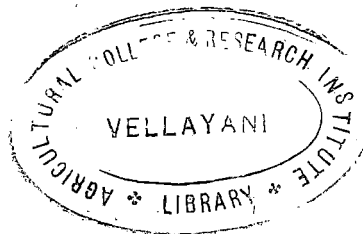


STUDIES ON
THE FEEDING POTENTIAL AND FOOD REQUIREMENTS
OF SOME APHIDIVOROUS INSECTS



BY
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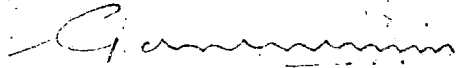
1967

C E R T I F I C A T E

This is to certify that the thesis herewith submitted contains the results of bonafide research work carried out by Miss. Sarala Devi, B. under my supervision. No part of the work embodied in this thesis has been submitted earlier for the award of any degree.

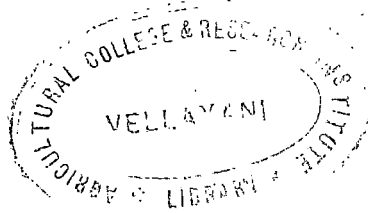


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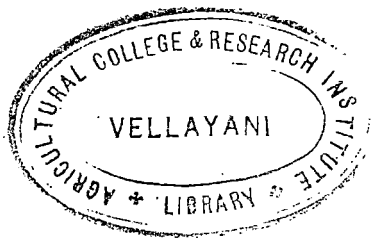
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SARALA DEVI, B.

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INTRODUCTION

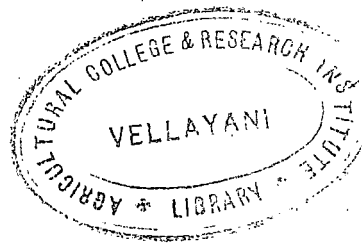
I N T R O D U C T I O N

The predators play a great role in the natural control of aphids. Among the aphidivorous predators coccinellids and syrphids are more important than the rest, they being highly efficient and handy predators. There is very little information on the food requirements of these aphidivorous predators and how potential they are in destroying the aphids. Some casual observations are however, available on the predating capacities of Chilomenes sexmaculata Fabr (Lefroy, 1909; Bagal and Trehan, 1945), Coccinella septumpunctata Linn (Bagal and Trehan 1945), Sevensus xerampelinus Muls (Lefroy, 1909), S. quadrillum (Kapur, 1942), Chilocorus nigritus Fabr (Rao, 1954), Brunnus saturalis F (Kapur, 1942), Adonia variegata Goze (Kapur, 1942), Rodolia cardinalis (Subramaniam, 1956), syrphid larvae (Deoras, 1942), and sphaerophoria scutellaris Fabr (Gupta, 1953; Lal and Haque, 1956; Imms, 1960; Sita Raman, 1956). There is practically no knowledge of the food requirements of the predators and how far they are able to survive under limited or restricted supply of food.

Knowledge of the routine capacity of the different predators in destroying the noxious pests and on their food requirements will help in selecting out the more efficient ones and making use of them for applied biological control. Hence the present investigations were taken up with a view to study the feeding potential of some common aphidivorous coccinellids and a syrphid and the feeding requirement of C. sexmaculata.

A review of literature on the Indian entonophagous coccinellids and syrphids is also presented.

**REVIEW OF
LITERATURE**



REVIEW OF LITERATURE

Coccinellids are the most important among the entomophagous predators in India. The role these play in the natural control of such pests as aphids, mealy bugs and scales is very significant. Syrphid maggots also have been found to be potential enemies of aphids. The following is a review of literature on the predaceous coccinellids and syrphids in India.

Coccinella septempunctata Linn.

Lefroy (1909) recorded this species as distributed throughout India. The larvae were found to feed on the wheat aphid, Macrosiphum granarium kby. and the mustard aphid, Aphis brassicae Linn. Husain and Nath (1927) found that C. septempunctata fed on the citrus Psylla. Rahman and Nath (1940) noted it as feeding on the eggs of Pyrilla perpusilla. Singh (1942) recorded its occurrence in Kumaun Hills feeding on Eriosoma. Bagal and Trehan (1945) reported the occurrence of C. septempunctata in Bombay and found it feeding on the young nymphs of Peregrinus maidis. The maximum number of aphids consumed by individual larvae and pairs of adults of C. septempunctata are 420 and 22574 with an average of

106.29 under controlled conditions. Lal and Sing (1945) also noticed it in the Kumaun Hills feeding on all stages of Eriosoma lanigerum. He observed that it could survive without food for about a month and that 15-20 generations could occur in the field in one year in the case of C.septempunctata. Varma (1954) noted 9 varying grades of colour patterns in the adults of C.septempunctata. It was found that coalescing of the spots in the beetle was by the gradual spreading of the black pigmented areas along certain well defined lines. Sing and Nayyar (1961) found that each ovary of C.septempunctata consisted of 76-96 ovarioles. The females laid the first batch of eggs normally between 10-17 days after emergence and the number of eggs laid was variable in different females.

Chilomenes sexmaculata Fabr.

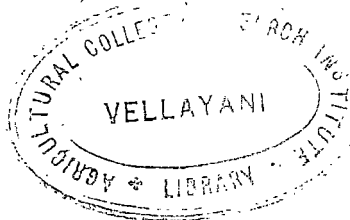
According to Lefroy (1909) C.sexmaculata was the commonest coccinellid in the plains and besides the cotton aphid, Aphis gossypii Glov. it fed on Aphis cardui Linn. and A.adusta Zehrt. The small spinose larva hatching from the egg of C.sexmaculata started feeding on the aphids and required about 200 aphids a day and lived thus for 1-13 days. The eggs were deposited on the leaves of the cotton plant among or near aphid colonies. In captivity about 90 eggs

were laid. Egg period was 5 days and pupal period 4-6 days. Subramaniam (1923) reported this species as most widely distributed species in India and they were often brightly coloured and were remarkable for the wide range of colour variations which they exhibited. Hussain and Nath (1929) recorded Citrus psylla Diaphorina citri as one of its hosts. According to Kapur (1940) it fed on various stages of Aleurolobus barodensis. M, a serious pest of sugarcane in Orissa. Rahman and Nath (1940) noted that the coccinellid controlled the Indian sugarcane leaf hopper, Pyrilla perpusilla. Modawal (1941) observed that it did not copulate unless it was fully fed. Pruthi (1942) reported the occurrence of a species of Tetrastichus as parasitic on the larvae and pupae of C.sexmaculata. Bagal and Trehan (1945) found that the adults of C.sexmaculata fed on the young nymphs of Peregrinus maidis on sorghum. The maximum number of aphids consumed by individual larvae and pairs of adults of C.sexmaculata were 303 and 16,321 with an average of 60.84 per day. Subramaniam (1950) recorded Homalotylus flaminus (Palman) as a parasite on the grubs of C.sexmaculata in Bangalore. Rakshpal (1951) observed that the elytral spots developed gradually after 2½ hours of emergence and that the full compliment of colouration developed in ten hours. Futturudriah and Channa basavanna(1953)

noted Homalotylus sp., Tetrastichus sp., and an undetermined braconid parasite attacking the grubs of C. sexmaculata. David (1964) noted that C. sexmaculata caused considerable reduction in the population of the sugarcane aphids. Khan and Husain (1965) observed that it enjoyed a country wide distribution and was well established as an aphidivorous predator especially on groundnut aphids. They also found that when there was no host for it to feed upon cannibalistic activity occurred, adults and grubs feeding on eggs and pupae of their own species.

Scymnus spp.

Lefroy (1909) noticed Scymnus xerampelinus Muls. throughout the plains. He observed that it required 75 aphids daily for its food and lived for 7-10 days. The larva was clothed with white waxy processes, the pupa remained in the cast larval skin and the pupal period lasted for a week. Ayyar (1925) recorded that the adult beetles fed on the eggs of nim mealy scale, Pulvinaria maxima Green. Cigar shaped white eggs were laid by the female singly on the body of the female scales. The hatching grub found its way to the egg sac of the scale, burrowed into it and fed on the eggs inside. Kapur (1940) reported that Scymnus nubilus Muls. and S. gracilus (Motsch.)



preyed upon various stages of Aleurolobus barodensis Mask, a serious pest of sugarcane in Orissa. Again Kapur (1942) recorded that they were commonly found in the Punjab and Delhi and were very active predators on aphids and scales. Aphis laburni Kalt. A.gossypii Glov, A.maidis Fitch., A.nerii Fons., and Myzus persicae (Suls) were consumed by the adults and grubs of S.nubilus Muls. and S.quadrillum Motsch. The adults were also found to feed on Aonidiella aurantii (Maskell) and A.orientalis (Newstead) in Delhi. A grub consumed from 8-14 aphids or nymphs in a day and from 12-18 nymphs were consumed by a beetle in a day. The eggs were laid only on plants infested with Aphis laburni, usually in batches of 4 eggs, in concealed places such as under the cast skins of aphids. The female had a fairly long ovipositor. Pupal period was 4.8 to 7.4 days. The adults lived for 25-50 days and they did not exhibit cannibalism. David (1964) noted that Sevanus spp. caused considerable reduction on the population of the sugarcane aphids.

Chilocorus nigrinus Fabr.

Lefroy (1909) reported that C.nigrinus fed on A.cardui Linn. as well as on several scale insects like Asterolecanium. Husain and Nath (1929) found that it fed

on various stages of Aleurolobus barodensis a serious pest of sugarcane. Kapur (1940) recorded C. nigrinus as commonly occurring in Orissa. Rao (1954) found that both adults and nymphs of C. nigrinus fed on the scales, one grub consuming nearly 8 individuals in a day. Inside the rearing cages the insect lived for ten days only without food, and 20 days with sugar solutions. Again he noted (Rao, 1959) the beetles assembled in considerable numbers on the under surface of banyan tree leaves for aestivation, each tree containing more than 1000 individuals. Trials showed that they could be used for biological control. David (1964) observed that it played an important role in the reduction of the sugarcane aphids. Khan and Husain (1965) found that C. nigrinus enjoyed country - wide distribution feeding on the groundnut aphids.

Brumus suturalis F.

