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Evaluation of different diets on biological parameters of ladybird beetle, *Coccinella undecimpunctata* L. (Coleoptera : Coccinellidae)

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ABSTRACT

In this study, the effect of different diets on the biological characteristics of *Coccinella undecimpunctata* L. were studied under laboratory conditions of $26 \pm 1^\circ\text{C}$ and $65 \pm 5\%$ R.H. Three diets namely; AD1 (as basic artificial diet), AD2 (as improvement artificial diet), aphid, *Aphis craccivora* Koch frozen as well as live aphid, (*A. craccivora*) as control were evaluated on the biological aspects of *C. undecimpunctata*. Results showed that the mean larval duration recorded 10.64 days, when larvae fed on control. It extended to 14.26, 14.56 and 21.27 days for frozen aphid, AD2 and AD1, respectively. Larval survival percentages were 93.33, 83.33, 73.33, and 60.00% when larvae reared on control, AD2, AD1 and frozen aphid, respectively. The maximum pupation percentage (92.86%) recorded in control, while minimum (66.67%) on frozen aphid. Adult emergence percentages on control was 92.31%, with sex ratio of 54.17%. Whereas, it 80.00% with sex ratio of 62.50% when larvae fed on AD2. Ovipositional period of mated female extended to 56.63 days and reproduced about 992.26 eggs throughout its lifespan, on control, whereas the lowest one (189.50 eggs) was noticed with AD1. Treatment control and AD2 gave the best result for egg fertility (95.62 and 75.90%), egg hatching (95.01 and 79.20%), respectively. Highest growth index was recorded with control (4.75) almost similar to artificial diet (AD2) (3.39). In general, AD2 played an important role in whole life cycle of *C. undecimpunctata* for mass production and proved better on most above parameters.

Keywords: Artificial diets, *Coccinella undecimpunctata*, *Aphis craccivora*.

INTRODUCTION

Biological control is considered one of the beneficial actions in managing pests and their damage. It depends on using natural enemies for reducing the numbers of insect pests and mites (Dreistadt and Statewide 2014). Coccinellids are considered among the most important predaceous insects attacking aphids, mealy bugs, spider mites, thrips, jassids, whitefly, scale insects and eggs of lepidopterous (Gautarm, 1994 and Obreycki and Kring, 1998).

Eleven spotted ladybird beetle, *Coccinella undecimpunctata* L. (Coleoptera : Coccinellidae) is a potential bio-control agent which is used in the biological control for a large wide of pests such as aphids as well as eggs and new hatching of lepidopteran insects which can be found in different parts of the world with different environmental conditions (Hodek *et al.* 2012). The predator's natural population, however, is usually so low in the field due to unregulated use of insecticides that it fails to provide satisfactory control of the pest August (2007, 2008); (August *et al.*, 2007). Rearing coccinellids on natural food *i.e.* living aphids, is very difficult and also uneconomical method (Ohkada and Matsuka, 1973).

The predator can be mass cultured in the laboratory by using natural and artificial diets (Sarwar and Saqib, 2010 and Mohamed *et al.*, 2020). Artificial diets for insects generally must contain the following components: proteins but sometimes free amino acids, lipids, carbohydrates, vitamins and minerals (Cohen, 2005). Numerous laboratory studies support the notion that non prey foods (artificial

diets) improve fecundity over prey / hosts alone, sometimes can even support reproduction in the absence of prey altogether.

Therefore, the objective of the study is about the diets which can help to rear substantial number of the predator *C. undecimpunctata* under laboratory conditions for mass release to eradicate pests in greenhouse and open fields.

MATERIALS AND METHODS

The present study was carried out in Plant Protection Department, Zagazig University, Egypt under the laboratory conditions of $26 \pm 1^\circ\text{C}$ and $65 \pm 5\%$ R.H.. In this experiment *Coccinella undecimpunctata* L. were reared on live aphids (*Aphis craccivora* Koch) as control, frozen aphids (*A. craccivora*) as well as, two artificial diets.

Stock culture of *Coccinella undecimpunctata* L.

Larvae of *C. undecimpunctata* were collected from faba bean, *Vicia fabae* Linnaeus, fields infested with *A. craccivora*. The larvae were kept in cylindrical plastic vials, 4 cm diameter and 7 cm height, with tightly fitting lids. The larvae were daily provided with *A. craccivora* as food until pupation. Emerged adults (females and males) were placed in glass Petri dishes measured 2.5cm height with 10.5 cm diameter. *C. undecimpunctata* adults were examined daily, then, provided with the aphids, *A. craccivora* as prey and distilled water which supplied on cotton pads. The egg-masses were transferred into plastic vial (7x2 cm) and observed daily until hatching.

