The Spotted Lady Beetle, *Coleomegilla maculata* (De Geer), as a Predator of European Corn Borer Eggs[1]

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ABSTRACT

The spotted lady beetle, *Coleomegilla maculata* (De G.), is a known predator of the eggs of the European corn borer, *Pyrausta nubilalis* (Hbn.), but the actual extent of control had never been determined. The fecula of the spotted lady beetle and other predators found on corn plants were characterized and a method devised for collecting these pellets beneath the site of borer eggs. By examining the fecula, it could be determined whether this beetle had fed. In two different fields under observation 16.5 and 15.3% of the eggs were fed upon.

Studies on food preference and potential egg consumption showed that the spotted lady beetle would feed only upon pollen, pea aphids, *Macrosiphum pisi* (Harr.), or eggs of the European corn borer, when these foods were on appropriate plants, in this case older corn leaves and alfalfa. It was found that the number of eggs an individual adult spotted lady beetle could consume averaged 59.4 per day. Temperature and rainfall had no significant effect upon feeding.

The spotted lady beetle, *Coleomegilla maculata* (De G.), is one of the commonest and most uniformly distributed insects in Delaware. The form which occurs here falls into Timberlake's race *lengi*. It can be found readily on a great variety of plants, is present early in the spring, and maintains a fairly high population late into the fall. Although its food preference is known to be variable, the extent of its host range has not been completely determined. Its recorded food consists of eggs of the European corn borer, *Pyrausta nubilalis* (Hbn.) (Baker *et al.* 1949); the pea aphid, *Macrosiphum pisi* (Harr.); melon aphid, *Aphis gossypii* Glov.; cabbage aphid, *Brevicoryne brassicae* (L.); currant aphid, *Capitophorus ribis* (L.); greenbug, *Toxoptera graminum* (Rond.); German grain aphid, probably *Macrosiphum granarium* (Kby.); chinch bug, *Blissus leucopterus* (Say); eggs of the Colorado potato beetle, *Leptinotarsa decemlineata* (Say); and of the bollworm, *Heliothis zea* (Boddie); larvae of the asparagus beetle, *Crioceris asparagi* (L.); and of the cottonwood leaf beetle, *Chrysomela scripta* F.; and corn pollen (Britton 1914). It has been reported by Cody (1927) to feed on the persimmon psylla, *Trioza diospyri* (Ashm.); by Richardson (1915) on a syrphid fly *Mesogramma polita* Say; by Everly (1938) on a mirid *Trigonotilus rubicornis* (Geoffrey); and by Caffrey & Worthley (1927) on both a pentatomid *Podisus placidus* Uhl. and a reduviid *Sinea diadema* Fab. Folsom (1909) reported that it fed on coccinellid eggs and pupae, including eggs of its own kind, as well as on adults of *Coccinella sanguinea* Say. The latter observation seems to have been based on a misidentification. He apparently meant *Cycloneda munda* (Say).

The relative abundance of the spotted lady beetle, its frequent presence on corn plants, and the knowledge that it fed on European corn borer eggs, suggested that it might be an important factor in the biological control of the borer. With this in mind, a study was made of its habits, particularly of those in which it is associated with the European corn borer.

Some investigators of the European corn borer have praised the spotted lady beetle highly as a destroyer of borer eggs, while others did not think it of great value. It was evident that either little attention had been paid to the spotted lady beetle as a predator or that its feeding habits fluctuated considerably from one area to another. Baker *et al.* (1949) credit it with destroying 50% of the eggs at Toledo, Ohio, while others have not been so specific. Crawford & Spencer (1922) indicate that it " . . . probably does more good than any other . . . " and " . . . was repeatedly seen to eat every egg mass it found." Drake (1926) claimed that it occasionally fed on egg clusters. Huber *et al.* (1928) refer to it as devouring eggs, but felt that the percentage destroyed was probably very small. Marston & Dibble (1930) and Caffrey & Worthley (1927) attribute frequent egg feeding to it.

Several predators, including the spotted lady beetle, feed on the eggs of the European corn borer. Among these are the thirteen-spotted lady beetle, *Hippodamia tredecimpunctata* (L.); the convergent lady beetle, *Hippodamia convergens* Guer.; a small red mite *Trombidium fuliginosum* Koch (Bartholomai 1954); *Orius insidiosus* Say and *Nabis ferus* (Linn.) (Beard 1943); and the larvae of an elaterid *Crypotohypnus abbreviatus* Say (Hawkins & Devitt 1953). Bartholomai (1954) also mentions that several species of thrips, chrysopids, and spiders feed upon eggs and larvae to a lesser extent.

