THE MEXICAN BEAN BEETLE IN MEXICO [1]

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INTRODUCTION

The Mexican bean beetle (*Epilachna corrupta* Muls.) is a destructive pest of beans in Mexico. Although this insect is apparently indigenous to the country and has a wide range of distribution, little is known

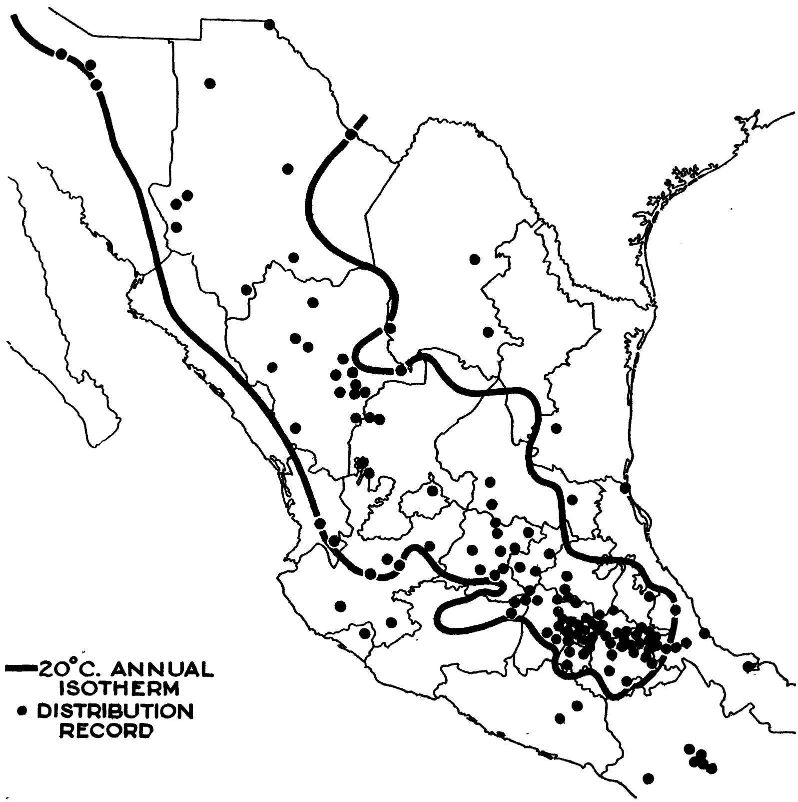

FIGURE 1.—Distribution of the Mexican bean beetle in Mexico.

concerning its biology. A study of the Mexican bean beetle was therefore undertaken at Mexico City in 1930.

[1] Received for publication Feb. 6, 1935; issued July 1935. This study was made at the suggestion of N. F. Howard, in charge of pea and bean insects, Division of Truck Crop and Garden Insect Investigations, Bureau of Entomology and Plant Quarantine. It was carried on in cooperation with the Mexican Department of Agriculture.
[2] Now with the Division of Fruit Insects.
[3] Thanks are due Alfonso Dampf, of the Mexican Department of Agriculture, for assistance in procuring altitude records and to Leopoldo de la Barreda for making unpublished distribution records available.

DISTRIBUTION

Although many legumes are grown in Mexico, beans seem to be the preferred food plant of the bean beetle. In the States of Guanajuato, Zacatecas, Jalisco, Michoácan, Aguascalientes, Queretaro, Durango, Puebla, Veracruz, and San Luis Potosí, where commercial acreages of beans are grown, the bean beetle causes destruction to the crop periodically. Dampf (*9*)[4] says that, in all parts of the Republic where beans are cultivated, agriculturists know the bean beetle as the most terrible pest of this legume, occasionally causing complete loss of the crop. This is contrary to Sweetman's statement (*11, p. 226*) that "The insect is not a serious pest over much of Guatemala and Mexico * * *." Beans are grown from sea level to an elevation of approximately 10,000 feet, but the most extensive cultivation is found within these States, principally on the broad, central plateau having an elevation of 1,500 to 2,000 feet in the north and 7,000 to 8,000 feet or more in the Valley of Mexico or the vicinity of Mexico City (fig. 1). The 20° C. isotherm roughly depicts the limits of this plateau.

