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Biology and Feeding potential of Ladybird Beetle, Coccinella septempunctata Linnaeus (Coleoptera: Coccinellidae) on cabbage aphid, Brevicoryne brassicae (Linnaeus) under Laboratory Conditions

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ABSTRACT

Among the different predators coccinellid beetles play an important role in the natural suppression of destructive insect pests. Coccinella septempunctata, an important coccinellid beetle with worldwide distribution was found very active on different insect pests. An experiment was conducted to study the biology and feeding potential of C. septempunctata Linnaeus on Cabbage aphid, Brevicoryne brassicae (Linnaeus) under laboratory conditions (26 ±2˚C and 65 ±5% R.H.). The present study was done in Entomology laboratory, department of Zoology, university of Kashmir during the year 2014-2015. The results revealed that incubation period of C.septempunctata were 3-5 days. Total grub period was observed 10.49 days. Pupal period was recorded to be 4.66±1.52 days and after that adults emerged out. Also during the present study both the adults and grubs of C. septempunctata were found voracious feeders on cabbage aphid. The fourth instar devoured maximum number of aphids. The mean aphid consumption under different host density was observed. Also higher prey consumption rate was observed by adult female as compared to adult male.

Key words: Cabbage aphid, Consumption, Feeding potential, Grubs and Voracious.

I.INTRODUCTION

Coccinellids, persistently known as ladybird beetles belong to the order Coleoptera and the family Coccinellidae, are the forthcoming predators of as array of insect pests, principally aphids, scale insects, mealy bugs, thrips and other soft bodied insects, besides phytophagous mites. This family gained the interest of many investigators as important group of predatory in the biological control of insect pests attacking different crop plants [1]. There is also a lot of information available about the possibilities of using ladybird beetles in biological control [2] [3] [4] [5] [6] [7] [8].The biological control with Coccinellids has contributed greatly and suppressed the pests below economic damage [9]. In addition to this Coccinellid predators are tolerant to many insecticides which are an advantage over other predators [10].

C.septempunctata is a common species used for biological control in agriculture settings, as its main prey is the aphid, a major agricultural pest. *C. septempunctata* is one of the most successful aphidophagous insects to control aphid populations. The ability of *C. septempunctata* to be so successful in a large range of habitats makes it especially beneficial to humans who need crop security from aphid infestations [11]. The predator beetle is an efficient feeder and prey on wide range of soft bodied insects. Both adults and grubs are voracious feeder of aphid species. Many aphid species are serious pests of different crops. *B. brassicae* commonly known as cabbage aphid is important pest of cruciferous vegetables in Kashmir valley. Colonies of this aphid are found on both lower and upper leaf surfaces and in leaf folds of developing heads, on leaf stalks, and on leaf axles. They feed by sucking sap from their hosts which causes wilting, yellowing and general stunting of the plants [12].They prefer feeding on young leaves and flowers and often go deep into the heads of Brussels, sprouts and cabbage [13]. Colonies of aphids are found on upper and lower leaf surfaces, in leaf folds, along the leaf stalk, and near leaf axils. The cabbage aphid is of agricultural concern because it is a vector of at least 20 viral pathogens that can cause diseases in crucifers and citrus. Both wingless (apterae) and winged (alate) forms are able to transmit viruses, but the wingless aphids demonstrate a higher rate of transmission [14]. Aphids also cause major losses to broccoli by reducing yield, with real damage being contamination of harvested heads of broccoli [12] [13].The present study for that reason was undertaken for obtaining information on biology and predatory potential of *C. septempunctata* on cabbage aphid, *B. brassicae* under laboratory conditions.

II.MATERIALS AND METHODS

2.1 Laboratory Maintaince

The studies on the biology and predatory potential of *C.septempunctata* on *B.brassicae* were carried under controlled conditions. The experiment was conducted in the Entomology laboratory of department of Zoology, University of Kashmir under controlled conditions (26 ±2˚C and 65 ±5% R.H.). The present study was done during the year 2014-2015. Adults of *C. septempunctata* were collected by net sweeping method and hand picking method [15]. The net used for collection was made of white muslin cloth with long handle. Hand picking method was mostly adopted for collection. The collected specimens were kept in collecting jars and collection tubes and brought to Entomology laboratory Department of Zoology for rearing.

