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Feeding potential and life table of lady bird beetle (*Coccinella septempunctata* L.) grub on crape myrtle aphid (*Tinocallis kahawaluokalani*) under laboratory conditions

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Abstract
The research was conducted to investigate the feeding potential, oviposition, larval and pupal stages of Lady Bird Beetle (*Coccinella septempunctata*) on Crape Myrtle Aphid (*Tinocallis kahawaluokalani*). The research was conducted at the department of Entomology Laboratory, PMAS Arid Agriculture University Rawalpindi. It was observed that feeding potential of the 1st, 2nd, 3rd and 4th larval instar of *C. septempunctata* was affected significantly (P<0.05) by host density. The feeding potential of *C. septempunctata* were observed, the offered aphids were 17, 20, 20 and 30. The average aphids consumed were 9±0.10, 12±0.80, 12.4±1.1 and 23±1.4 by the 1st, 2nd, 3rd and 4th instar of *C. septempunctata* grubs, respectively. Feeding potential increased while the host density increased significantly 9±0.10, 12±0.80, 12.4±1.1 and 23±1.4. The *C. septempunctata* Consumption percentage were also increased 52.9±0.60, 60±4.00, 62.1±5.81 and 85.4±1.9 on all the grub instars, respectively. The *C. septempunctata* life table stages were observed i.e., oviposition period, total number of eggs laid, total number of grubs emerged, eggs incubation period and hatchability percentage. The average eggs layed was 88.6, average number of grubs emerged was 82.8, average eggs incubation period was 3.6 days and the total hatching percentage was 86.2%. The mean larval period completion was 13.5 days and pupal stages completion was 5.2 days respectively.

Keywords: Feeding potential, *Coccinella septempunctata* and crape myrtle aphid

1. Introduction
Crape myrtle *(Lagerstroemia indica* L) is widely commercialized ornamental shrub and is native to temperate in many tropical and subtropical regions of the world [1]. It is widely cultivated throughout the Mediterranean region, as well as in other warm regions as for its colorful and long-lasting flowers. It is high valued as a landscape, heat and drought tolerance plant. It is very important for the host plants to be in good physiological health and to be clean from pests and disease. Insect species frequently decreases the quality of ornamental plants and leads to economic losses, making it necessary to study its pest-risk assessment. Under favorable weather condition pest population builds very rapidly and requires repeated application of insecticides to control this dreaded pest, thereby necessitating the exploitation of biocontrol agents.

Crape myrtle aphid (*Tinocallis kahawaluokalani*) belongs to the family Aphididae is a major arthropod pest and it was first time detected in Bulgaria greenhouse (located nearby Black Sea) at the end of May and early in June in 2009. *T. kahawaluokalani* has been reported from North America [2, 3], Hawaii [4], Thailand [5], China, Taiwan, Japan [5, 2] and India [6]. They are pale yellow with dark brown markings on the head and prothorax. The antennae are 6 segmented, the processus terminal is less than 1.5 times as long as the base of the sixth antennal segment. Paired tubercles on the tergum of the first and second abdominal segments and dark veins on the forewings are very distinctively marked and easily identified. Winged viviparous females reach lengths from 1.02 to 1.8 mm. *T. kahawaluokalani* is a monoecious and holocyclic species, producing oviparous female and a late males in autumn [7]. It often infests plants in ornamental nurseries and landscapes on underside of leaves and is particularly attracted to a new growth [8].

The biological control of aphids by coccinellid predators is of great importance due to the predaceous habit of both grub and adult [9]. When coccinellid feed on aphids the beetles always start laying bunches of eggs [10]. The family of Coccinellidae is very voraciously feeder and has great value. The predators and many other insects controlling the crop pest and helping the farmers and keep the crop pest incidence below below threshold level [11].

Functional response is usually measured to provide insights into the suitability of a predator as a biological control agent. The type of functional response, that is the shape of the relationship of the number prey eaten to the prey available, influences the dynamics of the predator prey population and may contribute to the stability of predator prey systems [12, 13]. Thus the objectives of this study were to determine the effect of aphid density on the number of aphids consumed or killed by the predator.

The present study was carried out to check the feeding potential of the grub of *C. septempunctata*, oviposition, fecundity, longevity of larval and pupal stage feeding on natural diet the Crape Myrtle aphid (*T. kahawaluokalani*).

2. Materials and Methods

The present study was conducted in biocontrol laboratory PMAS Arid Agriculture University, Rawalpindi in 2012. The research was conducted under control lab condition. The temperature, relative humidity and light duration were fixed at 25 °C, 50-60% RH and 14 D: 10L on growth chamber.

