The Morphology and Biology of the Mexican Bean Beetle, Epilachna corrupta.

by

Arthur E. Mallory

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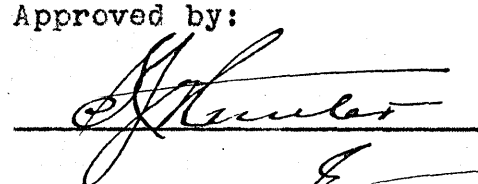
Approved by:



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Introduction

In the semi-arid regions of the southwest the Mexican Bean Beetle is a very important pest of the bean crop. During the season of 1919 it was the author's privilege to make some careful observations on the life economy of this insect while employed by the United States Bureau of Entomology, and later to make a study in some detail of its morphology.

The Mexican bean beetle belongs to the highly beneficial ladybird family, Coccinellidae. It is one of the very few species of this family known to feed from choice upon vegetation. Other members of this family are among our most beneficial predatory insects, feeding almost exclusively upon plant lice, scale insects, soft bodied larvae, and insects eggs. This particular species has chosen the bean as its food and has become a pest of major importance. In a few widely separated localities of the United States it is to the bean crop what the Colorado Potato Beetle is to the potato crop, a most significant pest in the region which it inhabits. It is far more difficult to control than its striped neighbor because of the susceptibility of the bean plant to injury from the use of arsenical sprays.

I am indebted to Professor S. J. Hunter and Dr. H. B. Hungerford for their enthusiasm, encouragement,

and helpful suggestions, which made this paper possible; to Dr. B. P. Lawson for his interest and help with the work; to Mr. C. Howard Curran, Mr. W. H. Brown, Mr. J. L. Bruer, for many kindly courtesies while in the laboratory; to Dr. H. G. MacMillan of Greeley, Colorado for taking the photographs; to Mr. Philip Readio for photographing my drawing, and to Prof. W. H. Hargrove and Prof. F. A. Ogle of Greeley, Colorado for their aid in securing live material.

History

This insect has been known by various common names such as "spotted bean-beetle", "bean bug", "bean beetle", "bean ladybird", and "Mexican bean beetle", any one of which would be quite appropriate. Since the last named title has appeared in several official publications it is quite likely it will become the established name. It is the name that will be used in this paper.

According to Leng (23)* in his catalog of Coleoptera of North America the original description of the Mexican bean beetle was by Mulsant (27) in 1850. It was described from Mexico as Epilachna corrupta, and according to J. F. Wielandy (34) its injuries were observed in New Mexico at about the same period.

In 1859 Dr. J. L. LeConte catalogued Epilachna corrupta from eastern New Mexico. The description by

*Numbers refer to corresponding number in Bibliography at the end of this paper.

Bland (1, p. 256) in 1864 of Epilachna maculaventris is undoubtedly this same species and is so listed by Leng (23) in his catalog of Coleoptera mentioned above.

In 1883 Drs. LeConte and Horne (22 p. 118) in their Classification of Coleoptera of North America, after a description of the genus, state....."The genus extends from the Eastern States to Arizona where Epilachna mexicana occurs, but has not occured in maratime California, although Epilachna corrupta has occured at Lake Tahoe. In this same year Professor George H. Stone (29 p. 198) writes to C. V. Riley, then Government Entomologist, as follows: "By this mail I am sending you a tin box containing larvae and perfect beetles, which promise to have as unenviable a reputation as Doryphora 10-lineata. From egg to the grave they are voracious. They are good judges of food. With me they have confined their attack to black wax beans and enclosed leaves and pods show their mode of attack. The early broods ate nearly all kinds of vegetables in a neighboring garden. They are rapidly spreading in the vicinity. I judge there are two or three broods each year like Doryphora. The adult beetles are not so active as their ten lined relatives however. They do not drop when the plant is shaken, so readily as the potato beetle. I have had but little chance to study them as they appeared only a few days ago. Within that time they have eaten almost every leaf on a good sized patch of wax beans, and today I have made arrangements to have them all picked

by hand, so they shall not have a chance to hibernate." (August 26, 1883).

The above letter contains our first known account of the food and injurious habits of this species.

J. F. Wielandy (34 p. 113-115 and 34 p. 121) writing to the United States Bureau of Entomology mentions this insect several times, and describes at some length its appearance, depredations, and habits as follows:

Extracts from First Letter.-Springer, New Mexico, July 23, 1889....."I have described this plant (referring to Convolvulus) so particularly because the larger of two species of bugs, which is of a paler color and with fewer less marked black dots (the one in the small box), is found in large quantities on the plants and the Mexicans have an idea, whether correct or not (of this I am no judge because I am not an entomologist), that the frijole chinch (the smaller bug in the square box), which is the destructive bug that preys on the beans, originates from the other. The convolvulus bug appears early in the spring. I gathered it on plants myself in May. The bean bug appears in July. The bean bug commits great depredations on bean fields, often destroying them entirely. The only means the Mexicans have found to somewhat prevent its ravages is to plant their beans late, about the middle of July, the bug appearing to swarm in smaller numbers later in the season. The chief season for the

Mexican bean bug seems to be from the middle of July to the first of September----------.

The reply from the United States Bureau of Entomology to Mr. Wielandy is as follows: "I have your letter of the 22nd, 23rd, and 24th of July and also all of the specimens which you mention--------. The insect which you call the New Mexican bean bug is Epilachna Corrupta, one of the few plant-feeding lady-birds--------. The application of an arsenical poison early in the season should be an effective remedy against the bean bug-------". (July 31, 1889) Extracts from the Second Letter.-Springer, N. Mex., July 30, 1889. - "In order to investigate the Mexican bean bug more fully (there being no beans in this immediate neighborhood) I went last Sunday to Watrous, some fifty miles south of this place on the Atchison, Topeka & Santa Fe Railroad, where I examined the farm of Mr. William Kroenig, who is, with me, one of the very few persons who take an interest in such matters in New Mexico. The result is that I am enabled to send you today the insect in the egg stage, the larva, and the imago stage. The pupae I am not able to procure for reasons evident enough. In conversing with Mr. Kroenig I find the following facts: That he has known the insect since he has been in this region, which is about forty years; that it was then just as bad as now; that it is found chiefly on beans cultivated in old fields, and on land newly cultivated is comparatively

scarce, or even unknown, for the first few years; that it frequently destroys the entire crop; that the only way to keep down its ravages to some extent is to plant the beans during the interval between the first appearance of the bugs and their second appearance in the fall. The question with me now is to find out if they have more than one brood, and if so, how many. During my visit I examined a new field of beans in which there were no insects. From that we went to a corn field in which there were beans planted among the corn. We there found chiefly larvae and only four bugs. The bugs had apparently laid their eggs and died. The larvae were nearly all the same size. I also found three bunches of eggs, which, together with the larvae, I put in a small vial with a mixture of alcohol and water. The parent bug appeared about the 15th of July for the first time in this locality possibly a few days sooner. On the 20th they, as well as the eggs, were nearly all gone, I finding, as stated, only four bugs and three bunches of eggs.-----I am positive that another appearance of the full grown bug occurs in September and October, because I saw some of them at that time of the year myself. You have no doubt received some of the bugs I sent you last week enclosed in letters; one being found on a species of Ipomeae or Convolvulus; the other being the notorious Mexican bean bug, which is the brown bug of the Coleoptera order

Sixteen spotted. I will continue my observations on this insect. I send you a few bean leaves to show you the manner in which its depredations are committed. You will notice that it does not eat the leaf, but only the parenchyma on both sides. It also eats the pods, flowers and the very small young pods....."

Extract from Third Letter--Santa Fe, N. Mex., July 26, 1890--"I notice on page 376 of Insect Life Vol. II for May and June 1890, that the Epilachna corrupta, which I trust will continue to be known vulgarly as the New Mexican Bean-bug or New Mexican bean-eating Lady-bird --for I have not been able to learn that it feeds upon any other plant except those of the Phaseolus family --is also found in Colorado. From this I infer that the so-called arid region of the Rocky Mountains is its native habitat. But I also venture to fortell that if it should ever chance to spread further east, it will prove as destructive to the bean there as the Doryphora decemlineata once proved to the potato. You suggest Paris green as a remedy, and it may therefore be interesting to you to know that I have tried its appliance, and to learn how it resulted. I may say that it effected a radical cure. It killed not only the insects, but also a great part of the vines (especially those of the wax pod varieties, which appear more delicate), and utterly ruined several rows of new varieties, such as the

Yosemite Mammouth, Dwarf Lima, Bush Bean, Flageolet Wax, Black-eyed Wax, etc., which I had obtained from New York at considerable expense for trial in our soil and climate.....The only bean plants which escaped entirely unscathed under the Paris green treatment, among some fifteen sorts grown in rows side by side for experimental purposes, were the native frijoles, which remained entirely unaffected by the corrosive action of the arsenious poison. The row of these Mexican beans now stands in the garden, still growing in wonderful exuberance, and covered with an immense profusion of pods, some of these already ripening, while of the other beans probably not over one-fourth are alive. I would therefore advise great care in the use of arsenical compounds with beans, as it appears to corrode and burn both the leaves and the stalks. The solution used was at the rate of 1 pound to 100 gallons of water and was applied about three weeks ago, once.....The Epilachna made its appearance here about the 25th day of June and now some belated stragglers are still occasionally met with. The only safe remedy I know of against the insect is to plant the beans either very early, or very late, here from the 15th of April to the first of May, and from the 15th of June to the 10th of July. The beetle does not seem to trouble the very young plants and is not found after the first of August in this locality and latitude....."

In 1897 Rev. Henry S. Gorham (16 p. 242) considered this species with the Coccinellidae of Central America, indicating the synonymy, and the distribution in Mexico, Guatemala, and Panama, with notes on variation and colored illustrations of the adult and of the larvae.*

In 1899 Dr. F. H. Chittenden (7) in his article, "Insects Injurious to Beans and Peas", gives a short account containing a general description of this insect, its injury, and a suggested remedy. In this same year Thomas L. Casey (3) in his "Revision of the American Coccinellidae" characterizes this species comparing it with Epilachna borealis.

In 1900 Dr. Cockerell (12) stated that this species was the "bane of bean growers in New Mexico, from Chicorico Canon.....to the Mesilla valley."*

In "Notes on Colorado Insects" by A. N. Caudell (5) 1902, we find this account,-'The bean ladybird (Epilachna corrupta)' "An extreme case of injury by this spotted bean beetle was observed near Fort Collins, where a large patch of beans had nearly every leaf killed by the larvae of this insect. At that time, in July, the beetles were in the pupal state, hanging in great numbers from the underside of the leaves.....The insect is described by Professor Gillette in Bulletin 19 of the

*References taken direct from Chittenden U. S. Dept. Agric. Bulletin No. 843

Colorado Experiment Station.'"

In a list of Coleoptera found in New Mexico we find this statement by W. Knaus (21), 1906,'Epilachna corrupta, Muls., Common, damaging potato vines and beans near Wootens.' It is very likely that this report as far as the potato was concerned was incorrect since this species is rarely, if ever found, feeding on anything except plants belonging to Phaseolus family.

In 1907 H. C. Fall and T. D. A. Cockerell (14) gave its distribution by localities in New Mexico, and reported it as injurious to beans in each case. A. W. Morrill (26 p. 185) in 1913 gives a brief note on its distribution in Arizona. E. O. Essig in his publication of 1915 (13 p. 219) states that Epilachna corrupta is said to have been found in California, but gives no specific localities. It is very likely that this insect has not yet occurred in California.