TABLE 1.—*Localities in Mexico where the Mexican bean beetle has been recorded*

Locality	Altitude	Reference [1]
Federal District:	*Feet*	
Contreras	Over 7,500	X.
Mexico City	7,349	(*3*), X.
San Jacinto	7,349	(*7*), X.
Tacuba	7,349	R.
Xochimilco	7,349	X.
Mexico (State of):		
Acozac		(*3, 10*).
Amecameca	8,189	X.
Apasco [Apaxco]		(*8, Bol. 2, p. 558*).
Chalco	7,450	(*10*), X.
Chicoloapam		(*10*).
Hacienda del Prieto [Naucalpan]		R.
Lechería	Over 7,000	R.
Naucalpan		R (*Epilachna*).
San Andrés Atenco [Tlalnepantla]	Over 7,000	(*8, Bol. 3, p. 501*).
Temamatla		(*10*).
Temascalcingo		R.
Toluca	8,845	X.
Tenango	Over 8,000	(*10, 1*).
Texcoco	7,349	(*10*), X.
Zacualtipan, Estado General González		R.
Morelos:		
Cuautla	4,235	X.
Cuernavaca	5,059	X (*1*).
Puente de Ixtla	3,200	X.
Puebla:		
Acatzingo		R.
Actopan		(*10*).
Amozoc		(*8, Bol. 2, p. 559*).
Atlixco	6,171	(*1*), X.
Chalchicomula	8,333	(*8, Bol. 2, p. 558*).
Chiautzingo	7,516	(*7*).
Cholula	7,054	(*1*), X.
Cuetzalan del Progreso [Zacapoaxtla]		R.
Huejonapa [Huejonapan]		R.
Huixcotla-Tecamachalco	6,742	R, (*10, 3*).
Malpaís		(*8, Bol. 2, p. 558*).
Matamoros Izúcar	4,350	(*1*).
Nopalucan, Hacienda de "La Florista"		(*8, Bol. 2, p. 332; 10*).
Puebla	7,093	(*1, 3*), X.
Quecholac		R.
Rancho de San Cayetano, Tecamachalco		(*3, 10*).
San Cristóbal, Texmelucan		R.
San Hipolito		(*8, Bol. 3, p. 245*).

[1] Numbers refer to literature cited from which records were obtained, the volume and page number being given where confusion might arise; X indicates observations made by the authors; and R indicates records from the files of the Mexican Department of Agriculture.

[4] Reference is made by number (italic) to Literature Cited, p. 1001.

TABLE 1.—*Localities in Mexico where the Mexican bean beetle has been recorded*—Continued

Locality	Altitude	Reference
Puebla—Continued.	*Feet*	
San Jerónimo Xayacatlán		R.
San Marcos		(*10, 3*).
San Martín Texmelucan		R.
Santa Ana Coapan [near Puebla]		(*8, Bol. 3, p. 245*).
Tecali		(*10, 3*), R.
Tepatlaxco		R.
Tepeaca	7,405	(*8, Bol. 2, p. 332*).
Texmelucan		(*8, Bol. 3, p. 501*).
Tlaixpan		R.
Tlalancaleca		(*8, Bol. 2, p. 848*).
Veracruz:		
Córdoba	2,756	(*1*).
Jalapa	4,681	(*1*), X.
La Charca Atoyac	Nearly 1,500	R.
Orizaba	4,212	(*1*).
San Andrés Tuxtla	1,184	R.
Veracruz	6	(*7, p. 248*)[1].
Guerrero:		
Chilpancingo	4,461	(*1*).
Omilteme [Rancho de, Chilpancingo?]		(*1*).
San Marcos		R.
Xucumanatlan		(*1*).
Oaxaca:		
Guelavía, Distrito Tlacolula	Over 5,000	R.
Juquila		(*1*).
Matatlán, Distrito Tlacolula	Over 5,000	R.
Oaxaca City	5,068	(*1*), X.
Quiavini, Distrito Tlacolula	Over 5,000	R.
San Marcos Tlapasola, Distrito Tlacolula	Over 5,000	R.
Hidalgo:		
Bomintzá		(*7*).
Mixquiahuala de Juárez		R.
Rancho del Refugio Atotonilco de Tula		R.
Tepeji del Río		(*7*).
Tula	6,778	(*8, Bol. 3, p. 501*).
Queretaro:		
Cadereyta de Montes	6,814	R.
Querétaro	6,079	(*3*).
San Juan del Río	6,489	(*7*).
Michoacan:		
Aporo		R.
Maravatío	6,824	(*10, 3*).
San Andres Coru		R.
San Miguel el Alto		R.
Nayarit:		
Chapalilla		(*8, Bol. 2, p. 559*).
Tepic	3,067	(*8, Bol. 3, p. 501*).
Colima:		
Colima City	1,656	R (*Epilachna*).
Guanajuato:		
Allende [San Miguel Allende]	6,135	R (*Epilachna*).
Celaya	5,931	R.
Dolores Hidalgo	6,519	R.
Guanajuato	6,725	(*1; 8, Bol. 2, p. 559*).
Hacienda de Carrancí [Cortazar]		(*3, 10*).
Hacienda de Noria de Charcas, San José de Iturbide		(*10*).
Salamanca	5,646	(*10*).
San Diego de la Unión		(*8, Bol. 2, p. 848*).
San José de Iturbide		(*10*).
San Luis de la Paz		R.
Taranandacuau [Tarandacuao?]		R.
Jalisco:		
Guadalajara	4,987	X.
Hacienda de Las Pilas		(*10*).
Huejuquilla el Alto		R.
La Grulla Autlán		R.
Mezquital		R.
Orendain [near Refugio]		(*8, Bol. 2, p. 558*).
San Martín Hidalgo		R.[2]
Villa de Guadalupe		(*10, 3*).
Aguascalientes:		
Rincón de Romos		(*10*).
San Luis Potosí:		
Estación Micos		(*8, Bol. 2, p. 148*).
Hacienda de Bleados [Bledos]		(*1*).
Alvarez Mountains		(*1*).
San Luis Potosí	6,158	R (*8, Bol. 3, p. 501*).