2.1 Sample collection

Adults of lady bird beetle (*C. septempunctata*) were collected from the Agriculture fields and reared at biocontol laboratory. The beetle each pairs were selected for oviposition and kept into the separate petri dishes to get the batches of eggs for the experiments.

2.2 Feeding potential of *C. septempunctata*

Feeding potential of *C. septempunctata* grubs and adult were observed on different instars against prey densities *of T. kahawaluokalani*. The grubs of first, second, third and fourth instars of *C. septempunctata* were obtained from the culture maintained in the laboratory for experimentation. To the each grub instar the different number of prey density was provided along with crape myrtle leaves. All the treatments were replicated 10 times and observe after 24 hour interval. The numbers of consumed and unconsumed aphids were counted to ascertain the feeding potential of the predator till the grub entered into the pupal stage. The record of dead aphids in each petridish was also maintained.

2.3 Study of life stages

In the experiment the lady bird beetle adult pairs were collected from the field and reared in the laboratory. The each paired were reared in separate Petri dishes. The eggs laid by each paired in separate Petri dishes the eggs batches were record for the following parameters.

2.3.1 Eggs laying potential

The different lady bird beetle adults paired were reared in separate Petri dishes to observe that how many eggs were laid by signal pair.

2.3.2 Oviposition duration

The each paired lady bird beetle laid eggs were kept separately in Petri dish and observed the oviposition period that in how many days the eggs will hatch.

2.3.3 Total number of grubs emerged:

The total number of eggs laid by each paired were observed that from the total number of each eggs how many eggs were successfully hatched and how many spoiled. The averages were worked out.

2.3.4 Eggs incubation and hatchability percentage:

The eggs laid by each paired were observed that in how many days the grubs were emerged and from the total number of eggs laid the hatching percentage were worked out.

2.4 Statistical Analysis of Data

The data was arranged for replication for the analysis of variance to assess the significant differences in aphid functional response by *C. septempunctata* up to fourth instar of grubs.

3. Results and Discussion

3.1 Functional response of *C. septumpunctat*

Regarding the feeding efficiency of *C. septempunctata* the 1st, 2nd, 3rd and 4th larval instar the average aphid consumption was increased significantly 9±0.10, 12±0.80, 12.4±1.1 and 23±1.4 with increasing host density 17, 20, 20 and 30 of aphids (Table 1), whereas the average consumption percentage were also increased 52.9±0.60, 60±4.00, 62.1±5.81 and 85.4±1.9 respectively under controlled conditions. The fourth instar grub consumed 23±1.4 aphids when the aphid density was 27, which is 85.1% of the total aphid population. The average consumption of fourth instar grub was found 23±1.4 when the corresponding prey density was maintained at 25, 25, 25, 30, 30, respectively. This study revealed that the functional response of fourth instar grub was found to be the maximum, followed by the third instar, and second instar grub. There is no literature to corroborate the present findings. However [14] elucidated the functional response of the third instar grub of *C. septempunctata* showing a non-linear relationship between the amount of consumption and the density of *T. kahawaluokalani*. They have further reported that an individual of third instar grub consumed 20 aphids per predator at the prey population of 20 aphids but consumed more aphids, i.e. 349 ± 26.8 aphids at a density of 1600 aphids during the same period of 24 hours. The functional response of the grub is of type-2 of [15]. The present finding evidenced that the prey density has a significant influence on the rate of prey consumption.

Attempts to investigate the biology and feeding potential have also been made by these workers but very little information is available on effect of prey density on feeding efficiency whereas several workers reported that the predator feeds on more aphids at higher density because the probability of contact was greater at higher prey density than at lower density. This study confirmed the results of the study of [16] which reported that *C. septempunctata* is unable to detect its prey either by vision or by olfaction and the search is random [17]. The probability of contact with the prey at a higher density would tend to increase per unit area. However, [18] reported that aphidophagous *coccinellids* are attracted to higher prey population. Thus, it was concluded that the aphid density greatly affected the feeding potential. Under higher host density, less distance will be covered by the ladybirds as compared to those under lower host density.

Functional response of grubs of *Coccinellid* has been deputed in (Table.1). The first instar larval period last for 2 days, 17 aphids were supplied and grubs consumed 9±0.10 aphids and percentage consumption of 52.9+0.60. Similarly second instar larvae last for 2 days 20 aphids were given and 12±0.80 aphids were consumed with consumption percentage of 60±4.00. In third instar larvae persist for 4 days and of 20 aphids were supplied and of 12.4±1.1 aphids were consumed with consumption % age of 62.1±5.81. Fourth instar last for five days and consumed 23 aphids per day when 27 aphids were given 23±1.4 average SEM were consumed consumption with % age of 85.4±1.9.