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Rearing of *Coccinella undecimpunctata* L. on *Aphis craccivora* Koch. as (control)

A. craccivora individuals were collected from infested faba bean fields. The aphid was reared in the laboratory, at means of 26±1°C and 65 ±5% RH, on faba bean young plants which grown in plastic pots number 10, 20 cm diameter and 17 cm height. Once the plants had 2-3 leaves, newly healthy ones were placed beside the infested plants to maintain the culture throughout the experimental period.

Thirty newly hatched larvae were placed solely in a Petri dish, 2.5 cm height with 10.5 cm diameter.

Each larva was provided daily with sufficient number of different stages of *A. craccivora* on pieces of faba bean leaves (ca. 25 aphid individuals) which replaced daily in each Petri dish till pupation.

Rearing of *Coccinella undecimpunctata* L. on frozen aphids, *Aphis craccivora* Koch.

In this experiment, the live aphid, *A. craccivora* were obtained from infested faba bean plants which reared in the laboratory, then frozen at temperature 0°C in plastic container (20 x 8 cm) for 24 hrs. When it became completely frozen, then taken and keeping into small container at same temperature.

Thirty newly hatched larvae of *C. undecimpunctata* were placed separately in Petri dishes as previously described. The larvae were provided daily with enough numbers of the frozen aphids (ca. 25 frozen aphids) till pupation to determine the biological parameters.

Rearing of *Coccinella undecimpunctata* L. on artificial diets

Basic artificial diet (AD1)

To enhance the larval efficiency for rearing, different diet combinations according to Smirnoff (1985) were used as shown in Table (1).

Table 1. Components of the basic artificial diet.

Diet	Ingredients	Weight or Volume
Basic artificial diet (AD1)	Fresh chicken liver	100 g
	Sucrose	20 g
	Yeast extract	10 g
	Egg yolk powder	10 g
	Peptone	5 g
	Multi vitamins and minerals	1 g
	Casein	3 g
	Chlortetracycline	1 g

In AD1 (basic artificial diet) all ingredients were weighed carefully, then prepared according to as follows: Fresh chicken liver was cut in pieces, blended in electric grinder and put in refrigerator for 24 hours. To prolong the shelf life of the diet, 0.6 g potassium sorbate and 1.0 g chlortetracycline were added, and then the powder ingredients such as, sucrose, egg yolk powder, peptone, casein were mixed. After that, yeast extract was added to enhance the fecundity. And finally, multi vitamins and minerals were added. At this point, the mixture was a semi-solid and was ready to be given to larva and adult in glass Petri dishes.

Artificial diet 2 (AD2):

This diet (AD2), consisted of basic artificial diet plus 3.0 g from each of royal jelly , propolis and pollen grains for each 50 g of the basic artificial diet.

The two abovementioned artificial diets were tested as food for the *C. undecimpunctata* larvae and adults. In each diet, thirty newly hatched larvae were placed singly in Petri dishes. The artificial diets were offered to larvae on white papers, 3.5 x 0.5 cm each which changed daily till the larvae completed their development.

In addition to the artificial diets, larvae were supplied with 10 % honey solution in water, dripping out of a circular petri - dish (fitting the inner periphery of the Petri dish) through three outlets plugged with cotton. As soon as the cotton got dry, the Petri dishes were refilled with honey solution. Then, the following parameters were evaluated for each treatment.

a- At larval stage:

- Percentages of survival of each larval instar.
- Larval durations.
- Pupation percentages.

In all treatments, newly emerged adults, male and female, of *C. undecimpunctata* were paired in Petri dishes and provided with 10 % honey solution in impregnated cotton. The adults were provided also by the same diet which its larvae reared on before.

b- At adult stage:

- Adult emergence
- Pre- oviposition, oviposition and post – oviposition periods
- Fecundity, fertility and hatchability
- Longevity
- Sex ratio
- Incubation period

Growth index and success index

Growth index (Pant, 1956) and success index (Prasad and Bhattacharya, 1975) were compared as

$$\text{Growth index (G.I.)} = \frac{N}{AV}$$

where:

N= Percent adult emergence

AV = average development period (days)

For success index , various indices were calculated as :

$$\text{Larval period index (L.P.I.)} = \frac{\text{Larval period (days) in control}}{\text{Larval period (days) in treatment}}$$

$$\text{Pupal period index (P.P.I.)} = \frac{\text{Pupal period (days) in control}}{\text{Pupal period (days) in treatment}}$$

$$\text{Pupation index (P.I.)} = \frac{\text{Percent pupation in treatment}}{\text{Percent pupation in control}}$$

$$\text{Adult emergence index (A.E.I.)} = \frac{\text{Percent adult emergence in treatment}}{\text{Percent adult emergence in control}}$$

$$\text{Success index} = \frac{\text{L.P.I.} + \text{P.P.I.} + \text{P.I.} + \text{A.E.I.}}{4}$$

Statistical Analysis

The differences among treatment means and their variance were appraised through F test (ANOVA), calculated according to COSTAT Computer Program (2005).

