INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 14, No. 6, p. 251-260, 2019
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Effects of preys on survival, development, sex ratio and number consumption victims of *Apertochrysa* sp. at laboratory conditions

Mohammed A. Ali Alasady*, Dzolkhifli Bin Omar, Yusof Bin Ibrahim, Rohani Binti Ibrahim

Department of Plant Protection, Faculty of Agriculture, University Putra Malaysia, UPM, Serdang, Selangor, Malaysia

Article published on June 30, 2019

Key words: *Apertochrysa* sp., Predation, Consumption capacity, Survival, Malaysia.

Abstract

The effect of prey on development, survival, sex ratio and consumption capacity of newly recorded predator *Apertochrysa* sp. on aphid *Rhopalosiphum maidis* and eggs of *Corcyra cephalonica*, were studied at laboratory to optimize the suitable prey for rearing and to determine the potential of it on different insect pests. The *Apertochrysa* sp. was successfully cultured and complete it's life cycle on *C. cephalonica* eggs, *R. maidis*, *Aleurodicus disperses* Russell and *Aleurocanthus woglumi* Ashby. The total developmental times were 29.5, 25.4, 22.8 and 30 days respectively. The total consumed number of aphids *R. maidis* was 110 nymphs per larva. The highest number of nymphs was consumed by the third instar larva (42.95 aphids/ larva), followed by second instar (36 aphids/ larva), then the first instar (31.14 aphids/ larva), further more the nymphs consumed during the first four days by the adults was 22.4 nymphs per adult. The total *C. cephalonica* eggs consumed was 795 eggs per larva, that 494.5 eggs were consumed by third instar of larva, 232.1 eggs by second instar of larva and 68.4 eggs by first instar of larva.

***Corresponding Author:** Mohammed A. Ali Alasady ✉ alasady61@yahoo.com

Introduction

The green lacewings (Neuroptera: Chrysopidae) are an important group of insect predators (Dean and Satasook, 1983). It has agronomical importance (Ohm & Holzel, 2002). The new record green lacewing *Apertochrysa* sp. from agro-ecosystem in Malaysia can play a very important role in Malaysian agriculture (Alasady *et al*., 2010). The larvae of green lacewing can be reared on natural food like aphids (Petersen and Hunter, 2002), immature stages of spiraling whitefly, *Aleurodicus dispersus* Russell (Mani & Krishnamoorthy, 1999; Ramani, 2000), semi artificial diet based on the algae *Chlorella vulgris* (Zaki & Gesraha 2001), factitious diets like the frozen eggs of *Angasta kuehniella* (Nakahira *et al*., 2005; Silva *et al*., 2007), *Sitotroga cerellela* (Ulhaq *et al*., 2006), *Corcyra cephalonica* (Krishnamoorthy & Nagarkatti, 1981; Patel *et al*., 1988; Singh *et al*., 1994a), or artificial diet (Cohen & Smith, 1998; Lee & Lee, 2005; Uddin *et al*., 2005). While most adults of green lacewings can be fed on artificial diets (Ulhaq *et al*., 2006; Nakahira *et al*., 2005; Zheng *et al*., 1993; Johnson & Hagen, 1981).

The type of diet and prey have affect on the larval developmental time, adults longevity, fertility and fecundity (Ulhaq *et al*., 2006; McEwen & Kidd, 1995), the survival, life table parameters (Pappas *et al*., 2007; Elsiddig *et al*., 2006; Chen & Liu, 2001) and also can affect the green lacewings functional responses (Balasubraman & Swamiappan, 1994). However the life table parameters of different species of green lacewings are varied when they are reared on the same prey (Bakthavatsalam *et al*., 1994).

The pre-oviposition period also can be affected by the type of prey. Petersen & Hunter, (2002) reported that the pre-oviposition period of *Chrysoperla nigricornis* females is significantly longer when the larvae fed on a mixture of the two aphid species *Monellia caryella* (Fitch) and *Melanocallis caryaefoliae* (Davis) compared with each aphid species alone. The amount of food have effects on the vigor of green lacewings. The fertility and fecundity of *Ch. carnea* decreases when its larvae given a low food-supply of eggs of *Ephestia kuehniella*. These findings are relevant to mass rearing programs for this biological control agent (Zheng *et al*., 1993).