[2]Doubtful record. There is no certainty that *Epilachna corrupta* is the species to which reference is made.

TABLE 1.—*Localities in Mexico where the Mexican bean beetle has been recorded*—Continued

Locality	Altitude	Reference
Tamaulipas:	*Feet*	
Ciudad Ocampo	1,142	(*10*, *3*).
Tampico	3	(*11*).
Durango:		
Barrazas	Nearly 6,696	(*8*, *Bol. 3*, *p. 501*).
Canacatlan [Canatlán]		R.
Durango	6,197	(*7*), R.
Hacienda de El Salto [Pueblo Nuevo]		R.
Nombre de Dios	Nearly 6,500	(*10*).
Pánuco de Coronado		(*10*).
San Bartolo		(*10*).
San Bernardo el Oro		(*10*).
San Gabriel		(*10*).
San Juan de Guadalupe	Nearly 5,000	(*10*).
San Juan del Río		(*10*).
San Pedro Otáez		(*8*, *Bol. 3*, *p. 501*).
Santiago Papasquiaro	6,696	R.
Suchil		R.
Tepehuanes		(*8*, *Bol. 3*, *p. 501*).
Villa General Vicente Guerrero		(*8*, *Bol. 3*, *p. 501*).
Coahuila:		
Monclova	1,758	(*1*).
Saltillo	5,246	(*1*).
Section around Torreón	3,641	(*8*, *Bol. 2*, *p. 558*).
Chihuahua:		
Batopilas [Batopilillas]	5,105	R.
Casas Grandes	Nearly 4,777	R.
Chihuahua	1,564	(*1*; *8*, *Bol. 2*, *p. 558*).
Chínipas	Over 5,000	R.
Ciudad Juárez	3,753	R.
Hacienda de San Simón Guadalupe y Calvo		R.
Hidalgo del Parral	5,449	R.
Ojinaga	2,759	R.
Yoquivo [Real Yoquivo]		R.
Sonora:		
Atil		(*7*).
Cucurpe		(*10*).
Estación Esqueda		R.
Magdalena	2,595	(*10*).
Tlaxcala:		
Calpulálpan		(*1*).
Contla		(*7*, *p. 128*) [2].
San Bartolo Tepujahualco [Tepeyahualco]		R.
San Pablo del Monte		R.
Zacatecas:		
Canutillo		(*8*, *Bol. 3*, *p. 501*).
Sombrerete		(*8*, *Bol. 3*, *p. 501*).
Unknown localities:		
Hacienda del Rincón		(*3*).
Presidio		(*1*).

[2] Doubtful record. There is no certainty that *Epilachna corrupta* is the species to which reference is made.

Locality records from the Biologia Centrali-Americana (*1*), unpublished records and publications of the Mexican Department of Agriculture (*7*, *8*, *9*, *10*), and field observations of the writers have shown the bean beetle to be present in 22 States and the Federal District (table 1). These records are not complete, but they show the wide distribution of the insect in the better known parts of Mexico. Unfortunately it has been impossible to procure altitude records for all the places in which the Mexican bean beetle has been found. However, it may be noted from the altitudes given that most of these places are from 5,000 to 7,000 or more feet above sea level. The extremes of elevation are 3 feet at Tampico, Tamaulipas, and 8,845 feet at Toluca, Mexico. Most of the records came from the States of Mexico, Puebla, Durango, Guanajuato, and Chihuahua, all of which are situated on the central plateau. Whether this is due to the fact that more beans are grown in these States and hence more people report damage, or whether the damage actually is greater there than elsewhere, is not known.