Lefroy (1909) reported that B. suturalis was common in the plains, feeding on the cotton aphids, cotton mealy bugs and probably other sucking insects. The larva was reared on Phenacoccus insolitus Gr. It ate the mealy bugs in all stages and pupated among them. Husain and Nath (1929) found it feeding on the citrus psylla Diaphorina citri. Kapur (1940) observed that it was fairly common throughout the year except during the extremes of climate. It occurred all over India. He also found (Kapur, 1942) that a grown up

grub consumed from 10-15 aphids or mealy bugs in a day. An adult consumed about 16-30 nymphs of the aphid or mealy bug in a day. According to him the mode of feeding of the grub was remarkable. It fed by a process of alternate sucking and regurgitation of the soft body contents of the prey. Eggs were laid in clusters of 4-23 in concealed places. Incubation period was 4-2 days. There were 4 instars. The larvae congregated for pupation. Pupal period was 4-5 days, 5-6 generations were completed in an year. The grubs and adults exhibited cannibalism rarely. It could be utilized in the field of biological control. Ahamad (1942) found that the introduction of the Coccinellid, B. suturalis for the control of Pyrrilla gave encouraging results. Rao (1942) observed that B. suturalis was a predator of the nymphs of Pseudococcus saccharicola, a new pest of sugarcane in India but that it afforded little control. Hussain and Khan (1945) reported that B. suturalis fed gregariously on eggs and larvae of various Aleurodids. In 1965 they recorded it as an important predator of groundnut aphid.

Adonia variegata (Goze)

Kapur (1940) reported A. variegata from the Punjab and Delhi. Again he (Kapur, 1942) recorded that Adonia variegata fed on Myzus persicae Sulze on raddish, Aphis malvae, Brachycaudus punis (Koch.), B. hermala, Hyalopteris atriplices

and Eriosoma lanigerum. The number of aphids consumed by the adult was very variable. Often the females consumed more than the males and the number varied from 35 to 75 nymphs per day. When sexes were equally represented the average came to 45 nymphs a day. The total number of nymphs consumed by a single beetle during the life time came to 1260 for male and 1530 for a female. He observed that the mode of feeding of the adults and grubs was similar. The inner soft contents of the prey was eaten and heavily chitinized parts were left undevoured. The eggs were laid on the under surface of the leaves. The average longevity of the adults decreased with increased temperature. The sex ratio was 3 males to 4 females. 6-8 generations were passed each year. They could live without much activity for over 2 months even if no aphids were provided. The larvae and adults exhibited cannibalism in the rearing cages.

Rodolia spp.

Kapur (1949) recorded that Rodolia rufficollis, Rodolia amabilis, R. natara, and R. minima fed on Icerva purchasi. Subramaniam (1950) noted a parasite, Homalotylus faminium, on Rodolia grubs predating on the fluted scale, Icerva purchasi Mask. He reported R. cardinalis, R. amabilis, R. breviscula and R. fumida from Mysore state and R. cardinalis.

R. glurini, R. nataria and R. minima from Madras. He further (Subramaniam, 1955) found that the larvae of R. cardinalis destroyed the eggs of I. purchasi. He recognised that 200-250 eggs were consumed by a larva.

Other Coccinellids

Besides the more important coccinellid predators mentioned above several other species were recorded in India by various authors. For example Lefroy (1909) recorded Aulis vestitus Muls., as a predator of Monophlebus sp. and Clanis soror We., as feeding on the castor mealy wing, Aleurodes sp. Subramaniam (1925) recorded Synia melanaria Muls., as a predator of Contosoma ostenum Dist., Kapur (1940) found that the adults of larvae of Coelophora Octosignata Muls., C. perrotteti Muls. and Verania sp. preyed upon various stages of Aleurolobus barodensis Mask., a serious pest of sugarcane in Orissa. Fennah (1940) mentioned about the introduction of the Coccinellids, Cryptognatha nodiceps Marsh., C. similima Sic., C. flaviceps Crotch., Pentilia egens Muls, and Asya trinilatus Marsh., from Trinad against the coconut scale, Aspidiotus destructor Sign., Puttarudriah and Channa basavanna (1952) found a new coccinellid, Synoncha grandis Thumb, feeding on a colony of the aphid Oregma bambusicola Takahashi, on bamboo bush in Bangalore. Both adults and larvae fed on the aphids. Another similar

large lady bird beetle Anisolemnia dilatata Fabr., was noted along with it but in lesser numbers. Both these species were found to breed successfully in the laboratory on a larger number of species of aphids infesting a variety of plants such as groundnut, cotton, cowpea, pea, rose, jack, brinjal, cabbage, raddish, mustard, and other vegetable and orchard crops. They further (Putterudraiah and Channa basavanna 1953) gave a list of beneficial coccinellids occuring in Mysore. These coccinellids were Synonycha grandis Thunberg, Anisolemnia dilatata Fabr., Synia melanasia Muls., Chilomenes sexmaculata Fabr., Alesia sp., Coccinella spp., Coelophora bisellata Muls., Verania cardoni (Weize) and Propylea 14-punctata Linn. Large numbers of the grubs were noticed to be destroyed by a Eulophid parasite tetrastichus sp. and this happened usually when the predator had been very abundant in a field. Another parasite recorded was Hemalotylus sp. Lal (1952) found that Anuraphis helichrysi Kalt., a serious pest of peach in hilly areas of U.P. were attacked by a number of coccinellids namely: Coelophora sauzeti Muls Illeis sp. Adonia variegata Coez., Balia eucharis Muls., B.brachme Oastri Muls. and Oenonia bileonustulata Weise.

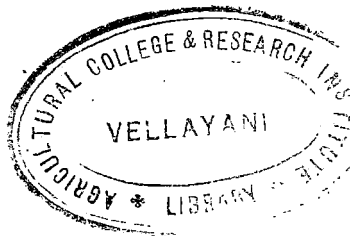
Rao (1952) reported the occurrence of Cryptolcemus montrouzieri Muls., in India Krishnamurthy (1952) reported

it from Bangalore. David (1954) noticed that Calliphora sp. and Verania sp. caused considerable reduction in the population of the sugarcane aphids. Khan and Husain (1965) recognised Harmonia sp. and Verania sp. as important predators of the groundnut aphid.

Aphidivorous syrphids

Lefroy (1909) reported that about 67 species of syrphids were noticed in India. They were commonly called as the 'Hover-flies'. The syrphid larvae fed exclusively on aphids, which did much damage to plants of various kinds. The adult fly laid its eggs on plants infested with aphids. The larval skin hardened and formed a case of puparium enclosing the true pupa. Bhatia and Shaffi (1933) recorded the occurrence of Xanthogramma (Sphaerophoria) javanus Wied. which attacked aphids on cotton. Uttah (1940) found that in Delhi district the syrphid larvae fed on a number of aphids which included Rhopalosiphum pseudobrassicae F. on safflower and M. avenae F on wheat, barley etc. Deoras (1942) observed that a single syrphid larva destroyed about 484 aphids in 4 hours. The maggots were very voracious feeders. The aphid was held by the mouth and sucked dry. When very hungry they could suck about 2 aphids per minute. Lal and Gupta (1953) observed that the syrphid Sphaerophoria seutellaris (Fabr) preyed upon aphids in India and afforded

useful control. The larvae attacked one another in the absence of aphids and survived without food for a long period provided water was available. Lal and Haque (1956) recognized that the syrphid, S.scutellaris was of potential importance in India for the control of aphids, particularly, Rhopalosiphum pseudobrassicae on which the larvae fed. The larvae destroyed 401-493 aphids each at 19.8°C and 68.3 per cent relative humidity completing their development in 8-9 days and consumed 308-339 aphids at 22.2°C and 71 per cent relative humidity and completing their development in 12-13 days. Imms (1960) reported that economically the predacious larvae of this family were notable in being important enemies of aphids, coccids and other Homoptera. The capacity of syrphid larvae for the rapid destruction of aphids was found to be remarkable. He observed that the entire insect was never devoured, but only the soft and readily assimilated body contents were sucked out. Husain (1965) observed that the syrphids formed a very important beneficial group of insects from the economic point of view in the control of groundnut aphids. Of the syrphids, S.scutellaris was the most important aphidophagous species in India. Sita Raman (1966) recorded that a single larva of Xanthogramma scutellare required on an average of 123 aphid, A.craccivora per day.



MATERIALS AND METHODS

MATERIALS AND METHODS

Materials

1. Insects

(a) Chilomenes sexmaculata Fabr.

The eggs of C. sexmaculata were collected from the field on glyricidia and cow pea plants infested with Aphis craccivora. Grubs which hatched out from these eggs were utilized for finding out their feeding potential. Adults of C. sexmaculata required for the feeding experiments were obtained either by rearing them out in the laboratory or from pupae collected from the field.

(b) The pupae of Scymnus quadrillum and Pseudaspidemarus circumflexa:- These were collected from the field on cow pea and glyricidia plants infested with A. craccivora. The emerging adults were used for the feeding experiments.

(c) Xanthogramma scutellare Fb (Syrphidae) eggs of X. scutellare Fb were collected from the field. The silvery white oval eggs could be easily located among colonies of A. craccivora on glyricidia or cow pea.

(d) Aphids

Two species of aphids, viz., A. craccivora and Toxoptera odinae vd were used in the feeding experiments.

Of these the former was collected on glyricidia and cow pea and latter on mango. Parts of shoot bearing colonies of the aphid were collected and brought to the laboratory. Only medium sized aphids were used in the experiments.

2. Equipments

These included the following:-

1. Specimen tubes
2. Petridishes
3. Muslin cloth
4. Camel hair brush
5. Blotting paper

Methods

Feeding experiments

The required number of aphids was placed on tender terminal shoots of glyricidia or mango as the case may be, which were cut to a length of 5 cms. The shoot bearing the aphids was then placed in a petridish on wet blotting paper. One grub or adult was then introduced into the petridish allowing it to feed on the aphids provided. The aphids were supplied every morning and difference of aphids supplied and those left over was recorded daily.

DETAILS OF EXPERIMENT AND RESULTS

DETAILS OF EXPERIMENTS AND RESULTS

A few experiments were conducted to find out the feeding potential of some of the common aphidivorous insects. These studies were made with grubs and adults of Chilomenes sexmaculata Fabr, adults of Scymnus quadrillum Motsch, and Pseudaspidimerus circumflexa and the larvae of the syrphid, Xanthogramma scutellare Fb. Following are the details of these studies and their results.

Experiment No. I

Daily consumption of the aphid Aphis craccivora by the larval stages of Chilomenes sexmaculata Fabr.

Experimental details.

Larvae of C. sexmaculata used: First instar grubs which had just hatched from eggs collected from the field were used for the experiments.

Aphids used: Colonies of Aphis craccivora infesting glyricidia and cow pea were collected from the field together with the shoots they infested and brought to the laboratory.

Aphids which had relieved themselves of their oral anchorage within the plant tissues and were freely moving about alone were used for the studies. Individuals of the same size (medium size) were selected for feeding the grubs.

Number of first instar grubs used for starting the experiment:	80
• Experimental period:	29-9-1966 - 7-1-1967.
Temperature during the experimental period:	76.75 - 86.47°F.
Relative humidity during the experimental period	88.66%
Procedure:	The selected aphids were put on small pieces of the host shoot and exposed to feeding by individual grubs within petri dishes. For the full details of the procedure see under 'Methods'.

Results.