There have been several recent publications concerning this insect, all within a few years of each other, due to simultaneous activity on the part of State Experiment Stations. D. E. Merrill in 1917 is first with a bulletin for the New Mexico Experiment Station (25). This bulletin gives at some length a very comprehensive and detailed account of the injurious habits, life history and distribution and suggested methods of control. Two bulletins from the United States Bureau of Entomology are next by

F. H. Chittenden (9) and F. H. Chittenden and H. O. March in 1919 and 1920 respectively (10). The latter of these two bulletins gives in a more general way accounts of the distribution, injurious habits, life history, and suggested methods of control. Two publications appear in 1921. The first by W. E. Hinds (19) gives a general account of the very recent, 1918 or 1919, introduction of this species into the state of Alabama. The second is by George M. List of the Colorado Experiment Station (24). This bulletin embodies in detail the life history records and control experiments covering a period of four seasons. Prior to his bulletin in 1921 Mr. Hinds has several short articles in the Journal of Economic Entomology (18) concerning the introduction of this species into Alabama. A popular article by J. Sidney Cates (4) dealing with the introduction of this species into the South and East and its possible results appeared in the Country Gentlemen in 1922. A bulletin by A. M. Bentley, of the Tennessee State Board of Entomology, No. 41 was published in 1922.

Popular descriptions of the Mexican bean beetle were published by Gillette (15) in 1898, Sanderson (28 p. 315) in 1915, and Chittenden (8 p. 109) in 1917.

Distribution

Until the last few years the operations of the

Mexican bean beetle have been confined to the semi-arid regions of Arizona, New Mexico and Colorado extending well down the Arkansas valley. It has been known in these regions for more than fifty years. Its distribution in Colorado is confined largely to the foothill regions of the eastern slope of the Rocky Mountains. The older settlers report injury to beans during the early development of the oldest sections of the state. Native food plants have never been found in these states. This would indicate that it is not a native of these regions. The literature and early records suggest that it came into the United States from Mexico, (3 p. 103), (9), (22), where it undoubtedly has native food plants.

It has occurred in these semi-arid regions at altitudes up to 7000 feet and at winter temperatures as low as thirty degrees below zero. The injury to the bean crop has been frequently quite severe, but the spread has seemed to be slow and in a general way but little damage was done in the Plains region. In July 1920 this species was found to be well established in Alabama, when specimens were sent to the Alabama Experiment Station from certain counties in that state. This is its first known appearance east of the Mississippi River. Since that time it has spread to other nearby counties in Alabama and across the line into Georgia. Its introduction into these southern regions is supposed to have occurred in shipments

of either alfalfa hay or beans or possibly both materials produced in the infested regions of Arizona, New Mexico, and Colorado. (18 p. 486 and 430).

The Mexican bean beetle has demonstrated its ability to adapt itself to new climatic conditions. There seems to be no natural barrier to prevent its steady spread to all parts of the United States wherever beans are grown. Nothing can prevent its advance into New York and Michigan where large quantities of beans are grown. The annual dissemination by flight is certain. The author has seen the adults rise high in the air and sail to other parts of the field. While this method of distribution is important, observations would indicate that it is not so important as distribution by commercial shipments of hay and grain.

It is an interesting fact, but this Mexican bean beetle is the third major pest we have received from Mexico. The first two, viz; the Colorado Potato beetle, and the boll wevil may be said to have done some good along with their depredations. The Colorado potato beetle is largely responsible for the use of arsenicals, which are used so extensively today to protect plants from the ravages of insects. The second, the boll wevil, we all know has effected a most wonderful improvement in Southern farming.

There is then the possibility that the Mexican bean

beetle will be an important factor in causing the bean growers to develop new and improved methods of farming.

The known distribution of this pest in the United States is shown in figure 1.

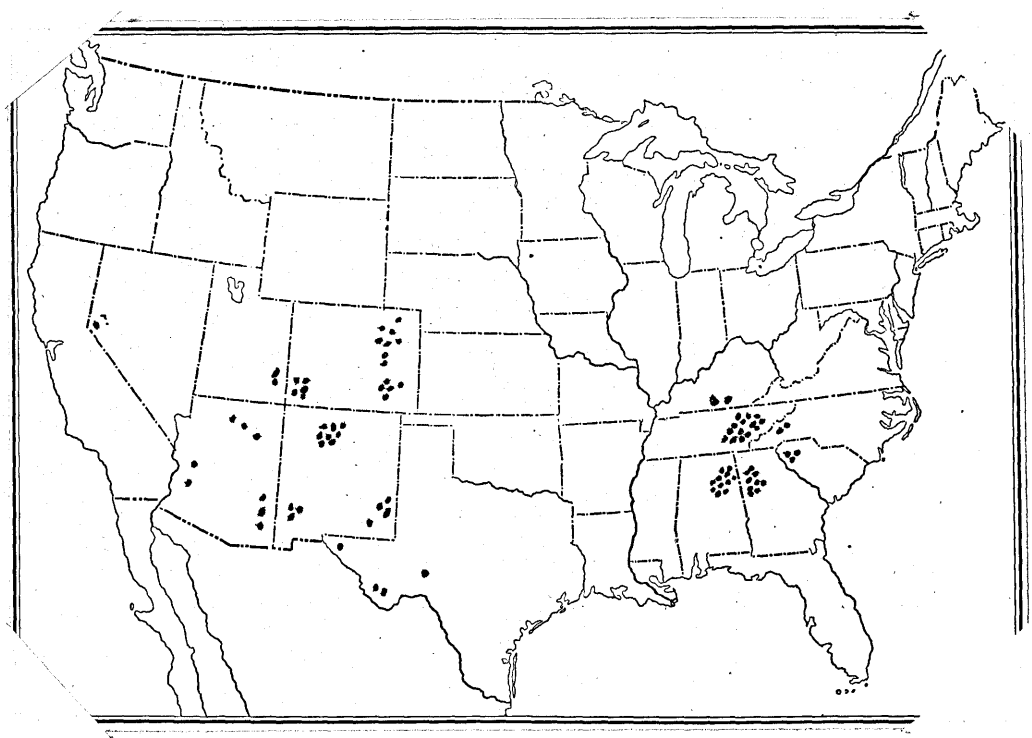

Fig.1. Map showing the distribution of the Mexican Bean Beetle in the United States. April 1,1923.

Anatomical Descriptions

The Mexican bean beetle belongs to the highly beneficial family of Coccinellids. It is one of the few plant feeding species of ladybird beetles and therefore becomes injurious rather than beneficial.

The adult (Pl. I, f. 1) is a robust "hard shelled" beetle, oval in outline, densely pubescent, and very closely but unevenly punctured. The newly developed adult is cream yellow. Each elytron is marked with eight small black spots of variable size, three of which are sub-basal, the median less basal, and three in a transverse range just before the middle, scarcely larger than the sub-basal, the median a little larger, and two near the apical fourth, placed near the inner fourth and the outer third. The under surface and legs are pale throughout. The adults grow darker with age until they become a dark bronze color. At this time the spots are not so conspicuous.

The genus Epilachna (Epi, 'above'; lachna, 'wool') to which this individual belongs is a very large genus especially in the tropics of the western hemisphere. Only three or four species occur within the United States.

The original descriptions of the genus by Chevrolat (6) and the species by Mulsant (27 p. 815) follow:

EPILACHNA (,sur; ,duvet). ins. - Genere de Coléoptères subpentamères trimères de Latreille, famille de Coccinellides (Aphidiphages, Lat.), créé par nous, et adopté par M. Dejean, qui, dans son Catlogue, en mentinne 49 espéces,

dont 27 originaires d'Amérique, 11 d'Afrique, 6 d'Asie, 3 de l'Océanie et 2 d'Europe. Plusieurs sont communes á deux parties du monde; une trentaine d'espécies, soit nouvelles, soit connues antérieurement, doivent être ajoutées a ce nombre. Nous citeeons les 5 Coccinelles suivantes, qui appartiennent à chacun des continents, savoir: Coccinella boralis, bifasciata Fab., flavicollis Ol., signatipennis d'Urville et undecimmaculata F. Cette derniére se trouve aux environs de Paris, sur la Bryone, Bryonia dioica, dont elle ronge les feuilles. Tout sont phylloghages.

Les Epilachna sont de couleur rouge brique, à points ou bandes noire, noire ou bleue, à taches rouges; le corps en dessus est couvert d'un duvet épais; les élytres sont ou ovalaires ou un peu acuminées sor la suture; les tarses offre offrent un crochet double de chaque côte, l'interne est plus court. (Taille: 7 à 12 millim. de long sur 6 à 9 de largeur). (6.)

Epilachna corrupta, Mulsant, "Ovale; brune, garnie d'un duvet gris cendré, en dessus. Elytres ornées chacune de huit points noirs et dénundés; trois, pres de la base, en rangée argnee en arriere sur chaque étui; trois, en rangée transversale un peu aprés les deux cinquièmos de la longeur; les septième et huiteme, en rangée oblique; l'interne, vers les deux tiers; l'externe, ver les trois quarts. Pieds, d'un brun rouge livide. Long. 0^{m},0060 (2 2/3 l) - Larg. 0^{m},0048 (2 1/8 l).

Corps brun, garnie d'un duvet gris cendré. Labre, Antennes, Palpes et Pieds d'un brun rouge livide. Tout le reste du corps brun ou d'un brun noir. L'examplaire, d'une médiocre fraicheur d'apres lequel a été fait cette description, a la même form que l'E. Mariana, et se trouve éliquete de la main de Dejean comme appartment à cette espèce; mais il s'en èloigne visibilment par un duvet épais, d'une teinte paraissant plus grise, par ses points dénudés et surtout par le nombre de ceux-ci, et par la position des deux derniers.
Patrie: le Mexique (Collect. Chevrolat)"

The following description is by Drs. LeConte and Horn; (22, f. 118):

Coccinellidae phytophagi---The form of the mandibles, which are armed with several teeth, is the only character which distinguishes this series from the

Genuine Coccinellidae. It consists of a single group, Epilachiae, of which three species of Epilachna are the only representatives in our fauna. They are rather large, pubescent insects, resembling in form Chilochorous more than any other genus. The sides of the prothorax are but slightly curved and are broadly explanate; those of the elytra are rather strongly reflexed. The epipleura are horizontal, broadly concave, but do not distinctly extend to the sutural tip. The metasternal and ventral lines are well defined, the legs are moderately retractile; thighs not very deeply sulcate beneath, tibae with an acute external edge, and shallow groove for the reception of the tarsi; the claws in Epilachna are cleft with the lower cusp nearly as long as the upper one. The genus extends from the Eastern States to Arizona, where E. mexicana occurs, but has not occurred in maritime California, although E. corrupta has occurred at Lake Tahoe.

Anatomical Descriptions

The Adult

The Head - The head is deeply inserted, with the pronotum covering a considerable portion of the eyes. The epistoma is narrowed from the base leaving the antennal fossae completely exposed. The antennae of 11 segments are long with loosely articulated club, inserted within very small exposed foveae remote from the eyes. The head is without

spots.

The Mandibles - The mandibles are bifid at the tip and denticulate on inner side (Pl. 1 f. 3), stout and chitinous with three prominent acute teeth, densely pubescent on inner side and on the inner margin. The denticulations are serrated on their edges in the newly emerged specimens.

The Labrum - The labrum is transversely rectangular, slightly larger medially. The anterior margin is covered with a short dense pubescence. The posterior half is densely covered with long yellowish hairs many of them extending beyond the anterior margin. A narrow clypeus is evident (Pl. 1, f. 2). The sensory pits, each supplied with a tactile hair, are situated in the sub-basal angles.

