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Ahmad-Ur-Rahman Saljoqi
Department of Plant Protection, The University of Agriculture, Peshawar-Pakistan.

Naila Asad
Department of Plant Protection, The University of Agriculture, Peshawar-Pakistan.

Javed Khan
National Agricultural Research Center, Islamabad-Pakistan.

Ehsan-ul-Haq
National Agricultural Research Center, Islamabad-Pakistan.

Sadur-Rehman
Agriculture Research Institute, Tarnab, Peshawar-Pakistan.

Zelle Huma
Department of Plant Protection, The University of Agriculture, Peshawar-Pakistan.

Humna Gul Saeed
Department of Human Nutrition, The University of Agriculture, Peshawar-Pakistan.

M. Nadeem
Department of Plant Protection, The University of Agriculture, Peshawar-Pakistan.

M. Salim
Department of Plant Protection, The University of Agriculture, Peshawar-Pakistan.

Bashir Ahmad
Department of Plant Protection, The University of Agriculture, Peshawar-Pakistan.

Hayat Zada
Department of Plant Protection, The University of Agriculture, Peshawar-Pakistan.

Correspondence:
Dr. Ahmad-Ur-Rahman Saljoqi
Department of Plant Protection, The University of Agriculture, Peshawar-Pakistan.

The impact of temperature on biological and life table parameters of *Chrysoperla carnea* Stephens (Neuroptera: Chrysopidae) fed on cabbage aphid, *Brevicoryne brassicae* (Linneaus)

Ahmad-Ur-Rahman Saljoqi, Naila Asad, Javed Khan, Ehsan-ul-Haq, Sadur-Rehman, Zelle Huma, Humna Gul Saeed, M. Nadeem, M. Salim, Bashir Ahmad, Hayat Zada

Abstract
The impact of temperature on biological and life table parameters of *Chrysoperla carnea* (Stephens) fed on cabbage aphid, *Brevicoryne brassicae* (L.) were evaluated at four different temperatures i.e. 20±1 °C, 24±1 °C, 28±1 °C and 32±1 °C with 65±5% RH and a photoperiod of 16:8 (L:D) hours in Insect Pest Management Program (IPMP), Institute of Plant and Environmental Protection (IPEP), National Agricultural Research Center (NARC), Islamabad during, 2012. Results showed that over all rearing at 28±1 °C the observed developmental, reproductive characteristics and life table parameters of *C. carnea* were found better, which proved to be the best among the other tested rearing temperatures. It was inferred from the present findings that rapid development of *C. carnea* was observed at 32±1 °C, which can be useful if quick development is desired in laboratories. At 28±1 °C, the recorded total female fecundity was highest, as females tend to oviposit a total of 323.9±0.2 eggs per female. Highest survival rate (96%) from egg to adult emergence was recorded at 28±1 °C as compared to all other temperatures. Highest survivorship rate (Lx) (0.896), maximum oviposition rate per female per day (Mx) (323.9) and highest values of R_0 (264.95), r_m (0.0655) were obtained by rearing of *C. carnea* at 28±1 °C. The longest mean generation time (T) (64.2), doubling time (DT) (9.678) and death rate (Dx) (24.48) of *C. carnea* was achieved by rearing at 20±1 °C.

Keywords: Biological characteristic, Cabbage aphid, *Chrysoperla carnea*, Life table parameters, Temperature