However the food requirements of green lacewings species are not similar. These requirements depend on the specific species and its stage, for instance the larvae of *Ch. carnea* use honeydew as a food source in the presence of suitable prey (Hogervorst *et al*., 2007), while the adults may feed on honeydew, nectar, pollen, or they may be predaceous. The females of some 15 species of green lacewings must consume aphids before producing eggs (Principi & Canard, 1984). The feeding habits of most chrysopids are still unknown. The maize aphid *Rhopalosiphum maidis* (Fitch) an important pest feeds on a variety of graminaceous plants, both cultivated and wild. The more important hosts are maize, sorghum and sugar cane. The spiraling whitefly *A. disperses* (Russell) is a polyphagous, and feed on less than 20 common economic and ornamental plants. Fruit trees such as guava and mango are common food plants. While seven food plants have been recorded, including mango, citrus and coffee are attacked by citrus black fly *Aleurocanthus woglumi* (Ashby) in Malaysia (Chong *et al*., 1991).

The parameters of life table and estimating functional responses are the main methods for evaluating the predators-insect pest's relationships. The methods used to measure the functional responses are very useful to quantify the biological control efficiency of natural enemies (Gao *et al*., 2007). Many studies explained how to estimate the functional responses of predators on prey (El-Serafi *et al*., 2000; Chen & Liu, 2001; Gao *et al*., 2007; Silva, 2007). Generally different techniques were used to evaluate the efficacy of natural enemies and can be classify as direct or indirect methods. Direct techniques like Laboratory estimation of predation power, direct observation, sentinel prey, trace of prey remains, labeling prey, detection of prey remains in the gut of a predator, addition of life table analysis (Dent & Walton, 1997; El-Serafi *et al*., 2000; Chen & Liu, 2001). While the indirect techniques can be by observing the pest

populations in presence and absence of natural enemies, for instance physical barriers, chemical barriers and hand removal (Dent & Walton, 1997; Prasad, 1989).The short interaction between predator and its prey, and the small number of remaining prey that can be detected make the predation estimation more difficult than parasitism (Dent & Walton, 1997).There are many factors that can have effect on the functional responses, for instance the species of predator (Singh *et al*., 1994b; Bakthavatsalam *et al*., 1994), the species of the prey (El-Serafi *et al*., 2000; Chen & Liu, 2001), availability of food (Zheng *et al*., 1993; Silva, 2007), or the environmental factors like temperature (Song & Heong, 1997), in this case we always need realistically estimated parameters (Badii *et al*., 2004; Menezes *et al*., 2005).

Gao *et al*., (2007) estimated the feeding potential of *Ch. sinica* as a biological control agent depending on its ingestion and the energy content of its prey *Aphis gossypii*.The maximum feeding potential of predator can be evaluated under laboratory conditions (Dent & Walton, 1997), and can give good idea of feeding potential of predator but the feeding under laboratory is not same as feeding under actual field conditions (Lopez *et al*., 1976; Perdikis & Lykouressis, 2002). However, there is little information available regarding the effects of prey on development and survival of green lacewing and no available data about the role of *Apertochrysa* sp. in controlling different insect pests.Therefore the aim of this work is to study the effects of various preys' species on preimaginal development, survival and sex ratio of the green lacewing *Apertochrysa* sp. to optimize the suitable prey for rearing and to determine the potential of it on different insect pests. And also to determine the number of victims of new recorded predator in Malaysia *Apertochrysa* sp. on aphid *R. maidis* and eggs of *C. cephalonica* under laboratory conditions.

Materials and methods

*Rearing of Apertochrys*a sp.

