parasite there is a definite drop in the percent emerging female progeny.

The female parasite was observed searching most diligently in and around moth webbing. Hosts in webbing which she parasitized yielded a significantly higher percent females than free hosts. Moreover, it was shown that the females do not require a carbohydrate source, such as honey, for successful reproduction. On the contrary, the percent female progeny increases when they are left with hosts as their only food source. If we assume that a higher percentage of females in the progeny is a measure of better adaptation of the parasite to its environment and would, therefore, lead to better ultimate success, we may conclude that *B. hebetor* females are best adapted to seach in places where no honey, honeydew, or nectar serve as food, and where their hosts are covered with webbing.

Such places are the grain silos, flour mills, bakeries, and other places where *A. kuehniella* develops. The life cycle of this host, which emerges out of its food medium to pupate in the open while wrapped with webbing, also fits well into the picture. Contrarily, the cotton fields in which *B. hebetor* was collected as a parasite of numerous Lepidoptera throughout the season (Gerling 1971), does not constitute an optimal habitat for the action of this parasite, particularly when its hosts are exposed caterpillars such as *Spodoptera littoralis* or *Heliothis* spp.

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Seasonal Abundance of *Perilitus coccinellae*[1] and Its Coccinellid Hosts and Degree of Parasitism in Central Missouri[2]

J. V. RICHERSON[3] AND C. J. DELOACH[4]

ABSTRACT

Approximately 20% of 10 species of coccinellids collected from alfalfa, turnips, corn, and weed fields from December 1965 through June 1967 were parasitized by *Perilitus coccinellae* (Schrank). Populations of adult *P. coccinellae* peaked at about 54 per 100 sweeps during August and September. The 2 most common coccinellids collected were *Coleomegilla maculata* (DeGeer) and *Hippodamia convergens* Guérin-Méneville. The rate of parasitism varied with the size of the host species.

Perilitus coccinellae (Schrank) is the most common parasite of adult coccinellids in most of the world (Richerson 1970) and it has been reported to parasitize 6–20% of its hosts (Balduf 1926, Ibraham 1955, Walker 1961, Iperti 1964, and Lipa and Sem'yanov 1967). Sluss (1968) found that parasitism significantly reduced feeding by the beetles, but they did not die until 3 or 4 days after the parasite emerged. Parasitized males could mate normally (Sluss 1968), but females ceased ovipositing ca. 10 days before the parasite emerged (Smith 1960). Reported here are results of experiments conducted at the Biological Control of Insects Research Laboratory, Columbia, Mo., to measure the degree of

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Table 1.–Seasonal fluctuations in populations of coccinellids in weeds, alfalfa, turnips, and corn. Columbia, Mo. 1966.

Species	Number collected								
	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Total
				Weeds[a]					
Coleomegilla maculata	72	55	48	50	178	94	76	56	629
Hippodamia convergens	67	48	37	39	48	50	159	57	505
H. parenthesis	0	0	0	25	32	26	14	0	97
Cycloneda munda	0	0	0	18	24	28	9	0	79
Brachyacantha ursina	0	0	7	13	19	11	5	0	55
H. tredecimpunctata	0	0	0	0	3	1	0	0	4
Scymnus sp.	0	0	0	0	2	0	0	0	2
Coccinella novemnotata	0	0	0	0	0	2	0	0	2
				Alfalfa[a]					
C. maculata	73	57	48	55	183	101	84	52	653
H. convergens	70	49	41	46	49	53	166	59	533
H. parenthesis	0	0	0	27	39	31	18	3	118
C. munda	0	0	0	15	21	27	13	0	76
B. ursina	0	0	4	10	11	15	2	0	42
H. tredecimpunctata	0	0	0	0	1	2	0	0	3
Scymnus sp.	0	0	8	15	29	46	21	0	119
C. novemnotata	0	0	0	0	3	7	0	0	10
				Turnips[b]					
C. maculata	73	61	46	51	187	97	79	51	645
H. convergens	71	53	44	43	48	52	163	52	478
H. parenthesis	0	0	0	12	28	22	9	0	71
C. munda	0	0	0	6	8	14	3	0	31
B. ursina	0	0	1	4	8	13	4	0	30
H. tredecimpunctata	0	0	0	0	1	1	0	0	2
Scymnus sp.	0	0	0	0	0	0	0	0	0
C. novemnotata	0	0	0	0	2	4	2	0	8
				Corn[b]					
C. maculata	—	—	47	196	108	91	69	53	564
H. convergens	—	—	44	45	47	51	160	66	413
H. parenthesis	—	—	0	14	28	20	12	0	74
C. munda	—	—	0	4	10	17	2	0	33
B. ursina	—	—	5	11	11	9	3	0	39
H. tredecimpunctata	—	—	0	8	32	83	11	0	134
Scymnus sp.	—	—	0	0	0	0	0	0	0
C. novemnotata	—	—	0	0	0	0	1	0	1

