

## Seasonal occurrence and biological parameters of the common green lacewing predators of the common pistachio psylla, *Agonoscena pistaciae* (Hemiptera: Psylloidea)

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**Key words.** Chrysopidae, lacewings, *Chrysoperla lucasina*, Psylloidea, *Agonoscena pistaciae*, pistachio psylla, population density, weeds, intrinsic rate of increase, theoretical threshold, food consumption, biological control

**Abstract.** Species in the *carnea* complex of the common green lacewing are predators of the common pistachio psylla, *Agonoscena pistaciae* in both cultivated pistachio plantations and on wild pistachio plants in Iran. The seasonal occurrence of common green lacewings was monitored in pistachio orchards from 2007 to 2008. In addition, the effect of different temperature regimes on preimaginal development, survival and prey consumption of the predatory lacewing *Chrysoperla lucasina* fed on *A. pistaciae* nymphs were studied under controlled conditions. The adults of common green lacewings first appeared on pistachio trees in mid April and were most abundant in early July, decreased in abundance in summer and increased again in October. The relative density of common green lacewings was higher in pistachio orchards where the ground was covered with herbaceous weeds than in those without weeds. In the laboratory females of *C. lucasina* laid an average of 1085 eggs over 60 days at 22.5°C. The maximum prey consumption occurred at 35°C when the larvae consumed 1812 fourth instar psyllid nymphs during their larval period. The intrinsic rate of natural increase ( $r_m$ ) was 0.11. The total development (egg-adult) required 385 degree-days above the theoretical lower developmental threshold of 9.6°C.

### INTRODUCTION

The common pistachio psylla, *Agonoscena pistaciae* Burckhardt and Lauterer (Hemiptera: Psylloidea: Rhinocolinae), is the most destructive insect pest of cultivated pistachio trees, *Pistacia vera* Linnaeus, in Iran (Mehrnejad, 1998, 2001). It is a major pest in many pistachio growing regions in countries around Iran's borders, such as Armenia, Iraq, Turkey and Turkmenistan, as well as Mediterranean regions such as Greece and Syria (Burckhardt & Lauterer, 1989, 1993; Mart et al., 1995; Bolu, 2002; Souliotis et al., 2002). *Agonoscena pistaciae* is controlled almost exclusively by applying pesticides, however environmental contamination and resistance to insecticides (Mehrnejad, 1998, 2003) has stimulated an interest in the role of biocontrol agents in reducing the abundance of this pest.

Lacewings of the family Chrysopidae are polyphagous predators and important biological control agents of aphids and other soft-bodied phytophagous insects. Certain chrysopid species, mainly of the genus *Chrysoperla*, have been successfully mass-reared and used in biological control of agricultural pests (New, 1988; Brooks & Barnard, 1990). Larvae of the common green lacewing are predacious and feed on a wide range of small, soft-bodied arthropods. In addition, in order to meet their nutritional requirements for growth and development they also consume foods such as honeydew (Bond, 1980; McEwen et al., 1993; Hogervorst et al., 2008). In contrast to the larval stage, the adults are not predaceous, feeding on

nectar, pollen and honeydew (Hagen et al., 1970; Principi & Canard, 1984; Villenave et al., 2005). The common green lacewings of the *carnea* complex are general insect predators and a major component of the beneficial entomofauna in agro ecosystems (Thierry et al., 2002). As *Chrysoperla carnea* (Stephens) sensu lato is a generalist predator, it is mass reared for release in glass-houses and field crops (Thierry et al., 2002; Mochizuki & Mitsunaga, 2004).

The taxonomy of *Chrysoperla* Steinmann within the “*carnea*-complex” is well studied and a detailed overview can be found in Canard & Thierry (2005) and Henry & Wells (2007). As a consequence of the previous ambiguous placement of species within this complex and confusion concerning the morphological separation of these species, previous records of this complex may have been misidentified or included in the *Chrysoperla carnea* group (Farahi et al., 2009). The common green lacewing, *Chrysoperla carnea* sensu lato is considered to be a complex of sibling species. Mirmoayedi & Thierry (2002) report several species of the *carnea* complex from Kermanshah and Golestan Park. The Iranian chrysopids fauna includes 46 species (Mirmoayedi, 2008), which occur in 25 of the 30 provinces of Iran. However, there is no information on the occurrence of green lacewings in Kerman province, the major pistachio growing area in Iran, either on herbaceous plants, bushes or trees. The present study reports the results of both field and laboratory experiments. For the field study the green lacewing adults were not identified to species and the name

