Zusammenfassung

Versuche mit 26 Verbindungen zur Sterilisation von Trogoderma granarium Everts

Von 26 Substanzen, darunter 21 Alkylverbindungen, wurde die Wirkung hinsichtlich Sterblichkeit, Fertilität und Lebensdauer nach Behandlung der Puppen und Käfer getestet. Als am wirksamsten erwies sich Thiotepa, gefolgt von Tepa, Metepa und Ent 61969.

References

Borkovec, A. B.; Nagasawa, S.; Shinohara, H., 1968: Sterilization of Azuki Been Weevil, *Callosobruchus chinesis* by metepa and hempa. J. econ. Ent. *61*, 695–698.

Chaudhary, J. P.; Kapil, R. P., 1976: Reproductive biology of khapra beetle, *Trogoderma granarium* Everts. (Coleoptera: Dermestidae). Z. ang. Ent. *81*, 30–37.

Kapil, R. P.; Kashyap, N. P.; Kumari, S., 1973a: Evaluation of metepa as a chemosterilant of *Trogoderma granarium* Everts. Indian J. Ent. *35*, 36–42.

— Kumari, S.; Kashyap, N. P., 1973b: Longevity of Khapra beetle *Trogoderma granarium* Everts. treated with metepa. Indian. J. Ent. *35*, 172–174.

Rahman, K. A.; Sohi, G. S.; Sapra, A. N., 1945: Studies on stored grains in the Punjab VI. Biology of *Trogoderma granarium* Everts. Indian J. agric. Sci. *15*, 85–92.

Singh, O. P.; Teotia, T. P. S., 1968: A simple apparatus for dipping treatment of insects for varying period of a time. Indian J. Ent. *30*, 250–254.

Laboratory of Plant Protection, National Research Centre Dokki, Cairo, Egypt

Studies on the cannibalistic behaviour of the predatory larvae of Adalia bipunctata L. (Col., Coccinellidae)

By Nadia Z. Dimetry[1]

Abstract

Laboratory observations on the cannibalistic behaviour of *Adalia bipunctata* larvae revealed that when two fourth instar larvae, one was well fed and the other was starved for 24 hours and were confined together without aphids, more than 50 % of the well fed larvae cannibalised on the starved ones. Also when the fourth instar larvae were given the choice of feeding on aphids or eggs of the same species, they preferred feeding on aphids. Starvation for varied periods induced cannibalism and as starvation period increased cannibalism increased. Cannibalism is of frequent occurrence between varied instars.

1 Introduction

The literature dealing with the cannibalistic behaviour of the predatory Coccinellidae is scanty and meagre. The searching behaviour of these insects

[1] This work was carried out in Institut für Pflanzenpathologie und Pflanzenschutz der Universität Göttingen, West Germany and was continued in Laboratory of Plant Protection, N.R.C. Egypt.

Z. ang. Ent. 81 (1976), 156–163

ISSN 0044-2240 / ASTM-Coden: ZANEAE

however, has received little attention as the work done by BANKS (1957) who studied the behaviour of the first and fourth instar larvae of *Adalia bipunctata* L. and *Coccinella septempunctata* L. DIXON (1959) investigated the searching behaviour of the predatory coccinellid beetle *Adalia decempunctata.*

The aim of the present study is to investigate the cannibalistic behaviour between well fed and starved fourth instar larvae. To find the food selection behaviour and their ability to feed or cannibalise on alternative food, the effect of starvation on mortality and cannibalism.

2 Materials and methods

Normal laboratory rearing procedures were used where *Adalia bipunctata* adults were collected from field and were allowed to reproduce in the laboratory. The beetles were fed daily an excess of green peach aphids, *Myzus persicae* (Sulzer). The aphids were reared on brussels sprouts plant in a green house. The food was renewed daily and the total number of eggs laid were taken and incubated at 20° C, 70 % RH and 16 hours photoperiod until hatching occur where the larvae were used for the different experiments.

