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PREDATION EFFICIENCY AND SOME BIOLOGICAL ASPECTS OF THE PREDATOR *CHRYSOPERLA CARNEA* (STEPHENS) (NEUROPTERA: CHRYSOPIDAE) LARVAE FEEDING ON DIFFERENT EGG PREYS UNDER LABORATORY CONDITIONS

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ABSTRACT: Studies have been conducted on the effect of the type of prey on Predation efficiency and some biological aspects of *Chrysoperla carnea* (Stephens), Results indicated that the type of food has a significant impact on the incubation period of eggs, larval and pupal periods, as well as the percentage of survival larvae, emergence percentages of adult and the sexual ratio. The results showed that the shortest of the incubation period, larval and pupal periods when larvae feed on *Sitotroga cerealella* , *Corcyra cephalonica and Galleria mellonella* . The results were in the same trend for the survival rate of the larvae, the emergence percentages of adult, longevity of adult, fecundity and fertility. The obtained results showed that *S. cerealella*, *C. cephalonica*, *G. mellonella* eggs were the most preferred food for *C. carnea* larvae.

Key words: Egg preys, Predation efficiency, Biological aspects, *Chrysoperla carnea* (Stephens); Mass rearing

INTRODUCTION

Biological control is one of the main methods that are followed within the integrated pest management program. Biological control is the use of natural enemies that reduce the population density of pests to a level less than the economic threshold level (DeBach, 1965), which requires conducting chemical control. Thus, it reduces the use of pesticides and chemicals, which cause environmental damage and harm to humans and animals. Natural enemies include parasites, predators and pathogens, which represent the sides of the triangle of biological control. (Williamson and Smith, 1994). In order to biological control be effective and successful, it is the possibility of mass rearing natural enemies in a large scale so that they can be applied over large areas. The mass rearing of natural enemies depends on raising the hosts or prays or through the use of artificial diets in laboratory, in these cases the materials used in mass rearing must be cheap so that they can be applied and used widely (Larock and Ellington, 1996).

The green lacewings, *Chrysoperla carnea* (Stephens) is considered one of the predators that has proven great success in different agricultural systems, because it is polyphagous, , it preys on many types of insect pests such as aphids and eggs of many insects, as well as some small stages of many insect pests (Yuksel and Goemen, 1992; Singh and Manoj, 2000; Zaki and Gesraha, 2001). It was used in many countries of the world as one of the most important insect predators in bio – control app;ications and integrated pest management programs (Venkatesan *et al*., 2000, 2002, Obrycki *et al*., 1989). It has been possible to mass rearing it and trade it commercially on a large scale in many countries due to its ease of mass rearing in laboratory (Uddin *et al*., 2005, Tauber *et al*., 2000, Liu and Chen, 2001, Atakan, 2000).

The aim of this research was to study the effect of feeding on different preys (*Sitotroga cerealella, Corcyra cephalonica, Galleria mellonella Pectinophora gossypiella, Erias insulana and mixed preys*) eggs by studying the larval development of *C. carnea* under laboratory conditions and the predatory efficiency of these larvae by using previous preys. For mass production and thereafter field application against main pests.

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MATERIALS AND METHODS

Developmental parameters of *Chrysoperla carnea* on five natural preys were studied. The natural hosts were **(***Sitotroga cerealella* (Oliver) (frozen eggs),*Pectinophora gossypiella* , *Galleria mellonella* , *Corcyra cephalonica,* , pink bollworm, *Pectinophora gossypiella* (Saund.) , spiny bollworm *Erias insulana* and mixed host diet which contained all five egg preys. Eggs of *S. cerealella* taken from laboratory culture were provided to the larvae of *C. carnea* under control conditions (26±2°C; 65±5% R.H).

