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Investigation effect three diets on life table parameters *Chrysoperla carnea* (Steph.) (Neuroptera: Chrysopidae) under Laboratory Conditions

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ABSTRACT

The common green lacewing, *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) is best-known as biocontrol agent. The suitability diet was important in mass-rearing and releasing field. *C.carnea* has a serious role at IPM cultures apposite of aphid and whitefly pest. For this purpose, *Schizaphis graminum* (Rondani) (Hemiptera: Aphididae), *Bemisia tabaci* Gennadius (Hemiptera: Aleyrodidae) biotype-B 3rd nymphs stage and Semi artificial diet as prey for Life table parameters was evaluated. All experiments were conducted at 25 ± 5 ^{0}C, 60± 5% RH and photoperiod of 16:8 (L:D).This study, the collected data was analyzed by using Jack Knife model and SAS (9.1) soft ware and experimental design was formatted Completely Randomized Design (CRD) and comparison among means followed by Tukey's HSD post hoc test. The highest Lx (number of individuals alive between age *x* and *x+1*) and the lowest d_x (numbers dying during the age interval *x*) were 0.99 and 0.005 (%) that belonged semi artificial diet. Reproductive and stable population parameters such as Net Fertility rate, Net reproductive rate (R_0), Gross reproductive rate (GRR), Intrinsic of increase (r_m), Mean generation time (T_c) and Doubling time (DT) in aphid, whitefly and semi artificial diets were 244.9±4.1, 170.2±3.4, 364.6±2; 175.43±4.33, 156±5.4, 267±4.8; 0.143±0.005, 0.124±0.004, 0.185±0.002; 34.93±0.47, 38±0.74, 29.79±0.57 and 4.83±0.08, 5.58±0.06 and 3.74±0.05, respectively. According to these results, semi artificial diet was appropriate diet.

Keyword: *Chrysoperla carnea*, life table parameters, *Schizaphis graminum*, *Bemisia tabaci*, Semi artificial diet.

INTRODUCTION

The greenbug is thought to be palearctic in origin and is now found in North, Central and South America, Europe, Africa, the Middle East and Asia (Blackman and Eastop, 2000). Greenbug saliva has enzymatic activity that breaks down cell walls and chloroplasts in susceptible plants (Al-Mousawi *et al.,* 1983) and addition greenbugs transmit plant viruses including barley yellow dwarf (Murphy, 1959), sugarcane mosaic (Ingram and Summers 1938) and maize dwarf mosaic (Nault and Bradley, 1969). Insecticides are the front line defense against greenbugs in small grain crops (Hays *et al.*, 1999), because of populate environment, now all attention orientated at natural enemies. *Bemisia tabaci* Gennadius; this whitefly was thought to be a new biotype of *B. tabaci* (designated variously as B biotype, Florida biotype, or poinsettia biotype), possibly introduced from the Middle East. Bemisia can cause economic damage to plants in several ways. Heavy infestations of adults and their progeny can cause seedling death, or reduction in vigor and yield of older plants, due simply to sap removal. When adult and immature whiteflies feed, they excrete honeydew, a sticky excretory waste that is composed largely of plant sugars. The honeydew can stick cotton lint together, making it more difficult to gin and therefore reducing its value. Sooty mold grows on honeydew-covered substrates, obscuring the leaf and reducing photosynthesis, and reducing fruit quality grade (Bellows *et al.,* 1994). Bemisia rarely reaches outbreak population levels in natural environments or in agricultural situations where no insecticides are applied. In these situations, natural biological control keeps Bemisia below economically injurious levels. Much mortality is caused by minute parasitic wasps (parasitoids) in the aphelinid family. Female parasitoids lay their eggs inside the whitefly nymph or between the whitefly and the leaf surface, depending on the genus of wasp. The immature parasitoids develop within the whitefly host, eventually consuming the entire host, except the integument. The immature parasitoid pupates within the integument of the host and the adult parasitoid emerges through a round hole. The most common parasitoids attacking Bemisia in Florida are in two genera, Encarsia and Eretmocerus. *Encarsia pergandiella* (Howard) and *Encarsia transvena* (Timberlake) are common throughout the States, while *Encarsia nigricephala* Dozier is common in north central Florida. Several species of Eretmocerus are also common throughout the States. Eretmocerus species cause mortality to whiteflies by host-feeding, in addition to parasitism. Females stab the immature whitefly repeatedly with their ovipositor and then turn around and feed from the wound, obtaining valuable protein with which to provision their eggs (Gerling and Mayer, 1996). *Chrysoperla carnea* (Stephens) is an important predator in agriculture. The value of this predator as a biological control agent arises not only from its widespread occurrence and broad range of prey but also from the fact that each of its three larval stadia are voracious polyphagous feeders, capable of consuming their own body mass in prey each day. It is estimated that possibly up to one third of the successful biological insect pest control programs are attributable to the introduction of *C. carnea* and release of insect predators (Williamson and Smith, 1994). There is a huge amount of literature available for mass rearing of *C. carnea* from early 60s in simplified units, cylindrical plastic cages and other techniques of shifting of adults for diet and cleaning of rearing units (Tulisalo and Korpela, 1973; Hassan, 1975; Morrison, 1977; Tulisalo, 1978; Karelin *et al*., 1989; Pal-Singh and Varma, 1989). El-Serafi (2000) effect of four aphid species on Certain Biological characteristics and life table parameters of *C. carnea* and *Chrysopa septempunctata* (Wesmael) studied under laboratory Conditions. Gautam (2009) compared life table analysis of Chrysopids reared on *Phenacoccus solenopsis* (Tinsley). Sattar (2010) investigated on *C. carnea* as a biological control agent against cotton pests in Pakistan at Ph.D Theses. Uddin (2005) reared lacewings, *C. carnea* and *C. oculata* (Neuroptera: Chrysopidae), on prepupae of Alfalfa Leafcutting bee, *Megachile rotundata* (Hymenoptera: Megachilidae). Feeding activity and life history characteristics of *C. carnea* were evaluated at different densities (Atlihan *et al.,* 2003). Chen and Liu (2001) surveyed relative consumption of three aphid species by the lacewing, *C. rufilabris*, and effects on its development and survival. (Zhang *et al.,* 2010) studied suitability of *Aphis craccivora* (Hemiptera: Aphididae) and *B. tabaci* (biotype-B) as prey for *C. pallens*. Atlihan *et al.,* (2004) reported that the more aphids (Hyalopterus pruni Geoffroy) consumed by C. carnea immature stages the higher the R0 and rm of the resulting adult females.

