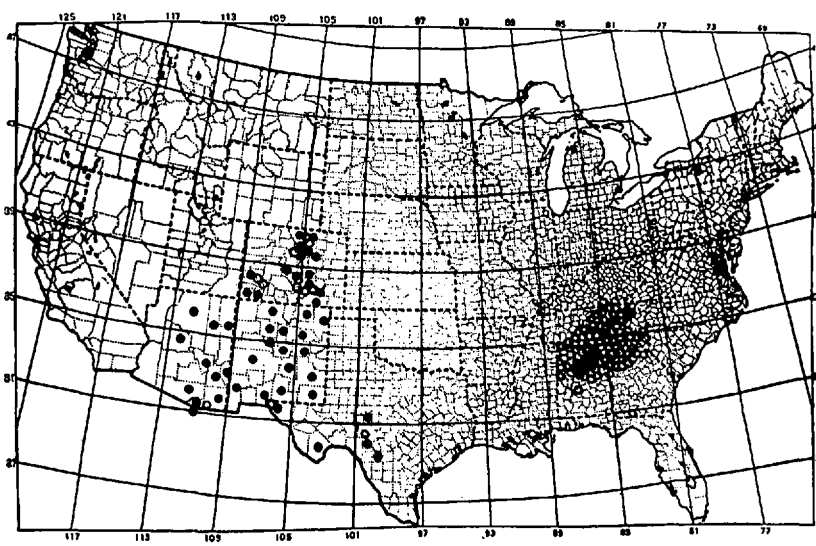

Fig. 8.—Map showing distribution of Mexican Bean Beetle to Dec. 31, 1921.

Distribution in 1921

The accompanying map (Fig. 8), prepared under the direction of Dr. F. H. Chittenden and Mr. J. E. Graf, shows the present known distribution of the Mexican bean beetle in the United States. The trend of distribution in the Southeastern United States is northward and, with the exception of the Thomasville, Ga., infestation, follows the mountainous or hilly country. This latter infestation is heavy over a small area and is important in that it indicates the ability of the species to thrive in flat country under extreme southern conditions. The insect has demonstrated its resistance to lower extremes of temperature and high altitudes in the West, and it will flourish also in the Northern and

Eastern United States, when it reaches these sections, as it undoubtedly will in course of time.

Life History Notes

Emergence from hibernation was first observed March 22, 1921, when adults and eggs were taken in the field. A series of frosts a week later destroyed all bean plants and eggs but did not affect the adults. Table I, the data of which were taken from 209 experiments, gives an idea of the life history as investigated the past season 610 feet above sea level.

Table I.—Life-History Data on The Mexican Bean Beetle in the South-eastern United States

Experiment No.	Date eggs deposited	Incubation period	First instar	Second instar	Third instar	Fourth instar	Pupation period.	Date of emergence	Developmental period	Mean temp.
			Days	Days	Days	Days	Days		Days	°F
LH 1.......	Mar. 22	15	8	7	7	12	9	May 19	58	64.9
LH4 3G..	June 7	5	4	4	3	5	6	July 4	27	82.7
LH1 1G2..	July 11	5	3	3	3	6	5	Aug. 5	25	84.6
LH5 20G2	Aug. 23	7	3	3	3	6	5	Sep. 19	27	81.1
LH6 3G3	Sep. 16	6	4	3	4	16	13	Nov. 1	46	68.6

Four generations from first egg to first adult were completed in the insectary near Birmingham, Ala., and the temperature would have permitted another generation to develop, at least partially, but this did not occur. A period of from 6 to 10 days, averaging 7 days, elapsed during July and August between the emergence of the female from the pupa and egg deposition.

