Responses of an Imported Coccinellid, *Propylea 14-punctata*,[1] to Aphids[2] Associated with Small Grains in Oklahoma[3]

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ABSTRACT

An imported coccinellid, *Propylea 14-punctata* (L.), was maintained in the laboratory on an artificial diet and the following aphid species associated with small grains in Oklahoma: *Schizaphis graminum* (Rondani), *Rhopalosiphum maidis* (Fitch), *R. padi* (L.), *Macrosiphum avenae* (F.), *Sipha flava* (Forbes), *Hysteroneura setariae* (Thomas), and *Aphis helianthi* Monell.

P. 14-punctata survived well on all species of aphids and on the synthetic diet when free water was accessible. Nutritional quality of the diet and aphid species varied, as evidenced by differences in: longevity, preoviposition period, and fecundity of adult beetles; beetle ova fertility; survival and percentage mortality by stadia of F_1 generation immature beetle progeny; and sex ratio of F_1 generation beetle progeny.

Propylea 14-punctata (L.) is a European coccinellid with a distribution covering most of that continent. In its native habitat it is a common predator of *Aphis fabae* Scopoli and other aphids that occur on a wide variety of cultivated and noncultivated plants (Banks 1955). *P. 14-punctata* was imported into this country to test its effectiveness against the greenbug, *Schizaphis graminum* (Rondani). In May 1970, our laboratory received 20 adult beetles from the USDA Insect Identification and Parasite Introduction Research Branch, Mooreston, N. J., for possible deployment against the greenbug in Oklahoma. Our beetles came from the imported stock that was originally collected at Crest (Drome), France, by the Insect Identification and Parasite Introduction Research Branch, USDA (Rogers et al. 1971).

It is known that not all aphids are suitable hosts for all coccinellids. Iperti (1966) stated that some aphid species reduce oögenesis or prevent complete vitellogenesis in some coccinellids. *Aphis craccivora* Koch feeding on *Glycridia* was toxic to *Coccinella septempunctata* L. larvae (Azam and Ali 1970[5]). Other detrimental effects of aphids to coccinellids include lengthening of larva stadia (Smith 1961), slowing of growth rate (Smith 1965a), shortening of starvation period during food scarcity (Smith 1965b), and increasing premating period (Azam and Ali 1970[5]). With these facts in mind, it was thought that field releases of *P. 14-punctata* for greenbug control in Oklahoma should be preceded by laboratory studies to determine its responses not only to the greenbug but also to other aphid species which it might encounter in or near small grains. Responses of *P. 14-punctata* to a synthetic diet also were studied.

Materials and Methods

As adult beetles emerged they were segregated into male and female pairs and maintained on their respective hosts in cages described previously (Raney et al. 1971). Aphid species serving as hosts for *P. 14-punctata* in this study included: greenbug, *Schizaphis graminum*, (biotype C); corn leaf aphid, *Rhopalosiphum maidis* (Fitch); yellow sugarcane aphid, *Sipha flava* (Forbes); English grain aphid, *Macrosiphum avenae* (F.); the so called oat-bird cherry aphid, *R. padi* (L.); rusty plum aphid, *Hysteroneura setariae* (Thomas); and *Aphis helianthi* Monell, an aphid of sunflowers. Sorghum hybrid RS-610 served as a host plant for all aphid species except *M. avenae* and *A. helianthi*. These 2 species were maintained on 'Rogers' barley, and transplanted wild sunflowers, *Helianthus* spp., respectively. Except as noted below, an excess of aphids was always present for beetle consumption.

Four pairs of beetles also were maintained for 30 days on a synthetic diet composed of 50% dried baby beef liver, 40% yeast, and 10% sucrose and then transferred to greenbugs for the remainder of the tests. Some beetles were left on the diet and H_2O entirely for longevity determination. The diet and water were administered free choice by the technique of Smith (1960).

Cages containing paired beetles were examined daily for the presence of ova. As ova were found they were transferred to a pot containing greenbugs. Any resulting larvae were reared on greenbugs. Biological data sought included longevity, preoviposition period, and fecundity of parents; ova fertility; survival and mortality patterns among F_1 generation larvae; and sex ratio of progeny resulting from parents consuming different host-diets.

All phases of the tests were conducted under lab-

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[2] Homoptera: Aphididae.

