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Effect of Storage Duration and Low Temperatures on Reproductive Characteristics of *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae)

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Abstract.- Green lacewing, *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) among the predators is an important component of biological control in integrated pest management of crops and vegetables. Reproductive characteristics of *C. carnea* lead towards its effectiveness against target pests in a particular set of environmental conditions. The present study was carried out to investigate the reproductive characteristics of *C. carnea* under laboratory conditions. Effect of low temperature and storage durations on the reproductive parameters of *C. carnea* at adult stage on different temperature conditions have showed that the reproductive parameters as pre-oviposition period, oviposition and adult life span were comparatively better for both short and long term storage durations. Although the adult survived after stored at 6 and 8^{o}C temperature conditions, storage was better for both long and short term durations at 10^{o}C. So, it is obvious from the present findings that whenever, needed to conserve particular strains in laboratories for experimentation or field releases, storage at 10^{o}C gave prolonged survival to adults without the detrimental effects.

Key words: Storage temperature, storage duration, *Chrysoperla carnea*.

INTRODUCTION

Common green lace wing, *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) is a natural enemy of many insects and is present worldwide in many cropping systems (Lopez *et al*., 1976). This naturally occurring predator is found in many agro ecosystems with broad range of hosts from harmful insects fauna of crops (Tauber *et al*., 1993) and can be reared under laboratory conditions on different hosts (Hamed *et al*., 2009; Nadeem *et al*., 2012). It commonly feeds in larval form, while adult sucks cell sap of leaves in crops, vegetables, fruit plants and weed habitats. This predator has a tremendous predacious potential and can consume many species of insect pests, such as nymph of whiteflies, aphids, thrips and eggs of bollworms and other soft bodied insects (Gurbanov, 1984; Hashami, 2001; Atlihan *et al*., 2004; Silva *et al*., 2007). As a voracious feeder of pests in field crops, field releases are giving successful results and its larvae have a wide range of prey upon insects (Reddy and Manjunatha, 2000).

Storage of insects can be achieved by holding them either in diapause or non diapause conditions under low temperatures (Nordlund and Morrison, 1992; Chang *et al*., 1995). Low temperature regimes, prolonged the shelf life of eggs of *C. carnea* (Arroyo *et al*., 2000). In adults of *Chrysolperla carnea*, short to long term storage can be attained at low temperatures with least significant effects (Albuquerque *et al*., 1994; Chang *et al*., 1996). Previous work showed that a lot of research has been reported on studying the biology, rearing and field releases of *C. carnea* (Albuquerque *et al*., 1994). Tauber *et al*. (1997a), observed more than 85% survival to adults and indicates that survival decreased as the storage duration increased. Reproduction in adults after storage of 30 and 60 days at 10^{o}C was almost at par to that of the control (un-stored at 24^{o}C) which in progress of oviposition after 6 days. All females laid fertile eggs and the average rate of oviposition was 15-18 eggs/day with 97% egg fertility. At 120 days of storage, the reduction in reproductive performances was in comparable to that of 30 and 60 days storage. Tauber *et al*. (1997b) have reported the variation in

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life history in *Chrysoperla carnea* after stored at low temperature and their results showed that storage of diapaused adults, at 5^{o}C temperature for 13 weeks yielded with better survival and reproduction ability as compared to un stored at 24^{o}C. Chang *et al.* (2003), have carried bulk rearing, production and storage of *Chrysoperla carnea* with four *Carnea* biotype and one *Mohave* biotype population. *Mohave* population showed delayed oviposition as compared to *Carnea* populations. Survival to diapased adults after storage of first 18 weeks recorded high among all the 4 *Carnea* populations and survival remained high up to 35 weeks of storage in other 3 *Carnea* populations. After 6 weeks storage, adults tended to produce average fecundity ranged from 400-900 eggs/female. However, in commercialization, the storage by the effective means is still lacking. Realizing the need of storage, the efforts were carried out in the present investigations to sort out a suitable low temperature for certain durations with good post storage quality of *C. carnea.*