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“common green lacewings” is used in this article. A colony of *Chrysoperla lucasina* (Lacroix) was established in an insect rearing room and chrysopids from this culture were used in the laboratory experiments. In order to evaluate the native biocontrol agents of *A. pistaciae*, the seasonal occurrence of common green lacewings was monitored in 2007 and 2008 at Rafsanjan, the main pistachio production area in Kerman province, Iran. The preimaginal development and survival of the green lacewing, *C. lucasina* fed *A. pistaciae* nymphs at different temperatures were studied. The reproductive potential and adult longevity of this species were also determined under controlled conditions.

## MATERIAL AND METHODS

### Field survey, occurrence and abundance of common green lacewings

Trends in the abundance of common green lacewings from early spring to late autumn were monitored on pistachio trees in two experimental orchards in Rafsanjan, the main pistachio production area in the southern part of Iran. The first experimental site was located 40 km south-east (Naseriyeh's pistachio research station) and the second 9 km north-west (Rafsanjan's pistachio research station) of Rafsanjan city. The first experimental site was 8 km from the nearest pistachio plantation and the second in a large pistachio plantation. Each orchard of 5 ha contains 2500 30 year old pistachio trees, of the well known commercial cultivar, Ohadi. The orchards were divided into two parts; (1) no tillage, where the ground was normally covered with herbaceous weeds and (2) weeds removed using a cultivator in early and late spring. The experimental orchards were treated in a similar way to commercial orchards, with the same fertilizer and irrigation regimes but no insecticides were applied during the survey periods. The dominant herbaceous weeds at the experimental sites were; *Chenopodium album* Linnaeus, *Sal-sola kali* Linnaeus, *Cynodon dactylon* (Linnaeus) Persson and *Alhagi camelorum* Fischer.

Both sites were sampled at 15 day intervals from April to November using a white beating tray (Mills, 2005; Speight, 2005) measuring 60 × 50 cm. On each sampling occasion 30 trees were checked, one branch on each of the four aspects of the trees (120 branches per sample) was beaten at each experimental site. Samples were collected from patches of 500 trees at the center of the experimental sites; however, the trees were randomly chosen on each sampling occasion. Sampling was carried out at the same time of day throughout the survey, 8–10 a.m. in spring and summer, 9–11 a.m. in autumn. The tray was held beneath a branch and the limb was struck sharply three times with a 40 cm long rubber hose. Adults of the common green lacewing that fell onto the tray were counted and recorded.

### Insect cultures

A laboratory colony was established with adults of the green lacewing, *C. lucasina* collected from a pistachio orchard in the suburbs of Rafsanjan. The stock culture of green lacewings was maintained in ventilated plastic boxes (30 × 25 × 15 cm) at 25 ± 1°C and a photoperiod of 16L : 8D, and fed psyllid nymphs. The lacewings were provided with fresh pistachio leaves infested with psyllid nymphs every morning and the old leaves removed. Five generations of *C. lucasina* were completed before the tests. Adults were fed a 1 : 1 : 1 diet of honey, yeast and water. Adult lacewings from these colonies served as the parent stock for all rearing experiments.

## Laboratory experiments

All laboratory trials were conducted under controlled conditions (27.5 ± 0.5°C, 55 ± 5% RH and 16L : 8D) unless stated otherwise. The lacewing larvae were fed 4<sup>th</sup> instar pistachio psyllids. Prey were presented in a pistachio leaf-disc cage (Mehrnejad, 1998) made of a plastic Petri-dish (52 mm in diameter) with a 20 mm diameter hole in the middle of the lid, which was covered by a piece of fine net (2 mm mesh) to provide ventilation. Agar medium (8 g/l) was used as a source of moisture for the leaf discs. A young and fully developed pistachio leaf was cut to the same size and shape as the dish and placed lower side down on the 3 mm thick agar medium covered by filter paper. The pistachio leaves were collected from nut bearing pistachio trees, *Pistacia vera* Linnaeus (cultivar Ohadi). Eight leaf-disc cages and two small glass jars containing a saturated “Magnesium Nitrate” salt solution (for maintaining relative humidity 55 ± 5%) were placed in a plastic box (30 × 25 × 15 cm) inside an incubator. The light intensity of about 13 watt/m<sup>2</sup> in the incubators was provided by white fluorescent lamps. The nymphs of the pistachio psyllid were regularly collected from pistachio orchards and used as a food for the lacewings used in the experiments.