Data on the number of aphids consumed by the individual larvae of the first, second and third instars are tabulated in Appendices I, II and III respectively, and these are summarised in Tables 1, 2 and 3 respectively. It is observed that the majority of the first instar grubs moult on the third day. The number of aphids consumed by a single grub on the first day of hatching varies from 2 to 5, with an average of 3.48. On the second day the corresponding figures are 2-7 and 4.92 respectively. During the first instar stage a single grub consumes 2-15 aphids with an average of 8.98 aphids. The number of aphids consumed on the first day of the second instar is 1 to 20 with an average of 5.48. The corresponding figures for the second day are 1 to 24 and 5.62 respectively. The number of aphids consumed on the third day is 2 to 15, the average being 5.76. During the second instar, majority of the grubs moult on the third day and a single grub consumes 2-38 aphids with an average of 24.13. 1 to 30 aphids are eaten by a third instar grub on the first day, the average being 15.75. On the second day the number of aphids eaten are 12 to 45 with an average of 22.76. On the third day the feeding rate varies from 5 to 30 aphids with an average of 17.78. Majority of the grubs pupate on the third day of

the third instar. The average number of aphids consumed in the third instar stage is 58.76.

Out of the 80 first instar grubs with which the experiment was started only 54 moulted giving giving rise to the second instar grubs, there being 32.5% mortality among them. The average duration of the first instar is seen to be 2 days. Among the second instar grubs there is 70.36 mortality. Out of the 54 grubs used there are only 16 survivals. The average duration of the second instar is 3 days. There is a survival of 81.25% among the third instar grubs. The average duration of this instar is 3 days.

Experiment No. 2.

Effect of supplementing the aphid diet of the larvae of *C. sexmaculata* with sugar solution, on their survival and feeding.

Experimental details.

In the feeding experiments using the larval stages of *C. sexmaculata*, a condition arose when the first instar larvae died without feeding on the aphids supplied.

TABLE I

Summary of observations made on the feeding potential of the first instar grub of C. sexmaculata (Summarised from Appendix I)

1st day

Total No. of grubs used	80	
No. of aphids consumed per grub	Range	2 - 5
	Average	3.48

2nd day

No. of grubs dead	13	
Percentage of survival	83.75%	
No. of aphids consumed per grub	Range	2 - 7
	Average	4.92

3rd day

No. of grubs dead	16	
Percentage of survival	76.12%	
No. of grubs moulted	44	
No. of aphids consumed per grub	Range	2 - 10
	Average	3.9
No. of aphids consumed per grub during the first instar	Range	2 - 15
	Average	8.98

TABLE II

Summary of observations made on the feeding potential of the second instar grub of C. sexmaculata (Summarised from Appendix II)

1st day

Total No. of grubs used	54	
No. of aphids consumed per grub	Range	1 - 20
	Average	5.48

2nd day

No. of grubs used	52	
No. of grubs dead	20	
Percentage of survival	61.53%	
No. of aphids consumed per grub	Range	1 - 24
	Average	5.62

3rd day

No. of grubs died	5	
No. of grubs survived	27	
Percentage of survival	34.37%	
No. of aphids consumed per grub	Range	2 - 15
	Average	5.76

4th day

No. of grubs died	11	
No. of grubs survived	16	
Percentage of survival	59.26	
No. of aphids consumed per grub	Range	1 - 14
	Average	5.94
Percentage survival of grubs during second instar	29.63%	
Average duration of the second instar	3 days	
No. of aphids consumed per grub during second instar	Range	2 - 33
	Average	24.13

TABLE III

Summary of observations made on the feeding potential of the third instar grub of C. sexmaculata (Summarised from Appendix III)

<u>1st day</u>			
Total No. of grubs used	16		
No. of aphids consumed per grub	Range	1 - 30	
	Average	15.75	
<u>2nd day</u>			
No. of grubs died	3		
Percentage of survival	81.25%		
No. of aphids consumed per grub	Range	12 - 45	
	Average	25.76	
<u>3rd day</u>			
No. of grubs survived	13		
Percentage of survival	100%		
No. of aphids consumed per grub	Range	5 - 30	
	Average	17.78	
<u>4th day</u>			
No. of aphids consumed per grub	Range	3 - 14	
	Average	6.5	
No. of grubs pupated	3		
Percentage survival of grubs during third instar	81.25%		
Average duration of the third instar	3 days		
No. of aphids consumed per grub during third instar	Range	42 - 76	
	Average	58.76	

Feeding of the grubs with sugar solution in addition to feeding them with aphids was tried as a remedy for this. Details and results of the experiment are given below:

Number of first instar grubs used for starting the experiment:

10

Experimental period:

3-11-1966 - 10-12-1966.

Temperature during the experimental period

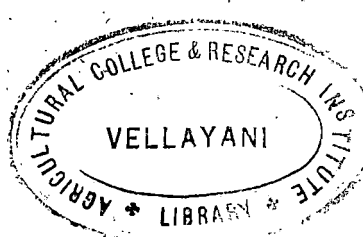
78.76 - 86.76°F.

Relative humidity:

91.57%

Procedure:

Small pieces of host shoots were dipped in sugar solutions and these were used for colonising the aphids selected for feeding the grubs. The sugar solution was thus supplied only to the first instar grubs. Rest of the details of the experiment as in Experiment No.1.



Results.

Results of the experiment are shown in Appendices IV, V and VI and their summaries in Tables 4, 5 and 6. The number of aphids consumed by a larva on the day of hatching of the grub is 2-4, the average being 2.8. On the second day a grub eats 3-5 aphids with an average of 4.22. During the first instar a single grub consumes about 5-9 aphids with an average of 7.11. The number of aphids eaten on the first day of the second instar varies between 14 and 20, the average being 17.22. On the second day the corresponding figures are 12 and 24 and 19.44. Most of the grubs moult on the third day. The average number of aphids consumed by a grub during the second instar stage is 27.41 with an average of 38.44. 21 to 31 aphids, with an average of 28.11 are consumed by the grub on the first day of the third instar, on the second day the corresponding figures are 34 to 45 and 39.33 respectively. All of them pupate on the third day.

Out of the 10 first instar grubs used for the experiment only one dies. Average duration of the first instar lasts 2 days. None of the second instar grubs die, the average duration of the third instar is 3 days. No mortality on the grubs is noticed during the third instar also. The average duration of this instar is 2 days.

TABLE IV

Summary of the observations made on the feeding potential of the first instar grub of C. sexmaculata on A. craccivora and sugar solution (Summarised from Appendix IV)

1st day

Total No. of grubs used	10
No. of aphids consumed per grub	Range 2 - 4 Average 2.8

2nd day

No. of grubs dead	1
Percentage of survival	90%
Average No. of aphids consumed per grub	Range 3 - 5 Average 4.22

3rd day

Percentage of survival	100%
No. of grubs moulted	9
No. of aphids consumed	Nil
Per cent survival of grub during 1st instar	90%
Average duration of first instar	2 days
No. of aphids consumed per grub during first instar stage	Range 5 - 9 Average 7.11

TABLE V

Summary of the observations made on the feeding potential of the second instar grub of G. sexmaculata on A. craccivora and sugar solution (Summarised from Appendix V)

1st day

Total No. of grubs used	9
No. of aphids consumed per grub	Range 14 - 20 Average 17.22

2nd day

No. of grubs dead	NIL
Percentage of survival	100%
No. of aphids consumed per grub	Range 12 - 24 Average 19.44

3rd day

Percentage of survival	100%
No. of grubs moulted	8
No. of aphids consumed per grub	16
Percentage survival of grubs during second instar	100%
Average duration of second instar	2 days
No. of aphids consumed per grub during second instar stage	Range 27 - 41 Average 38.44

TABLE VI

Summary of observations made on the feeding potential of the third instar grub of C. sexmaculata on A. craccivora and sugar solution (Summarised from Appendix VI)

1st day

Total No. of grubs used	9
No. of aphids consumed per grub	Range 21 - 31 Average 28.11

2nd day

Percent survival	100%
No. of aphids consumed per grub	Range 34 - 45 Average 39.33

3rd day

No. of grubs pupated	9
No. of aphids consumed by a grub	30
Percent survival of grubs during 3rd instar	100%
Average duration of 3rd instar	2 days
No. of aphids consumed per grub during 3rd instar stage	Range 55 - 96 Average 70.78

Experiment No. 3.

Daily consumption of the aphid, *A. craccivora* by the adults of *C. serripunctata* reared out in the laboratory

Experimental details.

Adults of <i>C. serripunctata</i> used:	Adults of <i>C. serripunctata</i> reared out in the laboratory were used for the feeding experiments.
Total number of adults used:	10
Experimental period:	12-10-1966 - 24-11-1966.
Temperature:	76.82 - 85.82°F.
Relative humidity:	88.82%
Procedure:	The counted number of aphids put on the small pieces of the host shoot were introduced into clean, sterilized test tube, and closed with a muslin cloth. Observations were taken every day between 8.30 and 12.30 A.M. Rest of the details as in Experiment No. 2.

Results.

The results of the experiment are shown in Appendix VII and an extract of this is given in Table 7.

TABLE VII

Summary of observations made on the feeding potential of the adults of C. sexmaculata (bred in the laboratory) on A. craccivora (Summarised from Appendix VII).

No. of adults used:	10	
Survival period of adults	Range	13 - 45
	Average	33.1
Total No. of aphids consumed by an adult during its life	Range	263 - 1301
	Average	906.7
No. of aphids consumed by an adult per day	Range	8 - 44
	Average	27.22

The adults consume the whole body of the aphids excepting their highly sclerotized portions. On the day of emergence one adult eats 10-30 aphids with an average of 20.7. The number of aphids consumed by an adult per day ranges between 10 and 46. The average feeding rate per day of individual adult beetles ranges between 20.33 and 31.05. The longevity of the adults varies from 13 to 45 days, the average life of the beetle being 33.1 days. The maximum number of aphids consumed by a beetle is 1301, consumed in 43 days. The weighted mean of the number of aphids eaten per day by a beetle is 27.22.

Experiment No.4.

Daily consumption of the aphid, *A. craccivora* by the adults of *C. sexmaculata* reared out from pupae collected from the field.

Experimental details.

Adults of <i>C. sexmaculata</i> used:	The pupae of <i>C. sexmaculata</i> were collected from the leaves and shoots of glyricidia and cow pea which were infested by <i>A. craccivora</i> . The adults emerging out from these pupae were used for the experiment.
No. of adults used:	19
Experimental period:	17-11-1966 - 27-2-1967.
Temperature:	76.31 - 86.95°F.
Humidity:	86.49%
Procedure:	As in the Experiment No.1.

Results.