Uvarov (*12, p. 130*) states: "This beetle is a serious pest in the parts of Mexico which have a hot and very damp climate * * *." However, with the exception of infestations reported from the vicinity of Tampico, Tamaulipas,[5] Colima, Colima, and Veracruz, and possibly San Andres Tuxtla and La Charca Atoyac, Veracruz, the bean beetle does not appear to be present in the hot, damp coastal regions. Were it present or doing considerable damage, we should expect to find more records from the State of Veracruz, where commercial acreages of beans are grown.

SEASONAL ACTIVITY

At various times during the growing season of 1930 a few localities outside of the Federal District were visited in order that the situation as to bean beetle infestation might be ascertained. The results of these visits are summarized in table 2.

TABLE 2.—*Mexican bean beetle infestation in various localities in Mexico on different dates in 1930*

Date	Place	Elevation	Bean beetle situation
		Feet	
Apr. 28	Tampico, Tamaulipas [1]	3	No beans growing.
June 5	Veracruz, Veracruz [1]	6	Beans not infested.
6	Jalapa, Veracruz [1]	4,681	One adult beetle taken.
11	Puente de Ixtla, Morelos	3,200	Beetles found.
15	Monterrey, Neuvo Leon	1,771	No beans found.
17	San Luis Potosi, San Luis Potosi [1]	6,158	Do.
July 1	Cordoba, Veracruz [1]	2,756	Do.
4	Cuernavaca, Morelos [1]	5,059	All stages; severe damage.
9	Chilpancingo, Guerrero [1]	4,461	No beans found.
10	Acapulco, Guerrero	3	Do.
16	Cholulu, Puebla [1]	7,054	All stages; severe damage.
	Atlixco, Puebla [1]	6,171	Do.
Aug. 8	Guadalajara, Jalisco	4,987	Few larvae taken.
22	Oaxaca City, Oaxaca [1]	5,068	Young beetles and few larvae found.

[1] The bean beetle has been reported from this place (table 1).

In sections where there is a pronounced dry season, the bean beetle is present in the fields only during the wet summer months. There is considerable variation in annual precipitation within the area of known bean beetle distribution. In the vicinity of Jalapa and Cordoba it ranges from 60 to 85 inches and is distributed throughout the spring, summer, and fall. Around Torreon, in northern Mexico, the rainfall is only about 10 inches, and this occurs almost entirely during the summer months. In general, the period of summer rainfall is shorter and the precipitation less as the elevation and distance inland, northward, and westward from the Jalapa-Cordoba district increase.

A climograph (hythergraph) for Mexico City published by Graf (*2*) shows that the monthly temperature rises rapidly from January to May and declines during the 4 rainy months that follow. If temperature is the deciding factor in breaking the dormancy of the bean beetle, we should expect to find the beetle on beans grown under

[5] ROBLEDO, F. G. OUTSTANDING ENTOMOLOGICAL FEATURES FOR MEXICO FROM JANUARY TO JUNE 1931. U. S. Dept. Agr., Bur. Ent. Insect Pest Survey Bull. 11:412–416. 1931. [Mimeographed.]

irrigation during April and May in Cuernavaca, since similar temperature changes occur there. The fact that the bean beetle does not appear in Cuernavaca and Mexico City until the summer rainy season indicates that moisture and increasing temperature furnish the stimulus required to bring the beetles from localities where they have passed the dormant period. The small summer crop of beans is grown in Cuernavaca without irrigation, and all the plants are defoliated by the beetle.

In 1929 some beans that had been planted in a protected spot at the Mexico City laboratory escaped the October frosts. Beetles and larvae migrated to these plants from other beans that had been killed by defoliation and frost. A sprinkler was used for several hours each day in order to maintain a high humidity. Beetles remained on these plants, and all stages of the insect were found there as late as February 3, when the observations were discontinued. This was 4 months after their normal occurrence in the field. Later work by the senior author in Columbus, Ohio, has shown that the bean beetle can easily be reared through the winter months under greenhouse conditions.

CLIMATE OF MEXICO CITY

According to Marcovitch and Stanley (*5, p. 676*):

> During July and August, the months most favorable for bean growing, maximum temperatures of but 70° F. are reached in Mexico City (Hernandez, 1923). * * * May, the hottest month in the year, has a maximum temperature of but 75° F. These comparatively low temperatures and the generous rainfall of 16 inches for the summer months, are the climatic conditions the bean beetle has been exposed to for numberless generations and undoubtedly present the optimum requirements for breeding.

In another place (*4*) Marcovitch gives the mean summer temperature as 60° to 65° F. and the rainfall as 4 inches.