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[5] K. M. Azam and M. H. Ali. 1970. A study of factors affecting the dissemination of the predatory beetle, *Coccinella septempunctata* L. Final Technical Report (FG-IN-249, A7-ENT-40). Department of Entomology, College of Agriculture, Andhra Pradish Agricultural University, Rajendranagar, Hyderabad, India.

oratory conditions of 12-hr photoperiods, 27±2.5°C, and RH exceeding 45%.

Results and Discussion

None of the aphids appeared to be toxic to adult *P. 14-punctata* (Table 1). Except for the males feeding on *R. maidis* and *S. flava*, the mean longevity was 2 months or longer. In general, females lived longer than males. Both males and females lived longer while consuming *M. avenae* and *R. padi* than when consuming other species. Male and female *P. 14-punctata* lived a mean of 90 and 125 days, respectively, when consuming *R. padi*. Maximum longevity occurred also when *R. padi* served as the host, where a male and a female lived for 129 and 147 days, respectively.

Table 1 shows that *P. 14-punctata* adults survived for a mean of 2 months while consuming *S. graminum*, with maximum longevity exceeding 3 months for both sexes. *S. graminum* is consistently the most economically important aphid affecting small grains in Oklahoma. With the exception of *S. flava*, the remainder of the aphid species mentioned here can build up to tremendous populations before destroying small grain crops. Observations indicate that these aphids may be important in permitting early-season buildup of *Hippodamia convergens* Guérin-Méneville, and other native predators of aphids in small grains. The longevity data of Table 1 indicate that these aphids of lesser economic importance could become important also in serving as alternate hosts for field released *P. 14-punctata* at times when *S. graminum* may not be abundant.

Adult beetles maintained exclusively on the beef diet and water survived in excess of 2 months. Again females outlived males. One female survived 88 days on the diet. Survival of the beetles while utilizing the diet was dependent upon the presence of free water. When water was not available the beetles died in less than a week. Smith (1965c) reported that the access to drinking water increased the longevity of *Coccinella trifasciata perplexa* Mulsant by about 35%. When the beetles were transferred from the synthetic diet to *S. graminum* after 30 days, their longevity equaled that of the beetles which had been maintained on *S. graminum* for their entire adult life.

Table 1.—Longevity of *P. 14-punctata* adults while consuming different host-diets.

Host	Days longevity			
	Male		Female	
	Mean	Range	Mean	Range
S. graminum	61	30–111	60	24–93
R. maidis	51	23–59	61	25–88
R. padi	90	37–129	125	28–147
A. helianthi	44+[a]	17–78	51+	31–70
M. avenae	70	31–111	117	98–131
S. flava	42	27–50	67	46–93
H. setariae	23+	—	23+	—
Artificial diet[b]	60	14–76	88	67–113

[a] Test terminated because of aphid depletion.
[b] Diet = 50% dried beef liver, 40% yeast, and 10% sucrose; adults were given diet for 30 days and then maintained on *S. graminum*.

Table 2.—Reproductive effects of host-diets upon *P. 14-punctata*.

Host	No. of pairs	$\bar{x}$ pre-oviposition period (days)	Ova deposited	Ova/♀
S. graminum	4	9.2	1366	341.5
R. maidis	4	9.8	959	239.8
R. padi	4	18.0	647	161.8
A. helianthi	4	13.6	950[a]	237.5
M. avenae	4	55.3	205	51.3
S. flava	4	21.2	861	215.3
H. setariae	1	9.0	180[a]	180
Artificial diet[b]	4	9.3[c]	997	249.3
Total (or mean)	29	18.2	6165	210.8

[a] Test terminated because of aphid depletion.
[b] Diet = 50% dried beef liver, 40% yeast, and 10% sucrose; adults were given diet for 30 days and then maintained *S. graminum*.
[c] Avg no. days after transference to *S. graminum*.

