

EFFECT OF STORAGE DURATION AND LOW TEMPERATURES ON THE DEVELOPMENTAL STAGES OF *CHRYSOPERLA CARNEA* (STEPHENS) (NEUROPTERA: CHRYSOPIDAE)

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ABSTRACT

Chrysoperla carnea (Stephens) (Neuroptera: Chrysopidae) known as common green lacewing, its adult feeds only on plant nectars and larva is the voracious feeder of aphids and hence used in biological control of insect pests. In present study, the effective storage temperatures at optimum durations for the developmental stages of *C. carnea* under laboratory conditions was carried out. The consequence of storage duration and low temperatures on the different developmental stages of *C. carnea* at egg, larval, pre-pupal and pupal stages revealed that the storage of eggs at temperatures of 6, 12, 14 and 16°C gave short term storage up to 15-20 days with minimum detrimental effects to the developing embryo. Whereas, 8 and 10°C conditions of storage suited for both short and long term storage for 40 days. It is inferred from the results that whenever, needed to conserve strains of *C. carnea* in laboratories for experimentation or field releases, the storage at low temperatures of 8°C proved effective for both short and long term durations.

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

INTRODUCTION

Chrysoperla carnea (Stephens) (Neuroptera: Chrysopidae), the potent predator, is a voracious feeder of whiteflies, aphids and other soft bodied insects (Hashami, 2001) and gaining importance in integrated pest management (Sattar and Abroo, 2011) and can be reared successfully under laboratory conditions (Hamed *et al.*, 2009; Nadeem, 2010). It is commonly present in larval and adult forms on leaves of crops, vegetables, fruit plants and weeds habitats in high humidity areas like in greenhouses and irrigated crops etc. Adults of *C. carnea* feed upon plant nectars while, larvae are the voracious feeder of aphids, eggs of whiteflies and their nymphs, thrips and even small larvae of lepidopterous pests. It can consume many aphids in its larval span (Atlihan *et al.* 2004). It has been found to be effective at controlling the cotton whitefly, *Bemisia tabaci* in cotton crops in Pakistan (Kareim, 1998). Being a good predator of field crop insect pests, its field releases gave successful results. Gurbanov (1984) used *Chrysoperla carnea* against the thrips and aphids, the population of thrips reduce to 95.6% and those of aphids, 98.5%. It's larvae have a broad range of prey upon insects (Hydron and Whitecomb, 1979; Reddy and Manjunatha, 2000). Effectiveness of larvae, against target pests has been demonstrated in field crops, orchards and green houses (Hagley and Miles, 1987). At low temperature regimes, the shelf life of *C. carnea* eggs can be prolonged (Arroyo *et al.*, 2000; Nadeem *et al.*, 2012) and the environmental

effects upon the viability of green lacewing eggs (Gardner and Giles, 1996).

Tauber *et al.*, 1997a, have carried out studies and observed that the survival decreased as the storage time increased and the survival was observed to be more than 85%. Reproduction, after 30 and 60 days of storage at 10°C, was almost very similar to that of the control (un-stored), at 24°C, which started oviposition after 6 days. All females laid fertile eggs and the average rate of oviposition was 15-18 eggs/day, with 97% fertile eggs. At 120 days of storage, the reduction in reproductive performances was in comparison to that of 30 and 60 days of storage duration. Again, Tauber *et al.*, 1997b, have reported the variation in life history in *Chrysoperla carnea* in storing at low temperature and their results showed that storage of either diapausing adults, at 5°C temperature for about 13 weeks yielded better survivorship and reproduction performance than those reared and stored at 24°C (Control). Arroyo *et al.*, 2000 have worked on the short term storage capacity and relatively good post storage quality and sorted out an optimum temperature for the maximum days of storage with a minimum effect on the quality after studying life history by exposing different stages at low to moderate temperature conditions. Storage of egg of three Neotropical species such as *Ceraeochrysa externa* (Hagen), *C. smith* (Navas) and *Chrysoperla externa* (Hagen) were tested at five temperature regimes between 4.5 to 15.6°C for 3 weeks. Study indicated that newly laid eggs of three species can be stored without hatching for two weeks at 15.6°C and storage of *C. externa* eggs

extended to three weeks, at 12.8°C. Sometimes, in mass rearing laboratories, the surplus *C. carnea* needs storage at low temperatures prior to field releases with least detrimental effects to quality. So, the present study was planned to find out the storage effects on the survivor of developmental stages of *C. carnea* including the egg hatching, larval period, pre pupal and pupal stages.

