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Rearing of *Chrysoperla carnea* (Neuroptera: Chrysopidae) on Facticious & artificial diet and its impact on the reproductive potential of the adult female

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Abstract
Studies were conducted to find out the effects of different diets (Factitious + Artificial B) on the survival of *C. carnea* and to determine the impact of these diets on the reproductive potential and longevity of the adult female. The 1st instar larvae of *C. carnea* were released into the factitious/artificial diets place in Petri dishes kept at room temperature ranging from 25-30 Ċ. Five different foods viz eggs of sitrotoga cerealella, artificial diet A, B and chicken liver were provided to the larvae of *C. carnea*. Maximum larval duration (24.9 days) in artificial diet A, followed by artificial diet B (23.9 days) and chicken liver (23.2 days) was recorded whereas minimum larval duration was recorded in the mix diet of factitious + artificial diet B but statistically all the diets were at par. The percent hatchability was high (86.5%) in mix diet of factitious + artificial B while minimum hatchability 75% and 75.5% was observed in artificial diet A and chicken liver respectively with similar statistical values. Highest pupal duration (15.4 days) and 14.6 days) was recorded in artificial diet A and B with similar statistical value whereas lowest pupal duration period (10.9 days) was recorded in mix diet of (factitious + artificial B). The reproductive period of adult female (6.3 days) was high in (factitious + artificial B) followed by factitious diet (4.8 days). The minimum reproductive period (2.4), (2.7) and (3.3 days) was observed in artificial diet A, B and chicken liver respectively with similar statistical values. Highest longevity period (12.5days) and 12.1 days) and (10.1days) were observed in mix diet, factitious and chicken liver whereas minimum longevity period was (4.2 days) and (5.4days) observed in artificial diet A and B respectively with similar statistical values.

Keywords: Chrysoperla carnea, Facticious & artificial diet, reproductive potential, female

1. Introduction
Chrysoperla carnea (Stephens) or green lacewing is voracious predator of eggs and small larvae of all the lepidopterous pests, aphids, jassids, fruit borers and mealy bugs, it has an advantage over egg parasitoids that it can feed on both egg and larval stage of pests and also its hosts range is much broader. The adult has bright green or yellowish brown body with green wing veins, often tinged with brown orange and red color. The head bear large compound eyes which are iridescent and a pair of long, filliform antennae longer than the body. The wing venation is more complicated with more branching and cross veins. The eggs are laid in cluster and are provided with elongated pedicles, which are fixed to leaves and other objects. The larvae have short, broad body with well-developed sickle-like mandibles and maxillae. Numerous hooked hairs are present on the surface of the abdomen and the larvae usually conceal their identity by covering themselves with the remain of their prey [1].
Over the past years of research on nutrition of entomophages, there have been several reports of diets for
An artificial diet based rearing system would be useful only if the targeted entomophage were able to meet criteria such as high kill rates, good search qualities, and proven non-destructiveness to other beneficial orthropods or crop plants. *Chrysoperla* spp. which are highly generalist predators, meets all of these criteria. *Chrysoperla* spp. However, the commercially available *chrysoperla* spp. are all produced on factitious host such as eggs of *Sitotroga cerealella* (O.) (Lepidoptera: Tineidae) or *Ephestia kuehniella,* making these predators too expensive for use in large scale open field agricultural settings. Considerable progress has been made in the manipulation of *Chrysoperla* spp. Colonies for augmentative purposes [2, 3].

2. Materials and Methods

To study the effects of different diets on the larval development of *Chrysoperla carnea (Stephens)* and to evaluate the larval development period and re-productive potential of the adult female, an experiment was conducted in completely randomized design with five treatments repeated ten times each in the Biological Laboratory, Eco Conservation Initiatives (ECI) May –October, 2007. The adults of *C. Carnea* were collected from the fields during night and placed in the glass cages (35x25cm) at Eco Conservation Initiatives (ECI) Laboratory Skardu. The eggs of *Chrysoperla carnea* and *Sitotroga cerealella* were collected/ obtained from adults rearing in the Laboratory. The larvae were offered various diets. The treatments were:

T1 = Factitious diet (*S. cerealella eggs*)
T2 = Artificial diet A
T3 = Artificial diet B
T4 = Factitious diet + Artificial diet
T5 = Chicken Liver

The following research trials were conducted to achieve the main objectives of the study:

A. Host Rearing for Factitious Diet (T1)

Sitotroga cerealella (Olive) was reared on wheat grains in iron chambers having five trays. 2 mg of *S. cerealella* eggs were mixed in each tray of chamber containing ½ kg of wheat grains. The *S. cerealella* cultures were maintained at 25-30 °C and 60-70% R.H. On emergence *S. cerealella* adults were collected in oviposition jars (14x15 cm) with wire gauze at the bottom. The oviposition jars were placed on maize starch in plastic plates. The starch of oviposition jars was passed through 80-size mesh to collect eggs of *S.cerealella*. These eggs were used as factitious diets for mass rearing of *Chrysoperla carnea* larvae.

B. Rearing of Larvae on Artificial Diet

The artificial diets with various concentrations were prepared and provided to the emerged 1st instar larvae of *C. carnea* to investigate the effectiveness of these artificial semi-liquid diets on the survival and larval development of *Chrysoperla carnea (Stephens)*. The artificial diets were consisted of the ingredients as mentioned below:

Composition of Diet- A (T2)

5g (14.18g), Enzymatic protein Hydrolasate of Yeast, 12.50g (31.85g), Choline Chloride 00.50g (1.42g) Ascorbic Acid, 08.75g (22.29g) Fructose, 12.50 ml (31.85 ml).Water (Distilled)

Composition of Diet-B (T3)

100 g diet was consist of 5g Honey, 5 g Sugar, 5g Food Yeast Flakes, 6g Yeast Hydrolasate, 1g Casien Hydrolasate, 10g Egg yolk and 68 ml Water (Distilled).

To carry out the research trial, artificial food with various concentrations as mentioned above were provided to the 1st instars larvae in plastic Petri dishes (8.75cm) with different methods i.e. in the form of tinny droplets, shredded pieces of sponge soaked in the diet and tinny drops of diet covered with Para film and five 1st instars larvae were released with the help of fine camel brush in each Petri dish. Each treatment was repeated 10 times and the Petri dishes were observed on daily basis under binocular to determine the effectiveness of the diet for larval development. The foods (diets) were replaced every two days for the 1st and 2nd instars larvae and every day for the 3rd instars larvae. These foods were presented up to maximum F2 generations so that the concentrated food adults could be made available for the present study

A. Rearing of *C. carnea* larvae on the mixture of factitious & artificial diet (T4)

The artificial diet A (which during our preliminary testing produced promising results so a droplet of it was added in the center of the Petri dish) and factitious diet (the frozen treated eggs of *sitotroga cerealella*) were placed in the same Petri dish and newly hatched larvae were released. For this treatment 10 replications were taken and the Petri dishes were observed under the simple binocular microscope (10x swift-Japan) to determine the effectiveness of mixture of natural and artificial diets on the development of *C.carnea* larvae and the reproductive potential and longevity of the adult female.

B. Rearing of *C. carnea* larvae on chicken liver.(T5)

Chicken liver is a rich source of protein and other vital minerals which is an essential element of larval diet for its development and also required for egg formation (Oogenesis). Therefore, 100 gm chicken liver was collected and grinded in the aseptic conditions to make it a semi liquid paste. Also 2mg streptomycin was added to avoid bacterial growth and was presented to the *Chrysoperla carnea* larvae in Petri dishes in 10 replications. The Petri dishes was then observed under the binocular to study the effects of the diet on the larval development, fecundity and longevity of the adult female.

The following parameters were studied during the course of this research:

1. Larval development period
2. Percent emergence of adults.
3. Reproductive period of adult female.
4. Percent hatchability.
5. Longevity of adult.

The standard procedure for calculating each of the above mentioned parameters was as follow:

2.1 Larval development period

Counted numbers of larvae were exposed to each treatment containing natural and artificial diets in each replication. Date and time of molting of 1st instars larvae into second instars was recorded. Similarly the date and timing of 2nd, 3rd and then pupation was also recorded. This has provided the complete duration of all the larval developmental stages of *Chrysoperla carnea* on different diets. The total development period has been calculated for each diet. The duration of pupal period was considered from the time when the 3rd instar larvae started spinning cocoon till adult emergence.

2.2 Percent emergence of adults

The pupal cocoons from each treatment were collected in Petri dishes and placed in the Chrysoperla adult rearing plastic glass cages (35x25cm) specified for different foods and were observed daily. From each Petri dish the date of first adult emerged and the date of last adult emerged were recorded to find out the emergence period. The numerical data regarding this parameter was noted by subtracting the date on which the last adult emerged from the date on which the first adult emergence.

