**Comparative Study of the Biology of *Coccinella septempunctata* (Coleoptera: Coccinellidae) Reared on Four Artificial Diets and Two Species of Aphids (Homoptera - Sternorrhynca: Aphididae).**

BY

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**ABSTRACT**

Laboratory experiments were carried out to study some biological aspects of the seven spotted ladybird beetle, *Coccinella septempunctata* L. (Coleoptera: Coccinellidae) reared on four different artificial diets and two natural prey species (*Aphis fabae* and *Rhopalosiphum padi*) under laboratory conditions of 25±2 ̊C and 65±5 % R.H. Data indicated a positive correlation between food type (artificial or natural) and biological characteristics of the predator. *A. fabae* was the best prey for *C. septempunctata,* as the incubation periods of eggs was (4.58 days),the hatchability percentage (93.6%), eggs mortality (6.4%) and shortest total larval period (15.15 days) were recorded. The total larval mortality was the lowest (4%) when larvae were fed on 4th instar larvae of *A. fabae.* Feeding on natural preys, specially, on *A. fabae*, led to adults had longer longevity periods (57.06 days for females and 40.96 days for males) than those fed on the artificial diets. Also, females resulted from feeding on *A. fabae* deposited highest numbers of eggs (565.67eggs/ female). *R. padi* followed *A. fabae* as good diet for rearing *C. septempunctata*. Among the four artificial diets, diet (B; dried eggs yolk) was the best; as the incubation period of egg recorded (5.7 days), hatchability percentage (77.20%), mortality percentage of eggs (22.8%), total larval period (19.08 days), total larval mortality (24%) and longevity periods were (57.37 days for females and 33.81 days for males). Females resulted from feeding on diet (B) deposited (212.13eggs/ female). Diet (D) followed diet (B) giving promising results. The artificial diet (A) gave the least values of the characteristics of the predator *C. septempunctata*.

**Key word:** *Coccinella septempunctata* - Aphids - Artificial diets - Biology - Feeding capacity.

**INTRODUCTION**

The family Coccinellidae is comprised of 5,200 described species worldwide (**Hawkeswood, 1987).** Coccinellids occupy various habitats; have a high searching capacity, and a wide range of prey species as, aphids, scale insects, mites, mealy bugs, leaf-hoppers and other soft bodied insects (**Jalali *et al.,* 2009 and Sharma and Joshi 2010**). When the prey is abundant, they are voracious feeders in the larval and adult stages. Coccinellids demonstrate a strong tendency towards increased oviposition with increased food consumption **(Hodek and Honek, 1996).**

The seven spotted ladybird beetle aphidophagous species *Coccinella septempunctata*L.is one of the most important predators of aphids. At its larval and adult stages, it feeds on aphids and suppresses their populations **(Sarwar and Saqip, 2010). Ashraf (2010)** indicated that *C. septempunctata* growth rate of population size has been affected by the type of food and temperature. Furthermore, fecundity and longevity parameters have to coincide with its egg - laying capacity and are directly affected by type of diet available (**Rondoni *et al,* 2014).**

Aphids are very serious piercing and sucking insect pests feeding by sucking the plant sap mainly through leaves and growing tips. They are controlled, mainly, by different chemical insecticides leading to environmental pollution and insects’ resistance to insecticides. The extensive and repeated use of insecticides has disrupted the natural balance between these pests and their natural enemies **(Amer and Marei, 2001)**. To protect the plants and environment, biological control of aphids is a good tool for their control to substitute the highly toxic insecticides **(Bellows, 2001).** Aphids should be available during the rearing time to maintain the predators rearing process **(Mahyoub *et al.,* 2013).** Among ladybeetles, *C. septempunctata* L. is the most effective predator upon *Aphis gossypii* Glover, which is an economically important pest of melon. Also, this predatory beetle is important as active predator on *B. tabaci* nymphs on different agricultural crops **(Khan, and Wan, 2015).**

Development of artificial diets has facilitated mass rearing of some predatory insect species for biological control purposes. Over the last century, much intensive research has been carried out on recipe optimization, functional supplementary components and rearing substrate material of artificial diets **(Bruzzone *et al.,* 1990 and Murai *et al.*, 2001)**. In addition, components of the artificial diets, properties and state (liquid or solid) can strongly affect feeding efficiency of mass-reared coccinellid species (**Bukero *et al.*, 2015).**

The present study was carried out to investigate the biology of *C. septempunctata* when reared on four different artificial diets compared with nymphs of two species of aphids as a natural prey species.