Chrysoperla carnea mass rearing:

The larvae were obtained from the biological control laboratory of the Faculty of Agriculture, Cairo University, and then mass rearing for several generations in the laboratory conditions (25 ± 2 °C& 65± 5% R. H.) as described by Hassan, (2014) in the biological laboratory of the Faculty of Agriculture, Menoufia University. Green lacewings *Chrysoperla carnea* larvae were obtained from adults reared on the eggs of the Angoumois grain moth, *Sitotroga cerealella* (Olivier). The laid eggs were collected daily and kept under the same conditions .The newly hatched larvae were fed on eggs of Angoumois grain moth, *S. cerealella.*

Preys rearing:

a-Sitotroga cerealella: The eggs of *Sitotroga cerealella* moth were obtained from the biological control laboratory of the Faculty of Agriculture, Cairo University during 2019. The obtained eggs were used for classical mass rearing of *Sitotroga* eggs as described by (Abdel-Hameid , 2018).

b-Pectinophora gossypiella: The eggs of Pink bollworm *Pectinophora gossypiella* were obtained from bollworm department, plant protection Institute, pink bollworm larvae were reared in the laboratory conditions for several generations on artificial diet as described by Abd El- Hafez *et al.* (1982) .

c-*Corcyra cephalonica*: Fresh Rice moth *Corcyra cephalonica* eggs were obtained from the biological control laboratory of the Faculty of Agriculture, Cairo University. The eggs of *C.cephalonica* were kept in refrigerator to be used before hatching.

d-***Galleria mellonela :*** The *G .mellonella* larvae were collected from the domestically bee hives and reared for many generations on artificial diet containing (Wheat flour 350 g, corn flour 200 g, milk powder 130 g, backing yeast powder 70 g, honey 100 ml, and glycerin 150 ml, (Metwally, *et al* 2012).Larvae, pupae, and adults were kept in darkness at 28-31 C and 60% humidity , adults kept in glass jars covering with filter paper to obtained the eggs which will use as a food for the tested predator .

e- *Earias insulana (*Boisd): The eggs of spiny bollworm *Earias insulana* were obtained from bollworm research department, plant protection research Institute , which reared in the laboratory conditions at 26±1^{0}C and 75±5 R.H on artificial diet as described by (Amer, 2015) .

f- Mixed host diet: In mixed host diet all five hosts were given in equal proportions in glass vials (2.5cm diameter and 8.5 cm length) covered with black muslin cloth piece. The larvae were fed with eggs/ nymphs in these jars till pupation.

Developmental parameters:

For developmental parameters experiments, newly emerged unfed larvae were placed in plastic tubes, sealed at both, these tubes contained different tested preys' egg. Three replicates were used for each one, and each replicate contained 10 tubes, and each tube contained 10 newly hatched larvae. To avoid cannibalism between the larvae used in the experiment, pieces of paper were used and folded several times.

The newly hatched larvae were placed in plastic vials (2.5 cm diameter and 8.5 cm length) covered with black muslin cloth. Each prey was offered till pupation and adult emergence same procedure was used in mixed host diet. Incubation period, larval period, pupal period, larval survival rate and adult emergence percentages were estimated.

The percentage of hatchability was recorded by collecting eggs with Sharp blade then put it on black muslin cloth and counted then kept for hatching. Fresh emerging adults were paired in the rearing glass (4 x 7.5 cm), fed with standardized adults' diet which described by Hassan (2014). Longevity, fecundity, and fertility were recorded.

Preadation effecincy of C. *carnea* larvae on different prey species:

Feeding efficiency of *C. carnea* larval instars, 1st, 2nd and 3rd was studied on the eggs of **(***Sitotroga cerealella* (Oliver) (frozen eggs),*Pectinophora gossypiella* , *Galleria mellonella* ,*Corcyra cephalonica,* pink bollworm, *Pectinophora gossypiella* (Saund.) , spiny bollworm *Erias insulana* and mixed host diet. 1st instar larvae of *C. carnea* were given 100 eggs, using glass tubes (2x7 cm.) tightly closed with compressed cotton piece. Three replicates were used / prey species. The same technique was applied for the 2nd and 3rd instars, numbers of consumed and of attacks eggs were recorded daily for each instar.

Statistical analysis:

The obtained data were statistically analyzed by (one-way analysis of variance, ANOVA). Means were compared by using Duncan's Multiple Range Test (1955) with the help of SPSS computer software (2010) . Five percent significance level was considered for ANOVA. The result reported as Mean ± S.E.

RESULTS AND DISCUSSION

Development of immature stages fed on different egg preys:

Table No. 1 shows the measures of development in the incomplete instars of the insect under study. From the results, it was found that the type of food affected the incubation period of eggs, the period of the larval stage and the pupal stage, and also how it had an effect on the life rate of the larvae, as well as the pupae, the exit of adults and the sex ratio.