3 Experiments and results

3.1 Searching behaviour

Single leaf of brussels sprouts free of aphids was cemented on a sheet of paper. Two fourth instar larvae, one was starved for 24 hours and signed with red colour and the other was well fed were confined together on the plant leaf under inverted Petri-dish of 20 cm in diameter which was fixed on the paper by modelling clay. The whole apparatus was put under illuminating area. Observations were carried out after 0.25, 0.5, 1, 3, 6, 12 and 24 hours. Eleven replicates were done and the percentage of cannibalism

Table 1. The rate of cannibalism between well fed and starved fourth instar *A. bipunctata* larvae for 24 hours

Exp.	Well fed larvae cannibalised on starved ones after							Starved larvae cannibalised on well fed ones after						
	1/4	1/2	1	3	6	12	24 hr	1/4	1/2	1	3	6	12	24 hr
1	–	–	–	–	–	–	y	–	–	–	–	–	–	–
2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
3	–	–	–	–	–	–	–	–	–	–	–	–	–	z
4	–	–	–	–	–	–	y	–	–	–	–	–	–	–
5	–	–	–	–	–	–	z	–	–	–	–	–	–	–
6	–	–	–	–	–	y	–	–	–	–	–	–	–	–
7	–	–	–	–	–	–	–	–	–	–	–	–	–	–
8	–	–	–	–	–	–	–	–	–	–	–	–	–	–
9	–	–	–	–	–	–	–	–	–	x	–	–	–	–
10	–	–	–	–	–	–	z	–	–	–	–	–	–	–
11	x	–	–	–	–	–	–	–	–	–	–	–	–	–

– = no cannibalism; y = partial cannibalism; x = starting cannibalism; z = complete cannibalism.

between well fed and starved larvae was calculated. The results obtained are shown in table 1, from which it is evident that the total number of the well fed larvae cannibalised on the starved ones was 6 (54.5 %). The number of starved larvae that cannibalised on the well fed larvae was 2 (18.25 %). In 3 cases (27.25 %), no cannibalism happened. Therefore strong and healthy larvae have good opportunity to survive and cannibalise on the weak or starved ones. On the other hand, starved larvae in many cases cannot defend themselves when confined with well fed larvae and therefore few numbers can survive and cannibalise on the well fed larvae.

3.2 Selection behaviour

A sprouts brussels leaf was cemented on a white paper and 200 2nd and 3rd instar aphids were fixed on the left side of the leaf and 200 *A. bipunctata* newly laid eggs were cemented on the right side of the plant leaf. Four newly moulted fourth instar *A. bipunctata* larvae were released in the centre of the leaf. The larvae were confined on the plant leaf under inverted Petri-dish at 25–26° C and 16 hr photoperiod. The total number of eggs or aphids eaten were counted after 24 hours. Ten replicates were done. The results obtained in Table 2 clarified that, although the amount of eggs was the same as the amount of aphids, yet the total number of aphids eaten in 24 hours in 3.5 times the amount of eggs eaten per a single larva.

Table 2. Selection behaviour by *A. bipunctata* 4th instar larvae given a mixture of equal numbers of aphids *Myzus persicae* and *A. bipunctata* eggs

Exp.	Eggs cemented on the right side Total No. of eggs eaten/4 larvae/day	Aphids cemented on the left side Total No. of aphids eaten/ 4 larvae/day	Eggs cemented on the left side Total No. of egg eaten/ 4 larvae/day	Aphids cemented on the right side Total No. of aphids eaten/ 4 larvae/day
1	43	133	10	145
2	40	176	38	126
3	28	138	44	189
4	90	111	36	151
5	32	165	96	120
6	21	118	16	128
7	45	135	56	120
8	53	160	16	112
9	22	147	35	155
10	41	135	43	160
Averg. No. of aphids or eggs eaten/larva/day	10.4 ± 1.5	35.5 ± 1.6	9.7 ± 1.9	35.1 ± 1.8

Another experiment was conducted to see whether alternation of direction is effective in selecting the prey. The aphids were cemented on the right side of the leaf and *A. bipunctata* newly laid eggs were cemented on the left side. Similar results were obtained (table 2). This indicates that there exist another stimulus rather than the contact stimulus mentioned before by BANKS (1957), DIXON (1959) and RUSSEL (1970) that attracted the larvae to eat aphids better than eggs and the ratio is 3.5:1. Also alter-

nation of direction did not affect the ratio of aphids to eggs eaten and this certify the presence of the other factors which may be chemosensory factors which will be studied later in further experiments.