2.3 Reproductive period of adult female

The adults emerged in the specified cages were observed daily and the date on which first laying egg was recorded. The laid eggs were harvested on daily basis and shifted to the Petri dishes for further investigation in the experiment and the date of last egg harvesting was also recorded. The reproductive period of female have been calculated by subtracting the date of first eggs harvest from the date on which last egg was harvested.

Reproductive Period = Date of first egg laying-Date of last eggs laid.

2.4 Percent hatchability

The percent hatchability in each diet was calculated by using the following formula:

$$\text{Percent Hatchability} = \frac{\text{No of larvae hatched x 100}}{\text{Total No of fresh Eggs}}$$

For percent hatchability, ten replications were taken and counted number of fresh eggs (100) of *Chrysoperla carnea* were placed in each Petri dish and were observed on daily basis under binocular, the number of eggs hatched and un-hatched eggs were counted for 2-3 days and then percent hatchability was calculated on the basis of data by using the above formula.

2.5 Longevity of adult

The pupae were then transferred to the adult rearing cage marking with the concerned treatment and replication. The emergence date of adults from each pupa was observed besides noting the date of death of each adult. The longevity of the *Chrysoperla carnea* has been determined by subtracting the date of emergence of adult from the date of death of the last adult.

3. Results and Discussion

The effects of different diets on the larval development of *Chrysoperla carnea* (Stephens) were studied and the reproductive potential of the adult female

3.1 Larval development period

3.1.1 Total larval Duration (Days)

Statistical analysis of the data showed that the sub-parameter total larval duration was highly significantly affected by the various dietary treatments**.** The data (Table 1) exhibited that minimum (22.5) total larval duration was recorded in factitious diet + artificial diet while maximum total larval duration (24.9) was recorded in artificial diet A followed by the artificial diet B (23.9). However, the minimum value was statistically at par with the factitious diet (22.9) and the chicken liver (23.2). Sengonca and Schimmel [4] worked on the larval period of *Chrysoperla carnea*. Bichao and Araujo [5] determined the total quantity of eggs of *Sitotroga cerealella* required to complete larval development in the predator *C. carnea*. Moreover, Letardi and Caffarelli [6] tested a liquid artificial diet for feeding larvae of *C. carnea* of which two groups of larvae were reared on artificial diet.

Obrycki *et al.* [7] reported that immature development of *C. carnea* requires 20.5, 21.6, and 24.9 days. According to Zheng *et al* [8]. larvae that had a suboptimal food supply in the 1st instar had a significantly longer development time. Yoldas [9] reported the average larval period of *C. carnea* feeding on *M. euphorbiae* was 9.93 and 11.4 days for the 1st and 2nd generation, resp., while with T. vaporariorum the larval period was 10.25 and 11.9 days, resp. Thite and Shivpuje [10] reported that Larval development was completed in 7.60 days when larvae were provided with eggs of *Corcyra* and cotton aphids. Zaki and Gesraha [11] reported that feeding the newly hatched larvae of the predator on water extract of the algae extended the larval duration up to 30 days, and the larvae failed to pupate.

Table 1: Total Larval Duration of *Chrysoperla carnea* as affected by different diets

Treatment	Total Larval Duration (TLD)
S. cerealella eggs(Factitious diet)	22.9 C*
Artificial diet A	24.9 A
Artificial diet B	23.9 B
Factitious diet + Artificial diet	22.5 C
Chicken Liver	23.2 BC
$LSD_{0.05}$ for Total larval duration	*0.8363*
COV (%)	*0.2936*

3.2 Percent emergence of adults

3.2.1 Total pupal duration (Days)

ANOVA of the data indicated that total pupal duration was highly significantly affected by the dietary treatments**.** The data in Table 2 showed that maximum total pupal duration (15.40) was recorded in artificial diet A which was statistically at par with the artificial diet B (14.60). On the other hand minimum (12.20) total pupal duration was recorded in factitious diet + artificial diet. The reason for the maximum total pupal duration may be the adequate and suitable required nutrients in the artificial diets as compared to the factitious diets. Similar work was performed by Sengonca and Schimmel [4] who reported pupal duration and larval mortality on the basis of two different diets. Moreover, Vlcheva [12] reported that feeding on *S. cerealella* increased larval mortality and also increased the mortality and duration of development of the pupae and reduced cocoon weight and adult fecundity. Balasubramani and Swamiappan [13]. revealed that pupal development period was shorter on *B. tabaci* and *A. biguttula* and longer on neonate larvae of *H. armigera*. The most rapid development occurred when the prey was pupae of *B. tabaci* or eggs of *C. cephalonica*.