Early in the course of these studies it became evident that the larvae of the spotted lady beetle feed on corn borer eggs only to a minor extent. One reason is that this coccinellid apparently lays eggs only at sites of aphid colonies. This apparent fact is supported by the observation that larvae never were found on corn until the corn leaf aphid, *Rhopalosiphum maidis* (Ashm.), appeared. Another reason for the small amount of egg predation by the larvae is their limited mobility. They commence moving about in search of other sources of food only when the aphid colonies become decimated. The larvae were observed feeding on corn borer eggs, but only after the corn leaf aphid had nearly disappeared. For this reason these studies were directed toward the activities of the adult.

METHODS.—*General Observations.*—During the course

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of insect-pest-survey work, observations were made on the activities of the spotted lady beetle over the 2-year period 1957 and 1958. Notes on this beetle were made principally in fields of corn, alfalfa, and clovers. An average of 15 fields of corn were visited weekly between June 1 and September 30 each year.

Food Preference of Caged Adults—Field-collected spotted lady beetle adults were confined in cages and offered, as food, a choice of pea aphids, corn pollen, and European corn borer eggs. The pea aphids were collected in the field as needed. Corn pollen was collected from plants grown in the greenhouse. The borer eggs were obtained from an oviposition chamber constructed according to the description of Briand (1929). Aphids, eggs, and loose pollen were first placed in a small battery jar and a pair of spotted lady beetle adults introduced therein. Later, pollen caked on a fragment of corn leaf was offered to the beetles. Several different arrangments of cages containing a small corn stalk with egg masses pinned to its leaves and a sprig of alfalfa containing pea aphids were tried. In one experiment, a cage was constructed from two battery jars. One jar was filled with water and covered by a piece of corrugated paper pierced with two holes; a stalk of alfalfa bearing pea aphids was inserted in one hole and a seedling corn plant bearing European corn borer eggs was placed in the other. The second jar, inverted over the first, contained a pair of adult spotted lady beetles. In another experiment a cardboard box, 12 in.×7 in.×4 in., was divided by a transverse partition and a pair of holes punctured through the bottom of each compartment. It was then placed over a pan of water and a leaf from a seedling corn plant and a stalk of alfalfa inserted through each pair of holes. The corn leaves each bore a European corn borer egg mass. The alfalfa stalk in one compartment bore pea aphids, the other did not. An adult spotted lady beetle was placed in each compartment and confined by a glass plate covering the box. In all these experiments, the feeding behavior of the beetles was observed for a minimum of 5 days.

Artificial Infestation of Plants.—European corn borer larvae were collected from fields during the fall and winter of 1957. These overwintered in an outdoor cage and were taken into the greenhouse at Newark in April. The emerging adults were introduced into the oviposition chamber referred to above (Briand 1929), in which eggs were deposited on waxed paper. The egg masses were cut from the paper and the individual eggs counted. They were then placed on the adhesive surface of a $\frac{1}{2}$ in.×6 in. strip of plastic adhesive tape. Six or seven masses were placed in a row on this tape in such a manner that none of the adhesive surface was exposed to interfere with feeding. This strip was taped to the undersurface of a blade of corn in a field at Newark and was then covered by a 5 in.×2 in.×1 in. cage constructed from 16-mesh wire screen in such a way that it could be attached to the leaf beneath the eggs. An adult spotted lady beetle was placed in the cage, to remain there throughout the experiment. Each day the strip of tape holding the egg masses was removed and replaced by a freshly constructed one. Each strip was examined under the microscrope, upon return to the laboratory, to determine the number of eggs consumed. A maximum-minimum thermometer, the upper surface of which was shaded to simulate conditions existing beneath the leaf, was placed on a level with the cage and as close as possible to it. The temperature was recorded each day. Daily precipitation was determined by using an 8-in. rain guage.

Natural Feeding in Corn Fields—Two corn fields, about 5 miles apart, and both in the vicinity of potato fields heavily infested by first generation European corn borer, were selected in Kent County for these observations. One was located near Pearson's Corner and the other near Dover. As each European corn borer egg mass was located, the leaf bearing it was marked and a 3- by 5-inch index card was suspended under it by plastic strips (fig. 1.). The cards, waterproofed by dipping in hot paraffin, were coated on the upper surface with a thin layer of tanglefoot to catch the fecal pellets of any predators feeding on the egg masses. The fields were visited twice a week to hunt egg masses, to place cards and to examine cards previously placed. As soon as an egg mass, under observation, had hatched or disappeared, the card beneath it was removed and returned to the laboratory for examination. No more than three rows in either field were used in this study, since thus limiting the area facilitated return to all the marked leaves.