[a] No./100 sweeps.
[b] No./30 min collecting with aspirator.

parasitism by *P. coccinellae* of the important species of coccinellids in central Missouri.

Methods

Parasitization was measured in the following species of coccinellids collected near Columbia: *Hippodamia convergens* (Guérin-Méneville, *H. parenthesis* (Say), *H. tredecimpunctata* (L.), *Coleomegilla maculata* (DeGeer), *Cycloneda munda* (Say), *Coccinella novemnotata* (Herbst), *Olla abdominalis* (Say), *Adalia bipunctata* (L.), *Brachyacantha ursina* (F.), and *Scymnus* sp. Collections were made from December 1965 through June 1967. During the spring, summer, and fall, adults and cocoons of *P. coccinellae* were collected by sweeping and searching (100 sweeps plus 1 hr searching/site per crop) at 4 locations each week. Coccinellids were collected each week from alfalfa and weeds (100 sweeps/site at 4 sites) and from turnips and corn (30 min searching/site at 2 sites). Each week during the winter, 150 beetles were dissected from aggregations of coccinellids in an abandoned peach and apple orchard near Rocheport, Mo.

Results

Host Abundance

Coleomegilla maculata and *H. convergens* were the most abundant species of coccinellids in the samples, and *Coccinella novemnotata* was the least abundant (Table 1). In addition to the 8 species in Table 1, *A. bipunctata* and *O. abdominalis* were active and numerous in the fall on *Spirea* and various other ornamental plants and in the spring on weeds around orchards and forests. These 2 species probably are hosts for parasites in late fall or early spring, before the other coccinellids disperse from their overwintering sites. Populations of the same species of beetles were about equal in each of the 4 types of vegetation sampled for 6 of the 8 species. However, *H. tredecimpunctata* was more abundant on corn and *Scymnus* sp. was more abundant on alfalfa than on the other 3 types of vegetation. Most species