2.2 Stock Culture

For rearing of *C.septempunctata* experiment was initiated by collecting adults from fields. Mating pairs were kept in glass jars covered with muslin cloth. They were provided with abundant supply of food in the form of infested twigs of aphids until oviposition. Dry twigs were replaced with fresh ones after every 24hrs in order to avoid contamination. The glass jars were also provided with crumpled paper to act as oviposition site. The eggs lay on crumpled paper and on walls of glass jars were removed with the help of camel hair brush. They were counted and transferred in Petri dishes for further experimental studies.

2.3 Rearing of *Coccinella septempunctata*

The life history of *C.septempunctata* was studied under the laboratory conditions. The eggs were taken from stock culture and were kept in Petri dishes. In order to maintain humidity moist filter paper were placed at bottom of Petri dish. The filter paper was replaced daily to avoid contamination till hatching. By careful observations incubation was recorded. The newly hatched first instar grubs were placed gently with the help of camel hair brush and transferred individually in Petridishes. They were also provided with food (aphids). Larval duration of each instar was recorded after moulting and also different larval instars were separated from each other by head capsule measurement [16]. Measurement of head capsule was done with the help of digital vernier calliper. The adults were sexed by examing their genetilia and size, usually females are larger than males. Adult male and female were allowed to mate in a separate glass jar covered with muslin cloth and provided with sufficient food supply. Adult longevity, premating, mating and oviposition period were observed and recorded carefully. All observations were replicated five times up to the two successive generations.

2.4 Feeding Potential

For carrying out the feeding potential of *C.septempunctata* eggs from stock culture were used and kept in separate petri dishes. After hatching from eggs, the first instar grubs of *C.septempunctata* were transferred into petri dish (9cm diameter) with the help of camel hair brush. For feeding potential, 1st instar grubs were placed in different petri dishes. They were provided with known number of aphids. In order to record consumption rate, the number of aphids left out after 24hr were counted. The number of aphids consumed during 24hr was recorded and whole experiment was repeated four times but with increased number of known aphids. A similar method was followed to record consumption rate of second, third and fourth instars using known number of aphids for each instar. For feeding potential of adults known number of aphids was given to them. Consumption rate was recorded after 24 hr interval by counting the number of live aphids. Whole experimental was replicated five times by increasing number of aphids.

2.5 Data Analysis

Statistical analysis was done by using SPSS (Version 16.00), Minitab statistical software and MATLAB software. Further data was subjected to one way ANOVA using Tukey's test at 5%.

III.RESULTS AND DISCUSSION

3.1 Life history

3.1.1 Eggs

Female *C.septempunctata* laid clusters of bright yellow, smooth and cigar shaped eggs. On an average 42 eggs were laid by female on each ovipositing day and each egg measures about 1.21 mm in length and 0.50 mm in breadth (TABLE I). In present experiment incubation period varies and ranges between 3-5 days with an average of 4 days under laboratory conditions. [17] Reported average mating period, ovipostion and fecundity as 43 minutes, 8 days and 44 eggs respectively nearly close to that in present studies. [18] Recorded incubation period of 3-4 days. [19] Recorded incubation period of 4.3± 0.81 days.

TABLE I. Measurement of egg of *Coccinella septempunctata*

Variable	N	Mean ± SD	Minimum	Maximum
Egg Length (mm)	10	1.21 ± 0.044	1.15	1.29
Egg Breadth (mm)	10	0.50 ± 0.017	0.47	0.53

N= number of observations

3.1.2 Larval Stages

The newly emerged grubs were dull coloured and with sluggish activity. On the basis of data recorded the larvae passed through four stages. Expected head width of each instar was also determined by Dyar's ratio [16] which shows growth ratio remains constant between the moults. Each instar was progressively longer the preceding instar (TABLE II).