The laboratory culture of *Apertochrysa* sp. was established from eggs collected from citrus plant in orchards, UPM fields, Serdang /Malaysia, then reared at (25±1ºC, 55-85% RH, and 12: 12D photoperiod) conditions. The new larvae were fed on frozen *C. cephalonica* eggs individually to prevent cannibalism are placed in plastic Petri dishes (10cm dia. x 1cm height) until pupate. The adults that emerged from the pupae in the Petri dish were sent to oviposition plastic cage (37x28cm dia and 22cm height) covered with black organza cloth, and provided daily an artificial diet (3gm sugar, 2.5gm yeast, 2.5ml honey, 3gm powder milk (instead of casein) by smearing the wall of the cage by special brush daily. First generation of a laboratory culture was used in these experiments.

The preys R. maidis and C. cephalonica

Aphids *R. maidis* and frozen *C. cephalonica* eggs were used as preys for *Apertochrysa* sp.. Aphids were collected from sweet corn planted in research farm of University Putra Malaysia (UPM) on a piece of host plant leaf and transferred directly to Petri dishes (10cm x1cm dia.) provided with wetable filter papers.

While the frozen eggs of *C. cephalonica* were collected from laboratory culture which reared on semi diet composed from sterilized maize, rice, wheat and semolina in ratio 1:1:1:1 maintained at 22ºC, 55-85% RH, and 12L: 12D photoperiod.The number of aphids and eggs in each Petri dish and the aphids placed in oviposition cage were counted and recorded before being introduced to the predator as preys.

Effect of prey on preimagenal developments, survival and sex ratio of Apertochrysa sp.

Newly emerged first instar larvae >24h (first generation) of *Apertochrysa* sp. numbering 88, 11, 10 and 7 were transferred individually with the help of a fine hair brush into plastic Petri dishes (10cm dia. x1cm height) with a lid to prevent larvae cannibalism. The larvae were provided daily with enough numbers of frozen *C. cephalonica* eggs, fresh nymph of *R. maidis*, *A. disperses* Russell and *A. woglumi* Ashby respectively, and maintained at 25ºC with 55-85% RH, and 12L: 12D photoperiod regime.

The larval ecdysis, larval development period, pupal period, adult's emergences and adult sex ratio were checked and recorded daily. Only the individuals that

successfully completed their development and changed to the next stages were considered to calculate the developmental time.

Predation

The numbers of victims consumed by green lacewing *Apertochrysa* sp. on aphid *R.maidis* and frozen eggs of *C. cephalonica* were done under laboratory conditions (28-31C°, 55-85% (RH) and 12L: 12D photoperiod regime) as follows:

The predation on the aphid R. Maidis.

Completely Randomized Design (CRD with unequal replicates (each individual of tested stage or instar as one replicate) was used to test the predation of *Apertochrysa* sp.. The *Apertochrysa* sp. larvae (9 individuals of 1st instar, 5 individuals of 2nd instar, 5 individuals of 3rd instar with24h ages) were added to the Petri dishes individually and 5 adults with24h ages were placed individually in oviposition cages, containing the counted and enough numbers of aphids *R. maidis*.Fresh numbers of aphids were provided daily to the *Apertochrysa* sp. predatory stages after removing all the previous preys. Control without predator was conducted to record the natural death of aphids. Daily molting checked of predator and preys consumed were counted.

Only the individuals that successfully completed their development and changed to the next instar were considered in calculating the larval consumption. While the adults preys consumption were calculated only for first four days to prove the ability of adults as predacious stage.

The numbers of consumed preys (N_C) were calculated using the following equation:

$$N_C = N_H - \left(N_H \frac{n_d}{n} 100\right)$$

Where,

N_C = Number of preys consumed

N_H = All number of dead individuals in Petri dish contains the predator.

n_d =Number of dead preys in Petri dish without predator after 24 h.

n = Number of live preys placed in Petri dish without predator.

