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THE CONSEQUENCES OF EGG CANNIBALISM IN *ADALIA BIPUNCTATA* [*COLEOPTERA : COCCINELLIDAE*]

BY

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When eggs of *Adalia bipunctata* L. are offered to larvae of their own species, these larvae are able to develop to adults. Reducing the daily egg supply results in decreased larval survival and pupal weight and especially fecundity of the adult females. The duration of larval development is significantly increased, the longevity of adults is shortened.

Cannibalism on eggs is of wide occurrence in the predacious *Coccinellidae*. CLAUSEN (1916) observed that the hatching of the larvae was sometimes protracted in egg batches of *Hippodamia convergens* GUERIN and that the first larva to hatch attacked the unhatched eggs. HAWKES (1920) recorded a similar behaviour in *Adalia bipunctata* L. and found that about a quarter of the larvae were destroyed before dispersal.

BANKS (1956) and HAGEN (1962) observed that *A. bipunctata* larvae remained clustered together on the empty egg shell for 12-24 hours, in this way cannibalism is favoured.

The importance of this kind of cannibalism for the coccinellid population is not quite clear. BANKS (1956), DIXON (1959) and BROWN (1972) stated that the larvae by feeding on eggs are able to make a more prolonged search for aphid food. DIXON (1959) recorded that the loss of unhatched eggs of *Adalia decempunctata* L. by cannibalism was of little consequence since most of these eggs were not viable. KOIDE (1962) succeeded in obtaining complete larval development of *Coccinella septempunctata* by feeding on an exclusive diet of eggs of their own species.

The present investigation was carried out to ascertain whether the eggs of *A. bipuntata* can be a full diet for larvae and adults of this species. Using eggs, known quantities of food could be offered

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to the larvae and the influence of different food quantities on the adult life could be investigated.

Materials and methods

A. bipunctata was collected in the field and was reared for some generations at 25-26°C, with a 16 hours photoperiod, larvae and adults were fed on aphids (*Myzus persicae* SULZ.) from a stock colony on Brussels sprouts. Adult females were taken from this colony to oviposit among aphid colonies within glass jars and the eggs were incubated at 25-26°C and 75 % relative humidity until the larvae hatched. These were then reared separately in glass tubes. They were given daily a known number of eggs or aphids. The daily consumption, survival, duration of the instars and the pupal weight were recorded. The life span of the adults fed on eggs and on aphids was also compared.

Experiments and results

Influence of egg supply on larval survival and food consumption

Each larva was supplied daily with 5, 10, 15, 20, or 40 newly laid eggs respectively in glass tubes 5 × 1.5 cm and the larval development was observed. Ten replicates were used in each experiment.

The results (table 1) show that the survival of larvae increased with increasing number of eggs offered ($P < 0.05$). The larvae which were offered 5 eggs daily failed to produce adults but all larvae on 20 eggs per day reached adulthood.

The total number of eggs consumed increased significantly with increasing number of eggs offered. There was also a marked difference in the food consumption between the larvae offered 20 and 40 eggs although there was no difference in survival. Food consumption increased with each instar, especially the fourth. The latter instar was most voracious because of an increase in both the daily consumption and the number of feeding days. Normally, the larvae had four instars, but when 10 eggs were offered daily, 4 out of 20 larvae underwent a fifth instar. In doing so, however, their overall egg consumption was similar to that of normal larvae and they pupated and produced adults normally.

Effect of egg supply on larval duration and pupal weight

Table 2 shows that the number of eggs offered daily influenced the duration of larval development which increased considerably with decreasing egg numbers. The less-well supplied larvae thus fed over a longer time and the total number of eggs consumed did

TABLE 1

Influence of the number of eggs offered on larval survival and food consumption of Adalia bipunctata *(Initially 20 first instar larvae in each test)*

No. of eggs offered daily/larva	No. of pupae obtained	No. of adults emerged	Aver. No. of eggs consumed/instar					(Aver. total) No. of eggs consumed/larva
			1	2	3	4	5	
5	2	0	6	14	26	67	—	113 ± 6.8
10	10	10	12	16	24	88	—	140 ± 4.3
	4	4	11	7	11	19	95	143 ± 3.6
15	16	16	12	13	42	97	—	164 ± 2.8
20	20	20	14	16	38	102	—	170 ± 3.8
40	20	20	15	31	48	136	—	230 ± 4.5

not increase in the same ratio as the number of eggs offered daily (table 1). With the well fed larvae, the duration of the fourth instar was nearly double that of the third instar, but when food was scarce the fourth instar period was greatly prolonged. When five eggs were offered daily only 2 out of the 8 larvae which reached fourth instar succeeded in pupating.