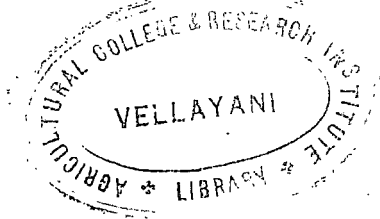
Data on the number of aphids consumed by the adults are tabulated in Appendix VIII and summarised in Table 8. The number of aphids consumed by the adults on the day of

TABLE VIII

Summary of observations made on the feeding potential of the adults of C. sexmaculata whose pupae are collected from the field (Summarised from Appendix VIII)

No. of adults used:	19
Survival period of adults:	Range 3 - 103 Average 35.21 days
Total No. of aphids consumed by an adult during its life:	Range 120 - 7606 Average 1812.05
No. of aphids consumed by an adult per day	Range 34 - 109 Average 51.36

emergence varies between 34 and 64 the average per beetle being 41.95. The average feeding rate of individual beetles per day ranges between 35.15 and 77.74. The number of aphids consumed per day ranges between 34 and 109. The longevity of the adults varies from 3 to 103 days, the average being 35.21. The maximum number of aphids eaten by a beetle is 7606, consumed in 103 days. The weighted mean number of aphids consumed per beetle per day through out their life time is 51.36.



Experiment No. 5.

Daily consumption of the aphid Toxoptera odinae by the adults of C. sexmaculata reared out from the pupae collected from the field.

Experimental details.

Adults of C. sexmaculata used: The pupae of C. sexmaculata were collected from the field and brought to the laboratory and placed in a sterilized petridish for emergence. The newly emerged adults were used for the feeding experiments.

Aphids used: Colonies of Toxoptera odinae infesting tender shoots and leaves of mango were collected from the field together with the shoots and brought to the laboratory. The selection of the aphids for the experiment was as mentioned under Materials and Methods.

Number of adults used: 15
 Experimental period: 17-1-1967 - 1-4-1967
 Temperature: 76.72 - 90.43°F
 Relative humidity: 84.24%

Results.

The results of the experiment are given in Appendix IX and summarised in Table 9.

TABLE IX

Summary of observations made on the feeding potential of the adults of G. sexmaculata on Toxoptera Odinae (Summarised from Appendix IX)

No. of adults used	15
Survival period of adults	Range 5 - 81 Average 46.81
Total No. of aphids consumed by an adult during its life	Range 1330 - 7595 Average 5611
No. of aphids consumed by an adult per day	Range 45 - 124 Average 92.38

The number of aphids consumed by the beetle on the day of emergence is 45 to 75, the average being 67.33. The average feeding rate per day of the individual beetles varies between 88.67 and 100.66. The number of aphids consumed per day ranges between 45 and 124. The weighted

mean of the number of aphids eaten per beetle per day through out its life time is 92.38. The longevity of the adult beetle ranges from 5 to 31 days, the average being 46.89 days. The maximum number of aphids consumed by an adult beetle is 7139 in 31 days.

Experiment No. 6.

Survival of the adults of *C. sexmaculata* when fed with 30 aphids per day for the first 17 days and 15 aphids per day for the rest of the period.

Experimental details.

Adults of *C. sexmaculata* used: The pupae were collected from the field and the adults which emerged out from them were used for the experiment. The aphids used for the feeding was *A. craccivora*.

Number of adults used: 11
 Experimental period: 31-12-1966 - 2-3-1967
 Temperature: 71.87 - 87.33°F
 Relative humidity: 83.74%

Procedure:

30 medium sized aphids were selected and introduced into the tube as in the other experiments. For the first 17 days the individual beetles were supplied with 30 aphids each. Subsequently they were fed with 15 aphids each per day and this was continued till the beetles died. Rest of the details as in Experiment No. 1.

Results.

Appendix X gives the results of the experiment. The adult beetles survive for 6 - 60 days and within this range they consume 169 - 1130 aphids with an average of 17.51 aphids per day per beetle. The average longevity of the adults is 37.36 days.

Experiment No. 7.

Survival of the adults of *C. sexmaculata* when fed with 15 aphids per day throughout its life.

Experimental details.

Number of adults used: 5
 Experimental period: 19-1-1967 - 3-3-1967.

Temperature: 75.04 - 87.31°F.
 Humidity: 83.58%
 Procedure: 15 medium sized aphids were selected and colonised on pieces of the host shoot and introduced into the tube. The rest of the experimental details as in Experiment No.1.

Results.

Results of the experiment are tabulated in Appendix XI. The adults live for 2 - 58 days with an average of 39.6 days.

Experiment No. 2.

Survival of the adults of *C. sexmaculata* when starved.

Experimental details.

Number of adults used: 13
 Experimental period: 29-12-1966 - 26-1-1967.
 Temperature: 78 - 87.37°F.
 Relative humidity: 83.24%
 Procedure: The adult beetle was taken in a clean tube and was supplied with a piece of glyricidia twig. Rest as in Experiment No. I.

Results.

Results are shown in Appendix XII. For 4 - 5 days the beetles move about actively searching for their prey. Then they decreasingly become weak and die in 6 - 7 days, average duration of life is 6.15 days.

Experiment No. 9.

Daily consumption of the aphid, *A. craccivora* by the adults of *Scymnus quadrillum*

Experimental details.

Adults of *S. quadrillum* used: Adults of *S. quadrillum* emerging from the pupae collected from glyricidia, cow pea and Eupatorium in the field were used for the feeding experiments.

Aphids used:	<u><i>A. craccivora</i></u> .
No. of aphids used:	21
Experimental period:	25-11-1966 - 25-1-1967
Temperature:	76.9 - 89.12°F.
Relative humidity:	87.52%
Rest as in Experiment No. I.	

Results.

Results are shown in Appendix XIII and summarised in Table 10.

TABLE X.

Summary of observations made on the feeding potential of the adults of Sayornis quadrillum (Summarised from Appendix XIII).

No. of adults used:	21	
Survival period of adults:	Range	18 - 65
	Average	46.67
Total No. of aphids consumed by an adult during its life	Range	181 - 582
	Average	473.43
No. of aphids consumed by an adult per day	Range	2 - 20
	Average	9.26

On the day of emergence a single beetle consumes 6 - 13 aphids with an average of 9.43. 2 to 20 aphids are eaten by an adult per day. The average feeding potential per day per beetle is 9.26. The average feeding rate per day of individual adult beetle ranges between 9.25 to 11.50. The longevity of the adults varies from 18 to 65 days, the average life of the beetle lasting 46.67 days. The maximum number of aphids consumed by a beetle is 546 consumed in 65 days. The weighted mean of the number of aphids eaten per day by a beetle is 8.41.

Experiment No. 10.

Daily consumption of the aphid *Aphis craccivora* by the adults of *Pseudaspidimerus circumflexa*.

Experimental details.

Adults of *Pseudaspidimerus circumflexa* used: Pupae were collected from the leaves and shoots of glyricidia and cow pea plants in the field from among aphid colonies. The adults emerging out from them were used for the experiment.

Number of adults used:	20
Experimental period:	4-11-1966 - 17-12-1966.
Temperature:	77 - 86.95°F.
Relative humidity:	88.95%
Rest as in Experiment No. I.	

Results.

Results of the experiment are tabulated in Appendix XIV and summarised in Table 11. The number of aphids consumed by the adults on the day of emergence of the beetle is 8 to 13 with an average of 10.55.

TABLE XI

Summary of observations made on the feeding potential of the adults of Pseudaspidimerus circumflexa on A. craccivora. (Summarised from Appendix XIV)

No. of adults used:	20	
Survival period of adults:	Range	10 - 44
	Average	28.25
Total No. of adults consumed by an adult during its life:	Range	95 - 504
	Average	276.8
No. of aphids consumed by an adult per day	Range	1 - 19
	Average	9.83

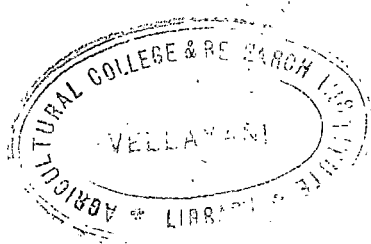
The maximum number of aphids consumed reaches upto 19 aphids per day. The average number of aphids consumed by the individual beetles per day ranges between 9.02 and 12.5. The longevity of the adults varies from 10 to 44 days the average life of the beetle being 28.25 days.

Experiment No. 11.

Daily consumption of the aphid A. craccivora by the larvae of the syrphid, Xanthogramma scutellare

Experimental details.

Larvae of Xanthogramma scutellare used: The eggs collected from the field were put in a clean sterilized petri dish on



wet blotting paper. The larva which hatched from it were used for the experiment.

Number of larvae used: 14
Experimental period: 25-1-'67 - 3-2-'67.
Temperature: 77.46 - 89.97°F.
Relative humidity: 82.4%
Rest as in Experiment No. I.

Results.

Results of the experiment are tabulated in Appendix XV and summarised in Table 12.

TABLE XII

Summary of observations made on the feeding potential of Xanthogramme scutellare

No. of maggots used:	14	
Larval duration:	Range	6 - 7
	Average	5.07
Total No. of aphids consumed per larva	Range	287 - 1448
	Average	457.55
Average No. of aphids consumed per larva after hatching.	1st day	20.50
	2nd day	32.85
	3rd day	51.36
	4th day	79.86
	5th day	92.86
	6th day	103.43
	7th day	100.00

The maggot eats 7 - 28 aphids on the day of hatching, the average rate being 20.5. The number of aphids consumed per day ranges between 7 and 110. The average feeding rate per day of individual maggots ranges between 42.50 and 68.22. The longevity of the maggots is 6 - 7 days, the average being 5.07 days. Most of them pupate in the 7th day. The maximum number of aphids consumed by a maggot is 485 aphids consumed in 7 days.

DISCUSSION

DISCUSSION

Results of the experiments presented will show that the feeding capacity of the grub of C. sexmaculata is least in its day of hatching and increases gradually as the grub grows. A grub has a maximum life of eleven days and the average number of aphids consumed on these days are 3.48, 4.92, 3.9, 5.48, 5.62, 5.76, 5.94, 15.75, 22.76, 17.76 and 6.5 aphids respectively. It may be noticed that there is a set back in the number of aphids consumed per grub on the third day of the first instar and fourth day of the second and third instars. This is because most of the grubs moult on these days and those which do not, feed little. On the whole it may be seen that starting from an average consumption of 3.48 aphids per day on the day of hatching the number of aphids consumed increases to 22.76 per day consumed by the third instar grub on its second day. The average number of aphids consumed by the grub during its different instars are 8.98, 24.13 and 58.76 for the first, second and third instars respectively. According to Lefroy (1909) a grub of C. sexmaculata requires 200 aphids during its larval stage while Bagal and Trehan (1945) observed that the maximum number of aphids consumed by a grub is 303. In the present investigations it has been

seen that a grub during its larval stage consumes on an average of 93.62 aphids and lives for a period of 8-11 days.

