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INVESTIGATIONS ON A SOUTH AMERICAN EPILACHNA SP. AND THE IMPORTATION OF ITS PARASITE LYDINOLYDELLA METALLICA TNS. INTO THE UNITED STATES

(COLEOPTERA, COCCINELLIDAE; DIPTERA, LARVAEVORIDAE)

By PAUL A. BERRY AND HARRY L. PARKER,[1] *Bureau of Entomology and Plant Quarantine, United States Department of Agriculture*

In 1938 Felisberto Camargo sent some specimens of *Epilachna* sp. (Coccinellidae) and *Lydinolydella* Tns. (Larvaevoridae) to the United States National Museum. In his correspondence at that time he stated that *L. metallica* Tns. was parasitic on *Epilachna* sp., and that this parasite might be useful in the control of *E. varivestis* Muls. Consequently, when the South American Parasite Laboratory of the Bureau of Entomology and Plant Quarantine was established at Montevideo, Uruguay, in 1940, the study of the natural enemies of *Epilachna* was undertaken as one of the principal projects.

The survey was conducted at points in Argentina, Uruguay, Paraguay, and Brazil. Several species of *Epilachna* from diverse zones were obtained in varying numbers and were reared and studied. During these investigations one species of larvaevorid (tachinid) fly that attacks the *Epilachna* larvae was reared. This fly, *Lydinolydella metallica*, was abundant, especially around Campos do Jordão, Brazil, and appeared suitable for colonization in the United States. Consequently,

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various lots of puparia were reared and forwarded to Hoboken, N. J., over four seasons. The adult flies emerging from these puparia were used for liberation in beetle-infested areas and also for further experiments in the United States. Phorids, although abundant at that time and quite effective as predators, were not colonized, owing to the possibility of their attacking eggs of beneficial Coccinellidae.

During this work various observations were made on the biology and habits of *Lydinolydella metallica*, as well as on the habits of the different species of *Epilachna*. For the convenience of future workers these observations are recorded in this paper.

Epilachna sp. in South America

Epilachna sp., which has been referred to in literature as *E. humeralis* Latr., appears to be more or less limited to altitudes between 700 and 1,200 meters. During this work it was found only in the region of Campos do Jordão and San Paulo, Brazil, where its principal food plant is *Solanum auriculatum* Ait., called locally *fumo bravo*. However, it was observed feeding somewhat freely on three other species of unidentified *Solanum*.

Habits and Biology of Epilachna sp.

In the above-mentioned region the adults were active in April, May, and June, the time during which all our observations were made. They are probably more or less active throughout the year, or at least their active season extends over a longer period than has been indicated, as adults, eggs, and larvae were present in the field during this entire period.

The adults feed on the leaves of *Solanum auriculatum*, and when abundant cause considerable destruction of the foliage.

Egg deposition is quite heavy during the early part of May, but by the end of the month it has fallen off considerably. Larvae are abundant during the latter part of May and in June. By the end of June few larvae are left and adults appear in great numbers. The heavy larval-pupal period therefore is late in May and early in June. The eggs are deposited in masses, usually on the under surface of the leaf, but occasionally on the upper surface also. The leaf surface selected for oviposition appears to be determined by its position and exposure to light. The leaves that lie horizontal seldom have an egg mass on the upper surface when they are exposed to strong light, whereas leaves hanging vertically or in an upright position frequently have egg masses on the upper surface, especially when protected from direct sunlight. The number of eggs per mass was determined from a random

sample of 33 egg masses. In this sample, 36 was the smallest and 110 the largest number of eggs per mass, an average of 77 eggs per mass. The eggs hatch within 6 to 10 days.

The newly emerged larvae start feeding on the leaf surface. At first they feed in compact groups, but have a tendency to become partially separated as they grow older and increase in size. They seldom become solitary, however, and are practically always found in groups within a small area. They continue to feed in the area where they hatch until the food supply is exhausted and if not mature by that time they migrate in a group to new foliage. This migration is usually upward, but may take place either laterally or downward, depending on food supply. The larvae feed on either surface of the leaves, but usually on the lower surface away from direct sunlight. When full fed they attach themselves to the leaf on which they have been feeding and there pupate, often in groups of 8 to 10 individuals. The larval stage lasts from 14 to 21 days at ordinary temperatures.

The pupa remains attached to the leaf, where it develops in 5 to 8 days. The emergence of the adult completes the life cycle.

Habits and Biology of Other Species of Epilachna

Little information was obtained on the biology of other species of *Epilachna* studied, but their habits are somewhat similar.