The pupal period was not affected by the quantity of food (table 2). The pupal weight is positively correlated with the number of eggs offered and nearly proportional to the number consumed (table 1). Larvae which were offered 20 or 40 eggs daily, produced pupae of nearly the same weight as larvae fed with sufficient number of aphids (DIMETRY, in press). Thus the provision of 20 or 40 eggs in this species satisfied the food requirement of the larvae under the conditions of the experiment.

TABLE 2

Effect of the egg supply on the larval and pupal durations and pupal weight of A. bipunctata

No. of eggs offered daily/larva	Aver. duration of larval instars in days					Aver. total larval period in days	Aver. pupal period in days	Aver. pupal weight in mg.
	1	2	3	4	5			
	2.5	3.5	5.6	17.0	—	28.5 ± 0,96	—	5.0 ± 0.2
10	4.2	2.6	2.8	9.5	—	19.1 ± 0,30	7.6 ± 0.14	7.7 ± 0.5
	4.0	1.0	2.0	3.5	9,5	20.0 ± 0.46	7.7 ± 0.13	7.9 ± 0.2
15	2.6	2.5	3.5	7.5	—	16.1 ± 0.28	7.4 ± 0.36	9.4 ± 0.6
20	2.3	2.2	3.3	7.0	—	14.8 ± 0.25	7.3 ± 0.64	10.0 ± 0.26
40	3.0	3.0	2.2	5.0	—	13.2 ± 0.13	7.5 ± 0.33	12.9 ± 0.13

EFFECT OF EGG FEEDING ON FECUNDITY AND LONGEVITY OF ADULTS

Single larvae were offered daily different numbers of eggs as in the previous experiments. Each resulting female was put in glass jars with a single male under the same standard conditions. If the males were too few, others were obtained from the stock colony. In every jar, 2 leaves of Brussels sprouts were offered. Ten egg batches (approximately 120 eggs) marked with red colour were stuck on one of the two leaves. The other leaf was free from eggs. In a control treatment, larvae were fed with a surplus of aphids (*Myzus persicae* SULZ.) and the pairs of resulting adults were put in glass jars with two leaves, one of them furnished with 120 fourth instar aphids; the other leaf was free from aphids. Daily, all leaves were changed, new food was given and the number of eggs laid was counted. The experiment was done at 20°C, and 16 hours photoperiod.

Beetles that were given 40 eggs daily during their larval stages and a surplus of eggs as adults proved to be nearly as viable as those in the control treatment (table 3). The adult life span including pre-oviposition and oviposition periods was extended but fecundity was decreased. This may be due to the difference in food or to a difference in oviposition stimulus given by eggs and aphids, although some eggs were laid both on leaves free of aphids and of eggs.

Larvae that were given only 20 eggs daily had greatly shortened oviposition period and adult longevity. Consequently, the fecundity was mostly decreased. Less than 20 eggs daily during the larval development were insufficient to produce fertile adults: the beetles died before the beginning of the oviposition period.

Thus, the quantity of larval food had a great influence on the adult life.

Discussion

The results obtained from the foregoing experiments demonstrate that eggs of *A. bipunctata* like those of *Coccinella septempunctata* (KOIDE, 1962) are suitable food for the larvae of the same species to reach maturity and for the adults to lay eggs. In contrast KEHAT (1968) reported that the larvae of *Pharoscymnus numidicus* PIC., cannibalising an abundant number of eggs developed to the fourth instar but did not pupate. If the number of eggs available to the larvae was reduced, development to the adult stage was possible, but the fecundity of the adults was greatly decreased. Thus the main effect of food scarcity during larval stages on the predator population occurs after more than three weeks.