1. Introduction
Cabbage aphid, *Brevicoryne brassicae* (Linnaeus), is the most damaging aphid species and causes high loss of yield in *Brassica* crops thus reducing its marketable value [1]. It causes direct damages resulting from feeding, which may induce plant deformation and indirect damages caused either by honeydew production or by transmission of viruses [2] and it is a vector of 20 virus diseases in a large range number of plants [3].
Chrysoperla carnea Stephens (Neurotera: Chrysopidae) is one of the most important generalist predators [4]. The larval stages are active in suppressing pest, while it is free living in adult stages. Larvae of *C. carnea* are voracious predator of soft bodied arthropods such as aphids, whitefly, thrips, American bollworms, mites, army worms, small larvae of beetles, eggs of lepidopterous insects etc. Larvae of *C. carnea* are voracious and feed on insect pests [5]. *C. carnea* has got a considerable attention as a biological control agent because of its ability to control a variety of insect pests having higher searching ability and wide adaptability in field [6].
C. carnea can tolerate to the wide ranges of ecological factors and also easy to be mass reared and applied in the field for the control of different types of insect pests [7]. Temperature is one of the most important environmental factors which can affect the insect biology [8, 9]. The activities of insects are affected by change in environmental conditions. It influences the developmental rate of particular insect species and can also effect its seasonal population [10]. The so called vital factors exert a direct influence on metabolism. However one and the same parameter i.e. temperature could be both vital factor (development slows down with the temperature decrease) and a cue factor (low temperature could induce diapauses) [11].

Therefore, it is very important to study the relation-ship between temperature and development for any economically important species.

Life table parameters are the most important factors to be determined in the ecological studies and fundamental to general biology [12]. Life table parameters include age specific fecundity rate (Mx), (Lx) is the survivorship of females living from birth to age (X), the mean generation time (T) and doubling time (DT) and the net reproductive rate (R0). From these parameters, the intrinsic rate of natural increase (rm) is regarded as the best available single description of the population growth of species under given conditions. It can be determined by its developmental time and reproduction rate. It has been used to compare species under different environmental conditions and as an index of population rate response to selected preys. However, very little information is available with life table parameters of *C. carnea* in Pakistan. Life table parameters at different temperatures give an important task for the management of pest in different environmental conditions [13].

The present work is intended to bring some basic information on the impact of temperature on the biological and life table parameters of *C. carnea* fed on B. brassicae, which could be usefully employed for mass and quality production of the *C. carnea* under local environmental conditions.

2. Materials and Methods

2.1 Culture maintenance of Cabbage aphid, B. brassicae

For mass rearing of cabbage aphid, Cabbage plants were sown in glass house in small beds and also in plastic pots of size 7½" x 6" (Height x Width). The plants were sown with different time intervals to ensure proper supply to the predator. Aphid culture was maintained on these plants and also in pots under wooden cages of size 2′ (height), 3½′ (length) and 1½′ (width). The aphid colonies were renewed with new seedling to ensure continuous supply to the predator throughout the experimental duration.

2.2 Rearing of predator, *C. carnea*

C. carnea adults were reared in a rectangular cage, made of 6 cm thick, transparent plastic sheet. The cage is 35 cm long, 35 cm high and 20 cm wide. Two circular windows, each of 13 cm diameters, covered with lids of the same material, situated diagonally near opposite corners of a front wall of the cage, are made for handling adults, as well as for cleaning sanitation and provision of water in petri dish etc. Artificial standard foods containing yeast + sugar + honey + water were provided in small food bowls, of 0.5 cm diameter, engraved in the upper side of two plastic rods each of 4 mm thick and 22 cm long, running width wish at the opposite ends inside the cage where the adult maximum. A sieve of circular holes (2 mm diameter) is drilled into the sidewalls to ensure proper ventilation in the cage, for better survival and fecundity of adults; a black granulated paper underside the removable top of the new cage is a real substitute for the black organdycae top as an oviposition substrate.

2.3 Developmental durations of immature Stages and survival rate of *C. carnea* fed on Cabbage aphid

The experiments were conducted on the biological parameters of immature stages of *C. carnea* at four constant temperatures under growth chamber. Two hours fresh eggs of *C. carnea* were collected from stock culture with razor. 100 eggs were counted under binocular microscope and kept in Petri dishes. In each Petri dish 10 eggs were kept with 10 replications. Tissue paper was provided at the bottom of Petri dishes to avoid desiccation. The experiment was repeated 10 times at each temperature level separately in growth chamber under controlled conditions.