MATERIAL AND METHOD

Culture predator

C. carnea adults were originally collected from the experimental source of the Tehran University (Pakdasht, Tehran, Iran) they were maintained on polyester cylinder tubes that inside spreads on scalar paper and spout covered with mesh. All cultures were kept in lab condition 25 ± 5^0C, 60± 5% RH, and photoperiod of 16:8

(L:D).The adults were fed with artificial diet on plastic board (3×15 cm),drop-likely. The eggs were collected daily by razor blade and used stable green-lacewing colony source. New-born larvae potted on petri-dishes, separately, and feed by any diet treatments (3 rd nymphet stage aphid, whitefly and drops of semi artificial diet).

Culture Aphid and Whitefly

Adults were collected form experimental source of Iranian Research Institute of Plant Protection, Tehran- IRAN. Experimental wheat and tomato pots were kept in mesh covered cages (1×1×1m) in a greenhouse (to prevent parasitoids attack) maintained at lab condition. The infested leaves were cut and transmitted on new pots to generation experimental source. For obtain 3^{rd} nymphet stages, special pots were inoculated by the infested leaves, for one day, and removed. Than all offspring were same-old (24 h).

Preparation semi artificial diet

This diet was mixture of honey, yeast, essential amino acid, B vitamin groups, and water (10%, 15%, 25%, 2.5%, and 47.5%).

Release

Newly hatching larvae *C. carnea* were released on infested leaves of tomato and wheat with 3^{rd} nymphal stages of *B. Tabaci*, S. *graminum*, and semi artificial diet in separate petri dishes (7.5×1.5 cm).Whitefly, aphid -infested leaves, and semi artificial diet were replaced with fresh ones daily.

Fertility and incubation period of the egg

One hundred *C. carnea* eggs laid by 30 pairs of adults (24h-old) were collected from the laboratory maintained stock and kept in two plastic petri-dishes (covered with fine muslin cloth for ventilation) until hatching. Preliminary test showed that each female oviposited_3 eggs (3_10) per day (Zhang *et al*., 2010). A piece of filter paper was placed at the bottom of the petri-dishes, and a few drops of water were added as needed to maintain humidity. The petri-dishes with the insects were kept in a growth chamber. The *C. carnea* eggs were inspected carefully every 8 h and number of larvae hatched were recorded.