TABLE II. Comparison of observed (mean) and expected values of head capsule width (mm) of the grubs of *Coccinella septempunctata*

Mean observed head capsule width of IST instar grub (N=10) = 0.25 mm

Mean observed head capsule width of 2nd instar grub (N=10) =0.39 mm

$$\text{Growth ratio (Dyar's ratio)} = \frac{\text{Head capsule width of 2nd instar grub}}{\text{Head capsule width of ist instar grub}}$$

= 0.39/0.25

=**1.5 mm**

Mean observed head capsule width of 4th instar (mature grub) (N=10) = 0.69 mm

Larval instars	Head capsule width (mm)			Difference (mm)
	Observed (Mean± SE)	Range	Expected[a]	
I	0.25 ±0.03	0.20- 0.35	0.25	0.00
II	0.39 ± 0.03	0.35- 0.50	0.37	0.02
III	0.52 ±0.02	0.50- 0.65	0.58	0.06
IV	0.69± 0.59	0.65- 0.80	0.78	0.09

[a]Expected head capsule width established by Dyar's ratio (1.5 mm). Multiplying Dyar's ratio with the observed head capsule width of 1st instar grub gives the expected head capsule width of 2nd instar which when multiplied again with Dyar's ratio gives expected head capsule width of 3rd instar and so on.

3.1.2(a) First instar grub

First instar was light black in colour possessing four dark black patches on each abdominal segment. The grub was about 1.77 mm to 1.84 mm in length and 0.4 mm to 0.6 mm in breadth. Total duration of first instar was found in range of 2.0 to 3.5 days under laboratory conditions.

3.1.2(b) Second instar grub

It is black coloured grub with more sclerotized. It possesses light patches on the dorsolateral and lateral on first and fourth abdominal segments. The length of second instar grub ranges between 3.2 mm to 3.7 mm and breadth 0.6 mm to 0.8 mm. Total duration was found in range between 2.0 to 3 days.

3.1.2(c) Third instar grub

It is light black in colour with well developed mouth parts. The dorsolateral and lateral patches on first and fourth abdominal segments are orange in colour. The length ranges between 5.1 mm to 6 mm and breadth 2.0 mm to 2.9 mm and total duration was found in range of 1.5 to 3 days.

3.1.2 (d) Fourth instar grub

It is deep grey in colour and final instar grub. Its size ranges between 10 mm to 10.9 mm in length and 2.8 mm to 3.5 mm in breadth and total duration of fourth grub ranges between 2 to 4 days. [20] Reported the mean duration of 1st, 2nd, 3rd and 4th instar grubs were 2.45 ±0.13, 2.20± 0.09, 2.45± 0.14 and 3.20±0.13 respectively which is in accordance with present study. However these were contradict with those of [19] who reported that mean duration of 1st, 2nd, 3rd and 4th instar grubs were 2.9 ±0.42, 4.69 ±0.47, 5.4±0.66 and 7.5 ±0.58 days respectively.

3.1.3 Pupal stage

The pupa is yellow in colour which later develops black marking on its dorsal side. Anterior portion of pupa is oval while posterior end is irregular in shape. In early pupa eyes are not clearly visible but in later stage a pair of compound eyes are found on head region which is slightly curved towards the ventral side. The pupa measures 6.1 mm in length and 3.8 mm in breadth. The pupal duration ranged from 4 to 8 days with a mean of 5 days under laboratory conditions. [21] Reported the pupal period was 6.4 days on *Aphis gossypii* and [22] reported 5.35 ±0.15 days on *Lipaphis erysimi.*

3.1.4 Adult

On emergence from pupa, the elytra and the wings are light yellow in colour with no spotting. After that spots start appearing and gradually turn distinctly black in colour. Adults are ovoid in shape having convex dorsum. The elytra were red in colour with black spots of nearly rounded in shape. There were seven spots and all of them were equal in size. Three spots were on each elytron while seventh spot was on middle close to head. On an average adult measures 7 mm in length and 5.9 mm in breadth. [20] reported 84.62±1.41 and 87.33±1.35 the mean adult male /female longevity. *C. septempunctata* was found to complete its life cycle from egg stage to adult emergence 20 to 30 days with a mean of 23 days under laboratory conditions (TABLE III) (Fig.1).