RESULTS AND DISCUSSION

The effect of two different artificial diets (basic artificial diet AD1 , improvement basic artificial diet AD2, frozen aphids and natural prey (live aphids) as control, on

the development of *Coccinella undecimpunctata* L. was studied. The evaluation of these artificial diets on *C. undecimpunctata* would help to ascertain the suitability of artificial diet for its mass rearing under laboratory conditions and release in the greenhouse, open field and the results were discussed as follow:

1. Effect of different diets on the immature stages of *C. undecimpunctata* L.

Egg stage

Data presented in Table (2) and Fig. (1) showed that the incubation period of laid eggs by the predator of *C. undecimpunctata* were significantly differed owing to be the type of food during the larval stage. They were 3.40 ± 0.15 , 5.57 ± 0.16 , 4.19 ± 0.23 and 3.70 ± 0.16 , when the larvae were fed on *A. craccivora*, frozen aphid, AD1 and AD2, respectively.

Table 2. Effect of different diets on the durations of *Coccinella undecimpunctata* L. immature stages under laboratory conditions of $26 \pm 1^\circ\text{C}$ and $65 \pm 5\% \text{RH}$.

Food type	Mean duration (days)							
	Egg incubation period	Larval stage				Pupal stage	Total development al period	
		First instar	Second instar	Third instar	Fourth instar			Total larval stage
Mean \pm S.E.	Mean \pm S.E.	Mean \pm S.E.	Mean \pm S.E.	Mean \pm S.E.	Mean \pm S.E.	Mean \pm S.E.	Mean \pm S.E.	
<i>A. craccivora</i> as control	3.40 ± 0.15 c	2.39 ± 0.10 c	2.29 ± 0.09 b	1.75 ± 0.11 c	4.21 ± 0.13 c	10.64 ± 0.21 c	5.40 ± 0.16 b	19.44 ± 0.41 d
Frozen aphid	5.57 ± 0.16 a	3.64 ± 0.15 b	3.41 ± 0.11 a	3.10 ± 0.16 b	4.11 ± 0.16 c	14.26 ± 0.29 b	4.58 ± 0.19 c	24.41 ± 0.55 e
AD 1	4.19 ± 0.23 b	5.19 ± 0.19 a	3.64 ± 0.18 a	5.39 ± 0.20 a	7.05 ± 0.17 a	21.27 ± 0.34 a	6.27 ± 0.21 a	31.73 ± 0.41 a
AD 2	3.70 ± 0.16 bc	3.39 ± 0.17 b	2.48 ± 0.14 b	3.48 ± 0.14 b	5.25 ± 0.21 b	14.56 ± 0.25 b	5.30 ± 0.21 b	23.60 ± 0.44 b
F. value	37.71**	54.98**	25.53**	102.20**	62.41**	285.56**	10.11**	270.35**

- ** indicates highly significant differences between means at 0.01 level of probability.

- Means in each column followed by similar letters are statistically insignificant at 0.05 level of probability.

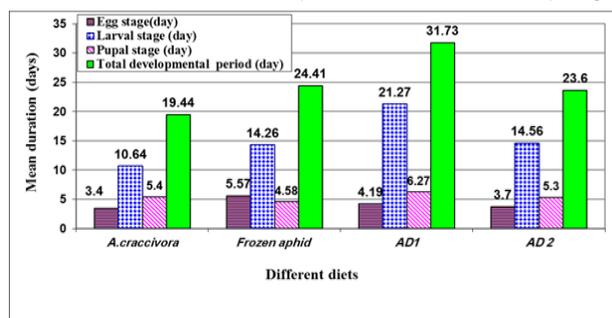


Fig. 1. Effect of different diets on the durations of *Coccinella undecimpunctata* L. immature stages under laboratory conditions of $26 \pm 1^\circ\text{C}$ and $65 \pm 5\% \text{RH}$.