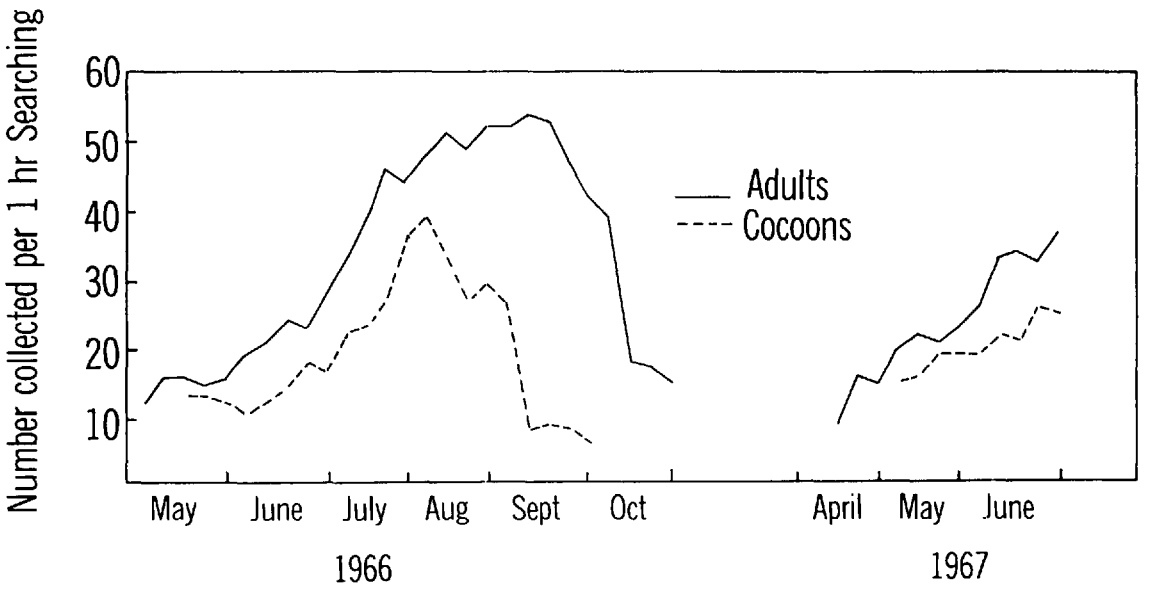

FIG. 1.—Average number per location of adults and cocoons of *P. coccinellae* collected in Boone County, Mo., from alfalfa, corn, turnips, and weeds.

reached peak populations in either July or August, except for *H. convergens*, which reached its peak population in September. Seasonal fluctuations in population were nearly identical in all crops for the 6 species which showed no plant preference. The only exception was *C. maculata* which reached its peak population a month earlier in corn than in weeds, alfalfa, or turnips. This peak coincided with pollen production in corn. Although aphidophagous, *C. maculata* may consume pollen during periods of low prey density.

Parasite Abundance and Degree of Parasitization

Adult *P. coccinellae* were found from April to late October. Populations of adults peaked at 54 parasites collected/hr per site in August and September 1966 (Fig. 1). At least 4 weeks are required for each parasite generation; therefore, 4 or 5 generations/year may occur in central Missouri. Oglobin (1913), Balduf (1926), Hudon (1959), and Iperti (1964) reported the same number of generations per year as in our study. Most coccinellids require 20–35 days to complete a generation (Balduf 1935, Clausen 1962), and have only 1 or 2 generations/year, depending on the environmental factors (Hagen 1962). In Missouri, both host and parasite have similar generation times, but oviposition of the host is affected by the availability of food. Therefore, scarcity of food during the midsummer often precludes another generation of the host, whereas the parasite may continue to attack available hosts and produce a new generation.

The degree of parasitization between host species varied from 0 to 27% (Table 2). Larger species generally were parasitized more heavily than smaller species, with one exception: *Coccinella novemnotata*, the largest species, was 4th in order of rate of parasitization. The group of species *C. munda*, *O. abdominalis*, *A. bipunctata*, and *H. parenthesis*, which were similar in size, were about equally parasitized. Preference for larger host species also was demonstrated in laboratory tests (Richerson and DeLoach 1972).

The seasonal rate of parasitization of *H. convergens* (Fig. 2) decreased from 60% in December 1965 and 32% in November 1966 to 10–15% in early spring of both 1966 and 1967. This decrease possibly was caused by the parasite consuming the fat reserves of its host, resulting in the death of both. After dispersal of the beetles in mid-April, parasitization of *H. convergens* increased to nearly 100% in early July and mid-August 1966, and to 50% in mid-June 1967. However, parasitization of *C. maculata* generally decreased from a midwinter high to a midsummer low (except for a temporary increase in early June of both years). During mid-

Table 2.—Parasitization by *P. coccinellae* of 10 species of coccinellids.

Species	Size (mm)	No. dissected[a]	% parasitized
Hippodamia convergens	6.0×4.0	3,517	26.8
Coleomegilla maculata	6.0×4.0	12,650	20.0
H. tredecimpunctata	5.7×3.5	237	14.3
Coccinella novemnotata	6.5×4.6	21	9.5
Cycloneda munda	4.5×3.5	294	7.5
Olla abdominalis	5.2×4.3	248	6.1
Adalia bipunctata	4.5×3.5	251	5.2
H. parenthesis	5.0×3.5	424	5.1
Brachyacantha ursina	3.8×2.5	270	1.8
Scymnus sp.	2.0×1.5	122	0.0

[a] Total number dissected from December 1965 through June 1967 from alfalfa, corn, turnips, and weeds in Boone, Co., Mo.