TABLE III. Duration (in days) of different life stages of *Coccinella septempunctata* on aphid, *Brevicoryne brassicae*.

Parameter	Observations			Mean ±SD
	A	B	C	
Mating period (in minutes)	**60**	**45**	**40**	**48.33± 10.40**
Oviposition (in days)	**6**	**7**	**8**	**7.00 ± 1.00**
Fecundity (eggs in batch)	**62**	**40**	**32**	**44.66 ± 15.53**
Incubation period (in days)	**5**	**4**	**3**	**4.00 ± 1.00**
1st instar (in days)	**3**	**3.5**	**2**	**2.83 ± 0.76**
2nd instar (in days)	**2.5**	**3**	**2**	**2.50 ±0.50**
3rd instar (in days)	**2**	**3**	**1.5**	**2.16 ±0.76**
4th instar (in days)	**3**	**4**	**2**	**3.00 ±1.00**
Prepupal period (in days)	**2**	**2**	**2**	**2.00 ±0.00**
Pupal period (in days)	**5**	**6**	**3**	**4.66 ±1.52**
Male longevity (in days)	**84**	**80**	**87**	**83.66 ±3.51**
Female longevity (in days)	**87**	**88**	**90**	**88.33± 1.52**

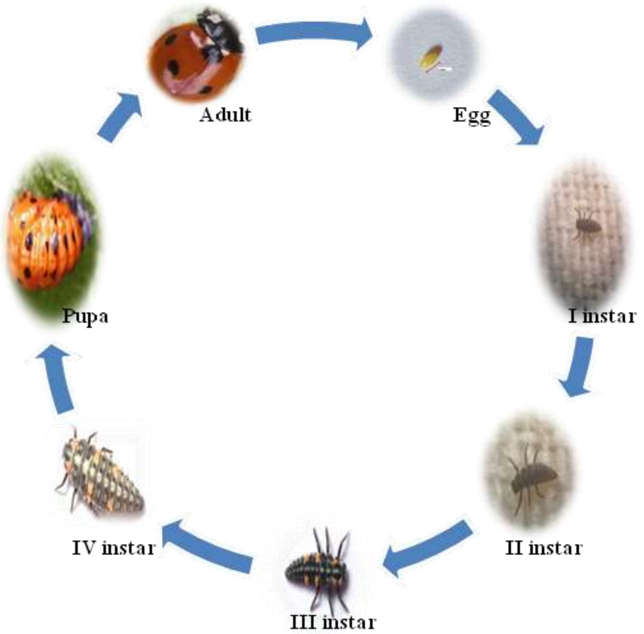

Fig.1. Life Cycle of *Coccinella septempunctata*

3.2 Feeding Behaviour

3.2.1 Feeding potential of grubs of *C. septempunctata*

The results obtained during the present study showed the comparative feeding rate of different grubs of *C. septempunctata* on *B.brassicae*. The present data showed that as grubs increased with age and as they underwent successive moulting to next instar the feeding rate also get increased. Similar observations were found by [17]. The results also revealed that all the grubs of *C.septempunctata* were voracious feeders; however the 4th instar devoured more number of aphids. [23] [24] reported that larvae of lady bird beetle, *C.septempunctata* behaved aggressively and their feeding on aphids was voracious.

When the data was subjected to one way ANOVA, the results revealed that in first instar grub treatment I, II and III were significantly similar to each other but IV treatment was found insignificant to treatment I and significant to II and III treatment at $p \leq 0.05$ (TABLE IV). In second instar grub treatment I was found significantly similar to II treatment but insignificant to III and IV treatment (TABLE V). Likewise in case of third instar grub treatment I and II were significantly similar to each other but different from IV treatment. Treatment III and II were also significantly similar to each other but show insignificance difference with IV treatment (TABLE VI). In fourth instar grub all the four treatments were found significantly different. This showed that increase in number of aphids offered is significantly different (TABLE VII). Also aphid consumption of 1st, 2nd, 3rd and 4th instar grubs of *C.septempunctata* was affected significantly by host density. The mean aphid consumption under host density of 40 in four instars was 37.5%, 70%, 87.5% 95% respectively under laboratory conditions. Similarly mean aphid consumption under host density of 60 in four instars was 36.6%,6.6%, 70%,91.6% resp. under host density of 80 it was 31.24%,53.75%,65%,95% resp. and for 100 it was 28%,50%,66%,93% resp.