The predation on the eggs of C. cephalonica

Completely Randomized Design (CRD) was used to test the predation of *Apertochrysa* sp. on frozen eggs of *C. cephalonica*. Ten individuals of 1st, 2nd and 3rd instar of green lacewing were fed separately with 300, 500 and 800 frozen eggs of *C. cephalonica* respectively. Each individual was considered as one replicate. Preys consumed were recorded daily and daily larvae of *Apertochrysa* sp. were checked for molting. The larval preys consumption was regarded only the successful individuals that completed their developments and changed to the next instar. The numbers of consumed preys (N_C) were obtained directly recording the empty frozen eggs.

Data analysis

The data was analyzes by Analysis of variance (ANOVA) followed by Duncan test to compare the effect of preys species on developmental time of *Apertochrysa* sp. deviation from 1:1 sex ratio and survivals were assessed with Chi-Square test.The rate of consumption data of green lacewing *Apertochrysa* sp. on aphid *R. maidis* and the frozen eggs of *C. cephalonica* with instar and within the ages of instars were analyzed by one-way analysis of variance (ANOVA) using Excel Microsoft office followed by LSD multiple range test ($P<0.05$**)** for comparing between the means.

Results and discussions

Effect of preys on perimaginal developmental time, survival and sex ratio of Apertochrysa sp.

Influence the type of preys on development of *Apertochrysa* sp. is summarized in (Table 1). The results showed that type of preys has significant effect on the mean total larval developmental period. The fastest development of larvae was recorded on *A. disperses* nymphs (9.7 days) while the larval developmental period was prolonged to (16.2 days) with *A. woglumi* nymphs. No significant differences

were noticed between the larval developmental times when using *R. maidis* and *C. cephalonica* (12.2, 11.3 days) respectively. The shortest total preimaginal developmental time (from first instar to adult's emergence) was recorded on the nymphs of *A. disperses* (22.8 days), followed by developmental time on *R. maidis* nymphs (25.4 days) and *C. cephalonica* frozen eggs (25.5 days). While the longest development period was noticed when the larvae of *Apertochrysa* sp. fed on the nymphs of *A. woglumi* (30 days) which recorded significant difference with other preys.

Table 1 Effect of preys on development and survival of *Apertochrysa* sp. with (55-85% RH and 12L: 12D photoperiod regime.

Stages	Developmental time ± SD days (number that completed th stage)			
	R. maidis	A. disperses	A. woglumi	C. cephalonica
1st instar	3.8±0.7 bc (11)	3.2 ± 0.4 c (10)	6 ± 2.1 a (7)	4 ± 0.7 b (88)
2nd instar	4.0 ± 0.8 b (11)	3.2 ± 0.4 c (10)	5.6 ± 1.1 a (7)	3.6 ± 0.5 b (84)
3rd instar	4.4 ± 0.9 a (9)	3.3 ± 0.5 b (10)	4.6 ± 1.1 a (6)	3.7 ± 0.7 b (71)
Total larval dev.	12.2 ±1.5 b (9)	9.7 ± 0.5 c (10)	16.2 ± 4.0 a (6)	11.3 ± 1.2 b (71)
Pupa	13.3±1.4 ab (9)	13.1±0.7 b (10)	13.8 ± 0.4 ab (6)	14.2 ± 1.5 a (71)
Total development	25.4 ±1.3 b (8)	22.8 ± 0.6 c (10)	30 ± 4.2 a (5)	25.5 ± 2.1 b (61)
Survival (%)	72.7 B	100 A	71.4 B	69.3 B
Sex ratio F:M	1♀: 1♂N	1♀: 1♂N	1.2♀:0.8♂ N	1.1: 0.9N

Within the same rows, data followed by the same small letter are not significantly different by ANOVA followed by Duncan test (P = 0.05, d.f = 3, 80, F = 13.53, 22.92, 5.99, 24.19, 2.62, 12.79, respectively), the data followed by different capital letters are significantly different by chi square (d.f =4, $\chi^2_{calc.}$= 45, P = 0.01) and the sex ratio are not differ significantly from 1:1 (d.f = 4, $\chi^2_{calc.}$= 0.609, P = 0.05).