An atlas published by the Mexican Department of Agriculture (*6*) summarizes the temperature records [6] taken at the Tacubaya (Federal District) station (about 4 miles from San Jacinto and at a slightly higher elevation) for the period 1921–25. The mean daily temperatures were as follows: March, 17.8° C.; April, 17.1° C.; May, 17.6° C.; June, 16.4° C.; July, 15.4° C.; August, 15.7° C. The maximum temperatures are not given, but the mean temperatures indicate that the maximum temperatures were higher than those given by Marcovitch and Stanley (*5*). The same atlas (*6*) shows that the total precipitation at the Tacubaya station, as averaged for 1921–25, was 411.4 mm for June, July, and August, and 582.2 mm for the 4 months from June to September, inclusive. The records for San Jacinto (*6*), within a quarter of a mile from the place in which the present studies were made, for the same periods were 356.5 and 492.3 mm, respectively.

Thus there are several conflicting records for the precipitation and temperature in the vicinity of Mexico City. This may be due to the fact that there are several meteorological stations in the Federal District, which might be designated as Mexico City, and the records of these stations vary considerably although they are less than 4 or 5 miles apart. It is, however, incorrect to base conclusions concerning the natural habitat of *Epilachna corrupta* on such information.

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[6] Obtained by taking the mean of the maximum and minimum daily temperatures and averaging them to get the monthly mean temperature.

In 1930 the writers placed a sheltered hygrothermograph 12 inches above ground in the middle of a bean field where life-history studies were being made. A summary of the temperature records taken on this instrument from July 1 to September 30, as given in table 3, indicates that the mean maximum temperature for the summer months was above 25° C. The weather that year was normal. The maximum daily temperature was recorded at about 2 p. m. and was maintained for but a short time. After the daily rain the temperature dropped rapidly until about 4 a. m.

TABLE 3.—*Summary of daily temperature records at Mexico City (San Jacinto), July 1 to September 30, 1930*

Record	July	August	September	For 3 months
	°C.	*°C.*	*°C.*	*°C.*
Maximum:				
High	30.0	30.0	34.5	
Low	23.0	20.0	25.0	
Mean	25.7	27.1	29.9	27.8
Minimum:				
High	14.0	13.0	13.0	
Low	8.0	7.0	2.5	
Mean	11.3	9.7	9.1	10.1
Daily mean:				
High [1]	19.2	19.4	20.1	
Low [1]	14.6	14.9	14.9	
Monthly mean	16.7	17.2	17.7	17.2

[1] Summary of readings at 2-hour intervals.

The beginning of the rainy season of 1930, like that of 1929, preceded the emergence of the beetles from dormancy by approximately 2 weeks. During this season there was, as a rule, some precipitation every day, usually late in the afternoon or in the evening. The daily average relative humidity was close to 70 percent and showed little variation from early in June until the middle of September, when the rains became less frequent.

Other environmental factors, such as light and barometric pressure, may have more than a minor influence, directly or indirectly, on the bean beetle. At the altitude and latitude of Mexico City the sunlight is intense and contains more ultraviolet than at higher altitudes. At this altitude (7,349 feet) the mean barometric pressure is only 23.43 inches.

The writers consider that the field data obtained on the temperature and the number of generations a year do not indicate optimum climatic conditions for breeding the bean beetle. The low daily mean temperatures preclude the development of more than a single generation of *Epilachna corrupta* in the vicinity of Mexico City. Marcovitch and Stanley, after saying (*5, p. 676*) that climatic conditions in Mexico present "optimum requirements for breeding", also say (*5, p. 769*) that "At 25° C. the greatest percentage reached maturity, so that this temperature may be considered as the optimum." The work reported in this paper will show that 25° is more likely to be the optimum temperature than the temperatures that prevail in Mexico City.

EXTENT OF BEAN BEETLE INFESTATIONS IN VICINITY OF MEXICO CITY

The severest infestations in the vicinity of Mexico City in 1929 and 1930 were found in a large, dry lake bed between the villages of Mixquit and Chalco, 33 miles southeast of Mexico City. The soil here is alkaline and of a fine, silty texture. Mountains are not far distant. Each year this lake bed is planted to corn and interplanted with beans. There was considerable variation in the degree of infestation in this lake bed; in some places the plants were completely defoliated while in others there was little or no injury. It is estimated that less than half the plants showed any great injury. This variation did not seem to be due to any difference in the varieties of beans