After hatching, 50 counted number of first instars larvae of *C. carnea* were transferred in transparent Petri dishes of size 10 cm separately. The Petri dishes were covered with muslin cloth at the top tight with rubber band separately. 1st and 2nd nymphal instars of aphids were provided on specific host plant leaves for feeding. The Petri dishes were kept in growth chamber at each four constant temperatures. The data was recorded on the immature stages at four constant temperature regimes on incubation period, Survival rate, molting time, developmental duration, pre-pupal and pupal period, total duration from egg to adult emergence and survival rate from egg to adult emergence.

2.4 Longevity, reproductive capacity and life table parameters of adult *C. carnea* fed on Cabbage aphid

The studies were conducted on the biological parameters of adult *C. carnea* fed on cabbage aphid at four constant temperatures under growth chamber. Freshly emerged, one day old adults of *C. carnea* were collected from stock culture, which was reared on cabbage aphid. A total 20 male/female were paired and kept in chimney glasses. The top of the chimney glasses were covered with black sheet paper as an oviposition substrate. At the bottom of chimney glass Petri dishes were kept, in which a small Petri dish was provided with artificial diet. The diets were changed daily. The chimney glasses were kept under growth chamber at four constant temperatures. The experiment was replicated 20 times. The insects were observed daily for Pre- oviposition period, Oviposition period and Post-oviposition period in each replicate. During the oviposition period the eggs were collected from black sheet over the chimney glasses daily. The eggs were counted and kept in Petri dishes for hatching under growth chamber at required temperature upon hatching the larvae were fed the same host for further generation and calculation of female progeny per female per day for calculation of life table parameters. The observations were recorded on pre-oviposition period, oviposition period, post-oviposition period, fecundity, male and female longevity.

The life table parameters of *C. carnea* were constructed at four constant temperatures from already collected data with the following formulas.

T: is the mean generation time from egg to adult emergence. T is calculated in days.

Lx: is survivorship of female from the beginning of age interval T

Total adult emerged/ total number of eggs

Dx: mortality rate, the number of individual dying during the age interval T

Mx: total eggs produced per female at age interval T. Mean fecundity rate

R_o: The net reproductive rate, the number of female offspring that left during her lifetime by one female. It is equal to the sum of the Lx.Mx or Σ Lx.Mx

r_m: The maximum population growth, the intrinsic rate of increase calculated by; loge Ro/T

DT: Doubling time, the number of days required by a population to double, calculated by; loge 2/ rm.

The data collected was statistically analyzed by using Computer Software i.e. Statistics 8.1 and the means were separated from one another by using LSD test [14]. The data was used for construction of life table parameters.

3. Results and Discussion

3.1 Developmental durations of immature stages and survival rate of *C. carnea* fed on cabbage aphid, at four different constant temperatures

Results of the comparative study to evaluate effective rearing temperature for *C. carnea* on the developmental parameters at stages of eggs, larvae and pupae as shown in table 1, revealed significant differences among the tested rearing temperatures. The results indicated that incubation periods 4.9±0.09, 3.9±0.09, 3.3±0.10 and 2.7±0.11 days were recorded at 20±1 °C, 24±1 °C, 28±1 °C and 32±1 °C, respectively. Same trend of decrease in the incubation period of *C. carnea* with the increase of temperature was also recorded by Nadeem *et al.* [10]. They recorded incubation period (Days) 10.3±0.31, 5.9±0.39, 4.5±0.57, 4.0±0.00, 4.0±0.01 at 20±1 ˚C, 25±1 ˚C, 28±1 ˚C, 31±1 ˚C and 35±1 ˚C, respectively.