RESULTS.—*Bionomics of the Spotted Lady Beetle in Delaware.*—The adult is easily identified in the field (fig. 2). The ground color varies from rose to crimson. A pair of black spots appears on the thorax and 10 black spots on the elytra, 2 of which are centered between the elytra. The prothorax is approximately 5 mm. long by 3 mm. wide. The larva has a ground color of creamy yellow, a pair of cocoa brown spots on each thoracic segment, and mottled brown and yellow patches on all the abdominal segments except the fourth, which is almost entirely yellow.

It was found to overwinter as an adult either individually under the bark of the American sycamore, *Platanus occidentalis* L., under leaf sheaths of corn, or in aggregations at the base of trees and beneath rubbish. During the early spring it commonly was observed on the flowers of yellow rocket, *Barbarea vulgaris* R., and dandelion, *Taraxacum officinale* Weber. Later in the spring it established itself in clovers and alfalfa and during the summer months was found more or less abundantly on all crops in Delaware. The larvae, however, could not be found except in clover, alfalfa, and aphid-infested corn. The number of generations appeared to be from four to five a year.

The only parasite of the spotted lady beetle according to Thompson (1943) is a braconid, *Perilitus coccinellae* (Schrank) which attacks only the adult, as far as is known. During the course of this study observations were made upon the amount of parasitism in the field. At Pearson's Corner in the first week of July 191 adult lady beetles were observed on 700 plants; three of these were obviously parasitized as they bore the characteristic cocoon of *P. coccinellae* between their legs. This indicated about 1% parasitism. Later in the season it became apparent that a greater percentage were parasitized, although no actual counts were made. Only *P. coccinellae* adults were reared from this material (Cushman 1922).

Caged Feeding.—Observations on a caged adult of the spotted lady beetle indicate that it has a high predation

FIG. 1.—Cards suspended from corn leaves to collect fecula of the spotted lady beetle.

potential on eggs (table 1.). During the 13 days of this experiment 713 eggs were consumed, an average of nearly 60 a day, and it is probable that more would have been eaten had they been available. Neither temperature nor precipitation appeared to have any significant effects upon the number of eggs eaten. It was observed also, that the larger egg masses are seldom entirely consumed.

Food Preference.—In these studies it was found that this lady beetle would not feed on corn pollen, pea aphids, or European corn borer eggs when these were simply placed in the bottom of the cage. They did feed upon corn pollen when it was offered on a piece of a leaf from a corn plant that had reached the tassel stage. Also they fed freely on pea aphids when these were on alfalfa plants. At no time, however, did they feed upon corn borer egg masses located either on corn seedlings or on isolated leaves from corn seedlings. The beetles actually appeared to avoid contact with the corn seedlings.

Table 1.—Amount of feeding by one adult *Coleomegilla Maculata* on European corn borer eggs in a leaf cage on sweet corn, Newark, Delaware, 1958.

DATE	NO. OF EGGS EATEN	TEMPERATURE (° C.)			PRECIPITATION (IN.)
		Max.	Min.	Mean	
June 11	75	36	21	28.5	0.95
12	55	37	18	27.5	0
13	?[a]	38	21	29.5	0.01
14	33	33	10	21.5	0
15	31	25	10	17.5	0
16	44	29	10	19.5	0
17	75	30	8	19.0	0
18	63	31	11	21.0	0.21
19	45	32	15	23.5	0.21
20	83	21	15	18.0	0.05
21	65	22	13	17.5	1.3
22	78	29	11	20.0	0
23	66	32	11	21.5	0
Total	713				
Average	59.4				

[a] Two masses of eggs had hatched; 65 larvae were missing; 12 eggs were eaten.