### Development and survival

Newly laid eggs (<6 h) were used to determine the incubation period by recording whether they had hatched every 12 h. Newly emerged larvae were placed individually in plastic Petri dishes (52 mm in diameter) with a 20-mm diameter hole in the middle of the lid, which was covered by a piece of fine net (2-mm mesh) to provide ventilation. Larvae were fed psyllid nymphs. These larvae were checked once a day and fresh pistachio leaves infested with psyllid nymphs were added and old leaves removed from the dishes every morning. Larval mortality was recorded daily until pupation and pupae checked every day until adult eclosion. On the day of pupation the pupae were weighed and the sex determined after adult emergence. These experiments were conducted at nine constant temperatures: 15, 17.5, 20, 22.5, 25, 27.5, 30, 32.5 and 35 ± 0.5°C.

The rate of development from egg to adult was plotted against temperature to determine the thermal constant (degree day developmental time) for *C. lucasina* (Campbell et al., 1974; Jervis & Copland, 1996). The rate of development was plotted as the reciprocal of developmental time (days). A third-order polynomial regression curve gave the best fit to the data on the developmental rates recorded at the different constant temperatures. Temperature in the mid-range of the polynomial curve (linear area) were selected and used to fit a linear regression. The equation of linear regression ( $y = a + bT$ ) was then used to predict the  $T_1$  and  $K$ , where  $y$  is the rate of development and  $T$  is temperature. The theoretical lower threshold for development ( $T_1$ ) was calculated from the formula  $T_1 = -a/b$ , and the thermal constant ( $K$ ) was also obtained using the formula  $K = 1/b$ .  $K$  is the reciprocal of the slope  $b$  of the regression line (Campbell et al., 1974). The mean for each temperature and lower developmental threshold were calculated using the pooled data for female developmental time from egg to adult eclosion at each temperature.

### Reproduction

In this experiment the daily potential oviposition of female lacewings during their whole life under controlled conditions (22.5 ± 0.5°C, 50–60% RH and 16L : 8D) was determined. Newly emerged females and males were selected and then individually released into a cylindrical culture cage (25 cm height, 20 cm diameter). Adults were supplied with a 1 : 1 : 1 mixture of honey, yeast and water. At the same time on each day the

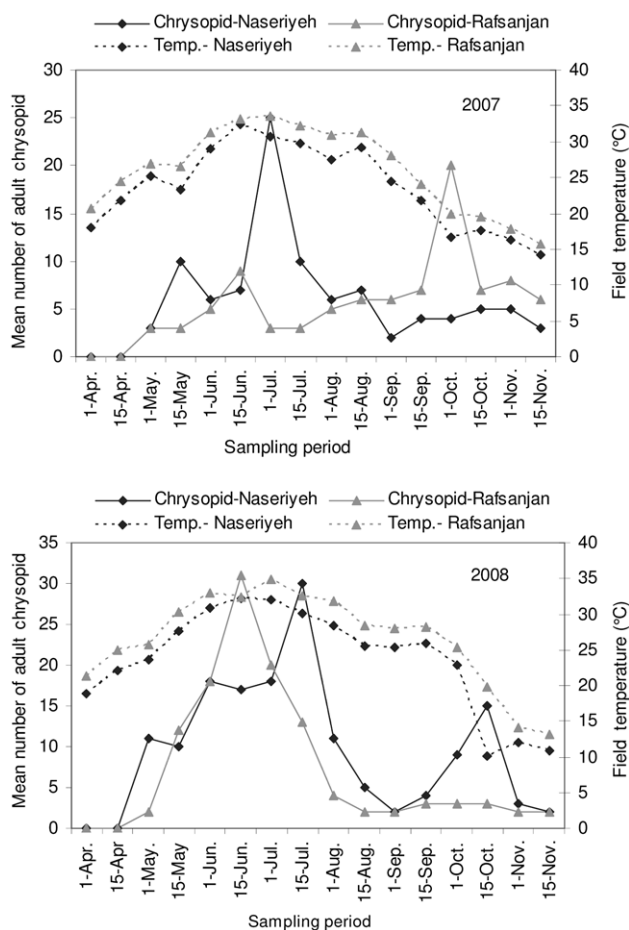


Fig. 1. Trends in the numbers of adults of the common green lacewings and field temperatures recorded throughout the pistachio growing season in 2007 and 2008 at two experimental sites.

number of the eggs was counted and the females carefully transferred to new cages. The females were kept with a male throughout this experiment. The pre-oviposition period is the number of days from eclosion to the start of oviposition. The number of eggs laid by 18 females was recorded.