Table 1: Developmental period in days (Mean± SE) Of *C. carnea* fed on *B. brassicae* at four different constant temperatures

Developmental duration	Temperatures (°C)			
	20±1	24±1	28±1	32±1
Incubation period	4.9±0.09a	3.9±0.09b	3.3±0.10c	2.7±0.11d
1st instar duration	3.8±0.16a	3.2±0.18b	3.0±0.15b	2.8±0.18c
2nd instar duration	4.2±0.21a	4.0±0. 21a	3.6±0.21b	3.2±0.16b
3rd instar duration	4.8±0.25a	4.4±0.26b	4.0±0.25c	3.6±0.24d
Total larval duration	12.7±0. 67a	11.7±0.69b	10.6±0.66c	10.7±0.65c
Pre-pupal duration	1.8±0.99a	1.4±0.08b	1.3±0.08bc	1.0±0.07c
Pupal duration	7.1±0.40a	6.2±0.39b	5.9±0.40c	5.0±0.33d
Total duration from egg to adult emergence	26.5±0.06a	23.1±0.03b	21.4±0.04c	19.8±0.04d

Means followed by same letters (rows wise) are non significant at P≤ 0.05

The insect passes through three larval instars before transforming into pupal stage. Maximum first instar duration 3.8±0.2 days were noted at 20±1 ˚C, while minimum 2.8±0.1 days were found at 32±1 ˚C. At temperature 24±1 °C and 28±1 °C, 3.2±0.18 and 3.0±0.15 mean first instar duration was recorded, respectively. Maximum 2nd instar durations, 4.2±0.2 and 4.0±0.21 days was recorded at 20±1 ˚C and 24±1 ˚C, respectively. It was followed by 3.6±0.21days recorded at 28±1 °C, while minimum 2.8±0.2 days were recorded at 32±1 ˚C. Highest duration, (4.8±0.25 days) was recorded at 20±1 ˚C which was followed by 4.4±0.26, 4.0±0.25 and 3.6±0.24 days durations recorded at 24±1 °C, 28±1 °C and 32±1 °C, respectively. The results showed that with increasing temperature developmental duration for different instars of *C. carnea* were significantly decreased. Previous workers reported different developmental duration for different instars. Khan *et al.* [15] reported the average duration of the first, second and third instars were 3.6±0.07, 3.0±0.11and 2.0±0.06 at 24±1 °C, 28±1 °C and 32±1 °C, respectively when fed on rice meal moth. Mannan *et al.* [16] also reported same trend on the developmental durations of *C. carnea* fed on Aphis gossyppi and Myzus persicea.

Maximum total larval developmental duration 12.7±0.67 days were recorded at 20±1 ˚C and it decreased with the increase of temperature. So, lowest total larval developmental duration 10.6±0.66 and 10.7±0.65 days were recorded at 28±1 ˚C and 29±1 ˚C, respectively. These results were in conformity with Nadeem *et al.* [10], who reported *C. carnea* larval duration (Days) 20.4±0.12, 12.9±0.21, 11.0±0.14, 10.2±0.11 and 10.0±0.10 at 20±1 ˚C, 25±1 ˚C, 28±1 ˚C, 31±1 ˚C and 35±1 ˚C, respectively.

Same trend of decrease in case of pre-pupal and pupal developmental durations with the increase of temperature was also observed as it was for the larval instars, where decrease was recorded in the durations with the increase of the temperature ranges. A maximum pre-pupal and pupal developmental durations i.e. 1.8±0.99 and 7.1±0.40 days was noted at 20±1 ˚C. It was followed by pre-pupal (1.4±0.08 days) and pupal duration (6.2±0.39days) recorded at 24±1 ˚C. 1.3±0.08 days prepupal and 5.9±0.40 days pupal duration was recorded at 28±1 ˚C, while lowest 1.0±0.7 and5.0±0.33 day's prepupal and pupal duration was recorded at 32±1 ˚C, respectively. Our results agreed to the work carried by Albuquerque *et al.* [16], who have reported that rearing at 40 ºC was highly lethal towards developmental traits of the adult predator, *C. carnea*. The developmental traits of *C. carnea*, in our findings, gradually decreased with the increase in rearing temperature and it supports the work reported by Nadeem *et al.* [10]. who have observed the developmental time of *C. carnea* tends to be faster at 20±1 ˚C (44.1±0.14) and 25±1 ˚C (28.1±0.13) but slow (22.2±0.11 days) at 28±1 ˚C and (21.2±0.10 days) at 31±1 ˚C.

