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A MASS REARING STRATEGY OF *CHRYSOPERLA CARNEA* STEPHENS (NEUROPTERA: CHRYSOPIDAE) UNDER VARIABLE LIGHT WAVELENGTH AND LIGHT INTENSITY

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ABSTRACT

The present study was conducted to determine the effect of different light wavelengths and light intensity on fecundity and developmental parameters of *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae). Three photoperiod regimes were applied with five different light wavelengths (red, yellowish, bluish, green and white) under controlled temperature conditions 26 ± 2°C and 65 ± 5% RH. *C. carnea* females responded green light (495–570 nm) for egg laying and laid the highest 18.33 ± 0.33, 15.67 ± 1.45 and 12.33± 0.88 eggs in varying photoperiod regimes in order of Green > Red > White > Blue > Yellow. Light intensity also affected the fecundity and developmental parameters of *C. carnea*. The shortest developmental time and fecundity was recorded in 6384 $W.m^{-2}$.

Through the combination of a-biotic factors like photoperiod, light wavelength and light intensity can help with improved mass production technology at an appropriate cost of *C. carnea* for farmers and commercial insectaries around the world.

Key words: *Chrysoperla carnea*, Egg laying, photoperiod, light wavelengths, light intensity

INTRODUCTION

Chrysoperla carnea is an important polyphagous insect predator. It is found worldwide feeding on many insect species on wild plant, meadow, orchards, bushes and on crops. *C. carnea* is very effective against the soft body insects like mealy bugs, immature scales, spider mites, aphids, thrips, whiteflies, and other insects (Saminathan *et al.*, 1999). During its life span a single *C. carnea* can consume around 500 aphids, therefore, it is called “aphids’ lion” (Sattar *et al.*, 2007). Being a voracious predator, *C. carnea* is used around the world for the pest control. Public and private biological control laboratories are pouring efforts for its rearing on a commercial scale (Wang and Nordlund, 1994) Mostly the egg cards of *C. carnea* are released in vegetable and field crops for IPM purpose (Daane *et al.*, 1996).

A-biotic factor like photoperiod, light wavelengths, light intensity, and light reflection properties can influence the biology of an organism(Omkar *et al*., 2005). So far studies have been conducted on the effects of different light wavelengths by various scientists on Crustaceans (Aarseth and Schram, 1999), *Drosophila melanogaster* (Sakai *et al.*, 2002), hawk moth, *Manduca sexta* (L.) (White *et al*., 1994) and lady bird beetle (Omkar *et al*., 2005). Biology of *C. carnea* is also affected by a-biotic factors, including temperature, photoperiod, relative humidity, and CO_2. In view of the previous reports on others insects, it was presumed that *C. carnea* could be affected with different light. Since the rearing of *C. carnea* is an important feature for augmentation method of biological control with *C. carnea*, therefore, if discovered, a positive correlation with a certain light wavelengths would lead to more economic rearing of *C. carnea*. Thus the present study was carried out to determine the effect of different light wavelengths on fecundity of *C. carnea*. With an aim that this study will help public and private insectaries to improved mass rearing technology of *C. carnea* at an appropriate cost of production.

MATERIALS AND METHODS

Chrysoperla carnea was reared in the Biological Control Laboratory of Pangrio Sugar Mills limited the under the controlled temperature of 26 ± 2 °C with the relative humidity of 65-70%. Newly emerged adults *C. carnea* were kept initially in cages for four days. Standard diet of 20 mL warm water, 2 g brewer’s yeast, 1 g honey and 5 mL Nulure® (a.i. Protein hydrolysate) was given in droplets with the help of camel hair brush in the cage's walls. After four days of matured adults were paired and released in four liter glass jars (10 pairs /jar) and the aforesaid standard diet was given on white paper cards. Different batches of the pair were kept under three different photoperiod regimes (16/8, 14/10, and 24/0) with different light wavelengths (60 watt incandescent light bulb of wavelength red, yellow, blue, green and white) for 20 days were tested. For controlling the result of light intensity on fecundity and developmental parameter of *C. carnea*; 1795, 3192 and 6384 Wm^{-2} incandescent light bulb (spectral distribution: red, green and blue) was used for 20 days. Glass jars (mouth) were covered with black muslin cloth for egg laying. The cover cloths were changed and eggs were harvested for the data recording on fecundity by *C. carnea* female. Each treatment had five replicates.

Statistical analyses were done using Tukey test with IBM SPSS® Version 19.

RESULTS AND DISCUSSION

Among the all light wavelengths, *C. carnea* females performed better under green light for egg laying and laid the highest numbers of eggs, i.e. 18.33 ± 0.33, 15.67 ± 1.45 and 12.33± 0.88 eggs in varying photoperiod regimes in order of Green > Red > White > Blue > Yellow (Table 1). The photoperiod also affects the fecundity of *C. carnea*. The *C. carnea* female laid the maximum number of eggs in green light as *C. carnea* compound eyes consist of green receptor (R1-6) due to which *C. carnea* recognize green color of wavelength between 495-550nm. *C. carnea* prefer green color as they are found on fresh green leaf as they can find honey dew produced by the aphids, a site for egg laying or a resting place (Kral and Stelzl, 1998). It is also reported that as maximum numbers of eggs are laid in spring due to the presence of green plantation and consequently the host insects thereon. This fact has been reported by Canard *et al.* (1984) that the *C. carnea* female laid maximum number of eggs in spring season. Leather *et al.* (1992) confirmed that the *C. carnea* female laid maximum eggs in spring. Spectral distribution of incandescent light bulb also played a vital role in this study as major part of spectra contains green color.