3.3 Effect of starvation

Two newly moulted fourth instar larvae starved for six, twelve, twenty four and fourty eight hours were confined together in glass tubes 10 cm in length and 3.5 cm in diameter at 20° C. The percentage of cannibalism in each case were recorded after 1, 10, 15, 30, 60, 120, 180 and 360 minutes. Ten replicates were conducted in each test. The total percentage of cannibalism after 6 hours were calculated. The results obtained are shown in

Table 3. Effect of starvation on cannibalism of *A. bipunctata* 4th instar larvae

Time of starvation in hr	% of cannibalism after 1 min.	10	15	30	60	120	180	360	Total % of cannibalism after 6 hr
6	0	0	0	0	10	0	0	0	10
12	0	0	10	0	0	0	10	10	30
24	0	10	0	0	10	20	20	40	100
48	40	20	30	10	–	–	–	–	100

Table 3, from which it is clear that 6 hours starvations for the last instar larva is not so fatal and therefore only 10 % cannibalism occur. Starvation for 24 or 48 hours caused 100 % cannibalism during the period of 6 hours and cannibalism happened so early.

This result confirms that starvation is considered as one of the most important factors that affect greatly the percentage of cannibalism which occur among larvae.

3.4 Cannibalism between similar stages

Experiment 1

Ten larvae of each instar were confined together in a glass tube 15 cm in length and 3.5 cm in diameter. The percentage of cannibalism between similar stages were recorded after 1, 2, and 3 days. The results obtained are shown in table 4.

In case of first instar, 5 % cannibalism occur after 24 hours and 4 % after 48 hours, 0 % after 72 hours i. e. the percentage of cannibalism between the first instar decreases as the time increases. On the other hand, the percentage of normal mortality increases greatly after the second day where more than 50 % died from starvation. The percentage of still living larvae was high after 24 hours (61 % survived). After 72 hours, all the larvae died either from starvation or from cannibalism.

As to the second instar larvae, the percentage of cannibalism after the first day increased to 20 % and then decreased progressively to 0 % after the third day. The percentage of normal mortality decreased greatly than in the first instar larva because the larva here is somewhat bigger and can tolerate starvation for longer period.

Regarding to the third and fourth instar larvae, maximum percentage of cannibalism occurred between the larvae where 62 and 74 % of the larvae cannibalised after 3 days respectively. The percentage of normal mortality decreased greatly to 10 and 0 %.

So, it can be concluded that the percentage of cannibalism increases as the larva increases in age and reaches the maximum in the fourth instar larva. The percentage of normal mortality on the other hand decreases significantly as the larva increases in age. So cannibalism is frequently happened in bigger instars.

Experiment 2

Two larvae only of similar stages were confined together in a small tube 3 cm in length and 1.5 cm in diameter and the behaviour of the larvae were followed. The percentage of cannibalism in all instars decreased in comparison with the foregoing experiment where crowding plays an important role in increasing the percentage of cannibalism. Also, the opportunity for the larva to find one another is greater than in case of two larvae only and therefore the percentage of cannibalism increased. On the other hand, the percentage of normal mortality increased than in the first case because the larva died from starvation (table 4). Therefore crowding increases the percentage of cannibalism in all instars.

3.5 Cannibalism between different stages

Hundred percent cannibalism was observed between larvae of different instars and the eggs after 24 hours. Pupae were on the other hand highly resistant to larval attacks, apparently due to their protective integument, only 20 % of pupae were attacked by fourth instar after 48 hours. The degree of cannibalism between second and first instars; third and second and fourth and third instars was relatively small being on an average 70, 60 and 67 % respectively after 24 hours exposure. 100 % cannibalism occurred between third and first, fourth and first & fourth and second instars respectively.

4 Discussion

Laboratory observations on the cannibalistic behaviour of *A. bipunctata* larvae led to the suggestion that cannibalism seems to be primary and not temporary response factor. Analysis of observations on the incidence of predation by the well fed larvae when confined together with the starved ones of the same age confirms that more than 50 % of the well fed larvae cannibalised on the starved ones and this proofs the phenomena that cannibalism occurs primary and not causally. This result is in agreement with FLESCHNER (1950) who reported that cannibalism would be detrimental to the species. Thus the efficiency of the average surviving predator is increased by cannibalism, so permitting the steady density of predators to be maintained in a lower density of prey than would otherwise be possible.