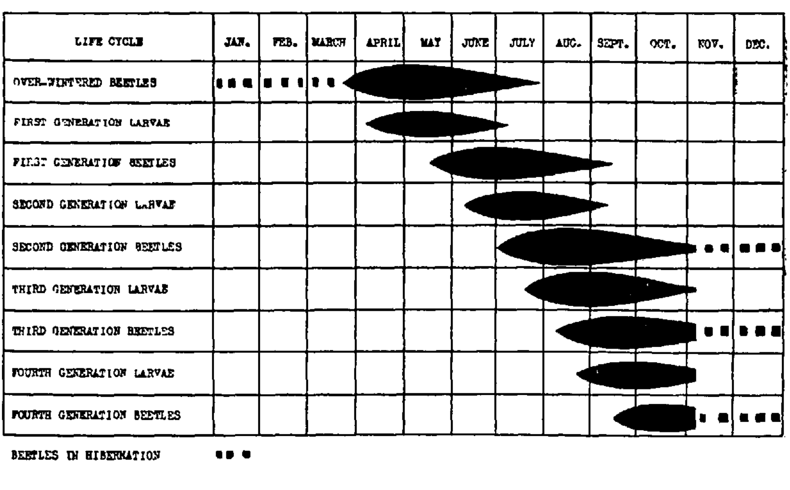

Fig. 9.—Seasonal history of Mexican Bean Beetle, Birmingham, Ala., 1921

Successful development has not been observed at a temperature below 60° F. Eggs withstood 31° F., March 29. The highest daily mean temperature during summer (U. S. Weather Bureau Record) was 88° F., August 1.

The number of eggs in a mass ranges from 5 to 76, with an average of 52.7 eggs in a group, calculated from 207 groups. The largest number of egg masses laid by a single female was 34 comprising 1,669 eggs. Of 1,691 beetles, 51.45 per cent. were males and 48.55 percent were females.

Fertile eggs were obtained from females collected in hibernation and isolated, showing that fertilization in the spring is not necessary.

Dispersion

Flight is the most important means of natural dispersion. Marked beetles have been taken 5 miles from the point of liberation in one instance and 3½ miles in two instances, as table 2 shows.

TABLE 2.—RECORDS OF FLIGHT OF MEXICAN BEAN BEETLES

[1]Date liberated	Number of marked beetles liberated	[2]Collections of marked beetles		
		Date collected	Distance from point of liberation (by shortest air route).	Number of marked beetles collected.
1921		1921	MILES	
Aug. 4.......	550	Aug. 8	3.5	1
Aug. 17.......	5,000	Aug. 18	0.25	[3]5
		Aug. 19	5.	3
		Aug. 20	2.2	[4]1
		Aug. 24	3.5	2

[1]Liberation was made at 720 feet above sea level.
[2]In two instances, collections were made in opposite directions.
[3]Others observed but not collected.
[4]Crossed hills 800 to 1,150 feet above sea level.

Insect Enemies and Natural Control

In addition to the list of species already published, the following have since been determined from field observations as enemies of *Epilachna corrupta*: The lepidopterous larvae, *Prodenia ornithogalli* Guen., *Laphygma frugiperda* S. & A. and *Heliothis obsoleta* Fab., and the diadem assassin bug (*Sinea diadema* Fab.). These species were fed a restricted diet of bean beetle larvae and pupae in confinement, and two species matured. In the insectary and some of the field cages the ants, *Solenopsis geminata* Fab. and *Pheidole* sp., destroyed pupae.

None of these species is of much value in natural control.

Hibernation

Hibernation is the most pronounced characteristic of the family Coccinellidae which the Mexican bean beetle retains. The beetle hibernates gregariously, as well as singly, but not in as large groups or as compactly as *Megilla maculata* DeG., and many other coccinellid species in California. Many individuals occur singly, and colonies are not compact. At this writing, December 15, the beetles are still congregating, as determined by marking beetles in colonies with different colored waterproof marks, and observing them at intervals. Table 3 gives a brief summary of the data on hibernation.

Table 3.—Data on Hibernation of the Mexican Bean Beetle.

Total number of searches	Searches with positive results	Searches with negative results	Total number of beetles found	Number of beetles found singly or in small groups	Number of beetles found in groups of 25 or more in 200 sq. ft. or less	Number of colonies with 25 beetles or more in 200 sq. ft. or less
303	104	199	2,198	977	1,221	12

Colonies of Marked Beetles

Colony No.	Original number of beetles, in colony when marked	Date marked	Observations on marked beetles					
			Date	Number of new beetles	Number of painted beetles	Date	Number of new beetles	Number of painted beetles
		1921	1921					
1 Red	149	Nov. 22	Dec 9	47				
2 Black	299	Nov. 18	"	103		[1]Dec. 15	168	161
3 Purple	80	Dec. 10	Dec. 15	8	68			
4 White	65	"	"	12	43			
5 Green	72	Dec. 13	"	0	70			
6 Red	103	"	"	0	96			

[1]Destroyed by intruders.

It will be noted that beetles are not only joining these colonies, but some of the original beetles are leaving, and that the insect is not completely dormant during the winter in northern Alabama.