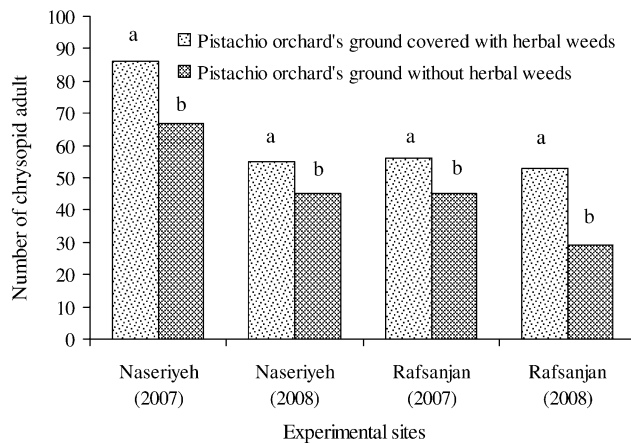


Fig. 2. Total number of adults of the common green lacewing collected from April to November in 2007 and 2008 on pistachio trees in orchards with and without a ground cover of herbaceous weeds.

#### Life table parameters

Results of the development and reproduction experiments (developmental period, mortality, sex ratio and daily reproduction) at  $22.5 \pm 0.5^\circ\text{C}$  were compiled into a life table for *C. lucasina*. Life table parameters were: the age ( $x$ ) of the cohort in terms of the number of days from when the eggs were laid;  $l_x$  (age-specific survival) the probability of a female surviving to age  $x$ ;  $m_x$  (age-specific fecundity) the number of female progeny produced per unit time by a female of age  $x$ . The following demographic parameters, e.g. intrinsic rate of increase ( $r_m$ ), generation time ( $T$ ), doubling time ( $DT$ ), net reproductive rate ( $R_0$ ), gross reproductive rate ( $GRR$ ) and cohort generation time ( $T_c$ ) were calculated for the whole life span of *C. lucasina*. The parameters were calculated using the QBASIC program (Jervis & Copland, 1996).

#### Prey consumption

Newly-hatched larvae of *C. lucasina* were selected and placed singly in pistachio leaf-disc cages containing a constant number of 4th instars psyllid nymphs, 50 fourth instar psyllid nymphs for 1<sup>st</sup> and 2<sup>nd</sup> instar lacewing larvae and 100 fourth instar psyllid nymphs for 3<sup>rd</sup> and 4<sup>th</sup> instars lacewing larvae. This experiment was conducted at seven constant temperatures, 15, 22.5, 25, 27.5, 30, 32.5 and 35 (all  $\pm 0.5^\circ\text{C}$ ), a photoperiod of

TABLE 1. Mean duration (days) and percentage mortality of the eggs, larvae and pupae of *C. lucasina* reared at different constant temperatures,  $55 \pm 5\%$  r.h. and 16L : 8D photoperiod, and fed on the nymphs of *A. pistaciae*.