The statistical data showed that 4th instar grub consumed more aphids than any other grubs. [5], [25] and [19] also reported that among all larval stages, 4th instar fed voraciously for many days (Fig.2).

TABLE IV. Feeding potential of first instar grub

Treatments	No. of Aphids offered	Mean of Aphids consumed* (Consumption)	Mean Consumption (Percentage %)
I	40	15± 4.35[a]	37.5
II	60	22± 3.00[ab]	36.6
III	80	25± 2.64[ab]	31.25
IV	100	28± 6.24[b]	28

*Mean of 3 replications/treatment. Mean followed by same letter in each column are not significantly different by Tukey's test at 5%.

TABLE V. Feeding potential of second instar grub

Treatments	No. of Aphids offered	Mean of Aphids consumed* (Consumption)	Consumption (Percentage %)
I	40	28 ± 2.64[a]	70
II	60	34 ± 3.00[ab]	56.6
III	80	43 ± 5.00[bc]	53.75
IV	100	50 ± 3.00[c]	50

*Mean of 3 replications/treatment. Mean followed by same letter in each column are not significantly different by Tukey's test at 5%.

TABLE VI. Feeding potential of third instar grub

Treatments	No. of Aphids offered	Mean of Aphids consumed* (Consumption)	Consumption (Percentage %)
I	40	35±3.60a	87.5
II	60	42±3.60ab	70
III	80	52±4.58b	65
IV	100	66±3.60c	66

*Mean of 3 replications/treatment. Mean followed by same letter in each column are not significantly different by Tukey's test at 5%.

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TABLE VII. Feeding potential of fourth instar grub

Treatments	No. of Aphids offered	Mean of Aphids consumed* (Consumption)	Consumption (Percentage %)
I	40	38±6.55[a]	95
II	60	55±3.00[b]	91.6
III	80	76±3.60[c]	95
IV	100	93±5.00[d]	93

*Mean of 3 replications/treatment. Mean followed by same letter in each column are not significantly different by Tukey's test at 5%.

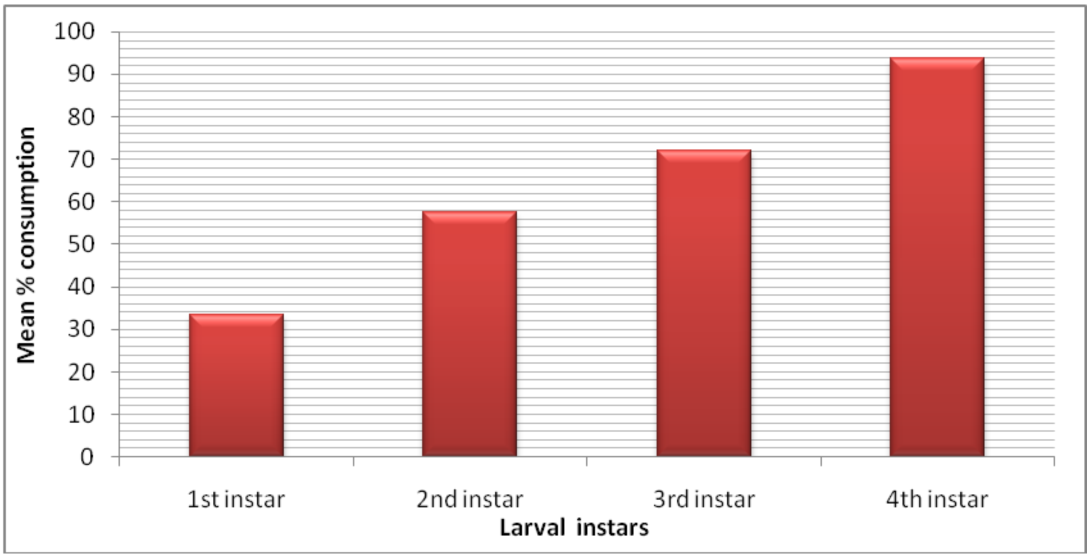

Fig.2. Graph showing mean consumption of aphids by different grubs of *Coccinella septempunctata.*