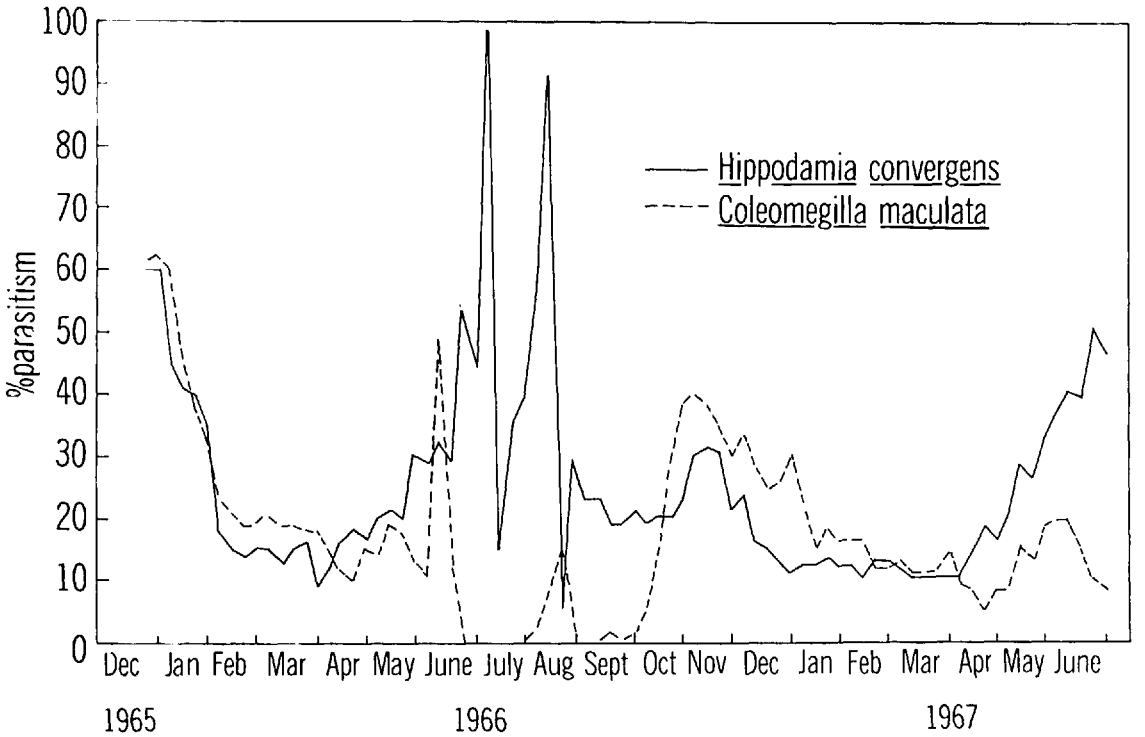

FIG. 2.—Average percent parasitism of *C. maculata* and *H. convergens* from alfalfa, corn, turnips, and weeds by *P. coccinellae*.

summer, parasitization of *H. convergens* averaged 50%, whereas that of *C. maculata* averaged only 3%, although both species were equally abundant during this period. No explanation for the differences in seasonal rates of parasitism between the 2 hosts was apparent.

In the laboratory, parasitized beetles died or stopped feeding 8–14 days before unparasitized beetles of the same age. Parasitized beetles also consumed fewer aphids than unparasitized beetles. The effect of parasitism on host longevity could not be determined in the field, since the age of the adult coccinellids was not known. We conclude that *P. coccinellae* parasitizes sufficient adult *H. convergens* and *C. maculata* to greatly reduce their numbers and consequently to reduce their value in control. However, the percent reduction in control would be somewhat less than percent parasitism, since beetles continue to feed and reproduce for several days after being parasitized.

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