These results are in harmony with those obtained by some authors such as Mahyoub *et al.* (2013), who stated that the incubation period ranged from 2 to 3 days, when the larvae of the predator fed on fresh aphids. Bukero *et al.*, (2015) mentioned that the mean incubation period was 3.30 ± 0.37 and 5.70 ± 0.37 days, with feeding predator larvae on fresh aphids and frozen aphids, respectively. Imam, (2015) reported that the incubation period of *C. undecimpunctata* eggs was 5.10 ± 0.51 days, when larvae were fed on *A. craccivora*.

Larval and pupal durations

The results given in Table (2) and illustrated in Fig. (1) indicated that the mean durations of the 1st, 2nd, 3rd and 4th larval instar were 2.39 ± 0.10 , 2.29 ± 0.09 , 1.75 ± 0.11 and 4.21 ± 0.13 days, with the mean total larval duration of 10.64 ± 0.21 days, when the larvae were fed on fresh aphid, *A. craccivora* as control. The corresponding mean durations recorded 3.64 ± 0.15 , 3.41 ± 0.11 , 3.10 ± 0.16 , 4.11 ± 0.16 days, with the mean total larval duration 14.26 ± 0.29 days, 5.19 ± 0.19 , 3.64 ± 0.18 , 5.39 ± 0.20 and 7.05 ± 0.17 days, with the mean total larval duration of 21.27 ± 0.34 days and 3.39 ± 0.17 , 2.48 ± 0.14 , 3.48 ± 0.14 and 5.25 ± 0.21 days with the mean total larval duration of 14.56 ± 0.25 days in 1st, 2nd,

3rd and 4th larval instar for larvae fed on frozen aphid, AD1 and AD2, respectively.

Regarding the pupal stage, the results in Table (2) showed that the mean duration of pupal stage was 5.40 ± 0.16 , 4.58 ± 0.19 , 6.27 ± 0.21 and 5.30 ± 0.21 days, when the larvae were fed on *A. craccivora*, frozen aphid, AD1 and AD2, respectively. Statistical analysis of variance using F. test clearly revealed that all these differences reach significance at 0.01 level of probability.

The present results are in accordance with the findings of El-Heneidy *et al.* (2008) who stated that the total larval duration of *C. undecimpunctata* was 13.02 ± 0.12 , days when the larvae fed on fresh *A. craccivora*. Sattar *et al.* (2008) stated that the total larval and pupal durations were 18.30 and 4.90 days, when the larvae of the predator reared on fresh aphids, respectively.

Imam (2015) reported that the total larval duration and the mean pupal stage were 23.40 and 5.30 days on fresh *A. craccivora*., respectively. Bukero *et al.* (2015) mentioned that the total larval duration and the mean pupal stage were 8.50 and 3.20 days on fresh aphids, whereas they were 12.90 and 4.60 days on frozen aphids, successively.

Total developmental period

Data obtained in Table (2) and Fig. (1) revealed that the highest mean total developmental period of the predator was 31.73 ± 0.41 days, when the predator was reared on AD1 (artificial diet), whereas the lowest one 19.44 ± 0.41 days was observed with feeding predator larvae on fresh *A. craccivora*. Statistical analysis revealed that the differences between total developmental period means as affected by different diets were highly significant.

The present results are in close agreement with those obtained by Mahyoub *et al.* (2013) who stated that the total developmental period of the predator ranged between 16.00 to 21.00 days, when feeding on fresh aphids. Also, Gupta and Kumar (2017) reported that the total duration up to adult emergence reached to 22.80 days was observed on diet consisted of (soybean flour 14 g, honey 3 ml, yeast 3 ml,

ascorbic acid 0.31 g, multi – vitamins 0.31 g, sodium ascorbate 0.31 g , methylparaben 0.31 g, 10 % formaldehyde 0.15 ml, agar 1.5 g and water 77 ml). Mohamed *et al.* (2020) mentioned that the mean developmental period of *C. undecimpunctata* was 25.58 days on fresh aphids.

Larval survival and percentage of pupation

As shown in Table (3) and Fig. (2), the survival rates of the 1st, 2nd, 3rd and 4th laval instars were 93.33, 100.00, 100.00 and 100.00 %,when the larvae were fed on *A. craccivora* as control, respectively, with the mean percentage of pupation was 92.86 %. The corresponding means of survival rate were 83.33, 88.00, 90.91 and 90.00 %, with the mean percentages of pupation 66.67; 90.00, 92.59, 92.00 and 95.65 %, with the mean percentage of

pupation 72.73; 93.33 , 89.29 , 100.00 and 100.00 % , with the mean percentage of pupation 80.00% for 1st, 2nd, 3rd and 4th laval instars when the larvae fed on frozen aphid, AD1 and AD2, respectively. Generally , the highest larval survival (93.33 and 83.33%) were observed when larvae fed on *A. craccivora* and AD2 , whereas the lowest values of (73.33 and 60.00%) were recorded when *C. undecimpunctata* larvae were fed on AD1 and frozen aphid.

