Effect of type of food on fecundity in Coccinella septempunctata L. (Col., Coccinellidae)

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Three successive generations of *Coccinella septempunctata* L. reared in the laboratory laid an average of 1325, 1217 and 1882 eggs when fed on *Acyrthosiphon pisum* (Harris), the best food.

Females fed on *Macrosiphum rosae* began to lay eggs significantly earlier than those fed on *Myzus persicae* (Sulz.), and laid more than twice as many eggs.

Quick-frozen *Acyrthosiphon pisum* were less suitable as food for the females than were living pea aphids. A significantly smaller number of females began to lay eggs, and twice the time elapsed before the onset of egg-laying in females that had eaten frozen aphids as compared with those that had eaten living aphids. The females which had been given living aphids laid on average more than twice as many eggs per day as those fed on frozen aphids.

The food of the larvae had no effect on the onset of egg-laying or the number of eggs. The food of the adult had no significant effect on the proportion of eggs that hatched.

Females fed on an artificial diet laid no eggs.

Recently, an increasing amount of research has been done on the possibility of using ladybirds (*Coccinellidae*) for the biological control of insect pests. To attain the maximum rate of reproduction, the effects of the quantity and quality of the food on the fecundity of ladybirds have been investigated.

Hodek (1967) divided the food acceptable to ladybirds into two groups. With suitable food the females lay eggs, and the larvae develop. Any other accepted diet is only alternative food. However, not all types of food that have proved suitable are of equal value in promoting fecundity or larval development. A few comparisons have been made (e.g. Blackman 1965, 1967, Iperti 1966, Okamoto 1966) on the suitability of various species of aphid as food for the sevenspotted ladybird (*Coccinella sptempunctata* L.). The suitability of quick-frozen aphids (Shands et al. 1966) and of various artificial foods (e.g. Smirnoff 1958, Sundby 1968) has also been studied.

The purpose of the present study was to ascertain the number of eggs laid by *C. septempunctata* and the effects of various foods on the number of eggs and on the rate of hatching. The foods compared were the rose aphid (*Macrosiphum rosae* L.) and the green peach aphid (*Myzus persicae* Sulz.) as well as frozen and living pea aphids (*Acyrthosiphon pisum* Harris). The suitability of the artificial diet developed by Smirnoff (1958) as food for the females was also investigated.

Material and methods

The seven-spotted ladybirds used in the experiment were from the continuous stock maintained at the Department of Pest Investigation, which came from hibernated specimens gathered at Käkölä in spring 1970 (see Hämäläinen and Markkula 1972).

The egg-laying of three successive generations was investigated in the laboratory, where the average diurnal temperatures varied from 20 to 28°C and the relative humidity from 40 to 70 %. The diurnal period of light was 18 hours. When the natural photoperiod was shorter, it was extended by means of mercury lamps. For food the ladybirds were given nothing but *A. pisum*. The specimens of each generation were kept together for two

weeks for copulation after they had become adults. When egg-laying began, the females were placed separately in glass jars (diameter 9 cm, height 4 cm) with disks of filter paper at the bottom for the retention of moisture and thin gauze to cover the top. The aphids were given to the ladybirds on broad-bean leaves and other plant parts. New food was added and the eggs were counted and removed from the jars every 24 hours. Food was always available to the ladybirds in the jars.

The suitability of *M. rosae* and *M. persicae* as food for the females of *C. septempunctata* was compared in the almost natural weather conditions of the insectary. The specimens were hibernated females gathered in nature. They had copulated but had not eaten aphids or laid eggs when brought to the insectary on 1 June 1970. Some were given *M. rosae* as food, and others *M. persicae*. From each group the twenty females that first laid eggs were included in the experiment, which was discontinued in mid-September, at the termination of egg-laying.

The egg-laying of females of the seventh generation fed on frozen or living *A. pisum* was compared in the laboratory in conditions similar to those during the egg-laying of the first three generations.

Half the larvae of the seventh generation were reared to adulthood on frozen pea aphids, and half on living pea aphids. The adults of both these groups were divided into two groups and given either frozen or living aphids. The frozen aphids were supplied twice a day because they dried up quickly. The test was discontinued 50 days after the appearance of the first eggs.

