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THE MEXICAN BEAN BEETLE IN CONNECTICUT

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CONTROLLING THE BEAN BEETLE

Bean beetle injury may be avoided by spraying or dusting combined with certain cultural practices. Spraying is more effective. There are two generations of the insect a year and both larvae and adults feed on the plants.

Spray

Magnesium arsenate	3 lbs.
Casein lime	2 lbs.
Water	100 gals.

Dust

Magnesium arsenate	1 lb.
Hydrated lime	5 lbs.
or	
Barium fluosilicate	1 lb.
Hydrated lime	5 lbs.

To Apply Insecticide

1. Apply about June 15 and June 25 to early plantings. For later plantings, about July 20, July 30, and August 9. Lima and pole beans may require all five applications.

2. Apply to the under side of leaves.

3. Cover the entire surface.

4. Spray or dust before the injury is severe. Afterwards it is too late.

5. The insecticides mentioned above should not be used after the pods are half-grown unless the beans are washed before marketing. A pyrethrum-soap mixture may be used instead.

Cultural Practices

1. Destroy the hibernating quarters of the adults near cultivated fields.

2. Plow under or pull up and destroy all beans as soon as the crop is harvested.

3. The shorter the growing period, the less time the plants are exposed to attack. Promote rapid growth and early maturity by thin planting, proper fertilization, and thorough cultivation.

THE MEXICAN BEAN BEETLE IN CONNECTICUT

The Mexican bean beetle is a serious enemy of beans in every section of the United States in which it is present. Since its introduction into Connecticut in 1929, it has become a major pest in all parts of the state. This report gives the results of experimental work and field observations in 1931. It is intended as a report to gardeners, and contains information that will assist them in controlling the pest. Important material pertaining to the problem has been taken from publications of the Federal and State agencies.

On account of the short period of time available for the investigations, no attempt was made to cover the subject completely and work was confined to the more important practical problems involved. These investigations will be continued and a complete report given at a later date.

HISTORY AND DISTRIBUTION

The Mexican bean beetle, *Epilachna corrupta* Mulsant, was described in 1850 from specimens from Mexico, which has been considered its native home, but it is possible that it may be indigenous to parts of Arizona and New Mexico as well. Serious damage from attacks of the bean beetle were recorded as early as 1883 (32)[1], and a correspondent of the United States Department of Agriculture stated that it was present and caused damage as early as 1850 (10). Although this latter record depends on memory and may not be strictly accurate, it proves that the Mexican bean beetle was known in this country at a very early date.

Chittenden and Marsh (11) reported that the bean beetle was present in Colorado, Arizona, New Mexico and Texas. Merrill (31) included Utah, although the record was vague. Thomas (34) reported that specimens of the Mexican bean beetle were sent on June 30, 1920, from two places in Alabama, and conversation with growers convinced him that the beetle was present in the fall of 1918. The communities in which the beetle was discovered received several carloads of alfalfa from Colorado and New Mexico, and it was assumed that these shipments carried in enough beetles to start the infestations. On May 1, 1921, the Federal Government

[1] Numbers refer to bibliography, page 107.

established a quarantine covering the infested portions of Alabama. Scouting during that month showed that the beetle was spreading rapidly, and that the infestation was more widely scattered than had been supposed. Therefore, the quarantine was revoked on July 23, 1921.

In 1921 the bean beetle was present in Alabama, Georgia, South Carolina, Tennessee and Kentucky, and in 1922 it spread into Virginia. Since then it has spread northward as far as Ontario, Canada, and westward into Indiana and Mississippi. It occurs in New England as far north as Brattleboro, Vt., including Massachusetts, Rhode Island and Connecticut. In the western states, it has spread from the four states infested in 1919 into Wyoming, Utah and Nebraska.

Dr. E. P. Felt reported the presence of the bean beetle in Stamford, Conn., in July, 1929. Britton (3) reported it as being present in Brookfield, Darien, Monroe, New Canaan, Ridgefield, Sherman, Stamford, Westport, Wilton, Canaan, Salisbury, Washington, Meriden, New Haven, Orange, Wallingford and Hartford. In 1930 Britton (4) reported its occurrence in many towns in the eastern part of the state. In 1931 beetles were found in practically every bean field visited.

The manner of introduction has been a source of comment from market gardeners throughout the state. Many growers believe that the beetle was carried into the state in shipments of green beans from southern states. We have every reason to believe that this is incorrect. In 1928, Hamilton (17) reported that the bean beetle was present in all parts of New Jersey. It was easily possible for the beetle to fly into Connecticut from New Jersey, as it is a comparatively strong flier, and it undoubtedly entered the state in this manner.

Entomologists in general have been greatly interested in the probable spread of the Mexican bean beetle. Chittenden and Marsh (11) expected spread into several western states, but made no mention of spread into the eastern part of the country. Sweetman and Fernald (33) stated that southern New England and the Connecticut River Valley offered favorable conditions for the development of the bean beetle. They predicted that in this region the beetle would be a serious pest, and that in other parts of Connecticut and Massachusetts it would be less abundant. If their calculations are correct, the insect has reached its maximum spread in New England.

DESCRIPTION

The family Coccinellidae, or ladybirds, belongs to the order Coleoptera, or beetles. This family is very important economically, since it includes some highly beneficial insects as well as two pests.

There are about 40 species of Coccinellids known to be present in Connecticut. Thirty-eight of these are beneficial, as they feed on various insect pests, but two species are injurious, namely, the squash lady beetle, *Epilachna borealis* Fabricius, and the Mexican bean beetle, *Epilachna corrupta* Mulsant.

The adult Mexican bean beetle (Figure 1) normally is about a quarter of an inch long, but when food is scarce, many adults are much smaller than this. Occasionally a few specimens are larger.

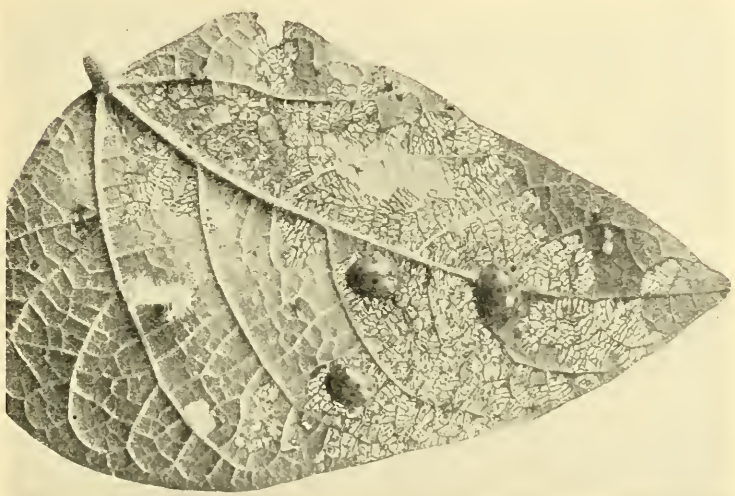

FIGURE 1. Adults of the bean beetle on an injured leaf which shows the skeletonized feeding areas. Natural size.

When the adults first emerge, they are pale yellow in color and no spots are present, but after a few hours, the eight small black spots appear on each wing-cover. As the wing-covers harden, the color becomes darker. Similarly, as the beetle becomes older the color deepens. Over-wintering adults are dark copper-colored when they leave hibernation in the spring.

The eggs (Figure 2) are usually deposited on the under surface of bean leaves, but occasionally, when the plants are severely infested, a few egg-masses will be deposited on bean pods or on the upper surface of leaves. These eggs are yellow in color and are laid in irregular groups containing from 40 to 60 each as a rule. If a female is interrupted during oviposition, the mass may be smaller. In general, these eggs resemble those of the Colorado potato beetle, but are much lighter in color.

The young larvae (Figure 2) which hatch from the eggs are about one-sixteenth of an inch long and yellow in color. When they first hatch they are pale yellow and are covered with numerous branched spines. For several hours after hatching they remain on the eggshells. During this time the skin hardens and the spines become darker. For a few days they feed in a colony on the leaf on which the eggs were deposited, but as they grow older, they disperse over the entire plant, usually seeking comparatively young leaves.

FIGURE 2. Eggs of the bean beetle at left, newly hatched larvae on the old egg-cluster at right. Four times natural size.