From the previous results in table (1), it became clear that the incubation period for eggs differed significantly according to the food, the shortest period of incubation for eggs was 2.25 followed by 2.31 , 2.61 and 2.80 days on *C. cephalonica* , *S. cerealella* ,*G. mellonella* and mixed diet, respectively, while the longest period of incubation was 3.83 days followed by 3.85 days that was when the larvae in the first generation were fed on *E. insulana* and *P. gossypiella* ,respectively.

As for the larval stage, the results showed that the larval period was also significantly affected by the type of food provided to the larvae in the previous generation, as the shortest period for the larval stage was 8.86 days followed by 8.89 9.84 and 9.99 days, respectively, when the larvae fed on. *S. cerealella*, C *cephalonica* , ,*G. mellonella* and mixed diet, respectively. While the longest period of the larval stage was 13.00 followed by 11.83 when the larvae fed on *E. insulana* and *P. gossypiella*, respectively.

The same trend occurred for the pupa stage. The pupal period differed significantly, where the results were in the same direction, but it was not strong, the shortest period for the pupae was7.15 days when the larvae fed on *S. cerealella*, while the longest pupal period was 7.77 days when the larvae fed on *E. insulana.*

Data also, showed that prey species has a strong effect on the biology and development of *C. carnea* immature stages, where the development was rapid and the shortest larval periods occurred when larvae fed on *C. cephalonica, S. cerealella* and *G. mellonella* eggs these results agreed with (Balasubramani &Swamiappan 1994, Sattar *et al.* 2011, Mannan et al. 1997, Saminathan *et al.* 1999, Bansod and Sarode 2000, Tesfaye and Gautam, 2002). They studied the effect of food type on the biology of *C.carnea* and recorded the same effect. Hassan (2014) studied the feeding capacity and host preference of *C. carnea*, also found that there were significance differences between the mean consumed numbers of *C. cephalonica* eggs, *P. gossypiella* and *S. cerealella*; Also, the study of host preference (Free Choice) showed that *C. cephalonica* was the most preferred one.

The results also indicated that the survival rate of the larvae differed significantly according to the type of food, and the highest survival rate of the larvae was 98.00 followed by 92.5 % when the larvae fed on *C. cephalonica* and *S. cerealella* respectively, while the lowest percentage survival was 62.00 followed by 62.5 %.when the larvae fed on *E. insulana* and *P. gossypiella* ,respectively. As for adult emergence percentage, the highest percentage was recorded and it was 98.00% followed by 88.5, 85.00 % when the larvae fed on *C. cephalonica* and *S. cerealella* and *G. mellonella* while the lowest percentage was 55.00 followed by 58.5 % when the larvae fed on *E. insulana* and *P. gossypiella* ,respectively .These results indicated that prey spices has a great effect on larval survival and adult emergence and significant positive correlation between prey consumed during larval stage and adult body weight of *C. carnea*. (Tesfaye and Gautam, 2002, Obrycki *et al.* 1989).

As for the sexual ratio, it was noted that it did not differ much according to the food, the high sex ratio was 1.8 when the larvae fed *C. cephalonica* and *S. cerealella* and *G. mellonella*.while the sex ratio was 1.7 on mixed diet, also these ratio were 0.9 and 0.8 on *P. gossypiella* and *E. insulana* (Liu and Chen (2001) and Zheng *et al.* (1993)

Data obtained in Table (2) showed that pre-oviposition , oviposition and pre-oviposition were significantly differed. The longest pre-oviposition period of *C. carnea* was 3.81 days after feeding on *C. cephalonica* but the shortest pre-oviposition was 3.11. days after feeding on *P. gossypiella*.The longest oviposition period of *C. carnea* females was 17.9 days recorded on *C. cephalonica* followed by 17.81 days on *G. mellonella* .The maximum mean of post-oviposition period was 7.22 followed by 7.32 and 7.10 days recorded on *C. cephalonica* , *G.mellonella* and mixed diet, respectively. The maximum mean fecundity of *C. carnea* was 503.3 followed by 422.8 , 419.91 and 410.63 Eggs/ female recorded when fed as larvae on *C. cephalonica* , *S. cerealella* ,*G. mellonella* and mixed diet, respectively.