**MATERIALS AND METHODS**

**Stock culture of the aphids**

Faba bean aphid *Aphis fabae* (scop) (Homoptera: Aphididae) was used as a laboratory prey stock culture for experiments.

Heavily infested faba bean seedlings with *A. fabae* were brought from Syngenta Center that were collected from faba bean fields at Qaha, Qalubia Governorate. Stock culture of this aphid species was reared under laboratory conditions of 25±2 ̊C and 65±5 % R.H. Dense culture of this aphid, soon, became available through parthenogenetic multiplication. So, enough quantities of aphids were always available for achieving desired experiments. The following technique was followed:

* Broad bean (*Vicia faba*) seeds were planted in plastic pots containing wet sawdust. Pots were placed in muslin screen cages to protect aphids from any natural enemies.
* The seeds were sown at 1-2 cm depth and followed with daily irrigation.
* Once the first leaves of seedlings started to appear, about five days from sowing.
* Old infested faba bean leaves were cut with a scissor and placed, gently, between the new seedlings. Within few hours, the aphids move and climb to the new seedlings and multiplied on them.

The infested seedlings were daily monitored until the population of *A. fabae* increased and became enough to be used as prey for feeding the ladybird beetles.

**The Bird cherry-oat aphid *Rhopalosiphum padi*:**

Individuals of *R. padi* were brought as heavily infested wheat seedlings from the Department of Biological Control, Plant Protection Research Institute, A.R.C. at Giza, Egypt. Infested seedlings were transferred to the Biological Control Laboratory, Dept. of Plant Protection, Faculty of Agriculture at Moshtohor, for rearing the predator. Aphid individuals were translocated to clean uninfested wheat seedlings grown under laboratory conditions of 25±2˚C and 65±5 %R.H. Wheat grains were planted in plastic pots placed in muslin screen cages kept in the laboratory. New uninfested seedlings were exposed for infestation by *R. padi* every three days to insure enough quantities of aphids as prey for coccinellids during the whole period of experiments.

Strong cultures of the two aphid species were available during the rearing time so that enough quantities of all of the 4 nymphal instars of *A. fabae* and *R. padi* were available to achieve the desired experiments on *C. septempunctata*.

**Stock culture of the coccinellid predator**

**On natural preys:**

Every five pairs (males and females) of the predator *C. septempunctata* were placed in a glass chimney cage, covered on the top with muslin cloth pieces set in position by rubber bands. Each glass chimney cage was provided with pieces of black paper for egg-laying. The predator was provided daily with fresh leaves infested with adequate numbers of *A. fabae* individuals to serve as food. Female adults deposited their eggs on the leaves of faba bean seedlings or on black paper strips. Deposited eggs were, daily, counted and placed in Petri-dishes for starting the rearing of the predator, after hatching. The hatched larvae of the predators were provided daily by adequate numbers of aphids, until pupation. Resultant pupae were kept in another cage until adults’ emergence. The same technique was followed for rearing *C. septempunctata* on *R. padi.*

**On artificial diets:**

To reach the most suitable artificial diet for rearing *C. septempunctata*, many artificial diets were prepared and offered to the predator larvae and adults. Only, four of these artificial diets showed promising results. *i.e.,* as they led the predator to complete its life-cycle. Components of the four artificial diets are shown in Table (1). The four artificial diets were; A (dried milk diet), B (dried yellow eggs yolk), C (chicken liver) and D (wheat seeds germ diet).

For preparing each of the four diets, the same method described by **Bahy El-Din (2014)** was followed in this investigation.

**Biological characteristics of *C. septempunctata***

**Incubation period of eggs and hatchability percentages:**

Five groups of freshly deposited eggs, 50 each, from females that were reared on either of the natural preys (*A. fabae* and *R. padi****)*** or the artificial diets under the laboratory conditions of 25±2 ̊C and65±5% R.H., were transferred to clean Petri-dishes until hatching. At the time of hatching the incubation period of egg was estimated among eggs of each group (5 replicates). Percentage of eggs hatching and that failed to hatch were, calculated.