At a stage during these investigations considerable mortality was experienced among the first and second instar grubs when fed with aphids only and the first instar grubs often refused to accept the aphids supplied even when the aphids were of the first instar stage. When the first instar grubs soon after hatching were supplied with sugar solution in addition to aphids the result was spectacular and it was observed that there was 90 per cent survival among the first instar grubs and no mortality in the subsequent instars. Further the feeding rates of the grubs fed with the sugar solution (in addition to the aphids) increased considerably, these were 7.11, 38.44 and 70.73 aphids per grub for the first, second and third instar respectively as against 8.9, 24.13 and 54.36 aphids respectively consumed by a grub reared out without sugar solution. This indicates that the grub fed with sugar solution is more powerful and vigorous than that fed only with the aphids. It may be that the carbohydrates play an important role in the nutrition of the insect. It thus appears that in nature the grub feeds on other materials to provide for this carbohydrates component and the honey dew secretion of the aphids and nectar are rich sources of this component.

The capacity of the adults of C. sexmaculata to consume aphids has been found to vary considerably depending upon the condition under which they were bred. Between the adults reared out in the laboratory on aphids only and those obtained from pupae collected from the field, the feeding rate is far more higher in the field bred adults than in the laboratory reared ones. Thus the average feeding rate of individual beetles, per day ranges between 20.23 and 31.05 in the former and 35.15 and 77.74 in the latter, the weighted means of the consumption of aphids per day per grub being 51.36 and 92.38 respectively. The observation may be correlated with the observation referred to previously on the nutrition of the grub. It appears that the laboratory reared beetles are weaker than the field reared beetles and this may be because in the field it is able to get a complete food. It may be pointed out in this connection that this beetle has been observed to feed on nectar in the field. Besides the feeding potential, the longevity of the adults also varies in the two types of beetles, the longevity has been found to be 13 to 45 days (average 33.1 days) in the laboratory reared beetle and 3-103 days (average 35.21 days) in those collected from the field. The maximum number of aphids consumed by the beetle is 1301 in the former and 7606 in latter types.

Comparing the capacity of the adults of C. sexmaculata to feed on different types of aphids it has observed that the beetle is able to consume a considerably more number of the mango aphids Toxoptera odinae than of A. craccivora; the average of feeding rate per day of the beetle on T. odinae is 67.33 and that on A. craccivora 92.38. Bagal and Trehan (1945) observed this to be 60.84 nymphs of Periclerinus maidis. The higher number of T. odinae consumed by the beetle appears to be due to its smaller size as compared with the other.

Experiments conducted on controlled feeding of adults of C. sexmaculata have shown that the adults can survive without affecting its normal duration of life even when the number of aphids consumed is reduced to 15 per day from the ad libitum level of 51 aphids per day. The adults however could not survive starvation for more than 6-7 days.

There exists a general correlation between the number of aphids consumed per day by the adult beetle and its longevity. Thus it is seen that generally, individual beetles which have a higher feeding rate survive for longer periods and viceversa.

The female of C. sexmaculata consume more aphids than the males and the females are larger in size than the

males, it has been seen that the average feeding rate per day is 94.38 aphids for female and 91.91 aphids for male. The death rate of the female is less than that in males.

Among the predators C.sexmaculata, Pseudaspidimerus circumflexa, S.quadrillum and X.scutellare the adult of C.sexmaculata has been found to be the most potential predator of the aphid consuming 45 to 124 aphids of the species. Z. odinae and 34 to 109 A.craccivora per day with a maximum of 7139 and 7606 respectively. Its survival periods lasts 5 to 81 and 3 to 103 days. The maggot of X.scutellare which consumes 7-100 aphids per day lives for 5-7 days feeding a maximum of 485 aphids. Adults of S.quadrillum eats 2-20 aphids per day lives for 13-65 days consuming a maximum of 582 aphids per adult. Adults of P.circumflexa has an eating rate of 2-19 aphids per day live for 10-44 days, consuming upto 504 aphids per adult.

SUMMARY

S U M M A R Y

Studies have been made on the feeding potential and food requirements of the grubs and adults of Chilomenes sexmaculata Fabr, and the feeding potential of adults of Scymnus quadrillum Motsch, and Pseudaspindimerus circumflexa and the maggots of the syrphid, Xanthogramma scutellare Fb.

The first instar grub of C.sexmaculata feeds on an average of 3.48 aphids of Aphis craccivora during its first day and 4.92 aphids during its second day and on a total of 8.98 aphids during the whole instar. The first instar lasts for an average of 2 days and suffers a mortality of 32.5% under laboratory conditions. The second instar grub feeds on an average of 5.48 aphids on its first 5.62 on its second, 5.76 on its third and 5.94 on its fourth day. The second instar has an average duration of three days and suffers a mortality of 70.37%. A grub of this instar consumes a total of 24.13 aphids on average. The average consumption of the third instar grub is 15.75, 22.76, 17.78 and 6.5 on the first to fourth days respectively. The third instar grub feeds on an average of 58.76 aphids and lives for a period of 3 days suffering a mortality of 18.75%.

The average number of aphids (A.craccivora) consumed by a grub of C.sexmaculata when fed with sugar solution in

addition to aphid is 7.11 on the first instar, 38.44 on the second instar and 70.78 in the third instar. The grubs suffer 10% mortality on the first, and no mortality in the subsequent instars.

The adults of C. sexmaculata, reared out in the laboratory on A. gracivora feeds on an average of 27.22 aphids per day and 906.7 aphids during its life time which lasts on an average of 33.1 days. The adults of C. sexmaculata obtained from the pupae collected from the field consumes on an average of 51.36 aphids per day and 7606 aphids during its life lasting 35.21 days on an average.

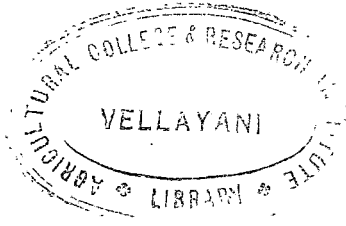
X A field bred adult of C. sexmaculata eats on an average 92.38 aphids of the species Toxoptera odinae per day and a total of 5611 aphids during its life time which occupies 46.81 days on an average.

Experiments on controlled feeding of the adults of C. sexmaculata with A. gracivora show that it survives for a period of 37.36 days on an average when fed with 30 aphids per day for the first 17 days and 15 aphids per day for the rest of the period, for 39.6 days when fed with 15 aphids per day through out its life, and for 6.15 days when completely starved.

The adult of S. quadricollis (field bred) consumes on an average of 9.26 aphids (A. craccivora) per day and 473.43 aphids during its whole life lasting on an average 46.67 days.

The adult of P. circumflexa (field bred) has a feeding rate of 9.83 aphids (A. craccivora) per day and 276.3 during its life which lasts on an average 28.26 days.

The feeding potential of the maggot of K. scutellare is 382.85 aphids during its larval duration which lasts for an average of 5.07 days.



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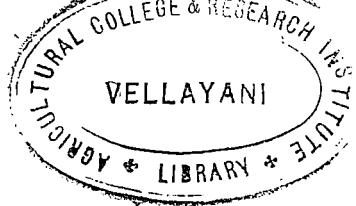
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APPENDIX

Appendix I

Feeding potential of the first instar grub of *C. sexmaculata*
on *A. craccivora*

Serial number of grub	Date of hatching from the egg	Number of aphids eaten on days after hatching			Total number of aphids consumed
		1st day	2nd day	3rd day	
I	II	III	IV	V	VI
1	29-9-66	2	6	m	8
2		2	4	m	6
3		2	5	8	15
4		3	5	m	8
5		3	5	m	8
6		3	5	D	8
7		4	4	D	8
8	30-9-66	3	D	"	3
9		3	6	m	9
10		4	6	m	10
11		4	7	m	11
12		5	7	m	12
13		4	5	m	9
14		3	6	m	9
15		5	6	m	11
16		6	4	m	10
17		4	6	"	10
18		4	5	"	9



Appendix I (Contd.)

I	II	III	IV	V	VI
19		4	6	"	10
20		2	3	"	5
21		3	4	"	7
22	2-10-66	2	3	"	5
23		3	2	"	5
24		3	4	5	12
25		3	4	m	7
26		3	3	"	6
27		2	3	"	5
28		3	2	"	5
29	3-10-66	1	D	-	1
30		3	5	m	8
31		3	4	m	7
32		3	3	m	6
33		1	D	-	1
34		1	D	-	1
35		2	3	4	9
36		3	6	m	9
37	17-11-66	4	6	"	10
38		5	8	"	13
39		6	7	"	13
40		5	9	"	14

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Appendix I (Contd.)

I	II	III	IV	V	VI
41		5	10	D	15
42		5	9	10	24
43		4	9	m	13
44		3	6	D	9
45		4	9	m	13
46		5	9	m	14
47		5	8	m	13
48		4	9	m	13
49		4	7	m	11
50		5	8	m	13
51	18-11-66	4	D	D	4
52		5	D	D	5
53		5	4	m	9
54		4	D	-	4
55		5	4	m	9
56		4	4	3	11
57	29-11-66	4	5	2	11
58		3	3	D	6
59		3	5	D	8
60		3	D	D	3
61		3	2	D	5
62		2	D	D	2

Appendix I (Contd.)

I	II	III	IV	V	VI
63		2	1	D	3
64		4	5	2	11
65		3	3	D	6
66		4	3	2	9
67		4	3	D	7
68		3	1	D	4
69	3-11-66	6	4	3	13
70		4	3	2	9
71		3	D	D	3
72		1	D	-	1
73		5	3	M	8
74		4	D	-	4
75		3	2	D	5
76		4	3	2	9
77		4	3	D	7
78		2	D	-	2
79		2	4	M	6
80		3	4	M	7
		279	330	43	652

Appendix II

Feeding potential of second instar grub of *C. sexmaculata*
on *A. craccivora*

Serial number of grubs	Date of moulting to second instar grub	Number of aphids eaten on day after moulting				Total number of aphids eaten
		1st day	2nd day	3rd day	4th day	
I	II	III	IV	V	VI	VII
1	1-10-66	6	6	4	1	17
2		5	6	5	6	22
3	2-10-66	6	7	4	5	22
4		8	7	4	2	21
5		7	5	4	4	20
6		D	-	-	-	0
10	2-10-66	8	7	6	9	30
11		8	5	6	10	29
12		7	4	1	D	12
13		5	2	1	D	8
14		8	2	D	-	10
15		6	5	1	8	20
16		8	7	5	7	27
17		4	4	2	D	10
18		6	5	5	7	23
19		10	6	1	D	17
20	4-10-66	4	2	D	-	6
21	5-10-66	5	5	9	11	30

Appendix II (Contd.)