MATERIALS AND METHODS

Present experiment was conducted to find out the optimum storage temperature and duration for the storage of predator, *Chrysoperla carnea* (Stephens) at developmental stages in the cooled incubators at Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad under laboratory conditions. The eggs of the predator, *C. carnea*, were taken from the mass rearing laboratory and stored separately at 6, 8, 10, 12, 14 and 16°C, in cooled incubators for 5, 10, 15, 20, 25, 30 and 40 days in complete darkness. Experiment was laid out in Completely Randomized Design (CRD) by making three repeats at each treatment. At each temperature and storage duration, fifty fresh eggs of same generation were placed in incubators in Petri plates. After completing the storage period, according to each treatment for each temperature regime, the eggs were kept at normal laboratory conditions *i.e.*, 25±2°C temperature and 65±5% relative humidity. After egg hatching, larvae were fed on eggs of *Sitotroga cerealella* (Olivier) which were reared on wheat grains (Hamed and Nadeem, 2010 and 2012). Biological life parameters of the development stages of *C. carnea* includes egg hatching (nos.), larval duration (days), pre-pupal duration (days) and pupal duration (days) were recorded and compared according to treatments. Data were statistically analyzed by MSTAT-C software programme and means were compared by Duncan multiple new range test (Steel *et al.*, 1997). Microsoft excel programme was used to calculate standard error (±SE).

RESULTS AND DISCUSSION

Developmental parameters of the predator, *Chrysoperla carnea* were compared after the eggs were held at low temperatures (6, 8, 10, 12, 14 and 16°C) in incubators for delayed embryonic development for different durations (5, 10, 15, 20, 25, 30 and 40 days). Result revealed that period of egg hatching (days) showed statistically differences ($F= 2.600$, $df=5$, $P= 0.0086$); ($F= 5.1928$, $df=5$, $P= 0.0091$); ($F= 12.0569$, $df=5$, $P= 0.0002$); ($F= 10.5060$, $df=3$, $P= 0.0038$); ($F= 6.86$, $df=2$, $P= 0.125$); ($F= 7.0074$, $df=2$, $P= 0.0269$); ($F= 1.3550$, $df=2$, $P= 0.3269$) at various temperatures and storage durations (Table 1). Hatching period (days) of eggs of *C. carnea* after held for 5 days showed the lowest

(4.2) at 8°C and prolonged (6.3) after held at 6°C conditions without higher rates of mortality to embryo inside the eggs. At 12°C, storage was recorded up to 20 days and similarly at 14 and 16°C, eggs were hatched within 20 to 40 days in incubators during storage. Hence, it is clear from the data that 12, 14 and 16°C temperature gave only short term storage whereas, 6, 8 and 10°C temperatures gave storage up to 40 days without the detrimental affects to embryo during the processes of development inside the eggs.

Various non significant differences of larval period (days) for all the tested temperatures and storage durations (Table 2) was ranged from the lowest (15.0) to the highest (17.9) for 5 to 40 days storage at 6°C. At 8°C storage conditions, the larval period ranged from 11.7 to 15 days for 10 and 30 days, respectively. Larval period was prolonged at 6°C and tends to be optimum at 8°C and 10°C as compared to other temperature conditions.