Temperature $\pm 0.5^\circ\text{C}$	Egg		Larva		Pupa		Total (egg to adult)	
	Incubation period $\pm$ s.e.	Mortality (%)	Developmental period $\pm$ s.e.	Mortality (%)	Developmental period $\pm$ s.e.	Mortality (%)	Development $\pm$ s.e.	Mortality (%)
15	15.20 $\pm$ 1.62a (119)	27.10	41.72 $\pm$ 1.62a (78)	42.06	30.75 $\pm$ 1.62a (33)	28.04	87.67	97.20
17.5	8.89 $\pm$ 0.13b (106)	26.92	20.43 $\pm$ 0.59b (95)	30.77	22.39 $\pm$ 0.59b (56)	13.08	51.71	70.77
20	6.74 $\pm$ 0.08c (94)	21.70	16.44 $\pm$ 0.32c (83)	21.70	15.06 $\pm$ 0.32c (60)	7.55	38.24	50.95
22.5	5.72 $\pm$ 0.10d (116)	11.65	14.04 $\pm$ 0.12d (91)	19.42	12.38 $\pm$ 0.12d (57)	7.77	32.14	38.84
25	4.11 $\pm$ 0.14e (133)	11.40	11.38 $\pm$ 0.13e (95)	11.90	8.62 $\pm$ 0.13e (75)	4.76	24.11	28.06
27.5	3.50 $\pm$ 0.07f (58)	13.64	9.80 $\pm$ 0.12f (48)	18.18	7.80 $\pm$ 0.12f (33)	9.09	21.10	40.91
30	3.32 $\pm$ 0.01f (58)	17.24	8.98 $\pm$ 0.13f (48)	18.96	7.07 $\pm$ 0.13fg (33)	12.07	19.41	48.27
32.5	3.38 $\pm$ 0.00f (68)	30.68	7.62 $\pm$ 0.10g (61)	20.45	6.72 $\pm$ 0.10g (50)	11.36	17.72	62.49
35	3.73 $\pm$ 0.09ef (66)	34.54	7.48 $\pm$ 0.15g (43)	40.00	7.05 $\pm$ 0.15fg (14)	14.54	18.26	89.08
P value	0.001		0.001		0.001			

Means within columns followed by different letters are significantly different. Data analyzed using one-way ANOVA (Fisher's test at 0.05). Values in brackets indicate the number of individuals used in the experiments.

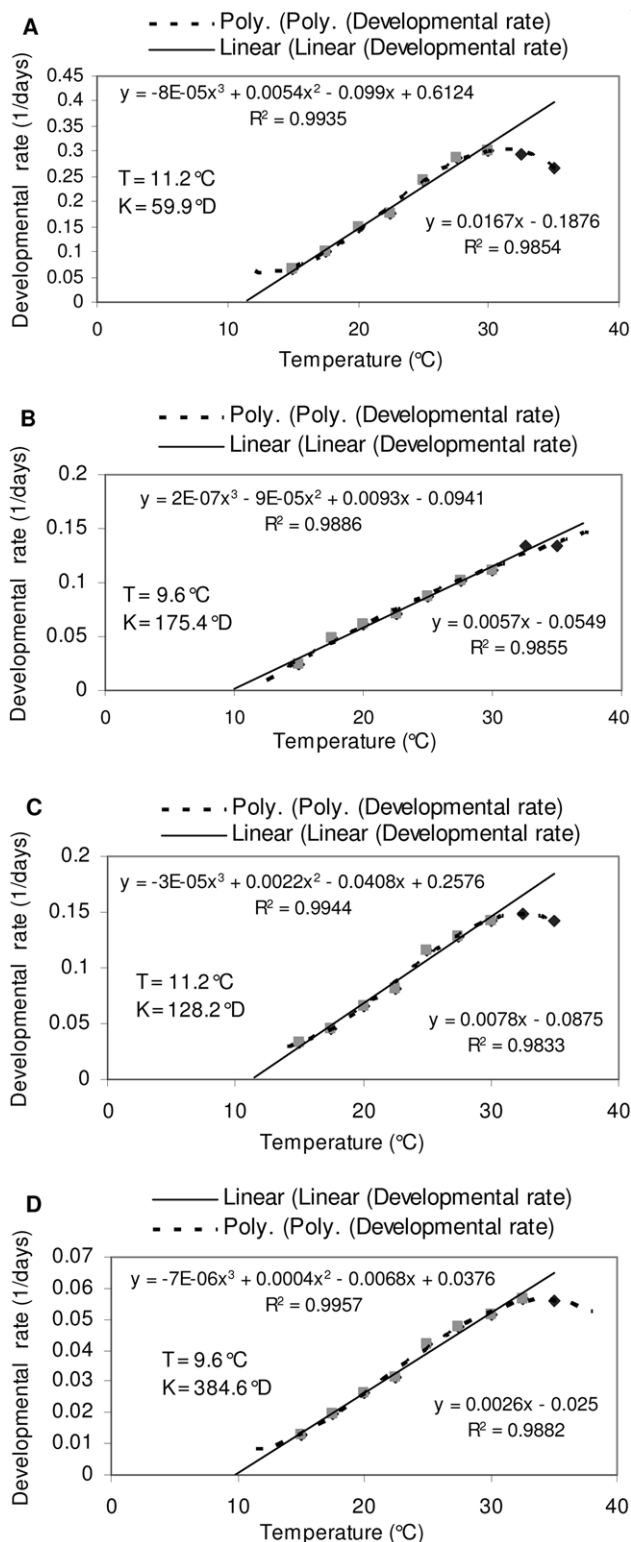


Fig. 3. Relationship between the rate of development of the immature stages of *C. lucasina* fed a diet of nymphs of *A. pistaciae* and temperature (A – egg, B – larva, C – pupa, D – total developmental rate, egg to adult).

