Fecundity, Aphid Consumption and Survival of the Aphid Predator *Adalia bipunctata* L. (Col., Coccinellidae)

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In the laboratory, *Adalia bipunctata* had a rate of increase of 335 imagines per female. At 18°C, the life cycle was completed in 36.6 days; the oviposition period was 3 months. Aphid consumption per larva (measured at 18°C, feeding ad libitum) during the larval period was 188; during 3 months an egglaying pair consumed 3096 aphids. Survival was greatly influenced by temperature. Starved larvae lived almost twice as long when they could cannibalize an egg compared to those fed on water only. Honey slightly prolonged larval survival, whereas imagines had almost normal longevity when offered honey.

In Norway, three aphid predators, *Coccinella septempunctata* L., (Col., Coccinellidae), *Chrysopa carnea* Stephens (Neur., Chrysopidae), and *Syrphus ribesii* L., (Dipt., Syrphidae) have been studied by Sundby (1966, 1967, 1968). The present experiments concern a fourth common aphid predator, *Adalia bipunctata* L. (Col., Coccinellidae) that has not previously been studied in Norway.

Among the attributes of an effective natural enemy (Doutt & DeBach 1964), I have studied in the laboratory (i) rate of increase (including fecundity and developmental period); (ii) theoretical number of aphids consumed by larvae and imagines during one summer; (iii) ability to survive unfavourable periods (i.e. duration of survival without aphid food).

MATERIAL AND METHODS

All material was collected as overwintered imagines at the end of May 1967 and 1968 at Vollebekk, Ås, southern Norway.

Oviposition experiments were carried out in small glass jars covered with cloth gauze. There was one male and one female in each jar. Eggs were isolated, and soon after hatching the larvae for feeding and survival experiments were placed separately in petri-dishes to prevent cannibalism. To secure sufficient humidity, the bottoms of glass jars and petri-dishes were covered with filter papers that were moistened once a day. The peach aphid *Myzus persicae* (Sulzer) was used as prey both for larvae and imagines. The number of aphids

Table I. Characteristics of reproduction of *A. bipunctata*

(a) Data from 12 pairs kept at about 22 °C

	mean ± S.E.
Fecundity (number of eggs per female)	1466 ± 124
Egg development (in days)	3.39 ± 0.01
Number of larvae per female	456 ± 44
Hatching per cent	31.7 ± 6.2
Oviposition period (in days)	89 ± 8.8
Longevity (in days) of males	72 ± 2.6
Longevity (in days) of females	135 ± 3.2

(b) Data from 8 pairs kept at 18 °C of 8–28 °C. Observation period 87 days

Egg-batches per female	mean	43.5
	range	14–82
Number of eggs per batch	mean	15.4
	range	2–43
Infertile eggs		37.0%
Fertile eggs cannibalized		3.4%
Fertile eggs unhatched		7.1%

consumed was checked and a new supply given at the same time every day. Imagines also received honey on the moistened cloth. The aphids were reared in the laboratory on swedes *(Brassica napus napobrassica* (L). Rchb.). Experiments were carried out at room temperature (about 22°C) and in incubators with constant or varying temperature conditions (Ellingsen 1969).

RESULTS AND DISCUSSION

Rate of increase

Twelve egglaying pairs were kept for observation from time of collection until they died. Data on oviposition and longevity are summarized in Table Ia. It is shown that *A. bipunctata* has a high fecundity and a long oviposition period. The values resemble those of El Hariri (1966), but lie above earlier records cited by El Hariri (1966). The total proportion of hatched eggs was low, 31.7 per