Pre-pupation period (days) showed significant to non significant ranges ($F= 1.9235$, $df=5$, $P= 0.1638$); ($F= 3.1249$, $df=5$, $P= 0.0491$); ($F= 4.0517$, $df=5$, $P= 0.0219$); ($F= 5.3032$, $df=3$, $P= 0.0264$); ($F= 9.9116$, $df=2$, $P= 0.125$); ($F= 13.9837$, $df=2$, $P= 0.0055$); ($F= 2.1732$, $df=2$, $P= 0.1214$) at the various tested temperatures and storage durations (Table 3). After 5 days storage durations, the pre-pupal period was lowest (4.1) at 8°C and the highest (5.6) at 10 and 12°C whereas, 4.2, 5 and 5.5 at 6, 14 and 16°C, respectively. At 10, 15, 20, 25, 30 and 40 days storage, the lowest pre-pupal period (4.0, 4.6, 4.8, 4.9, 4.3 and 5.3) was observed at 8°C and the highest were observed at various temperatures at 6, 10, 12, 14 and 16°C.

Pupal period (days) varied at significant differences ($F= 2.6099$, $df=5$, $P= 0.0805$); ($F= 4.0094$, $df=5$, $P= 0.0227$); ($F= 8.5352$, $df=5$, $P= 0.0012$) ($F= 13.2005$, $df=3$, $P= 0.0018$); ($F= 3.7039$, $df=2$, $P= 0.896$); ($F= 3.816$, $df=2$, $P= 0.853$); ($F= 5.6570$, $df=2$, $P= 0.0416$) at the various tested temperatures and storage conditions (Table 4). At 5 days storage conditions, the lowest (7.4) were observed at 8°C followed by 9.5, 10, 10.8, 10.1 and 10.3 at 6, 10, 12, 14 and 16°C, respectively. After 10, 15, 20, 25, 30 and 40 days storage, the lowest pupal period were observed as 8.5, 8.7, 8.5, 8.1, 9.4 and 8.3, respectively. Relatively lesser and at par pupal period was recorded at 8 and 10°C as compared to other temperature conditions.

Results of present study are in context to the previous workers as Nadeem *et al.*, (2012) who have reported that low temperatures have profound effects on the development of *C. carnea* are in the line to our study. Consistent results to our study has reported by Tauber *et al.*, 1997a and Arroyo *et al.* (2000) who have evaluated that 10°C is well suited for the egg storage of *C. carnea*; where all reproductive characters were favorably towards the insect development. Variation in susceptibility of this

low temperature may be due to the *C. carnea* strains which were used in studies.

Table 1. Effect of different low temperatures and durations on the egg hatching period (days)

Temp	Days						
	5	10	15	20	25	30	40
6°C	6.3±0.55 a	6.7±0.66 a	6.8±0.26 a	6.5±0.40 a	6.7±0.35 a	6.8±0.46 a	7.1±0.45 a
8°C	4.2±0.44 ab	4.4±0.55 b	4.5±0.32 bc	4.4±0.67 bc	4.6±0.50 b	4.9±0.38 b	5.4±0.25 a
10°C	5.1±0.15 ab	4.4±0.63 b	5.4±0.32 b	5.3±0.46 ab	5.3±0.35 ab	5.2±0.31 b	5.9±1.19 a
12°C	4.8±0.54 ab	4.5±1.19 b	4.3±0.88 bc	3.0±1.37 c	-	-	-
14°C	4.6±0.47 ab	4.2±0.46 b	4.0±0.63 cd	-	-	-	-
16°C	4.4±0.50 ab	3.1±0.26 b	3.0±0.12 d	-	-	-	-

Values sharing different letters in a row are statistically non significant at 5% level; ±SE= Standard error.

Table 2. Effect of different low temperatures and durations on the larval period (days).