**Table (1): Components of four tested artificial diets used for rearing *C. septempunctata.***

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **NO.** | **Ingredients** | **Weight (in gm)** | | | |
| **(A)** | **(B)** | **(C)** | **(D)** |
| 1 | Dried milk | 17.54 | 0.00 | 0.00 | 0.00 |
| 2 | Dried yellow eggs yolk | 0.00 | 20.48 | 0.00 | 0.00 |
| 3 | Chicken liver (powdered) | 0.00 | 0.00 | 17.00 | 0.00 |
| 4 | Wheat grain germ | 0.00 | 0.00 | 0.00 | 17.61 |
| 5 | Fresh aphid | 1.00 | 1.00 | 1.30 | 1.30 |
| 6 | Dry powdered aphid | 3.11 | 3.16 | 3.50 | 3.60 |
| 7 | Sugar (powder) | 56.70 | 56.00 | 57.00 | 57.80 |
| 8 | Yeast (powder) | 5.60 | 3.20 | 6.55 | 4.80 |
| 9 | Pollen grains | 5.74 | 6.00 | 4.60 | 5.74 |
| 10 | Maize oil | 1.20 | 1.12 | 1.22 | 1.20 |
| 11 | Royall jelly | 1.60 | 4.00 | 3.50 | 2.00 |
| 12 | Bee honey | 2.10 | 2.00 | 1.43 | 1.60 |
| 13 | Multi- vitamins | 3.00 | 1.04 | 2.50 | 2.16 |
| 14 | Streptophenicol | 2.41 | 2.00 | 1.40 | 2.10 |
| Total | | 100 | 100 | 100 | 100 |

**A** (dried milk diet). **B** (Dried yellow eggs yolk).

**C** (powdered Chicken liver). **D** (Wheat grain germ).

**Durations of larval and pupal stages**

**On natural preys:**

For estimating the larval and pupal durations, a group of twenty five neonate *C. septempunctata* larvae were placed, individually, in plastic cups lined with filter papers. Each larva was daily provided with counted enough number of aphid nymphs (starting with 30 nymphs/larva/day). The offered nymphs were increased as the larvae grew older. The numbers of consumed aphids were counted and recorded. Depending upon detection of the larval exuviae, the duration of each larval instar and the total larval period were estimated and recorded. As the larvae pupated and the emergence of *C. septempunctata* adults occurred the total larval and pupal periods and percentage of adults’ emergence were estimated. Mortality percentages among larvae and pupae were estimated.

**On artificial diets**

The same technique, used for rearing *C. septempunctata* on *A. fabae* and *R. padi,* was followed in case of rearing on the artificial diets (A, B, C or D). One gram from each diet was placed on the filter paper in the plastic cups for feeding different larval instars. The artificial diets were replaced by new fresh diets every three days .The larvae were daily examined to record durations of each larval instar, total larval period and the pupal period. Mortality rates among larvae and pupae were recorded.

**Effect of feeding on natural and artificial diets on longevity and fecundity of *C. septempunctata***

Fifteen couples of *C. septempunctata* adults (15males and 15 females) representing 15 replicates were used in the experiment. Every couple was confined in a glass chimney supplied with black paper stripes and offered the natural or artificial diet. Longevity, fecundity and ovipositional periods (pre-oviposition, oviposition and post-oviposition periods) were also estimated.

**Statistical analysis**

Statistical analysis was carried out by using the least squares procedures for analyzing the data as described by **SAS (1996)**. The data measured as percentages were subjected to arcsine transformation to approximate normal distribution before being analyzed. Tests of significance for the differences between means were carried out according to **Duncan (1955)**.

**RESULTS AND DISSCUSSION**

**Durations of immature stages**

**Incubation period of eggs and hatchability and mortality percentages**

From data presented in Table (2), it is observed that the means of incubation period of *C. septempunctata* eggs obtained after rearing on artificial diets, were generally, longer (5.7-7.9 days) than those recorded on aphids (4.58 and 5.04 days, respectively). Shortest incubation period (4.58 days) was insignificantly shorter than that recorded on *R. padi* (5.04 days), and significantly, shorter than those recorded on the artificial diets.