In both tests the methods of investigation were similar to those used when the egg-laying of successive generations was investigated.

A total of 50 females (of the second, third and seventh generations) were fed in the laboratory on the artificial died developed by Smirnoff (1958).

The hatching of the eggs was investigated by placing groups of eggs separately in plastic cylinders or in glass tubes to develop.

Results

Fecundity in three successive generations

The females of the first generation laid 1325 eggs on average, those of the second generation 1217 and those of the third 1882, their diet having been *A. pisum* (Table 1). The variations between individuals were considerable in every generation. As many as 8 of the 40 females investigated laid more than 2000 eggs, the largest number of eggs from a single female being 2957. About 70 % of the total number of eggs was laid during the first half of the egg-laying period (Fig. 1).

The numbers of eggs are not comparable, for the conditions, e.g. temperature and amount of food, differed to some extent during egg-laying.

Effect of food on fecundity

Macrosiphum rosae and *Myzus persicae* as food

The females fed on *M. rosae* started to lay eggs on average after 12 days on this food, and those fed on *M. persicae* after 15 days. On average, those fed on *M. rosae* laid 964 eggs in 67 days, and those fed on *M. persicae* 411 in 47 days (Table 2). The differences are statistically significant. The variation between individual females was great.

There was no significant difference in hatching of the eggs between females that had eaten *M. rosae* and those that had eaten *M. persicae*.

Quick-frozen and living *Acyrthosiphon pisum* as food

The females fed on living *A. pisum* started to lay eggs on average 20 days and those fed on