Field observations on an isolated farm proved that the spring migration from hibernation lasted at least as late as the middle of May. March was exceptionally warm, averaging 7.7° F. daily excess above normal. Field observations indicated that the peak of emergence was late in April and early in May.

The preferred winter quarters, so far as observed, are wooded slopes, especially pine and oak growths. Well protected spaces, where branches, tree trunks, or other obstructions have caused accumulations of leaves or pine needles, are chosen. The beetles occur in this material at a depth of an inch or more, seldom resting on the ground, and as yet have not been found hibernating in the soil. The beetles ordinarily have been observed under good drainage conditions, but usually considerable moisture is present. As hibernating material dries out, the beetles seek a moist location and go deeper under the leaves. On warm days they become active.

A few beetles have been found hibernating 1 mile from the nearest bean field, 25 individuals three-fourths of a mile from the nearest field, and large numbers one-fourth and three-eights of a mile from the nearest fields. The majority of those observed, however, were within one-fourth of a mile of bean fields which had been destroyed.[1]

From information gained in 1921, it is evident that a "clean-up" practice which merely includes the garden patch or small farm is not likely to be of great value. A few beetles always occur in gardens and bean fields, but may be considered stragglers.

Table 4 gives the length of life of the adults, by generations, obtained from first eggs of first pairs in each case, which were checked with field cages, from insectary records.

This species may be considered a double-generation insect in the Southeastern United States, while it is a single-generation insect in the Western and Southwestern United States, and probably in many parts of old Mexico. In Alabama it could undoubtedly survive, however, with one generation under certain conditions. Owing to a retarded issuance from hibernation of a certain percentage and because of the longevity of the beetles, there is an overlapping of generations, which

TABLE 4.—LENGTH OF LIFE OF ADULTS OF THE MEXICAN BEAN BEETLE

Generation	Number of beetles	Developed From —	Developed To —	Date of death of majority beetles	Date of death last beetle	Beetles entering hibernation	Approximate length of life
		1921	1921	1921	1921	PER CENT	MONTHS
Overwintering (1920–1921)	397			late May	July 27		7–8
First	339	May 18	July 11	middle of July	Sep. 13		2
Second	540	July 1	Sep. 15	last half of August	....	5.37	(1)
Third	542	Aug. 5	Nov. 4	early half of October	....	55.17	(1)
Fourth	274	Sep. 13	Nov. 4	late October	....	90.88	(1)

[1]Still living, November 4.

[1]Early in April, 1922, Mr. J. E. Graf, Bureau of Entomology, accompanied by Mr. J. G. Hamilton of Torrance County, New Mexico, found the Mexican bean beetle hibernating 17 miles west of Estanica in loose colonies in piles of oak leaves and pine needles, 7½ miles from any bean fields. Beetles in trash near bean fields were extremely rare.

resulted the past season in the occurrence of the peak of infestation in late July and early August. In the late summer and early fall the beetles became extremely active. One field of beans was carefully picked free of adults almost daily in October, and during 24 hours adults flew in from other fields which had been destroyed.

Artificial Control

The Mexican bean beetle feeds in both larva and adult stages on the underside of the leaves of bean and other food plants. The larva consumes relatively greater quantities of leaf tissue and consequently is the more destructive stage. Since the larva does not leave the plant under normal conditions, because of its great susceptibility to direct sunlight, which causes it to succumb in a few minutes where shade temperatures are over 90° F., the proper distribution of a stomach poison to the underside of the leaves is essential.

The susceptibility of bean foliage to injury from arsenical treatment is well known and the practical application of arsenicals must be made with this in mind. Injury to bean foliage is probably a complex result of at least several contributing factors. The season's observations indicate: (1) That the water-soluble arsenic content of an arsenical is an important factor; (2) that the stability of the arsenical is probably a factor; (3) that the soluble mineral content of water used when wet sprays are applied is an important factor[2]; (4) that there are seasonal variations in the susceptibility of bean plants to injury; and (5) that the vigor of the plants appears to be a factor. Plants withstood spray applications better in early spring and late fall than during the heat of the summer, even when applications were made with arsenicals and water from the same source. Wet sprays were almost consistently more injurious than dusts, even though the application of the latter as practiced in the experiments distributed more of the arsenicals per acre.