Comparing the means of incubation period of eggs after rearing on the tested artificial diets, the shortest period (5.7 days) was recorded on diet B ( dried yellow eggs yolk), being insignificantly different from that reared on *R. padi* and diet D (Wheat seeds germ diet) (5.04 and 5.96 days, respectively). Whereas, rearing *C. septempunctata* on chicken liver (C) or dried milk (A) diets led to eggs that manifested the, significantly, longer periods (7.58 and 7.9 days, respectively) than those recorded from of the remaining diets.

As for the hatchability percentages of the deposited eggs, those recorded after rearing on the two natural preys (*A. fabae* and *R. padi*) (93.6 and 90%, respectively) were, significantly, higher than those recorded on the artificial diets. Among the 4 artificial diets, the highest hatching percentage (79.2%) resulted after rearing on the wheat seeds germ diet (D), followed by the dried yellow egg yolk diet (B; 77.2%), the chicken liver diet (C; 72.8%). dried milk diet (A; 48%). Consequently, rearing on diet (A) led to, significantly, the highest mortality percentage (52%) followed, descendingly, by diets C (27.2%), B (22.8%) and D (20.8%). While, rearing on *A. fabae* and *R. padi* led to, significantly, lower mortality percentages (6.7 and 10 %, respectively; Table, 2).

**Table (2): Incubation period of eggs and percentages of egg hatchability of *C. septempunctata* after rearing on four artificial diets and two aphid species under laboratory conditions.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Eggs**  **Tested diets** | **Incubation period** | **Hatchability %** | **Mortality %** |
| **A** | 7.90±0.19 **A** | 48.00±1.91 **D** | 52.00±2.15 **A** |
| **B** | 5.70±0.19 **CB** | 77.20±1.91 **CB** | 22.80±2.15 **CB** |
| **C** | 7.58±0.19 **A** | 72.80±1.91 **C** | 27.20±2.15 **B** |
| **D** | 5.96±0.19 **CB** | 79.20±1.91 **B** | 20.80±2.15 **CB** |
| 1. ***fabae*** | 4.58±0.19**D** | 93.60±1.91 **A** | 6.40±2.15 **D** |
| ***R. padi*** | 5.04±0.19 **CD** | 90.00±1.91 **A** | 10.00±2.15 **D** |

\*Data are presented as means±standered error. \*\*Means followed by different letters in each column are significantly (p<0.05)different. \*\*Data from (50 egss/ treatment).

**Larval and pupal stages**

In this experiment, the larvae of *C. septempunctata* were fed on the 2nd and 4thinstar nymphs of *A. fabae* and *R. padi* and the four artificial diets throughout the whole larval period. From data recorded in Table (3), the four larval instar durations were, significantly, longer when reared on diet (C) or diet (A). These durations were, significantly, shorter by rearing on diet (B) or (D). Rearing on either of the two aphid species in their 2nd or 4thinstars caused, significantly, the shortest durations than those on the artificial diets. Data concerning total larval durations showed the same trend of effectiveness of different diets on *C. septempunctata* larval durations (Table,2). Longer total larval periods (25.25 and 25.13 days) were recorded for larvae fed on diets (C) and (A), respectively. Among the 4 artificial diets, larvae reared on diets (B) and (D) manifested shorter durations (19.08 and 19.87 days, respectively). On the contrary, rearing on 2nd and 4thnymphal instars of *A. fabae* or *R. padi* led to much shorter total larval period (15.15 - 18.6 days; Table, 3). The shortest larval duration (15.15 days) was recorded after feeding on the 2nd nymphal instar of *A. fabae*, followed by that fed on *R. padi* of the same nymphal instars (15.38 days).

Regarding the mortality percentages among the different instar larvae of *C. septempunctata* during rearing on the 6 diets, data in table(3) confirmed much lower mortality rates by rearing on the natural diets {nymphs of *A. fabae* or *R. padi* (0 - 8 %)}, compared to those reared on the artificial diets (4.76 - 21.05%). The total larval mortality was the lowest (4%) when larvae were fed on 4th instar larvae of *A. fabae*, but reached a maximum of (44%) when they were reared on diet (A), followed by 40% by rearing on the diet (C). Generally, the total larval mortality percentages were much lower (4 - 16%) by rearing on aphids than when reared on the artificial diets (24 – 44%) (Table, 3).