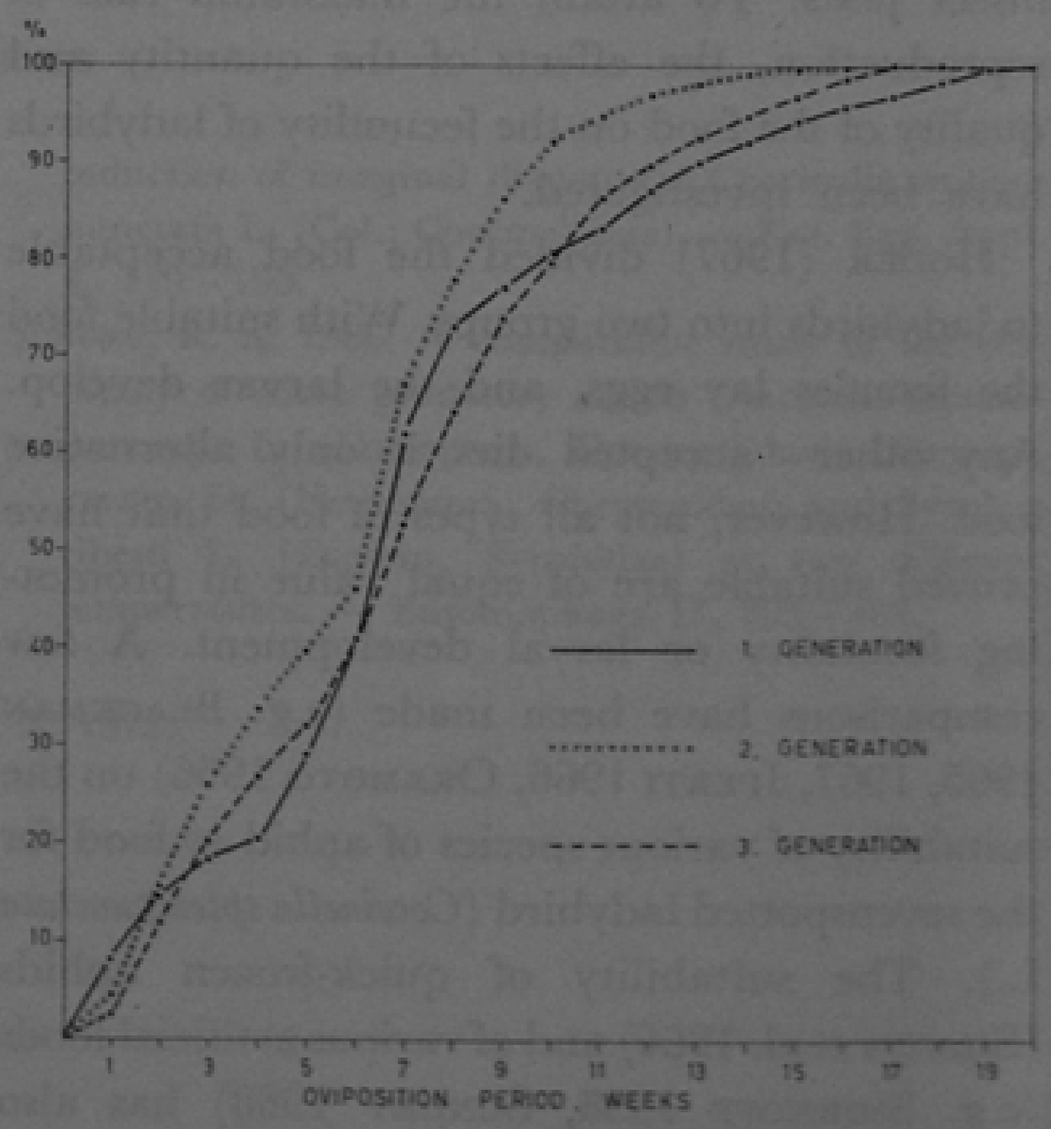

Fig. 1. The number of eggs laid weekly as a percentage of the total number of eggs in three successive generations.

Table 1. Egg-laying of three successive generations of *Coccinella septempunctata* fed on *A. pisum*.

Generation	Number of females	Preoviposition period, days	Oviposition period, days	Postoviposition period, days	Total lifespan, days	Number of eggs	Eggs/day
1.	18	Mean 41.7 ± 2.2 Range 39 — 47	84.3 ± 36.4 1 — 137	9.7 ± 31.1 1 — 134	135.7 ± 31.7 78 — 179	1 325.2 ± 568.3 53 — 2416	18.1 ± 9.7 9.2 — 53.0
2.	12	Mean 21.1 ± 5.3 Range 15 — 33	55.6 ± 38.8 8 — 117	11.8 ± 30.7 0 — 109	88.5 ± 42.3 26 — 153	1 217.0 ± 936.8 76 — 2957	20.7 ± 7.6 10.6 — 28.1
3.	10	Mean 14.0 ± 3.8 Range 8 — 17	80.6 ± 27.1 37 — 118	7.8 — 10.9 0 — 35	102.1 ± 28.8 57 — 136	1 882.2 ± 603.8 1095 — 2545	23.9 ± 4.8 18.4 — 32.8

frozen aphids 40 days after emergence. On average, the former laid 933 eggs during the period investigated, and the latter 273. The differences are statistically significant. However, the food of the larvae did not have any significant effect upon the time at which egg-laying began or upon the number of eggs (Table 3).

Of the 32 females fed on frozen food, only 17 (53 %) started to lay eggs. Of the 29 females fed on living aphids, 26 (90 %) did so. The difference is statistically significant.

However, there was no significant difference in the rate of hatching of the eggs of these two groups of females.

Artificial food

C. septempunctata did not lay eggs when fed on the artificial food developed by SMIRNOFF (1958). Nor did the larvae develop.

Discussion

The literature contains a great deal of information about the number of eggs of *C. septempunctata*. A comparison with previous data is difficult, for research conditions and foods have varied and sometimes are not even stated. The greatest number of eggs on record is probably 3 765 (BAGAL and TREHAN 1945).

Table 2. Egg-laying of hibernated *Coccinella septempunctata* fed on *M. rosae* or *M. persicae*.

	Fed on M. rosae	Fed on M. persicae	t-value
Number of females	20	20	
Preoviposition period, days	Mean 11.6 ± 1.6 Range 8 — 13	15.4 ± 4.6 8 — 21	3.4 **
Oviposition period, days	Mean 67.3 ± 15.1 Range 16 — 92	47.4 ± 8.1 23 — 88	3.7 **
Number of eggs	Mean 964.3 ± 587.4 Range 67 — 2288	410.8 ± 227.6 46 — 870	11.6 ***
Eggs/day	Mean 14.3 ± 8.6 Range 0.9 — 30.9	9.6 ± 6.6 1.3 — 18.4	2.3 *
Hatching rate	77.3 % of 1769 eggs	74.8 % of 1153 eggs	

Table 3. Egg-laying of *Coccinella septempunctata* fed on living and on quick-frozen *A. pisum*, in the early part of the period of oviposition.