Table 2: Total Pupal Duration of *Chrysoperla carnea* as affected by different diets

Treatment	Total Pupal Duration
S. cerealella eggs (Factitious diet)	12.20 C*
Artificial diet A	15.40 A
Artificial diet B	14.60 AB
Factitious diet + Artificial diet	10.90 D
Chicken Liver	13.70 B
$LSD_{0.05}$ for Total pupal duration	0.9048
COV (%)	7.52%

3.3 Percent Emergence of Adults

The emergence of adults from the cocoons form from the larvae fed with different diets was significantly affected. The data in table 3 showed that maximum number of adults (86%), (66%) and (46%) emerged from the larvae fed with mixed, factitious and chicken liver respectively. Whereas minimum adult emergence (26%) was recorded in artificial diet A and B with the same statistical values.

Table 3: Percent emergence of total number of survived larvae of *Chrysoperla carnea* as affected by different diets

Treatment	Percent number of survived larvae
S. cerealella eggs (*Facticious diet*)	66 b
Artificial diet A	26 d
Artificial diet B	26 d
Factitious diet + Artificial diet	86 a
Chicken Liver	46 c
$LSD_{0.05}$ for % number of female	*12.74*
CV (%)	*28.28*

3.4 Percent Larval Mortality

The statistical analysis of data showed that larval mortality was significantly affected by different dietary treatments. The data in table-4 revealed that minimum larval mortality (14%) was observed in the mix diet (Factitious + artificial diet B) followed by (34%) and (54%) in factitious diet and chicken liver. Whereas maximum larval mortality (74%) and (64%) was recorded in artificial diet A and B with similar statistical values.

Table 4: Percent Larval mortality of *Chrysoperla carnea* as affected by Different diets

Treatment	Percent larval mortality
S. cerealella eggs (Factitious diet)	34 c
Artificial diet A	64 ab
Artificial diet B	74 a
Factitious diet + Artificial diet	14 d
Chicken Liver	54 b
$LSD_{0.05}$ for % total dead larvae	15.19
CV (%)	35.14

3.5 Percent formation of cocoons.

The formation of cocoons of *Chrysoperla carnea* was significantly affected by the different dietary treatments. The data in table-5 showed that maximum cocoon formation (86%) was recorded mix diet. In factitious diet (66%) cocoons formed and in chicken liver the formation of cocoons were (52%). While minimum number of cocoons (26%) was formed in artificial diet A and B with similar statistical values.

Table 5: Percent of total number of cocoon formed of *Chrysoperla carnea* as affected by different diets

Treatment	Percent of cocoons formed
S. cerealella eggs(Factitious diet)	66 b
Artificial diet A	26 d
Artificial diet B	26 d
Factitious diet + Artificial diet	86 a
Chicken Liver	52 c
$LSD_{0.05}$ for % total cocoon formed	12.82
CV (%)	27.80

3.6 Percent Emergence of males

The statistical analysis of data exhibited that the emergence of males was significantly affected by the different dietary treatments. The data at table-6 showed that maximum male emergence (36%) was recorded in mix diet followed by (32%) fed with factitious diet and (14%) males emerged from the larvae fed with chicken liver. The minimum (4%) of males emerged from the cocoons fed with artificial diet B and (6%) inartificial diet A with same statistical values.

Table 6: Percent emergence of males of *Chrysoperla carnea* as affected by different Diets

Treatment	Percent of male *C. carnea*
S. cerealella eggs(Factitious diet)	32 a
Artificial diet A	6 b
Artificial diet B	4 b
Factitious diet + Artificial diet	36 a
Chicken Liver	14 b
$LSD_{0.05}$ for % number of male	16.07
CV (%)	96.95

3.7 Percent emergence of females

The ANOVA of data exhibited that percent emergence of females was also affected significantly by the different dietary treatments. The data in table-7 showed that the ratio of female emergence was highest (38%) in mixed diet followed by (22%) and (20%) in chicken liver and factitious diets. While minimum female emergence ratio (10%) and (16%) was observed in artificial diet A and B with similar statistical values.

