Journal of Entomology and Zoology Studies
Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2018; 6(1): 691-697

Received: 03-11-2017
Accepted: 04-12-2017

Shaukat MA
Studying at Department of Entomology, University College of Agriculture & Environmental Sciences, The Islamia University of Bahawalpur, Punjab, Pakistan

Correspondence
Shaukat MA
Studying at Department of Entomology, University College of Agriculture & Environmental Sciences, The Islamia University of Bahawalpur, Punjab, Pakistan

Feeding behaviour and life durations of *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) feeding on a variety of hosts

Shaukat MA

Abstract
It is investigated that a perennial grass leaves orientation provides a hiding place for aphids to escape from the attack of green lace wings. Traditionally predators of arthropods have been less discussed on the base of their special prey. The interactions of predator-prey are categorized on three trophic levels (i.e. Plants, predators and prey). Predators are at the top of food linkage and interact between just for a shared prey. Research on influence of different hosts on biology of *Chrysoperla carnea* (Stephens) were examined under laboratory conditions at 26±2 °C and 65±5% R. H. shows that the incubation period of eggs of *C. carnea* females eating different hosts as immatures are significantly (P<0.001) different from each other. The natural hosts are: cotton aphids, *Aphis gossypii* (*Glov.*) (nymphs/adults), American bollworm, *Helicoverpa armigera* (Hb.) (eggs), Pink bollworm, *Pectinophora gossypiella* (Saund.) (eggs), cotton mealy bug, *Phenacoccus solenopsis* (Tinsley) (Pseudococcidae: Homoptera) (nymphs) and Angoumois grain moth, *Sitotroga cerealella* (Oliver) (frozen eggs). The present study was done to observe predatory behaviour of *chrysoperla carnea* and how it can successfully be implied in initializing an effective biological control programme. The study was started from April, 2016 and research was finalized on October, 2016.

Keywords: *Chrysoperla carnea*, green lacewings, feeding behaviour, variety of hosts, interaction with other vertebrates

Introduction

Chrysoperla carnea(Green lacewings) are also regarded as aphid-lion possesses a wide range of hosts like white flies, thrips, mealy bugs, aphids as well as eggs of different arthropods.(Carrillo and Elanov, 2004) [12]. Green lacewings have been most emphasized in its family due to effective foraging, abundant occurance, easy raring and habitat parameters. Larvae feed on different arthropods and adult just feed on products and byproducts of plants. (El-Serafi *et al*., 2000) [19]. Family members of chrysopidae family feed on aphids including *Aphis glycines* Matsumura (Ragsdale *et al*., 2011) [36], *Myzus persicae* Sulzer (Pappas *et al*., 2007) [34]. In current scenario, research is conducted on feeding behaviour of *C. carnea* on Wheat Aphid *(Schizaphis graminum*). This helps in utilization of predation behaviour of *C. carnea* as an efficient tool in biological control programmes. In past, biological control programmes have focused on special natural enemies and their close association with target pest. (Doutt 1964, Beddington *et al*. 1978, Hassell, 1978) [10, 17, 25]. Some studies have shown the distribution of general predators by using supplementary resources in an ecosystem which is highly changed, like ecosystems in annual cropping system. (Ehler and Miller 1978 [18], Riechert and Lockley 1984[38], Murdoch *et al*. 1985, Wiedenmann and Smith, 1997) [51]. Supplementary resources may include plant material (Alomar and Wiedenmann 1996) [3] or alternative prey, including detritivores (Settle *et al*. 1996) [42]. Uncommon herbivores (Karban *et al*. 1994) [27], or even potentially competing other species of predators (Sunderland *et al*.1997) [45]. In field enclosures, the praying efficacy of predators can be replenished if the behaviour of confined arthropod has been changed due to the presence of cages. Field examinations have shown that caging practices did not enhance the impact of predator in predator-prey relationships. (Sih *et al*. 1985) [43]. It is not clarified properly the importance of food shortage and mortality due to food scarcity but ratio between arthropod prey and plant nectar has been reported as a certain important food sources. Arzet (1972) and Duelli (1981) observed the occurrence of cannibalism in the predator *Chrysoperla carnea* (Stephens) and studies by B/insch (1964) and Egger (1974) revealed that *C. carnea* larvae cannibalized eggs.