Epilachna paenulata Germ. has been recorded from the provinces of Buenos Aires, La Rioja, Salta, Jujuy, Chaco, Córdoba, Misiones, Corrientes, Entre Rios, La Pampa, Río Negro, Chubut, and Santa Fe, in Argentina, and also from Brazil and Paraguay (Bosq). We found it to be quite abundant in Uruguay and Argentina in 1940-41. This species feeds on the leaves of Cucurbitaceae and does considerable damage to squash, cantaloup, and watermelon (Bosq). It also attacks wild plants of this family and is frequently found on *Cayaponia ficifolia* Cogn. It is also known to attack beans. We found this species feeding on squash during December, January, and February in Argentina, Brazil, Uruguay, and Paraguay. Collections were made, but no parasites were reared nor were there any indications of parasitism. No records of parasites of this insect have been found.

Epilachna eusema (Weise) has been recorded from Salta and Tucuman, Argentina (Bosq). The principal food plant appears to be *Solanum auriculatum,* and most of the collections made during our survey were taken from this plant at an altitude of about 1,200 meters, near Tucuman, only a few specimens being taken at a lower altitude. Hayward (in pri-

vate communication) calls this plant *S. verbascifolium*, but it has the "ears" characteristic of *S. auriculatum*. Bosq further states that it attacks several species of wild Solanaceae and that at times it also attacks cultivated plants.

Epilachna placida Muls., has been recorded from Tucuman and Salta, Argentina, and from Bolivia (Bosq). The adult beetles feed on *Aristolochia argentina* Gris, but apparently there are no records at present of the food habits of the larvae. They probably feed, however, on the same host plants as the adults.

Epilachna cacica (Guer.) has been recorded from Salta, Jujuy, Tucuman, Misiones, and Corrientes, Argentina, and from Brazil and Paraguay (Bosq). This species feeds on the foliage of cultivated Cucurbitaceae, including squash, cantaloup, and watermelon.

Epilachna circumcincta Muls., adults and larvae, were taken on unidentified solanaceous plants by the writers at Belo Horizonte and Viçosa, Brazil, in May 1944. No parasites were reared from the larvae.

Epilachna marginella F., was taken in small numbers in Itaquaquecetuba, Santa Isabel, and Viçosa, Brazil, on the foliage of *Sechium edula* Sw.

Epilachna spreta (Muls.), adults, were collected on cucurbits at Belo Horizonte and Viçosa, Brazil, in June 1944.

Epilachna patricia (Muls.) occurs in Salta and Tucuman, Argentina, and has also been recorded from Bolivia, its food plant being *Solanum verbascifolium* L. (Bosq).

Epilachna claudestina Muls. is reported from Brazil (Costa Lima, pp. 283-284). Costa Lima states that it feeds on Cucurbitaceae, but he does not give any specific localities nor species of plants on which it feeds.

In addition to these species, a small number of adults of several species, not yet determined, were taken in sweepings in various localities.

The Larval Parasite, Lydinolydella metallica Tns.

The known hosts of *Lydinolydella metallica* in South America are *Epilachna* sp., *E. cuscma* Weise, *E. marginella* F., and *Doryphora quadrisignata* (Germ.) (Chrysomelidae).

Lydinolydella metallica was abundant in all the larval collections of *Epilachna* sp., i.e., the brown species formerly thought to be "*humeralis.*" Great numbers were found in the area around Campos do Jordão and San Antonio. The parasitization by *L. metallica* was determined by dissecting samples of full-grown host larvae during May and June, coincident with the extensive collections made for shipment. The host larvae were most abundant at that time, and it is possible that

a study made later in the season would show a higher percentage destroyed by the parasite due to the decrease in beetle population. At the time observations were made in 1940, parasitization was 40 percent; in 1941, 67 percent; in 1942, 47 percent; and in 1943, 63 percent.

During the 4 years of observations *Epilachna* sp. maintained heavy populations in the limited area in which the work was done. The densities of populations, however, did vary from year to year, i.e., they shifted from one locality to another in small restricted areas. Along one road the plants would have a heavy infestation one year, but the next year would have practically no specimens, although a few kilometers distant they would be abundant. In general, the population as a whole throughout the area appeared to remain about the same for the 4-year period. Collections could be obtained the last year in about the same numbers with about the same effort as when the work was started.

Parasitization by *Lydinolydella metallica* of the other hosts mentioned was based on numbers too few to be significant. No intense infestations of these hosts, except *Epilachna cusema* at Tucuman where parasitization was good, were encountered during this work. Furthermore, the observations and rearing for parasites on the other species were limited to a few scattered individuals, or at best to small colonies. Available data thus indicate that *Epilachna* sp. is the favored host of *L. metallica*.