The Maxillae - The form and relative proportions of the maxillae are shown in Plate 1 figure 4. The cardo, stipes, and palpifer are all easily distinguished, being separated from each other by distinct sutures. The galea is a broad spongy lobe distinctly separated from the subgalea. The lacinia is much smaller and from a lateral view appears as an oblong appendage. Both galea and lacinia are densely covered with a stout pubescence. The palpi are four jointed. The fourth joint, securiform and much larger than either of the others, is well supplied on the inner surface with sensory pits, many of which are supplied with tactile hairs.

The Labium - The labium is shown in figure 5 Plate 1. The

mentum is trapezoidal with a tuft of hairs in the conter. The ligula is oval. The palpi are three jointed, the last joint oblong and truncate at the tip. The pubescence is still evident, although not as dense as on other parts of the mouth.

The Thorax - The thorax as usual consists of three distinct segments. The prothorax articulates freely with the mesothorax, but the mesothorax and the metathorax are firmly connected. The prothorax is transverse, of rather small size, broadly explanate, the apex deeply emarginate. The pronotum is without spots. The front coxae are closed behind and separated by the prosternum. The metasternal and ventral lines are well defined. The legs are moderately retractile. The tibiae are provided with a narrow groove for the reception of the tarsi. The tarsal claws are cleft with the lower cusp nearly as long as the upper one. The tarsi in reality are four jointed, the third joint being small and rigidly joined to the fourth thus giving the appearance of only three joints (Pl. 1, f. 6).

Internal Anatomy

The only parts of the internal anatomy that have been studied in detail for this paper are the reproductive organs of both sexes. Since the nature of the gentalia is destined to play such an important part in systematic Entomology it is interesting to see what we have in this particular individual. Dr. David Sharp and Mr. F. Muir

have done an extensive piece of research on the "Anatomy of the Male Genital Tube in Coleoptera" (30 and 31) and the nomenclature which they have used will be used in this paper. The following general description of the male gentalia is given by the above named authors. "The term genital tube is used because it conveys the idea of the chief characteristics of the parts. Whatever else they may be, however different they may appear, their combination to form a perfect tube without orifices is remarkable; the one orifice that exists is not a real one. It arises from the invagination of the tube into itself. The genital tube is therefore a doubled tube, one end of which is a continuation of the body wall, while the other divides into a fork of which one branch proceeds to each testis." (30 p. 600). Quoting further from Dr. Sharp: "The morphology of the male genital tube (in Colecptera) is really very simple. It may be reduced to an elongate continuous tube, which is made to appear shorter and more complicated by a system of invaginations, in some respects, comparable to an old fashioned telescope." (31, p. 210)

The following parts can be distinguished in the male tube of Epilachna corrupta (Pl. IV, f. 1):

bt Base of tegmen

bp Basal piece

ej Ejaculatory duct

ll Lateral lobes

mf Median foramen

ml Median lobe

mo Median orifice

ts Median strutt

te Testis

A group of sclerites entering into the formation of the genital tube is termed the Aedeagus. It consists of two parts viz.; the median lobe (ml) and the tegmen which is divided into two parts; the basal piece (bp) and a pair of lateral lobes (ll). The basal piece (bp) is chitinized until it forms a complete tube surrounding the median lobe (ml). The lateral lobes (ll) consist of a pair of slender organs, their outer surface being continuous with the basal piece (bp) and their position being such that they lie one on each side of the median lobe (ml). In general these two parts together form a ring like structure through which the median lobe protrudes and works freely back and forth. This structure is called the tegmen. On account of the extensive chitinisation of the basal piece in Epilachna corrupta these two pieces instead of forming a ring like tegmen as shown in Anatis ocellata (Pl. V. f. 3) form a tublar structure as described above. The median lobe or penis as it is called by some authors (Verhoff 35 p. 1-80) is well developed and quite distinct from the tegmen. It is a long "S" shaped tube highly chitinized on the distal

end while the basal part is entirely membranous (bt). In the dissected specimen there is a small amount of play within the curved tubular tegmen. The median orifice (f. 1, mo) is situated on the distal end and the median foramen (mf) at the basal extremity. The ejaculatory duct enters the median lobe thru the median foramen (f. 1, Pl. IV.). The ejaculatory duct is of considerable length, and is rather easy to discover in the fresh specimens, but is somewhat difficult to detect in older material. It divides near the center of the abdomen into two branches each one of which proceeds to a testis. Proceeding apically it enters the median lobe through the median foramen. According to Sharp and Muir (30 and 31) it continues into the median lobe until it joins the "internal sac". By most authors the internal sac is considered a part of the ejaculatory duct. By Sharp and Muir (as above) it is considered separately and generally speaking is larger than the duct, membranous, and connecting basally with the duct and apically with the distal end of the median lobe at the median orifice. It is generally supposed that it is everted and enters the female tract during copulation. The above authors (30) also state that in some cases the ejaculatory duct and the internal sac are undifferentiated, and in this case it is difficult to say just how much is evaginated during copulation. This is the case when the median lobe is long and slender as in the case of Epilachna corrupta.

The internal sac as a part of the genital tube has been the least investigated. Its study is quite difficult and is therefore often passed over. No attempt was made by the writer to evert the internal sac of Epilachna corrupta for as stated above in this type of median lobe the internal sac is undifferentiated and practically impossible to evert.

From a study of Sharp (31 - 1918) the writer would gather that the internal sac is the most important part of the entire tract, all the other parts of the mechanism being merely accessory. There is a wide field for some further investigations dealing with this delicate piece of mechanism in the Coleoptera which according to the present tendencies, is likely to play a very important part in the field of systematic entomology.

A single strutt (Pl. IV. f. ts and 7) proceeds from the tegmen and is attached to the median lobe and gives support to the muscles which actuate it. This strutt is fastened on the ventral part of the tegmen between the lateral lobes. It is expanded at its end (Pl. IV. f. 7) and fits on the expanded portion of the median lobe to which it is attached by muscles.

The aedeagus when at rest and drawn into the abdomen lies on its side, and when thrust out the median lobe points downward.

The aedeagus of Anatis oscellata (Pl. V. f. 3) is

included here for comparison. The chitinization of the basal piece here forms a shield shaped plate. The ring like tegmen is shown very clearly. The median lobe has a large amount of play through the tegmen. The median lobe is about the same length, slightly more slender, with a base not nearly as large when compared to the same structure in Epilachna corrupta. The tegminal strutt is long and slender as compared to that of Epilachna corrupta. The figures of the aedeagus and and median lobe of Epilachna crysomelina, and the median lobe of Epilachna argus (Pl. V. f's. 5, 6, 4) were taken from Verhoff's figures (35 1-80) and show some interesting comparisons with our Epilachna corrupta.

There is apparently a wide difference in the structure of the basal piece in E. crysomelina as compared to that in E. corrupta. In E. crysomelina it is more like the general type forming a shield like piece instead of a tubular structure as in E. corrupta. There is also a noticeable difference in the tegminal strutts, that of E. crysomelina being much narrower and longer than in E. corrupta. The median lobes of the three species of Epilachna resemble each other more in form and structure than any other parts.

The entire aedeagus of Epilachna corrupta is quite constant in its structure and form as will be noted by a study of the figures shown in Plate IV. These constant

characters were found in a larger number of individuals than those figured here (Pl. IV). The constancy of these characters in E. corrupta and the variations as pointed out above in the genus would, it seems, make them of real specific value.

No doubt the observations here are not extensive enough upon which to make taxonomical generalizations. Nevertheless since the genital systems of Insecta are beginning to play such an important part in taxonomy it seems well to suggest that this part of the anatomy might be used to an advantage in the Epilachna.

Function

The general function of the male genital tube of course is to transfer the seminal fluid from the body of the male to the female genital conduit. Female Coleoptera are in most cases, if not all, supplied with a spermatheca, a special vessel for the reception of the matter transmitted through the male genital tube. Just whether this matter must be placed directly in the spermatheca or any place in the female conduit is an open question. The general opinion is that the placing of the fluid in any part of the female tube is adequate. Sharp and Muir (30 and 31) hold the view that the male structures in a large number of cases actually place the sperm in the spermatheca however remote that vessel may be from the orifice of the female conduit.

This question can be answered only by taking a large number of species, killing them, and dissecting these organs out while in copula. This is a difficult piece of work to do because the muscles which control the genital organs relax when the insect is killed.

The lateral lobes in this species (E. corrupta) are paired and longitudinal in arrangement. Some morphologists consider them as modified abdominal appendages. It is suggested by Sharp and Muir (30 p. 536) that this may not be the case since since some Coleoptera have never possessed lateral lobes. This point is an open question and is beyond the scope of this paper. They (the lateral lobes) are generally considered as "claspers" to grasp and hold the female during copulation. In E. corrupta they are placed on the outside of the female venter and appear to have no hold. This is the case in all Coccinellidae.

The Female Genital System

The female genital system as taken from the newly emerged specimen is a comparatively simple apparatus (Pl. VI. f. 1). The following parts are easily distinguished; a group of sclerites which make up the pygidium (sc) the vagina (vg), the spermatheca (sp), the oviducts (ovd), and the ovaries (ov). The pygidium is not visible from the outside. It is enclosed between the sixth tergite and the sixth sternite.

External Sex Characters

The two sexes are exactly alike as to their markings.

The males are slightly smaller than the females. The sixth sternite in the male is marked with a slight central indentation (Pl. VI f. 7). The rear edge of the sixth sternite in the female is entire (Pl. VI. f. 3). The sixth tergite and the sixth sternite are arranged in the same position in both the male and female.

The Larva

The larva (Pl. II f. 1, 2, 3) is a yellowish spiny creature. The spines are at first yellowish in color but become darker at the tips and more conspicuous as the larva grows older. (Pl. II f. 4) The body is ~~heaviest in~~ widest at the ~~center~~ middle and tapers sharply anteriorly and posteriorly. The head is moderately prominent. The same is true of the mandibles and other mouth parts, which with the eyes are darker in appearance than the rest of the body. The legs are rather long and stout and each is armed with a single small sharp claw. The newly hatched larva measures about 1.6 mm. in length and the full grown larva about 8.75 mm. The larva (moults) four times during its development. After each moult except the pupation moult the larvae are pale yellow in color becoming darker after a few hours. The larval stages are described as follows:

First stage. The spines are very closely appressed when the yellowish larva frees itself from the egg. As the chitin dries, the spines become erect and are seen to be branched at and near the tip. The tips of the branches

later become darker. The larva is about 1.3 mm. long by 0.6 mm. wide. The body tapers sharply and is recurved downward. There is a row of four spines across the rather prominent prothorax. On the rest of the body there are six longitudinal dorso-lateral rows, the spines on the outside rows being very small and very few.

Second stage. After the first moult the larva is about 2 mm. long and the tip of the abdomen is slightly more curved than in the first stage. The spines are longer and more branched. The rows of spines are the same in number but more pronounced.

Third Stage. After the second moult the larva is 4 mm. long. The spines are longer, more branched from the sides and dark tipped. The rows are now plainly seen. In this stage the larva takes on a humped back appearance as mentioned above, the highest and widest portion of the body being about the middle portion. The body tapers sharply posteriorly, not so much anteriorly.

Fourth Stage. At the beginning of the fourth stage the larva is about 5.5 mm. long and increases to nearly 1 cm. in length before the pupation moult. About the only difference between the larva in this stage and the third is the size.

It is during this stage that the maximum amount of damage is done, since the larva is largest in size and this is the longest stage.