Where wet sprays were used without serious injury to the foliage, better insect control was obtained than with dusting and this was undoubtedly due to the more effective distribution of the arsenical to the lower surface of the leaves, and the better adhesion of the particles.

Arsenical Sprays

The commercially available arsenicals tested, viz., calcium arsenate, zinc arsenite, lead arsenate, and Paris green, used as wet sprays, caused

[2]Valuable assistance was received in this phase of the work from Dr. Wm. Moore and Mr. C. M. Smith of the U. S. Bureau of Entomology.

injury in too many cases to make their recommendation general. Magnesium arsenate, formerly a commercial product, was injurious to a marked degree in only 2 out of 31 treatments; but since this arsenical is not now available, and in view of the fact that it has been tested during only one season, it cannot be generally recommended. As formerly prepared, it is unsuitable for dusting.

With present knowledge, wet sprays cannot be generally recommended, and growers are advised to try them out under local conditions, using the purest water available, preferably rain water collected from buildings. Zinc arsenite is the safest commercially available arsenical tested. It will effect efficient control if applied at the rate of three-fourths of a pound to 50 gallons of water, or at the rate of one ounce to four gallons. It should be applied to the underside of the leaves, at a high pressure, with a nozzle set at right angles to the discharge tube. The mixture must be continually agitated. An acre of bush beans in full leaf requires from 50 to 75 gallons of liquid, the rows being sprayed from each side with a small sprayer.

Paris green, as is well known, cannot be applied to beans because of the certain burning of the foliage.

Dusts

Successful dusting of garden beans for the control of the Mexican bean beetle requires the application of the poison to the underside of the leaves. This can be done best on a small scale with available machinery by means of a bellows type of duster provided with a long spout on a flexible hose, which makes it possible to direct the dust to the underside of the leaves and to distribute it among the clusters of hanging leaves. Care must be exercised to avoid distributing too much dust per acre, and in heavy puffs at the stroke of the bellows.

Cloud dusting in the early morning with various types of hand machines was not thoroughly successful on bush beans, the force of the air blast when directed against the ground being insufficient to carry the dust thoroughly to the underside of the leaves. On large acreages better results may be obtainable by the use of power machines.

Arsenical dusts gave control in direct proportion to the percentage of arsenical in the dust. No appreciable foliage injury was obtained from any of the arsenicals used when these were diluted 9 times with hydrated lime, but control was far from perfect. Applications must be made every 5 or 6 days, where infestation is heavy, and must be started as soon as the beans put out true leaves.

Calcium arsenate is the best arsenical available to southern growers for dusting purposes, but it will cause defoliation of beans in most cases unless diluted, and only the best grades must be used.

Nicotine dusts, contining from 1 to 10 per cent of nicotine sulphate, by weight, gave no control.

Pyrethrum, or insect powder, is a powerful contact insecticide, especially against the adult bean beetle. A good grade may be diluted as much as one-half with cornstarch or hydrated lime. It is not so effective against the larva, and does not affect eggs or pupae under field conditions. The cost and scarcity, as well as the impracticability of a contact insecticide against an insect of this nature, prohibit its general use either for farm or garden.

Derris, while superior to pyrethrum powder, falls in the same category.

Use of Sprayed Beans as Food

Chemical analyses of beans which had been wet-sprayed by a grower 7 days previous to picking prove that little danger of arsenical poisoning results from the application of arsenicals in the relative proportions of 2 pounds of lead arsenate to 50 gallons of water. From a quart of green beans picked June 3 from a field which had been sprayed thoroughly May 27, less than one-fiftieth of what is ordinarily considered a lethal dose of arsenic was present in very careful washings, and one-hundredth of a lethal dose was left on the beans. Nine other samples from experimental plots treated with various arsenicals as dusts and sprays showed less than 10 milligrams of arsenic expressed as As_2O_5 in very careful washings from a quart of green beans, picked 21 days after the last aresenical treatment. All visible traces of insecticides should be washed from green beans, however, before cooking.

Cultural Practices and Crop Substitutes

All stages of the beetle are destroyed by covering them with one inch or more of clay soil during the summer. In cases of heavy infestation, fields should be plowed under.

About Birmingham, Ala. in 1921, early planting was impracticable because the beetles were afield before the last frosts. Very early plantings of bush snap beans, however, produced a crop in locations where infestation was not so heavy.

The discovery of a number of wild host plants[4] in addition to those already recorded, and in addition to the cultivated hosts already recorded, indicates the futility of attempting to eradicate this species by discontinuing the planting of garden beans.