It was found also that hunger influenced the extent of cannibalism (Arzet, 1972; Bond, 1978; Baumg, irtner *et al*., 1981). Cannibalism among larvae of *Coccinella septempunctata* L. was reported by Johnssen (1930). Several authors observed egg cannibalism by larvae (Dixon, 1959; Shah, 1980; Basedow, 1982; Mills, 1982) and Banks (1955) also observed adults feeding on eggs. In *C. septempunctata* the extent of cannibalism was also dependent on hunger (B-insch, 1964; Kehat, 1968). The competitive interactions between *C. carnea* and *C. septempunctata* were studied by B.insch (1964) and Ickert (1968). *Chrysoperla carnea* has been recognised as a potential biological control agent due to its high adaptability in field, efficient foraging behaviour and predator of a variety of arthropods. (Morrison, 1985) [33]. *C. carnea* can easily be mass reared in the laboratory and used against insect pest in the field (Syed *et al*., 2008) [43]. Developmental duration and survival rate of *C.carnea* are influenced by temperature, relative humidity, photoperiod, food quality and quantity (Adane and Gautam, 2002) [1]. One of the most important influencing factor in the development rate of a particular insect species is temperature because different insect species have some different temperature requirements at different developmental stages. (Birch, 1948) [1]. Observations has also been recorded to collect information on the biology of immature stages of *C.carnea*, when feeding on *C.cephalonica* eggs at three different temperature levels, which could be usefully employed for mass and quality production of the predator under local environmental conditions. Biological control is the natural mechanism of parasitoids, predators and pathogens in keeping other organisms' density at a lower average level than would occur in their absence (DeBach, 1965) [16]. The advantages of biological control are a lot. The predators are scattered in about 167 families of 14 orders of class Insecta. Among the predacious insect orders, Coleoptera, Neuroptera, Hymenoptera, Diptera and Hemiptera contain specially (natural enemies) predators. It is estimated that possibly up to one third of the successful biological insect pest control programmes are attributable to the introduction and release of insect predators (Williamson and Smith, 1994) [52]. A natural enemy (either predator, parasite or pathogen) may be used in inoculative releases, as reported by Warner (2001) [51]. Cost of rearing and quality control procedures are a necessity. The easy access and utilization of necessary hosts for the growth of predator population make it possible. The cost of developing and maintaining good quality natural enemies is a small price to pay for consistent and satisfactory performance in the field (Larock and Ellington, 1996) [28]. The procedures necessary will vary with the entomophagous species and the intended usage (Penny *et al*., 2000; Florkin and Jeuniaux, 1974)[21]. The green lacewings, *Chrysoperla carnea (*Stephens) is a cosmopolitan polyphagous predator, often seen in agricultural systems. It has been recorded as an effective generalist predator of aphids, coccids, mites and mealy bugs etc. (Yuksel and Goemen, 1992, Singh and Manoj, 2000, Zaki and Gesraha, 2001) [55, 54, 44]. It has been exclusively used in biological control of aphid populations (Venkatesan *et al*., 2000, 2002) and other insect pests (Obrycki *et al*., 1989) [33] because of its ubiquitous nature, polyphagous habits, and compatibility with selected chemical insecticides, microbial agents and amenability to mass rearing (Ridgway *et al*., 1970; Ridgway and Murphy, 1984; Obrycki *et al*., 1989; Uddin *et al*., 2005) [38, 33, 50]. Commercial marketing and mass-rearing has been practiced in North America and Europe (Liu and Chen, 2001; Balasubramani and Swamiappan, 1994; Tauber *et al*., 2000) [30, 7, 48] for control of many insect pests (Ridgway *et al*., 1970; Sengonca *et al*., 1995; Daane *et al*., 1996; Legaspi *et al*., 1996; Atakan, 2000) [42, 38, 15, 5]. It has examined that the influence of consumption of *P. solenopsis* nymphs, *A. gossipii* nymphs/adults, *H. armigera and P. gossypiella* eggs, mixed diet comprising all hosts in equal proportions, all major insect pests of cotton and compared with the factitious host (*S. cerealella* eggs) of *C. carnea*, one of the major species of predators in cotton crop ecosystem on development and survival of C. carnea. Green lacewing, *Chrysoperla carnea* generally known as aphid-lion is generalist predator of a wide range of pest species such as mealybugs, aphids, thrips, whiteflies and mites (Canard and Principi, 1984; Liu and Chen, 2001; Yadav and Pathak, 2010) [30, 54].

Materials and Methods

Biology of *Chrysoperla carnea* on five natural hosts was studied in Bio- control laboratory, Nuclear Institute of Agriculture Tando Jam. The natural hosts were cotton aphids, *Aphis gossypii* (Glov.) (nymphs/adults), American bollworm, *Helicoverpa armigera* (Hb.) (eggs), pink bollworm, *Pectinophora gossypiella* (Saund.) (eggs), cotton mealy bug, *Phenacoccus solenopsis* (Tinsley) (Pseudococcidae: Homoptera) (nymphs) and Angoumois grain moth, *Sitotroga cerealella* (Oliver) (frozen eggs). The eggs of first four hosts were collected from cotton field of Institute and reared in laboratory for experimental purpose on natural diet. Eggs of *S. cerealella* taken from laboratory culture, maintained for this purpose were provided to the larvae of *C. carnea* under control conditions (26±2 °C; 65±5% R.H). This experiment had eight replications and each treatment consisted of 50 individuals**.** All biological parameters including egg incubation, larval and pupal period (days), and total food consumption, pupal and adult survival, longevity of male and female (days), pre, post and oviposition (days) and fecundity per female with percent fertility were recorded daily. To avoid cannibalism, newly hatched (2 h old) larva was kept singly in glass vials (2.5 cm diameter and 8.5 cm length) covered with black muslin cloth, was offered weighed host till pupation; same procedure was used in mixed host diet. The period of time from egg laying to hatching was considered incubation period; from hatching till spinning of cocoon was designated the larval period and from cocoon formation and coming out from pupal case as pupal period. The time after emergence of adults and start of oviposition was considered as pre-ovipositional period, the period of egg-laying was considered oviposition and post-oviposition period of female was recorded as period between the days female ceased egg laying to the day of death. To study the percent hatchability, eggs were harvested with razor and separated along with black muslin cloth, counted and kept for hatching. Two days old virgin adults were paired in the rearing glass chimney (4 x 7.5 cm), provided with standardized adults' diet on hard paper card and wet cotton was placed in glass vials in chimneys. The period of survival of each male and female was observed regularly in order to record longevity (days) and total number of eggs laid by each female during their oviposition period. 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. The developmental period of the immature stages and all parameters were recorded daily. Data collected on fecundity, fertility, incubation, larval instars, pupal period and other various aspects of predator biology were subjected to analysis of variance and the treatment means were compared using Duncan's Multiple Range Test (Gomez and Gomez, 1984) [24] with the help of MSTATC computer software as analysing tool.