MATERIALS AND METHODS

The present study was designed to find out the optimum storage temperature and duration of the predator, *Chrysoperla carnea* at its adult stage in cooled incubators. Experiments were carried out by using adults reared on eggs of *Sitotroga cerealella* (Olivier) (Hamed and Nadeem, 2012) from the offspring of naturally occurring *C. carnea* in crops supplied by the mass rearing laboratories at NIAB, Faisalabad and experiment was carried out in same laboratories. Adult of the predator, *C. carnea*, were held separately at temperatures of 6, 8 and 10°C and stored for 5, 10, 15, 20, 25, 30, 40, 50, 60, 70, 80 and 90 days in cooled incubators. Experiment was laid out in completely randomized design (CRD) with 3 repeats and 10 adults were kept at each temperature and storage durations. Adults were provided water and artificial diet made up of protein hydrolysate, yeast and honey. After completing the storage period according to each treatment and duration, adults were transferred and placed at standard temperature 25±2^{o}C and 65±5% relative humidity conditions. After storage, adults were paired in rearing chambers and keep on under observation for the record of biological life parameters of the predator. Pre-oviposition period (days) was recorded before egg laying. Oviposition, eggs laid (no) per female per day was counted from the cloth provided on upper side of rearing chamber and female adult longevity (days) recorded from all the observed conditions. Data were analyzed statistically by MSTAT-C software programme and means were compared by Duncan multiple new range test (Steel *et al*., 1997). Standard error (±SE) was calculated by Microsoft excel programme.

RESULTS AND DISCUSSION

Reproductive characteristics of *Chrysoperla carnea* at adult stages after held at low temperatures, 6, 8 and 10^{o}C storage without higher rates of mortality to adults at different durations (5, 10, 15, 20, 25, 30, 40, 50, 60, 70, 80 and 90 days) in comparison to the control narrated significant differences.

Results showed significant variations for pre-oviposition period (days) at 6^{o}C (F = 17.85, df = 11, P = 0.0000), 8^{o}C (F = 6.84, df= 11, P = 0.0000) and 10^{o}C (F = 5.88, df = 11, P = 0.0000) (Table I). Pre-oviposition period at 6^{o}C was observed as the lowest (6.6) after 5 days storage and increased gradually at other storage durations and reach to the highest (14) after 90 days of long term storage. Similar trend of pre-oviposition was witnessed at 8^{o}C conditions from 5 to 90 days storage. At 10^{o}C conditions the lowest (5.4) and the highest (9) period was recorded after 5 and 90 days of storage conditions, respectively. Our findings suggest that pre-oviposition period increased as the duration of storage increased from 15 to 90 days when compared to 7.1 days of pre-oviposition period at control conditions.

Oviposition of female after held under various temperature conditions showed significant variations at 6^{o}C (F = 16.67, df = 11, P = 0.0000), 8^{o}C (F = 8.86, df = 11, P = 0.0000); 10^{o}C (F = 7.7560, df = 11, P = 0.0000) (Table I) comparable to control 20.8 eggs/day/female. High rates of post storage pre-oviposition period were observed at 10^{o}C temperature conditions. Female oviposited 19 eggs per day after stored for 5 days and 8.3 eggs after storage of 90 days observed as the highest and

Table I.- Effect of different low temperatures on pre-oviposition period, oviposition/female/day and adult female longevity of adult *C. carnea*.