I	II	III	IV	V	VI	VII
22		4	6	10	14	34
23		2	D	-	-	2
24		5	4	10	m	19
25		2	1	D	-	3
26		6	3	1	D	10
27		5	2	1	D	8
28		5	3	7	10	25
30		2	D	-	-	2
31	6-10-66	4	2	1	D	7
32		5	6	15	m	26
35		1	4	3	D	8
36		3	D	-	-	3
37		3	7	15	m	25
38	19-11-66	3	D	-	-	3
39		17	15	10	D	42
40		11	11	15	D	37
42		8	D	-	-	8
43		10	20	9	D	39
45		2	D	D	-	2
46		8	D	D	-	8
47		10	D	-	-	10
48		4	D	-	-	4

Appendix II (Contd.)

I	II	III	IV	V	VI	VII
49		11	D	-	-	11
50		13	D	-	-	13
53		D	D	-	-	-
55	20-11-66	3	D	-	-	3
56		2	D	-	-	2
57	1-12-66	3	-	-	-	3
64		3	-	-	-	3
65		2	1	D	-	3
69	5-12-66	4	3	D	-	7
70		3	D	-	-	3
73		4	-	-	-	4
76		2	-	-	-	2
79		2	-	-	-	2
80	3-1-67	14	24	m	-	38
Total		296	191	155	95	737

Appendix III

Feeding potential of the third instar grub of
C. sexmaculata on A. gracivora

Sl. No.	Date of moulting to the 3rd instar	Number of aphids eaten on days after moulting					Total number of aphids consumed
		1st day	2nd day	3rd day	4th day	5th day	
1	6-10-66	2	D	-	-	-	2
2		9	15	30	10P	-	64
3		2	D	-	-	-	2
4		1	-	-	-	-	1
5		7	15	29	8 ^P	-	59
10		15	23	13	P	-	51
11		15	27	11	P	-	53
16		13	17	16	14	12 ^P	72
18	9-10-66	25	30	P	P	-	55
21		23	20	14	"	-	57
22		15	27	22	"	-	64
24		25	23	20	"	-	68
28	8-10-66	28	15	P	"	-	43
32		12	27	5	"	-	44
37		30	12	P	"	-	42
30	5-1-67	30	45	"	"	-	75
Total		252	296	160	32	12	752

Appendix IV

Feeding potential of the first instar grub of C. sexmaculata

A. craccivora and sugar solution

Sl. No.	Date of hatching	Number of aphids eaten			Total number of aphids consumed
		1st day	2nd day	3rd day	
1	3--11--66	3	3	m	6
2		2	D	-	2
3		3	5	m	8
4		2	3	"	5
5		3	4	"	7
6		4	5	"	9
7		3	5	"	8
8		2	4	"	6
9		3	4	"	7
10		3	5	"	8
Total		28	38	-	66

Appendix V

Feeding potential of second instar grub of C. sexmaculata
on A. craccivora and sugar solution

Sl. No.	Date of moulting into second instar	Number of aphids eaten on days after moulting			Total number of aphids consumed
		1st day	2nd day	3rd day	
1	5-11-66	15	24	m	39
3		15	12	"	27
4		14	23	"	37
5		18	15	16 ^m	49
6		17	20	m	37
7		18	19	"	37
8		20	21	"	41
9		18	20	"	38
10		20	21	"	41
Total		155	175	16	346

Appendix VI

Feeding potential of the third instar grub of C. sexmaculata
on A. craccivora and sugar solution.

Sl. No.	Date of moulting to the third instar	Number of aphids eaten on days after moulting			Total number of aphids consumed	Average number of aphids consumed
		1st day	2nd day	3rd day		
1	7-11-66	30	42	p	72	36.0
3		31	44	"	75	37.5
4		29	37	30 ^p	96	48.0
5		24	35	p	59	26.5
6		21	34	"	55	27.5
7		27	41	"	68	34.0
8		30	37	"	67	33.5
9		31	40	"	71	35.5
10		30	44	"	74	37.0
Total		253	354	30	637	

Appendix VII

Feeding potential of adults of C. sexmaculata reared out in the laboratory on A. craccivora

Sl. No. of beetle	Date of emergence of the adults	Number of aphids consumed on days after emergence of the adults											
		I	2	3	4	5	6	7	8	9	10	11	12
I	II	III											
1	12-10-66	30	25	18	26	10	15	25	32	25	11	20	22
2		17	18	20	10	10	8	15	17	11	9	15	20
3		21	22	23	29	20	30	27	22	9	19	23	15
4		20	24	15	25	12	14	20	15	9	20	22	22
5		22	23	20	30	25	17	17	20	11	24	23	23
6		20	19	23	25	13	15	13	13	22	20	20	22
7		10	16	23	16	19	29	13	13	14	15	24	23
8		15	13	15	35	13	13	14	20	20	16	23	29
9		23	32	30	25	23	17	13	16	13	25	22	23
10		24	34	30	27	29	20	19	31	35	29	24	21

Appendix VII (Contd.)

I	II	III											
		13	14	15	16	17	18	19	20	21	22	23	24
1	12-10-66	22	15	24	38	39	40	35	38	40	38	33	28
2	17	17	23	28	27	27	33	35	37	30	27	28	29
3		17	23	29	25	27	29	27	D (Total:437; Average:23)				
4		24	27	39	32	28	37	30	28	35	40	38	37
5		24	29	33	30	35	37	32	28	30	32	39	21
6		28	D (Total: 263; Average: 20.23)										
7		20	24	20	29	35	32	34	31	30	28	20	15
8		32	30	34	38	27	27	30	28	32	40	29	34
9		25	30	37	33	35	22	30	31	29	35	23	39
10		30	32	25	28	29	30	27	29	28	24	23	25

Appendix VII (Contd.)

I	II	III													
		25	26	27	28	29	30	31	32	33	34	35	36	37	38
1	12-10-66	29	29	30	25	27	30	27	34	34	38	39	44	44	43
2		27	30	25	20	40	35	27	38	39	40	42	43	35	30
4		35	29	36	40	37	36	29	30	40	44	42	39	50	45
5		D (Total: 627; Average: 26.13)													
7		D (Total: 543; Average: 22.5)													
8		36	20	36	40	37	36	29	30	40	44	42	46	45	39
9		40	31	20	13	20	21	25	23	30	29	27	25	24	25
10		26	27	28	29	30	31	35	39	29	30	30	32	33	29

I	II	III							
		39	40	41	42	43	44	45	
1	12-10-66	32	30	31	25	20	15	D (Total: 1275; Average: 23.98)	
2		37	32	41	35	D (Total: 1127; Average: 25.57)			
4		35	31	33	31	26	D (Total: 1301; Average: 30.26)		
8		41	44	D (Total: 1242; Average: 31.05)					
9		26	25	30	31	25	20	D (Total: 1171; Average: 26.61)	
10		D (Total: 1081; Average: 23.12)							

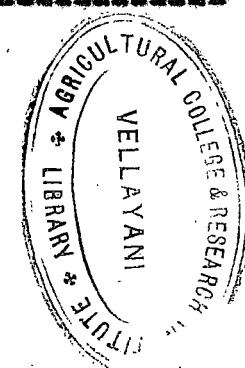
Appendix VIII

Feeding potential of adults of C. sexmaculata reared from pupae collected from the field
on A. craccivora

Sl. No.	Date of emergence of the adults	No. of aphids consumed on days after emergence of the adults												
		1	2	3	4	5	6	7	8	9	10	11	12	13
I	II	III												
1	17-11-66	34	44	42	D (Total: 120; Average: 40.00)									
2		35	34	48	54	50	55	45	33	41	55	50	49	45
3		34	43	47	50	60	45	52	39	45	44	49	55	52
4	18-11-66	40	39	50	39	33	30	29	D (Total: 260; Average: 37.14)					
5		46	51	40	30	36	45	32	45	43	45	46	43	35
6		37	49	45	45	42	30	36	35	32	45	40	45	46
7		40	47	45	46	35	45	42	31	30	41	25	20	10
8		40	48	60	40	45	46	35	30	15	D (Total: 359; Average: 39.89)			
9		38	50	52	43	43	47	45	33	42	43	49	54	55
10		49	59	50	44	35	36	43	35	45	38	27	30	29
11		40	56	53	45	37	35	34	35	D (Total: 340; Average: 42.5)				
12	23-12-66	46	45	41	69	67	60	51	68	44	60	50	35	46
13		37	41	44	55	60	59	54	56	40	45	40	41	46
14	31-12-66	52	63	59	45	34	39	45	33	21	27	23	25	19
15		40	61	47	27	30	36	53	67	40	35	29	25	34
16		64	57	53	59	40	41	27	35	40	41	25	36	50
17		40	61	50	49	50	34	49	44	39	37	21	36	20
18		57	46	49	63	50	43	49	20	39	43	20	20	31
19		61	46	57	40	41	42	30	26	33	25	15	24	20

Appendix VIII (Contd.)

	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
I	II		III														
2	28	39	45	50	45	41	43	56	40	52	69	61	57	39	40	56	52
3	27	31	41	40	39	36	40	40	46	45	61	49	54	45	54	57	56
5	D (Total: 536; Average: 41.23)																
6	48	35	D (Total: 623; Average: 41.54)														
7	D (Total: 457; Average: 35.15)																
9	52	55	57	61	69	75	59	58	60	62	66	68	50	51	57	55	63
10	36	30	D (Total: 591; Average: 39.4)														
12	45	48	45	36	43	34	39	45	55	54	43	50	37	32	40	49	40
13	43	39	27	25	25	33	32	29	36	29	29	46	31	28	42	28	57
14	23	D (Total: 513; Average: 36.64)															
15	27	21	D (Total: 572; Average: 38.13)														
16	48	30	34	27	45	28	20	30	23	20	D (Total: 878; Average: 38.17)						
17	36	36	35	49	21	20	34	35	29	19	26	26	40	51	48	34	29
18	36	44	39	35	29	28	32	25	D (Total: 593; Average: 37.73)								
19	47	35	49	D (Total: 591; Average: 36.69).													



Appendix VIII (Contd.)

	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
I	II							III								
2	59	41	29	55	41	45	71	52	51	50	54	56	52	47	59	51
3	58	35	30	50	50	41	49	61	52	50	55	48	42	38	51	38
9	38	50	50	52	51	40	45	52	54	56	58	49	55	62	64	66
12	60	61	65	75	81	84	88	86	80	66	71	61	45	47	49	60
13	25	41	50	45	80	42	30	31	34	39	32	30	40	41	42	55
17	25	26	40	31	38	31	36	60	51	61	59	65	69	71	72	77

	47	48	49	50	51	52	53	54	55	56	57	58	59	60	
I	II							III							
2	53	46	47	37	30	26	45	33	36	28	39	41	21	28	
3	51	48	43	33	42	39	35	31	40	46	41	49	32	47	
9	50	D (Total: 2514; Average: 53.48)													
12	60	74	71	80	84	100	97	109	80	82	89	92	82	90	
13	54	69	60	70	76	80	88	75	78	81	75	70	71	30	
17	79	82	74	50	57	55	76	75	68	69	70	77	80	70	

Appendix VIII (Contd.)