After four to six days of feeding, the larva molts. The body is fastened to the bean leaf at the tip of the abdomen, and the larva works out through a longitudinal slit in the old skin, which is left attached to the leaf. This molting takes place four times: The first, four to six days after hatching; the second, two to four days later; again, in three to five days, and finally, in six to ten days. Each successive stage is larger in size than the first, the full-grown larva being about one-third of an inch long. After each molt, the larva is soft and light yellow in color, but as the skin dries it becomes darker and the spines turn black. In cool weather the insect becomes darker. The last stage larva (Figure 3) feeds from five to seven days and then remains quiescent from one to three days before transforming to a pupa. During this time the larvae usually migrate to small leaves near the base of the plant and congregate in groups. Here they shed the last larval skin and transform to pupae. If the bean vines are destroyed by the larvae, the pupae may be found on grass blades or the under side of the leaves of any weeds present in the field.

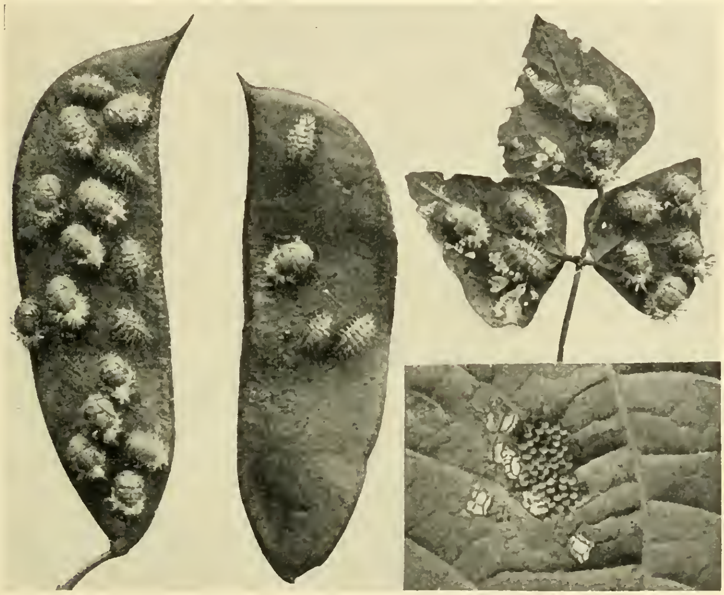

FIGURE 3. Larvae and pupae above, natural size; eggs in lower right-hand corner, twice natural size.

The pupa, or inactive stage, (Figure 3) neither feeds nor moves about. It is similar in size to the adult beetle, varying in color from light yellow to almost black, and is attached to the leaf. In cool weather black lines are visible on the upper side of the body. After a period of from seven to nine days the adult beetle emerges.

HOST PLANTS

Howard and English (23) give the following list of host plants in the order of their preference.

Tepary bean, *Phaseolus acutifolius*
Garden bean, *P. vulgaris*
Lima bean, *P. lunatus*
Beggarweed, *Meibomia* species
Hyacinth bean, *Dolichos lablab*

Cowpea and black-eyed pea, *Vigna sinensis*
Soy bean, *Glycine hispida*
Adsuki bean, *Phaseolus angularis*
Alfalfa, *Medicago sativa*
Sweet clover, *Melilotus alba*

These authors state that the chance of damage to sweet clover and alfalfa is remote. They report cases in which the bean beetle has been abundant enough to destroy bean plants and has thereafter fed on numerous other plants, such as corn, grasses, okra, egg plant, potato and squash. None of these plants were severely damaged by such feeding.

During the past year various kinds of legumes have been grown to determine the host preferred by the bean beetle. Several varieties of common garden beans and lima beans, both dwarf and pole, were planted. In addition to these, cowpeas, soy beans, the scarlet runner bean, the broad Windsor bean, the lentil, and the mung bean were grown.

The first planting, made on May 23, 1931, included all of these legumes. The plots were small, consisting of two 12-foot rows each. The over-wintering population of beetles was small, and few were noticed early in the season. At the height of the larval feeding period, July 13, observations on injury to the plants were made. This injury was designated as severe, moderate, slight, or none, and with such a classification, the varieties of beans were grouped accordingly. All of the dwarf green beans produced a fairly good crop. The dwarf lima beans also yielded fairly well, but the pole garden beans and limas produced a very small crop.

Moderate	Slight	No injury
Dwarf garden beans	Garden beans	Mung beans
Pencil pod black wax	White marrow	Lentils
Dwarf horticultural		
Crackerjack wax	Lima beans	Soy beans
Bountiful green pod	Burpee bush lima	
Navy	Sieva lima	Broad Windsor beans
Pole garden beans	Scarlet runner	Cowpeas
Golden cluster wax		
Mammoth horticultural		
Lima beans		
Fordhook bush lima		
Dutch case knife		
King of the garden pole		

At the time the first generation adults were flying, most of the varieties were moderately injured. Observations made July 31 showed the extent of injury to the different varieties to be as follows. The variety names of the common beans are not repeated.

Moderate	Slight	No injury
Dwarf garden beans	Soy beans	Mung beans
Pole garden beans	Scarlet runner beans	Lentils
Lima beans		Broad Windsor beans
		Cowpeas

The next observation was made August 31, when the second brood larvae were feeding. This shows the decided preference of the bean beetle for dwarf garden beans (Figure 4).

FIGURE 4. Host selection by the Mexican bean beetle. From the left, string beans (two rows), navy beans, lima beans, velvet beans and soy beans.

Killed	Severe	Slight	No injury
Dwarf garden beans	Lima beans	Soy beans	Mung beans
	Pole garden beans	Cowpeas	Lentils
	Scarlet runner beans		Broad Windsor beans

The first planting was followed by several others. On June 8, the hyacinth (Dolichos) bean and the French yard long bean were planted. On June 25, the velvet bean was added, as well as dwarf garden beans and dwarf limas. A third planting on July 11 consisted of dwarf garden beans and limas. The observations made on September 25 include all these plantings. (See page 80.)

PLANTED MAY 22

Killed[1]	Severe	Moderate	Slight	No injury
Scarlet runner beans	Lima beans	Cowpeas	Soy beans	Mung beans
				Lentils

[1]In addition to those killed August 31.

Planted June 25 and July 11

Killed	Severe	Slight	No injury
Dwarf garden beans	Dwarf lima beans	Soy beans Dolichos beans Yard long beans	Velvet beans

These later plantings yielded a very small crop of beans. A few string beans matured, but they were so badly scarred by beetles that they were not salable. The limas failed to produce any beans.

From these results the following host preference list for Connecticut is derived. The plants are listed in the order of preference. The preferred hosts include the common garden and lima beans. The second classification includes soy beans which are commonly grown in this state. The hyacinth beans, cowpeas and yard long beans are not grown extensively.

Host Preference List

Preferred	
Garden beans	*Phaseolus vulgaris*
Scarlet runner beans	*P. coccineus*
Lima beans	*P. lunatus*
Damaged somewhat but not preferred	
Hyacinth beans	*Dolichos lablab*
Cowpeas	*Vigna sinensis*
Yard long beans	*Dolichos sesquipedalis*
Soy bean	*Glycine max*
Immune	
Lentils	*Lens esculenta*
Broad Windsor beans	*Vicia faba*
Mung beans	*Phaseolus aureus*
Velvet beans	*Styolobium deeringianum*

In the southeastern states, Howard and English (23) noted that when preferred hosts were destroyed, the beetles would attack soy beans and cowpeas and cause considerable injury.

Larvae frequently defoliate a small planting of beans before they complete feeding, and in such cases they migrate to other plants. The distance they can travel was not determined, but it is believed that this is not great. In the cases noticed, other beans were growing near at hand and the larvae fed on these.

Some determinations of host plant preference by larvae were made by caging newly-hatched larvae on various legumes. Larvae fed readily on the common varieties of beans, but died without feeding when placed on mung beans, velvet beans, soy beans, broad Windsor beans and lentils. Several attempts were made with each of these legumes. When it became apparent that newly-hatched larvae would not survive, second instar larvae were used, but these failed to feed.

Newly-emerged adults were caged with each of these legumes to determine feeding. They fed freely on the soy bean and the mung bean, but died without feeding on the velvet bean, the lentil and the broad Windsor bean.

Table 1 shows the acreage of beans grown for sale in Connecticut, as estimated by the 1929 census.

The estimate does not include small gardens from which few beans are sold. According to seedsmen in New Haven, more bushels of seeds are sold in package lots to small growers than in large lots to market gardeners. Therefore, the acreage of garden and lima beans would be at least double the census figures. Since many growers plant beans several times a year, the figures would be underestimated rather than overestimated.