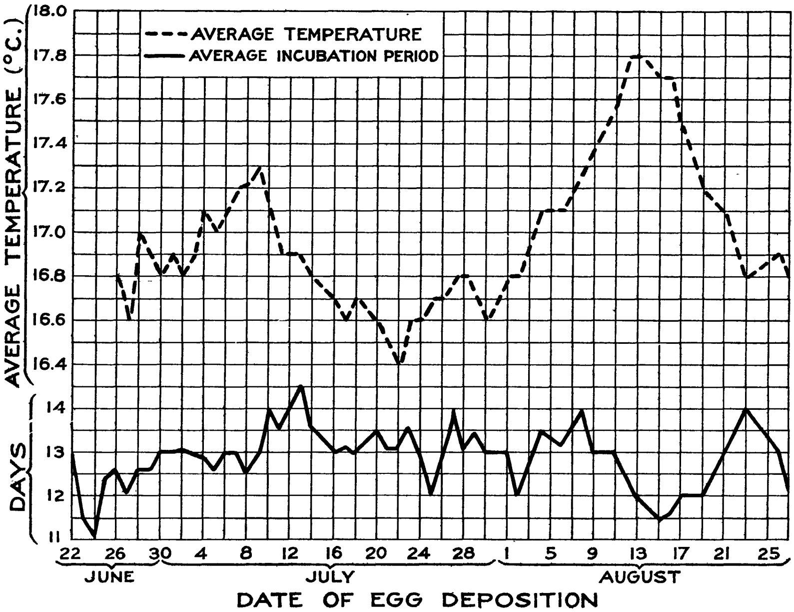

FIGURE 2.—Relation between the length of the incubation period of egg masses of the Mexican bean beetle and the temperature. The lower curve shows the average number of days required for the incubation of varying numbers of egg masses deposited each day during the season; the upper curve shows the average temperature during each of these incubation periods.

grown or to differences in soil or location. Other localities more remote from Mexico City showed more damage than was noted here.

LIFE-HISTORY STUDIES

Life-history studies were conducted in a field near the laboratory under conditions as nearly normal as possible. A wire-screen cylinder, 12 inches high and 8 inches in diameter, covered at one end, was inverted over a bean plant on which a pair of beetles had been placed. After an egg mass had been deposited on a leaf, the beetles were moved to another plant. Twelve pairs of beetles were kept under observation in this manner throughout the season. Each cage was observed daily, and records were continued until all the adults of the new generation had emerged.

OVIPOSITION

The first egg mass of the season was obtained the first week of June. The population of beetles in the field continued to increase until late in June, when the maximum number of adults that had passed the dormant period were found. The females continued to oviposit well into September, although by that time they were very much reduced in number. As the season advanced, the intervals between the successive depositions of egg masses became longer. A total of 148 egg masses was deposited, each mass containing from 5 to 60 eggs, the average being 49.73 ± 0.81 eggs.[7]

INCUBATION PERIOD

The length of the incubation period and its relation to temperature are shown in figure 2, in which are plotted the average time required for incubation of varying numbers of egg masses deposited on successive days and the average temperature during the incubation of egg masses deposited each day. For example, the average length of the incubation period of the 7 egg masses deposited on June 29 was 12.6 days, and the average daily mean temperature for this period was 16.9° C.

The incubation period is shown to range in length from 11.1 to 14.6 days. One egg mass, deposited on July 13, had an incubation period of 15 days, and 4 egg masses, deposited on June 23 and 24 and August 15 and 16, had incubation periods of 11 days, but such extremes were reduced by averaging them with records for other egg masses deposited on the same day. The average length of the incubation period for 148 egg masses was 12.94 ± 0.06 days. The average daily mean temperature for the season (June 26 to Sept. 7, inclusive) during which the incubation period was studied was 16.9° C. and the average relative humidity was 72.1 percent.

LARVAL PERIOD

In a similar way the length of the larval period and its relation to temperature are shown in figure 3. The average length of this period ranges from 36 days for eggs hatching on July 7 to 29.2 days for eggs hatching on August 14. The extremes, which are not shown when the average for the larvae in several cages is taken, are 37.2 days for an egg mass hatching July 4 and 28.0 days for an egg mass hatching August 14. The curve showing the length of the larval period has many irregularities that cannot be ascribed to variations in temperature but are probably due to the fact that the larvae may move about and may be shaded more or less by foliage on the plants. This means that the larvae are not always exposed to temperatures recorded on the thermograph. The average length of time spent in this stage of development, as determined from 127 cages containing 2,645 larvae, was 32.79 ± 0.14 days. The average mean daily temperature for the entire larval period, June 26 to September 30, was 17.2° C.; the average relative humidity was 69.7 percent.

[7] Throughout this paper the standard error of the mean is used and not the probable error.