	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77
I	II		III														
2	50	52	42	39	30	44	59	64	58	63	34	46	47	50	59	61	50
3	49	45	36	49	42	44	66	63	64	49	44	41	52	62	54	55	54
12	90	87	89	86	98	100	98	89	80	100	99	80	85	100	99	100	90
13	D (Total: 2831; Average: 47.18)																
17	78	80	78	70	74	100	92	87	84	90	85	80	84	88	90	87	88

	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	
I	II		III													
2	54	51	59	70	70	58	51	62	64	84	79	78	70	75	67	
3	51	50	60	68	70	65	68	70	73	80	82	71	69	66	75	
12	92	94	95	84	90	91	90	84	90	90	91	92	93	88	89	
17	80	86	88	86	90	91	90	91	83	82	85	89	88	87	90	

	93	94	95	96	97	98	99	100	101	102	103	104					
I	II		III														
2	77	60	51	70	75	80	50	D (Total: 5030; Average: 50.30)									
3	74	72	D (Total: 4713; Average: 43.18)														
12	77	78	91	88	94	96	99	99	100	87	97	D (Total: 7606; Average 77.74)					
17	D (Total: 5633; Average: 61.23)																

Appendix IX

Feeding potential of adults of C. sexmaculata on Toxonera odinae

Sl. No.	Date of emergence of adults	Number of aphids consumed on days after emergence of the adults														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
I	II	III														
1	17-1-67	65	74	90	100	100	80	104	105	89	81	88	103	96	108	80
2	18-1-67	57	73	88	93	102	85	95	95	79	90	92	94	87	100	81
3		65	75	80	92	100	103	97	80	93	82	103	113	93	95	83
4		63	90	92	100	101	99	113	100	115	89	100	104	93	100	60
5		64	74	90	101	102	96	102	101	99	100	99	90	87	81	90
6		75	90	85	78	88	96	80	90	97	96	94	91	90	88	92
7		75	74	80	103	86	78	74	71	80	89	80	106	84	81	91
8		75	87	85	103	86	78	74	71	83	99	80	106	84	81	91
9		75	85	104	100	80	104	100	98	118	106	104	97	89	86	100
10		75	90	102	100	91	109	100	99	93	89	92	71	90	86	100
11		72	90	104	100	91	100	98	100	109	124	110	71	90	86	100
12		75	90	105	119	110	110	91	109	111	120	115	130	100	106	115
13		75	120	103	104	100	107	102	104	105	94	110	119	114	104	102
14		75	90	109	105	109	105	109	116	101	107	96	108	95	81	83
15		75	88	99	95	67	83	76	69	91	93	37	96	90	95	96

Appendix IX (Contd.)

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
I	II		III													
1	100	88	86	89	81	77	99	89	99	90	86	79	82	80	89	88
2	89	87	84	88	85	76	82	90	81	84	86	84	82	84	82	90
3	110	91	90	92	87	84	92	89	86	84	89	87	87	85	90	94
4	89	79	81	98	91	71	91	95	84	90	89	85	89	82	83	87
5	95	100	89	87	88	85	84	91	93	94	90	88	70	90	80	90
6	D (Total: 1330; Average: 88.67)															
7	92	91	79	82	89	92	80	82	84	81	85	86	85	84	94	81
8	88	90	89	91	88	91	80	76	79	89	99	93	90	89	91	90
9	89	91	92	92	94	93	94	85	95	89	90	95	91	95	90	70
10	87	89	86	88	91	90	82	83	86	94	96	100	92	84	70	59
11	87	90	86	88	91	90	82	83	86	94	89	100	97	84	70	50
12	89	91	87	85	98	98	91	89	89	95	96	100	97	98	99	94
13	71	80	81	87	94	91	92	83	88	95	76	98	90	90	93	95
14	81	83	89	91	81	89	90	95	90	94	95	99	89	95	91	88
15	72	96	92	91	81	86	81	90	88	99	90	98	85	90	80	90

Appendix IX (Contd.)

I	II	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
		III														
1		90	92	79	92	90	91	92	90	94	92	90	96	99	79	87
2		86	84	76	97	94	91	95	89	90	91	85	90	98	81	88
3		81	78	78	89	101	100	91	90	92	81	90	110	114	101	112
4		91	92	92	91	88	89	94	90	92	95	94	115	114	101	112
5		89	79	79	85	94	98	88	92	95	92	90	92	88	95	89
7		89	90	90	94	91	105	89	78	88	84	90	87	92	93	90
8		92	85	95	100	100	101	94	100	97	90	84	90	91	94	89
9		89	85	85	100	101	100	92	102	100	101	100	88	102	91	92
10		89	85	D (Total: 2928; Average: 88.73)												
11		D (Total: 2812; Average: 90.71).														
12		D (Total: 3102; Average: 100.06).														
13		90	86	86	92	95	110	101	100	98	100	98	97	101	101	100
14		90	99	99	90	100	110	98	91	97	100	105	100	98	89	89
15		96	94	94	96	97	99	101	96	99	97	90	94	93	94	98

Appendix IX (Contd.)

I	II	47	48	49	50	51	52	53	54	55	56	57
		III										
1		90	104	110	101	102	109	114	109	100	98	79
2		94	99	105	100	105	114	109	100	98	89	49
3		95	90	91	96	92	110	105	104	94	100	98
4		95	91	99	96	99	111	114	102	91	101	100
5		94	111	112	110	105	108	99	80	D (Total:4954; Average: 91.74)		
7		92	113	115	114	110	114	115	105	110	101	100
8		90	108	119	112	114	115	110	114	100	98	99
9		88	95	103	111	115	108	114	101	105	97	91
13		90	113	104	114	108	D (Total: 4951; Average: 97.08)					
14		92	113	115	110	110	104	97	110	119	100	98
15		96	109	110	99	97	119	109	115	110	104	97

Appendix IX (Contd.)

I	II	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
		III														
1		89	90	91	95	89	90	91	92	95	94	87	90	94	87	90
2		D (Total:5032; Average: 88.28)														
3		94	91	95	89	90	95	91	93	75	90	92	93	91	93	90
4		99	100	94	101	92	94	96	91	93	89	91	93	87	88	91
5		91	92	82	92	92	90	87	92	95	95	81	84	87	88	89
8		94	98	90	90	89	91	92	87	95	91	94	89	90	92	90
9		85	91	100	95	99	93	95	92	89	85	90	94	93	97	91
14		91	77	85	100	92	92	87	85	91	93	85	88	93	91	93
15		90	84	89	101	88	97	90	92	97	91	87	88	91	92	98

I	II	73	74	75	76	77	78	79	80	81	82	
		III										
1		93	90	101	99	101	89	90	D (Total:7261; Average:91.91)			
3		88	93	95	87	91	93	96	89	D (Total:7364; Average:92.05)		
4		94	80	91	95	100	103	94	91	90	D (Total:7595; Average:93.77)	
7		90	82	92	93	95	89	87	86	80	D (Total:7306; Average:90.19)	
8		95	94	91	83	89	92	94	96	D (Total:7378; Average:92.23)		
9		96	95	93	89	91	D (Total:7295; Average:94.74)					
14		92	91	90	93	87	89	93	96	D (Total:7550; Average:94.80)		

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Appendix X

Survival of adults of C. sexmaculata when fed with 30 aphids per day for the first 17 days and 15 aphids per day for the rest of the period

Sl. No.	Date of emergence of the adults	Date of death	Total number of aphids consumed	Survival period in days
1	31-12-66	11-2-67	797	42
2		25-2-67	1065	55
3		14-2-67	875	45
4		19-2-67	501	19
5		30-1-67	355	13
6		23-2-67	974	53
7	1-1-67	25-2-67	1130	59
8		8-1-67	130	7
9		30-2-67	1080	60
10		29-2-67	1072	59
11		6-1-67	169	6

Average longevity of the adults - 37.36 days

Appendix XI

Survival of adults of C. sexmaculata when fed with 15 aphids per day

Sl. No.	Date of emergence	Date of death	Number of aphids consumed	Survival period in days
1	19-1-67	14-3-67	870	53
2		21-1-67	30	2
3		5-3-67	720	43
4		1-3-67	660	44
5		3-3-67	690	46
Average longevity			-	39.6 days

Appendix XII

Survival of adults of C. sexmaculata when fed with no aphids

Sl. No.	Date of emergence	Date of death	Number of aphids consumed	Survival period in days
1	29-12-66	4-1-67	Nil	6
2		"	"	"
3		"	"	"
4		"	"	"
5		"	"	"
6		5-1-67	"	7
7	19-1-67	25-1-67	"	6
8		"	"	"
9		"	"	"
10		"	"	"
11		"	"	"
12		"	"	"
13		25-1-67	"	7

Longevity - 6-7 days
Average longevity - 6.15 days

Appendix XIII

Feeding potential of adults of Sevmus quadrillum on A. craccivora

Sl. No.	Date of emergence	No. of aphids consumed														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		I	II												III	
1	25-11-66	7	6	9	10	11	12	10	12	16	7	10	14	10	17	12
2	26-11-66	10	7	9	10	15	13	11	9	10	8	9	9	10	10	12
3		8	8	7	10	11	7	9	16	10	7	7	7	9	10	12
4		8	10	10	17	9	9	10	14	9	7	8	8	8	9	11
5		9	11	8	8	13	9	9	13	13	14	9	8	8	8	10
6		9	11	8	6	11	13	10	7	8	8	13	9	8	10	15
7		10	7	12	10	9	8	10	11	12	7	8	8	10	9	12
8		13	12	12	8	9	9	16	12	9	8	8	12	10	9	12
9		9	10	6	10	10	13	13	10	8	4	6	9	11	7	9
10		11	9	5	8	13	9	12	16	15	9	8	9	10	9	9
11		13	10	10	8	12	11	14	11	7	7	7	6	10	9	8
12	12-12-66	11	13	10	9	7	10	8	7	6	9	9	7	10	11	8
13		10	13	10	8	12	8	8	7	9	8	8	8	8	12	13
14		12	13	7	12	9	9	9	11	5	7	12	8	9	13	14
15		10	14	9	8	7	11	7	8	11	10	9	8	15	13	13
16		13	10	7	12	11	6	6	13	8	9	10	12	12	15	14
17		8	9	15	11	11	10	8	8	6	8	10	15	12	12	11
18		7	9	9	6	8	13	7	8	8	9	8	12	12	13	17
19		7	5	9	10	9	9	10	13	12	11	8	9	12	16	14
20		6	9	6	7	12	9	10	9	8	9	9	13	9	13	20
21		8	15	10	8	8	8	17	7	6	9	10	12	10	15	15

Appendix XIII (Contd.)

