

## LABORATORY STUDIES ON THE REPRODUCTION OF *ADALIA BIPUNCTATA* (COLEOPTERA, COCCINELLIDAE)

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The pre-oviposition period, but not the longevity, of adult *A. bipunctata* was significantly shorter when they had been reared to the adult stage on *Microlophium evansii*, and then fed on *Acyrtosiphon pisum*, than when fed in the adult stage on *Aphis fabae*. When adult beetles, reared as larvae on *M. evansii*, were fed on *A. pisum* they laid twice as many eggs as similarly reared adults fed on *A. fabae*. The species of aphid fed to the insects during their adult life (but not their larval life) greatly affected fecundity, and *A. pisum* is perhaps a more nutritious food for *A. bipunctata* than *A. fabae* is. Virgin females laid infertile eggs but only half as many as those laid by mated females.

There is little information on the reproduction of *Adalia bipunctata* (L.), one of the most abundant coccinellid predators of *Aphis fabae* Scop. and other aphids in southern England. The total number of eggs laid by individual *A. bipunctata* was recorded by BURGESS (1903), CLAUSEN (1915) and FLUKE (1929) in America and by HAWKES (1920) in England. The effect of aphid diet on the fecundity of *A. bipunctata* under standardized laboratory conditions is now reported.

### METHODS

Cultures of virginoparous *A. fabae* and *Acyrtosiphon pisum* Harris were kept on broad beans in the glasshouse throughout the year and were used to feed *A. bipunctata* under constant artificial lighting (19 h/day), temperature (15° and 20°) and humidity (55—65% R.H.).

Newly emerged adult *A. bipunctata* were reared from pupae found on stinging nettles (*Urtica dioica* L.) infested with the aphid *Microlophium evansii* (Theo.). They were confined singly or in pairs in transparent plastic boxes enclosing a leaf of a broad bean plant on which aphids were put; the boxes had fine muslin on the upper and lower surfaces to allow ventilation. Plants were changed regularly at least once a week. Aphids were supplied each day so that the beetles had an excess of food and thus did not eat their own eggs. Cages were examined at 9 a.m. and 5 p.m. daily, when eggs were removed and counted, and mating recorded.

Four experiments were made at 20°, some females were kept with males (Treatments 1—3), others without (Treatment 4); in one experiment made at

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15°, the females were kept without males (Treatment 5). Adults reared on *M. evansii* during the larval stage were fed on *A. pisum* (Treatment 1) or *A. fabae* (Treatment 2); females reared as larvae on *A. fabae* were also fed on this aphid as adults, but some were caged with males (Treatment 3) and others without (Treatment 4).

## RESULTS

### *Pre-oviposition period*

The pre-oviposition period lasted 1—2 weeks at 20° and about 3 weeks at 15° (Table I). Females without males started to oviposit at the same time as those

TABLE I  
*Mean duration of the pre-oviposition period (days)*

	Treatments		Temperature	No. of insects	Mean duration (± S.E.)
Aphid food given to larva	adult				
1	<i>M. evansii</i>	<i>A. pisum</i>	20°	10	7.8 ± 1.2
2	<i>M. evansii</i>	<i>A. fabae</i>	20°	9	9.3 ± 1.2
3	<i>A. fabae</i>	<i>A. fabae</i>	20°	8	13.2 ± 1.3
4	<i>A. fabae</i>	<i>A. fabae</i>	20°	5	15.4 ± 1.6
5	<i>A. fabae</i>	<i>A. fabae</i>	15°	6	21.2 ± 1.8

Treatments 1—3: with males

Treatments 4, 5: without males

with males but their eggs were infertile. The beetles fed on *M. evansii* as larvae (Treatments 1 and 2) were larger and had more reserves of fat and glycogen than those fed on *A. fabae* as larvae, and their pre-oviposition period was significantly shorter than that of the smaller beetles reared as larvae on *A. fabae* (Treatments 3 and 4). Thus, the duration of the pre-oviposition period was influenced by the larval diet.

Females reared as larvae on *M. evansii* and fed on *A. pisum* during adult life, had the same pre-oviposition period as those fed on *A. fabae* during adult life; but the pre-oviposition period was significantly longer when the adults had been reared as larvae on *A. fabae* (Treatments 1 and 3).