The pupae developmental periods of *Apertochrysa* sp. were 13.3 days, 13.1 days, 13.8 days when fed on natural preys *R. maidis, A. disperses,* and *A. woglumi* respectively and not differ significantly. Whereas the pupal period was 14.2 days when reared on *C. cephalonica* eggs that differed significantly only with pupa developmental time of *Apertochrysa* sp. when fed on *A. disperses*. This indicates no large effect on pupae developmental time with various preys.

The highest survival of *Apertochrysa* sp. (100%) was recorded when fed on the nymphs of *A. disperses* and it differs significantly from the survivals when the larvae of *Apertochrysa* sp. fed on *R. maidis* (72.72%), *A. woglumi* (71.4%) and *C. cephalonica* eggs (69.3%) respectively (d.f =4 , $\chi^2_{calc.}$= 45 , P = 0.05). The sex ratio of emerging adults from four cultures were reared on four preys did not differ significantly from 1:1 (d.f = 4, $\chi^2_{calc.}$= 0.609, P = 0.05). The results showed that all preys had a strong effect on preimaginal developmental time. Similar variation has been recorded for *C. perla* when fed on various aphid species (Principi & Canard, 1984) or *Dichochrysa prasina* when fed on several preys (Pappas *et al.*, 2007) and *Ceraeochrysa cincta, Ch. cubana and Ch. smithi* when fed on *S. cerealella* eggs, *A. kuehniella* eggs and nymphs of *Myzus persica* (Lopez-Arroyo *et al.*, 2000).The results also showed significant variations on preimaginal developmental time of *Ch. carnea* when fed on *C. cephalonica* eggs, *Heliothis armigera* eggs, *H. armigera* neonates, *aphis gossypii, Amrasca bigutula* and *Bemisia tabaci*. Similar results were reported by El-Serafi *et al.*, (2000) when the *Ch. carnea* reared on four species of aphid. Contrast results were documented of *Ch. comanche* (Banks) and *Ch. nigricornis* Burmeister when fed on aphids *Monellia caryello* (Fitch) and *Melanocallis caryaefoliae* (Davis) and both aphids did not have effect on developmental time (Petersen & Hunter, 2002).

The results also showed some effect on survival and sex ratio of *Apertochrysa* sp. but not significant influence when maintained on the nymphs of *R. maidis, A. disperses, A. woglumi* and *C. cephalonica* eggs. While other studies showed that the survival of *Mallada boninensis* differed on various preys (Elsiddig *et al.* 2006; Shivankar & Singh, 1998; Nehare *et al.*, 2004) and three species of *Ceraeochrysa* sp. varied on survival when maintained on different preys (Lopez Arroyo *et al.*, 2000). The highest survival percentage and shortest developmental times were recorded when larvae of *Apertochrysa* sp. were fed on nymphs of *A. disperses.* However the eggs of *C. cephalonica* easier for rearing and more suitable.

The predation on the aphid R. maidis

The average numbers of aphids *R. maidis* consumed by larval instars and adults (in the first four days) of *Apertochrysa* sp. were showed in (Table 2). The results indicate that no significant differences between the three larvae instars. The first, second and third larvae instars consumed 31, 36 and 43 nymphs of aphids are recorded (28.3%, 32.7%, and 39%) of rate consumptions respectively. The larval aphid consumption increased gradually due to the food requirements for body development. The results also indicate that the prey consumptions differed significantly within the ages of each first and third instar, the first day consumption (15 and 19 individuals) and the second day consumption (11.27 and 21.8 individuals) within the first and third larval instars respectively recorded significant differences with other ages of instars, while these differences were not noticed in case of second instar. The high number of prey consumptions during the first ages of first and third instars as well as the lowest number of consumption during the final ages of these instars attributed to the long rest period (approximately12-24 h) of these instars before molting, while this period is (approximately 6-12 h) in second instar.

Table 2. Mean numbers consumed from aphid *R.maidis* during four days adults and larval instars of *Apertochrysa sp*. under laboratory condition (28-31°C, 55-85 % RH, 12L: 12D photoperiod regime).