In India, 72 species of aphidophagous coccinellids were reported by [19, 6]. *C. septempunctata* and *C. transversalis* were the most important. [20, 21] reported that these predators feed on 15 different aphid species in India and are an important natural biocontrol agent of aphids.

Insect pests have always been a threat to agriculture productivity in Pakistan, in result the crop productivity per unit area is still far less than the potential exists or when comparison is made with the achievements of advanced agricultural countries of the world. Thus for controlling these harmful insects, different chemicals (pesticides) are applied against different insect pests [22].

1. Total number of eggs laid by each predator pair
2. Oviposition period
3. Total number of eggs layed
4. Total number of grubs emerged
5. Eggs incubation period and hatchability percentage

Table 1: Aphid consumption by different larval instars of *C. Septempunctata*

Instars	Age (days)	Aphid offered (number)	Aphids consumption (number)	Consumption (%)
First instar	1st	17	8.9	52.3
	2nd	17	9.1	53.5
	Mean	17	(Av. SEM) 9±0.10	(% SEM) 52.9±0.60
Second instar	3rd	20	11.2	56
	4th	20	12.8	64
	Mean	20	(Av. SEM) 12±0.80	(% SEM) 60±4.00
Third instar	5th	20	12.5	62.5
	6th	20	10.6	53
	7th	20	10.9	54.5
	8th	20	15.7	78.5
	Mean	20	(Av. SEM) 12.4±1.1	(% SEM) 62.1±5.81
Fourth instar	9th	25	20	80
	10th	25	20.4	81.6
	11th	25	22.3	89.2
	12th	30	26.5	88.3
	13th	30	26.5	88.3
	Mean	27	(Av. SEM) 23±1.4	(% SEM) 85.4±1.9

3.2 Oviposition, larval and pupal durations of *C. Septempunctata.*

Oviposition percentage of *C. Septempunctata* is given in (Table.2). In the five replications R1, R2, R3, R4 and R5 the mean oviposition was 88.6 but the highest number eggs layed in (R3) were 35 eggs fallowed by (R2) 31, (R5) 23, (R4) 12 and (R1) 6 eggs respectively. The highest hatchability percentage was recorded on (R4) 100% because from 12 layed eggs 12 larvaes were emerged with the incubation period of 4 days fallowed by (R3) 94.12, (R2) 93.54, (R1) 83.33 and the lowest hatchability percentage was recorded on (R5) 60.8% because 14 larvaes were emerged out of 23 with the incubation period of 2 days. Mean larvaes emerged from the total eggs were 82.8 and the Mean Incubation period days was recorded 3.6.

3.3 Larval and Pupal Stages durations of *C. Septempunctata*

Larval and pupal stages duration is shown in the (Table.3). Ten replications were observed and average larval duration period was found 13.5 days and average pupal duration period was observed 5.2 days. So it means that the total larval period of *C. septempunctata* completed in 13.5 days and the pupal duration completed in 5.2 days.

This study confirmed the results of the study of [23] reported that the pupal stage may last from 3-12 days depending upon availability of food and temperature.

Table 2: Eggs Hatchability or Oviposition % age of *C. septempunctata*

No. S	Oviposition starting date	Hatching Date	Total Numbers of Eggs	Total Number of Larva emerged	Incubation Period Days	Hatching %
1	(R1) 19-10-2011	22-10 2011	6	5	3	83.33
2	(R2) 17-10-2011	22-10-2011	31	29	5	93.54
3	(R3) 20-10-2011	25-10-2011	35	34	4	94.12
4	(R4) 22-10-2011	26-10-2011	12	12	4	100
5	(R5) 22-10-2011	26-10-2011	23	14	2	60.8
Mean			88.6	82.8	3.6	86.2%

Table 3: Larvel and Pupal stages durations of *C. septempunctata*

No. S	Complete Larvel Period Duration in (Days)	Complete Pupal Duration Period Days
1	(R1) 13	5
2	(R2) 13	5
3	(R3) 15	6
4	(R4) 14	6
5	(R5) 13	5
6	(R6) 13	5
7	(R7) 14	5
8	(R8) 14	5
9	(R9) 13	5
10	(R10) 13	5
Mean	13.5	5.2

(R) Replication number.

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