

PREDATION OF APHIDS BY COCCINELLID LARVAE

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Abstract

Can. Ent. 113: 1043-1046 (1981)

We studied first and fourth instar larvae of *Coccinella trifasciata* L., *C. californica* Mannerheim, *C. undecimpunctata* L., and *Cycloneda polita* Casey searching for *Acyrtosiphon pisum* (Harris) on alfalfa seedlings and for *A. dirhodum* (Walker) on oat seedlings, in the laboratory. Styles of search varied considerably, but each species of larva could capture aphids on each species of plant. Observed differences in relative abundance of the four species of adult coccinellid in alfalfa and oat fields are not related to the success of their larvae in finding aphids.

Introduction

Adults of four coccinellid species have regularly occurred in field plots of alfalfa (lucerne) and oats at Vancouver during 6 consecutive years. The species are *Coccinella californica* Mannerheim, *C. trifasciata* L., *C. undecimpunctata* L., and *Cycloneda polita* Casey. Although all four species occur on both crops, their relative abundance differs between crops; *C. californica* is the most abundant on cereals, and *C. trifasciata* on alfalfa. The critical factor in coccinellid reproduction is larval survival, which depends on a higher aphid density than that required by adults (Frazer *et al.*, this series). This paper examines the possibility that the observed differences in adult densities reflect differences in the ability of larvae to capture aphids. The larval search parameters, estimated here, are also used in the broader study of the complete predator-prey relationship (Frazer *et al.*, this series).

Materials and Methods

Each larva observed was confined in a 20×40 cm arena under controlled environment. The arena contained a row of seedlings, of either alfalfa cv. Alfa, infested with pea aphids, *A. pisum*, or of oats cv. Fraser, infested with the rose grass aphid *A. dirhodum*. The numbers and instars of aphids on each plant were recorded for each test. Each arena was enclosed by a plastic fence 5 cm high, coated with polytetrafluoroethylene to prevent escape of the insects. The arena floor was Kraft paper, cut and taped to fit snugly around each plant. Initially, two average temperatures were used: 23.3° and 16.3° but larvae moved too slowly at the lower temperature so those tests were discontinued. The light intensity was about 3700 lux at the level of the arena floor and the relative humidity was 50%. The heights and number of leaves of alfalfa, or the number and lengths of each leaf of oats, were recorded for each test.

For each test a satiated first- or fourth-instar larva was starved for a known time, then placed on the arena floor near a plant. Thereafter its movements were timed and recorded for 3000 sec. A "rejection of plant" was recorded if a larva made physical contact with a plant but did not climb it. If it encountered part of another plant but remained on its current plant an "intersection" was recorded, whereas if it moved onto the new plant, a "new plant" was recorded. When a larva contacted an aphid, the aphid instar was noted. If the aphid was pushed or fell off the plant, the event was recorded. If the larva captured the aphid, the time taken to eat it was recorded.

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The initial experimental design was factorial, with 2 temperatures, 2 levels of hunger, first and fourth instar larvae of each of the 4 coccinellid species, and 2 plant species, each combination tested twice. However, vagaries in our production of larvae, aphids, and plants prevented the design from remaining orthogonal and the amount of replication varied (Table I). The range of plant densities and sizes in the areas varied but the average size of the plants multiplied by the average number of aphids at risk, were comparable for all combinations of treatments on either plant species (Table I). Plant 'size', measured in this way, cannot be compared between plant species.

The data on the plants, aphids, and larvae at the start of each test, the series and timing of events for each of the 226 tests, were coded and keypunched onto computer cards. A computer programme was written to check for keypunch errors and convert the elapsed times into the following intervals and statistics for each test: total times spent moving and not moving when the larvae were either on or off the plants, total time spent eating, average time spent on each plant, number of aphids which were contacted, eaten or which left the plant. From this basic set of variables, others were derived.

Table I. The numbers of larvae of two instars of four species of coccinellid used in experimental arenas with oats (O) and alfalfa (A), the total number of aphids at risk, average aphid density and average plant size* used for each category

Species	Instar	No.	Plant	Total aphids	Average	
					Aphids/plant	Plant size
<i>Coccinella californica</i>	I	14	A	341	2.6	136
	I	14	O	425	3.0	58
	IV	22	A	472	2.7	121
	IV	13	O	309	2.8	56
<i>Coccinella trifasciata</i>	I	13	A	315	2.7	136
	I	12	O	392	3.3	48
	IV	20	A	441	2.5	122
	IV	13	O	309	2.8	55
<i>Coccinella undecimpunctata</i>	I	11	A	250	2.8	150
	I	8	O	241	3.0	59
	IV	16	A	379	2.4	180
	IV	13	O	282	2.8	52
<i>Cycloneda polita</i>	I	17	A	420	2.5	134
	I	10	O	330	3.3	58
	IV	15	A	354	2.4	128
	IV	15	O	302	2.7	54

*Plant size is computed as number of leaves of a plant times its height in cm.

Results

The data are of three types: qualitative observations of aphid and larval behaviour; the outcome of interaction between aphids and larvae; and the time and motion data.