On rearing the predator on the 4th nymphal instar of *A. fabae* or *R. padi*, all *C. septempunctata* pupae emerged to adults (100% emergence). While, among pupae obtained after rearing on the 2nd nymphal instar of the two aphid species; mortality percentages were 8.3 and 4.5 %, respectively, indicating (91.7 and 95.5%) emergence. On the contrary, by rearing on the 4 tested artificial diets, higher mortality percentages occurred among the obtained pupae (32- 44% ; Table, 4). Data indicated much lower percentages of adults’ emergence, being (56%) after rearing on diets (A) and (C), these percentages increased to (68%) after rearing on diet B.

**Feeding capacity of larvae**

Larvae of *C. septempunctata* showed voracity for feeding on 2nd and 4th instar nymphs of *A. fabae* and *R. padi*. Data in table (5) show that the consumption rate / larva increased as the predator larvae grew older to the subsequent instar. On the 2nd nymphal instar of *A. fabae*, a single larva consumed 26.08, 63.41, 106.04 and 297.77 nymphs during the 1st, 2nd, 3rd and 4th larval instars of the predator, respectively. The respective correspondent numbers of the consumed 4th nymphal instars were 16.8, 36.92, 71.04 and 261.38 nymphs. While, in case of *R. padi* nymphs, the consumed numbers of the 2nd and 4th nymphal instars by a *C. septempunctata* larva were higher than those of *A. fabae* nymphs (Table,5).

Throughout the total larval stage a single *C. septempunctata* larva devoured (442.16 and 375.16) of *A. fabae* 2nd and 4th instar nymphs, respectively, opposed to (631.84 and 467.92 nymphs of *R. padi*; Table,5). These data indicated that the larva was, significantly, more voracious on *R. padi* than *A. fabae* at the same nymphal instar. This may be attributed to smaller size of *R. padi* than that of the same instars of *A. fabae*. It could be also noticed that *C. septempunctata* larvae fed on fewer numbers of 4th instar nymphs (375.16 and 467.92 nymphs of *A. fabae* and *R. padi,* respectively)than that devoured from the 2nd instar of either of the two aphid species (442.16 and 631.84, respectively. (Table, 5).

**Table (3): Mean durations (days) of *Coccinella septempunctata* immature stages reared on 2nd and 4th nymphal instars of *A. fabae* and *R. padi* as natural preys and four artificial diets at 25±2 ̊C and 65±5% R.H.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Stage**  **Diets** | | **Duration of Larval instars (days)** | | | | **Total larval stage duration**  **(days)** | **Pupal durations**  **(days)** |
| **1st** | **2nd** | **3rd** | **4th** |
| **Artificial diets** | **A** | 4.95±0.15 **A**  (2.8-6.8) | 6.20±0.17 **A**  (3.6-8.0) | 6.98±0.19 **A**  (4.6-9.6) | 8.51 ±0.20 **A**  (7.5-9.4) | 25.13±1.30 **A**  ( 18.1-30.2) | 10.07±0.3**A**  (7.0-10.8) |
| **B** | 3.20±0.15 **C**  (1.6-4.0) | 4.49±0.17 **B**  (3.0-5.9) | 5.89±0.19 **B**  (4.6-6.9) | 6.91 ±0.19 **C**  (4.6-8.3) | 19.08±1.30**ABC**  (19.2-24.1) | 7.56±0.32**BC**  (7.2-10.6) |
| **C** | 4.30±0.15 **A**  (2.0- 5.6) | 6.55±0.18 **A**  (4.6-8.2) | 7.25±0.20 **A**  (4.8-9.6) | 8.49 ±0.20 **A**  (7.0-12.3) | 25.25±1.30 **A**  (19.4-32.2) | 9.07±0.37**AB**  (9.0-12.8) |
| **D** | 3.70±0.15 **B**  (2.6-4.6) | 6.36±0.17 **A**  (4.0-7.2) | 5.85±0.18 **B**  (5.0-7.3) | 7.70 ±0.21 **B**  (6.2-9.8) | 19.87±1.30**ABC**  (18.2-26.3) | 8.64±0.30**BA**  (8.9-10.9) |
| ***A. fabae*** | **2nd** | 2.50±0.15 **D**  (1.6- 3.8) | 3.77±0.16 **C**  (3.4-4.3) | 4.11±0.18 **D**  (4.0-5.3) | 6.07±0.19 **E**  (5.3-7.0) | 15.15±1.30 **C**  (10.0-18.6) | 5.34±0.30 **D**  (4.8-7.0) |
| **4th** | 2.58±0.15 **D**  (2.0-3.0) | 3.76±0.15 **C**  (2.2-5.3) | 5.04±0.18 **D**  (3.3-6.5) | 6.67±0.18**CD**  (4.9-7.8) | 17.60±1.30 **CB**  (16.5-19.3) | 5.60±0.28 **D**  (4.9-8.0) |
| ***R. padi*** | **2nd** | 3.72±0.15 **C**  (2.6-40) | 3.56±0.16 **C**  (2.0-4.0) | 4.14±0.18 **D**  (3.0-5.0) | 6.20±0.19 **DE**  (5.4-6.9) | 15.38±1.30 **C**  (14.9-19.1) | 6.59±0.29 **C**  (6.4-8.3) |
| **4th** | 3.86±0.15 **B**  (3.1-4.3) | 4.25±0.16 **B**  (3.6-5.2) | 5.18±0.18 **C**  (4.8-6.2) | 6.40 ±0.19**CDE**  (6.4-7.5) | 18.60±1.30**ABC**  (18.0-21.6) | 6.67±0.30 **C**  (6.5-9.0) |