Table 7: Percent emergence of female of *Chrysoperla carnea* as affected by different Diets

Treatment	Percent of female of *C. carnea*
S. cerealella eggs(Factitious diet)	20 ab
Artificial diet A	16 b
Artificial diet B	10 b
Factitious diet + Artificial diet	38 a
Chicken Liver	22 ab
$LSD_{0.05}$ for % number of female	20.08
CV (%)	105.15

3.8 Percent Mortality of Cocoons

The mortality of cocoons was significantly affected by different dietary treatments. The data in Table-8 showed that minimum cocoon mortality (4%) was observed in artificial diet A and (14%) in mixed diet and artificial diet B. The maximum cocoon mortality ratio (16%) was observed in factitious diet and in chicken liver with similar statistical values.

Table 8: Percent Mortality of cocoons of *Chrysoperla carnea* as affected by different diets

Treatment	Percent of mortality of cocoons
S. cerealella eggs(Factitious diet)	16
Artificial diet A	4
Artificial diet B	14
Factitious diet + Artificial diet	12
Chicken Liver	16
$LSD_{0.05}$ for % number of dead cocoons	Ns
CV (%)	138.75

3.9 Reproductive period of adult female

3.9.1 Total reproductive period (Average)

Analysis of the data revealed that the total reproductive period (avg) was significantly affected by the different diets**.** The data in Table-9 showed that maximum total reproductive period (6.3) was recorded in factitious + artificial diet. However, it was statistically at par with natural diet (4.8). Minimum (2.4) total reproductive period was noted in artificial diet A which was statistically similar with artificial diet B (2.7) and chicken liver (3.3). Hasegawa *et al.,* [14]. Reported that larvae of *C. carnea* developed into adults on 4 chemically defined diets of different amino acid composition.

The diets were composed of 23 amino acids, sucrose, trehalose, 5 organic acids, 6 fatty acids, cholesterol, 11 mineral salts and 17 vitamins. Furthermore, Yazlovetskii *et al.,* [15]. Reviewed data on nutrition and artificial diets of *C. carnea* on the basis of earlier work on food requirements of the larvae. They mentioned chief biological indices of development e.g. survival and duration of development of the larval and pupal stages, adult fecundity. Balasubramani and Swamiappan [13]. Revealed that the total duration of the development period (egg to adult emergence) in *C. carnea* was 19.15, 19.35, 19.95, 20.15 20.60 and 22.50 days.

Table 9: Total reproductive period (average) of *Chrysoperla carnea* as affected different diets

Treatments	Total reproductive period (average)
S. cerealella eggs (Factitious diet)	4.8 AB*
Artificial diet A	2.4 B
Artificial diet B	2.7 B
Factitious diet + Artificial diet	6.3 A
Chicken Liver	3.3 B
$LSD_{0.05}$ for Total reproductive period (avg)	*2.874*
COV (%)	*81.83*

3.10 Percent hatchability

The percent hatchability in each diet was calculated by using the following formula:

$$\text{Percent Hatchability} = \frac{\text{No of larvae hatched x 100}}{\text{Total No of fresh Eggs}}$$

The data in Table-10 exhibited that maximum percent hatchability (86.5%) was recorded in the eggs laid by the adult female reared on the mixed diet (factitious + artificial diet B) followed by (82%and 80%) hatchability was observed in factitious diet and artificial diet B. While minimum (75% and 75.5%) hatchability was recorded in artificial diet A and chicken liver respectively with the same statistical values. Sengonca and Schimmel [4]. investigated the techniques for rearing the predator *C. carnea* for release as a biological control agent and reported the hatching rate of eggs on various diets. Karpacheva [16]. also described food consumption and fecundity of *C. carnea* larvae, on *Sitotroga cerealella* and its release against aphids in the greenhouse and in the field.

Table 10: Laying and percent hatchability of eggs of *C. carnea* as affected by different diets.