These results are in full agreement with the findings of some authors such as Sarwar and Saqib (2010) they found that the percentage of pupation of *Coccinella* sp. was 64.98 % , when larvae were fed on artificial diet (AD), which consisted of Agar 1.3 g , cane sugar 16 g, honey 6 g and protein hydrolyzate 1g.

Table 3. Effect of different diets on the survival, pupating, emergence and sex ratio percentages of *Coccinella undecimpunctata* L. under laboratory conditions of 26 ± 1°C and 65 ± 5 % RH.

Food type	Larval survival (%)					Pupation (%)	Emergence (%)	Sex ratio (Females%)
	1 st instar	2 nd instar	3 rd instar	4 th instar	Total			
<i>A. craccivora</i> as control	93.33	100.0	100.	100.	93.33	92.86	92.31	54.17
Frozen aphid	83.33	88.0	90.91	90.0	60.0	66.67	75.0	55.56
AD 1	90.0	92.59	92.0	95.65	73.33	72.73	68.75	54.55
AD 2	93.33	89.29	100.0	100.0	83.33	80.0	80.0	62.50

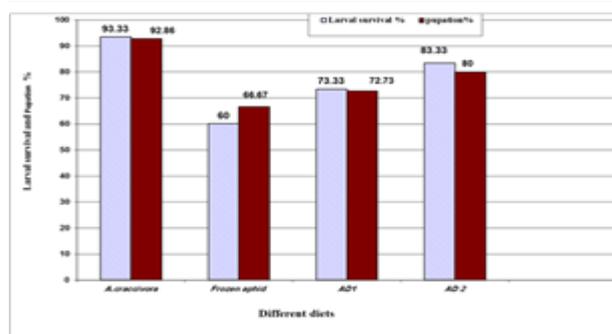


Fig. 2. Effect of different diets on the larval survival and pupation percentages of *Coccinella undecimpunctata* L. under laboratory conditions of 26 ± 1°C and 65 ± 5 % RH.

Bukero *et al.*, (2015) who reported that the maximum pupation percentages were 71.33 and 63.0 % when the larvae were fed on fresh and frozen aphids, respectively. Gupta and Kumar (2017) reported that the mean maximum larval survival and pupation percentage of *C. septempunctata* reached 63.30 and 66.10 % , when larvae were fed on frozen aphids.

1. Effect of different diets on some biological parameters of *Coccinella undecimpunctata* adults

Percentages of adult emergence

Data arranged in Table (3) cleared that the highest mean percentage of adult emergence attained 92.31, meanwhile the lowest one (68.75 %) was noticed when larvae were fed on AD1 diet.

Dissimilar results were obtained by Sattar *et al.* (2008) who reported that the mean percent emergence in male and female were 36.60 and 56.60 % , respectively when the predator fed on fresh aphids. On the other hand, the results found by Gupta and Kumar (2017) were agreement with the present ones who reported that the mean percentage of adult emergence was 86.70 % , when the larvae were reared on artificial diet consisted of (3 ml honey, 3 ml yeast, 0.31 g ascorbic acid, 0.31 g multivitamins, 1.5 g agar and water 77 ml.

Sex ratio

Data presented in Table (3) showed that the mean percentage of sex ratio (expressed at the ratio of female adult to the total number of emerged adults) attained 54.17 , 55.56 , 54.55, 62.50 % when the larvae fed on *A. craccivora* , frozen aphid , AD1 and AD2 , respectively.

Sattar *et al.* (2008) mentioned that the sex ratio (male to female) was 1: 1.50.

Pre- oviposition period

The results complied in Table (4) cleared that the pre – oviposition period ranged between 5.23 to 14.7 days. The shortest mean , 5.23 ±0.23 days was detected when the larvae were fed on *A. craccivora*, meanwhile the longest mean, 14.17 ±0.60 days was obtained when the larvae were reared on artificial diet (AD1). Statistical analysis of variance revealed that the differences among the means were highly significant.

The results found by Sarwar and Saqib (2010) agree with the present ones who mentioned that the pre oviposition period was 11.40 days, when the larvae of the predator reared on artificial diet which consisted of (1.3 gm agar, 16 gm cane sugar, 6 gm honey and 19 gm protein hydrolyzate). Also, Mohamed *et al.* (2020) stated that the pre – oviposition period was 5.57 days when the larvae were fed n fresh aphid.