\*Data are presented as means±standered error. \*\*Means followed by different letters in each column are significantly (p<0.05)different. \*\*Data from (50 eggs/ treatment).

**Table (4): percentages of larval mortality and adult emergence of *C. septempunctata* fed on the four artificial diets and 2nd and 4th nymphal instars of *A. fabae* and *R. padi* under laboratory conditions.**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Stage**  **Diets** | | **% Larval instars mortality** | | | | **Percentage of** | | |
| **Total larval mortality** | **Failure of adults emergence** | **Emergency rate** |
| **1st** | **2nd** | **3rd** | **4th** |
| **Artificial diets** | **A** | 12.00 | 9.09 | 5.00 | 21.05 | 44.00 | 44.00 | 56.00 |
| **B** | 8.00 | 8.33 | 4.76 | 5.00 | 24.00 | 32.00 | 68.00 |
| **C** | 12.00 | 9.09 | 5.00 | 21.05 | 40.00 | 44.00 | 56.00 |
| **D** | 8.00 | 8.69 | 14.28 | 5.00 | 32.00 | 40.00 | 60.00 |
| 1. ***Fabae*** | **2nd** | 0.00 | 8.00 | 4.34 | 4.54 | 16.00 | 8.30 | 91.70 |
| **4th** | 0.00 | 0.00 | 4.00 | 0.00 | 4.00 | 0.00 | 100.00 |
| ***R. padi*** | **2nd** | 0.00 | 8.00 | 4.34 | 0.00 | 12.00 | 4.50 | 95.50 |
| **4th** | 0.00 | 8.00 | 4.34 | 0.00 | 12.00 | 0.00 | 100.00 |

\*Data are presented as means±standered error. \*\* Data from 25 freshly emerged larvae / treatment.

**Table(5): Means of feeding capacity of *C. septempunctata* larva reared on the 2nd and 4th nymphal instars of *A. fabae* and *R. padi* at 25±2 ̊C and 65±5% R.H.**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Instar**  **Aphid species** | | **Consumption rate of aphid / larva** | | | | **Total larval consumption** |
| **1st** | **2nd** | **3rd** | **4th** |
| ***A. fabae*** | **2nd** | 26.08±1.14 **B**  (12-51) | 63.41± 3.19 **B**  (41-99) | 106.04±6.43 **B**  (59-132) | 297.77±12.50 **B**  (243-387) | 442.16±33.6 **B**  (177-517) |
| **4th** | 16.80±1.14 C (11-24) | 36.92 ±3.12 **C**  (18-66) | 71.04 ±6.04 **C**  (44-109) | 261.38±11.97 **B**  (200-349) | 375.16±33.6 **B**  (315-549) |
| ***R. padi*** | **2nd** | 37.16±1.14 **A**  (27-49) | 76.82 ±3.26 **A**  (35-111) | 179.26±6.29**A**  (97-289) | 408.05±12.50 **A**  (342-483) | 631.84±33.6 **A**  (254-865) |
| **4th** | 16.80±1.14 **C**  (16-28) | 33.58 ±3.19 **C**  (23=58) | 95.45± 6.43 **B**  (78-137) | 373.32±12.50 **A**  (235-495) | 467.92±33.6 **B**  (361-609) |