Duration	Pre-oviposition period (days)				Oviposition / female/day (Numbers)				Adult female longevity			
(Days)	Control	6°C	8°C	10°C	Control	6°C	8°C	10°C	Control	6°C	8°C	10°C
5	7.1±0.53	6.6±0.76 e	7±0.15 d	5.4±0.53 b	20.8±0.92	19±0.47 a	18.4±0.81 a	19.2±0.42 a	33.7±0.40	34±2.18 a	33.3±1.65 a	42.7±0.76 a
10		6.9±0.40 de	7.3±0.42 cde	5.5±0.32 b		18.6±1.02 a	16.3±0.64 ab	19±0.17 a		33±1.36 ab	33.2±2.62 a	32.1±2.37 ab
15		7.0±0.91 cde	7.5±0.38 d	5.4±0.25 b		18±1.63 ab	16.6±1.03 ab	18.3±1.06 ab		32.8±0.53 ab	32.1±1.06 ab	32.8±1.84 a
20		7.2±0.47 cde	7.6±0.72 cd	5.5±0.55 b		17.2±0.51 abc	16±0.76 ab	17.9±0.15 ab		32.1±1.94 ab	33.6±1.65 a	31.1±0.50 abc
25		7.3±0.56 cde	7.9±0.66 cd	5.2±0.12 b		15.9±1.15 bcd	15.7±0.78 bc	18±0.46 ab		30.7±2.06 abc	31.2±0.74 abc	30.0±0.38 abc
30		8.9±0.40 bcd	7.9±0.06 cd	5.5±0.26 b		15.2±0.90 cd	15.5±0.76 bc	16.8±0.89 abc		28.9±0.57 bcd	29.4±0.89 abcd	30.4±0.64 abc
40		9±0.78 bc	7±0.57 d	5.6±0.67 b		14±0.51 d	15.2±0.51 bc	16.1±1.23 bcd		27.4±0.56 cde	27.2±2.11 bcde	29.1±1.08 abc
50		9.3±0.61 b	7.7±0.93 cd	5.6±0.70 b		14.2±0.50 d	14.9±0.66 bc	15.4±1.06 cd		27.1±2.25 cde	26.5±1.04 bcde	28±3.5 abc
60		9.7±0.50 b	9.9±0.67 bc	5.8±0.91 b		13.7±0.82 d	14.2±0.64 bcd	15.9±0.46 bcd		24.8±2.05 de	25.9±2.93 cde	28.4±3.68 abc
70		13±0.86 a	12.7±1.06 a	8.1±0.56 a		11±0.31 e	13.1±0.81 cd	14.3±0.84 de		24.3±0.97 ef	25.8±1.08 cde	28±0.52 abc
80		13.3±0.44 a	12.2±2.06 ab	8.9±1.11 a		11±0.40 e	12.3±1.46 d	14.2±0.82 de		23.3±1.32 ef	24.1±1.88 de	26.4±0.61 bc
90		14±0.64 a	12±0.35 ab	9±0.44 a		8.3±0.51 f	9.4±0.72 e	12.3±0.74 e		20.1±0.81 f	22.4±1.28 e	25.7±1.59 c

Means with similar letters in a column are statistically non significant at 5% level; ±SE= Standard error.

the lowest one at 6°C storage conditions, respectively. At 8°C, female oviposit in a trend with increased duration, the number of eggs were decreased from 18.4 to 9.4 after 5 and 90 days of storage conditions, respectively. Oviposition at 10°C yielded better performance where female gave highest number of eggs by a single female ranged from 19.2 to 12.3 per day from 5 to 90 days of storage durations.

Different temperatures and durations had significant effects on adult female longevity (days) at 6°C (F = 9.98, df = 11, P = 0.0000), 8°C (F = 5.13, df = 11, P = 0.0000) and 10°C (F = 11.80, df = 11, P = 0.0000) (Table I). Our results illustrated that female respond to survive for 33.7, 34 and 33.3 days at 6, 8 and 10°C temperature conditions, respectively at 5 days storage. At 10 days storage 33, 33.2 and 32.1 days of female longevity were observed at 3 tested temperatures, respectively. After 15 days storage, longevity was almost same as 32.8, 32.1 and 32.8 days, respectively. Nevertheless the extended storage of adults at various temperatures and durations yielded better female longevity for short term storage up to 30 days which gave storage of almost one month at 10°C lower than un-stored (42.7 days) but prolonged the shelf life without the detrimental effects to adults. Adults withstand the prolonged storage for 90 days at all tested temperatures for 20 to 25.7 days of female adult longevity.

From the illustrations of our results it is clear that although adults were survived after stored at 6 and 8°C of temperature conditions but the reproductive parameters were comparatively better at 10°C conditions, for both short and long term storage up to 90 days. Results obtained in present study are inconsistent to the study reported by Tauber *et al*. (1997b), who have got storage of *C. carnea* adults at 5°C temperature conditions and got 24.4 eggs, after 30 days of the adult storage. Our results are in the line with the work reported by Tauber *et al.* (1997a) who have got oviposition by *C. externa* at 10°C upto 15 eggs per day for 60 days of adult storage and 10.1 eggs per day at 120 days storage. Comparable study to our results was carried by Chang *et al*. (2003) who has reported egg laying by female held for 42 days of storage.

CONCLUSIONS

The effect of storage duration and temperature on the reproductive characteristics as pre-oviposition period, fecundity/female/day and adult female longevity at the adult stage of *C. carnea* at different temperature conditions have showed that although the adults survived after held at 6 and 8°C temperature conditions but these characteristics were comparatively better at 10°C, for up to 90 days. However, comparative study is advisable for further investigations on other methods of storage of *C. carnea*.

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