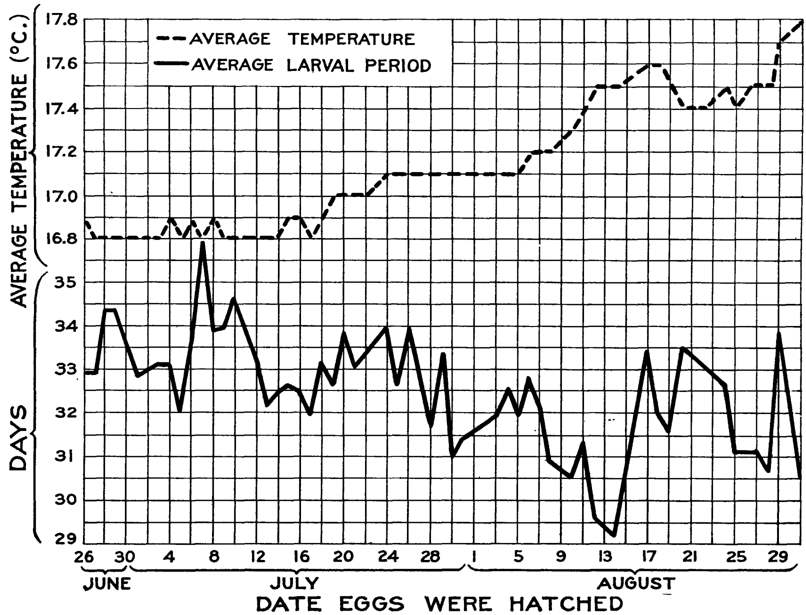

FIGURE 3.—Relation between the length of the larval period of the Mexican bean beetle and the temperature. The lower curve shows the average number of days required for the larval period of individuals from egg masses hatching each day during the season; the upper curve shows the average temperature during each of these periods.

The data concerning the length of time spent in the several instars, the prepupal period, and the total larval period are shown in table 4.

TABLE 4.—*Length of instars and prepupal and larval periods of Epilachna corrupta, San Jacinto, 1930*

Instar and period	Cages	Individuals	Length of period, based on the cage as a unit		
			Maximum	Minimum	Average
	Number	*Number*	*Days*	*Days*	*Days*
Entire larval period	127	2,645	37.2	28	32.79±0.14
First instar	96	2,667	10	6	7.75± .09
Second instar	90	2,463	9	5	6.12± .08
Third instar	81	2,144	9	5	6.71± .12
Fourth instar less prepupal period	70	1,421	11	6.9	8.45± .11
Fourth instar including prepural period	78	1,605	15.7	9	12.24± .12
Prepupal period	122	2,556	5.3	2.2	3.9± .05

PUPAL PERIOD

The length of the pupal period and its relation to temperature are shown in figure 4. The length of this period ranged from 9 to 12.6 days, but there were extremes of 13 days (individuals entering this period on Aug. 27) and 9 days (individuals entering this period on Sept. 22) when separate cages are taken into account. The average for 119 cages containing 2,090 pupae was 11.33±0.08 days. The average daily mean temperature for the time pupae were studied (July 26 to Oct. 4, inclusive) was 17.4° C.; the average relative humidity, 67.3 percent. Since the pupal period is shorter and the pupae remain fixed on the under surface of the leaves, the trend in temperature and its relation to the length of the pupal period are shown more clearly than for either the incubation period or the larval period. There are, however, several departures from the general trend that cannot be explained on the basis of temperature.

ENTIRE DEVELOPMENTAL PERIOD

One generation of *Epilachna corrupta* developed at Mexico City (San Jacinto) in an average of 56.74±0.21 days. The extremes were 61.8 and 50 days. These records represent 1,687 beetles contained in 94 cages. The average temperature for the 102-day period from June 26 to October 5, inclusive, was 17.2° C., and the average relative humidity was 66.6 percent. A total of 2,097 adults, including