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30					
I	II		III																	
1	10	10	8	7	13	12	8	10	11	9	8	12	8	9	11					
2	7	18	5	D	(Total: 131; Average: 10.06)											8	12	8	9	11
3	9	17	9	12	12	7	16	13	10	10	7	8	9	8	9					
4	8	17	11	7	13	7	15	16	7	16	6	14	6	9	8					
5	6	17	13	8	10	D	(Total: 211; Average: 10.55)											6	9	8
6	8	14	11	7	11	10	12	19	6	10	8	9	8	10	11					
7	9	15	12	11	18	13	18	13	7	13	11	10	11	7	9					
8	12	17	14	11	14	16	19	18	14	10	16	8	9	10	7					
9	8	15	17	8	11	16	12	9	8	10	10	12	11	10	12					
10	10	9	13	8	12	14	19	11	6	10	7	9	11	10	8					
11	12	13	11	8	15	16	15	13	6	10	7	9	10	7	10					
12	8	10	13	14	9	9	19	8	9	10	16	8	9	10	7					
13	7	10	11	17	16	10	10	9	8	10	10	12	11	10	12					
14	9	18	13	13	16	6	9	5	10	10	D	(Total: 262; Average: 10.48)				10	13			
15	7	17	15	14	17	6	13	7	11	9	11	9	10	11	13					
16	7	6	8	10	16	9	8	9	11	11	9	8	9	10	8					
17	12	10	15	14	15	12	10	8	12	11	9	7	9	11	11					
18	13	11	16	12	16	12	9	8	11	9	9	12	10	11	7					
19	13	16	13	12	18	12	13	9	9	8	11	6	9	10	10					
20	11	12	11	13	15	10	8	8	11	11	11	8	9	11	8					
21	13	15	9	13	14	11	7	12	10	11	10	10	10	11	7					

Appendix XIII (Contd.)

	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
I															
									III						
1	10	12	13	14	10	15	9	12	10	11	6	6	4	11	2
3	10	11	14	4	7	10	5	12	5	6	8	6	6	3	4
4	7	9	9	10	9	7	5	13	D	(Total: 356; Average: 9.63)	8	6	6	3	4
6	10	9	15	17	13	11	7	6	D	(Total: 366; Average: 9.63)	8	6	7	9	3
7	11	8	9	14	9	11	8	8	19	14	8	8	7	9	3
8	9	7	9	15	17	5	4	11	8	6	8	8	7	9	3
9	7	8	12	8	8	D	(Total: 351; Average: 10.03)	8	14	10	12	8	6	6	3
10	10	10	8	6	8	8	14	10	12	8	6	6	3	4	3
11	11	11	8	15	7	19	10	8	5	D	(Total: 403; Average: 10.33)	8	6	3	4
12	9	7	9	15	7	11	7	5	4	5	8	8	7	9	3
13	7	8	12	7	16	8	7	6	2	4	7	5	4	11	8
15	3	9	8	15	6	8	7	6	2	4	7	5	4	11	8
16	10	8	5	10	9	10	6	D	(Total: 582; Average: 8.95)	4	7	7	5	14	7
17	5	11	10	12	10	12	7	3	6	9	4	3	5	6	7
18	2	8	8	7	9	9	5	5	2	5	4	3	5	6	7
19	6	10	7	7	7	8	6	5	4	3	4	3	6	7	10
20	5	7	12	2	10	7	6	7	3	3	5	6	4	6	7
21	2	13	14	7	10	1	6	6	5	6	6	6	6	6	7

Appendix XIII (Contd.)

	46	47	48	49	50	51	52	53	54	55	56
I											
II											
						III					
1	3	9	8	10	11	12	9	11	8	D(Total:546; Average:10.11)	
3	3	7	2	5	5	6	4	5	5	4	4
7	4	4	6	8	10	9	5	6	4	D(Total:438; Average:10.68)	
10	7	2	5	5	6	4	5	5	4	4	2
12	4	4	6	8	10	9	5	6	4	D(Total:461; Average:8.54)	
13	6	8	D (Total: 433; Average: 9.21)								
15	8	9	11	18	15	13	9	8	7	9	5
17	6	5	9	10	9	8	4	4	3	2	6
18	9	5	6	6	6	7	6	4	4	4	6
19	5	4	3	6	4	5	6	7	8	9	7
20	2	4	3	6	6	6	8	7	6	5	4
21	6	5	4	3	6	5	6	7	8	7	D (Total: 491; Average: 8.93)

	57	58	59	60	61	62	63	64	65	66	
I											
II											
						III					
3	2	4	5	6	7	6	4	3	D(Total:459; Average: 7.64)		
10	4	5	6	7	6	4	3	D (Total: 509; Average: 8.08)			
15	2	6	4	4	8	7	3	4	2	D (Total: 582; Average: 8.95)	
17	4	6	7	8	6	4	5	D (Total: 538; Average: 8.54)			
18	5	6	6	7	5	3	7	D (Total: 491; Average: 7.79)			
19	6	5	D (Total: 496; Average: 8.55)								
20	D (Total: 453; Average: 8.09)										

Appendix XIV

Feeding potential of the adults of Pseudaspidimerus circumflexa on A. craccivora

Sl. No.	Date of emergence of the adults	Number of aphids consumed												
		1	2	3	4	5	6	7	8	9	10	11	12	13
I	II	III												
1	4-11-66	10	13	9	8	13	12	14	11	10	8	7	9	11
2		11	10	9	8	7	10	11	12	13	11	10	4	9
3		8	9	10	15	14	10	9	10	9	8	7	6	4
4		11	12	13	11	10	9	8	7	8	9	12	13	14
5		12	14	13	12	11	10	9	12	13	11	10	12	13
6		11	12	13	14	15	13	14	12	13	10	9	10	12
7		13	9	8	10	11	12	10	9	8	7	6	9	10
8	28-11-66	10	11	11	13	19	14	10	17	17	16	17	12	7
9	2-12-66	10	13	10	12	15	9	8	9	10	8	7	6	10
10	3-12-66	10	13	9	8	13	9	9	10	9	11	12	13	15
11		11	10	8	9	10	11	5	8	10	10	13	8	14
12		10	9	8	10	11	12	9	13	10	10	13	13	12
13		12	11	10	10	7	8	6	10	9	11	11	10	12
14		10	11	9	10	11	9	10	6	10	10	15	9	15
15		9	10	11	10	17	11	8	8	10	10	10	13	17
16		11	12	9	10	10	7	11	7	9	11	D	(Total:97; Average:9.7)	
17		12	11	10	10	13	10	8	10	10	10	10	10	17
18	21-12-66	10	7	10	15	14	9	10	11	10	15	5	10	7
19		10	9	8	7	5	10	12	10	11	11	7	9	8
20		10	9	10	7	15	12	8	14	12	11	7	8	9

Appendix XIV (Contd.)

	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
I	II		III													
1	10	12	13	11	10	9	10	11	12	9	10	12	11	10	7	8
2	10	8	9	10	11	10	12	13	9	8	7	8	10	9	11	12
3	D (Total: 119; Average: 9.15)															
4	11	13	15	10	12	13	15	17	14	11	12	14	13	10	9	12
5	11	10	9	11	12	13	14	12	11	10	9	11	10	11	12	13
6	15	14	11	10	12	13	14	10	11	9	11	12	15	14	12	11
7	D (Total: 125; Average: 8.93)															
8	10	15	15	16	15	10	9	11	16	16	12	15	16	10	6	15
9	14	7	8	11	12	10	9	10	8	7	9	10	6	10	10	8
10	13	13	15	D (Total: 182; Average: 11.38)												
11	10	7	14	19	16	11	12	12	10	10	11	14	15	14	13	10
12	11	8	5	D (Total: 164; Average: 10.25)												
13	9	D (Total: 136; Average: 9.7)														
14	15	10	13	11	16	17	13	10	11	11	12	10	10	11	12	10
15	22	11	19	14	10	5	D (Total: 225; Average: 11.34)									
17	15	7	14	15	7	14	15	17	8	11	12	14	11	12	13	12
18	8	9	10	7	6	D (Total: 173; Average: 9.61)										
19	9	12	12	13	12	D (Total: 175; Average: 9.72)										
20	9	10	8	D (Total: 159; Average: 9.94)												

Appendix KIV (Contd.)

	30	31	32	33	34	35	36	37	38	39	40	41
I												
							III					
1	9	10	9	11	10	12	13	11	10	9	8	7
2	13	14	13	13	14	15	12	11	10	9	10	7
4	11	10	12	10	11	12	9	8	7	10	8	9
5	13	13	15	12	11	10	7	8	11	D	(Total: 439; Average: 10.71)	
6	9	10	11	11	12	14	15	13	13	11	10	8
8	10	12	15	9	8	9	10	8	7	6	4	D (Total: 479; Average: 11.08)
9	7	9	11	12	10	9	8	6	5	4	2	D (Total: 359; Average: 8.97)
11	11	12	12	14	8	10	8	6	6	8	7	4
14	9	14	6	9	12	11	3	3	5	10	8	5
17	10	10	8	11	5	11	7	8	7	7	4	7

	42	43	44	45
I				
				III
1	5	D (Total: 424; Average: 10.09)		
2	5	D (Total: 436; Average: 10.38)		
4	D	(Total: 452; Average: 11.02)		
6	7	8	6	D (Total: 504; Average: 11.45)
11	10	(Total: 423; Average: 10.44)		
14	D	(Total: 422; Average: 10.29)		
17	7	D (Total: 426; Average: 10.39)		

Appendix XV

Feeding potential of the larvae of Xanthogramma scutellare on
A. craccivora

Sl. No.	Date of hatching	No. of aphids consumed								Total	Average
		1	2	3	4	5	6	7	8		
1	25-1-67	13	27	42	52	75	105	P	-	319	53.17
2	26-1-67	17	28	40	50	83	90	P	-	314	52.33
3		10	15	25	42	74	89	P	-	255	42.50
4		13	23	49	95	95	90	P	-	375	62.17
5	29-1-67	7	17	40	90	90	100	P	-	344	57.33
6	31-1-67	13	31	50	95	110	100	P	-	404	67.33
7	2-2-67	25	42	58	70	90	100	100	P	485	69.29
8		20	45	52	79	99	115	P	-	310	68.33
9		23	35	53	73	100	100	P	-	397	66.17
10		20	30	67	80	101	115	"	-	411	68.83
11		29	37	59	82	100	99	"	-	406	67.67
12		24	40	60	80	92	120	"	-	416	69.33
13		27	39	59	75	95	115	"	-	410	68.33
14		23	43	60	71	90	110	P	-	407	67.83
		237	460	719	1113	1300	1443	100	-	5353	
Average		20.5	32.86	51.33	79.86	92.86	103.43	100	-	384.36	