Oviposition period

As shown in Table (4) the longest mean of oviposition period (56.63±1.90) days was recorded when larvae were fed on fresh *A. craccivora*, while the shortest one, 37.80±2.44 days was obtained when the predator larvae were reared on frozen aphid. Statistical analysis of the data revealed highly significant differences among the means.

The present results are not in harmony with those obtained by Sarwar and Saqib (2010) who reported that the oviposition period was 9.20 days when the ladybird beetle fed on artificial diet consisted of (1.3 gm agar, 16 gm cane sugar, 6 gm honey and 19 gm protein hydrolyzate)

Table 4. Effect of different diets on the pre –oviposition, oviposition, post –oviposition periods and longevity of *Coccinella undecimpunctata* L. adults under laboratory conditions of 26 ± 1°C and 65 ± 5 %RH.

Biological parameters	Mean ± S.E.				F. value
	<i>A.craccivora</i> as control	Frozen aphid	AD 1	AD 2	
Female:					
Pre - oviposition period	5.23 ±0.23 c	6.40±0.51 bc	14.17 ±0.60 a	7.40 ±0.45 b	79.11**
Oviposition period	56.63±1.90 a	37.80±2.44 b	44.33 ±2.09 b	39.0 ±1.72 b	21.31**
Post - oviposition period	9.62±0.54 b	7.60 ±0.68 b	18.67 ±0.62 a	16.90 ±0.84 a	49.75**
Longevity	71.47±1.98 a	51.80 ±2.22 c	77.17 ±2.47 a	63.30 ±1.85 b	18.04**
Male:					
Longevity	42.64±1.67 c	38.50 ±3.12 c	75.20 ±3.11 a	53.50 ±4.58 b	25.67**

Post- oviposition period

As indicated in Table (4), the post oviposition period varied from 7.60±0.68 days on frozen aphid to 18.67 ±0.62 days on AD1. Statistical analysis revealed that the differences between means were highly significant.

The results found by Sarwar and Saqib (2010) disagree with the present ones who stated that the post oviposition period recoded 1.80 days on artificial diet (1.3 gm agar, 16 gm cane sugar, 6 gm honey and 19 gm protein hydrolyzate).

Female longevity

The results arranged in Table (4) and Fig. (3) clearly show that the adult female longevities averaged 71.47±1.98, 51.80 ±2.22, 77.17 ±2.47 and 63.30 ±1.85 days, for females reared on fresh *A. craccivora* , frozen aphid , AD1 and AD2 , consecutively. Statistical analysis cleared that the differences among the means were highly significant.

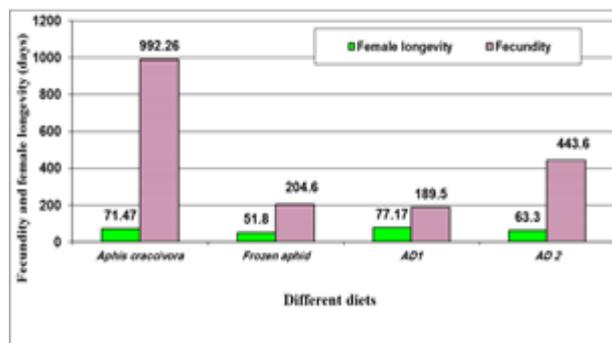


Fig. 3. Relationship between fecundity and female longevity when *Coccinella undecimpunctata* L. larvae fed on different diets under laboratory conditions of 26 ± 1°C and 65 ± 5 % RH.

Table 5. Effect of different diets on the fecundity, fertility and hatchability of *Coccinella undecimpunctata* L. under laboratory conditions of 26± 1°C and 65 ± 5 %RH.

Food type	Fecundity	No. of laid eggs / day	Fertility(%)	Hatchability(%)
	Mean ±S.E.	Mean ±S.E.	Mean ±S.E.	Mean ±S.E.
<i>A.craccivora</i> as control	992.26 ±44.28 a	17.60 ±0.62 a	95.62 ±1.17 a	95.01 ±0.93 a
Frozen aphid	204.60 ±9.70 c	5.47 ±0.32 b	58.20 ±2.67 c	59.66 ±4.86 c
AD 1	189.50 ±4.89 c	4.32 ±0.21 c	61.50 ±4.33 c	63.94 ±6.32 c
AD 2	443.60 ±17.86 b	11.54 ±0.64 c	75.90 ±3.13 b	79.20 ±2.29 b
F. value	119.16**	96.89**	39.40**	28.75**

El-Heneidy *et al.* (2008) found that the single mated female deposited 729 eggs when rearing on fresh aphids. Imam (2015) revealed that the mean number of eggs per female was 195.0 eggs when reared on *A. craccivora*.