The body is composed of three thoracic segments and ten distinct abdominal segments. The three thoracic segments taper slightly anteriorly from the first abdominal segment while the last six abdominal segments taper sharply thus giving the larva a spindle shaped appearance when viewed ventrally (Pl. II f. 2). If viewed dorsally the larva has a humped back appearance, due to the larger anterior abdominal segments and the longer spines on this part of the body. The first thoracic segment has a shining dorsal area with the four strong many branched spines arising from the anterior margin. The posterior margin is clothed with an irregular row of short stiff hair like spines (Pl. II f. 3).

The Head. The head (Pl. V f. 1 & 2) is a light brown in color, the anterior margin and the mandibles much darker. When removed from the body, it is a little longer then broad, the sides broadly rounded. The frontal area is marked by a slight depression. The genae are sparsely covered with stiff hairs. The antennae are small somewhat conical and three jointed. The second joint is twice as long as the first. The last joint is armed anteriorly with a bristle. The epistoma is represented by the thickened anterior margin of the front with which it is fused. It is usually darker in color, with the anterior margin nearly straight. The mandibles articulate with the lateral edges of the epistoma, which are raised and thickened, and with the anterior margin of the front.

The Mandibles. The mandibles are rather stout, triangular, with three teeth on the anterior half. The teeth do not all rise in the same plane. The apical tooth is acute and bifid. The sub-apical is acute and rises between the apical and the third at an acute angle. The third is longer than either of the others and bifid. When examined from a dorso-lateral view the mandible appears to have four teeth. (Pl. V. f. 2)

The Maxillae. The maxillae are much longer than broad and with a distinct inner lobe, the anterior portion of which is covered with fine hairs, while the outer portion is sparsely equipped with stouter and longer hairs. The cardo, stipes, and palpiger are fused into one piece. The palpi are four jointed (Pl. II. f. 1).

The Labium. The labium, viewed ventrally, has a narrow, barrel shaped sub-mental lobe attached to the maxillae. The mentum, palpiger, and ligula are fused. The palpi are short, conical, and two jointed. The inner part of the ligula is fleshy and contiguous with the pharynx.

The arrangement of the pubescence on both the maxillae and the labium does not seem to be characteristic or constant.

The Clypeus. The clypeus is broad at the base, the sides narrowed to the anterior margin. It is slightly shorter than the labrum and decidedly broader (Pl. II. f. 2).

The Labrum. The labrum is more chitinous, and trans-

versely rectangular, about twice as broad as long.

The Pupa

Two or three days before pupation the larvae cease feeding and attach themselves to the under side of the leaves, stems or pods of the bean plants, and often to other nearby plants. After attaching themselves the larvae go through the last moult by casting the larval skin back over the thorax to the rear of the abdomen where it remains in a whitish wrinkled mass, as a protection to the last third of the body. The tips of the spines still remain conspicuous on the cast skin.

The pupa is ovate in outline, about the size of the adult. It is yellow in color. The head is folded forward on the thorax and the posterior legs reach the tip of the wing sheath. This position of the head gives the body a rounded truncate appearance. The body tapers rapidly from the beginning of the thorax to the tip of the abdomen. The surface is sparsely covered with bristle-like setae, and long hairs. The tip of the abdomen terminates in two small black tiped conical processes (Pl. II f. 5 & 6).

Feeding Habits

The coccinellid family of lady-beetles is universally known as a highly beneficial family on account of the predaceous habits of the majority of the members of that family. It has been known for some time by those in a

position to know that the Coccinellidae are by no means as universally carnivorous as is generally supposed, but that vegetable matter forms a considerable portion of their food at certain seasons of the year. There is no question but that Coccinella 9-notata, Adalia bipunctata, and others of our most common lady-birds in both the larval and adult stages feed almost entirely, if not all together, on plant lice. They have been observed by many actually feeding voraciously on quite a number of species of aphids, so that this habit is in no doubt. On the contrary Epilachna corrupta and its cogener Epilachna borealis are famous as herbivores. This leads us to the question, just what, if any, difference in the mouth structures accompanies this difference in habits?

In Epilachna is found a stout chitinous mandible with a prominent acute apical tooth and two smaller internal teeth which might well belong to a carnivore (Pl. I. f. 3) and (Pl. III. f. 3). Coccinella and Adalia are equipped with a mandible that would as readily be referred to a pollen or a fruit feeder. The mandible is distinctly compound with all the sclerites distinctly marked, the apical tooth small and bifid (Pl. III. f. 3). It will be noticed from the figures that the differences are not confined to the mandibles (Pl. II. f's. 2, 4, 5 and Pl. III.) Coccinella and Adalia differs markedly in form from that of Epilachna. The sensory structures are more regularly

arranged in Epilachna than in Adalia and are much more numerous especially in E. borealis. The maxillae of the two groups are as different as the other parts, but represent more nearly in each case, structures compatible with the feeding habits of each group. Note the more chitinized galea in the case of Adalia and Coccinella as compared with the fleshy swab like galea of Epilachna.

This noted difference in the mouth parts has been used as a character in classification (22 p. 114) to divide the Coccinellidae into two series viz; Coccinellidae genuini and Coccinellidae phytophagi. The characters are not considered of sufficient importance to be used as sub-family characters. Casey in his "Revision of Coccinellidae" (3) does not use these characters at all and states that it is unpractical because of the difficulty of observing.

In the light of today this would not be a serious objection for the mouth parts of the Coleoptera are certainly as accessible as the genital organs. However the writer is convinced, so far as these studies are concerned, that the mouth parts of Epilachna offer no characters of specific value.

Life History and Habits as observed by the author at Greeley, Colorado, 1919

Hibernating adults which had successfully passed the winter began appearing about the middle of June. The first individuals were found June 16 feeding on beans. A week

to ten days later they began laying eggs. The bright yellow eggs were always deposited on the under side of the leaves in clusters of about forty or more (Pl. VII). About two weeks later, July 9-10, the eggs began to hatch. The tiny yellow larvae begin feeding in a colony near the egg cluster (Pl. XIII). As they grow older they become separated and do not necessarily confine their feeding to the underside of the leaf (Pls. VIII & IX). As the season advances they are found feeding on all parts of the plant, blossoms and pods included. The larvae were present in all stages from the first appearance until September 10, and perhaps even later. Ten or twelve days later, July 22, pupae were found. During the fore part of the season when foliage is plentiful pupation takes place on the underside of the leaf. In case the foliage has been extensively destroyed pupation may take place on either side of the leaf or on both sides. Twenty-five to thirty pupae on a single leaf are not uncommon. As many as one hundred on a single leaf were reported in a case where infestation was heavy. This congregating at the time of pupation seems to be characteristic of the species (Pl. XI). Pupae were observed on other plants near beans. This was the case when the foliage of the beans was almost destroyed.

On July 28 adults of the first brood were observed, and by July 30 they were numerous, gradually increasing in number until about September 1 when they seemed to have

reached their maximum in numbers. The first brood adults are much lighter in color then the hibernating individuals, being a bright yellow at the time of emergence. They gradually become darker, and at hibernating time some are a dark reddish-brown, almost as dark if not entirely so, as the hibernating individuals. Eggs deposited by this new brood were observed on August 28 and September 2. It is possible that eggs were deposited by this brood earlier than these dates. The evidence here is not conclusive enough. In any case the eggs were not plentiful.

There is no definite place in the life history of this species to separate the different broods. Apparently there are two broods or at least a partial small second brood for this locality. The fact that larvae were observed in all stages of development during the entire season would suggest two broods. Further the fact that first brood adults began issuing rather late, and that so few egg clusters were found in late August and September would suggest only a partial second brood.

Injury

So far as observed the bean ladybird confines its feeding to beans only. It has been taken on other plants but never found feeding. The variety of beans seems to make no particular difference as to susceptibility to attack. The adults do not appear to attack the very young plants to any considerable extent. This fact is probably

due to the small number of hibernating individuals. Furthermore the over wintering adults do not confine their attack, but move from plant to plant. Thus the damage is less noticeable. Altho the adults usually eat entirely thru the leaf, they often merely scrape the surface, leaving the net work of veins plainly visible. Later in the season as the foliage begins to die they attack the pods, sometimes completely riddling them, but usually eating out small spherical holes here and there along the pod. In the case of canning beans this injury may cause considerable loss, while on seed beans this damage may not cause so serious a loss (Pl. IX and Pl. X).

The percent of injury by the adult is small as compared to that caused by an equal number of larvae. The larvae begin their attack on the leaves. At first they invariably feed on the underside. Instead of eating thru they scrape the surface leaving the skeleton of the leaf in plain view. Altho with continued feeding in a limited space they may riddle the foliage. As they increase in size they scatter and while most of them continue to feed on the underside of the leaf, a few may be found feeding most any place on the plant.

Maximum damage occurred in this locality during the month of August. This is the period when the new adults are feeding along with the larvae, and the two broods of larvae overlap. Damage was generally worse near fences,

along ditch banks, and on beans receiving an extra amount of water by accident or seepage.

The above data may be summarized as follows:

Hibernating adults appeared--------June 16

Present in large numbers by--------June 25

Began depositing eggs--------June 25

Eggs began hatching----------July 10

Larvae began pupating----------July 22

Adults issued----------July 28

Egg clusters (1st brood) found-----Aug. 28
Sept. 2

Maximum numbers 1st brood adults---Sept. 1

Adults becoming sluggish----------Sept.10

Maximum damage----------Aug. 1 to Sept. 1

Second brood eggs were probably deposited, but not observed before, August 28.

The above data may be further summarized as follows:

Egg period Larval period	)	28 days
Pupal period		6 days
Total		34 days

The life cycle period here of 34 days compares favorably with the following life cycles as obtained by Mr. Marsh in 1916 and 1917 and the author at a later date. (1922)

The above summary, together with later data may be shown in schematic form as below. It will be noticed that there is a period in July and August when the two broods of larvae overlap. This period corresponds to the maximum damage referred to above.

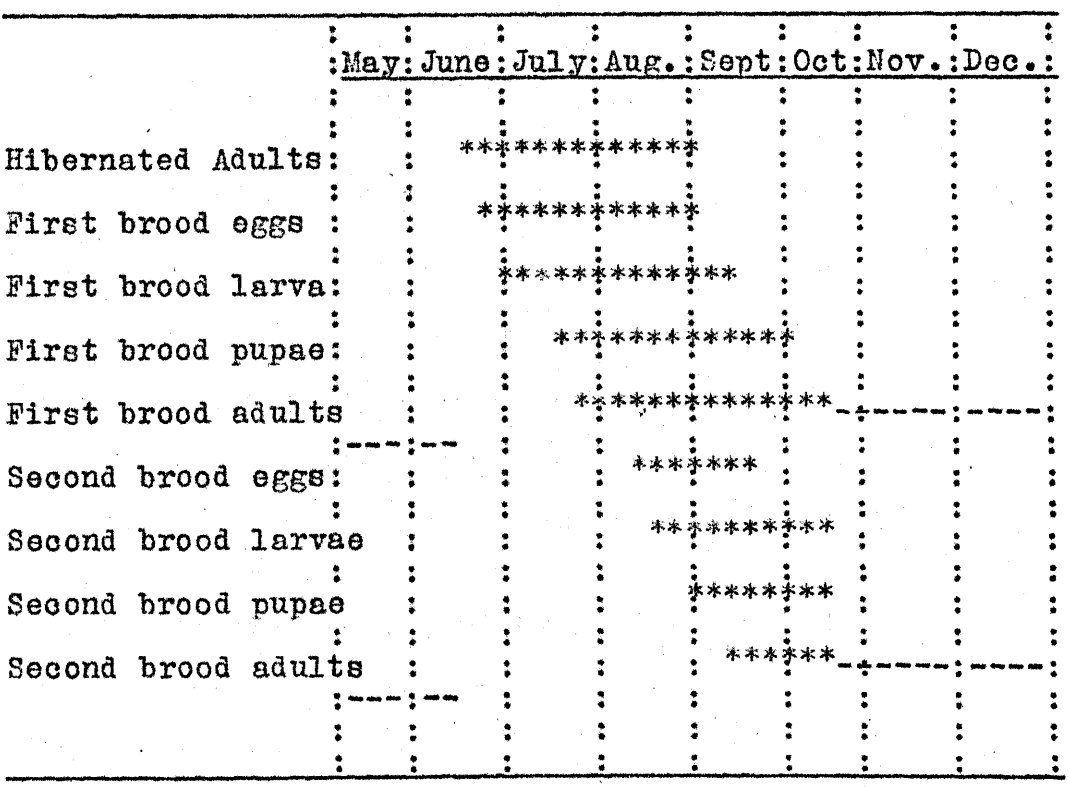

Figure 2

Second Generation

The second brood is not an important factor economically in Colorado. The season is usually so short that only a small percent of the first brood adults produce eggs for a second generation. In 1918 and 1919 the season was longer than usual and there were considerable portions of a second