The results of the present studies showed that temperature have significant effect on the survival rate of immature stages of *C. carnea*. The recorded average survival rate from egg to adult emergence was 80%, 90%, 96% and 84% at 20±1 °C, 24±1 °C, 28±1 °C and 32±1 °C, respectively (Table 2). These results agreed to the findings of Khan *et al.* [14], who have reported significant effects of the different temperatures on the % survival rate from egg to adult emergence.

Table 2: Percentage (%) of *C. carnea* survived from eggs to adult fed on *B. brassicae* at four different constant temperatures

Temperature (±1 °C)	Number of eggs used	Individuals survived (Nos)	Survival (%)
20	50	40	80
24	50	46	92
28	50	48	96
32	50	42	84

3.2 Longevity and reproductive capacity of adult *C. carnea* fed on cabbage aphid, at four different constant temperatures

The longevity and reproductive parameters of the adults of *C. carnea* showed as in table 3, reflected significant variations that were observed at different tested temperatures. Results in table 3, showed highest durations for all the parameters except fecundity duration at the lowest temperature, 20±1 °C. All these durations were decreased with the temperature increase and lowest figures were recorded for the durations of these parameters at the highest temperature (32±1 °C). The highest pre-oviposition period (11.7±0.02 days), oviposition duration (42.9±0.02 days), post-oviposition duration (10.2±0.03 days), male longevity duration (31.9±0.02 days) and of female longevity duration (64.2±0.02 days) was recorded at 20±1 °C. The shortest pre-oviposition duration (3.8± 0.04 days), oviposition duration (22.7±0.02 days), post-oviposition duration (5.1±0.04 days), male longevity duration (17.3±0.03 days) and female longevity duration (31.4±0.02 days) was

recorded at the highest temperature (32±1 °C), which was not lead to increase the potential of egg laying. All these temperatures had a significant effect on the fecundity of *C. carnea*. Highest number of eggs, 323.9±0.2 were recorded at 28±1 °C, which were followed by 182.7±0.2, 131.3±0.2 and 121.2±0.2 number of eggs recorded at 24±1 °C, 32±1 °C and 20±1 °C, respectively. These findings suggest that 28±1°C proved to be the best for egg laying and also proved to be overall suited one where, reproductive parameters were observed comparatively better to those at other temperature conditions. Results of our present findings were agreed to the work carried by Nadeem *et al.* [10] who have reported that rearing at 28±1 °C proved to be the best temperature for the reproductive parameters of *C. carnea*.

Table 3: Pre-oviposition, oviposition, post- oviposition periods and longevity (Days) (Mean±SE) of adults of *C. carnea* fed on *B. brassicae* at four different constant temperatures

	Temperatures (°C)			
	20±1	**24±1**	**28±1**	**32±1**
Pre-oviposition	11.7±0.02a	8.7±0.02b	4.5±0.03c	3.8± 0.04d
Oviposition	42.9±0.02a	37.9±0.02b	30.6±0.02c	22.7±0.02d
Post-oviposition	10.2±0.03a	9.3±0.03b	7.4±0.03c	5.1±0.04d
Fecundity	121.2±0.2d	182.7±0.2b	323.9±0.2a	131.3±0.2c
Male longevity	31.9±0.02a	26.7±0.02b	21.1±0.03c	17.3±0.03d
Female longevity	64.2±0.02a	50.1±0.02b	42.3±0.02c	31.4±0.02d