Concerning number of deposited eggs per day , data in Table (4) indicated that the mean number of laid eggs per day were 17.60 ±0.62, 5.47 ±0.32, 4.32 ±0.21 and 11.54

The present results are confirmed with those recorded by El-Heneidy *et al.* (2008) who stated that the female longevity of *C. undecimpunctata* recorded 78.05 days, when the larval were fed on aphids.

Male longevity

Data given in Table (4) revealed that the male longevities were 42.64±1.67, 38.50 ±3.12, 75.20±3.11 and 53.50 ± 4.58 days , when the larvae of predator were reared on fresh *A. craccivora* , frozen aphid , AD1 and AD2 , respectively. Statistical analysis of variance revealed that the differences among the means were highly significant.

These results disagree with those obtained by Sarwar and Saqib (2010) who mentioned that the mean male longevity of *C. undecimpunctata* (38.80 days) on fresh aphid as natural diet whereas, it was (0.00 days) on artificial diets consisted of (1.3 gm agar, 16 gm cane sugar, 6 gm honey and 19 gm protein hydrolyzate).

Fecundity

Data presented in Table (5) and Fig. (3) cleared that the mean numbers of eggs laid per female were 992.26 ±44.28, 204.60 ±9.70, 189.50 ±4.89 and 443.60 ±17.86 eggs, when the larvae were fed on fresh *A. craccivora* , frozen aphid , AD1 and AD2 , respectively. Statistical analysis of data revealed that the differences between all means of fecundity proved to be highly significant at 0.01 level of probability.

The present results are in accordance with those recorded by Ghanim and El- Adl (1997), who revealed that artificial diet (dry blood 24.24 % , sucrose 30.30 % , pollen grains 10.68 % , yeast (powder) 13.64%, royal jelly (capsules) 6.06 % , streptophenicol 3.03 % , multivitamins and minerals 9.09 % and aphid dry powder 2.96 %) was the best for rearing *C. undecimpunctata* because the fecundity of the females was higher on this diet than the other tested diets.

±0.64 eggs, when the larvae of predator were fed on *A. craccivora*, frozen aphid, AD1 and AD2, respectively. The number of laid eggs per day by *C. undecimpunctata* female was highly significant influenced by the tested food types.

These results are in harmony with those obtained by Mohamed *et al.* (2020) who cleared that the mean number of

laid eggs / day was (7.27 eggs), when the larvae of predator reared on fresh aphids.

Fertility

Data compiled in Table (5) indicated that the mean percentage of laid fertilized eggs per female was 95.62 ± 1.17 , 58.20 ± 2.67 , 61.50 ± 4.33 and 75.90 ± 3.13 % ,when the larvae of *C. undecimpunctata* were reared on *A. craccivora* , frozen aphid , AD1 and AD2 , respectively. The variance between different means

showed that the differences were highly significant with the tested food types.

These results are in full similarity with the findings obtained by Mohamed *et al.* (2020) who reported that the mean percentage of fertility was 80.27 % when the larvae were reared on fresh aphid.

Hatchability

Data shown in Table (5) cleared that the highest mean percentage of hatchability (95.01 ± 0.93 %) was obtained when the larvae were fed on *A. craccivora*, meanwhile, the lowest one (59.66 ± 4.86 %) was noticed when the larvae were fed on frozen aphid. Statistical analysis revealed that the differences between hatchability means as affected by different diets were highly significant.

These results are in agreement with these of El-Heneidy *et al.* (2008) who reported that the mean percentage of hatchability was 81.00%. Contrarily, Sarwar and Saqib (2010) found that the mean of hatchability % was (22.40) when rearing on AD consisted of (1.3 gm agar, 16 gm cane sugar, 6 gm honey and 19 gm protein hydrolyzate).

Mahmoud and Zarabi (2012) found that the mean hatched rate was 81.00% on diet consisted of honey 10%, yeast 15%, essential amino acid 25%, B. vitamin groups 2.5% and water 47.5%. Imam(2015) stated that the highest mean percentage of hatchability (96.3%) was obtained when the larvae were reared on aphid, *A. craccivora*.

3.Effect of different diets on success index and growth index of *C. undecimpunctata*

Results in Table (6) showed that the growth and success indices of different diets compared to the control. The highest growth index was recorded with control (4.75) followed by AD2 (3.39), frozen aphid (3.07) and AD1(2.17).

Table 6. Success and growth indices of *Coccinella undecimpunctata* L. receiving different diets under laboratory conditions of $26 \pm 1^\circ\text{C}$ and 65 ± 5 %RH.