Results

The results regarding the immature developmental duration, survival rate and predatory potential of *C. carnea* feeding on S. *graminum* under controlled conditions revealed that the mean duration of the egg stage was 3.8 ± 0.047 days with 87% hatchability. Previous authors have reported durations for egg stage and their hatchability. Qadeer (2012) [35] indicated that the duration of egg stage was 4.0±0.00 days at 26±1 °C which confirms the result of the present study. The insect passed through three larval instars before transforming in to pre-pupa. The average durations of first, second and third instars were 3.2 ± 0.033, 4.0 ± 0.045 and 4.8 ± 0.029 days with 88.5, 96.1 and 100 percent survival rate, respectively. Afzal and Khan (1978) [2] reported that the average duration of first, second and third instars were 3.20 ±0.09, 3.4 ±0.05 and 4.7±0.08 days, respectively. Lenardo *et al*. (2002) [29] reported the viability for first, second and third instars was 93.3%, 100% and 89.5% respectively for *C. everes* when feeding on *S. cerealella* eggs. As observed in previous studies, whole-plant searches indicated that densities of lacewing larvae and pupae are relatively low in comparison with densities of lacewing eggs, suggesting that an important mortality factor is operating on the early developmental stages. It was observed that a total of 136 neonate *Chrysoperla carnea* larvae foraging freely in the field for a cumulative observation period of 448.6 h. Only three instances of contact between the focal neonate *C. carnea* and other lacewing larvae were observed as 0.00669 6 0.00373 encounters/h [mean 6.1 SE]), and none of these contacts led to an attack. Thus, this study provides no evidence that cannibalism or interspecific predation within the family Chrysopidae were important sources of mortality *for C. carnea* larvae. Contacts between neonate lacewing larvae and non-chrysopid predators occurred far more frequently. Twenty-six encounters were observed between lacewings and arthropods that might act as their predators. Only first-instar *Orius tristicolor* were excluded from consideration as lacewing predators because of their small size and observations that they may be preyed upon by neonate *C. carnea*. Of the 26 encounters, 9 resulted in redation of the focal neonate *C. carnea* (0.0202 6 0.0068 predatory encounters/h). It was observed that neonate *C. carnea* being preyed upon by five species of hemipteran predators: *Orius tristicolor*, 4th instar nymph (1) and adults (2); *Geocoris pallens*, adults (2); *Geocoris punctipes*, adult (1); Geocoris sp., 4th-instar nymph (1); Nabis sp., 3rd-instar nymph (1); and Zelus renardii, adult (1). The results on the developmental duration of immature stages of *C. carnea* when feeding *C. cephalonica* eggs at three different temperature levels indicated that incubation period of *C.carnea* eggs was 4.9±0.08, 3.8±0.08 and 3.0 ±0.06 days at 24+1 °C, 28+1 °C and 32+1 °C, respectively. Josain and Sonia (2003) [26] reported that incubation period was 4 days at 25 °C, while Afzal and Khan (1978) [2] reported that incubation period of *C.carnea* eggs was 4.8 ± 0.4 days under laboratory conditions. The insect passes through three larval instars before transforming into pupa. The average duration of the first, second and third instars were 3.6 ± 0.07, 3.4± 0.11 and 4.9 ± 0.10 days at 24±1 °C respectively. Similarly, at 28±1 °C and 32±1 °C the average duration of first, second and third instars were, 2.7 ± 0.11, 3.0 ± 0, 4.0 ± 0.06 and 2.0±0.06, 2.8±0.07, 3.4±0.13 days, respectively. The result indicated that with increasing temperature developmental duration for different instars of *C.carnea* are significantly decrease. Previous workers reported different developmental duration for different instars Afzal *et al*. (1978) [2] reported the average duration of the first, second and third instars were 3.2±0.49, 2.8 0.20 and 6.9 0.49 days respectively, while Mari *et al*. (2006) [32] reported that developmental duration of first, second and third instars were 2.46±0.05, 4.36±0.10 and 5.91±0.19 days when feeding on aphid.