TABLE 1. ACREAGE OF MARKET BEANS IN CONNECTICUT, 1929

Variety	Acreage	Value	Yield
	Truck crops		
Snap beans	821	$120,599	———
Lima beans	76	12,826	———
Ripe beans (shell)	50	———	556 bushels
	Field crops		
Soy beans	735	———	———
Cowpeas	4	———	———

No effort was made to determine the exact amount of damage done by the bean beetle in Connecticut. Field observations were made in various parts of the state, and the following statements are rough estimates. In the southern and western parts of the state, approximately half of the late beans were destroyed (Figure 5). In fact, only those beans that were thoroughly sprayed produced a normal crop. In the northeastern part of the state the damage was not so severe, and in several places there was no appreciable injury.

The feeding done by hibernating adults in the spring was not particularly injurious in 1931. The first generation larvae caused severe damage where they were abundant. The first generation adults caused considerable injury. (Insectary observations indicate that the adults consume large quantities of foliage.) Second generation larvae were generally abundant and caused much injury. Second generation adults fed freely and completed the destruction of the beans that were growing at the time in the heavily infested area.

The small larvae apparently do not eat as much foliage as the large larvae in proportion to size. The larva will spend the first half of its feeding period on one leaf and then consume three or four leaves during the latter half. When confined in cages, individual adults apparently destroyed as much foliage as individual

Figure 5. Bean field severely damaged by the Mexican bean beetle.

larvae consumed during the entire larval life. Although most of the damage to bean plants is done by defoliation, both larvae and adults feed on green and lima pods after the foliage is destroyed. This damage is serious in that the scarred beans bring a lower price on the market than uninjured beans.

LIFE HISTORY

The Mexican bean beetle has two generations a year in New Mexico (31). According to List (26) only one complete generation and a partial second generation occur in Colorado. Howard and English (23) report two complete broods and a partial third brood in Alabama, although in one instance four generations were observed. The last two generations were incomplete. Thomas (34) observed similar conditions. In Virginia, Chapman and Gould (7) reported three generations a year. In South Carolina, Eddy and Clarke (13) found two complete and two partial generations a year, with only an occasional fourth generation adult. Jewett (25) observed three generations in Kentucky in the insectary. Cecil (6) stated that there were two generations in New York. In southern New Jersey, Hamilton (17) stated that there were probably three generations.

In most of its range the Mexican bean beetle has only two complete generations, and in those places recording more than two broods, the later broods are incomplete. This is true in spite of the fact that the growing season for beans in the southern states would allow six full generations (23). In Connecticut in 1931, the Mexican bean beetle had two complete generations.

First Generation

Over-wintering adults were collected in the field during the second week of June and placed in cages to obtain eggs. The time of incubation was determined from egg-masses deposited under observation. Three such masses were recorded for the first generation. In addition, five masses with less complete information were observed (Table 2). The average incubation period was eight days.

TABLE 2. INCUBATION PERIOD, FIRST GENERATION

Egg-masses deposited	Eggs hatched	Days incubation
June 15 12:00 M.[1]	June 23 9:00 A. M.	8
June 17 8:30 A. M.	June 26 10:00 A. M.	9
July 8 10:45 A. M.	July 16 10:00 A. M.	8
June 11	June 20	9
June 13	June 21	8
June 16	June 23	7
June 14	June 22	8
July 5	July 13	8

The larval period was determined from individual rearings, a single newly-hatched individual being placed on each bean plant which was covered with a small screen cage. The larval period averaged somewhat less in midsummer than in early summer (Table 3). Table 4 shows the duration of the pupal period.

TABLE 3. LARVAL PERIOD, INCLUDING PREPUPAL PERIOD, FIRST GENERATION

Date hatched	Number individuals	Number days	Average number days
June 20	6	20	
	6	21	20.7
	2	22	
July 5	4	18	
	2	19	18.7
	2	20	

TABLE 4. PUPAL PERIOD, FIRST GENERATION

Date started	Number individuals	Number days	Average number days
June 20	1	6	
	11	7	7.1
	3	8	
July 5	5	6	
	5	7	6.5

[1] First eggs deposited.

In these studies the shortest period required for development from egg to adult was 32 days, and the longest period 39 days. The period was three days shorter in midsummer than in early summer (Table 5).

Table 5. Total Developmental Period, First Generation

Date	Number individuals	Number days	Average number days
June 20	4	35	
	3	36	36.4
	7	37	
	1	39	
June 21	2	36	
	3	37	37.4
	4	38	
	1	39	
July 5	1	32	
	6	33	33.2
	3	34	

The period between emergence of adult females and deposition of eggs was determined for the first generation adults. Newly emerged adults were placed in cages and the date of the first eggs deposited was recorded. Since several females were present, the results represent the shortest period for the group of females. The time varied from 8 to 13 days, and the larger number of females required eight days (Table 6).

Table 6. Pre-Oviposition Period, First Generation

Number of cases	Pre-oviposition period in days
6	8
2	9
3	10
1	11
3	13

No effort was made to determine the number of eggs deposited by individual females. Howard and English (23) reported an average of 459 eggs per female from 69 individuals. The lowest number they obtained was 252 and the highest, 1,272.

Second Generation

The incubation period of second generation eggs is given in Table 7. The time required for larval growth was about the same for this brood as for the preceding one (Table 8), but the pupal period of the second was distinctly longer than the first (Table 9).

TABLE 7. INCUBATION PERIOD, SECOND GENERATION

Egg-masses deposited		Eggs hatched		Days incubation
July 22	2:00 P. M.[1]	July 29	4:00 P. M.	7
July 22	afternoon	July 30	10:00 A. M.	8
July 22	11:00 A. M.	July 30	10:00 A. M.	8
July 22	11:30 A. M.	July 30	10:00 A. M.	8
July 23	11:45 A. M.	July 30	10:00 A. M.	7
July 23	12:00 M.	July 30	10:00 A. M.	7
July 23	10:00 A. M.	July 31	10:00 A. M.	8
Aug. 5	10:00 A. M.	Aug. 13	10:00 A. M.	8

TABLE 8. LARVAL PERIOD, INCLUDING PREPUPAL PERIOD, SECOND GENERATION

Date hatched	Number individuals	Number days	Average number days
July 30	2	18	
	4	19	
	6	20	19.5
	1	21	
July 31	3	18	
	3	19	18.9
	2	20	
Aug. 5	22	21	
	6	22	21.2
Aug. 10	5	21	
	10	22	22.0
	2	23	
	1	25	

TABLE 9. PUPAL PERIOD, SECOND GENERATION

Date started	Number individuals	Number days	Average number days
July 30	14	9	9
July 31	7	9	
	1	10	9.1
Aug. 5	2	7	
	20	8	8.1
	6	9	
Aug. 10	7	8	
	10	9	8.7
	1	10	

[1] First eggs deposited.

Table 10. Total Developmental Period, Second Generation

Date started	Number individuals	Number days	Average number days
July 30	1	35	
	11	36	36.0
	1	37	
July 31	3	34	
	4	35	35.0
	1	36	
	1	37	
Aug. 5	21	37	
	5	38	37.2
	1	39	
Aug. 10	9	38	
	7	39	38.7
	1	40	
	1	41	

In general, the period required for complete development was not greatly different than for first generation individuals. The shortest time noted was 34 days and the longest, 41 days (Table 10).

Although no third brood was expected, the second generation adults, which emerged in August, were caged to determine the pre-oviposition period (Table 11). Very few third generation eggs were deposited, usually not more than one small mass in a cage. Many of these eggs did not hatch. The eggs that hatched were used to start mass rearings, but none of these yielded any adults. The September 14 mass was the earliest one that hatched, and cold weather killed the two surviving pupae before they transformed.

Table 11. Pre-Oviposition Period, Second Generation

Date emerged	Date deposited	Pre-oviposition period in days
August 20	September 4	15
August 28	September 5	8
August 27	September 5	9
August 29	September 14	16
August 30	September 18	20
Sept. 9	——	—

In late seasons, such as the 1931 season, it would be possible for a few third generation adults to develop, but this is unlikely to occur in the field. The second generation adults obtained were from early selections, that is, they were reared from the first egg-mass deposited in the spring, and again from the first egg-mass of the first generation adults.

Over-wintering adults, that is, beetles that hibernated in the fall of 1930, were caged to determine their length of life. These were collected from various parts of the state and were offered fresh food regularly. Specimens collected in Westport, June 24, were all dead July 6. Ten collected in Hartford County, June 22, lived longer. On July 18 two were alive, and one of these lived until August 28. This one beetle lived almost a year, since early second generation adults emerged August 27. In the field, there were very few over-wintering adults present at the time the first generation started emerging.