Whereas, the minimum were 384 and 337.3 eggs/ female when fed on *E. insulana* and *P. gossypiella*. The same trend was noticed in fertility , the maximum was 88.11 followed by 85.81 % on *C. cephalonica* and *S. cerealella*, but the minimum were 75.10 and 73.31 % on *P. gossypiella* and *E. insulana* . Longevities of adult female were significantly differed , the longest longevities were 28.94 followed by 28.64, 26.37 and 26.29 days on *C. cephalonica* , *S. cerealella* ,*G. mellonella* and mixed diet, respectively. The longest longevity of adult male was 21.33 days on *S. cerealella* but the shortest longivity was 14.21 on *E. insulana* there are in agreement with the results of (Bansod and Sarode (2000, Sattar et al. 2007 ,Sattar, 2010 ,Sattar *et al.* 2011, Saleh, 2017).

Predation efficiency of *C. carnea* larvae :

Results in Table (3) indicated that the three instars larvae of *C. carnea* fed on tested egg masses of different preys , but these instars were differ between them in the number of consumed eggs , where the consumed number raised by the increasing of larval instar. Also the total mean number of consumed eggs differed significantly when larvae fed on different egg preys. The total mean numbers of consumed eggs were 659.3, 681.1, 656.8, 538.8 , 513.7 and 552.5 eggs / larva when larvae fed on *S. cerealella, C. cephalonica, G. mellonella, P. gossypiella, E. insulana and* mixed eggs diet, respectively.The statistical analysis indicated that there was a significance difference between the mean total numbers of consumed eggs of different tested prey species and the most preferred eggs prey were *C. cephalonica* followed by, *S. cerealella* , *G. mellonella* and mixed eggs diet but the less preferred eggs preys were *P. gossypiella* and *E. insulana* . (Syed *et al.* ,2008, M. Sattar *et al*. 2011, Jokar and Zarabi, 2013 and Hassan , 2014)

Table (1): Developmental parameters of immature stages of C. carnea according to larval feeding on different types of egg preys.

Immature stages Developmental parameters	*Sitotroga cerealella*	*Corcyra cephalonica*	*Galleria mellonella*	*Pectinophora gossypiella*	*Earias insulana*	Mixed host diet	LSD
Incubation period (days)	2.31 ±0.15 b	2.25± 0.16 b	2.61±0.12 b	3.85± 0.18 a	3.83± 0.14 a	2.80± 0.13 b	
Instars period 1stInstar (days)	2.41±0.18	2.37±0.12	2.81±0.00	3.63±0.00	3.8±0.18	2.67±0.29	-
2ndInstar (days)	2.73±0.16	2.6±0.00	3.12±0.12	3.9±0.12	4.1±0.16	3.20±0.18	-
3rdInstar (days)	3.72±0.12	3.92±0.26	3.91±0.16	4.3±0.16	5.1±0.00	4.12±0.18	-
Larval period (days)	8.86±0.32 d	8.89±0.32 d	9.84±0.18c	11.83±0.26 b	13.00±0.25 a	9.99±0.32 c	4.51
Pupal period (days)	7.15±0.16 b	7.25±0.16 b	7.37±0.18 b	7.60±0.18 a	7.77±0.18 a	7 .42±0.25 b	0.71
Larval survival (%)	92.50±12.50a	98.00±0.00a	86.00±46.29b	60.00±18.90d	62.50±18.30d	75.00±16.40c	38.2
Adult emergence (%)	88.50±35.35b	98.00±0.00a	85.00±46.29b	55.00±53.45d	58.50±51.75d	77.50±51.75c	43.4
Sex ratio	1.8±0.22a	1.8±0.32a	1.2±0.13a	0.9±0.42	0.9±0.51	1.8±0.47a	0.91

Means followed by same letter with in a row are not differ significantly at P≤0.05

Table 2: Developmental parameters of adult stage of *C. carnea* according to larval feeding on different egg preys.