Incubation period: The results showed that the incubation period of eggs of *C. carnea* feeding on different hosts was significantly different from each other (F= 117.06; DF= 5, 42; *P*<0.001). It was 2.25, 2.28, 2.36, 3.85, 2.25 and 2.80 days on *A. gossypii*, *P. solenopsis, S. cerealella, H. armigera, P. gossypiella* and mixed host diet, respectively. The minimum incubation period of 2.25 days was recorded for eggs laid by females fed on *A. gossypii* and *S. cerealella* as larvae.

Table I: Effect of feeding of *C. carnea* on different hosts on different developmental parameters under laboratory conditions (Mean±S.E.).

Developmental parameters	*Aphis gossypii* (nymph/adults)	*Phenacoccus solenopsis* (nymphs)	*Helicoverpa armigera* (eggs)	*Pectinophora gossypiella* (eggs)	*Sitotroga cerealella* (eggs)	Mixed host diet
Incubation period (days)	2.25 c	2.28 c	2.36 c	3.85 a	2.25 c	2.80 b
Instars period 1stInstar (days)	2.62±0.18 b	2.87±0.12 b	4.00±0.00 a	3.00±0.00 b	2.50±0.18 b	2.87±0.29 b
2ndInstar (days)	2.75±0.16 c	3.00±0.00 c	4.12±0.12 a	4.12±0.12 a	2.75±0.16 c	3.50±0.18 b
3rdInstar (days)	3.12±0.12 c	3.62±0.26 b	4.25±0.16 a	4.25±0.16 a	3.00±0.00 c	4.62±0.18 a
Larval period (days)	8.50±0.32 d	9.50±0.32 c	12.37±0.18a	11.37±0.26 b	8.25±0.25 d	11.00±0.32 b
Pupal period (days)	7.75±0.16 bc	7.75±0.16 bc	8.37±0.18 a	8.50±0.18 a	7.37±0.18 c	8.25±0.25 ab
Larval survival (%)	87.50±12.50	62.50±18.30	75.00±46.29	50.00±18.90	100.00±0.00	75.00±16.40
Survival to adults stage (%)	87.50±35.35	62.50±51.75	75.00±46.29	50.00±53.45	100.00±0.00	62.50±51.75
Male longevity (days)	21.75±0.49 b	20.25±0.25 c	19.75±0.25 c	19.62±0.32 c	23.62±0.42 a	20.00±0.46 c
Female longevity (days)	38.00±0.65 a	32.25±0.72 b	30.87±0.39 b	30.87±0.35 b	38.62±0.62 a	31.25±0.99 b

Figures followed by same letter with in a row are not significantly different from each other at 5% DMRT.

Larval period: The results indicated that larval period of C. carnea feeding on different hosts is significantly different (F= 34.34; DF= 5, 42; *P*<0.001). Duration of first larval instar was 2.62, 2.87, 4.00, 3.00, 2.50 and 2.87 days, while duration of second instar was recoded as 2.75, 3.00, 4.12, 4.12, 2.75 and 3.50 days and that of third instar was 3.12, 3.62, 4.25, 4.25, 3.00 and 4.62 days, respectively, on A. gossypii, P. solenopsis, H. armigera, P. gossypiella, S. cerealella and mixed host diet. The order of complete larval developmental period on different insect prey species was *S. cerealella* > *A. gossypii* > *P. solenopsis* > mixed host diet > *P. gossypiella* > *H. armigera*. The complete larval developmental period was 8.50, 9.50, 12.37, 11.37, 8.25 and 11.00 days *on A. gossypii*, *P. solenopsis, H. armigera, P. gossypiella, S. cerealella*, and mixed host diet, respectively. The shortest and the longest larval period of *C. carnea* were recorded as 8.25 and 12.37 days on *S. cereallela* and *H. armigera* eggs, respectively.

Pupal period

The pupal period of *C. carnea* was significantly different on various hosts (F= 5.31; DF= 5, 42; *P*<0.001). The cocoon period of *C. carnea* was 7.75, 7.75, 8.37, 8.50, 7.37 and 8.25 days fed on *A. gossypii, P. solenopsis, H. armigera, P. gossypiella, S. cerealella,* and mixed host diet, respectively. The maximum to the minimum pupal period was in the order of *S. cerealella* >
A.gossypii > mixed host diet, *H. armigera, P. solenopsis* > *P. gossypiella.*

Larval and pupal survival

Analysis of data indicated a non-significant effect of hosts on the survival of *C. carnea* pupae (F= 1.35; DF= 5, 42; *P*>0.05) and adults (F= 1.40; DF= 5, 42; *P*>0.05). However, the maximum survival of pupae and adults was recorded when *C. carnea* was feeding on eggs *of S. cerealella* followed by nymphs and adults of A. gossypii. The minimum survival to pupal and adult stages was observed on eggs of *P. gossypiella.*

Reproductive attributes

Feeding of different hosts to larvae of *C. carnea* significantly affected its fecundity (F= 87.17; DF= 5, 42; *P*<0.001). Similarly, significantly (F= 36.37; DF= 5, 42; *P*<0.001) higher fertility of eggs of *C. carnea* was recorded when feed on eggs of *S. cerealella* as larval host followed by *A. gossypii*. The maximum mean adult male and and female longevity was recorded for *C. carnea* feeding on *S. cerealella* as a host followed by *A. gossypii.* There was significant (F= 17.13; DF= 5, 42; *P*<0.001) male and (F= 30.61; DF= 5, 42; *P*<0.001) female variation in adult longevity due to feeding on different hosts.
Predation of *Chrysoperla carnea.* The data showed significant differences (*P*<0.05) in the mean consumption of *C. carnea* on different stages of *P. solenopsis.*

Table II: Effect of feeding on different hosts on different reproductive attributes of *C. carnea* under laboratory conditions (Mean±SE).