Qualitative observations. The larvae of all four species behave similarly on both host plants. They follow the leaf edges, as the adults do, so that on alfalfa they sometimes walk around one leaf many times. On the elongated leaves of oats, the larvae are never 'trapped' in this way; but all species except *polita*, in following the edges, usually miss the aphids near the mid-rib.

After contacting an aphid, all four species search the locality very carefully, making frequent turns. This behaviour is similar to that of *Adalia bipunctata* (Banks

1957) and that of *A. decempunctata* (Dixon 1959). All species appear reluctant to leave the apex of the plant — an advantage on alfalfa since pea aphids congregate there, but a disadvantage on oats because most aphids are found on the leaf blade.

Each species has its distinctive style of search. The long-legged *polita* larvae usually straddle the undersurface of the oat leaf, often walking in the shade. *Californica* larvae seldom walk in the shade, and are less likely than other species to remain on one plant. *Californica* and *undecimpunctata* larvae walk much faster than the other two species and seldom capture the first aphid they contact; they simply run over it. The slower moving *polita* and *trifasciata* are more successful with their first aphid. *Trifasciata* larvae are the slowest moving; fourth instar *trifasciata* move no faster than the first instars of the other species.

Larval/aphid interactions. Encounters between larvae and aphids are grouped into three outcomes: the aphid is captured and eaten, permanently leaves the plant, or is merely contacted by the larva. In the latter case, the aphid may fall off the plant to avoid the larva, but subsequently climbs back on. The frequencies of these types of encounter vary according to age and species of both aphids and larvae. Older *A. dirhodum* are captured, and also leave the plant, more frequently than young (Table II). The reason is that the coccinellid larvae often fail to detect the first-instar aphids. Both trends are reversed in *A. pisum*: the older aphids are more likely to fall off the plant and so avoid capture, but generally climb back onto the same plant. Fourth-instar larvae capture aphids much more frequently than do first-instar (Table III; Wratten 1973; Hodek 1973). But there are no consistent differences in capture rates between species of larva or between species of aphid. In particular, there is no suggestion that *C. californica*, which predominates in oats, is particularly better at catching *A. dirhodum*, or that *C. trifasciata*, which predominates in alfalfa, is better at catching *A. pisum*.

Table II. The total numbers and instars of pea aphids on alfalfa and rose aphids on oats at risk and the percentages and standard errors of aphids that permanently left plants, or were captured. Every aphid at risk for 3000 sec

Aphid instar	Numbers		Left				Captured			
	<i>A. pisum</i>	<i>A. dirhodum</i>	<i>A. pisum</i>		<i>A. dirhodum</i>		<i>A. pisum</i>		<i>A. dirhodum</i>	
			%	S.E.	%	S.E.	%	S.E.	%	S.E.
I	603	924	9.1	1.1	0.76	0.28	4.1	0.81	1.8	0.44
II	741	731	7.3	0.95	1.4	0.43	2.2	0.53	2.3	0.56
III	743	419	4.8	0.78	6.0	1.1	0.67	0.30	2.9	0.81
IV	653	157	4.3	0.79	12.7	2.7	0.92	0.37	3.8	1.5
Adult	332	259	6.6	1.4	5.4	1.4	1.5	0.67	3.1	1.1
TOTAL	3072	2490	6.4	0.44	3.1	0.34	1.8	0.24	2.4	0.31

Discussion

We conclude therefore that the abundance of adult *C. californica* on oats, and of *C. trifasciata* on alfalfa, is not connected with larval predation efficiency, on which larval survival depends. The timings and capture rates estimated from this work are used in the wider study (Frazer *et al.*, this series).

Acknowledgment

We thank L. Woodgate for help in watching larvae.

Table III. The percentages and standard errors of *Acyrtosiphon pisum* (A.p.) on alfalfa, and *A. dirhodum* (A.d.) on oats, that permanently left the plant they were on, or were captured, by larvae of two instars of each of four species of coccinellid

Species	Instar	Aphid	Left		Captured	
			%	S.E.	%	S.E.
<i>Coccinella californica</i>	I	A.p.	2.3	0.81	1.5	0.66
	I	A.d.	0.5	0.34	0.9	0.46
	IV	A.p.	7.6	1.2	3.6	0.86
	IV	A.d.	1.6	0.72	2.6	0.90
<i>Coccinella trifasciata</i>	I	A.p.	2.2	0.84	0	0
	I	A.d.	0.5	0.40	0.3	0.27
	IV	A.p.	8.4	1.3	2.9	0.80
	IV	A.d.	5.8	1.3	4.5	1.2
<i>Coccinella undecimpunctata</i>	I	A.p.	4.0	1.2	0.8	0.56
	I	A.d.	1.7	0.83	1.2	0.70
	IV	A.p.	9.5	1.5	2.9	0.86
	IV	A.d.	6.4	1.4	2.8	0.98
<i>Cycloneda polita</i>	I	A.p.	0.7	1.2	0	0
	I	A.d.	2.1	0.79	0.9	0.52
	IV	A.p.	16.9	2.0	2.5	0.83
	IV	A.d.	6.6	1.4	6.3	1.4

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