First generation adults were present in very small numbers when the second generation started emerging and in cage tests all of the early first generation died before time for hibernation. Some late first generation beetles survived until hibernation, although the mortality was great.

Early second generation adults survived in small numbers until hibernation. Thirty-five per cent of such specimens survived until frost. This is a rather high mortality, and cage conditions might have been responsible for it. At any rate not all second generation adults survive until hibernation.

Individual larvae reared on various legumes revealed considerable differences in length of larval period (Table 12). The larvae required about one day longer on cowpeas than on garden beans and lima beans and almost six days longer on *Dolichos lablab* than on Crackerjack wax at the same period. Moreover, only three adults were reared from 27 newly-hatched larvae on *Dolichos lablab*. This would indicate that *Dolichos lablab* was not a very acceptable food plant for the larvae.

Table 12. Effect of Host on Duration of Larval Period

Host plant	Date	Number started	Number matured	Average larval period (in days)
Phaseolus vulgaris				
Crackerjack wax	July 31	10	8	18.9
" "	Aug. 10	20	18	22.0
Phaseolus coccineus				
Scarlet runner	July 31	15	9	19.3
Phaseolus lunatus				
Burpee bush lima	July 31	15	10	18.8
Vigna sinensis				
Clay cowpea	July 30	15	10	21.1
Dolichos lablab				
Hyacinth bean	July 29	15	0	...
	Aug. 8	12	3	27.7

These life history studies show that there are two distinct generations of the Mexican bean beetle in Connecticut. Some overlapping takes place, since a few adults of the first generation survive until the second generation adults start emerging. It is possible that a few third generation adults might mature, but there is no evidence that this occurs in the field. Few first generation adults survive to enter hibernation, and some second generation adults die before this period.

SEASONAL HISTORY

The over-wintering adults began to feed on beans during the first week in June in southern Connecticut in 1931, and feeding continued for several days before eggs were deposited. On June 9 eggs were found in small numbers in Ridgefield and on June 12 in Stamford and Westport. From then until the first week in July eggs were abundant. On July 10 first generation adults started emerging from pupation in Stamford and Westport. These were most abundant about August 1 and decreased in number until the last week of this month. On August 25 very few adults were seen in heavily infested fields.

Second generation eggs were found from late July until August 25, and three egg-masses were found in the field on September 24. These might have been second or third generation eggs, since second generation eggs were deposited in the insectary as late as September 29, and third generation eggs from September 5 to September 18. Second generation adults started emerging about September 1 and continued until about October 5. Adults became restless late in September and apparently migrated to hibernation quarters. Very few were present during the first part of October, although the first killing frost did not occur until October 19 in southern Connecticut.

During the season several trips were made to various parts of the state to get information concerning development of the generations. In general, these observations showed that light infestations were retarded in development as compared with severe infestations. Moreover, development in the northern part of the state was somewhat slower than in the southern part. The difference in development at Stamford and Salisbury was about one week. Eggs were found earlier in Stamford, and late in the season there was a larger percentage of adults in Stamford. In Mansfield the development was much more retarded than in Groton or Southington. This was undoubtedly due to later infestation in the spring.

Apparently most of the second generation individuals had ample time for development before the frost date. The average date of the first killing frost in the fall in New Haven is October 19. For the state, the date varies from October 10 at Winsted to October 25 at New London (35). In seasons having a killing frost earlier than these dates, many larvae and pupae of the bean beetle might be killed.

Migrations

In the spring the adults that come out of hibernation migrate to bean fields. Although they are not particularly numerous at this time of year, they apparently disperse over the country quite widely. The first generation beetles that emerge during the last half of July also migrate considerably. Apparently they will seek new host plants, even if an abundant supply of food is close at hand. In the fall the second generation adults begin to migrate soon after they emerge.

Hibernation

No hibernation studies have been completed as yet in Connecticut, but results of other investigators may be cited. Merrill (31) states that the beetles hibernate as close to the bean fields as possible, preferably under litter. List (26) found that they hibernate after fall frosts and remain under cover until hot weather the following June. Thomas (34) found large numbers wintering under leaves and pine needles in woodlands. In Alabama, the beetles did not remain in one place all winter, but became active on warm days. They left hibernation quarters during the last half of April and the first half of May. Howard and English (23) published detailed results of extensive hibernation studies in Alabama. They found that the beetles hibernate in colonies, chiefly under litter in rolling woodlands. They hibernated less frequently in debris in old fence-rows, in stone piles, under rubbish in gardens, and under woodpiles and were ordinarily found within a mile of bean fields. The survival was rather low in their cage tests, but was higher under natural conditions in the field. Emergence started early in April and continued until June, the majority leaving hibernation quarters by May 1.

In our studies, beetles in cages went into hibernation as early as September 15. Food was available and many beetles continued feeding until cooler weather in October. By October 8, half of the beetles had crawled under litter to hibernate. Most of them were hibernating on the following day, although the minimum temperature was only 44° F.

A few adults continued to feed until the first frost, which occurred October 19. These adults apparently crawled down to the ground and hibernated under the dead bean plants instead of flying away to seek other quarters.

NATURAL CONTROL

Environmental Factors

Certain environmental factors appear to have a marked effect on the abundance of the Mexican bean beetle. This is quite strikingly shown by the distribution of the insect in North America and by its direction of spread in the eastern part of the continent. The most important of these factors are the food supply throughout the growing season, the temperature and moisture conditions, and the suitability of hibernation quarters.

The question of an adequate food supply for this insect in Connecticut is solved, for the favorite food plants, garden beans in one variety or another, are grown throughout the season. The beetle will feed to some extent on a few other leguminous crops and on the beggar tick *Meibomia,* but none of these are as readily attacked as beans.

The effect of temperature and moisture on the vitality of this insect is quite striking, particularly during hot dry periods in the summer. Reports from the southern part of the infested area in the East state that during excessively hot dry weather, beetles in all stages die rather quickly and in great numbers. It is questionable whether this factor will be of any practical importance in Connecticut. Both Marcovitch and Stanley (29), and Sweetman and Fernald (33), consider the Connecticut climate well adapted to the insect.

The average mean temperatures for the summer months from 1920 to 1927, inclusive, in New Haven were as follows: June, 67.3° F.; July, 71.8° F.; August 70.0° F.; September 64.9° F. Moreover, in 1930, which the New Haven weather bureau reports as above the average in summer temperature, there were only 12 days during the entire year when the temperature was above 90° F. These 12 days were divided equally among four months, three days each in May, June, July, and August. In 1929 there were 10 days above 90° F., one in May, three in June, three in July, and three in September. In 1928 there were 12 days, five in July and seven in August, three of these days being consecutive in July and four in August.

The effect of drought on the beetle, according to Marcovitch and Stanley (29) depends on the number of consecutive days above 90° F. and the absence of precipitation. According to an index derived from a formula based on these considerations, any region having an index number of 2,000 or less is very favorable for the bean beetle, and the New England area has an index number of 328 (for Boston, Mass.). According to Sweetman and Fernald (33) a constant temperature of about 89.6° F. or higher is necessary at ordinary atmospheric humidities to kill the different stages of the insect, and constant temperatures around 71.6° F. are very favorable to incubation, larval and pupal development, and oviposition. Since a temperature of 89.6° F. rarely persists in New Haven more than eight consecutive hours, lethal summer climatic conditions cannot be counted upon to reduce the numbers of the insect. In 1926 in South Carolina, according to Eddy and McAllister (14) a heavy mortality due to hot dry weather occurred in late July, but the temperature rose to 103°, 104°, and 106° F. for several days, wilting the plants. Such conditions do not occur in this state.

The effect of the environment on insects during hibernation is sometimes disastrous and reduces the population markedly. As far as the bean beetle is concerned, Connecticut conditions do not appear to offer any great obstacle to successful hibernation, either in respect to climatic conditions or in regard to suitable shelter. The adults prefer to hibernate under woodland litter near the cultivated fields, and in Connecticut just such conditions prevail. Temperature and moisture conditions also appear favorable. The winters are not severe in this state, and rain and snow are quite abundant. Although in Virginia and South Carolina the normal survival of hibernating adults appears to be only about 15 per cent, this does not indicate necessarily a much greater mortality in Connecticut. In New Mexico the adults hibernate in snow-filled canyons, and in Colorado, where conditions are as severe as they are in Connecticut, the insect persists as a pest.