Mating occurred mainly after the females had started laying eggs and was rare during the pre-oviposition period.

### *Longevity of adults*

The longevity of adults was not affected by the species of aphid provided as food (Table II). Males lived as long as females (average, 80—90 days). After 73—76 days, 50% of the females of Treatments 1—3 on different aphid species were dead; the longevity of the females in Treatments 4 and 5 was not recorded. Most females died very soon after the end of egg laying.

TABLE II  
*Longevity of adults (days)*

Treatments		No. of insects	Longevity ( $\pm$ S.E.)
Aphid larva	food given to adult		
1	<i>M. evansii</i>	10	$77.1 \pm 9.2$
		10	$79.4 \pm 9.2$
		9	$81.1 \pm 9.7$
2	<i>M. evansii</i>	9	$89.7 \pm 9.7$
		6	$81.7 \pm 11.9$
3	<i>A. fabae</i>	8	$76.9 \pm 10.3$

### *Fecundity*

The total number of eggs laid was not determined by the quantity of reserve substances carried over from the larval stage (which depended on the species of aphid provided as food), for the fecundity of beetles fed on *M. evansii* during larval life (Treatment 2) did not differ significantly from that of beetles fed on *A. fabae* during larval life (Treatment 3, Table III). By contrast, the total number

TABLE III  
*Mean fecundity of females*

Treatments		No. of insects	Mean fecundity ( $\pm$ S.E.)	Mean No. of eggs/female/day ( $\pm$ S.E.)
Aphid larva	food given to adult			
1	<i>M. evansii</i>	10	$1535 \pm 158$	$20.4 \pm 1.6$
2	<i>M. evansii</i>	9	$761 \pm 166$	$8.8 \pm 1.6$
3	<i>A. fabae</i>	8	$738 \pm 176$	$9.3 \pm 1.7$

of eggs laid during the whole life of individual female *A. bipunctata* was affected by the species of aphid fed to the adult beetles (cf. Treatment 1 with Treatments 2 and 3, Table III). On the average, beetles fed on *A. pisum* laid twice as many eggs as those fed on *A. fabae* (Fig. 1).

The species of aphid fed to adult *A. bipunctata* is therefore apparently the most important factor determining the insect's fecundity.

As the adults lived for the same average period in each of the three treatments and females fed on *A. pisum* laid twice as many eggs as those fed on *A. fabae*, more eggs were laid per day on the average in this treatment (20 eggs/female/day) than in the other two treatments (9 eggs/female/day) (Table III).

Eggs were laid in batches or sometimes singly anywhere in the rearing cages.

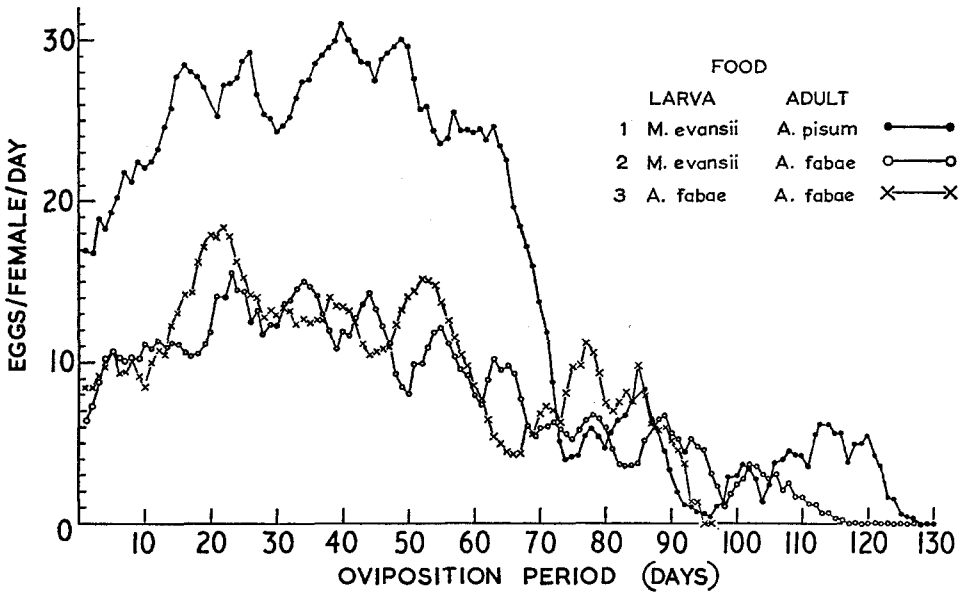


Fig. 1. The reproductive rate of *Adalia bipunctata* fed on different aphids.