\*Data are presented as means±standered error. \*\*Means followed by different letters in each column are significantly (p<0.05)different. \*\*\* Data from 25 freshly emerged larvae / treatment.

**Effect of food kind on ovipositional periods, longevity and fecundity of *C. septempunctata* adults**

**Ovipositional periods:**

The ovipositional periods of *C. septempunctata* females varied greatly when the predator adults were fed on different kinds of food, being 8.92 - 19.50 - 10.85 - 28.76 and 6.76 - 19.15 days for the pre oviposition, oviposition and post oviposition periods, respectively (Table, 6). The longest pre-oviposition period (19.5 days) was recorded from females reared on diet (B), being, insignificantly, longer than diet D (19.42 days) and *R. padi* treatment (18.7days), and significantly longer than the other 3 diets. On contrary, the shortest pre-oviposition period was recorded by rearing on diet (A) (8.92 days), followed by (C) diet and *A. fabae* (12.09 and 15.96 days, respectively).

As for the oviposition period, it was the longest for females reared on *A. fabae*(28.76 days), followed by those fed on *R. padi* (25.2 days). While, rearing on the tested 4 artificial diets showed shorter oviposition periods, being, significantly, shortest (10.85 days) on diet (A), and the longest (20.45 days) on diet (D) which was insignificantly, longer than rearing on the diet (B)(20.02 days) (Table, 6).

The post-oviposition period was significantly, the longest (19.15 days) by rearing *C. septempunctata* on diet (D), followed, insignificantly, by rearing on diet (B) (18.05days). This period was the shortest (6.76 days) for females reared on dried milk diet (A). Females reared on *A. fabae* or *R. padi* as natural diets showed post-oviposition period of (13.98 and 16.31 days, respectively (Table, 6).

**Adults’ longevity**

By feeding *C. septempunctata* adults on either of the 6 tested diets (4 artificial and two natural diets), it is clear from data recorded in Table (6) that females lived longer (21.47- 60.37 days) than males(15.04- 40.96 days). Generally, feeding on the two natural diets (*A. fabae* and *R. padi*) led to adults showed longer longevity than those fed on the artificial diets, although feeding on (B) diet or on (D) diet led to adults showed longevities close to those fed on nymphs of the two aphid species (57.37 and 56.42 days), respectively for females and (33.81 and 31.51) days for males fed on the two artificial diets, respectively), opposed to (57.06 and 60.37) days for females and (40.96 and 39.68 days) for males fed on *A. fabae* and *R. padi* nymphs, respectively (Table,6).

**Fecundity of *C. septempunctata* females:**

From data presented in table (6), it is clearly evident that *C. septempunctata* females fed on *A. fabae* and *R. padi* deposited higher numbers of eggs (565.67 and 508.93 eggs/ female, respectively), being significantly, higher than those recorded from females fed on the tested artificial diets. Among the artificial diets, the females fed on (D) diet deposited, significantly, the highest numbers of eggs (345.46 eggs/ female), followed significantly, by (212.13 eggs), deposited by females from (B) diet. The lowest number of total deposited eggs/ female (60.08 eggs) resulted from rearing on (A) diet (Table, 6).