Temp	Days						
	5	10	15	20	25	30	40
6°C	16.6±0.72 a	15.0±0.67 a	15.7±1.69 a	16.9±0.78 a	16.7±0.61 a	17.1±1.50 a	17.9±3.59 a
8°C	13.0±1.14 ab	11.7±0.55 ab	13.4±0.64 a	13.7±1.07 b	13.9±0.63 b	15.0±0.74 a	14.2±0.72 b
10°C	14.2±0.78 ab	12.9±1.33 ab	13.6±0.61 a	14.0±1.15 ab	14.6±0.86 b	14.8±1.24 a	16.1±0.78 ab
12°C	13.6±1.32 ab	13.7±0.85 ab	14.2±0.96 a	15.1±0.49 ab	-	-	-
14°C	12.9±1.39 ab	12.1±1.16 ab	12.8±1.35 a	-	-	-	-
16°C	12.8±1.86 ab	12.9±1.22 ab	12.9±0.93 a	-	-	-	-

Values sharing different letters in a row are statistically non significant at 5% level; ±SE= Standard error.

Table 3. Effect of different low temperatures and durations on the pre-pupation period (days)

Temp	Days						
	5	10	15	20	25	30	40
6°C	4.2±6.10 a	4.5±0.54 b	4.7±0.53 b	4.9±0.35 b	5.2±0.71 b	4.3±0.35 b	5.5±0.54 ab
8°C	4.1±0.31 a	4.0±0.25 b	4.6±0.36 b	4.8±0.49 b	4.9±0.46 b	5.2±0.47 a	5.3±0.85 ab
10°C	5.6±0.38 a	7.0±0.67 ab	5.8±0.40 ab	5.6±0.63 ab	8.3±0.62 a	6.4±0.36 a	6.8±0.59 a
12°C	5.6±0.38 a	6.0±0.61 a	7.3±0.74 a	6.8±0.63 a	-	-	-
14°C	5.0±0.61 a	5.4±0.36 ab	5.8±0.35 ab	-	-	-	-
16°C	5.5±0.71 a	5.7±0.93 ab	5.9±0.44 ab	-	-	-	-

Values sharing different letters in a row are statistically non significant at 5% level; ±SE= Standard error.

Table 4. Effect of different low temperatures and durations on the pupation period (days)

Temp	Days						
	5	10	15	20	25	30	40
6°C	9.5±0.67 ab	10±0.56 bc	9.7±0.65 b	9.9±0.12 b	10.3±1.40 ab	11.3±0.70 ab	12.0±1.17 a
8°C	7.4±0.79 b	8.5±0.53 c	8.7±0.51 bc	8.5±0.40 c	8.1±0.46 b	9.4±0.46 ab	8.3±0.97 b
10°C	10.0±0.46 a	10.1±0.68 bc	10.4±0.44 ab	10.9±0.85 b	12.0±0.96 a	12.6±1.04 a	11.9±0.91 a
12°C	10.8±0.72 a	12.3±0.57 a	11.5±0.61 a	12.9±0.60 a	-	-	-
14°C	10.1±0.79 a	10.7±0.70 ab	8.8±0.40 c	-	-	-	-
16°C	10.3±0.92 a	10.2±0.63 bc	11.8±0.66 a	-	-	-	-

Values sharing different letters in a row are statistically non significant at 5% level; ±SE= Standard error.

Conclusions: The consequence of storage duration and low temperatures, on the developmental stages of the *C. carnea* accomplished that temperature of the 8 and 10°C gave statistically at par storage of eggs for 20 days with minimum detrimental effects to developing embryo inside the egg for short term storage and 40 days for long

term storage. Effective field releases of stored eggs of *C. carnea* can be made either in controlled or natural field conditions. However, with an increase in storage duration, the developmental stages prolonged and increased in storage temperature only short term storage up to 15 days achieved.