Treatments	Eggs Laid per Female per Day (±SD)	Percent Hatchability (±SD)
Factitious Diet	7.20 b ±1.48	82.0 ab ±6.75
Artificial Diet A	4.50 c ±1.27	75.0 c ±6.24
Artificial Diet B	4.50 c ±1.43	80.0 bc ±7.82
Factitious + Artificial Diet	8.60 a ±1.65	86.5 a ±5.80
Chicken Liver	5.10 c ±1.45	75.5 c ±7.98
LSD (P≤ 0.05)	1.315	6.277
CV %	24.41	8.73

3.11 Longevity of adult

3.11.1 Total longevity period of the adult female

Data analysis showed that total longevity period of the adult was highly significantly affected by the different diets**.** Table-11 revealed that maximum total longevity period (12.5) was recorded in natural + artificial diet which was statistically similar to natural diet alone (12.1) and chicken liver (10.1) while minimum (4.2) total longevity period was recorded in artificial diet A. However, the minimum value was statistically similar to artificial diet B (5.4). Makarenko [17]. (1988) described the preparation of a dry diet for adults of *C. carnea* based on brewer's yeast autolysate and sucrose described that fecundity was increased 2.2- to 2.8-fold in comparison with the liquid diet. Letardi and Caffarelli [18] reared *C. carnea* on a liquid semi-artificial diet to study its effects on preimaginal development, mortality and female fecundity and longevity. Whereas Yoldas [9] reported the longevity of adult females fed on M. euphorbiae during the larval stage as 46.16, with fecundity of 750.66 eggs female^{-1}. Osman and Selman [19] reported that *C. carnea* larval diet exerts a significant effect on the rate of development, survival, cocoon weight and the fecundity of the adult females.

Table 11: Total Longevity Period of the adult female of *Chrysoperla carnea* as affected by different diets

Treatment	Total Longevity Period of the adult
S. cerealella eggs (Factitious diet)	12.1 A*
Artificial diet A	4.2 B
Artificial diet B	5.4 B
Factitious diet + Artificial diet	12.5 A
Chicken Liver	10.1 A
$LSD_{0.05}$ for Total longevity period of the adult	3.328
CV (%)	41.70

Laboratory temperature: 20-23 C

Replication No.	Total duration of Ist instar	Total duration of 2nd Instar	Total duration of 3rd Instar	Total larval duration
1	11	7	7	25
2	11	8	7	26
3	10	8	7	25
4	8	9	8	25
5	12	7	5	24
6	10	9	6	25
7	9	9	7	25
8	10	8	6	24
9	9	9	6	24
10	8	11	7	26

Larval development period on an artificial diet B T_3

Laboratory temperature: 20-23 C

Replication No.	Total duration of Ist instar	Total duration of 2nd Instar	Total duration of 3rd Instar	Total larval duration
1	8	9	6	23
2	9	9	7	25
3	9	9	6	24
4	8	9	5	22
5	10	7	6	23
6	9	9	6	24
7	10	9	6	25
8	8	8	8	24
9	8	9	7	24
10	10	9	6	25

Larval development period on a natural + artificial diet (A+B) T_4

Laboratory temperature: 20-23 C

Replication No.	Total duration of Ist instar	Total duration of 2nd Instar	Total duration of 3rd Instar	Total larval duration
1	6	9	7	22
2	8	8	5	21
3	8	9	6	23
4	10	7	5	22
5	9	9	5	23
6	8	8	6	22
7	8	9	5	22
8	11	7	5	23
9	11	6	6	23
10	10	9	5	24

Larval development period on a chicken liver T_5

Laboratory temperature: 20-23 C

Replication No.	Total duration of 1st instar	Total duration of 2nd Instar	Total duration of 3rd Instar	Total larval duration
1	11	7	5	23
2	9	6	6	21
3	9	8	7	24
4	9	9	4	22
5	11	7	5	23
6	8	11	5	23
7	9	8	6	23
8	12	7	5	24
9	8	8	8	24
10	9	9	7	25

Percent emergence of adults on a natural diet (*Sitotroga cerealella* eggs) T_1

Laboratory temperature: 20-23 C

Replication No.	Total no. survived larvae/Out of	Total no. of dead larvae	Total no. of cocoon formed	No. of male and female	Total pupal duration
1	4/5	1	4	2M, 1F	13 days
2	3/5	2	3	1M, 2F	12 days
3	3/5	2	3	1M, 3F	13 days
4	3/5	2	3	2M, 1F	10 days
5	4/5	1	4	1M, 3F	13 days
6	3/5	2	3	2M, 1F	10 days
7	2/5	3	2	2M, 0F	13 days
8	3/5	2	3	2M, IF	12 days
9	4/5	1	4	1M, 3F	13 days
10	4/5	1	4	2F, 2F	13 days