In considering the general environmental conditions throughout the year in Connecticut in relation to the abundance of the beetle, a few facts should be kept in mind. There are in this state two full generations a year and at times a partial third. The adults of the second generation hibernate. This is the normal situation in the Southwest. In Colorado conditions are not so favorable and in some years, due to either early cool weather in the fall or lack of food, no second generation is produced, for the first generation adults go into hibernation (26). Garman (15) reported that in Kentucky a few first generation beetles hibernated. During the active season it is a series of consecutive hot dry days that spells disaster, and in Connecticut the necessary extreme conditions appear to be lacking. It is evident that Connecticut climatic conditions are not too severe for the insect. The inference should not be drawn from the above statements that the population of beetles will not fluctuate from season to season. The implication is that the insect is with us to stay, and that at present the climatic factors offer no great promise of reducing its numbers to a relatively harmless level for any considerable period of time.

Predators

Many predaceous insects feed on bean beetle eggs, larvae and pupae. Some such insects are present in Connecticut and a few have been observed feeding on the bean beetle. A list of all such beneficial insects observed by other investigators on the bean beetle is as follows:

Predator	Family	Stage of host attacked
**Megilla maculata*	Coccinellidae	Eggs
**Coccinella sanguinea*	"	"
**Coccinella novemnotata*	"	" and larvae
**Hippodamia convergens*	"	" (rarely)
**Adalia bipunctata*	"	" and larvae
Arilus cristatus	Reduvidae	Larvae, pupae, adults
**Stiretus anchorago*	Pentatomidae	" " "
**Podisus maculiventrus*	"	" " "
**Harpalus caliginosus*	Carabidae	" " " (rarely)
**Scarites subterraneus*	"	" " "
Calosoma sayi	"	" " "
Tetracha carolina	Cicindellidae	" " "
Tetracha virginica	"	" " "
**Chrysopa oculata*	Chrysopidae	Pupae (rarely)
Chrysopa rufilabris	"	" "
**Prodenia ornithogalli*	Lepidoptera	"
**Laphygma frugiperda*	"	"

The last two were observed eating bean beetle pupae. These are ordinarily pests themselves, *Laphygma frugiperda* being the fall army worm. *Prodenia ornithogalli* is a cutworm and its action in eating other insects is very unusual. The lady-beetles, or Coccinellidae, commonly feed on aphids and other soft-bodied insects. *Podisus maculiventris* (Figure 6), the spined soldier bug, has been observed feeding on larvae and pupae in Connecticut. Nymphs of another Pentatomid, *Acrosternum hilare,* supposedly an enemy of beans, have been taken several times in Connecticut feeding on larvae and pupae.

Parasites

Three parasitic flies have been recorded from bean beetles in Alabama. One of these, *Phorocera claripennis,* a Tachinid, deposited eggs on larvae. It was not effective in control. The Sarcophagid, *Helicobia helicis,* is a general feeder and rarely attacks bean beetles. Both of these flies occur in Connecticut. The Tachinid, *Paradexodes epilachnae* Aldrich, was discovered in Mexico in 1921 where it parasitized from 30 to 50 per cent of the larvae late in the season. This parasite has been imported into the United States and liber-

*Present in Connecticut.

ated at several points and has been found more effective than all the other parasites and predators combined.

Two bacterial diseases attack bean beetle larvae and pupae, but these diseases are not very effective and their prevalence probably depends on certain weather conditions.

This list of enemies of the bean beetle is rather long, but only one, the Tachinid fly, *Paradexodes epilachnae* Aldrich, seems to be promising in reducing the number of bean beetles. Since this is not a native parasite, it will be necessary to import it into Connecticut. Moreover, it may not survive in this climate.

CULTURAL CONTROL

Destruction of hibernation quarters of the Mexican bean beetle is of some assistance in control. However, the majority of the

FIGURE 6. The spined soldier bug, *Podisus maculiventris* Say. Twice natural size.

adults pass the winter in woodlands, which cannot be burned over. It will undoubtedly do some good to turn under or destroy bean vines in the fall and clean out all fence-rows. This will destroy the nearby hibernating quarters and possibly delay attack on the beans in the spring, although very few beetles normally remain in the field over the winter.

The shorter the growing period, the less the beans are exposed to the beetle. Since the number of insecticide treatments depends on the length of time the beans are in the field, it is necessary to grow the plants in as short a time as possible to cut down the number of treatments. Therefore, all cultural methods that hasten maturity should be used. These include planting thinly, cultivating frequently, and fertilizing properly.

As soon as the last picking of beans has been made, the vines should be turned under. Chapman and Gould (8) have shown that the vines must be completely buried in order to kill bean beetle larvae and pupae. If a poor job of plowing is done, many beetles escape destruction. If the vines are heavy, it may be well to disc the field before plowing. This method of control is very important and should not be overlooked. The plowing should be done as soon as the beans are picked, since any delay will allow some beetles to mature. If plowing is impractical in small gardens, the vines and weeds may be pulled up and burned or buried.

Thin planting is important for two reasons. The beans will grow more rapidly than they will if they are too thick, and, in addition, it is much easier to spray or dust a field of beans when thinly planted. Otherwise, it is almost impossible to do a thorough job with insecticides.

The time of planting is important. Early beans, planted the first part of May, escape serious damage until the first brood larvae begin feeding in June. Beans planted about June 15 usually escape first generation damage and are not attacked by the bean beetle until the first brood adults emerge about July 15. Although it is impractical to plant only at this time, a second planting of beans could be made then and escape much serious damage.

Dwarf beans are more easily protected by insecticides than pole beans, on account of the shorter growing season. Pole beans require about twice as many applications of dust or spray as dwarf varieties.

One very important consideration is protection of all the beans planted. No grower should plant more than he can spray or dust, since beans that cannot be treated will offer a breeding place for a large number of beetles that will attack the sprayed crops, and unsprayed beans will probably not be profitable on account of beetle damage. Spraying and dusting will be more effective and more profitable if there are no untreated vines nearby.

INSECTICIDES

The bean plant is unusually sensitive to arsenical poisons. For this reason it has been difficult to find a suitable insecticide for the control of the Mexican bean beetle. The pest itself is not particularly hard to kill, since it feeds externally and can be reached easily.

The material first recommended for bean beetle control was Paris green, but this injured the beans very severely and for that reason could not be used. Arsenate of lead was used in Colorado (26) and New Mexico (31) and was fairly satisfactory, although some damage resulted. Later investigations have shown that arsenate of lead reduces the yield, even though no visible injury develops. Howard and English (23) found that pure lead arsenate dust at the rate of 14 pounds to the acre reduced the yield 59 per cent. When diluted with nine parts of lime at the rate of 18 pounds to the acre, the reduction in yield was 15 per cent. In nine cases the yield was reduced, and the reduction ranged from 15 to 59 per cent, which depended on the amount of lime used. In four cases, there was an increase in yield. Calcium arsenate was not quite so injurious except when it was used without lime, gypsum or sulfur. Visible foliage injury occurred in most cases. Magnesium arsenate caused no visible injury, but a reduction in yield occurred in three cases. One of these was pure material and the other two were diluted with hydrated lime.

When the materials were used in sprays, the foliage injury was about the same as in the case of the dusts. The reductions in yield were not so marked because of a severe infestation of bean beetles.

On Long Island, Huckett (24) investigated the tolerance of beans to insecticides under conditions similar to those in southern Connecticut. His tests were made on plants not damaged by the Mexican bean beetle and therefore the results were not influenced by beetle injury. In his spraying tests, the materials were applied at the rate of three pounds of material to 100 gallons of water. In one series Kayso was used at three pounds to 100 gallons and in another 4-6-50 Bordeaux mixture was used with the insecticide. The sprays were applied three times at the rate of 200 to 220 gallons to the acre. The yield of beans obtained from two pickings is given in Table 13, which is abridged from Huckett's report.

TABLE 13. WEIGHT OF PODS IN POUNDS PER 100 PLANTS

Insecticidal ingredients	Kayso-water	Bordeaux mixture
Arsenicals		
Lead arsenate	4.28	4.52
Calcium arsenate	4.65	4.71
Magnesium arsenate	7.98	7.27
Fluosilicates		
Cryolite	7.62	7.33
Barium fluosilicate		
Brand D	7.54	7.12
Brand B	8.17	8.05
Brand G	8.18	7.19
No insecticide	7.83	6.25
No treatment	7.65	8.18

Huckett also gave figures on the weight of vines, which show similar effects. It is evident that both lead arsenate and calcium arsenate caused a marked decrease in yield, even when used with Bordeaux mixture.