Reproductive parameters	*Aphis gossypii* (nymph/adults)	*Phenacoccus solenopsis* (nymphs)	*Helicoverpa armigera* (eggs)	*Pectinophora gossypiella* (eggs)	*Sitotroga cerealella* (eggs)	Mixed host diet
Pre-oviposition period (days)	3.37±0.18 b	3.62±0.18 ab	4.12±0.12 a	3.87±0.22 ab	2.37±018 c	3.37±0.18 b
Oviposition (days)	27.62±0.42 b	21.62±0.49 c	19.12±0.61 d	19.25±0.36 d	29.50±0.82 a	20.12±0.74 cd
Oviposition/ day/ female (days)	15.21±0.27 c	17.82±0.44 b	17.74±0.23 b	17.58±0.30 b	17.13±0.47 b	20.15±0.83 a
Post-oviposition (days)	6.87±0.47	7.00±0.56	7.62±0.26	7.62±0.32	6.75±0.25	7.50±0.42
Fecundity/ female	419.80±6.35 b	384.00±3.15 c	338.90±9.19d	337.80±3.61 d	503.30±9.17a	401.63±5.30bc
Fertility (%)	87.88±0.74 a	85.09±0.70 b	82.75±0.52 b	75.10±1.11 c	88.61±0.68 a	82.92±0.95 b

Figures followed by same letter with in a row are not significantly different from each other at 5% DMRT.

The feeding potential of *C. carnea* increased significantly with the advancement of larval stage of the predator. The third instar larvae of *C. carnea* consumed significantly higher number of 645.9 total first instar nymphs of *P. solenopsis* which differed significantly from 406.0 nymphs consumed by first instar and 426.3 nymphs consumed by second instar larvae of *C. carnea.* Similarly the average number of total second instar nymphs of *P. solenopsis* consumed by first instar larvae of *C. carnea* was significantly less than the other developmental stages of *C. carnea*. The first instar of *C. carnea* consumed minimum number of 62.12 second instar nymphs of *P. solenopsis* whereas; third instar of *C. carnea* consumed maximum number of 144.7 second instar nymphs of *P. solenops*.

Discussion

Predation risk may also decrease as lacewings grow. However, it is suspected that while some small-bodied predators, such as *Orius tristicolor*, may impose less mortality on larger lacewing larvae, larger predators, such as the Nabis spp. and *Zelus renardii* may become more important. *Zelus renardii* appears to respond strongly to moving prey (Cisneros and Rosenheim 1997) [14], and larger lacewings, which cover more substrate while foraging, may be at a much higher risk. The survival rate is 82%, 68% and 42% respectively. The shortest larval period is recorded *on S. cerealella* eggs, while longest on *H. armigera* eggs. The longest pupal period is also recorded while on feeding upon *H. armigera eggs.* Balasubramani and Swamiappan (1994)[7] studied development of *C. carnea* on different hosts in laboratory and found that larval development was rapid on eggs of *Corcyra cephalonica* (8.20 days) and longest on neonates of *H. armigera* (11.10 days). In present study, larval duration remained maximum (8.50 days) while feeding upon *P.gossipiella.* Mannan *et al*. (1997) [31] studied biology of *C. carnea* on *A. gossypii* and *M. persicae* and observed that larval duration was long when fed on *M. persicae*. Saminathan *et al*. (1999) [8] and Bansod and Sarode (2000)[39] studied biology and feeding potential of *C. carnea* on different hosts and noted developmental period of *C. carnea* ranged from 18.6 days on *Aphis cracivora to* 22.7 days on *H. armigera* neonate larvae. On feeding upon mixed hosts, it was studied that the male development period was (20 days) and that of female was (31.25days) Giles *et al*. (2000) [23] studied nutritional interactions among alfalfa, Medicago sativa and faba bean, *Vicia faba*, as host plants, pea aphid, *Acyrthosipnon pisum* an herbivore and *C. carnea* a predator. It was shortest when larvae were fed *A. gossypii* followed by *M. persicae* and *Lipaphis erysimi* (Liu and Chen, 2001) [30]. Ballal and Singh (1999) [6] and Bartlett (1984) [9] studied the host plant-mediated orientational and ovipositional behaviour of three species of chrysopids and found that *C. carnea* females had significantly higher preference for sunflower and cotton, while pigeonpea was less preferred. On cotton *C.carnea* preferred to lay more eggs on underside of leaves than on buds. Flint *et al*. (1979) [20] reported that damaged cotton plants release the terpenoid β caryophyllene which attracts *C. carnea*. Balasubramani and Swamiappan (1994) [7] studied development of *C. carnea* on different hosts in laboratory and found that larval development was rapid on eggs of *Corcyra cephalonica* (8.20 days) and longest on neonates of *H. armigera* (11.10 days). Mannan *et al*. (1997) [31] studied biology of *C. carnea* on *A. gossypii* and *M. persicae* and observed that larval duration was long when fed on *M. persicae*. Saminathan *et al*. (1999) [8] and Bansod and Sarode (2000) [39] studied biology and feeding potential of *C. carnea* on different hosts and noted developmental period of C. carnea ranged from 18.6 days on *Aphis cracivora to* 22.7 days on *H. armigera* neonate larvae. Giles *et al*. (2000) [23] studied nutritional interactions among alfalfa, Medicago sativa and faba bean, *Vicia faba*, as host plants, pea aphid, *Acyrthosipnon pisum* an herbivore and *C. carnea* a predator. Chemical analysis showed that aphids reared on faba bean had 6.3 times more levels of myristic acid. The duration of development *of C. carnea* was significantly different on three aphid species.