Percent emergence of adults on an artificial diet AT_2

Laboratory temperature: 20-23 C

Replication No.	Total no. survived larvae/Out of	Total no. of dead larvae	Total no. of cocoon formed	No. of male and female	Total pupal duration
1	2/5	3	2	0M, 2F	16 days
2	1/5	4	1	0M, 1F	15 days
3	2/5	3	2	0M, 2F	16 days
4	3/5	2	3	2M, 1F	14 days
5	1/5	4	1	0M, 1F	16 days
6	1/5	4	1	0M, 1F	14 days
7	1/5	4	1	0M, 0F	15 days
8	0/5	0	0	0M, 0F	15 days
9	1/5	4	1	1M, 0F	17 days
10	1/5	4	1	0M, 0F	16 days

Percent emergence of adults on an artificial diet B

T_3Laboratory temperature: 20-23 C

Replication No.	Total no. survived larvae/Out of	Total no. of dead larvae	Total no. of cocoon formed	No. of male and female	Total pupal duration
1	2/5	3	2	2M, 0F	15 days
2	1/5	4	1	0M, 2F	15 days
3	1/5	4	1	0M, 1F	14 days
4	1/5	4	1	0M, 0F	14 days
5	2/5	3	2	0M, 1F	15 days
6	1/5	4	1	0M, 0F	14 days
7	0/5	5	0	0M, 0F	15 days
8	1/5	4	1	0M, 1F	15 days
9	2/5	3	2	0M, 2F	13 days
10	2/5	3	2	0M, 2F	16 days

Percent emergence of adults on a natural + artificial diet (A+B) T_4

Laboratory temperature: 20-23C

S. No.	Repli No.	Total no. survived larvae/Out of	Total no. of dead larvae	Total no. of cocoon formed	No. of male and female	Total pupal duration
1	1	5/5	0	5	1M, 4F	13 days
2	2	4/5	1	4	1M, 3F	12 days
3	3	4/5	1	4	1M, 3F	10 days
4	4	4/5	1	4	3M, 1F	10 days
5	5	5/5	0	5	3M, 2F	10 days
6	6	4/5	1	4	0M, 4F	10 days
7	7	3/5	2	3	1M, 0F	11 days
8	8	4/5	1	4	3M, 1F	12 days
9	9	5/5	0	5	1M, 1F	11 days
10	10	5/5	0	5	4M, 0F	10 days

Percent emergence of adults on a chicken liver T_5

Laboratory temperature: 20-23 C

Replication No.	Total no. survived larvae/Out of	Total no. of dead larvae	Total no. of cocoon formed	No. of male and female	Total pupal duration
1	3/5	2	3	2M, 1F	15 days
2	2/5	3	2	2M,0F	13 days
3	2/5	3	3	1M, 2F	13 days
4	2/5	3	3	0M, 3F	14 days
5	3/5	2	3	1F, 0M	13 days
6	2/5	3	3	1M, 1F	14 days
7	1/5	4	1	0M, 0F	15 days
8	2/5	3	2	0M, 0F	14 days
9	3/5	2	3	1M, 0F	13 days
10	3/5	2	3	0M, 3F	13 days

Reproductive period of adult female on a natural diet (*Sitotroga cerealella* eggs) T_1

Laboratory temperature: 20-23 C

Replication No.	Number of male	Number of female	Number of eggs laid (Average)	Total reproductive period (Average)
1	2M	1F	4	9 Days
2	1M	2F	6	9 Days
3	0	3F	17	5 Days
4	2M	1F	1	3 Days
5	1M	3F	16	7 Days
6	2M	1F	0	2 Days
7	2M	0	0	0 Days
8	2M	IF	6	4 Days
9	1M	3F	11	6 Days
10	0	2F	9	3 Days

Reproductive period of adult female on an artificial diet AT_2

Laboratory temperature: 25-30

Replication No.	Number of male	Number of female	Number of eggs laid (Average)	Total reproductive period (Average)
1	0	2F	11	9 Days
2	0	1F	0	2 Days
3	0	2F	1	3 Days
4	2M	1F	2	5 Days
5	0	1F	0	1 Days
6	0	1F	0	0 Days
7	0	0	0	0 Days
8	0	0	0	4 Days
9	1M	0	0	0 Days
10	0	0	0	0 Days