brood. Mr. List (24 p. 35) estimates that for these years 25 per cent of the first brood beetles deposited second brood eggs. This estimate agrees with the author's observations for the second year, (1919) when there was a large second brood and in many cases the damage was quite severe. A large per cent of this second brood is destroyed and does not reach maturity. There are three vulnerable points here. 1. Many of the eggs are infertile. 2. Many of the larvae die in embryo, and 3. Many of the larvae die in the field due to cold weather. In view of the above factors a second generation may be a detriment to this insect in such a climate as Colorado. In warmer sections of the country this is not the case. In the experiments of N. F. Howard (36) at Birmingham, Alabama, four generations were completed in the insectary. Although temperature conditions favored a fifth generation it did not occur. First brood eggs were deposited March 22, 1921 and the fourth generation adults hibernated about November 5th. Successful development was not observed at a temperature below 60° F. Mr. Howard further states that this species (E. corrupta) is a double-generation insect in the Southeastern United States.

Hibernation

The Mexican bean beetles pass the winter in only the adult stage. They begin to disappear for hibernation in the fall as soon as frosts injure the food plants. They

remain inactive until the next June. The hibernating adults are very hard to find in Colorado. In the warmer regions of Alabama this does not seem to be the case (19 p. 16). Mr. List (24) reports very little data on this phase of the life history. The author found one specimen and part of another under a pile of bean vines and embedded in the soil and in the United States Experiment Station garden at Greeley, Colorado in December 1918. Later observations on September 13, 1922 revealed 6 or 8 specimens in a clump of box elder sprouts of one seasons growth. Most of these specimens were under a small American flag which had lodged in the sprouts and had become covered with leaves. They were quite active when disturbed. Further search on December 2, 1922 revealed 6 more specimens in the same clump of sprouts. These individuals were clinging close to the sprouts from $\frac{1}{2}$ to 2 inches below the surface of the ground. The above clump of sprouts was about 30 to 45 feet from a row of Golden Wax beans. This row of beans was well supplied with adults early in September, and it is quite likely these hibernating individuals had come from these beans. The beetle hibernates gregariously although the tendency seems to be to small groups. The habit of hibernation is the most pronounced characteristic of the family Coccinellidae which the Mexican bean beetle retains.

A very interesting life history record was worked

out by Mr. H. O. Marsh (10) in Colorado as follows: "A pair of beetles which developed in late August 1914, mated August 20th and were isolated. These beetles commenced hibernation October 12, and on November 10 the rearing cage containing earth and some dead bean leaves, under which the beetles rested, was placed in the laboratory cellar until May 20, 1915, when it was again placed in the open air. The beetles emerged from hibernation June 15, and began feeding. The first eggs were laid June 18, and from this stock the species was reared for two seasons (1915 and 1916) without a single break. The record for 1915 is given in Table I and that for 1916 in Table II.

Table I - Generations of Epilachna corruptain 1915. (Chittenden and Marsh, 1920, p. 8)

Life - history event	First generation issued	Second generation
Adults developed	Aug. 1914	July 19, 1915
First eggs deposited	June 18, '15	July 30, 1915
First eggs hatched	June 25, '15	Aug. 5, 1915
First larva matured	July 12, '15	Aug. 23, 1915
First larva pupated	July 13, '15	Aug. 24, 1915
First adult developed	July 19, '15	Sept. 1, 1915
Egg period	7 days	6 days
Larval period	18 days	19 days
Pupae period	6 days	8 days
Total duration	31 days	33 days

The 19 beetles which developed September 1, fed until September 23, when hibernation began. The cage was placed in the laboratory cellar November 10, 1915, and was removed to the open May 3, 1916. June 12, 16 beetles issued from hibernation, 3 having died during the winter, and began feeding. One pair mated June 13, and the record of the projeny is given in Table II.

Table II - Record of Generations of E. corrupta 1916

Life-history event	1st generation	2nd generation
Adults developed	Sept. 1, '15	July 17, '16
First eggs deposited	June 18, '16	July 30, '16
First eggs hatched	June 25, '16	Aug. 5, '16
First larva matured	July 10, '16	Aug. 21, '16
First larva pupated	July 11, '16	Aug. 23, '16
First adult developed	July 17, '16	Aug. 31, '16
Egg period	7 days	6 days
Larval period	16 days	18 days
Pupal period	6 days	8 days
Total period	29 days	32 days

The beetles which developed August 31, fed, without mating or depositing eggs, until October 5, when they began hibernating. November 10, 1916 the cage was placed in the laboratory cellar and removed to the open air April 17, 1917. The beetles issued from hibernation

June 15, 1917, and were then killed closing the record."

The following data showing the life cycle of Epilachna corrupta is taken from Chittenden and Marsh (10 p. 9).

Table III - Life cycle of E. corrupta

Event		Length of Stages
Eggs deposited	Aug. 10, 1916	----------
Larvae hatched	18	8 days
1st Moult	21	3
2nd Moult	25	4
3rd Moult	30	5
Larva reached maturity	Sept. 3, 1916	
Larva pupated, 4th Moult	5	6
Adults developed	12	7
Total number days to complete life cycle		33 days

An interesting life history comparison is found in the following data which the author worked out in the insectary at Lawrence, Kansas. On June 28, 1922 three pair of hibernating adults of Epilachna corrupta were taken in the field at Greeley, Colorado by Professor W. H. Hargrove, and mailed to us at the laboratory. Eggs were deposited enroute. The following table shows the life cycle.

First Series

Event	Date	Length of Stages
Eggs deposited	June 28, 1922?	-------
Larva hatched	July 5	7 days
Larvae pupated	19-22	14-17 days
Adults emerged	27-29	7--8
Length of life cycle		29-31 days

Second Series

Eggs deposited	July 5, 1922	------
Larvae hatched	11	6 days
Larva moulted	15	4
Larvae moulted	23	8
Larvae moulted	27	4 days
Larvae pupated	Aug. 4	8
	Did not emerge. All individuals died just before pupating or in the pupa stage.	
Length of larval period only		30 days

A further interesting comparison is in the egg records as obtained by Mr. Marsh in Colorado, with almost natural conditions, and that obtained by the author in the closed insectary at Lawrence, Kansas.

Table V - from Chittenden and Marsh (10 p. 9). Egg laying record of single female of E. corrupta 1916.

Date	No. Eggs	Date	No. Eggs
July 25	52	Aug. 11	54
28	50	15	56
29	53	18	58
Aug. 1	52	21	55
3	55	23	52
5	51	26	52
6	53	28	54
9	52	Sept. 2	51
	Total		850

Mr. Marsh's average for eight females was 845 eggs.

The following record was obtained by the author as explained above.

	Number eggs from seven females						
	#1	#2	#3	#4	#5	#6	#7
July 7	**********		Record started			**********	
July 8	0	24	0	0	0		
9	53	0	0	0	53	in	
10	0	0	68	0	0	0	
11	0	0	0	60	0	0	in
12						82	60
13							
14	53		51				
15		42		40			
16					11	55	21
17							
18					Died		
19							
20							
21		Died					
22							
23							
24							
25							
26							Died
27	Died		Died	Died		Died	
No. Clusters	2	2	2	2	2	2	2
Total eggs	106	66	119	100	64	137	81

The record here covers a period of twenty days, and does not account for the eggs which might have been laid by these same beetles in the field before they were taken, or enroute before the record was started.

In some of the small truck patches the attack of the bean ladybird was controlled by hand picking. In view of the distribution of the damage, as stated, clean farming or destruction of winter quarters is suggested as an important measure of control.

As to remedial measures, all possibilities were not worked out. On July 10 when the first larvae were observed, the following sprays were tested on large plots in a 9-acre field. Right-angle mist-producing nozzles were used. Approximately 80 per cent of the leaves were covered on one side or the other, the remainder varying from a small amount to none at all. The foliage was heavy.

Experiment No. 1. - Lead arsenate, powder, was used at the rate of 2 pounds to 50 gallons of water, with 2 pounds of hydrated lime added. Very little if any damage was noted from the spray. A few dead larvae were found.

Experiment No. 2. - Lead arsenate, paste, was used at the rate of 2½ pounds to 50 gallons of water. No damage to the plants was noted.

Experiment No. 3. - Zinc arsenite, paste, was applied at the rate of 2 pounds to 50 gallons of water. This strength caused no damage to the plants.

Experiment No. 4. - Bordeaux mixture, alone, formula 3-6-50, was applied to a plot. No damage was done to the

plants. This application seemed to be as effective as any of the foregoing during the earlier part of the season, but this plot showed a greater maximum damage after August 1 than did any of the others. The remainder of the field and a second field of 21 acres were sprayed with the same material and formula as number 1, viz, 2 pounds of lead arsenate, 2 pounds of hydrated lime, and 50 gallons of water.

Observations following these applications revealed a few dead larvae. To locate dead larvae was a difficult matter. Our opinion is that many were killed at the first feeding. If not killed then or very soon after, they fed to maturity. Up to August 1 all remedies tried seemed to be equally effective, the amount of damage to the plant being about the same for each plot. Undoubtedly these insecticides held the beetles and larvae in check. The 9-acre field had an unusually large number of hibernating beetles. After August 1 the damage seemed to increase quite rapidly, and was worse on the Bordeaux plot than on any of the others. A small unsprayed plot was entirely destroyed, most of the injury here being done before August 1.

In A. B. Owen's field of 9 acres, where spraying experiments were conducted July 10 and 11, the estimated damage was 12.5 per cent. It is believed that approximately 65 per cent of the larvae hatching before July 25

must have been killed by the lead arsenate or zinc arsenite. The number of adult beetles found in this field in early July undoubtedly was large enough to have damaged the crop to the same extent as in the special field mentioned above. This experiment, while not of the type anticipated, demonstrates that the attack of this species can be controlled by the use of either lead arsenate or zinc arsenite.

The combination spray consisting of Bordeaux mixture and an arsenical is a promising experiment. Undoubtedly the Bordeaux mixture, in case it proves a repellent against this insect, will serve as an important fungicide. It will add very little to the expense of spraying and will possibly increase the yield several bushels per acre by controlling minor fungous diseases.

Arsenate of calcium was not tried by the author. The results of the Colorado Experiment Station (24 P. 54) both with and without lime, were very unsatisfactory on account of the burning. The plants were practically destroyed when the 1 to 20 strength (1# to 20 gal. water) was used. The burning was somewhat less with the 1 to 40 and the 1 to 60 strengths but was very severe and all growth was stopped for a 10 or 15 day period.