Natural Feeding.—A total of 436 egg masses was located in the two fields in Kent County and the tanglefoot-coated cards placed beneath them. By comparing cards containing the fecula of the spotted lady beetle with those free of pellets, the percentage of egg masses fed on could be ascertained. The presence of at least one fecal pellet of the spotted lady beetle on a card was taken as

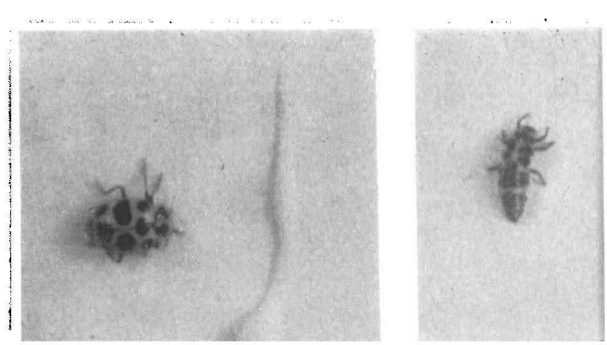

FIG. 2.—Adult and larva of the spotted lady beetle, *Coleomegilla Maculata* (De G.).

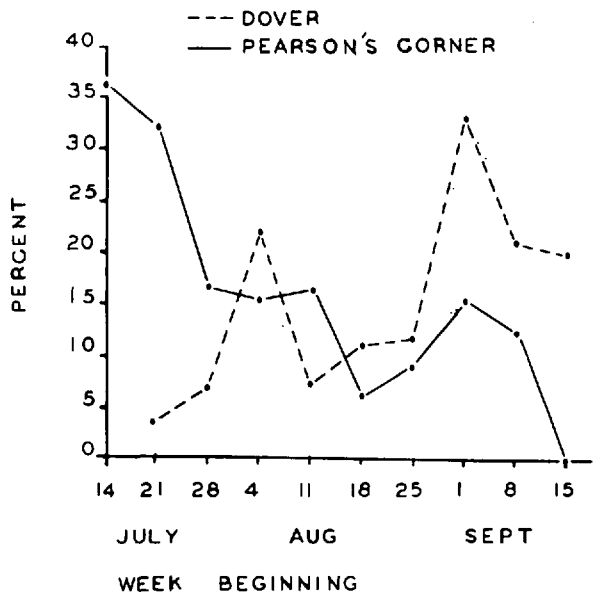

FIG. 3.—Percentage of European corn borer egg masses fed on by the spotted lady beetle in corn fields at Dover and Pearson's Corner during the summer of 1958.

a positive evidence of feeding. The ratio of these positive cards to those cards showing no evidence of fecula was compiled twice a week and the percentage of eggs fed on computed and averaged on a weekly basis. These percentages were taken for the fields under observation and plotted on a graph (fig. 3). On an average at Pearson's Corner and at Dover, of the tagged egg masses under observations, 16.5 and 15.3%, respectively, were fed on by this beetle.

DISCUSSION.—The method for determining the amount of feeding in the field originated from suggestions of S. W. Frost (1929). He states that the feculae of insects are a clear indication of their presence even after they have ceased feeding and have disappeared. Moreover, he indicated that the order and family can be determined by a critical examination of the color, texture, and size of the pellet. He further maintained that beetles, among others, discharge waste material soon after taking food because of their short digestive tract. Field observations of the fecal droppings of various insects tend to substantiate this.

Bearing this in mind, a critical examination of the previously undescribed fecula of the spotted lady beetle was made. When first dropped they are irregular, elongate, and light brown. They contain a variable amount of pinkish curdlike material at the terminals and may have other small irregular patches of this same material scattered over the surface (fig. 4-A). With age they turn almost black, but the pink-tinged areas remain. The size varies from 0.75 to 1.1 mm. long by 0.25 to 0.32 mm. wide. The pellet of the larva (fig. 4-B) is similar, both in color and size. The only fecal pellet observed on corn which might be mistaken for these is that of the convergent lady beetle (fig. 4-C), but in this case the pellet is marked with irregular patches of white curdlike material.

The number of fecal pellets found per card varied from one to nine, but most commonly there were three to five. The number of pellets could probably serve as an indicator of the relative number of eggs consumed in the mass but the developing of such an index was not considered during this work.

In figure 3 a high incidence of feeding at Pearson's Corner during the first week is indicated. This is followed by a rapid decline, a leveling off, another decline, a rise and then a sharp decline as borer-egg deposition finally subsided. The first decline is attributed to an increase in population of the corn leaf aphid and the second decline to the presence of pollen on the leaves. It has already been pointed out that both of these are highly favored foods of this beetle. The marked difference between the feeding curves of the two fields is in great part because of a difference in the stage of development of the plants. The corn at Pearson's Corner was in the pre-tassel stage when the first-generation borer adults commenced ovipositing, while the corn in the field at Dover was farther advanced, being well tasseled and with ears starting to form.