Stage	[1]N	Number of consumed preys (N_C) ± SD							
		1st day	2nd day	3rd day	4th day	5th day	total	%within the larvae	[2]A /L/D (±)SD
1st Instar	9	15.0 ± 4.1 a	11.27 ± 2.2 b	3 ± 4.6 c	1.66±3.6 c	0.21±0.63 c	31.14±11.17 AB	28.3 (110)	6.2 ± 6.51 B
2nd Instar	5	12.5 ± 2.82	14.2 ± 5.29	9.3 ± 4.27	-	-	36 ± 6.67 A	32.7 (110)	12 ±2.5 A
3rd Instar	5	19.0±3.74 a	21.81±2.58 a	2.06±2.35 b	-	-	42.95 ± 8.0 A	39.0 (110)	14.3±10.7 A
Adult (4days)	5	10.9 ± 3.1 a	7.6 ± 1 a	2.3 ± 2.1 b	1.6 ± 1.9 b	-	22.4 ± 5.9 B	-	5.6 ± 4.4 B
							132.49±8.636		

Within the same rows, data followed by the same small letter are not significantly different by T test (P = 0.05) and the data within the same column followed by same capital letter are not significantly different by T test (P =0.05).

[1] Number of individuals used.

[2] A/L/D= Average per larva per day.

The results in (Table 2) also showed that the adults of *Apertochrysa* sp. can prey on the nymphs of aphid *R. maidis* as a predatory stage consumed 22.4 individuals during the first four days. The adults prey consumption decreased gradually with age of adults and all adults only fed on nymphs of aphid die after 4 days, indicated clearly the need for divers type of food as requirements for adults developments and physiological functions. Although no significant differences between the averages of prey consumptions of three instars of *Apertochrysa* sp. the third instar recorded the highest number of predation (14.3 individuals) per larvae per day. The larval stage seems good predacious stage which can consume 110 individuals per larvae during its developmental time. However, the total nymphs of aphid *R. maidis* consumed (110 individuals) by predator in this study, which is less than the rate consumption of *Ch. carnea* on aphid *R.maidis* (260 individuals) mentioned by Shah, (2012).

This is close to the results obtained by Chen & Liu, (2001) of *Ch. rufilabris* on *A. gossypii* (141.6 individuals) and *Myzus persicae* (168 individuals) while farthest from the consumption rate of *Ch. carnea* and *Chrysopa septempuncata* on *R. maidis* (716.9 and 1043.9 nymphs) or on *A. gossypii* (1013.6 and 1579.8 nymphs) respectively documented by El-Serafi *et al.*, (2000) and less than the numbers of preys consumed by *Ch. sinica* when fed on *A .gossypii* (203.5-1281 individuals depend on the stage of aphid offered) (Gao *et al.*, 2007).

The predation on the eggs of C. cephalonica

The results in (Table 3) indicate that the numbers of larval prey's consumptions of *Apertochrysa* sp. on frozen eggs of *C. cephalonica* differ significantly with and within the larvae instars. The highest number of eggs consumption (494.5 eggs) was obtained in third instar larva and recorded significant differences with the second instar larva (232.1 eggs) and first instar larva (68.4 eggs). The total eggs consumed by the larval stage are 795 eggs per larva during the larval developmental period, 62.2% of these eggs consumed by 3rd instar, 29.2% by 2nd instar and 8.6% by 1st instar. The average consumed eggs per larva per day was 98.9 eggs, 46.4 eggs and 9.77 eggs for 3rd, 2nd and 1st instars respectively. No significant differences in the larval eggs consumptions were noticed during the first 5 days of 1st instar (15.3, 13, 12.9, 13.7, 10.8 eggs respectively) while all the first 5 days differed significantly with 6th day (3.6 eggs) and 7th day (0.9 eggs). The fourth day of 2nd instar recorded the highest number of larval eggs consumption (73 eggs) and differed significantly with 3rd day (59.6 eggs), 2nd day (51.8 eggs), 1st day (41eggs) and 5th day (6.7 eggs) respectively.The large number of eggs consumption of 3rd intar was found in case of age of 3rd day (177.3 eggs) showed significant differences with 2nd day (125.3 eggs), 1st day (107.2 eggs), 4th day (79.9 eggs) and 5th day (4.8 eggs). The lowest eggs consumptions were noticed in the final days of all three instars attributed to the stopping of larvae instars from feeding before molting or pupation.