In testing dust mixtures, hydrated lime was added to one series at the rate of four pounds to one pound of insecticide. In a second series, monohydrated copper sulfate, 15 parts, and hydrated lime, 85 parts, were used to dilute the insecticide. One pound of insecticide to four pounds of copper-lime constituted the mixture. This mixture is similar to proprietary calcium arsenate-copper-lime dusts. The dusts were applied three times at the rate of 40 pounds to the acre. In some cases the materials were applied to one group of vines wet with dew as compared with dry vines. Table 14 is abridged from Huckett's results. Some of these materials caused injury when dusted on wet plants and less injury on dry plants. However, lead arsenate and calcium arsenate were both injurious in every test. Magnesium arsenate was the best arsenical used, and barium fluosilicate was superior to cryolite.

Table 14. Weight of Pods in Pounds per 100 Plants

Insecticidal ingredients	Dust mixtures		
	Hydrated lime		Copper-lime
	Plants wet	Plants dry	
Arsenicals			
Lead arsenate	2.25	2.03	2.54
Calcium arsenate	.58	3.00	2.69
Magnesium arsenate	3.82	5.19	2.71
Fluosilicates			
Cryolite	2.76	4.20	3.51
Barium fluosilicate			
Brand D	4.02	5.03	4.66
Brand B	4.25	3.94	4.81
Brand G	7.12	3.83	7.90
No insecticide	4.06	6.95	5.00
No treatment	4.83	4.93	4.40

Since weather conditions on Long Island are similar to those of southern Connecticut, these results are important to growers in this state.

Magnesium arsenate is the only arsenical that can be used safely on beans under these conditions. Barium fluosilicate is as satisfactory as magnesium arsenate from the standpoint of injury to plants.

During the past 14 years many materials have been tried in an effort to control the bean beetle. It is not necessary to give a complete discussion of each of these, since most of them seriously injured the beans and were therefore impractical. Table 15 which was compiled from the literature, gives the materials used in a rough classification as to effectiveness in controlling the bean beetle and in injury to bean foliage.

Table 15. Effectiveness of Insecticides

Not effective in killing beetles

[1]Nicotine sulfate, 1 oz.—2 gals. (11)
Calcium fluosilicate (compound ?) (21)
Nicotine dust 4% (23)
Basic lead arsenate (23)
Hellebore (26)

[1]Used without soap.

Always injurious to bean foliage

Sodium arsenite (31)
Zinc arsenite (9, 11, 14, 18, 20, 23, 26)
Calcium arsenite (26)
London purple (14)
Paris green (9, 11, 16, 18, 26)
Arsenic sulfide (26)
Iron arsenate (26)
Lead arsenate (11, 14, 18, 20, 23, 24, 25, 26, 34)
Sodium fluoride (21)
Copper fluoride (21)
Sodium fluosilicate (14, 16, 21, 25, 27)

Occasionally injurious to bean foliage

Calcium arsenate (7, 9, 13, 14, 18, 19, 20, 21, 23, 24, 25, 26, 28, 30, 34).
Calcium arsenate, Bordeaux mixture } (9, 26)
Zinc arsenite, Bordeaux mixture } (9)

Usually safe on bean foliage

Magnesium arsenate (5, 7, 12, 13, 14, 16, 18, 19, 20, 21, 22, 23, 25, 26, 28, 30).
Barium fluosilicate (5, 14, 21, 24, 28, 30).
Cryolite (24, 27, 28, 30).
Calcium arsenate, Sulfur, Lime } (14, 16, 25, 34).
Monohydrated copper sulfate, Calcium arsenate, Lime } (5, 7, 12, 24, 34)

Results of Experiments in Connecticut

Since the work done on insecticides has shown that magnesium arsenate and barium fluosilicate are the most promising materials for bean beetle control, these two mixtures have been studied. A small plot of beans was planted for insecticide tests and by July 22 it was heavily infested by second brood larvae. Half the plot was sure crop wax, a dwarf wax bean, and half Fordhook bush lima. Two rows were treated with each material and suitable check rows were left untreated.

Three materials were used, as follows:

1.	Spray—Magnesium arsenate	2	pounds
	Casein-lime	3	"
	Water	100	gallons
2.	Dust —Magnesium arsenate	1	pound
	Hydrated lime	6	"
3.	Dust —Barium fluosilicate	1	pound
	Hydrated lime	6	"

The dusts were applied to the under surface of the leaves early in the morning when the wind did not interfere. The applications were made with a small plunger duster, with nozzle directed upwards. The sprays were applied with a four-foot rod and angle nozzle which was likewise directed upwards. No attempt was made to cover the upper surface of the leaves.

The materials were applied on August 6, 13, 18 and 31. The August 6 application was made when the young bean plants had five leaves. The adult beetles were feeding freely and a few egg-masses were present. The last application (August 31) was made when the young string beans were about three inches long. At this time injury to the check plots was very noticeable, but the foliage on the treated plots was not injured seriously.

The string beans were picked September 16, and the yield on the treated plots averaged about six pounds to the row. The check rows averaged one-half pound to the row. They had little foliage left, but the treated plots were still in good foliage. The plot that received the magnesium arsenate spray was almost free from injury, but the plot treated with magnesium arsenate dust showed some feeding. Plants dusted with barium fluosilicate were considerably injured. On October 9 the sprayed plot had much undamaged foliage, but the dusted plots were entirely defoliated. Each of these treatments was satisfactory in giving a crop of beans, but the spray was undoubtedly better than either of the dusts.

The lima beans were planted too late to yield a complete crop, so no yield records were kept. However, the appearance of the vines was practically the same as that of the string beans. The check plots were examined on October 9 and very few pods were found. The treated plots had numerous well-filled pods. There was no doubt that all the treatments were satisfactory in protecting the beans, but the sprayed plot retained its foliage a little longer than the dusted plots.

None of these materials caused any spray injury to the foliage in our experimental plots or in the field. A few growers used lead arsenate and most of them reported foliage injury, but some applied calcium arsenate with good results. A few dusted with proprietary mixtures containing copper, lime and calcium arsenate. These were very satisfactory, but are more expensive than dusts containing magnesium arsenate or barium fluosilicate and lime.

Growers in general had some difficulty in obtaining good results from insecticide treatments, but this was to be expected since the pest is a new one. Examinations in the field showed at least one important reason for failure in control in every case, namely, almost every grower waited until serious damage was done before applying an insecticide. When the larvae are small, they consume very little foliage and the injury is not conspicuous, but as they grow larger the injury becomes more evident. They are very easily killed when they are small, and treatment must be made at that time to be effective.

Many growers applied the poison to the upper surface of the leaves. Some adult beetles feed on the upper side, but most of the adults and all of the larvae feed on the under surface. Therefore the poison must be applied to the under surface to be most effective.

The material must be applied thoroughly in order to kill the insects. The exact amount used per acre is comparatively unimportant, but the operator should cover every leaf that can be reached by the poison. About 200 gallons of spray, or 40 pounds of dust, are required to treat an acre of full-grown beans. Less would be required on young beans.

As has been stated before, the beans should be thinned so that the spray or dust can be applied thoroughly. It is impossible to cover the foliage when the plants are very thick in the rows.

Number of Treatments

During the past season, no applications for over-wintering adults were necessary. The first application was needed about June 15 and the second was necessary about June 25. Two applications of spray or dust should be sufficient to protect early string beans. For later string beans, three applications of spray or four of dust should be applied, starting about July 20. The sprays should be applied about 10 days apart and the dusts one week apart.

Lima beans and pole beans require protection against both broods on account of the long growing seasons. Therefore, about five sprays or six dusts will be necessary.

Cost of Treatment

Estimates of the cost of spraying and dusting vary greatly. Howard and English (23) estimated the cost of spraying from $1.00 to $2.00 an acre for each application, and the cost of dusting $1.12 to $3.00 an acre for each application. These figures were obtained from the total cost of four treatments of bush beans drilled in rows three feet apart. The variations are due to differences in the cost of materials and type of machine used. The acreage expense was decreased when power machines were used. Marcovitch (28) gave the cost of power spraying as $1.30 to $1.75 an acre. With a bucket pump or compressed air sprayer, the expense came to about $2.40 an acre. Dusts applied with a rotary hand duster cost $1.50 an acre. Four applications of dust were required to equal three sprays in effectiveness. Cory, Sanders, and Henery (12) found that the cost of dusting varied from $1.04

to $2.91 an acre, depending on the amount of material used and the method. Hand dusting required two and one-fourth hours to cover one acre and a four-row duster one-half hour. A four-row sprayer required three-fourths of an hour to cover one acre, at a total cost of $1.78. These figures were taken from actual field operations conducted by commercial growers.