Table 2 presents the reproductive effects of host-diets upon *P. 14-punctata*. The mean preoviposition period of *P. 14-punctata* was markedly influenced by host species and the diet. Females feeding on *H. setariae*, *S. graminum*, and *R. maidis* had a mean preoviposition period of 9.0, 9.2, and 9.8 days, respectively. When *P. 14-punctata* was consuming *A. helianthi*, *R. padi*, *S. flava*, and *M. avenae*, the mean preoviposition period extended to 13.6 18.0, 21.2, and 55.3 days, respectively. While consuming the synthetic diet, females copulated frequently but they did not oviposit. However, they began ovipositing in an average of 9.3 days after being transferred to *S. graminum cultures*. These results are similar to those reported by other authors. Azam and Ali (1950[5]) reported that the premating period of *C. septempunctata* increased by 3 days when females were fed on *Aphis gossypii* Glover rather than on *Myzus persicae* (Sulzer). Only 7 of 13 coccinellid species oviposited when given synthetic diets by Smith (1965c).

While fecundity and fertility were low in this study, the data indicate that these factors were influenced by the host species. For example, ova deposited by females consuming *M. avenae* averaged 51.3/♀, compared with 341.5 for those consuming *S. graminum*. Female beetles consuming *S. graminum* deposited significantly more ova (5% level) than those consuming other aphid species. The fecundity of females feeding on *A. helianthi* and *H. setariae* would have been greater if the aphid supply had not been depleted.

The fecundity and fertility results in this study were discouraging, since earlier tests by us indicated that they should be much greater when *S. graminum* served as a host. Furthermore, our records show

Table 3.—Survival of *P. 14-punctata* F_1-generation larvae descended from parents consuming different host-diets.

Hosts of parents	No. surviving as						% survival to adult
	L_1[a]	L_2	L_3	L_4	Pupa	Adult	
S. graminum	99	60	54	51	51	49	49.4
R. maidis	52	37	34	34	33	30	57.6
R. padi	63	46	40	37	36	30	47.6
A. helianthi	32	22	16	13	13	12	37.5
M. avenae	49	37	19	17	13	13	26.5
S. flava	52	38	22	22	22	19	36.6
H. setariae	13	11	10	10	10	9	69.1
Artificial diet[b]	104	63	46	42	42	38	36.5
Total	464	314	241	226	220	200	45.3

[a] 1st, 2nd, 3rd, and 4th-stage larvae, respectively.
[b] Diet = 50% dried beef liver, 40% yeast, and 10% sucrose; adults were given diet for 30 days and then maintained on *S. graminum*.

that both the fecundity and fertility had been progressively declining during the past 6–7 months. Inherent injury and ova mortality from laboratory procedures, unnatural host effects (Gurney and Hussey 1970), and intraspecific cannibalism of 1st-stage larvae upon unhatched ova and embryos (Banks 1956) probably could not account for the reduction of reproductive vigor in our laboratory stock of *P. 14-punctata*. Investigation into the possible causes of decreased fecundity and fertility revealed that our stock had been reared for many generations in the laboratory and may possibly have originated from a single female. Hence, close inbreeding of such a gene pool over a period of time might explain the progressive reduction of reproductive vigor. A new heterogeneous stock of *P. 14-punctata* has been received, in which the fecundity is 3-fold that reported here, and ova fertility is 68% when *S. graminum* is used as a host. These values are equivalent to those reported for other species of coccinellids (Smith 1965c, Gurney and Hussey 1970).

Ova fertility of the new stock of *P. 14-punctata* is about 61% higher than it was for our inbred stock. Interpolation of the 61% hatch differential of ova between the old and new stocks of beetles indicates that ova hatchability might exceed 64% when any of the aphid species used here serves as a host for *P. 14-punctata*. However, until further studies are conducted, it is best to interpret these results with reservations. The discrepancy between the reproductive vigor of the old and new beetle stocks points out the importance of knowing the origin and history of laboratory cultures when interpreting biological data. Ignorance of these factors can easily lead to erroneous conclusions in biological investigations.

Table 3 gives the survival of *P. 14-punctata* F_1 generation larvae descended from parents consuming different aphid hosts. Survival from 1st-stage larvae to adults ranged from 26.5 to 69.1%. The survival rate could have been influenced by laboratory technique for it was sometimes necessary to transfer larvae from one pot to another when the *S. graminum* cultures become depleted or the plants died. However, since all larvae were handled identically and reared on *S. graminum*, it is probable that the difference in survival rate of F_1-generation larvae could be an indication of the nutritional quality of the different aphid species consumed by the parent beetles. It is known that aphids vary in their nutritional value to different coccinellids. It is known also that a particular aphid species varies in nutritional value to a particular coccinellid species as it

Table 4.—Percentage mortality of F_1-generation immature *P. 14-punctata* descended from parents consuming different host-diets.