Means followed by same letters (rows wise) are non significan

3.3 Life table parameters

Results regarding all life table parameters are given in table 4. Results showed that mean generation time (T) decreased as the temperature increased. The value of mean generation time was longest (64.2 days) at 24±1 ˚C, while it was shortest (31.4 days) at 32±1 ˚C. Mean generation time, 50.1 and 42.3 days was recorded at 24±1 ˚C and 28±1 ˚C, respectively. Results indicated highest survivorship of female (Lx) (0.896%) recorded at 28±1 °C, while lowest (0.817%) at 20±1 ˚C. Maximum oviposition rate per female per day (Mx) 323.9 at 28±1 ˚C, while minimum oviposition was recorded at 20±1 ˚C. Eggs laid were significantly different from each other at each temperature respectively. Results indicated that the death rate (Dx) was recorded 24.48, 23.92, 22.35, and 22.99 at 20±1 °C, 24±1 °C, 28±1 °C and 32±1 °C, respectively. Death rate was found highest at 20±1 ˚C, while lowest at 28±1 °C. The highest net reproductive rate (R0=264.95) was recorded at 28±1 ˚C, while the lowest value (R0=99.02) was recorded at 20±1 ˚C. The intrinsic rate of increase (rm) is a perfect indicator at which the growth of population is most favorable because it reflects the overall effects on development, reproduction and survival characteristics of a population [17]. Intrinsic rate of increase was highest at 32±1 ˚C, where as lowest (rm) was obtained at 20±1 ˚C. Results showed that population of *C. carnea* could be doubled every 9.678, 6.810, 5.253 and 4.592 days at 24±1 °C, 28±1 °C and 32±1 °C, respectively. The shortest time for doubling population (DT) was achieved at 32±1 °C, while the longest (DT) was recorded at 28±1 °C.

Table 4: Life table parameters of *C. carnea* fed on *B. brassicae* at four different constant temperatures

Temperatures (°C)	PARAMETERS						
	T	**LX**	**Mx**	**Dx**	**R_o**	**r_m**	**DT**
20±1 °C	64.2	0.817	121.2	24.48	99.02	0.0311	9.678
24±1 °C	50.1	0.818	182.7	23.92	163.89	0.0442	6.810
28±1 °C	42.3	0.896	323.9	22.35	264.95	0.0655	5.253
32±1 °C	31.4	0.870	131.3	22.99	114.23	0.0573	4.592

T is the mean generation time
Lx (survivorship) is the females living from birth to age X
Mx is age specific fecundity rate
Dx is the Death rate
DT is doubling time
R_0 is the net reproductive rate
r_m is the rate of population

It is clear from the results obtained on all parameters of life table that at 28±1 °C, *C. carnea* showed best performance as compared with the recorded results at all other temperatures. There are no published data on the effect of four different temperatures i.e. 20±1 °C, 24±1 °C, 28±1 °C and 32±1 °C on the life table parameters of *C. carnea* feeding on cabbage aphid.

4. Conclusion

It is concluded from the present study that *C. carnea* can be easily mass reared in laboratory at different temperatures. Our findings suggest that among the tested temperatures, 28±1°C gave effective rearing for the developmental and reproductive characteristics of *C. carnea* where, almost shorter developmental durations, highest survival rate from egg to adult emergence and more number of egg laid by female adult. Better performance was achieved at 28±1 °C regarding life table parameters of *C. carnea* as compared with the results obtained at all other temperatures. Further investigations are needed to compare between the biological characteristics and life table parameters which obtained from laboratory studies with that of semi-field and field experiments in field crops or green houses.