These figures show that dusting was usually more expensive than spraying, and also required a larger amount of insecticide. Treating an acre was considerably less expensive when four-row machines were used instead of hand-power machines. In estimating the cost, the price of the equipment was probably not included.

Equipment

Market gardeners who grow many beans will probably find it profitable to use a four-row sprayer or duster. These machines will do the work more economically than hand dusters or sprayers if the field is large and they are usually made so that the nozzles can be directed upwards to cover the under surface of the leaves. This type of machine is also adapted to use on celery, potatoes, and other vegetable crops.

For small plots of beans, a rotary hand duster or a bellows knapsack duster is sufficient. The nozzle should be adjustable so that it can be directed upwards. For very small gardens a knapsack sprayer is probably the best type, but the nozzle that comes with these sprayers should be replaced by a short rod and angle nozzle. A small barrel sprayer or wheelbarrow would be suitable for use on larger plots of beans, and with this a four-foot rod and angle nozzle should be used.

Recommendations

Since many growers have failed to apply enough material per acre to kill the beetles, less dilution of the insecticides is recommended for the 1932 season. The recommendations are as follows:

1. Spray—	Magnesium arsenate	3 pounds
	Casein lime	3 "
	Water	100 gallons
2. Dust —	Magnesium arsenate	1 pound
	Hydrated lime	5 "
3. Dust —	Barium fluosilicate	1 pound
	Hydrated lime	5 "

Proprietary Dusts

Many special dusts have been prepared by insecticide manufacturers for use against the bean beetle. Some of these are made by using combinations that have been found successful in controlling the pest. However, in most cases a large proportion of carrier is included so that the dust is ready for application. Many of them contain a fungicide that is not needed as a rule. Therefore, most growers will find it profitable to prepare their own dusts by mixing hydrated lime with the recommended materials.

Contact Insecticides

Pyrethrum-soap sprays may be used to kill bean beetles by contact. At present these are too expensive for field use, although they may be useful in small gardens. These sprays are not poisonous to man and for that reason can be used on string beans just before they are picked. The materials must hit the insects in order to kill them. They have no residual effect, but kill shortly after application. Several pyrethrum-soap sprays are on the market, and the amount of pyrethrum in them varies a great deal. The directions of the manufacturer must be followed in diluting.

Spray Residue

Both magnesium arsenate and barium fluosilicate are poisonous to man and for this reason some care must be taken in using them. If string beans are thoroughly protected until the first young beans are three or four inches long, they will usually mature a crop without further spraying or dusting. If spraying or dusting is necessary after the beans have formed, the beans should be washed thoroughly in two changes of clean water before they are sold. So far there has been no difficulty from poisonous residue on beans, but growers should be careful to avoid such residues.

If cowpeas, soy beans, or other such legumes grown for feeding livestock are seriously attacked by the bean beetle, they cannot be sprayed or dusted with poisonous materials. In such cases the legumes should be cut and cured before they are destroyed.

OTHER INSECTS INJURING BEAN FOLIAGE

The bean leaf beetle, *Cerotoma trifurcata* Forster (Figure 7), is occasionally a pest of beans in Connecticut. Britton (2) noted injury to string beans in 1918. The adult beetle feeds on native legumes such as *Meibomia* or tick trefoil and the larvae live on roots or stems below the surface of the ground. The adults appear in June and feed on the under side of the leaves, but the injury

(Figure 9) is of a different type than that caused by the Mexican bean beetle.

Adults of the Scarabaeid beetle, *Pachystethus lucicola* Fabricius,

FIGURE 7. Bean leaf beetle, five times enlarged.

FIGURE 8. Spotted cucumber beetle. Enlarged four times.

(Figure 10) were common on beans in July, 1931, in various parts of the state. These beetles fed on bean leaves, but apparently caused no serious damage. The injury is very different from injury caused

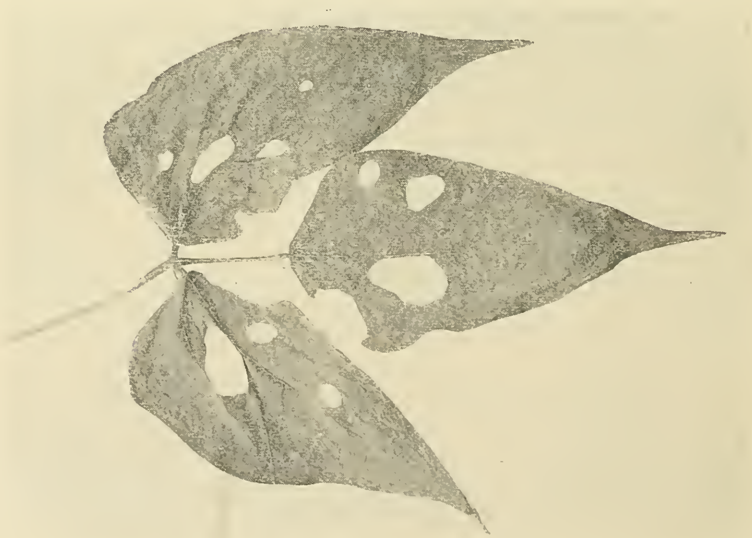

FIGURE 9. Bean leaf injured by bean leaf beetle. Reduced about one-half.

by the bean beetle. The *lucicola* beetles feed from the upper surface and do not skeletonize the leaves as the bean beetles do. Their injury is noticed as large holes in the leaves.

FIGURE 10. The Scarabaeid beetle. *Pachystethus lucicola*, a general feeder which occasionally feeds on beans. Twice natural size.

The spotted cucumber beetle, *Diabrotica duodecimpunctata* Olivier (Figure 8), is a minor pest of beans. This beetle feeds on the under surface of the leaves and causes a type of injury similar to adult bean beetle injury. The larva of this beetle is the southern corn root worm.

FIGURE 11. Larvae of the green clover worm feeding on a bean leaf. Natural size.

Striped cucumber beetles, *Diabrotica vittata* Fabricius, sometimes feed on young bean plants, skeletonizing the under surface of the leaves, but they are seldom severely injurious and usually attack only young plants.

The potato flea beetle, *Epitrix cucumeris* Harris, was found feeding on beans in Ledyard. The injury was similar to flea beetle injury on other plants.

The green clover worm, *Plathypena scabra* Fabricius (Figure 11), was present in Hamden in 1931, but caused no damage. According to Britton (1, 2), this worm was abundant enough to

FIGURE 12. The green soldier bug, *Acrosternum hilare*, a sucking insect which may attack beans. Twice natural size.

FIGURE 13. The Coreid bug, *Coriscus pilosulus*, a sucking insect which feeds on beans. Twice natural size.

cause serious injury in 1908 and 1919. The adult is a moth with a wing expanse of one to one and one-half inches. The fore wings are blackish or purplish brown in color, and the hind wings smoky brown without markings. The larvae feed on the under side of the bean leaves and are light green with darker green and fine white longitudinal stripes. When they are disturbed, they wriggle violently and either drop on silken threads or fall to the ground. This insect passes the winter in the adult stage. The eggs are laid singly on the under side of the leaves and hatch in from four to six days. The caterpillars mature in about 25 days and from 10 to 14 days are passed in the pupal stage. The pupae are found in the soil or in rolled leaves. There are two or three generations a year.

The green soldier bug, *Acrosternum hilare* Say (Figure 12), is a large green sucking insect that attacks various garden crops. It was common in 1931 in several places in the state. The adult bug is from one-half to three-fourths of an inch long, and bright green in color with the edges of the body having a yellowish border. In the cases in which it was observed on beans it was not particularly injurious.

The Coreid bug, *Coriscus pilosulus* Herrich-Schaeffer (Figure 13), was very abundant in one bean field in Thomaston. This is a black sucking insect about three-quarters of an inch long. Apparently it was not very injurious in this one case.