16L : 8D and a  $50 \pm 5\%$  RH. Each day the number of psyllids eaten was determined and the larvae moved to a new pistachio leaf-disc cage until they pupated.

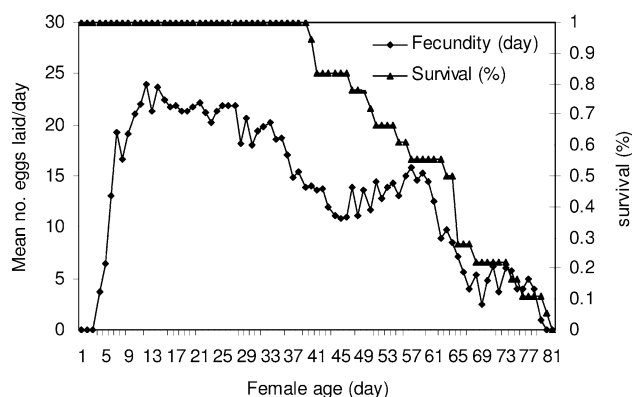


Fig. 4. Reproductive period and survival of female *C. lucasina* reared under controlled condition ( $22.5^\circ\text{C}$ ,  $55 \pm 5\%$  r.h. and 16L : 8D).

#### Data analysis

Data were analyzed using MINITAB program. Analysis of variance (ANOVA) was used to test the differences in all experiments. The LSD-tests at 0.05% procedure were used for pair wise comparison among means.

#### Lacewing identification and voucher specimens

The common green lacewing, *C. lucasina* was identified by Dr. A. Mirmoayedi, the University of Razi, Kermanshah, Iran. There are voucher specimens of this green lacewing in the insect collection, Department of plant protection, the University of Razi, Kermanshah.

#### RESULTS

##### Occurrence and abundance of common green lacewings

Common green lacewings were first recorded in pistachio orchards in early April and then continuously on pistachio trees until about mid November in both years of this study (Fig. 1). The abundance of adults on pistachio trees in orchards with a ground cover of herbaceous weeds was significantly greater than in orchards without weeds (Fig. 2).

The population of adults increased from April to July and then declined sharply from August to September at both experimental sites. The population of common green lacewings increased again in October but then decreased due to pistachio leaf fall and a lack of food in the form of psyllid nymphs. The first peak did not occur at the same time at both experimental sites but the second peak occurred in October at both sites (Fig. 1).

##### Development

The developmental period and immature mortality of *C. lucasina* were influenced by temperature. The mean developmental time decreased significantly with an increase in temperature from 15 to  $32.5^\circ\text{C}$  and then increased. The longest and shortest developmental period from egg to adult emergence were recorded at 15 and  $32.5^\circ\text{C}$ , respectively. The lowest mortality of the immature stages (eggs + larvae + pupae) was recorded at  $25^\circ\text{C}$  (Table 1).

A third order polynomial curve provided the best fit to the data on the developmental rate of this lacewing at dif-

TABLE 2. Number of prey consumed by larvae of *C. lucasina* fed fourth instar psyllid nymphs at different constant temperatures, 55 ± 5% r.h. and 16L : 8D photoperiod. Means in the second row followed by different letters are significantly different. Data analyzed using one-way ANOVA (Fisher's test at 0.05), n = 15 lacewing larvae per treatment.

Temperature (± 0.5°C)	15	22.5	25	27.5	30	32.5	35	P value
Number of psyllid nymphs consumed	1536.8b	1206.5c	1193.9c	860.3d	880.5d	1807.5a	1812a	0.001

Means within a row followed by different letters are significantly different.

ferent temperatures (Fig. 3). Based on these results, the lower temperature threshold for the development of the egg, larval and pupal stages was 11.23, 9.63 and 11.22°C, respectively. The lower temperature threshold for overall development was estimated to be 9.62°C and the thermal constant 385 Degree-days (Fig. 3).