The general summary of the Colorado Experiment Station (24 p. 54-55) is as follows: "During three of the four years that field experiments were carried

on, there were cases where arsenate of lead caused quite severe burning. However, the burning effect under average conditions was not severe enough to discourage its use. Experiments indicate that an effective strength that is reasonably safe as regards burning is one pound of powder to 40 gallons of water.

Arsenite of zinc has proved the most reliable insecticide. It caused burning of rather a serious nature in only two cases during the four years it was used. Three brands of this material were used. The tests indicate that the material is effective and reasonably safe when used at the rate of one pound of the powder to 40 or 50 gallons of water. The latter strength is, apparently, as effective as the former and should be less likely to burn and, under our present knowledge, is recommended as the most satisfactory spray for the bean beetle.

Better results were obtained when the arsenical insecticides were applied as a dust."

"One, two or three applications of spray may be necessary, depending upon conditions.

Early planted beans of an early maturing variety are most easily protected and are generally most successful in badly infested sections."

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EXPLANATION OF PLATES

PLATE I

1. Adult, Epilachna corrupta
2. Labrum
3. Mandible
4. Maxilla
5. Labium
6. Leg

PLATE I

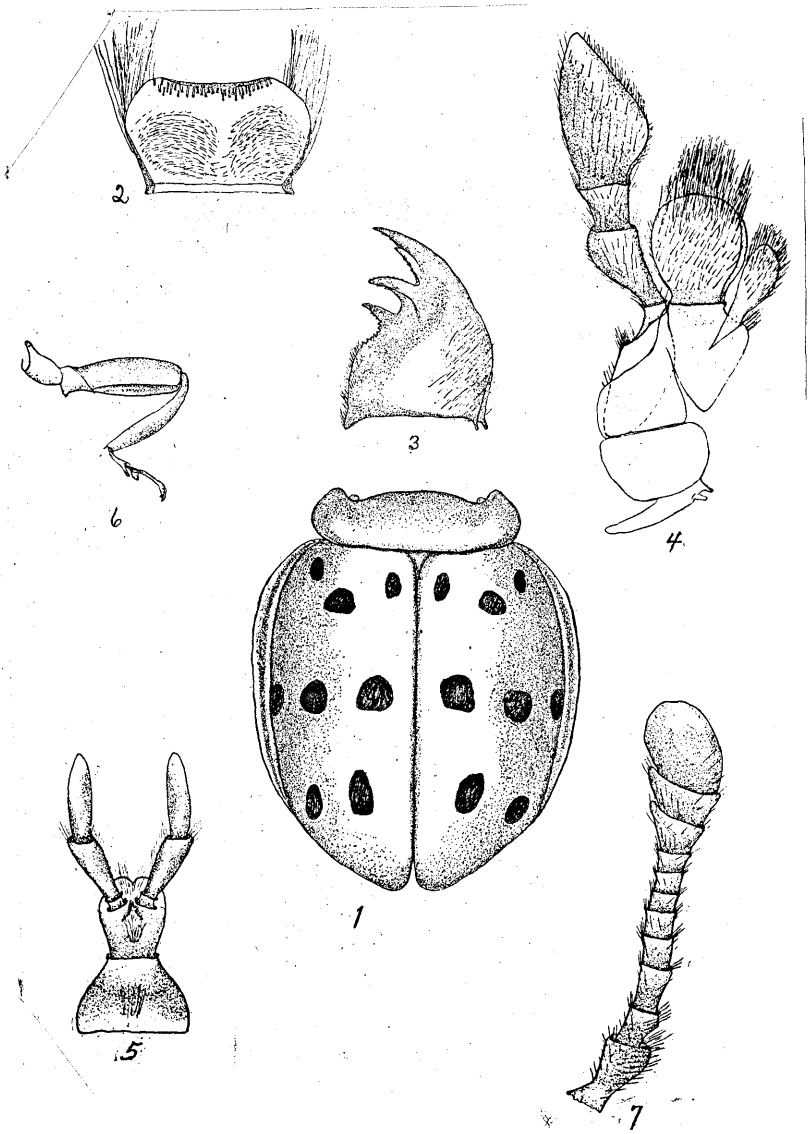


PLATE II

1. Larva, lateral view
2. Larva, ventral view
3. Larva, dorsal view
4. Spine, greatly enlarged
5. Pupa, ventral view
6. Pupa, dorsal view

PLATE II

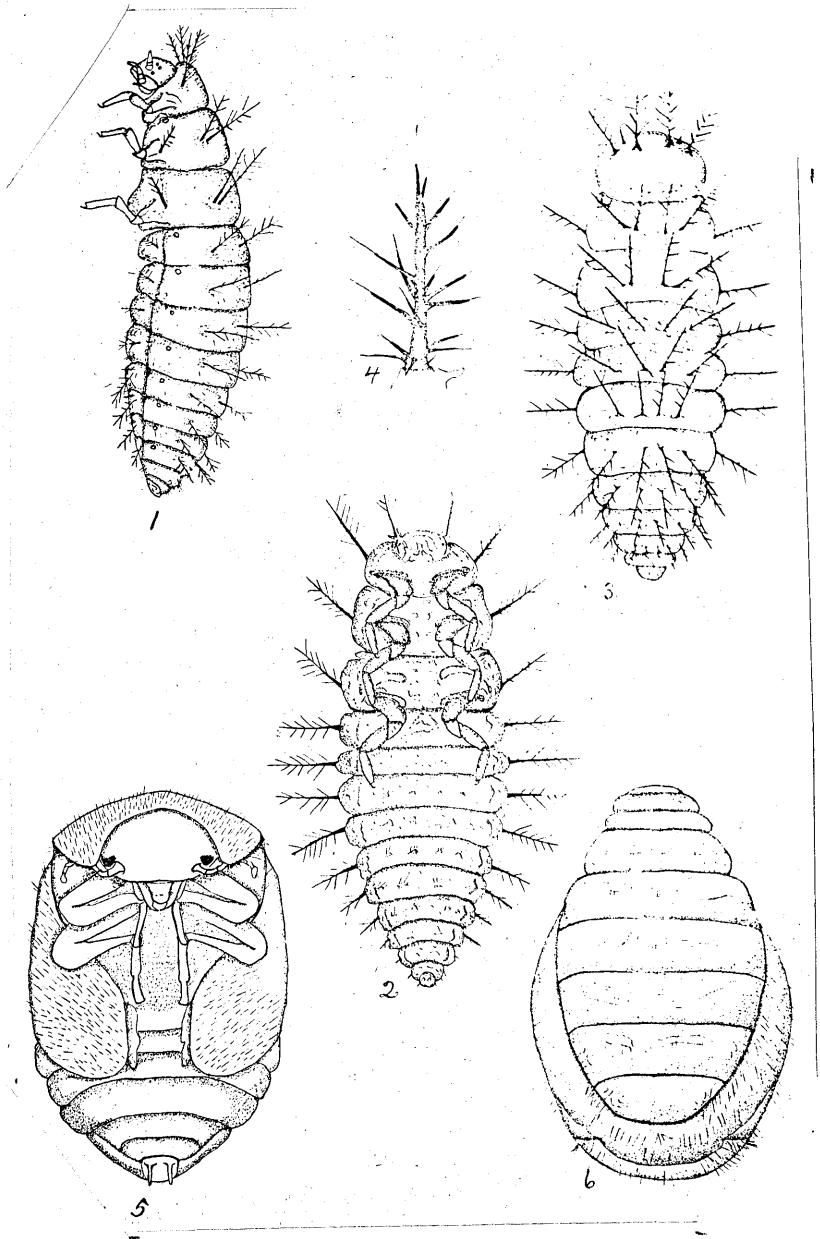


PLATE III

A. Mouth parts of Epilachna borealis. *

1. Labrum
2. Labium
3. Mandible
4. Maxilla

B. Mouth parts of Adalia bipunctata

1. Labrum
2. Labium
3. Mandible
4. Maxilla

* Figures taken from J.B.Smith, Entomological News, Vol.4, pg.123-124.

PLATE III

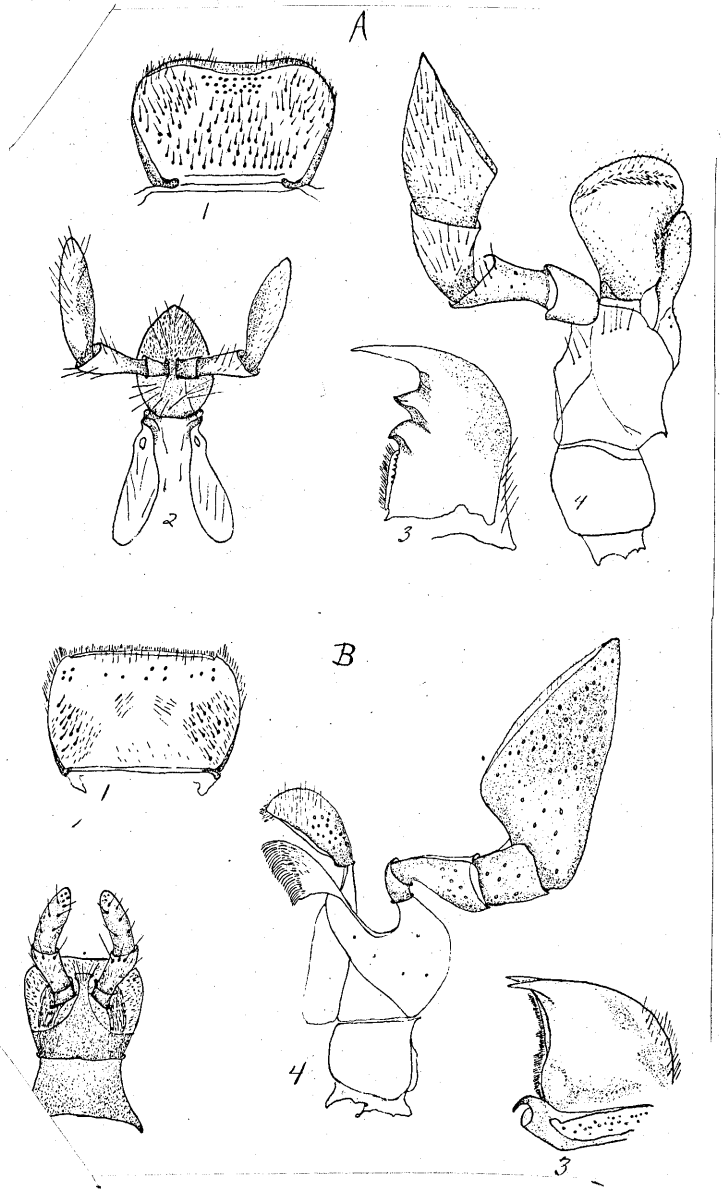


PLATE IV

1-6. Figures of the Aedaegus of *Epilachna corrupta*.