Conclusions

Of 136 neonate lacewing larvae observed foraging freely in the field for a total of 448.6 h, 9 are observed to be killed by generalist hemipteran predators. How should this central result be interpreted? At first, predation may seem to be a rare event. However, because the observed lacewings for only a tiny fraction of their total immature developmental period (4 h out of 12 d 5 1.4%), the fact that observed 9/136 5 6.6% and killed by predators indicates that predation is a major source of mortality. The task of projecting the total risk of predation during the three larval instars from the observed predation risk experienced by neonates is made difficult by two important lacunae in our knowledge. There is no estimate of predation rates during the night, and do not have an estimate of predation rates for older-lacewing developmental stages. A simplest case is described in which it is assumed that the risk of predation is constant at the value observed in the study (0.0202 predatory encounters/h) across the entire period of lacewing larval development. Assuming a 12-d larval developmental period, only 0.3% of neonate lacewing larvae are expected to survive to the pupal stage (95% CI: 0.006–14.3%). Predation risk may decrease at night; if it is assumed that a zero predation during the 10-h scotophase that is typical for mid- and late-season conditions in California, the estimate of larval survivorship is 3.4% (95% CI: 0.4– 32.1%).. The results of the present studies indicates that temperature have significant effect on the developmental duration and survival rate of immature stages *of C.carnea.* The result further indicates that out of the three-tested temperature T, one is more suitable temperature for rapid development and high survival rate. The results demonstrate the need for further studies on the effect of temperature for efficient and quality mass production of the predator. Larval food significantly affects the length of larval period. The shortest larval period is recorded *on S. cerealella* eggs, while longest on *H. armigera* eggs.

Acknowledgements

All the efforts in the preparation of this article solely concerned to me. Its all about due to the help of God, prayers of parents. I am also very thankful to The Department of Entomology to provide me their lab for work. I also appreciate to the worthy vice chancellor of The Islamia University of Bahawalpur to provide easy access to internet for students and researchers.

References

1. Adane T, Gautam RD. Biology and feeding potential of green lacewing, *Chrysoperla carnea* on rice moth. Indian Journal of Entomology. 2002; 64(4):457-464.
2. Afzal M, Khan MR. Life history and feeding behaviour of green lacewing, *C. carnea* (Stephens) (Neuroptera: Chrysopidae). Pakistan Journal of Zoology. 1978; 10(1):83-90.
3. Alomar O, Wiedenmann RN, editors. Zoophytophagous Heteroptera: implications for life history and integrated pest management. Thomas Say Publications in Entomology. Entomological Society of America, Lanham, Maryland, USA, 1996.
4. Ashfaq MA, Nasreen, Cheema GM. Advances in mass rearing of *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae). South Pacific Studies. 2004; 24:47-53.
5. ATAKAN E. Within plant distribution of predators Chrysoperla carnea, *Deraeocoris pallens* and *Orius niger* in cotton. Turkiye Entomology derision. 2000; 4:267-277.
6. Ballal CR, Singh SP. Host plant-mediated orientational and ovipositional behaviour of three species of chrysopids (Neuroptera: Chrysopidae). Biological Control. 1999; 16:47-53.
7. Balasubramani V, Swamiappan M. Development and feeding potential of the green lacewing *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) on different insect pests of cotton. Anz. Schardlingsk. Pflaanzensch. (Germany). 1994; 67:165-167
8. Bansod RS, Sarode SV. Influence of different prey species on biology of *Chrysoperla carnea* (Stephens). Shashpa. 2000; 7:21-24.
9. Bartlett AC. Genetic changes during insect domestication. In: Advances and challenges in insect rearing (eds. E. G. King and N. C. Leppla), U. S. Department of Agriculture Handbook, USDA, New Orleans, L. A. 1984, 2-8.
10. Beddington JR, Free CA, Lawton JH. Characteristics of successful enemies in models of biological control of insect pests. Nature. 1978; 273:513-519.
11. Birch LC. The intrinsic rate of natural increase of an insect population. Journal of Animal Ecology. 1948; 17:15-26.
12. Carrillo M, Elanov P. The potential of *Chrysoperla carnea* as a biological control agent of *Myzus persicae* in glass houses. Annuals of Applied Biology. 2004; 32:433-439.
13. Chacko MJ, Bhat PK, Rao LVA, Singh MBD, Ramanarayan EP, Sreedharan K. The use of the ladybird beetle *Cryptolaemus montrouzieri* for the control of coffee mealybugs. Journal of Caffeine Research. 1978; 8:14-19
14. Cisneros JJ, Rosenheim JA. Ontogenetic change of prey preference in a generalist predator, *Zelus renardii*, and its influence on the intensity of predator– predator interactions. Ecological Entomology. 1997; 22:399-407.
15. Daane KM, Yokota GY, Zheng Y, Hagen KS. Inundative release of common green lacewings (Neuroptera: Chrysopidae) to suppress *Erythroneura variabilis* and *E. elegantula* (Homoptera; Cicadelidae) in vineyards. Environmental Entomology. 1996; 25:1224-1234.
16. Debach P. Some biological and ecological phenomena associate with colonizing entomophagous insects. In: Genetics of colonizing species (eds. H. G. Baker and G. L. Stebbins), Academic Press, New York. 1965, 287-306.