**Table (6): Ovipositional periods, longevity and fecundity of *C. septempunctata* female reared on two natural preys and four artificial diets at 25±2 ̊C and 65±5% R.H.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Predator**  **Diets** | | **Ovipositional periods (in days)** | | | **Longevity** | | **Total eggs/**  **female** |
| **Pre-oviposition** | **Oviposition** | **Post-oviposition** | **♀♀** | **♂♂** |
| **Artificial diets** | **A** | 8.92±0.96 **C**  (3.4-15.6) | 10.85±0.84 **D**  (8.00-15.3) | 6.76±0.96 **E**  (5.4-8.8) | 21.47±2.92 **C**  (22.4-34.3) | 15.04±1.61 **D**  (10.2-22.6) | 60.08±17.32 **F**  (25-76) |
| **B** | 19.50±0.96 **A**  (17.4-21.7) | 20.02±0.84 **B**  (16.6-25.7) | 18.05±0.55 **A**  (13.4-21.4) | 57.37±2.92 **A**  (38.2-68.5) | 33.81±1.61 **B**  (18.9-41.7) | 212.13±15.4**D**  (120-280) |
| **C** | 12.09±0.96 **C**  (9.6-17.9) | 17.00±0.84 **C**  (13.0-19.9) | 10.75±0.60 **D**  (7.0-16.8) | 35.42±2.92 **B**  (35.8-47.8) | 21.76±1.61 **C**  (16.9-28.4) | 107.40±15.4**E**  (100-140) |
| **D** | 19.42±0.96 **A**  (12.0-26.7) | 20.45±0.84 **B**  (17.6-34.7) | 19.15±0.53 **A**  (16.0-27.9) | 56.42±2.92 **A**  (60.7-77.6) | 31.51±1.61 **B**  (29.2-38.2) | 345.46±16.6**C**  (268-386) |
| 1. ***fabae*** | | 15.96±0.96 **B**  (14.3-18.0) | 28.76±0.84 **A**  (18.0-34.7) | 13.98±0.55**C**  (12.1-15.0) | 57.06±2.92 **A**  (36.0-67.2) | 40.96±1.61 **A**  (35.5-48.0) | 565.67±15.4**A**  (298-676) |
| ***R. padi*** | | 18.70±0.96 **A**  (15.6-23.3) | 25.20±0.84 **A**  (21.1-30.8) | 16.31±0.53 **B**  (14.8-18.2) | 60.37±2.92 **A**  (55.2-69.4) | 39.68±1.61 **A**  (35.0-47.4) | 508.93±15.4**B**  (386-620) |

\*Data are presented as means±standered error. \*\*Means followed by different letters in each column are significantly (p<0.05)different. \*\*\* Data from 15 adults (male - female / treatment).

By rearing on artificial diets, insects may exhibit high survival rate, shorter developmental periods and higher weight gained and fecundity. So, adequate artificial diet is nutritionally comparable to a natural diet but with a lower cost **(Zanuncio *et al.,* 1996; and Dong *et al*., 2001).**

In Egypt, biological characteristics of the coccinellid predator, *C. septempunctata*, were studied by **El-Serafi *et al* (2002)** under laboratory conditions at 27±5 ̊C and 70±5%R.H., when the larval and adult stages were fed on artificial diets. The predator was also reared on the aphid species *Sitobion avenae* (natural diet) as a control. Their results indicated that the predator reared on natural diet revealed superiority in all biological characteristics during immature stages compared to those reared on artificial diet. These results agree with the present results.

All the diets (natural and/or artificial) affected significantly, the development of *C. septempunctata*. The natural diet comprising aphids as prey proved, significantly, superior to the artificial diets **(Sarwar and Saqib, 2010)**. The same authors reported that *C. septempunctata* reared on aphids as food gave significantly the uppermost results for all biological parameters as compared to artificial diets. Their study demonstrated that diet comprising aphids as natural host proved excellent for rearing of coccinellids, but if artificial diet and aphid were given simultaneously, development became faster and lady beetle could be reared more successfully.

As a conclusion, rearing of *C. septempunctata* on nymphs of either of the two aphid species under investigation; i.e., *A. fabae* or *R. padi* proved to be the best to obtain immature stages in shorter durations and much lower mortality rates than rearing on either of the 4 tested artificial diets. Rearing the predator on the 4 tested diets showed that, it was able to complete its life-cycle, but on (D) diet it manifested the highest reproductivity of egg and hatchability %, So, it could be stated that for mass rearing of *C. septempunctata*, it is, absolutely, better is the rearing on natural prey, while artificial diets could be utilized in case of scarce of aphids. In this respect, the two artificial diets, B (dried yellow eggs yolk diet) and D (wheat grains germ) may be considered a good substitution in case of the absence of aphids.

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