Life table study

Life expectancy and age specific life table parameter of green-lacewing were studied only using whitefly, aphid, and semi artificial diet as prey. At first, a life table is a detailed description of the mortality of a population giving the probability of dying and various other statistics at each age (Carey, 1993). Fifty 24-h laid eggs *C. carnea* placed separately on filter papers in petri dishes at 25±2 ,65±5% RH and a photoperiod of 16:8 (L:D) h. with passing incubation period and appearing first _age larvae, The petri-dashes were visited daily to larval mortality recorded and replaced fresh prey. Larval skins were best reasons that larvae went to next stage. With this method, a person was essential point that quantitative analyses of population were started by person. Life table parameter was determined by drawing Age Class (X) and the number of people surviving to age (N_x), and then used them, following models were determined: 1) $lx= Nx / N_0$ (l_x= proportion of individuals surviving to age x) (N_0=the number of people at the start of the experiment) 2) $p_x = l_{x+1} / l_x$ (*survival period*) (P_x= the probability of surviving from age x to x + 1 is designated) 3) $q_x = 1-p_x$(Age Specific Mortality) (*qx*=represent the probability of dying over these respective periods),4) $d_x = l_x - l_{x+1}$ (D_x= the difference in number of survivors for successive ages x and x + 1) is designated, 6) $T_x = \sum_{x=0}^{\omega} Lx$(*Tx*= the total number of days to be lived by the average individual within a cohort from age x to the last day of possible life is), and 7) $ex = Tx / lx$ (*ex*= the average age of death of an individual age x is simply its current age plus the expectation of life at that age).The age-specific survival rate (*lx*) and age-specific fecundity (m_x) were calculated per day. The net reproductive rate ($R_0=\sum l_x m_x$), intrinsic rate of natural increase [$r_m=InR_0(T)^{-1}$], finite rate of increase ($\lambda=e^{rm}$), mean generation time [$T = (\sum xlxmx)/R_0$; the sum of development time from the egg stage to half of the life expectation of females after sexual maturation], doubling time ($DT=Ln2/r_m$), and gross reproductive rate ($GRR=\sum mx$) were estimated (Birch, 1948; Southwood, 1978; Pang *et al*., 1984).

Statistical analyses

One away ANOVA followed by Tukey's HSD post hoc test was used to compare biological life table parameters on different diets. Differences were considered significant at p<0.01. All analyses were conducted using statistical software SAS 9.1.

RESULTS

The age-specific parameters of *C. carnea* in immature stages such as Lx, dx, and ex on Aphid, Whitefly, and semi artificial diet showed significant different (Table 1). Lx in egg and 1st instar non-significant difference but older stages highest Lx belonged semi artificial diet. The survival curves on diets were showed same-trend (Convex) and K-Strategy but Whitefly's survival curve is different from Aphid and semi artificial diet (Fig. 1). The Life Expectancy Process on diets showed descending trend and highest e_x belonged feeding on Whitefly (Fig.2). Reproductive parameters for this research kind of food were not effect on pre-oviposition period (Table 2.).

Table 1: Age-spacfic life table parameters of *C. carnea* on diets.

X(Stages of predator)	diet	L_x	q_x	d_x	p_x	e_x
Egg	3 rd instar of Aphid	0.96	0.015	0.015	0.984	24.05
	3 rd instar of whitefly	0.96	0.015	0.015	0.984	23.7
	Semi artificial diet	0.99	0.005	0.005	0.995	20.48
1st instar	3 rd instar of Aphid	0.95	0.012	0.012	0.987	19.03
	3 rd instar of whitefly	0.94	0.0206	0.02	0.979	22.01
	Semi artificial diet	0.98	0.005	0.005	0.995	16.4
2 nd instar	3 rd instar of Aphid	0.94	0	0	1	15.01
	3 rd instar of whitefly	0.88	0.004	0.004	0.995	18.58
	Semi artificial diet	0.97	0.006	0.006	0.993	13.15
3 rd instar	3 rd instar of Aphid	0.93	0.005	0.005	0.994	11.01
	3 rd instar of whitefly	0.84	0.01	0.016	0.981	14.59
	Semi artificial diet	0.96	0	0	1	9.83
Pupa	3 rd instar of Aphid	0.82	0.133	0.11	0.866	5.51
	3 rd instar of whitefly	0.72	0.122	0.08	0.877	8.36
	Semi artificial diet	0.9	0.125	0.12	0.875	3.83