Table 3. Mean numbers consumed from frozen eggs of *C.cephalonica* during larval instars of *Apertochrysa sp.* under laboratory condition (28-31ºC, 55-85 % RH, 12L: 12D photoperiod regime).

Stage	N[1]	Number of consumed preys (N_C) ± SD									
		1st day	2nd day	3rd day	4th day	5th day	6th day	7th day	Total	%consu-medeggs	[2]A/l/d (±)SD
1st instar	10	13.5±3.9 a	13±2.5 a	12.9±2.5 a	13.7±5 a	10.8±7.1 a	3.6±3.5b	0.9±1.3 b	68.4±17.C	8.6	9.77±5.3C
2nd instar	10	41±8.77d	51.8±6.8 c	59.6±6.77 b	73±4.95 a	6.7±9.6 e	-	-	2321±14.7B	29.2	46.4±25B
3rd instar	10	107.2±14.7bc	125.3±20 b	177.3±38.6 a	79.9±54.3 c	4.8±9.6d	-	-	494.5±40.8A	62.2	98.9±63.5A
Total	40								795		

Within the same rows, data followed by the same small letter are not significantly different by LSD (P = 0.05, LSD = 3.67, F = 16.54, d.f = 6,63)[1st], (P = 0.05, LSD = 6.91, F = 108.22, d.f = 4,45)[2nd] (P = 0.05, LSD = 28.73, F = 39,53, d.f = 4,45)[3rd] and the data within the same column followed by same capital letter are not significantly different (P = 0.05, LSD = 24.7, F = 637.63, d.f = 2, 27).

[1] Number of individuals used.

[2] A/L/D= Average per larva per day.

The total *C. cephalonica* eggs consumed by the larval stage of *Apertochrysa* sp. were 795 eggs per larva higher than the maximum number of prey consumption of *Ch. carnea* on eggs of *C. cephalonica* (732.35) that was reported by Balasubramani & Swamiappan, (1994).

However the feeding potential of green lacewings in the field was higher than the performance of the green lacewings reared in laboratory and the rate consumption of green lacewings increase with increasing the preys (Zheng *et al.*, 1993). The larval developmental periods of *Apertochrysa* sp. on *C. cephalonica* eggs were longer than their larval developmental periods on nymphs of *R. maidis* at laboratory conditions. Similar results were obtained by Pappas *et al.*, (2007) when the green lacewing predator *Dichochrysa prasina* reared on various preys.

Conclusions

The developmental periods with and within the stages of *Apertochrysa* sp. were highly affected by the type of prey. Among the preys tested the survival of *Apertochrysa* sp. was the best when fed on nymphs of *A. disperses* with shortest development period. However, the eggs of *C. cephalonica* were the most suitable for feeding the larvae of *Apertochrysa* sp. and could be used for mass-rearing.

The *Apertochrysa* sp. could successfully complete its life cycle on the nymphs of *R. maidis, A. disperses, A. woglumi* and *C. cephalonica* eggs. This high effect of *Apertochrysa* sp. against these pests and other Homoptera and Lepidoptera pests can make it an effective pest control in the field, which illustrated that the larvae and adults of green lacewing *Apertochrysa* sp. has great potential as a polyphgous predator. High rate of prey consumption obtained with larvae of *Apertochrysa* sp., 110 aphids of *R. madis* /larva and 795 eggs of *C. cephalonica* /larva, additional of understood preys consumption of adults and this potential could increase in the field.