As to the predation of *A. bipunctata* larvae on eggs, it is clear that,

Table 4. Rate of cannibalism between similar stages of *A. bipunctata* at 20° C

Instars used	10 larvae confined together				2 larvae confined together			
	Time in hr			Total %	Time in hr			Total %
	24	48	72		24	48	72	
First instar								
A1	0.5 ± 0.22	0.4 ± 0.16	0		0	0	0	
A2	5	4	0	9	0	0	0	0
B1	3.4 ± 0.76	4.9 ± 0.72	0.8 ± 0.26		0.8 ± 0.3	0.9 ± 0.27	0.3 ± 0.20	
B2	34.0	49.0	8.0	91	40.0	45.0	15.0	100
C1	6.1 ± 0.73	0.8 ± 0.26	0		1.2 ± 0.25	0.3 ± 0.20	0	
C2	61.0	8.0	0	0	60.0	15.0	0	0
Second instar								
A1	2.0 ± 0.26	1.0 ± 0.1	0		0.4 ± 0.16	0.1 ± 0.10	0	
A2	20.0	10.0	0	30	20.0	5.0	0	25
B1	2.0 ± 0.63	3.2 ± 0.23	1.8 ± 0.13		0.5 ± 0.16	0.5 ± 0.17	0.4 ± 0.21	
B2	20.0	32.0	18.0	70	25.0	25.0	20.0	70
C1	6.0 ± 0.51	1.8 ± 0.13	0		1.1 ± 0.24	0.5 ± 0.22	0.1 ± 0.10	
C2	60.0	18.0	0	0	55.0	25.0	5.0	5
Third instar								
A1	4.2 ± 0.31	1.0 ± 0.14	1.0 ± 0.14		0.5 ± 0.16	0.4 ± 0.16	0.1 ± 0.10	
A2	42.0	10.0	10.0	62	25.0	20.0	5.0	50
B1	0	0.5 ± 0.15	0.5 ± 0.09		0	0.1 ± 0.10	0.5 ± 0.15	
B2	0	5.0	5.0	10	0	5.0	25.0	30
C1	5.8 ± 0.42	4.3 ± 0.26	2.8 ± 0.33		1.5 ± 0.13	1.0 ± 0.25	0.4 ± 0.16	
C2	58.0	43.0	28.0	28	75.0	50.0	20.0	20
Fourth instar								
A1	3.5 ± 0.42	2.2 ± 0.24	1.7 ± 0.20		0.3 ± 0.14	0.6 ± 0.16	0	
A2	35.0	22.0	17.0	74	15.0	30.0	0	45
B1	0	0	0		0	0	0.5 ± 0.26	
B2	0	0	0	0	0	0	25.0	25
C1	6.5 ± 0.40	4.3 ± 0.33	2.6 ± 0.22		1.7 ± 0.21	1.2 ± 0.19	0.6 ± 0.15	
C2	65.0	43.0	26.0	26	85.0	60.0	30.0	30

A1 = Averg. No. of larvae cannibalised, A2 = % of cannibalism, B1 = Averg. No. of larvae died from starvation, B2 = % of larvae died from starvation, C1 = Averg. No. of living larvae, C2 = % of living larvae.

although *A. bipunctata* eggs can support growth well to the larvae and can proof itself sufficient to build another generation (DIMETRY 1974), yet in the present study, the larvae showed a great tendency to aphids, where one larva ate 3.5 times aphids than the number of eggs eaten. This is also in agreement with HODEK (1967), IPERTI (1966) and PUTMAN (1964) who concluded that *A. bipunctata* is polyphagous but is associated with aphids which live on trees and shrubs greater than 2 m in height. The present study confirms YADAVA and SHAW (1968) conclusion who stated that larvae and adults of *Coleomegilla maculata* appear to prefer aphids but will feed on alfalfa weevil larvae. On the other hand certain species like *C. undiecempunctata* L. do not feed on unhatched eggs or on each other while clustered on the egg batches (HAWKES and MARRINER 1927).

According to BLACKMAN (1965), different aphid species vary in their suitability as food for a particular coccinellid species. Thus, there is a degree of physiological specificity which is not associated with acceptability of food, since eggs seems to be accepted irrespective of their value as food.

Accordingly *A. bipunctata* larvae do not avoid feeding on the eggs of their own species but seemingly they select more of the suitable aphid. Thus, larvae given equal numbers of aphids *Myzus persicae* and eggs took an average of 35 aphids and 10 eggs. Therefore laboratory work would emphasize any ability to select, whereas only marked pereference for one aphid or strong avoidance reaction to another host would be important in the field where food is often scarce.

Starvation is one of the principal factor that induced cannibalism as in the present study, it is clear that 24 or 48 hours starvation induced 100 % cannibalism between fourth instar larvae. This is in agreement with Kehat (1968) working on *Pharoscymnus numidicus* (Coccinellidae) a predator of the date palm scale *Parlatoria blanchardi* stated that under conditions of food scarcity, cannibalism is of particular importance for survival.