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6. References

1. Costello MJ, Altieri AM. Abundance, growth rate and parasitism of Brevicoryne brassicae and Myzus persicae (Homoptera, Aphididae) on broccoli grown in living mulches. Agriculture Ecosystem and Environment 1995; 52:187-196.
2. Lashkari MR, Sahragard A, Ghadamyari M. Sublethal effects of imidacloprid and pymetrozine on population growth parameters of cabbage aphid, Brevicoryne brassicae on rapeseed, Brassica napus L. Journal of Insect

Sciences 2007; 14:207-212.
3. Ellis PR, Pink DAC, Phelps K, Jukes PL, Breeds SE, Pinnegar AE. Evaluation of a core collection of Brassica accessions for resistance to Brevicoryne brassicae. Euphitica 1998; 103:149-160.
4. Ashfaq M, Hassan M, Salman B, Salman W, Rana N. Some studies on the efficiency of Chrysoperla carnea against aphid, Brevicoryne brassicae, infesting canola. Pakistan Entomology 2007; 29:37-42.
5. Carrillo MA, Woolfolk SW, Hutchison WD. Multiple orifice distribution system for placing green lacewing eggs into vertical larval rearing units. Biological and Microbial Control 2004; 100:283-290.
6. Morrison RK. Handbook of insect rearing, Elsevier, Amsterdam the Netherlands, 1985, 419-426.
7. Hoddle MS, Robinson L. Evaluation of factors influencing augmentative releases of Chrysoperla carnea for control of Scirtothrips perseae in California avocado orchards. Biological Control 2004; 31:268-275.
8. El-Serafi HAK, Abdel-Salam AH, Abdel-Baky NF. Effect of four aphid species on certain biological characteristics and life table parameters of Chrysoperla carnea Stephen and Chrysopa septempunctata (Wesmael) (Neuroptera: Chrysopidae) under laboratory condition. Pakistan journal of Biological Science 2000; 3:239-245.
9. Rojht H, Budija F, Tradan S. Effect of temperature on cannibalism rate between green lacewings larvae (Chrysoperla carnea [Stephens], Neuroptera: Chrysopidae). Acta Agriculturae Slovenica 2009; 93:5-9.
10. Nadeem S, Hamed M, Nadeem MK, Hasnain M, Atta BM, Saeed NA *et al.* Comparative study of developmental and reproductive characteristics of Chrysoperla carnea (Stephens) (Neuroptera: Chrysopidae) at different rearing temperatures. The Journal of Animal & Plant Sciences 2012; 22:399-402.
11. Birch LC. The intrinsic rate of natural increase of an insect population. Journal of Animal Ecology 1948; 17:15-26.
12. Alasady MAA, Ibrahim YB, Ibrahim RB. Life Table of the Green Lacewing Apertochrysa sp. (Neuroptera: Chrysopidae) reared on Rice Moth Corcyra cephalonica (Lepidoptera: Pyralidae). International Journal of Agriculture and Biology 12, 266-270.
13. Mandour NS. Influence of Spinosad on immature and adult stages of Chrysoperla carnea (Stephens) (Neuroptera: Chrysopidae). Biological Control 2009, 2010; 54:93-102.
14. Gomez KA, Gomez AA. Statistical procedures for agricultural research. John Wiley and Sons, New York, 1984, 207-215.
15. Khan J, Haq E, Akhtar N, Gillani WA, Assad N, Masood MA *et al.* Effect of temperature on biological parameters of immature stages Chrysoperla carnea (Neuroptera: Chrysopidae) feeding on Rice Meal Moth, Corcyra cephalonica eggs. Pakistan Journal of Agriculture Research 2012; 25:224-227.
16. Mannan VD, Varma GC, Barar KS. Biology of Chrysoperla carnea (Stephens) on Aphis gossypii (Glover) and Myzus persicae (Sulzer). Journal of Insect Sciences 1997; 10:143-145.
17. Albuquerque GS, Tuber CA, Tauber MJ. Chrysoperla externa (Neuroptera: Chrysopidae): Life history and potential for biological control in central and south America. Biological Control 1994; 4:8-13.
18. Tasai JH, Wang K. Life table study of brown citrus aphid (Homoptera: Aphididae) at different temperatures. Environmental Entomology 1999; 28:412-419.