The black bean aphid, *Aphis rumicis* Linnaeus, frequently damages lima and broad Windsor beans. During 1931 it was abundant

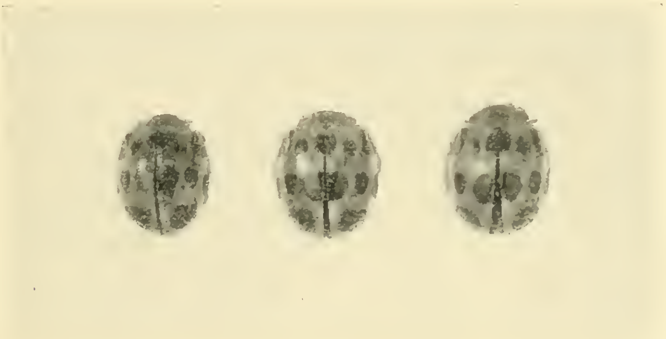

Figure 14. The squash lady beetle. Never feeds on beans. Twice natural size.

in many parts of the state. It passes the winter in the egg stage on deciduous shrubs, and migrates to other host plants in the spring. It is frequently abundant enough to cause injury.

The potato leafhopper, *Empoasca fabae* Harris, injured lima beans in many parts of the state in 1931. The injury was not especially severe. A pole bean, Burger's green pod, growing on the Station Farm, was seriously injured by this leafhopper. The leaves were badly curled and no beans matured. Another pole bean, early golden cluster, was damaged less severely.

The squash lady beetle, *Epilachna borealis* Fabricius (Figure 14), is sometimes seen on beans, especially if squash plants are growing nearby, but it will not feed on beans. It is larger than the Mexican bean beetle and has 12 large black spots on the wing-covers. The eggs and larvae are very similar to the eggs and larvae of the bean beetle.

SUMMARY

The Mexican bean beetle, a serious pest of garden beans, has been present in Connecticut since 1929. This insect is one of the two species of lady beetles which are injurious to plants in Connecticut. A description of the various stages is given. Although it feeds on several leguminous plants, garden beans are the favorite hosts and these are frequently killed by the insect.

The adult leaves its hibernating quarters late in May and early in June and lays its eggs on the leaves of bean plants. Both adults and larvae feed extensively on the foliage. The total developmental period from egg to adult requires from 33 to 39 days, and the total larval period is from 19 to 22 days in duration. The first generation of adults occurs from the middle of July until the last of August, and the second generation of adults occurs from the first of September until frost. These second generation adults hibernate under litter near the bean fields. A partial third generation may develop.

The climatic conditions in Connecticut appear to be favorable to the life of the bean beetle, and an abundant food supply is available. Certain parasitic and predaceous enemies prey upon the beetles to a limited extent, but no great degree of control is exercised. Cultural methods and insecticides must be relied upon to protect the plants. If properly applied, magnesium arsenate, either as a spray or dust, and barium fluosilicate, applied as a dust, will give good results. Other commonly used arsenicals injure bean foliage. The use of pyrethrum-soap sprays is recommended under certain conditions.

Brief mention is made of other insects injurious to the foliage of beans.

BIBLIOGRAPHY

(1) Britton, W. E. The green clover worm a pest of beans. In 8th Rpt. Conn. State Entomologist for **1908**: 828-832. 1909.

(2) Britton, W. E. Prevalence of green clover worm on beans. In 19th Rpt. Conn. State Entomologist for 1919, Conn. Agr. Expt. Sta. Bul. **218**: 165-170. 1920.

(3) Britton, W. E. The Mexican bean beetle in Connecticut. In 29th Rpt. Conn. State Entomologist, Conn. Agr. Expt. Sta. Bul. **315**: 581-585. 1930.

(4) Britton, W. E. Distribution of the Mexican bean beetle in Connecticut. In 30th Rpt. Conn. State Entomologist, Conn. Agr. Expt. Sta. Bul. **327**: 577. 1931.

(5) Burdette, R. C. The Mexican bean beetle. In Rpt. Dept. Ent. N. J. Agr. Expt. Sta. **1930**: 169. 1931.

(6) Cecil, R. The Mexican bean beetle. N. Y. (Geneva) Agr. Expt. Sta. Circ. **96**. 1928.

(7) Chapman, P. J. and Gould, G. E. The Mexican bean beetle in eastern Virginia. Va. Truck Expt. Sta. Bul. **65**. 1928.

(8) Chapman, P. J. and Gould, G. E. Plowing as an aid in Mexican bean beetle control. Jour. Econ. Ent., **23**: 149. 1930.

(9) Chittenden, F. H. The bean ladybird and its control. U. S. Dept. Agr. Farmer's Bul. **1074**. 1919.

(10) Chittenden, F. H. Evidence that the Mexican bean beetle was present in the United States as early as 1850. Proc. Ent. Soc. Wash., **26**: 19. 1924.

(11) Chittenden, F. H. and Marsh, H. O. The bean ladybird. U. S. Dept. Agr. Bul. **843**. 1920.

(12) Cory, E. N., Sanders, P. D., and Henery, W. T. Some phases of the Mexican bean beetle campaign. Jour. Econ. Ent., **23**: 146-149. 1930.

(13) Eddy, C. O. and Clarke, W. H. The Mexican bean beetle 1927-1928. S. C. Agr. Expt. Sta. Bul. **258**. 1929.

(14) Eddy, C. O. and McAllister, L. C., Jr. The Mexican bean beetle. S. C. Agr. Expt. Sta. Bul. **236**. 1927.

(15) Garman, H. The Mexican bean beetle in Kentucky. Ky. Agr. Expt. Sta., Circ. **31**. 1923.

(16) Guyton, T. L. and Knull, J. N. The Mexican bean beetle in Pennsylvania. Pa. Dept. Agr. Gen. Bul. **417**. 1925.

(17) Hamilton, C. C. The Mexican bean beetle and how to control it. N. J. Agr. Expt. Sta. Circ. **216**. 1929.

(18) Howard, N. F. The Mexican bean beetle in southeastern U. S. Jour. Econ. Ent., **15**:265-275. 1922.

(19) Howard, N. F. Control of the Mexican bean beetle in the eastern states. Quart. Bul. Miss. State Plant Board, **4**: 31-34. 1924.

(20) Howard, N. F. The Mexican bean beetle in the east. U. S. Dept. Agr. Farmer's Bul. **1407**. 1924.

(21) Howard, N. F. Some notes on the Mexican bean beetle problem. Jour. Econ. Ent., **21**: 178-182. 1928.

(22) Howard, N. F. and Brannon, L. W. The Mexican bean beetle and its control. Va. Truck Expt. Sta. Bul. **70**. 1930.

(23) Howard, N. F. and English, L. L. Studies of the Mexican bean beetle in the southeast. U. S. Dept. Agr. Bul. **1243**. 1924.

(24) Huckett, H. C. The tolerance of beans to sprays and dusts for the Mexican bean beetle. Jour. Econ. Ent., **24**: 200-204. 1931.

(25) Jewett, H. H. The Mexican bean beetle. Ky. Agr. Expt. Sta. Circ. **36**. 1927.

(26) List, G. M. The Mexican bean beetle. Colo. Agr. Expt. Sta. Bul. **271**. 1921.

(27) Marcovitch, S. Non-arsenicals for chewing insects. Jour. Econ. Ent., **18**: 122-128. 1925.

(28) Marcovitch, S. and Stanley, W. W. Cryolite and barium fluosilicate, their use as insecticides. Tenn. Agr. Expt. Sta. Bul. **140**. 1929.

(29) Marcovitch, S. and Stanley, W. W. The climatic limitations of the Mexican bean beetle. Ann. Ent. Soc. Amer., **23**: 666-686. 1930.

(30) Marcovitch, S. and Stanley, W. W. Two arsenical substitutes. Jour. Econ. Ent., **23**: 370-376. 1930.

(31) Merrill, D. E. The bean beetle *(Epilachna corrupta* Muls.) N. Mex. Agr. Expt. Sta. Bul. **106**. 1907.

(32) Riley, C. V. *Epilachna corrupta* as an injurious insect. In General Notes. Amer. Nat., **17**: 198-199. 1883.

(33) Sweetman, H. L. and Fernald, H. T. Ecological studies of the Mexican bean beetle. Mass. Agr. Expt. Sta. Bul. **261**. 1930.

(34) Thomas, F. L. Life history and control of the Mexican bean beetle. Ala. Polytechnical Institute Agr. Expt. Sta. Bul. **221**. 1924.

(35) Wilkinson, A. E. The vegetable industry of Connecticut. Conn. Agr. Col. Ext. Bul. **51**. 1922.