mo-Median orifice

bp-Basal piece

ll-Lateral lobes

bt-Base of tegmen

ml-Median lobe

ts-Tegminal strutt

bm-Base of median lobe

mf-Median foramen

ej-Ejaculatory duct

te-Testis

c--Cirrus

7. Tegminal strutt, greatly enlarged

PLATE IV

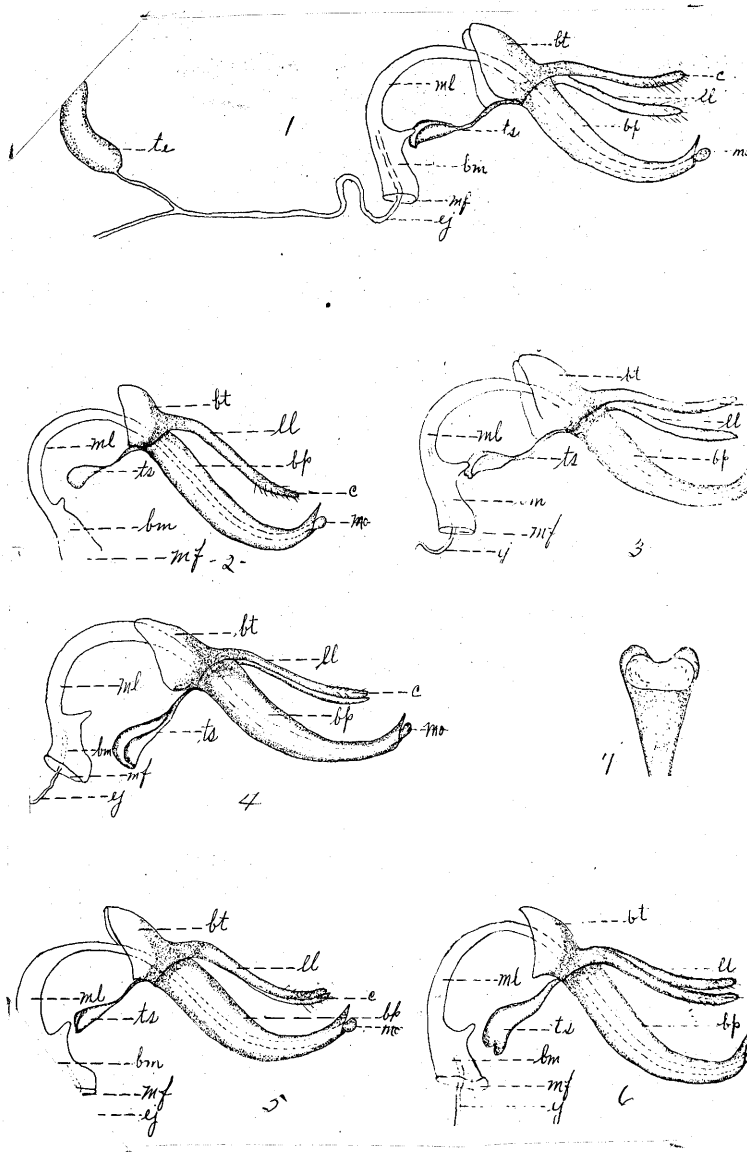


PLATE V

1. Head of Larva, ventral aspect

lp-Labial palp	at-Antenna
mp-Maxillary Palp	e--Eye
lb-Labium	of-Occipital foramen
mx-Maxilla	o--Occiput
me-Mentum	g--Gena

2. Head of Larva, dorsal aspect

1. Labium	5. Mandible
2. Labial palp	6. Labrum
3. Maxilla	7. Clypeus
4. Maxillary palp	8. Antenna

9. Ascelli

3. Aedaegus-Anatis oscellata

4. Median lobe, Epilachna argus *

5. Aedaegus of Epilachna crysomelina*

a. tegmen
6. b. median lobe

7. Drawings of Extruded Gentalia of Coccinellid, (By Mr. Grossbeck)

8. a. Edge of elytra seen from beneath
b. Edge of dorsal segment
c. So called 7th ventral segment
d. Sixth ventral segment
e. Fifth ventral segment
f. Penis and
g. Sipho (Using Verhoff's nomenclature)
h. Cirrus
1. Paramera

*Figures taken from Verhoff (35, 1-80)

PLATE V

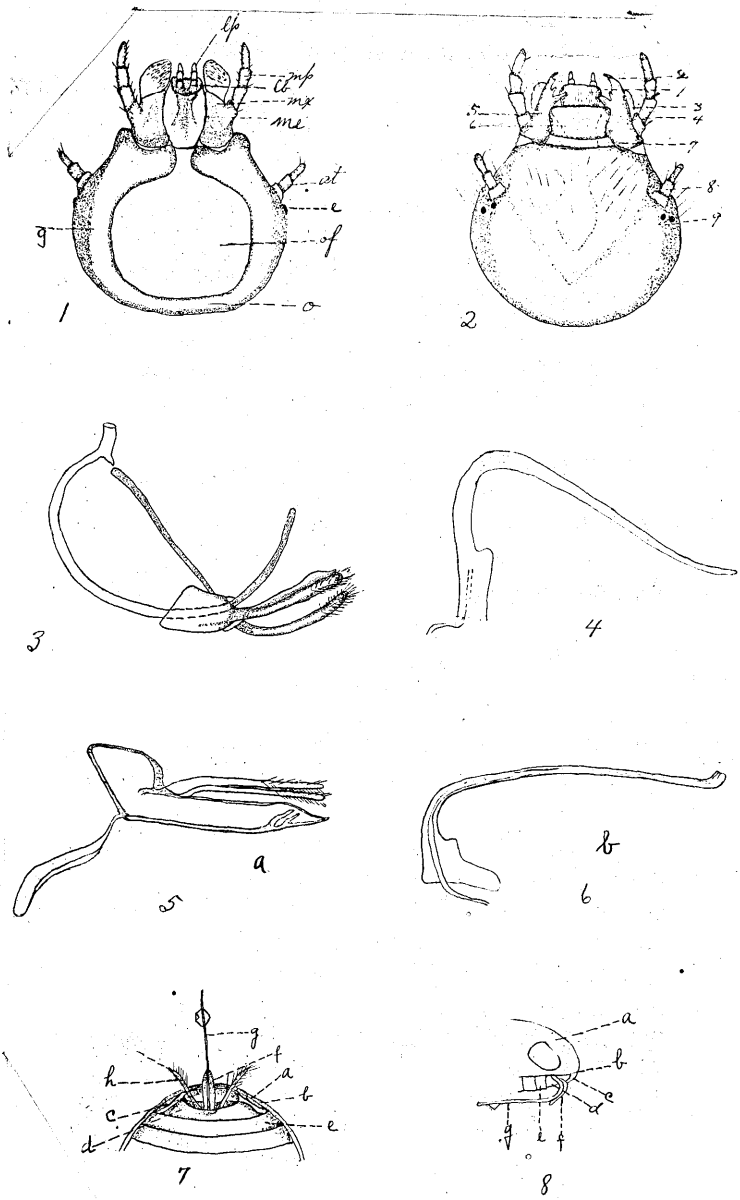


PLATE VI

1. Female reproductive system

   ov--Ovaries
   ovd-Oviduct
   sp--Spermatheca
   vg--Vagina
   sc--Genital plates (sclerites)

2. Genital plates of female

3. Sixth sternite of female

4. Sixth tergite of female

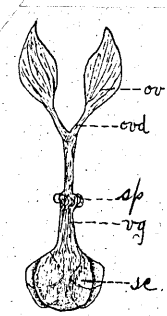
5. Male pygidium

6. Genital places of male
   sp--Spicule ?

7. Sixth sternite of male

8. Sixth tergite of male

PLATE VI



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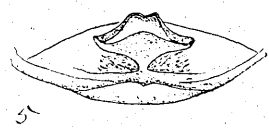

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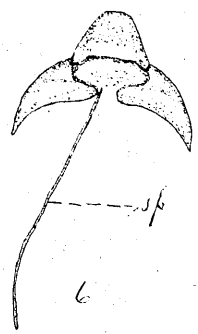

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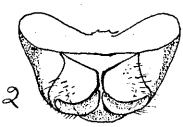

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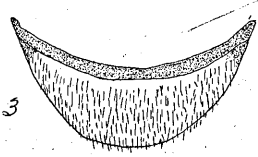

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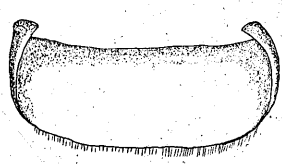

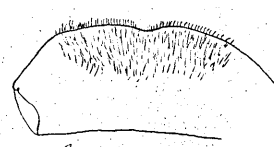

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PLATE VII

Leaf of bean plant showing egg cluster of *Epilachna corrupta*.

PLATE VII

PLATE VIII

Leaf of bean showing larvae and injury of *Epilachna corrupta*.

PLATE VIII

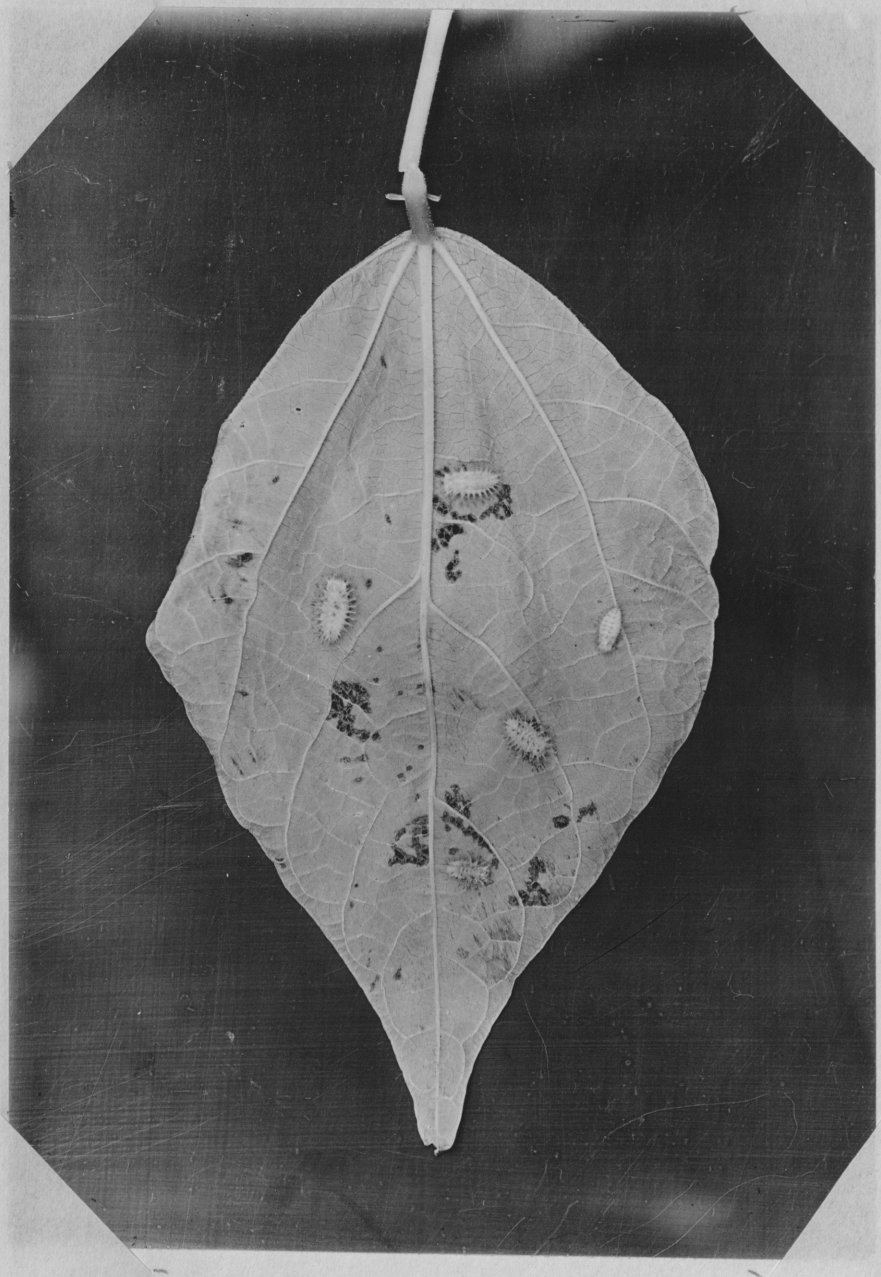


PLATE IX

Larvae, Epilachna corrupta full grown.