3.2.2 Feeding potential of Adults

The feeding potential of adult male and female of *C. septempunctata* on aphid, *B. brassicae* was done under similar conditions as in grubs. The one way ANOVA results revealed that in adult male all the four treatments were insignificant to each other at P≤0.05 (TABLE VIII). Similarly in adult female all the four treatments were found insignificant to each other (TABLE IX).The data showed that adult female consumed more than adult male. The higher prey consumption rates of adult females may be due to a higher nutrient requirement for special purposes such as egg production, or due to delayed satiation [26] or due to possible faster digestive rate of adult females [27]. Mean aphid consumption under host density of 120 in adult male and female was 95.83% and 98.33% resp. Likewise mean aphid consumption under host density of 140 was 97.14% in males and

97.85% in females, under host density of 160 it was 98.12% in males and 98.12% in females and for 180 it was found that consumption rate in males was 97.77% and in females it was 99.4% (Fig.3).

TABLE VIII. Feeding potential of adult Male

Treatments	No. of Aphids offered	Mean of Aphids consumed* (Consumption)	Consumption (Percentage %)
I	120	115±5.03[a]	95.83
II	140	136±2.00[b]	97.14
III	160	157±2.64[c]	98.12
IV	180	176±3.00[d]	97.77

*Mean of 3 replications/treatment. Mean followed by same letter in each column are not significantly different by Tukey's test at 5%.

TABLE IX. Feeding Potential of adult Female

Treatments	No. of Aphids offered	Mean of Aphids consumed* (Consumption)	Consumption (Percentage %)
I	120	118±1.00[a]	98.33
II	140	137±2.00[b]	97.85
III	160	157±2.00[c]	98.12
IV	180	179±1.50[d]	99.4

*Mean of 3 replications/treatment. Mean followed by same letter in each column are not significantly different by Tukey's test at 5%.

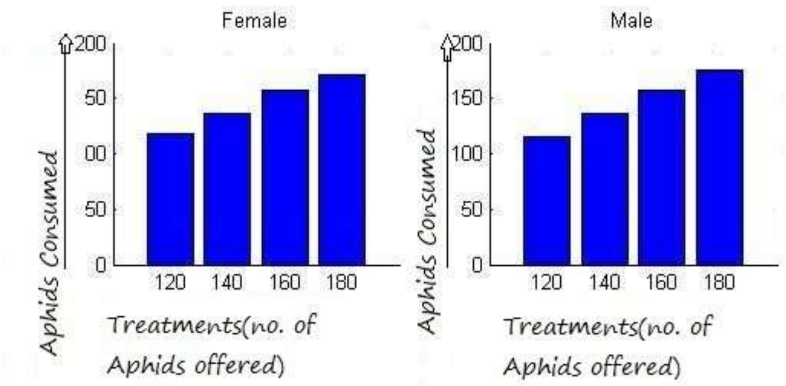

Fig.3. Graph showing Consumption of Aphids by male and female *Coccinella septempunctata*

IV. CONCLUSION

C.septempunctata has proved its efficiency as an important bio control agent against aphids. The present study revealed that the species completes its life cycle in 20 to 30 days with mean of 23 days. Due to its short life cycle it can be successfully used for mass rearing and then its establishment in pest prevalent regions. With respect to the feeding potential of *C. septempunctata* the results showed that it is the main predator of aphids (*B. brassicae*) and can be used best as biological control against aphid species. It has been recorded that both grubs and adults voraciously predated on aphid species. Also the aphid density greatly affected the feeding potential. At higher density, predation was higher and at lower density the rate of predation was also observed low. This seems to be a good quality of the predator to feed more at higher prey density and less at lower prey density. This quality of predator not only allows the predators to survive at low prey density but also helps in reducing pest population at higher density. This can prove efficient management strategies for the control of aphid species in horticulture and cropland habitat.

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