Lydinolydella metallica is widely distributed in South America, being found in Campos do Jordão, San Antonio, Santa Isabel, and Itaquaquecetuba, Brazil, and in the areas around Tucuman and Salta, Argentina. These regions are widely separated, and it seems likely that this larvaevorid is generally distributed throughout the area connecting these two zones.

Habits and Biology of Lydinolydella metallica Tns.

Adults of *Lydinolydella metallica* were reared for experimental purposes in the laboratory at Montevideo, Uruguay, from puparia whose larvae had issued from field-collected larvae of *Epilachna* obtained in Brazil. The adults were active and lived for 2 weeks or more in cages. It was not possible, in the limited time allotted to this problem to develop a technique for mating this species. The methods employed to induce mating consisted in exposing pairs or groups of adult flies to different light intensities and to various degrees of temperature and humidity when confined in containers of various sizes and shapes. No mating was observed and dis-

section of the old, weak, or dying females failed to reveal any normal egg development or other evidence of a single mating having taken place.

Oviposition by *Lylinolydella metallica* has not been observed by the writers, but examination of the fertilized female showed that the eggs were incubated in the uterus; larvae developing in the lower part of the uterus were perfectly formed. Since the female does not have a piercing type of ovipositor, it is apparent that eggs must be laid either on or near the host larva, more probably the former since the host larvae are exposed and easily accessible.

Eggs of *Lydinolydella metallica* were not found in the dissected larvae of *Epilachna;* probably they are deposited on the host and eclosion takes place within a few minutes after deposition. The young larvae presumably enters the host as does *Paradexodes epilachnae* Ald. (Landis and Howard).

The very small first-instar larvae are found living free in the body cavity of the host. Later, however, they appear to attach their posterior spiracles to the spiracular system of the host, usually in the region of the first or second abdominal segment. This point was not clear, however, in the preserved material, as some individuals appeared to remain free from attachment of any kind.

The first-instar larva (fig. 1, B) is somewhat cylindrical and tapers at the ends. It appears to consist of a retractile pseudocephalon and 11 clearly defined body segments, all of which are opaque white. Each segment bears between three and six rows of spines, chiefly at the anterior margins. The rows of spines are more pronounced on segments 1, 2, and 11. Ventrally at the union of the segments 5 to 11 are small areas supporting three to four rows of heavily sclerotized ambulatory spines. These spines have widely separated, bilobed bases.

The buccal armature consists of a single narrow oral hook, which bears notches on the anterodorsal surface (fig. 1, A). Above the oral hook is a narrow, partly sclerotized, hatching spine. Laterally and somewhat ventral to the oral hook are two prominent dental sclerites. Posterior to the fused hypostomal sclerites is the infrahypostomal bridge. The pharyngeal sclerites consist of two dorsal cornua and a fused ventral cornu.

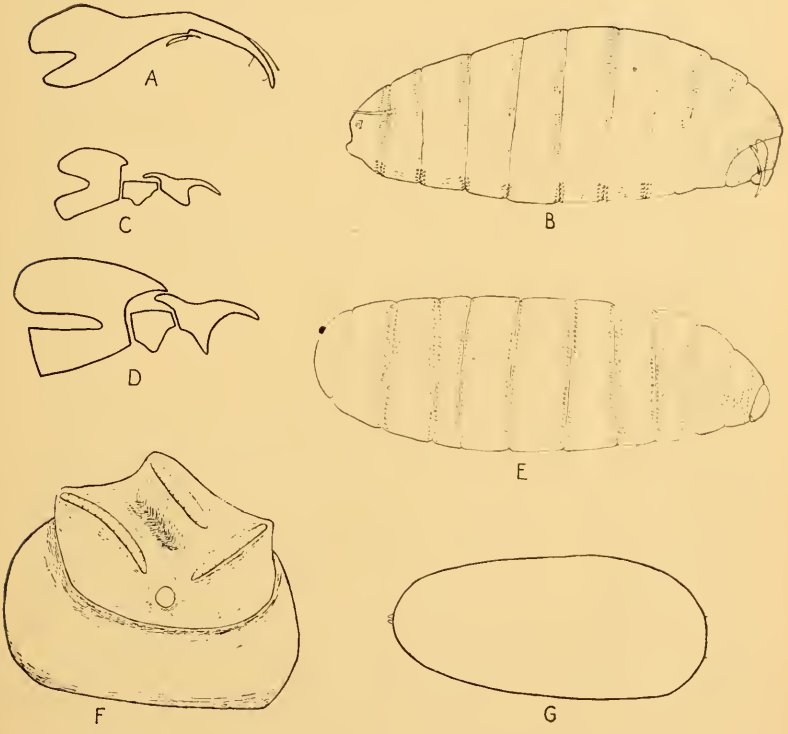
The two posterior spiracles open on the dorso-pleural portion of the cuticle of the last body segment.