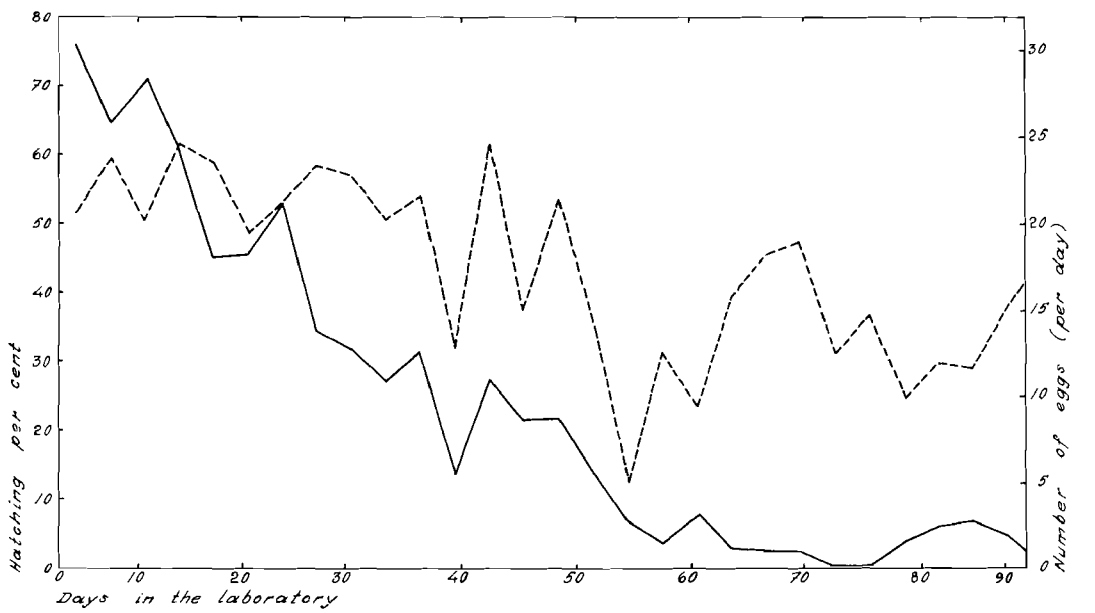

Fig. 1. Changes in hatching per cent and egg-production during 90 days (30th May-30th August) of *A. bipunctata* at room temperature 22°C. - - - the daily oviposition is calculated as a mean of 12 females in three-day periods, four days where a sunday comes in between. —— the hatching per cent is calculated as a mean in the same periods.

cent. Changes in hatching during the first 90 days, together with daily oviposition, are shown in Fig. 1. The decline in fertility seems to coincide with the aging and death of males. Hodek (1967), however, states that for most cocconellid species, one copulation is enough to give the female permanent fertility. In the present study copulations were observed quite frequently, and El Hariri (1966) found that in a twice-daily inspection during the whole experiment lasting for 130 days, males were seen to mate 3 to 22 times each (average 9-12 times each).

In order to examine more closely the eggs from which no larvae were obtained, new oviposition experiments were carried out with 8 pairs collected outdoors. Four pairs were kept at 18°C and four pairs at 8°-28°. Since no differences in results were obtained, the data from both temperature conditions are put together in Table Ib. The proportions of infertile eggs, and fertile eggs cannibalized or unhatched are given. The number of fertile cannibalized eggs (recognized by a black residue of the larval skin) depends on how long the batches go without removal of hatched active larvae; my experiments were inspected once daily. Number of egg-batches and number of eggs per batch were also studied (Table Ib). The cannibalistic behaviour of newly hatched larvae is shown in Fig. 2. The egg-batch was 6 days old, and infertile and fertile eggs can be distinguished as the latter appear grey. The last oviposition series had a higher proportion of hatched eggs, 52.5 per cent, than the series reported in Table Ia. At the beginning of the oviposition period the hatching per cent is high (Fig. 1), therefore Jöhnssen (1930) could report 94.6 per cent (395-674 eggs observed) and Banks (1956) 83.4 per cent (of 186 eggs). Infertile eggs increase in numbers towards the end of the period. In the present study, 37.0 per cent infertile eggs were found. Banks (1956) found only 4.8 per cent, and 12.4 per cent were cannibalized by earlier hatched larvae.

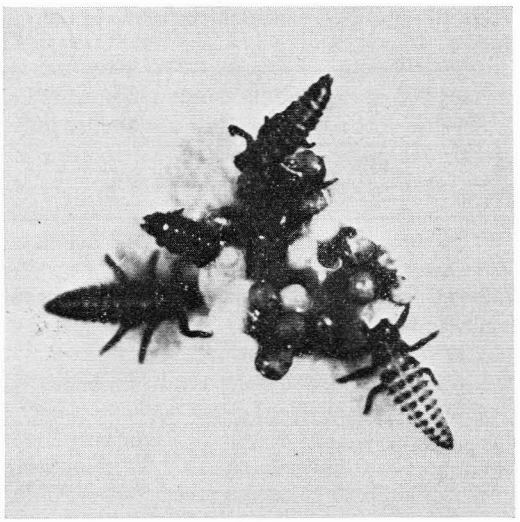

Fig. 2. A six days-old egg-batch of *A. bipunctata* cannibalized by newly hatched larvae.