Fig 1. Survival Curve of predator on dites

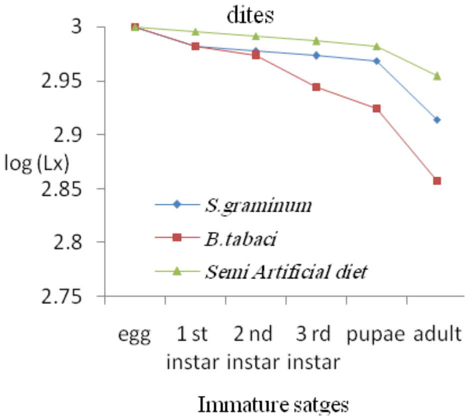


Fig 2. Life expectancy *C.carnea* on diets

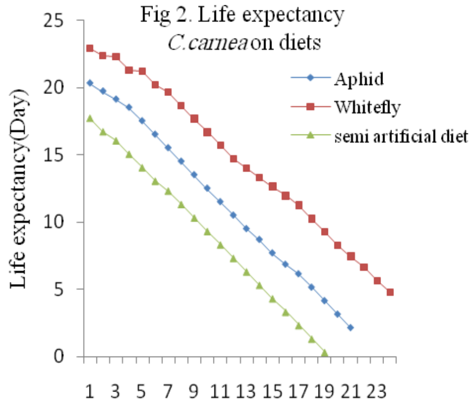


Table 2: The reproduction parameters of *C. carnea*

diet	Pre-oviposition period(Day)	No. egg/Female/Day	No. fertility/Female/Day	Gross fecundity rate(No. egg)
S. graminum	5.31±0.21[a]	11.75±0.22	9.56±0.14	335.25±9.8
B. tabaci	4.56±0.25[b]	10.15±0.38	7.9±0.11	304.75±7.2
Semi artificial diet	4.37±0.16[a]	15.67±0.59	12.79±0.15	470.25±9.8

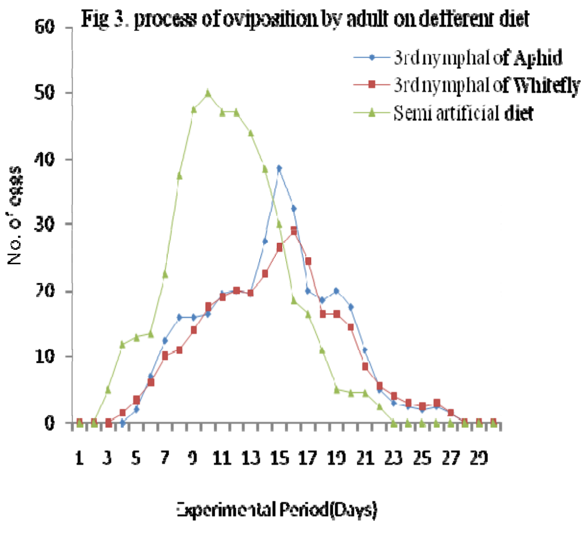
In column, different letters indicate significant differences at level of 0.01

The productive parameters on difference diets were significant difference. Semi artificial diet in all parameters was the highest values except gross hatched rate (Table 3 and Fig. 3). Among this parameters, Net fertility rate was important because it was impressed by two index (fertility and survival) that semi artificial diet was 364.6±2. Feeding on whitefly decreased reproductive parameters thereupon disturbed predator generation. Mean egg and fertility's laid by per female/day on semi artificial diets were 15.67±0.59 and 12.79±0.15 (No. egg). Gross hatched rate was 0.85, 0.77, and 0.81 on Aphid, whitefly, and semi artificial diet, respectively.

Table 3: The reproduction parameters of *C. carnea*

diet	Gross fertility rate (No. egg)	Gross hatched rate (%)	Net fecundity rate(No. egg)	Net fertility rate
S. graminum	286.98±4.35[a]	0.85	282.7±3.6[b]	244.9±4.1[b]
B. tabaci	237±3.5[b]	0.77	215.52±3.6[c]	170.2±3.4[c]
Semi artificial diet	283.83±4.6[a]	0.81	447±3.6[a]	364.6±2[a]

In column ,different letters indicate significant differences at level of 0.01



The Stable Population parameters of *C. carnea* are reasonable to verdict and showed significant difference (Table 4.). The lowest and highest mean generation time (T_c) and Doubling time (DT) were on semi artificial diet 29.79±0.57, 3.74±0.05and whitefly 38±0.74 and 5.58±0.06 (day). The highest Gross reproductive rate (GRR) and Net reproductive rate (R_0) was 267.8±2.7 and 254.05±3.3 (female /female / generation) on semi artificial diet. The intrinsic of increase (r_m) on aphid, whitefly, and semi artificial diet were 0.143±0.005, 0.124±0.004, and 0.185±0.002 (female/female/day).