The stigmatic hooks consist of a heavily chitinized shield-shaped plate with two sharply curved hooks at the top. They lie in the midline-ventral just below the openings of the anal stigmata.

The mandibles of the second-instar larva are shown in figure 1, C.

The second-instar larva resembles the first in that the number of rows and the arrangement of the cuticular spines are essentially the same. The spines covering the ventral fusiform area differ from those in the first-instar larva in that they are smaller, resembling those that circle the segment; they are also more numerous.

The third-instar larva (fig. 1, E) has a heavier cuticular armature circling the segments than does the second-instar larva. The ventral fusiform areas have larger and stronger spines and may aid the larva in locomotion after it leaves the host. The mandibles (fig. 1, D) are similar to those of the second-instar larva.



Text Figure 1. *Lydinolydella metallica.* A, Cephalopharyngeal mechanism of first-instar larva; B, first-instar larva; C, cephalopharyngeal mechanism of second-instar larva; D, cephalopharyngeal mechanism of third-instar larva; E, third-instar larva; F, one of the two posterior spiracular plates, showing stigmatic plate; G, outline view of puparium.

The two posterior spiracles open on a thick, semicircular, raised anal plate, the inner sides of which are flattened and opposed.

The puparium (fig. 1, F) is ovate, the width being greatest toward the anterior end, which is broadly rounded; the posterior end is slightly subconical. The puparia change from light yellowish to reddish, the ultimate color being a dark red. The puparium is smooth, except for the segmentation and spines of the third-instar larva, and the small anterior and large posterior spiracles (fig. 1, G).

Life Cycle of Lydinolydella metallica

The time required for the different stages of *L. metallica* to develop was not determined exactly, but the data available on this subject are included for practical purposes. The egg presumably hatches immediately after it is deposited on the host, and the young larva bores its way into the body cavity. The larva completes its development in the host within 12 to 17 days during May and June in Brazil. The periods may be somewhat shorter during the warmer months and longer during the colder months.

The pupal stage ranges from 9 to 14 days during May and June. This was determined from a sample of puparia that was brought from Brazil to Montevideo, as well as from data obtained from time of pupation in Brazil to time of emergence in the United States.

Collecting, Rearing, and Shipping of Lydinolydella metallica to United States

All large-scale collections of *Epilachna* sp. for rearing and shipping *L. metallica* to the United States were made in the areas around Campos do Jordão and San Antonio. Large leaves of *Solanum auriculatum* on which the host larvae were feeding were collected and placed in flour-sifter trays. These containers were so constructed that one could be placed on top of another. They could be stacked six to eight deep, and the top sifter either could be closed with mosquito netting held on by a rubber band or be left empty. This arrangement provided plenty of ventilation and the green leaves supplied plenty of moisture to maintain the puparia in good condition until they were removed. When transported long distances the stacks of trays were placed in cloth bags and tied down to keep them from separating. The trays were usually examined daily and the puparia removed, and fresh food was given to the *Epilachna* larvae. Occasionally, however, 2 or 3 days elapsed between examinations. During the longer periods the puparia remained in good condition, but if the trays were

crowded with larvae they exhausted the food supply and did not survive so well as when attended daily. The puparia were placed in damp sphagnum moss as soon as removed, as it is necessary to keep them moist until the flies emerge. If the puparia were allowed to dry, the percent of emergence was decreased considerably. A collection of twenty to thirty thousand *Epilachna* larvae constitutes a maximum number that one person can handle.

For shipment to the United States the puparia were packed in damp sphagnum moss in small wooden boxes, and sent by air.

During the 4 years 1940-43, 15,956 puparia of *Lydinolydella metallica* were obtained and shipped to the United States. From these shipments, 5,899 good flies were otained for liberation and experimental work in North America. Of these flies, 5,025 emerged in the laboratories in the United States: 874 flies had emerged en route, but were in good condition upon arrival when the containers were opened. These figures show that of the puparia shipped 37 percent produced good specimens. This appears to be a very low percentage of survival for air shipments, but these shipments were made during the war period and in several cases considerable delays caused complete loss of the consignments. When transportation required no more than 6 or 7 days from time of shipment to arrival, emergence from the puparia was as high as 76 percent. This figure is about as high an emergence as is usually experienced in laboratory rearing of this species. In order to obtain best results in shipping, puparia should not be in transit more than 9 to 10 days, as the flies that emerge en route seldom arrive in good condition.