Hosts of parents	% mortality during stadium[a]					% mortality prior to adult
	1	2	3	4	5	
S. graminum	39.4	10.0	5.5	0	3.9	50.6
R. maidis	28.9	8.1	0	2.9	9.1	42.4
R. padi	26.9	8.7	7.5	2.7	8.3	52.4
A. helianthi	31.3	27.3	18.7	0	7.6	62.5
M. avenae	24.4	48.7	10.5	23.3	0	73.5
S. flava	26.9	42.1	0	0	19.6	63.4
H. setariae	15.6	9.1	0	0	10.0	30.9
Artificial diet[b]	38.4	26.9	8.7	0	9.5	63.5
Total						54.7

[a] Stadia 1, 2, 3, 4, and 5, respectively, include 1st to 4th-stage larvae and pupae.
[b] Diet = 50% dried beef liver, 40% yeast, and 10% sucrose; adults were given the diet for 30 days and then maintained on *S. graminum*.

changes from one host plant to another (Azam and Ali 1970[5]). The survival rate of all groups of larvae in this study is equivalent to the 20–67% survival rate of *C. septempunctata* larvae when both the parents and the larvae were reared by choice on *Hyadaphis erysimi* (Kaltenbach).

Mortality of F_1 generation immature *P. 14-punctata* descended from parents consuming different aphid species was greatest during the 1st 2 larval stadia, usually during the 1st (Table 4). Mortality of 1st-stage larvae ranged from 15.6% for progeny of parents consuming *H. setareae* to 39.4% for progeny of parents consuming *S. graminum*. Larval mortality during the 1st stadium was probably due largely to cannibalism among 1st-stage larvae prior to dispersing from egg masses and cannibalism at the time of ecdysis of 1st-stage larvae into 2nd-stage larvae. Witter (1969) observed that the 1st larva of *Aphidecta obliterata* (L.) to molt usually consumed one or more of the other larvae while they were inactive during ecdysis. Another contribution to higher mortality during the 1st 2 larval stadia may have been due to overlooking some of the larvae when it was ncessary to transfer them to a new culture of *S. graminum*.

Mortality of larvae descended from parents consuming *M. avenae* and *S. flava* was nearly twice as high during the 2nd larval stadium as it was during the 1st. The reason is not known unless it is an indication of nutritional deficiencies of the parents' hosts. This is further indicated by the 23.3% mortality of 4th-stage larvae descended from parents consuming *M. avenae* and the 19.6% mortality of pupae descended from parents consuming *S. flava*. Mortality in other groups of 4th-stage larvae and pupae was less than 3% and 10%, respectively. Mortality of the progeny from parents that were maintained on the synthetic diet for 30 days and then changed to *S. graminum* was about 13% greater than for progeny of parents maintained on *S. graminum* exclusively.

We are not aware of any record which suggests that the diet of coccinellids affects the sex of progeny, yet the data in Table 5 indicates that it may with *P. 14-punctata*. Only the progeny descended from parents consuming *A. helianthi* and *H. setariae* exhibited a sex ratio approaching the expected 50:50 ratio of females and males. However, these samples were small, because the aphids were depleted prior to completion of the study. Progeny from parent beetles consuming *R. maidis* had a sex ratio of 2 ♀:1 ♂. Beetles consuming *S. graminum, R. padi, M. avenae,* and *S. flava*, respectively, produced progeny in which males outnumbered females by 1.6:1, 1.3:1, 3.3:1, and 1.7:1. Beetles which were maintained on the synthetic diet for 30 days prior to being given *S. graminum* produced progeny with a 2.5:1 male:female ratio. Azam and Ali (1970[5]) reported that *C. septempunctata* reproduced better when feeding on alfalfa aphids than when feeding on sorghum aphids. They failed, however, to identify clearly the criteria for better reproduction. A higher female:male ratio when feeding on alfalfa aphids would result in a more rapid population increase, thus giving the impression of "better reproduction."

Currently the sex ratio of progeny from the new stock of *P. 14-punctata* is being observed. Thus, far, the sex ratio of progeny descended from parent beetles consuming *S. graminum* has a sex ratio of more than 2 ♂:1 ♀.

Table 5.—Sex ratio of *P. 14-punctata* progeny descended from parents consuming different host-diets.