[3]Analyses by Mr. R. W. Allen, field assistant.

[4]*Meiboma tortuosa, M. canescens, M. viridiflora, Galactia volubilis, Lespedeza virginica.*

The growing of beans during alternate years may prove worthy of trial, but it would necessitate close community effort in areas at least the size of a large county, because of the prolonged flights of which the beetle is capable.

The use of the Windsor or broad beans (*Vicia faba*) as a substitute for garden beans for human consumption will only partially alleviate the situation, provided the crop meets with public approval, because in the South this crop can not be grown successfully during the summer. It is an excellent early-spring crop, however, under southern conditions, and the young, green seed, properly cooked, is relished by those who know it.

The use of substitute crops, since the soy bean and cowpea as forage and cover crops are threatened, may prove promising. The mung bean (*Phaseolus aureus*) has thus far proved absolutely resistant to beetle attack, and a bush variety of the immune velvet bean might fit into farm rotation in many cases. The adsuki bean, while slightly susceptible, is not favored by the beetle, and this crop also may be of value as a substitute.

Necessity for Thorough Study

A world-wide search for effective natural enemies, insect, bacterial, and fungus, is imperative before the bean beetle becomes more widely distributed. Adaptation of one of the known stomach poisons so that it may be applied with safety to the foliage of beans, involving determination of the causes of arsenical injury to foliage, is worthy of intensive study. Search for new stomach poisons should be constantly made. The perfection of machinery for the application of dusts to the underside of bean leaves is also important, and the solution of this last problem is essential to the successful adaptation of dusting to the control of other truck-crop insects.

Mr. G. E. Sanders: Is copper in small quantities, such as a mixture of a small quantity of Bordeaux dust, used in combination with arsenicals as a preventing agent?

Mr. N. F. Howard: We used a dust (our No. 23) comprising 10% commercial Bordeaux powder of 22% metallic copper content; 10% commercial arsenate of lead; and 80% hydrated lime. This dust did not injure bean foliage in any of nine applications, but a ten per cent. arsenate of lead-hydrated lime dust did not injure the foliage either. Copper in Bordeaux as a wet spray seemed to increase injury.

Mr. G. E. Sanders: You are sure it wasn't copper injury to the bean plants direct, instead of arsenical injury?

MR. N. F. HOWARD: No sir.

MR. G. E. SANDERS: There is an interesting point there. Magnesium arsenate proved quite a bit safer than calcium. I would like to hear the chemical reason for that from Professor Moore.

MR. WILLIAM MOORE: The conditions in the South, south of the James River, in geological surveys show that the natural water contains an excess of strong bases over strong acids, producing an alkaline water, due to sodium carbonate. Most if not all alkaline materials which give an alkaline reaction with phenolphthalein will react with acid lead arsenate.

It is of interest that although entomologists have been using lime for twenty years with lead arsenate to reduce the amount of soluble arsenate, the reaction of the lime actually increases the amount of soluble arsenate when mixed with acid lead arsenate. Concerning magnesium arsenate I believe there has been some objection by the Insecticide Board because of its injury. Mr. Howard reports from the South that magnesium arsenate gave less injury than with calcium arsenate. In the case of magnesium arsenate, the compound itself is somewhat more soluble than calcium arsenate. If there were no further decompositions more injury would be obtained with magnesium arsenate than with calcium arsenate but when the climate is such as to favor the action of carbon dioxide on the calcium arsenate, you get a decomposition of the calcium arsenate and it then becomes more injurious than the magnesium arsenate.

PRESIDENT GEORGE A. DEAN: We will now listen to Mr. W. E. Britton.

TOBACCO PLANT INJURED BY THE SEED CORN MAGGOT

By W. E. BRITTON,
State Entomologist, New Haven, Conn.

On the plantation of the Windsor Tobacco Grower's Corporation at Windsor, Conn., a large acreage of tobacco is grown under cloth for cigar wrappers. In one field of forty acres, one half, or twenty acres, soon after setting, had the plants injured by maggots which tunneled into the sides of the stems just below the surface of the ground. In some cases the injury was very slight and inconspicuous and showed only as a small pin-hole in the side of the stem, but in other cases the tunnel was considerably enlarged inside the stem and extended upward or downward in the pith for half an inch or more. A slight decay had started around the injury in some plants. The manager examined and