Reproductive period of adult female on an artificial diet B T_3

Laboratory temperature: 20-23 C

Replication No.	Number of male	Number of female	Number of eggs laid (Average)	Total reproductive period
1	2M	0	0	0 Days
2	0	2F	9	6 Days
3	0	1F	1	3 Days
4	0	0	0	0 Days
5	0	1F	6	7 Days
6	0	0	0	0 Days
7	0	0	0	0 Days
8	0	1F	0	4 Days
9	0	2F	5	3 Days
10	0	2F	9	4 Days

Reproductive period of adult female on a natural + artificial diet (A+B) T_4

Laboratory temperature: 20-23 C

Replication No.	Number of male	Number of female	Number of eggs laid (Average)	Total reproductive period (Average)
1	1M	4F	16	7 Days
2	1M	3F	11	8 Days
3	1M	3F	17	11Days
4	3M	1F	7	9 Days
5	3M	2F	1	5 Days
6	0	4F	16	13 Days
7	1M	0	0	0 Days
8	3M	1F	0	0 Days
9	1M	1F	6	5 Days
10	4M	0	0	0 Days

Reproductive period of adult female on a chicken liver T_5

Laboratory temperature: 10-23 C

Replication No.	Number of male	Number of female	Number of eggs laid (Average)	Total reproductive period (Average)
1	2M	1F	4	5 Days
2	2M	0	0	0 Days
3	1M	2 F	11	5 Days
4	0	3F	13	5 Days
5	0	1F	7	7 Days
6	1M	1F	2	5 Days
7	0	0	0	0 Days
8	0	0	0	0 Days
9	1M	0	0	0 Days
10	0	3F	9	6 Days

Longevity of adult on a natural diet (*Sitotroga cerealella* eggs) T_1

Laboratory temperature: 20-23 C

Replication No.	Total no. cocoons	Number of male	Number of female	Total no. adults	Total longevity period of adult
1	4	2M	1F	3	12
2	3	1M	2F	3	15
3	3	0	3F	3	12
4	3	2M	1F	3	10
5	4	1M	3F	4	16
6	3	2M	1F	3	18
7	2	2M	0	2	5
8	3	2M	IF	3	14
9	4	1M	3F	4	8
10	4	0	2F	2	11

Longevity of adult on an artificial diet AT_2

Laboratory temperature: 25-30 C

Replication No.	Total no. cocoons	Number of male	Number of female	Total no. adults	Total longevity period of adult
1	2	0	2F	2	5
2	1	0	1F	1	4
3	2	0	2F	2	7
4	3	2M	1F	3	11
5	1	0	1F	1	4
6	1	0	1F	1	5
7	1	0	0	0	0
8	0	0	0	0	0
9	1	1M	0	1	6
10	1	0	0	0	0

Longevity of adult on a artificial diet B T_3

Laboratory temperature: 25-30 C

Replication No.	Total no. cocoons	Number of male	Number of female	Total no. adults	Total longevity period of adult
1	2	2M	0	2	10
2	1	0	2F	2	11
3	1	0	1F	1	5
4	1	0	0	0	0
5	2	0	1F	1	5
6	1	0	0	0	0
7	0	0	0	0	0
8	1	0	1F	1	4
9	2	0	2F	2	8
10	2	0	2F	2	11

Longevity of adult on a natural + artificial diet (A+B) T_4

Laboratory temperature: 20-23 C

Replication No.	Total no. cocoons	Number of male	Number of female	Total no. adults	Total longevity period of adult
1	5	1M	4F	5	15
2	4	1M	3F	4	15
3	4	1M	3F	4	12
4	4	3M	1F	4	10
5	5	3M	2F	5	17
6	4	0	4F	4	18
7	3	1M	0	1	5
8	4	3M	1F	4	14
9	5	1M	1F	2	8
10	5	4M	0	4	11

Longevity of adult on a chicken liver T_5

Laboratory temperature: 25-30 C

Replication No.	Total no. cocoons	Number of male	Number of female	Total no. adults	Total longevity period of adult
1	3	2M	1F	3	9
2	2	2M	0	2	12
3	3	1M	2 F	3	12
4	3	0	3F	3	8
5	3	0	1F	1	13
6	3	1M	1F	2	10
7	1	0	0	0	7
8	2	0	0	0	9
9	3	1M	0	1	12
10	3	0	3F	3	9

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