17. Doutt RL. Biological characteristics of entomophagous adults. P. DeBach, editor. Biological control of insect pests and weeds. Reinhold, New York, New York, USA. 1964, 145-167.
18. Ehler LE, Miller JC. Biological control in temporary agroecosystems. Entomophaga. 1978; 23:207-212.
19. El Serafi HAK, Salam A, Bakey NF. Effect of four aphid species on certain biological characteristics and life table parameters of *C. carnea* (Stephens) and *Chrysoperla septempunctata* Wesmael (Neuroptera: Chrysopidae) under laboratory conditions. Pakistan Journal Biological Sciences. 2000; 3:239-245.
20. Flint HM, Salter SS, Walters S. Caryophyllene: an attractant for the green lacewing. Environmental Entomology. 1979; 8:1123-1125.
21. Florkin M, Penny C. Hemolymph composition. In: The physiology of insects, V. Academic Press, New York. 1974, 256-307.
22. Gautam S, Singh AK, Gautam RD. Olfactory responses of green lacewing, Chrysoperla sp. (carnea group) and Mallada desjardinsi on mealybug, *Phenacoccus solenopsis* (Homoptera: Pseudococcidae) fed on cotton. Acta Entomology Sinica. 2010; 53:497-507.
23. Giles KL, Madden RD, Payton ME, Dillwith JW. Survival and development of *Chrysopa rufilabris* (Neuroptera: Chrysopidae) supplied with pea aphids (Homoptera: Aphidiae) reared on alfalfa and faba bean. Environmental Entomology. 2000; 29:304-311.
24. Gomez KA, Gomez AA. Statistical procedures for agricultural research. John Wiley and Sons, New York, pp. 207-215. Florkin, M. And Jeuniaux, C., 1974. Hemolymph composition. In: The physiology of insects, V. Academic Press, New York. 1984, 256-307.
25. Hassell MP. The dynamics of arthropod predator prey systems. Princeton University Press, Princeton, New Jersey, USA, 1978.
26. Josian TC, Sonia MN. Development and consumption capacity of *Chrysoperla externa* (Hagen) (Neuroptera Chrysopidae) feed with *Cinara* spp. (Hemiptera Aphididae) under three temperature. Journal of Biological Control. 2003; 45:396-403.
27. Karban R, Hougen-Eitzmann D, English-Loeb G. Predator-mediated apparent competition between two herbivores that feed on grapevines. Oecologia. 1994; 97:508-511.
28. Larock DR, Ellington JJ. An integrated pest management approach, emphasizing biological control for pecan aphids. South-western Entomologists. 1996; 21:153-166.
29. Lenorado RB, Freitas SD, Auad AM. Biological aspects of the immature stages of the immature stages of *Ceraeochrysa everest*. Journal of Agricultural Sciences, (Piracicaba) Brazil. 2002; 59:423-429.
30. Liu T, Chen T. Effects of three aphid species (Homoptera: Aphididae) on development, survival and predation of *Chrysoperla carnea* (Neuroptera: Chrysopidae). Applied Entomology and Zoology. 2001; 36:361-366.
31. Mannan VD, Varma GC, Barar KS. Biology of *Chrysoperla carnea* (Stephens) on *Aphis gossypii* (Glover) and *Myzus perisicae* (Sulzer). Journal Insect Science. 1997; 10:143-145.
32. Mari JM, Nizamani SM, Bukaro A. Biological parameters of *Chrysoperla carnea* (Stephens) on mustard and wheat aphids. Pakistan Journal Agricultural Engineering Veterinary Sciences. 2006; 22(2):26-29.
33. Morrison RK. Handbook of insect rearing, Elsevier, Amsterdam the Netherlands. 1985, 419-426.
34. Obrycki JJ, Hamid MN, Sajap SA. Suitability of corn insect pests for development and survival of *Chrysoperla carnea* and *Chrysopa oculata* (Neuroptera: Chrysopidae). Environmental Entomology. 1989; 18:1126-1130.
35. Pappas ML, Broufas GD, Koveos DS. Effects of various prey species on development, survival and reproduction of the predatory lacewing *Dichochrysa prasina* (Neuroptera: Chrysopidae). Journal of Biological Control. 2007; 43:163-170.
36. Qadeer A, Muhammad R, Ahmad N, Ahmed J, Suleman N. Effect of different photoperiods on the biological parameters of Chrysoperla carnea under laboratory conditions, Journal of Basic and Applied Sciences. 2012; 136(8):638-640.
37. Ragsdale DW, Landis DA, Jacques B, Heimpel GE, Desneux N. Ecology and management of the soybean aphid in North America. Annual Review Entomology. 2011; 56:375-379.
38. Riechert SE, Lockley T. Spiders as biological control agents. Annual Review of Entomology. 1984; 29:299-320.
39. Saminathan VS, Muralibaskaran RK, Mahadevan NR. Biology and predatory potential of green lacewing, *Chrysoperla carnea* (Steph.) (Neuroptera: Chrysopidae) on different insect hosts. Indian Journal of agricultural Sciences. 1999; 69:502-505.
40. Sattar M, Hamed M, Nadeem S. Predatory potential of *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) against cotton mealy bug. Pakistan Entomologist. 2007; 29:103-106.
41. Sengonca C, Griesbach M, Lochte C. Suitable predator-prey ratios for the use of *Chrysoperla carnea* (Stephens) eggs against aphids on sugar beet under laboratory and field conditions. Z. Pflanzenkr. Pflanzenschutz. 1995; 102:113-120.
42. Sengonca C, Griesbach M, Lochte C. Suitable predator-prey ratios for the use of *Chrysoperla carnea* (Stephens) eggs against aphids on sugar beet under laboratory and field conditions. Z. Pflanzenkr. Pflanzenschutz. 1995; 102:113-120.
43. Settle WH, Ariawan H, Astuti ET, Cahyana W, Hakim AL, Hindayana D *et al*. Managing tropical rice pests through conservation of generalist natural enemies and alternative prey. Ecology. 1996; 77:1975–1988.
44. Sih A, Crowley P, McPeek M, Petranka J, Strohmeier K. Predation, competition, and prey communities: A review of field experiments. Annual Review of Ecology and Systematics. 1985; 16:269-312.
45. Singh NN, Manoj K. Potentiality of Chrysoperla carnea in suppression of mustard aphid population. Indian Journal Entomology. 2000; 62:323-326.
46. Sunderland KD, Axelsen JA, Dromph K, Freier B, Hemptinne JL, Holst NH *et al*. Pest control by a community of natural enemies. In W. Powell, editor. Arthropod natural enemies in arable land. III. The individual, the population, and the community. Acta Jutlandica. 1997; 72:271-326.
47. Syed AN. Ashfaq M, Ahmad S. Comparative effect of various diets on development of *Chrysoperla carnea* (Neuroptera: Chrysopidae). International Journal of Agriculture and Biology. 2008; 10:728-730.
48. Tauber MJ, Tauber CA, Daane KM, Hagen KS. Commercialization of predators: recent lessons from