PLATE IX

PLATE X

Leaf of bean plant showing injury of *Epilachna corrupta*.

PLATE X

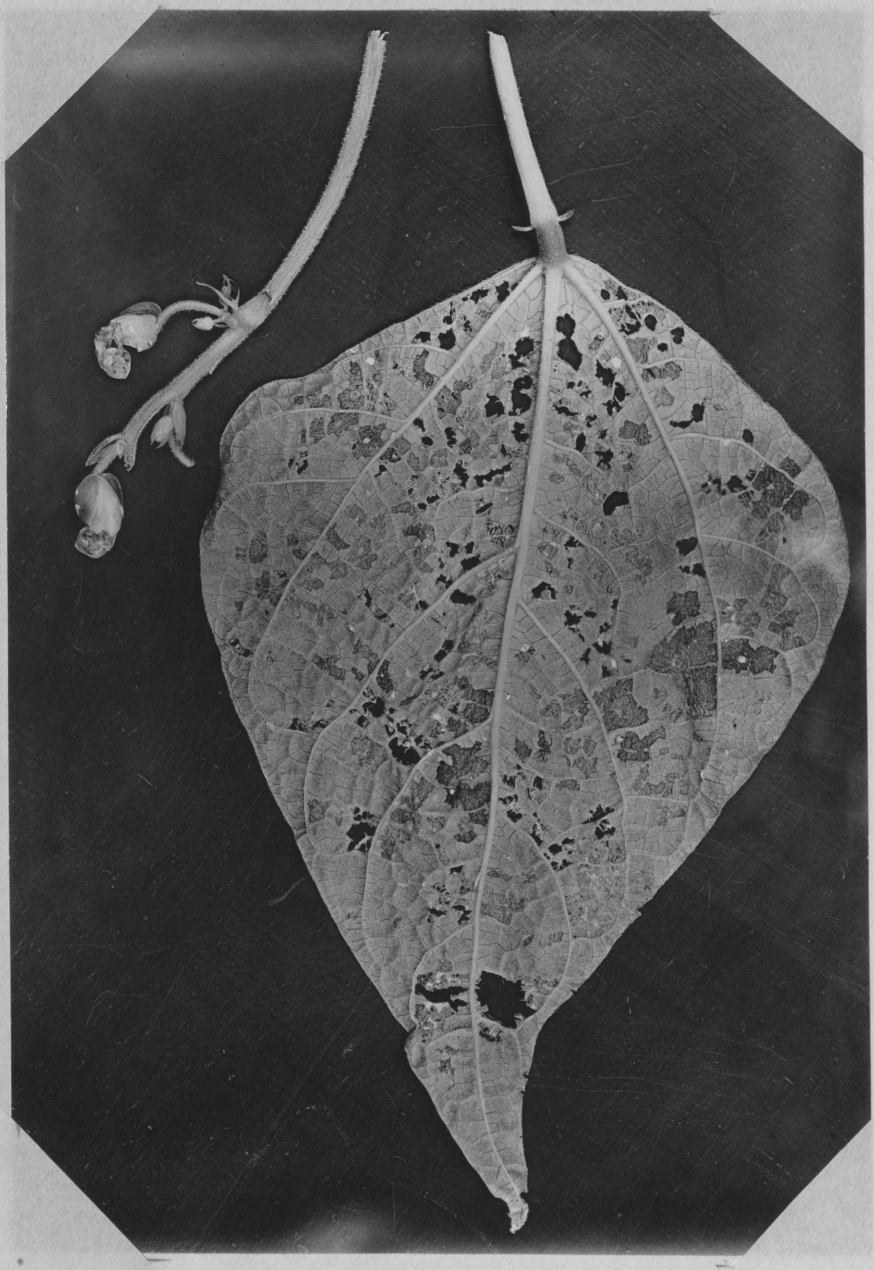


PLATE XI

Pupae, Epilachna corrupta, showing tendency to congregate at time of pupation.

PLATE XI

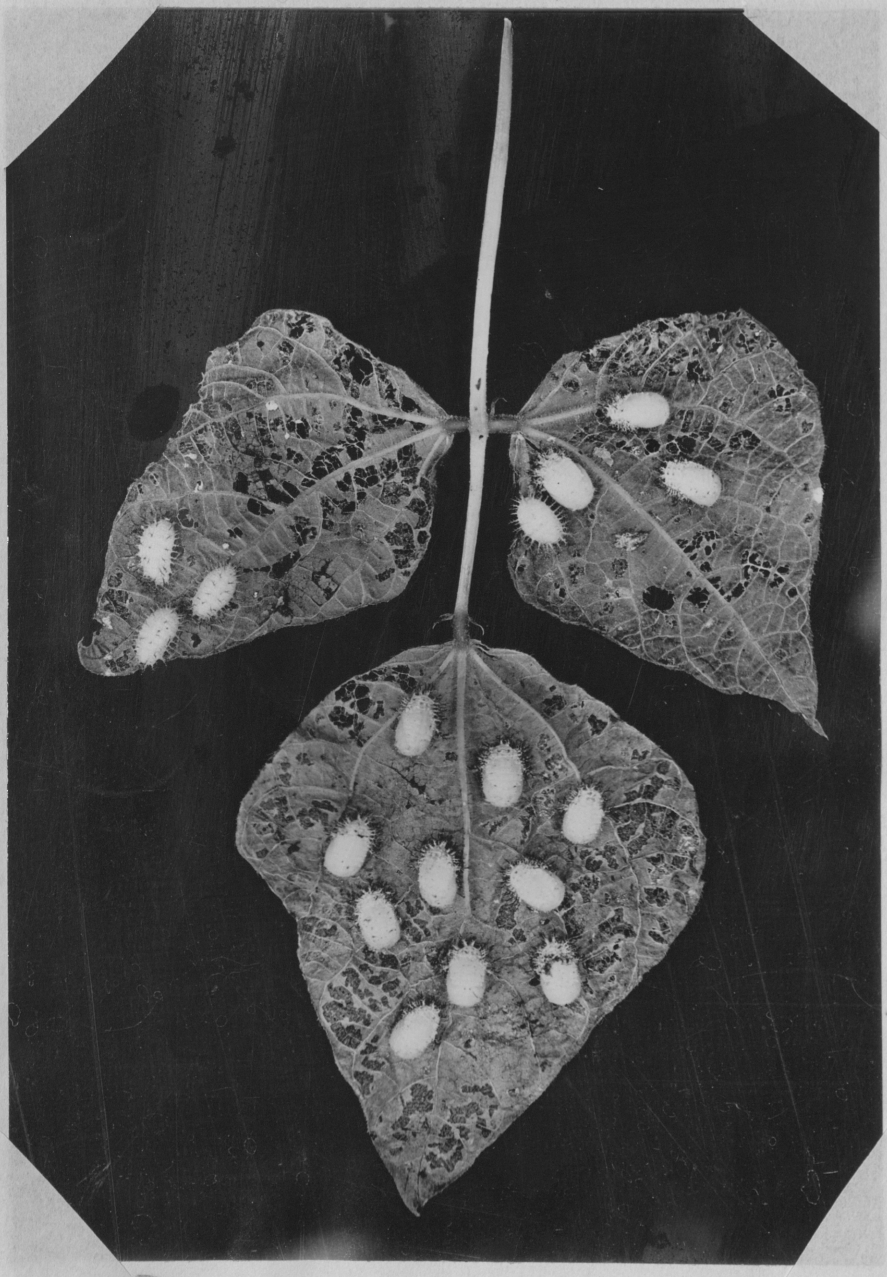
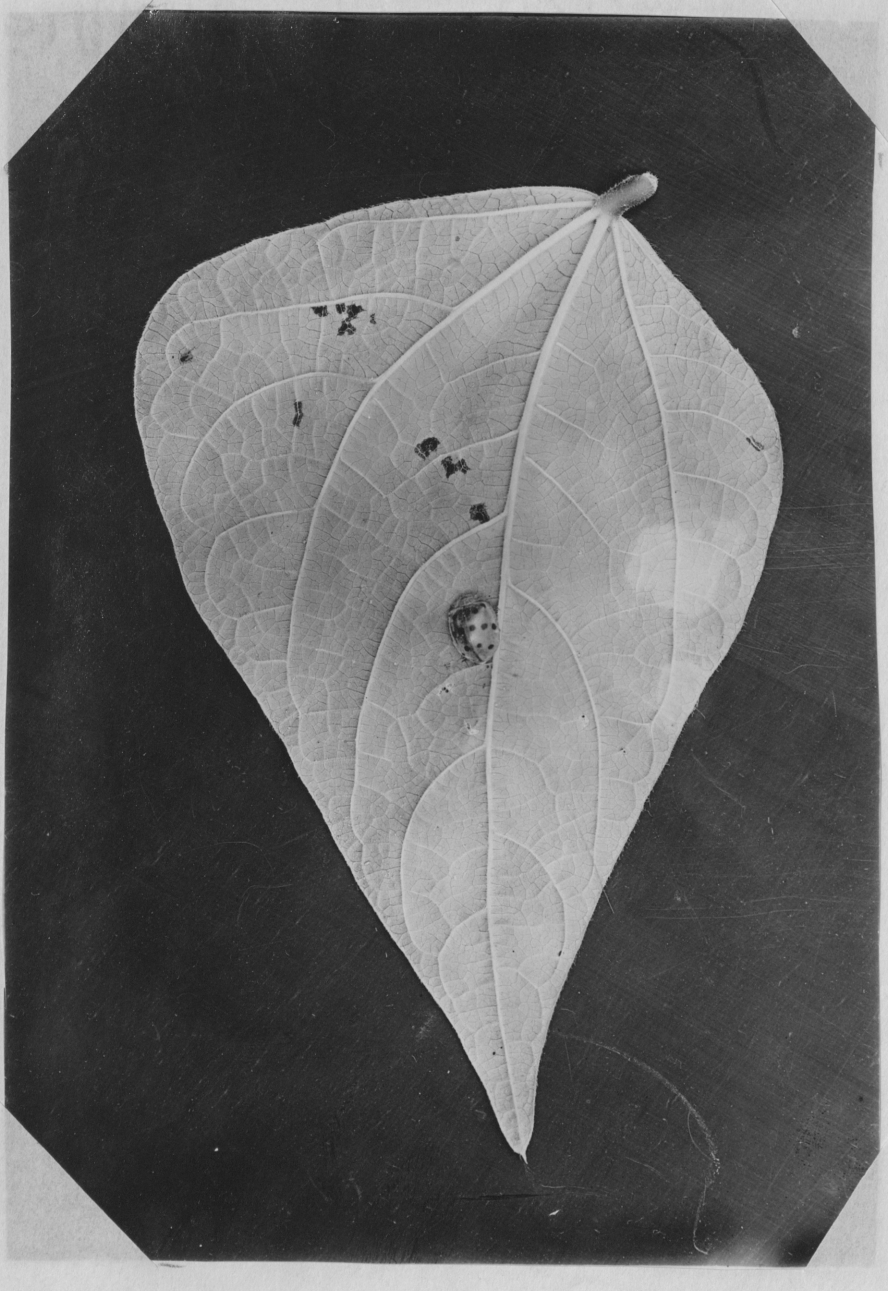


PLATE XII

Adult, Epilachna corrupta, and injury.

PLATE XII



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