Host of parents	No. of parent pairs	No. of progeny	Sex ratio of progeny ♂	♀
S. graminum	7	126	78	48
R. maidis	4	30	10	20
R. padi	4	30	17	13
A. helianthi	4	12[a]	5	7
M. avenae	4	13	10	3
S. flava	4	19	12	7
H. setariae	1	9[a]	4	5
Artificial diet[b]	4	38	27	11
Total	32	277	163	114

[a] Test terminated because of aphid depletion.
[b] Diet = 50% dried beef liver, 40% yeast, 10% sucrose; adults were given diet for 30 days and then maintained on *S. graminum*.

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An Ecological Study of Lepidopterous Pests Affecting Lettuce in Coastal Southern California[1]

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ABSTRACT

Studies conducted on winter lettuce grown in the absence of pesticides in coastal southern California in 1963, 1966–67, and 1967–68 revealed that the cabbage looper, *Trichoplusia ni* (Hübner); beet armyworm, *Spodoptera exigua* (Hübner); black cutworm, *Agrotis ipsilon* (Hufnagel); and granulate cutworm, *Feltia subterranea* (F.); were the principal lepidopterous pests. Altogether, 8 species of lepidopterous larvae were collected. Three species of braconids, 2 ichneumonids, and 3 tachinids were reared from the larvae with *Chelonus texanus* Cresson, *Hyposoter exiguae* (Viereck), and *Voria ruralis* (Fallén) being the most common parasites. *Trichogramma pretiosum* Riley was the only parasite reared from the eggs. In 1963, 82% of the seedlings were destroyed by lepidopterous larvae within 2 weeks after the seedlings were thinned in early November. The percentage of infested plants and average number of larvae per plant reached a maximum of 56% and 0.9, respectively, on Dec. 6, 1966, and 66% and 1.0 on Dec. 5 in 1967. At harvest in February, the number of larval-infested heads of lettuce averaged 0.7 in 1967 and 0.4% in 1968. Only cutworms were present.

In 1969, California produced 65.1% of the lettuce grown in the United States (Burlingame 1970). The crop ranked 8th among California agricultural commodities, being valued at $136,176,000. About 45% of the lettuce acreage is situated in southern California where the crop is primarily grown in the low desert areas of Imperial and Riverside Counties and in the coastal areas of Santa Barbara and Ventura Counties. The corn earworm, *Heliothis zea* (Boddie); cabbage looper, *Trichoplusia ni* (Hübner); and the beet armyworm, *Spodoptera exigua* (Hübner); are serious pests on lettuce (Anderson et al. 1952; Shorey and Hall 1962) with the corn earworm being primarily a problem on summer crops grown in the coastal areas and the cabbage looper and the beet armyworm attacking winter lettuce in the low desert areas. Although pesticides are regularly and frequently applied, these pests are increasingly difficult to control, and costs are increasingly expensive.

To determine the principal pests affecting winter lettuce in the coastal areas of southern California, the extent of their injury, and natural enemies associated with each, studies were conducted in 1963, 1966–67, and 1967–68 in the absence of pesticide applications. The results are reported here.

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Materials and Methods

A ¼-acre planting of "Great Lakes' lettuce was planted on the University of California's South Coast Field Station in Orange County on Oct. 14, 1963. In 1966 and 1967, ½-acre plantings were established on Oct. 17 and 6, respectively. The seed was planted in single rows 290 ft long with 30-in. centers. The plants were thinned about 4 weeks after planting. Planting, cultivation, irrigation, and other cultural practices were done by Station personnel, following local lettuce-grower practices, except that pesticides were not applied.

In 1963, 50 randomly selected seedling lettuce plants were examined in the field at weekly intervals; those injured and destroyed by lepidopterous larvae were recorded.

In 1966–67 and 1967–68, the numbers of lettuce plants infested and lepidopterous eggs and larvae present were determined by collecting 100, 50, or 25 plants (reduction based on size of plants) at random and examining each individually in the laboratory. In 1966 the fields were sampled at 3- and 4-day intervals through Dec. 13; otherwise, they were sampled at weekly intervals. At maturity 50–200 lettuce heads were collected at random at weekly intervals for 2–3 weeks, quartered, and examined for larval infestation. In February 300 heads were examined in 1967 and 500 in 1968.

In the 1966–67 and 1967–68 studies, the larvae