The most eggs laid in a batch by females fed on *A. pisum* was 36 and by females fed on *A. fabae* 27.

From a twice-daily inspection during the whole experiments lasting 130 days, males were each seen to mate 3 to 22 times (average, 9–12 times each).

#### DISCUSSION

This work shows that the species of aphids given as food to *A. bipunctata* during its adult life can greatly affect its fecundity. Adult beetles fed on *A. pisum* laid twice as many eggs as those fed on *A. fabae*; although the kind of aphid fed to the insects during their larval lives affected the length of the pre-oviposition period of the young females, their fecundity depended entirely on the kind of food they received in adult life. Although *A. pisum* is a much larger aphid than *A. fabae*, it contains relatively less dry matter (mean live weights of *A. pisum* and *A. fabae* were 0.12–3.04 mg and 0.04–0.62 mg, mean dry weights were 0.02–0.57 mg and 0.008–0.16 mg and the proportion of dry matter in the aphids was 14–20% and 20–24% respectively). *A. pisum* is possibly more nutritious than *A. fabae* for *A. bipunctata*, but no firm conclusion can be drawn until the numbers of both kinds of aphids eaten by adult *A. bipunctata* are known.

The fact that *A. bipunctata* is not particularly fecund when fed in the adult stage on *A. fabae* is surprising, for this is the commonest coccinellid predator of *A. fabae* on beans in southern England (BANKS, 1955).

LINSSSEN (1959) reviewed some records of the total eggs laid by *A. bipunctata* and said that the maximum number of eggs laid by one female was 418 (HAWKES,

1920), but he considered this exceptional. Other records were averages of 121 (BURGESS, 1903), 144 (HAWKES, 1920), 190 (CLAUSEN, 1915) and 275 (FLUKE, 1929) eggs per female, but the average fecundity that I have recorded is much greater than other records. FLUKE's record was for two individuals of *A. bipunctata* that had been kept isolated from males when egg laying began.

Unfertilized females of *Coccinella septempunctata* L. laid infertile eggs and their number was about half of that laid by fertilized females (BODENHEIMER, 1943). My results show that female *A. bipunctata* in the presence of males laid 9 eggs each per day during the first 10 days of the egg laying period, whereas isolated virgin females laid only 5 eggs each during the same period when fed on the same aphid, *A. fabae*.

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#### ZUSAMMENFASSUNG

#### LABORATORIUMSUNTERSUCHUNGEN ÜBER DIE VERMEHRUNG VON ADALIA BIPUNCTATA (COLEOPTERA, COCCINELLIDAE)

Die Praeovipositionszeit, jedoch nicht die Lebensdauer, von erwachsenen *A. bipunctata* war signifikant kürzer, wenn sie nach Aufzucht mit *Microlophium evansii* im Adultstadium mit *Acyrtosiphum pisum* statt mit *Aphis fabae* gefüttert wurden. Wenn erwachsene Käfer, die als Larven mit *M. evansii* aufgezogen worden waren, mit *A. pisum* gefüttert wurden, legten sie doppelt so viele Eier als entsprechend aufgezogene, aber mit *A. fabae* gefütterte Imagines. Die Blattlausart, welche den Käfern während ihres Imaginallebens — aber nicht während der Larvalentwicklung — als Nahrung geboten wird, beeinflußt ihre Fruchtbarkeit stark; und *A. pisum* ist vielleicht ein nahrhafteres Futter für *A. bipunctata* als *A. fabae*. Unbegattete Weibchen legten unbefruchtete Eier, aber nur halb so viele als begattete.

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