Food of larva	Food of adult	Number of females	Preoviposition period, days	Number of eggs	Eggs/day	Hatching rate
Living	Living	10	Mean 22.3 ± 2.9 Range 17 — 27	1 028.5 ± 614.1 211 — 2095	30.9 ± 13.7 9.6 — 54.3	
Frozen	Living	7	Mean 17.6 ± 9.1 Range 9 — 36	796.3 ± 237.9 466 — 1087	27.7 ± 7.6 18.3 — 36.8	
	Living	17	20.4 ± 6.5 9 — 36	932.9 ± 479.2 211 — 2095	29.6 ± 11.4 9.6 — 54.3	34.7 % of 3962 eggs
Living	Frozen	8	Mean 39.3 ± 11.7 Range 17 — 50	234.5 ± 199.1 43 — 589	12.0 ± 10.5 2.5 — 29.9	
Frozen	Frozen	8	Mean 40.5 ± 9.3 Range 26 — 54	311.1 ± 186.7 51 — 548	13.9 ± 7.8 5.1 — 26.1	
	Frozen	16	40.0 ± 10.2 17 — 54	272.8 ± 190.6 43 — 589	13.0 ± 9.0 2.5 — 29.9	32.9 % of 2404 eggs
Significance of differences as tested by variance analysis						
Food of larva						
F value			0.38	0.33	0.03	
Significance			—	—	—	
Food of adult						
F value			44.4	22.6	19.4	
Significance			***	***	***	

The type of food had a significant effect on egg-laying. *M. rosae* was more suitable than *M. persicae*. One possible cause for the superiority of *M. rosae* as food for egg-laying females is the greater size of these aphids. After catching one aphid, the ladybirds feeding on *M. rosae* obtained more nourishment than did those feeding on *M. persicae*. The amount of food has been found to have a significant effect on egg-laying (Ibrahim 1955, Dixon 1959).

Blackman (1967), too, found that *M. persicae* was inferior to *A. pisum* as food for egg-laying *C. septempunctata*. The seven-spotted ladybirds investigated by Sundby (1966) laid on average 814 eggs at a temperature of 21 °C when fed on *M. persicae* and honey.

The females fed on frozen *A. pisum* laid significantly fewer eggs than those fed on living aphids. One probable reason is that frozen aphids rapidly dry up at room temperature, and the ladybirds consequently find them unappetising. Shands et al. (1966) fed quick-frozen *Myzus persicae* and *Acyrthosiphon solani* (Kalt.) to *C. septempunctata*. However, they did not compare the effects of frozen and living aphids upon the numbers of eggs laid.

The food of the larva did not affect the fecundity of the adult. This is in accord with the observations made on *Adalia bipunctata* (L.) by El Hariri (1966) and Blackman (1967).

The artificial food developed by Smirnoff (1958) proved to be unsuitable for reproduction. Smirnoff (1958) reared ladybirds of many species, includning *C. septempunctata*, on this food, but his paper does not reveal whether yhis species laid eggs. Sundby (1968) fed seven-spot-

ted ladybirds on an artificial food containing liver, but without result. SMITH (1965) stated that liver is the best non-prey food for some species of ladybirds.

The type of food did not affect the proportion of eggs that hatched. According to BLACKMAN (1967), the eggs of females fed on bean aphids (*Aphis fabae* L.) had a clearly lower hatching rate (69 %) than those of females fed on *M. persicae* or *A. pisum* (80 — 86 %). *A. fabae* also causes a reduction in the fertility of the eggs of *A. bipunctata*, as compared with *M. persicae* BLACKMAN (1967).

The hatching rate of the eggs of the females fed on frozen or living *A. pisum* was quite low. This was probably because the females were specimens of the seventh generation. Degeneration has been established in *C. septempunctata* when reared for several successive generations without a diapause (HODEK and ČERKASOV 1961, see also HÄMÄLÄINEN and MARKKULA 1972). The females fed on *M. rosae* or *M. persicae* were, in contrast, hibernated specimens gathered in nature.

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