Mortality during larval and pupal stages is presented in Table II. First larval instar and pupae were most vulnerable.

Rate of increase of *A. bipunctata* during one summer in the present laboratory experiments was 335 imagines per female (i.e. 456 larvae per female with 28.6 per cent mortality in larval and pupal stages, assuming that there is only one generation a year at our latitude). At 18°C the life cycle was completed in 36.6 days. Imagines reared in the laboratory had

Table II. Mortality in larval and pupal stages of *A. bipunctata*.
Based on 197 newly emerged larvae

	1st larval	2nd larval	3rd larval	4th larval	pupal
Number dying in stage	37	7	12	6	20
Mortality rate per cent of those alive at beginning of stage	18.8	4.9	7.9	4.3	14.7

Table III. Aphid consumption per larvae in the various larval stages of *A. bipunctata*. Food supply was ad libitum

Temp.	N	1st instar mean ± S. E.	2nd instar mean ± S. E.	3rd instar mean ± S. E.	4th instar mean ± S. E.	total mean ± S. E.
18°	40	12 ± 0.7	19 ± 1.1	42 ± 4.2	118 ± 9.7	188 ± 13.7
28°	29	13 ± 1.0	20 ± 1.2	38 ± 3.3	97 ± 2.4	168 ± 14.1

Table IV. Aphid consumption per egg-producing pair or male of *A. bipunctata* kept at 18° and 8–28°. Food supply ad libitum

	N	per day mean	per day range	total in 90 days
Egg-producing pair	8	34.4	30.8–39.4	3096
Male	6	12.7	11.2–22.2	1143

a preoviposition period of 8.0 days; and, as reported by Ellingsen (1969), egg-, larval-, and pupal development are completed in 28.6 days.

The question about number of generations during the summer is not clear. I have found pupae late in September, but this can be explained by the long oviposition period of the overwintered generation. Jöhnssen (1930) reports two generations at Cologne in especially hot summers. In the present study four generations were reared during the winter at 18° and 18 hours light per day, and no symptoms of diapause were observed. Mortality in all stages increased with each generation.

Aphid consumption

Both larvae and imagines of *A. bipunctata* are aphid predators. Data on the number of aphids that were eaten are summarized in Tables III and IV. Larvae consumed the greatest number at the lower temperatures because the greedy 4th larval stage lasted longer (also reported by Jöhnssen 1930). This tendency may also be responsible for differing pupal weights that were 144 ± 51 mg at 15°C and 128 ± 8.8 mg at 28°C. Daily voracity increased with temperature. The egg-producing female consumed more aphids than the male, as the consumption of egg-laying pairs is more than twice that of the male (Table IV).

The number of aphids consumed during one summer (one generation a year) is, according to my experiments, 188 aphids per larva, and 3096 per egg-producing pair.

Survival without aphid food

Survival of newly hatched larvae and imagines kept without aphids is shown in Table V. Ability to survive was greatly influenced by temperature; the great difference between 6°C and 18°C indicates that periods of cool temperatures may prolong survival of larvae. Consumption of one egg almost doubled the survival period, compared to the survival of larvae fed only on water (the egg was in some

Table V. Survival (in days) of *A. bipunctata*

(a) Newly emerged larvae

Temp.	food offered	N	mean ± S. E.
6°	water only	30	13.9 ± 0.5
18°	water only	53	2.9 ± 0.1
18°	water ± honey	56	3.7 ± 0.1
18°	water + 1 egg	53	4.8 ± 0.1

(b) Newly emerged imagines. Experiments at 8–28°

food offered	N	mean ± S. E.
water only	42	6.04 ± 0.01
water + honey	16	54.6 ± 12.8

cases from the coccinellid *Propylea quattuordecimpunctata* (L.), which has eggs of the same size as *A. bipunctata)*. Cannibalism of the egg-batches was very common; its biological value seems clear, as the prolonged survival gives the larvae more time to search for prey. Cannibalism does not have the same value for imagines, because their flying ability gives them a much greater range. Honey slightly prolonged survival of larvae. Imagines given honey lived almost as long as those fed on aphids, but no eggs were produced. According to Hagen (1962) extra floral nectary secretions are commonly fed upon by many coccinellds. These types of food offer energy sources, but are probably nutritionally deficient for egg production.

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