The consignments of puparia from Brazil were handled by T. R. Gardner and H. D. Smith at the parasite receiving station at Hoboken. Most of the emerging flies were used in attempts to develop methods of laboratory rearing, but without success. Nine colonies of adult flies were released in the field in New Jersey in 1942 and 1943, but did not become established. This outcome is now believed to have been due to the seasonal cycle of the Mexican bean beetle in the United States. Here larvae are available for attack only during the summer, and a suitable alternate host to carry the parasite over the winter appears to be lacking.

Secondary Parasites

Brachymeria carinatifrons Gahan was reared in considerable numbers from small collections of puparia of *Lydinolydella metallica* obtained in San Antonio. Little information was obtained on this species, however, except that parasitiza-

tion must take place while the *Lydinolydella* larva is still within its host. This secondary parasite is widely distributed in South America.

Spilochalcis sp. near *nigropleuralis* Ash. was recovered in small numbers from collections of *L. metallica* puparia obtained while in the larval stage in the vicinity of Salta. As in *B. carinatifrons*, parasitization apparently takes place through the host larva.

Megaselia spp. Predaceous on Epilachna Eggs

Three species of Phoridae were found feeding on the eggs of *Epilachna*. These all belong to the genus *Megaselia* and were determined by Tomaz Borgmeier. These phorids were common in the Campos do Jordão region, where they often destroyed a high percent of the *Epilachna* eggs. In some cases practically all the eggs in a mass were consumed, whereas in others only a few would be attacked.

It was not considered advisable to try to introduce these predators into the United States, owing to the possibility of their attacking also the eggs of beneficial Coccinellidae.

Summary

Several species of *Epilachna* or plant-feeding Coccinellidae are widely distributed over the agricultural areas of Brazil, Uruguay, and Argentina. Some species, however, appear to be restricted to certain areas. This restriction seems to be determined by altitude, food plants, or climate, or possibly a combination of these three factors.

In general, the damage done to agricultural crops does not appear to be severe, although melons, cucurbits, and various cultivated crops are attacked by some species.

Epilachna sp., apparently an undescribed species similar in habitus to *humeralis* Latr., was found in great quantities in the region of San Antonio and Campos do Jordão, São Paulo, Brazil, where it attacked the wild bush *Solanum auriculatum* (*fumo bravo*).

A larvaevorid fly, *Lydinolydella metallica*, was the only parasite of importance found attacking *Epilachna* in South America. This fly is widely distributed and attacks three species of *Epilachna*—*Epilachna* sp., *E. cusema*, and *E. marginella*—as well as *Doryphora quadrisignata*. Parasitization of *Epilachna* sp. by this fly ranged from 40 to 67 percent during 1940-43.

Significant numbers of puparia of *Lydinolydella metallica* were shipped to the United States for study and colonization on *Epilachna varivestis* Muls.

Two secondary parasites, *Brachymeria carinatifrons* and

Spilochalcis sp. near *nigropleuralis*, were reared from puparia of *Lydinolydella metallica*.

Three species of Phoridae belonging to the genus *Megaselia* were found to be predaceous on the eggs of *Epilachna*.

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THE OVIPOSITION OF THE TWO-STRIPED WALKINGSTICK, ANISOMORPHA BUPRESTOIDES (Stoll)

(ORTHOPTERA, PHASMIDAE)

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Entomologists generally accept the walkingsticks as insects that drop their eggs indescriminately and make no provision for their young. Both Blatchley and Comstock, as well as other writers, present this impression. Undoubtedly many of the members of the Phasmidae do follow this pattern.

During the autumn of 1948 the writer had the opportunity to observe great numbers of a large black and white walkingstick near Salt Springs, Marion County, Florida. Specimens of the insects were collected and submitted to the United States National Museum for identification. Mr. C. F. W. Muesebeck reported that the specimens had been examined by Dr. A. B. Gurney who considered them to be a color variation of *Anisomorpha buprestoides* (Stoll). The National Museum specialists urged that cage studies of these insects be made in order to definitely establish the correct taxonomic status.

In the autumn of 1948 several thousand pairs of these walkingsticks were observed in the field and their oviposition habits were of special interest. Here is a member of the family Phasmidae that definitely makes provision for the protection and insured hatching of eggs. Although there are no apparent modifications of the legs, the female of *Anisomorpha buprestoides* (Stoll) is a fossorial insect during the egg-laying season. Small pits are dug in the sandy soil by the female walkingstick, both the prothoracic legs and the mesothoracic legs aiding in the excavating.