### Reproduction

The pre-oviposition and oviposition periods of *C. lucasina* at 22.5°C were on average 4.1 and 54.2 days, respectively. The highest numbers of eggs were laid between the 12<sup>th</sup> and 33<sup>rd</sup> day of adult life. Then the reproduction decreased gradually with some fluctuations until death (Fig. 4). Average longevity of adult male and female lacewings were 60 and 55.70 days, respectively. The females began dying on the 40<sup>th</sup> day after emergence (Fig. 4).

### Prey consumption

The larvae of *C. lucasina* consumed 1536 fourth instar psyllid nymphs during the course of their larval development at 15°C. Prey consumption decreased significantly with increase in temperature up to 27.5°C and then increased up to 1812 fourth instar psyllid nymphs at 35°C (Table 2).

### Life table parameters

The life table parameters for *C. lucasina* were determined under controlled condition. The net reproductive rate ( $R_0$ ) was 543.8 female progeny per adult female per generation. The intrinsic rate of natural increase ( $r_m$ ) was 0.11. The generation and doubling time of this lacewing was 52.1 and 6.4 days, respectively (Table 3).

### DISCUSSION

Several predatory insects and mites attack *A. pistaciae*, including the common green lacewing (Mehrnejad, 2010). All immature stages of *A. pistaciae* are suitable prey for the larvae of *C. lucasina* (Hasani-Sadi et al., 2010). However, the nutritional ecology, prey preference

and food requirements for development, reproduction and population dynamics of common green lacewings in pistachio orchards have not been studied. In addition, the species of chrysopid associated with cultivated or wild pistachio trees have not been identified. Based on the results of the present study, adults of the common green lacewing are present throughout the growing season in pistachio orchards, i.e., from mid April to November, and there are two peaks in adult abundance during the pistachio growing season. The first peak occurred around mid July (late spring through to early summer) and the second peak in early autumn (October). Geon-Hwi et al. (2000) similarly record two peaks of *Chrysopa pallens* (Rambur) on red pepper at Iksan, Chonbuk, Korea, in mid to late July and September. There was a negative correlation between the abundance of adult common green lacewings and the temperature recorded in the field. With increase in temperature in summer the number of adult lacewings decreased and then increased again when temperatures decreased in autumn. It is also recorded that with an increase in temperature from 22.5°C to 32.5°C the fecundity of *C. lucasina* decreases sharply to 5 eggs and adult life to 14 days (Hasani-Sadi et al., 2010). Souza & Carvalho (2002) also record that decreases in temperatures are associated with an increase in the number of *Chrysoperla externa* (Hagen) in the field.

The field survey revealed that there are more common green lacewings on pistachio trees in orchards with a ground cover of herbaceous weeds than in orchards without weeds. Many field studies indicate that ground cover in orchards can provide food, a refuge and a habitat for several important natural enemies. In this regard, Thies & Tscharnkte (1999) state that more heterogeneous vegetation bordering or surrounding cultivated areas can serve as sites for oviposition and overwintering and provide a wide choice of food for beneficial organisms. In pistachio orchards, it appears that herbaceous weeds provide shelter for adult common green lacewings and alternative prey, like aphids, for their larvae. Mehrnejad & Jalali (2004) report that the two aphid species *Aphis gossypii* Glover and *Aphis craccivora* Koch are abundant on herbaceous weeds in pistachio orchards at Rafsanjan, Iran. In addition, weeds and wild plants in agroecosystems provide a significant source of food in and around fields, in the form of pollen and nectar, for natural enemies (Cowgill et al., 1993; Colley & Luna, 2000). Based on the present results, herbaceous weeds play an important role in determining the abundance of common green lacewings in pistachio orchards, however the decision to remove or maintaining of weeds in pistachio orchards must be based on what is appropriate for the

TABLE 3. Life table parameters of *C. lucasina* reared at 22.5°C, 50–60% r.h. and 16L : 8D photoperiod, n = 18.

Values	Life table parameters
543.76	Gross reproductive rate (GRR)
286.90	Net reproductive rate ( $R_0$ )
0.09	Capacity for increase ( $r_c$ )
0.11	Intrinsic rate of increase ( $r_m$ )
6.09	Cohort generation time ( $T_c$ )
52.13	Generation time (T)
1.11	Finite capacity of increase ( $\lambda$ )
6.38	Doubling time (DT)

IPM plan for pistachio plantations. The influence of psyllid population density on lacewing abundance is unclear and needs to be investigated further, as in this study adults were collected in unsprayed orchards and psyllid eggs and nymphs were present on pistachio trees throughout the growing season.