The L24/D0 photoperiod regime showed the significant results ($F= 14.712$; $DF= 4$; $P=0.000$) with a maximum number of eggs are laid as compare to others photoperiod regimes as L24/D0 > L16/D8 > L14/D10 (Table 1). *Chrysoperla carnea* showed the maximum fecundity in photoperiod of L24/D0 and same results were reported by Ahmed *et al*. (2012).

The effect of light intensity on fecundity of *Chrysoperla carnea* was also observed and the results showed that light intensity also affects fecundity of *C. carnea* ($F= 8.097$; $DF = 2$; $P < 0.05$) as the fecundity increase as the light intensity increases (Fig. 1).

Table 1. Effect of light wavelengths and photoperiod on fecundity of *Chrysoperla carnea* female.

Wavelength	**Light / Dark Period**		
	L16/D8	**L14/D10**	**L24/D0**
Red (620–750 nm**)**	13.00 ± 0.57b	10.66 ± 0.88bc	16.00 ± 1.15ab
Yellow (570–590 nm**)**	10.00 ± 0.57d	9.00 ± 1.15c	11.00 ± 0.57d
Blue (450–495 nm**)**	11.00 ± 0.57cd	9.33 ± 0.88cd	12.33 ± 0.88c
Green (495–550 nm**)**	15.67 ± 1.45a	12.33± 0.88a	18.33 ± 0.33a
White (380-750nm**)**	11.33 ± 0.33bc	10.00 ± 1.00ab	14.00 ± 0.57bc

Figures followed by same letter with in a column are not significantly different from each other at 5% Tukey test.

Table 2. Effect of light intensity on biological parameters of *Chrysoperla carnea*.

Light Intensity (Wm^{-2})	**Incubation period (Days)**	**Larval period (Days)**	**Pupal period (Days)**	**Sex ratio**	
				Male	**Female**
1795	4.5 ± 0.33a	8.0 ± 0.40a	5.5 ± 0.28a	1.5 ± 0.00 c	2.6 ± 0.00 c
3192	3.6 ± 0.12 b	7.6 ± 0.33 b	4.5 ± 0.29bc	1.8 ± 0.00 b	3.8 ± 0.00 b
6384	3.0 ± 0.02 c	6.0 ± 0.00 c	4.0 ± 0.00 c	2.2 ± 0.00 a	5.0 ± 0.00 a

Figures followed by same letter with in a column are not significantly different from each other at 5% Tukey test.

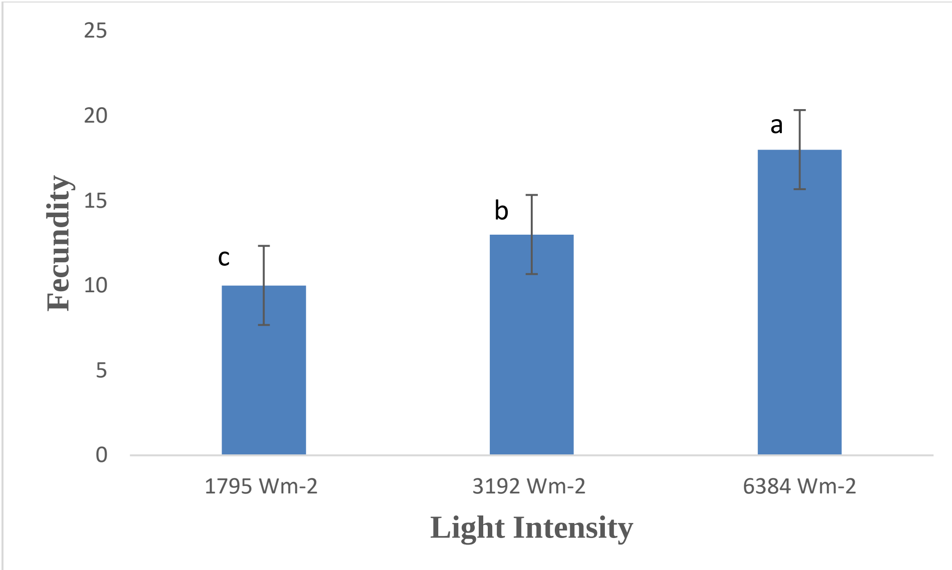

Fig. 1. Effect of light intensity on fecundity of *Chrysoperla carnea* female.

The light intensity improves the developmental parameters of *C. carnea* (Table 2). The Short incubation (3.0 ± 0.02 days), larval (6.0 ± 0.00 days) and pupal period (4.0 ± 0.00 days) was recorded at 6384 $W.m^{-2}$ light intensity. The maximum sex ratio of 5:2 (F: M) was also recorded at 6384 Wm^{-2} light intensity. The light intensity also affects fecundity and developmental parameters of *C. carnea*. The light wavelength dependency was also observed in other insects like *Drosophila melanogaster* but no report was reported for *C. carnea* so far. In case of *Drosophila melanogaster* species showed a high mating inclination in light with longer wavelengths and less mating activity under UV light as male courted lies with a female (Cobb and Ferveur, 1995; Sakai *et al*. 2002). Omkar *et al*. (2005) studied the light wavelengths on life attributes of two species of lady bird beetle. Both the species showed fast development, caused the most aphids' predation, and laid a large number of eggs under white light. Zhang *et al*. (2010) studied the mass rearing of black soldier flies by using an artificial light of quartz iodine lamp for maximum oviposition and mating purpose. Wang *et al*. (2014) reported that the green light and light intensity of 1500 lux yielded the highest fertility and fecundity of ladybird beetle *Propylea japonica.*

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