REFERENCES

- Arroyo, J.I., C.A. Tauber and M.J. Tauber (2000). Storage of lacewing eggs: post storage hatching and quality of subsequent larvae and adults. *Biol. Contr.*, 18: 165-171.
- Atlihan, R., B. Kaydan and M.S. Özgökce (2004). Feeding activity and life history characteristics of the generalist predator, *Chrysoperla carnea* (Neuroptera: Chrysopidae) at different prey densities. *J. Pest Sci.*, 77: 17-21.
- Gardner, J. and K. Giles (1996). Handling and environmental effects on viability of mechanically dispensed green lacewing eggs. *Biol. Contr.*, 7: 245- 250.
- Gurbanov, G.G. (1984). Effectiveness and use of common green lacewing (*Chrysoperla carnea*) in control of sucking pests and cotton moths on cotton. *Biol. Nauk.*, 2: 92-96.
- Hagley, E.A.C. and N. Miles (1987). Release of *Chrysoperla carnea* Stephen (Neuroptera: Chrysopidae) for control of *Tetranychus urticae* Koch (Acarina: Aphidae) on peach grown in protected environment structure. *Can. Entomol.*, 119(2): 205-206.
- Hamed, M. and S. Nadeem (2010). Mass rearing of *Sitotroga cerealella* (Olivier) (Lepidoptera: Gelechiidae) in newly designed chambers. *The Nucleus*, 47(4): 323-326.
- Hamed, M. and S. Nadeem (2012). Effect of cereals on the development of *Sitotroga cerealella* (Olivier) (Lepidoptera: Gelechiidae) and subsequent quality of the egg parasitoid *Trichogramma chilonis* (Ishii) (Hymenoptera: Trichogrammatidae). *Pakistan J. Zool.*, 44(4): 923-929.
- Hamed, M., S. Nadeem, and A. Riaz (2009). Use of gamma radiation for improving the mass production of *Trichogramma chilonis* and *Chrysoperla carnea*. *Biocontr. Sci. Tech.*, 19(1): 43-48.
- Hashami, A.A. (2001). Insect pest management in the 21st century. PARC, Islamabad, Pakistan, pp. 27.
- Hydron, S.B. and W.H. Whitecomb (1979). Effects of larval diet on *Chrysopa rufilabris*. *Fla. Entomol.*, 62: 293-298.
- Kareim, A.I. (1998). Searching rate and potential of some natural enemies as bio-control agent against the *Bemisia tabaci* (Homoptera: Aleyrodidae). *J. Appl. Entomol.*, 122: 487-92
- Nadeem, S. (2010). Improvement in production and storage of *Trichogramma chilonis* (Ishii), *Chrysoperla carnea* (Stephens) and their hosts for effective field release against major insect pests of cotton. Ph.D. thesis (unpublished). Deptt. of Entomology, Univ. Agri., Faisalabad.
- Nadeem, S., M. Hamed, M.K. Nadeem, M. Hasnain, B.M. Atta, N.A. Saeed and M. Ashfaq (2012). Comparative study of developmental and reproductive characteristics of *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) at different rearing temperatures. *J. Animal Plant Sci.*, 22(2): 399-402.
- Reddy, G.V.P. and M. Manjunatha (2000). Laboratory and field studies on the integrated pest management of *Helicoverpa armigera* in cotton, based on pheromone trap catch threshold level. *J. Appl. Entomol.*, 124(5-6): 213-221.
- Sattar, M. and G.H. Abro (2011). Mass rearing of *Chrysoperla carnea* (Stephens) (Neuroptera:Chrysopidae) adults for integrated pest management programmes. *Pakistan J. Zool.*, 43:483-487.
- Steel, R.G.D., J.H. Torrie, and D.A. Dickey (1997). Principles and procedures of statistics. A biometrical approach. 3rd ed. McGraw Hill Inc., New York.
- Tauber, M.J., C.A. Tauber and J.I.L. Arroyo (1997b). Life history variation in *Chrysoperla carnea* implications for rearing and storing a Mexican population. *Biol. Contr.*, 8: 185-190.
- Tauber, M.J., G.S. Albuquerque and C.A. Tauber (1997a). Storage of non-diapusing *Chrysoperla externa* adults: influence on survival and reproduction. *Biol. Contr.*, 10: 69-72.