Food type	Growth Index (GI)	Success Index (SI)
<i>A.craccivora</i> as control	4.75	1.00
Frozen aphid	3.07	0.86
AD 1	2.17	0.72
AD 2	3.39	0.87

Concerning the success index of the predator fed on different diets, it was found that larvae fed on fresh *A. craccivora* and AD2 exceeded the other tested diets, recording 1.00 and 0.87, respectively.

These results are in harmony with those obtained by Gupta and Kumar, (2017) who found that highest growth index was obtained with soaked soybean diet(SS) (4.05) almost similar to control (4.0), followed by soybean flour (SF), bee pollen , drone larvae and frozen aphid diets as 3.8, 2.4, 1.98 and 1.94, respectively. Similary, data showed that

success index of the adults fed on artificial diet containing soybean 1.03 was almost similar to control (1.0), whereas the diets containing bee pollen, drone larvae and frozen aphid was lower than control as 0.83, 0.84 and 0.78, respectively.

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تقييم بيئات غذائية مختلفة على المقاييس البيولوجية لأبي العيد نو الإحدى عشر نقطة *Coccinella undecimpunctata* L. محمد أحمد إبراهيم يوسف ، ولاء مجاهد محمد يوسف هلالى و شيرين مجاهد محمد يوسف هلالى قسم وقاية النبات - كلية الزراعة - جامعة الزقازيق - الزقازيق - جمهورية مصر العربية

أجريت هذه الدراسة بهدف تقييم بيئات غذائية مختلفة على المقاييس البيولوجية لأبي العيد نو الإحدى عشر نقطة تحت الظروف المعملية $26 \pm 1^\circ \text{C}$ و $65 \pm 5\%$ رطوبة نسبية. تم تقييم ثلاث بيئات غذائية وهي AD1 (البيئة الصناعية الأساسية)، AD2 (البيئة الصناعية المحسنة) ومن البقوليات المجدد بالإضافة إلى تربية المقترس على من البقوليات الحى (الكنترول). أظهرت النتائج المتحصل عليها أن متوسط فترة نمو الطور اليرقى كانت 10,64 يوماً عند تربية المقترس على من البقوليات (الكنترول)، حيث امتدت تلك الفترة إلى 14,26 ، 14,56 و 21,27 يوماً وذلك بالتغذية على من البقوليات المجدد، AD2 و AD1 ، على التوالي. بينما كانت متوسطات نسب البقاء للطور اليرقى 93,33 ، 83,33 ، 73,33 و 60,00 % وذلك بتغذية يرقات المقترس على الكنترول، AD2 ، AD1 ومن البقوليات المجدد، على الترتيب. سجلت أعلى نسبة مئوية للتعدر (92,86 %) مع الكنترول، بينما أقلها (66,67 %) لوحظت عند تغذية اليرقات على من البقوليات المجدد. بلغت نسبة خروج الحشرات الكاملة لمعاملة الكنترول (92,31 %) بنسبة جنسية 54,17 ، بينما كانت 80,00 ، 75,00 و 68,75 % بنسب جنسية (62,50) ، 55,56 و 54,55 % بتربية اليرقات على AD2 ، من البقوليات المجدد و AD1 ، على التوالي. استغرقت متوسط فترة وضع البيض للإناث الملقحة (56,63) يوماً منتجة 992,26 بيضة خلال دورة حياتها، بمعدل وضع بيض يومي تعده 17,60 بيضة وذلك بتربية المقترس على الكنترول، فى حين وجد أن أقل متوسط لتعداد البيض (189,50) بيضة) قد لوحظ بتغذية المقترس على البيئة AD1 . كانت متوسط فترة حياة الحشرة الكاملة الأنثى أطول من الذكر فى جميع المعاملات. نتج عن تغذية المقترس على الكنترول والبيئة AD2 أفضل النتائج لنسبة البيض المخصب (95,62 و 75,90 %) ونسبة الفقس (95,01 و 79,20 %)، على الترتيب. سجل أعلى معدل لدليل النمو مع الكنترول (4,75) والذى تشابه إلى حد ما مع البيئة الصناعية المحسنة (AD2) (3,39) متبوعاً بالمن المجدد و AD1 مسجلاً 3,07 و 2,17 ، على التوالي. بصفة عامة، اتضح من النتائج السابقة أن البيئة الصناعية (AD2) المحسنة تلعب دوراً هاماً فى حياة المقترس أبى العيد نو الإحدى عشر نقطة للإنتاج الكمى حيث أثبتت أنها من أفضل البيئات المختبرة على الصفات سابقة الذكر.