Table 4: The Stable Population parameters of *C. carnea*

Diet	The Stable Population parameters					
	T_c(Day)	DT(Day)	λ(female/female/day)	r_m(female/female)	R_0(female/female/generation)	GRR(female/female/generation)
S. graminum	34.93±0.47[b]	4.83±0.08[b]	1.154±0.006[b]	0.143±0.005[b]	149.61±2.7[b]	175.43±2.5[b]
B. tabaci	38±0.74[a]	5.58±0.06[a]	1.132±0.004[c]	0.124±0.004[c]	112.01±3.4[c]	156.3±3.1[c]
Semi artificial diet	29.79±0.57[c]	3.74±0.05[c]	1.203±0.002[a]	0.185±0.002[a]	254.05±3.3[a]	267.8±2.7[a]

In column, different letters indicate significant differences at level of 0.01

DISCUSSION

Our results showed that semi artificial diet was appropriate diet for development of *C. carnea*, whereas 3rd instar *B. tabaci* was not (Zhang, 2010).The survival of *C. carnea* immature obtained of this study (0.92 % on aphid and 0.86 % on whitefly) was comparable to 78% on *A. craccivora* at 25 ^{0}C and 82.8% at 27^{0}C on *A. gossypii* Glover (Zhang *et al*., 2010; Lee *et al*. 2000). Lee and Lee (2005) observed that the survival rate of *C. pallens* was about 89% on an artificial diet that is similar to our results. Sattar (2010) valued larval survival on *A. gossypii* (nymph/adults) 87.50±12.50, on artificial diet 91.50±0.63 that is similar to this research. Chen and Liu (2001) studied effects of *A. gossypii* and *Myzus persicase* on *C. rufilabris*: survival (100,100 %). Our result showed first type survival curves on three diets that mean maximum mortality was happen old-stages (Zhang *et al.,* 2010). Our data showed that *C. carnea* larvae that fed on 3rd instar of *B. tabaci* reared on tomato 28% of pupae was abnormal and died before reaching the adult stage but different of many author such as Legaspi, Nordlund, and Legaspi, 1996 reported that *C. rufilabris* larvae feeding on *B. tabaci* reared on poinsettia and lima bean lived only to the third instar and died before reaching the pupal stage; however, larvae provided whitefly from cucumbers and cantaloupes reached the adult stage. They speculated that *B. tabaci* reared on poinsettia or lima bean were nutritionally inadequate for the lacewing, or the whitefly reared on these plant hosts may have an accumulative toxic effect on *C. rufilabris* (Legaspi *et al*., 1994). The difference in this even could be due to superabundant honeydew that was ejected by whitefly colony as food assistance role in development predators and prey species, environmental conditions, or geographical population of *C. carnea*. Sattar (2010) pre-oviposition period reported on *A. gossypii* (nymph/adults) 3.37±0.18(day) that is similar to our observation but Zhang *et al.,*2010 reported on *A. craccivora* 8.76±0.81(day) that is different from our result. The differences in these parameters could be due to host plants, prey species, environmental conditions, or geographical populations. Zhang *et al,* (2010) female fecundity of *C. pallens* was 326 eggs when fed on *A.craccivora*, El-Serafi (2000) reported female fecundity of *C. carnea* on *A. gossypii*, *S. avenae*, *R. maidia* and *A. nerii* (480.2±14.2, 320.26±10.9, 336.44±12.5, and 215.7±9.6) was similar to our result but Sattar (2010) fecundity on *Aphis gossypii* (nymph/adults) was 419.80±6.35 and Lee *et al*., (2000) reported that fecundity was 1637 eggs when fed on *A. gossypii*. The differences in these parameters could be due to host plants, prey species. However, it is difficult to compare across studies because of the different species of predator and prey and the different experimental methods. Because the survival, development, and reproduction of a predator are affected by prey, it is necessary to evaluate life table parameters of predators fed on the same target prey types. However El-Serafi (2000) valued stable pupation parameters such as R_0, r_m, λ, T ,and DT on four aphid species *A. gossypii*, *A. avenae*, *R. maidia*, and *A. nerii* that was 219.81, 142.2,151.61, 86.93;

0.1259, 0.1447, 0.1255, 0.0089; 1.1342, 1.1557, 1.1337, 1.0933; 42.82, 34.27, 40.99, 50.01 and 5.50, 4.79,5.52,77.88,repectively.Zhang *et al* .,2010 documented GRR, R_0, r_m, λ, T ,and DT on *A. craccivora* 203.08, 201, 0.1324,1.1416, 40.08 and 5.2352. The later author confirmed our results.

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