green lacewings (Neuroptera: Chrysopidae: Chrysoperla). American Entomologists. 2000; 46:26-38.

49. Tesfaye A, Gautam RD. Effect of adult food supplements on reproductive attributes and longevity of *Chrysoperla carnea* Stephens (Neuroptera: Chrysopidae). Annual Plant Protection Science. 2002; 10:198-201.
50. Uddin J, Holliday NJ, Mackay PA. Rearing lacewings, *Chrysoperla carnea* and *Chrysopa oculata* (Neuroptera: Chrysopidae), on prepupae of alfalfa leafcutting bee, *Megachile rotundata* (Hymenoptera: Megachilidae). Proceedings of entomological Society of Manitoba. 2005; 61:11-19.
51. Wiedenmann RN, Smith JW, Jr. Attributes of natural enemies in ephemeral crop habitats. Biological Control. 1997; 10:16-22.
52. Warner G. Spiders stalk and snare tree fruit pests. Good-Fruit Grower. 2001; 52:31.
53. Williamson FA, Smith A. Agrow report (DS 95) Biopesticides in crop protection. PJB Publications. 1994, 120.
54. Yadav R, Pathak PH. Effect of temperature on the consumption capacity of *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) reared on four aphid species. The bioscan. 2010; 5:271-274.
55. Yuksel S, Goemen H. The effectiveness of *Chrysoperla cranea* (Stephens) (Neuroptera: Chrysopidae) as a predator on cotton aphid, *Aphis gossypii* (Glov.) (Homoptera: Aphididae). Proceedings to Second Turkish National Congress of Entomology. 1992, 209-216.
56. Zaki FN, Gesraha MA. Production of the green lacewing, *Chrysoperla carnea* (Steph.) (Neuroptera: Chrysopidae) reared on semi-artificial diet based on algae, Chlorella vulgaris. Journal of applied Entomology. 2001; 125:97-98.