Cannibalism between similar or different instars is of frequent occurrance especially in the last instars. Also, crowding of the larvae induced cannibalism although the space area offered to the single larva in the small tube is nearly 1/7 the space offered to the single larva in case of the crowded conditions. Pupae were highly resistant to larval attacks apparently due to their protective integument and this is in agreement with KEHAT (1968).

Zusammenfassung

Über das kannibalische Verhalten der räuberischen Larven von Adalia bipunctata L.

Laboruntersuchungen ergaben, daß von je 2 L_4 des Marienkäfers *A. bipunctata*, deren eine gehungert hatte und die andere wohlgenährt war, die letztere in mehr als 50 % der Fälle die erstere auffraß. Wenn den Viertlarven die Wahl zwischen Blattläusen oder Eiern der eigenen Art als Nahrung überlassen wurde, zogen sie Blattläuse vor. Verschieden lange Hungerperioden lösten Kannibalismus aus, der um so mehr ausgeprägt war, je länger der Hunger dauerte. Besonders häufig trat Kannibalismus zwischen verschieden alten Larvenstadien auf.

References

BANKS, C. J., 1957: The behaviour of individual coccinellid larvae on plants. Br. J. Animal Behav. *5*, 12–24.

BLACKMAN, R. L., 1965: Studies on specificity in Coccinellidae. Ann. appl. Biol. *56*, 336–338.
DIMETRY, N. Z., 1974: The consequences of egg cannibalism in *Adalia bipunctata* L. (Coleoptera: Coccinellidae). Entomophaga *19*, 445–451.
DIXON, A. F. G., 1959: An experimental study of the searching behaviour of the predatory cocinellid beetle *Adalia decempunctata* L. J. Anim. Ecol. *28*, 259–281.
FLESCHNER, C. A., 1950: Studies on searching capacity of the larvae of three predators of the citrus red mite. Hilgardia *20*, 233–265.
HAWKES, O. A. M.; MARRINER, T. F., 1927: A preliminary account of the life history of *Coccinella 11-punctata* (L.). Trans. ent. Soc. Lond. *75*, 47–52.
HODEK, I., 1967: Bionomics and ecology of predaceous Coccinellidae. Ann. Rev. Ent. *12*, 79–104.
IPERTI, G., 1966: The choice of oviposition sites in aphidophagous Coccinellidae. Ecology of Aphidophagous Insects (ed. by I. HODEK). Academia, Prague, 1965, 121–122.
KEHAT, M., 1968: The feeding behaviour of *Pharoscymnus numidicus* (Coccinellidae), predator of the date palm scale *Parlatoria blanchardi*. Ent. exp. et appl. *11*, 30–42.
PUTMAN, W. L., 1964: Occurrence and food of some coccinellids (Coleoptera) in Ontario peach orchards. Can. Ent. *96*, 1149–1155.
RUSSEL, R. J., 1970: The effectiveness of *Anthocris nemorum* and *A. confusus* (Hemiptera: Anthocoridae) as predators of the sycamore aphid, *Drepanosiphum platanoides*. 1. The number of aphids consumed during development. Ent. exp. et appl. *13*, 194–207.
YADAVA, C. P.; SHAW, F. R., 1968: The preferences of certain coccinellids for pea aphids, leaf hoppers and Alfalfa weevil larvae. J. econ. Ent. *161*, 1104–1105.

Institut für Angewandte Zoologie, München

Zur Kenntnis der Fliedermotte, Gracilaria syringella (F.) (Lepid., Gracilariidae)

3. Ökologie, Gradologie und Bekämpfung[1]

Von I. KIZIROGLU

Mit 5 Abbildungen

Abstract

On the knowledge of Gracilaria syringella (F.) (Lepid., Gracilariidae). 3. Ecology, gradology and control

The duration of development of the eggs, larvae and pupae and their dependence upon several environmental factors were investigated. In all cases the temperature proved to be the main factor. The thermal-constant values of development amounted to C = 117,5 for the eggs and C = 316,5 for the larvae. The weight of male pupae coming from larvae fed with *Fraxinus* were markedly smaller than those descended from larvae fed with *Syringa* or *Ligustrum*.

Young ash-trees were relatively more attacked than elder one. In 1973 the two generations of *G. syringella* showed a decrease of egg-density of 1/4 to 1/3 caused by abiotic fac-

[1] Dritter und letzter Teil der gekürzten Fassung einer vom Fachbereich Forstwissenschaft der Univ. München angenommenen Dissertation.

Z. ang. Ent. 81 (1976), 163–187

ISSN 0044-2240 / ASTM-Coden: ZANEAE