Another major difference between the two fields was that the population of the spotted lady beetle at Pearson's Corner was higher (29 per 100 plants) than at Dover (3 per 100 plants) during the first few weeks of observation. As the season progressed, however, the population of these beetles tended to increase at Dover and to decrease at Pearson's Corner. This fluctuation in density of the spotted lady beetle in the two fields presents a problem that was not resolved. It seemed evident from the food preference tests that the presence of the egg masses on the corn was not the attractant factor. The stage of the corn, on the other hand, appeared to be an attractant stimulus. The European corn borer ordinarily is more attracted to corn in the pre-tassel stage for oviposition than to the older corn. In this case, however,

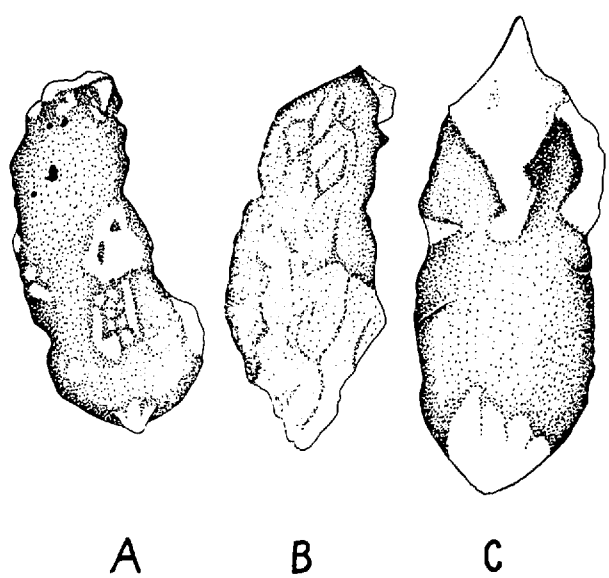

FIG. 4.—Fecula of lady beetles. A. Pellet of spotted lady beetle *Coleomegilla maculata* (De G.), adult. B. Pellet of spotted lady beetle larva. C. Pellet of convergent lady beetle, *Hippodamia convergens* (Guer.), adult.

they oviposited heavily on both the younger and older plants. This fact would indicate that the corn borer is not overly particular about its egg-laying site when its population is high, as it was in this case, and there is an acceptable host plant available. On the other hand, the spotted lady beetle appears to be more particular, and is attracted more to pre-tassel corn than to older plants. Thus the simultaneous appearance of borer eggs and spotted lady beetles on corn results from this beetle's not being attracted to corn until it has attained the height at which it is most attractive for corn borer oviposition.

The amount of feeding on corn borer eggs by the spotted lady beetle was less than anticipated; only about 16% of the egg masses were fed upon. The percentage of eggs actually consumed could not be determined by this method for, except in rare instances, the larger egg masses were not entirely consumed. The beetles have such a restless feeding habit that slight disturbances cause them to cease feeding and to fly away, seldom to return to the same egg mass.

Other species of insects were occasionally observed feeding on the egg masses. These were larvae of chrysopids and an adult *Orius* sp. Adult chrysopids were not observed feeding on corn borer eggs but their eggs were observed on corn leaves early in the spring and the adults were very common all summer. A considerable number of the tanglefoot-coated cards contained their feculae, which are distinguished by a dark color and cylindrical shape. This fact suggests that they may feed on corn borer eggs, but such activity was never observed.

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The Description of Insect Numbers[1]

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ABSTRACT

In economic entomology, particularly forest entomology, the description of insect numbers in absolute terms may be misleading. The effect of an individual on its host varies tremendously between species and this gives rise to unwarranted comparisons within current systems. The insect-host relationship between *Recurvaria starki* Freeman and *Pinus contorta* Dougl. is reviewed and used as an example in the erection of a three-class system for the description of insect numbers based on the effect of the insect on its host.

At the present time, a number of terms are used to describe levels of insect abundance. Through repeated usage these gain general acceptance and a limited or standard meaning when applied to single insect species. However, because the same terms are applied to populations of many different insects, confusion exists with respect to their exact meanings. With the ever increasing interest in critical sampling and interpretation of sampling results in terms of population dynamics (Morris 1955), a description of insect numbers based on biological grounds would be of value.

TERMS USED.—In the literature of economic entomology, "epidemic" and its corollaries are used to describe a population of insects which, for some reason is considered to be of adverse economic effect. "Endemic" is used to describe a population which is of no current economic interest. "Endemic" is also used to describe an organism which is native to the area concerned (Benton & Werner

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