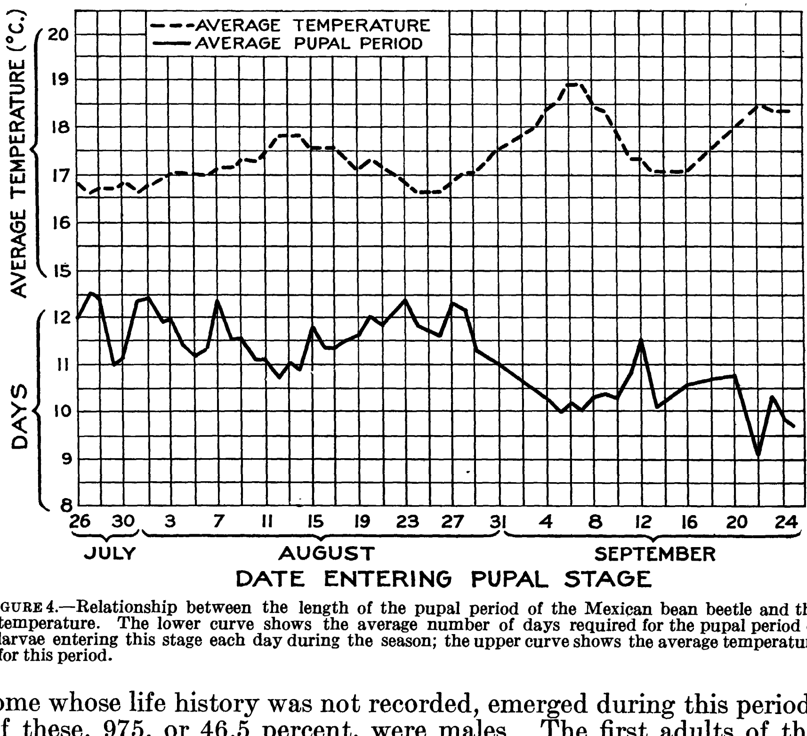

FIGURE 4.—Relationship between the length of the pupal period of the Mexican bean beetle and the temperature. The lower curve shows the average number of days required for the pupal period of larvae entering this stage each day during the season; the upper curve shows the average temperature for this period.

some whose life history was not recorded, emerged during this period. Of these, 975, or 46.5 percent, were males. The first adults of the season appeared July 26, 1930. Marcovitch and Stanley (*5*) determined the length of the developmental period of the bean beetle in the laboratory at four constant temperatures. If a curve is drawn to represent their results at these temperatures (fig. 5), the writers' figure for the total period of development from egg to adult (56 days) will pass through this curve.

BEHAVIOR LATE IN THE SEASON

Seven female and six male beetles that emerged August 8 were placed in a cage for observation. The beetles fed ravenously, but there was no oviposition until August 26, when a mass of 5 eggs was recorded. Four scattered eggs were laid September 5, and a mass of

31 was deposited September 12. The beetles consumed less and less foliage, and in the second week of September they ceased feeding altogether. Thereafter they remained in a state of torpor in protected places on the plant. The beetles were completely bronzed during this period.

OVERWINTERING

Beetles can be found in the fields until the frosts of early October destroy the plants. It is a matter of conjecture where the beetles pass the dry season from October until June. E. G. Smyth [8] reports the natives as saying that swarms of adults were seen to rise from the fields when there was no longer food and that they were carried off by the wind. Alfonso Dampf found an adult bean beetle in wheat stubble on the grounds of the Mexican Department of Agriculture in the winter of 1928.

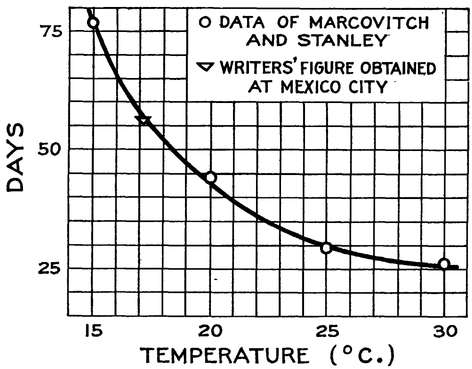

FIGURE. 5.—Relationship between the length of the total developmental period of the Mexican bean beetle at constant temperature as determined by Marcovitch and Stanley (*5*) in Knoxville, Tenn., and also as determined by the present writers under field conditions in San Jacinto, Mexico.

SUMMARY AND CONCLUSIONS

The Mexican bean beetle (*Epilachna corrupta* Muls.), a widely distributed and destructive pest of beans in Mexico, has been recorded from elevations ranging from 3 to 8,845 feet, chiefly within the area delimited by the 20° C. isotherm, which includes most of the central plateau of Mexico. Precipitation and extremes of temperature within this area vary considerably. The effects of these factors on the development of the bean beetle have been determined only in Mexico City.

Severe damage caused by this insect was observed at Atlixco, Puebla (6,171 feet), and at Cuernavaca, Morelos (5,059 feet). In the vicinity of Mexico City the heaviest infestation was found near the villages of Mixquit and Chalco, but less than half of the plants showed any serious injury.

Life-history studies made near Mexico City under field conditions show the length of time spent in each developmental stage throughout the season and its relation to the temperature. One generation of bean beetles matured in an average of 56.74 ± 0.21 days at a mean

[8] Correspondence with N. F. Howard, 1923.

temperature of 17.2° C. and an average relative humidity of 66.6 percent.

Apparently the destruction of the bean plants by frost has much to do with the disappearance of the adult insects from the fields in the fall. In one instance beetles continued to feed and oviposit 4 months beyond the time of their natural occurrence in the field. This was probably due to the favorable temperature and humidity maintained in a protected spot where beans were grown. It is not known where and how the adults pass the dry season in Mexico.

Optimum conditions for the bean beetle are not found in the Valley of Mexico, if we consider temperature, number of generations, and injury done to beans.

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