The developmental period of *C. lucasina* was temperature dependent as previously recorded by Azema & Mirabzadeh (2004) and Kuznetsova (1969) for *C. carnea*. The developmental period of *C. lucasina* is longer than that of its prey, *A. pistaciae*, at temperatures ranging from 15 to 35°C (Mehrnejad & Copland, 2006). The lower temperature threshold for the whole development of this lacewing was estimated to be 9.6°C, which is lower than that reported for its psyllid prey, *A. pistaciae* (10.7°C) (Mehrnejad & Copland, 2006). This parameter is a positive feature for this predator as it means it can start developing before its prey in early spring. However, the thermal constant for this lacewing (385°D) was found to be much higher than that for its psyllid prey (238°D) (Mehrnejad & Copland, 2006). Thus at a particular temperature, *A. pistaciae* develops faster than its predator *C. lucasina*, which means this predator is unlikely to be an effective biological control agent of *A. pistaciae*.

It is reported that the fecundity of *C. carnea* is both affected by the quality and amount of food available (Azema & Mirabzadeh, 2004). *C. lucasina* laid an average of 1085 eggs over 60 days when its larvae fed on psyllid nymphs. In comparison, *C. carnea* lays 465 eggs when reared at 25°C (Jafari-Nodoshan, 1998) and *C. lucasina* an average of 5 eggs over 14 days when kept at 30°C (Hasani-Sadi et al., 2010). The intrinsic rate of natural increase ( $r_m$ ) recorded for *C. lucasina* in this study was 0.11 at 22.5°C, which is less than the 0.14 and 0.21 at 20 and 25°C, respectively, previously recorded for its psyllid prey (Mehrnejad & Copland, 2006). Thus, it is unlikely that *C. lucasina* is an effective biocontrol agent of the common pistachio psyllid. Van Lenteren & Woets (1988) suggest that natural enemies might be effective biological control agents, if among other criteria their intrinsic rates of increase are equal to or larger than that of the pest. However, Huffaker et al. (1977) suggest that one should not conclude that a natural enemy with a lower  $r_m$  than that of its host will be a poor biological control agent. Therefore, *C. lucasina* would appear to be an unsuitable biocontrol agent for augmentation release with the view of reducing the abundance of *A. pistaciae*. However, the results and observations indicate that common green lacewings are psyllidophagous predators and can be found in psyllid colonies in both cultivated pistachio plantations and on wild pistachio trees. The common green lacewings naturally play a role in reducing psyllid abundance. So, an appropriate conservation technique for pistachio orchards is to conserve the beneficial insects and increase their efficiency.

In conclusion, the results indicate that *C. lucasina* can successfully complete its development and subsequently lay eggs when fed on *A. pistaciae* nymphs. The larvae of this lacewing consumed a large number of psyllid nymphs

during their larval development, which is a positive feature of this predator, however fewer survived and it took longer for them to complete their development than certain other predators of the common pistachio psyllid, such as the ladybirds, *Oenopia conglobata contaminata* (Menetries) (Coleoptera: Coccinellidae) (Mehrnejad & Jalai, 2004) and *Adalia bipunctata* (Linnaeus) (Coleoptera: Coccinellidae) (Arab-Hormozabadi, 2005; Atiqi, 2010; Jalali, 2001). The quantity of prey consumed by the lacewing larvae was determined in the laboratory and might differ from that eaten in the field. It possibly encounters more than one prey species on pistachio trees, such as psyllid eggs, larvae of moths and beetles and non-prey food like psyllid honeydew. Mehrnejad (unpubl.) records that the larvae of common green lacewings attack the early instars of the pistachio fruit hull borer moth, *Arimania komaroffi* Ragonot feeding on clusters of developing pistachio nuts. In addition, several reports indicate that *C. carnea* eats a wide range of prey, including the eggs and early instars of numerous moth and beetle species, aphids and other soft-bodied insects (Obrycki et al., 1989; Tauber et al., 2000). Therefore, further studies are needed to determine the suitability of the different potential foods, combinations of different foods and their availability on this predator's food preference and performance.

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