Adult developmental parameters	*Sitotroga cerealella*	*Corcyra cephalonica*	*Galleria mellonella*	*Pectinophora gossypiella*	Earias insulana	Mixed host diet	LSD
Pre-oviposition period (days)	3.21±0.18 b	3.81±0.18 ab	3.51±0.12 a	3.11±0.22 ab	3.37±018 c	3.12±0.18 b	0.71
Oviposition/ day/ female (days)	16.21±0.27 c	17.91±0.44 b	17.81±0.23 b	14.58±0.30 b	14.13±0.47 b	16.15±0.83 a	3.66
Post-oviposition (days)	6.87±0.47	7.22±0.56	7.32±0.26	6.32±0.32	6.15±0.25	7.10±0.42	1.22
Fecundity/ female	422.80±5.35b	503.30±8.17a	419.90±9.19d	337.80±4.61d	384.00±2.15 c	410.63±3.30bc	33.6
Fertility (%)	85.81±2.63 a	88.11±0.62 b	82.43±0.61 b	75.10±2.11 c	73.31±0.57 a	82.61±0.75 b	15.1
Male longevity (days)	21.33±0.49 b	20.61±0.25 c	19.62±0.25 c	17.33±0.32 c	17.12±0.42 a	19.31±0.46 c	4.51
Female longevity (days)	26.29±3.43 a	28.94±5.11 b	28.64±2.31 b	24.71±3.21 b	23.65±2.33 a	26.37±4.12 b	5.56

Means followed by same letter with in a row are not differ significantly at P≤0.05

Table (3) : Predation efficiency of *C. carnea* larvae on different preys eggs

Tested preys	Mean numbers of consumed eggs				
	1 st	2 ed	3 rd	**Total**	**L.S.D**
Sitotroga cerealella	35.1	178.3	445.9	659.3 ±22.41b	35.3
Corcyra cephalonica	45.3	183.2	452.6	681.1 ±25.31a	
Galleria mellonella	33.5	197.5	425.8	656.8 ±0.21.50b	
Pectinophora gossypiella	30.2	150.3	358.3	538.8 ±0.19.42c	
Earias insulana	33.1	135.4	345.2	513.7 ±0.20.36c	
Mixed eggs diet	38.6	161.3	352.6	552.5± 0.18.11b	

Means followed by same letter with in a column are not differ significantly at $P\leq0.05$

Conclusion

The previous study aimed to evaluate the food provided to the most important predator, which is used in biological control operations. Where the effect of the eggs of some insects was studied as food provided to the aphid larvae, and it became clear from the results that the best food was eggs of *C. cephalonica* followed by, *S. cerealella, G. mellonella*. It can be recommended to use the eggs of the previous insects in operations Intensive production of this predator to release it in the fields, and this needs more future studies to maximize the benefit of the types of food provided to this predator.

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الكفاءة الافتراسية و بعض الجوانب البيولوجية ليرقات أسد المن الاخضر *Chrysoperla carnea* (Stephens) (Neuroptera: chrysopidae) بتغذيتها علي فرائس مختلفة تحت الظروف المعملية

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قسم الحشرات الاقتصادية و الحيوان الزراعي- كلية الزراعة – جامعة المنوفية - مصر

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دراسة تأثير نوع الفريسة التي تتغذى عليها اليرقات على بعض الجوانب البيولوجية لمفترس اسد المن الاخضر *Chrysoperla carnea* (Stephens)، و أشارت النتائج إلى أن نوع الغذاء له تأثير كبير على فترة حضانة البيض و اليرقات والعذراء. وأظهرت النتائج أن أقصر فترة حضانة فترة اليرقات والعذارى وكذلك نسبة اليرقات الحية ونسب ظهور الحشرات الكاملة والنسبة الجنسية عندما تتغذي اليرقات علي بيض الفرائس كانت النتائج *Sitotroga cerealella*و *Corcyra cephalonica*و *Galleria mellonella*. على التوالى اما بالنسبة لمعدل بقاء اليرقات ، ونسب ظهورالحشرات الكاملة، وطول فترة حياة الحشرة الكاملة، وعدد البيض الذي تضعه الانثي و معدل الخصوبة . و اظهرت النتائج المتحصل عليها ان بيض *Corcyra cephalonica* و *Sitotroga cerealella* و*Galleria mellonella* على التوالى كان الاكثر تفضيلا ليرقات اسد المن