UYGUN (1971) found an approximately linear relationship in *Aphidoletes aphidimyza* (ROND.) between the number of aphids consumed by the larvae and the fecundity of the adults. The present

TABLE 3

Effect of egg feeding on the fecundity and longevity of adults A. bipunctata

Type of food offered to larva daily	No. of replicates	Aver. pre-oviposition period in days	Aver. oviposition period in days	Aver. post-oviposition period in days	Aver. total No. of eggs female	Aver. longevity of adults in days male	female
5 eggs	—	No adults emerged					
10	6	—	—	—	—	3.0 ± 0.1	6.3 ± 0.12
15	6	—	—	—	—	7.0 ± 0.22	13.0 ± 0,56
20	8	19.0 ± 0.66	37.0 ± 0.91	9.0 ± 0.25	35.0 ± 4.2	44.2 ± 0.99	65.0 ± 1.3
40	9	17.9 ± 0.62	102.4 ± 1,58	4.9 ± 0.42	850.2 ± 45.9	103.0 ± 6.1	125.2 ± 8.8
aphids *(Myzus persicae)*	10	11.5 ± 0.81	89.6 ± 2.85	5.4 ± 0.62	1067.4 ± 80.2	74.4 ± 7.9	106.5 ± 5.8

study in *A. bipunctata*, feeding on its own eggs, gave an non-linear relationship between the quantity of larval food and female fecundity. The type of relationship, therefore, may be dependent on the kind of food.

Under natural conditions, larvae of *A. bipunctata* are extremely unlikely to depend on eggs throughout their development. Therefore, the reduction of fecundity may be of minor importance. On the other hand, development is possible with relatively few eggs if aphids are not available. This indicates a well developed tolerance to starvation in this insect and hence the capacity to survive at very low prey densities. This capacity on the one hand and the ability to destroy large numbers of prey insects at high host densities on the other hand, are of primary importance for the efficiency of a natural enemy. Increased survival of the newly hatched larvae through feeding on eggs is important for the existence of the population (BANKS, 1956).

The incidence of egg cannibalism depends to some degree on the density of eggs batches. This may be arise because the newly hatched larvae can find their way to the unhatched eggs in the other batches. If aphids are available in sufficient numbers egg cannibalism is probably reduced. Cannibalism within the same egg batch depends primarly on the percentage of non-hatching eggs.

Food consumption in *A. bipunctata* as in many other insects is greatest during the last larval instar. Similar results with other aphid predators were obtained by RUSSELL (1970) on Anthocorids, UYGUN (1971) on *Aphidoletes aphidimyza* and ARZET (in thesis 1972) on *Chrysopa carnea* (STEPH.). Therefore, the larvae of the last instar need a greater searching ability to satisfy their food requirement. The larvae with an additional instar also consumed most of their food during their last (5 th) instar. Induction of the extra instar probably occurred in early larval life because the second instar was greatly shortened with a consequent reduction in food consumption. The nature of this influence that affected only larvae with daily food supply of ten eggs is unknown.

The larvae of *A. bipunctata* are able to adjust to a small supply of food by greatly prolonging their time of development, consequently the influence of food supply on the pupal weight is reduced to some degree. In *A. aphidimyza* and in *C. carnea*, the larval duration is less affected by food supply (UYGUN, 1971; ARZET, thesis 1972).

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RÉSUMÉ

Conséquences du cannibalisme de ses œufs par *Adalia bipunctata* *(Coleoptera : Coccinellidae)*

Les larves d'*Adalia bipunctata* (L.), qui ont été alimentées avec des œufs de la même espèce, peuvent se développer normalement jusqu'au stade imaginal. La mortalité et la durée de développement des larves augmentent lorsque le nombre d'œufs offerts chaque jour comme aliment décroît, le poids des nymphes diminue mais la durée du stade nymphal reste inchangée. L'influence d'une offre de nourriture inférieure à l'optimum au cours de la vie larvaire, est particulièrement forte sur la fécondité et la longévité des adultes. Une réduction de l'alimentation ayant une influence faible sur la durée des stades larvaires et sur le poids des nymphes, provoque une diminution très importante de la fécondité des femelles. Après une réduction plus grande de l'alimentation des larves, les femelles meurent avant le début de la période de reproduction. Après un approvisionnement alimentaire plus riche en œufs, la durée de vie des coccinelles est un peu plus longue, mais leur fécondité est un peu plus faible que celle obtenue avec des adultes provenant d'un élevage conduit avec une offre d'acariens en excès.

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