When compare the potential of our predator with others members of Chrysopidae we find promising predator may be ready to continue to mass-rearing and release as inundative biological control. The 1st, 2nd and 3rd larvae instars of *Apertochrysa* sp. have good performance against *R. maidis* which showed it can be released at any instar against Homoptera pests, while the highest potential against *C. ceohalonica* eggs was noticed in 3rd instar larvae may be better for suppression the Lepidoptera pests.

Funding

This work supported by the [University Putra Malaysia] under grant number [16920].

References

Badii MH, Hernández-Ortiz E, Flores AE, Landeros J. 2004. Prey stage preference and functional response of *Euseius hibisci* to *Tetranychus urticae* (Acari: Phytoseiidae, Tetranychidae). Experimental and Applied Acarologyl **34,** 263-273.

Bakthavatsalam N, Singh SP, Pushpalatha NA, Bhummannavar BS. 1994. Life tables of four species of chrysopids (Neuroptera: Chrysopidae). Journal of Entomological Research **18,** 357-360.

Balasubraman V, Swamiavvan M. 1994. Development and feeding potential of the green lacewing *Chrysoperla carnea* Steph. (Neur.: Chrysopidae) on different insect pests of cotton. Anzeiger für Schädlingskunde, Pflanzenschutz, Umweltschutz **67,** 165-167.

Chen TY, Liu TX. 2001. Relative consumption of three aphid species by the lacewing, *Chrysoperla rufilabris*, and effects on its development and survival. Biological Control **46**,481-491.

Chong KK, Ooi PAC, Tuck HC. 1991. Crop pests and their management in Malaysia. Kuala-Lumpur: Tropical Press Sdn. Bhd.

Cohen AC, Smith K. 1998. A New concept in artificial diets for *Chrysoperla rufilabris*: The efficacy of solid diets. Biological Control **13,** 49-54.

Dent TR, Walton MP. 1997. Methods in Ecological and Agricultural Entomology. U.K: Cambridge University Press. Cab international.

El-Serafi HAK, Abedel-Salam AH, Abedel-Baky NF. 2000. Effect of four aphid species on certain biological characteristics and life table parameters of *Chrysoperla carnea* Stephen and *Chrysopa septempunctata* Wesmael (Neuroptera :Chrysopidae) under laborator conditions. Pakistan Journal of biological Sciences **3(21),** 239-245.

Elsiddig SIY, Gutam RD, Chander S. 2006. Life table of the predator, *Mallada boninensis* (Okamoto) (Chrysopidae: Neuroptera) on the eggs of *Corcyra cephalonica* Staintion and larvae of *Tribolium castaneum* Herbst. Journal of Entomological Research **30(4),** 301-307.

Gao F, hui liu Z, Ge F. 2007. Energy budgets of the Chinese green lacewing (Neuroptera: Chrysopidae) and its potential for biological control of the cotton aphid (Homoptera: Aphididae). The Authors Insect Science **14,** 497-502.

Hogervorst PAM, Wackers FL, Carette AC, Romeis J. 2007. The importance of honeydew as food for larvae of *Chrysoperla carnea* in the presence of aphids. Journal of Applied Entomology **132,** 18-25.

Johnson JB, Hagen KS. 1981. A neuropterous larva uses an allomone to attack termites. Nature London **289,** 506-507.

Krishnamoorthy A, Nagarkatti S. 1981. A mass rearing technique for *Chrysopa scelestes* Banks (Neuroptera: Chrysopidae). Journal of Entomological Research **5,** 93-98.

Lee KS, Lee JH. 2005. Rearing of *Chrysopa pallens* (Rambur) (Neuroptera: Chrysopidae) on Artificial Diet. Entomological Research **35(3),** 183-188.

Lopez JD, Ridgway Rm, Pinell RE. 1976. Comparative efficiency of four insect predators of the bollworm and tobacco budworm. Environmental Entomology **5,** 1160-1164.

Lopez-Arroyo JI, Tauber CA, Tauber MJ. 2000. Storage of lacewing eggs: post-storage hatching and quality of subsequent larvae and adults. Biological Control **18,** 165-171.

McEwen RK, Kidd NAC. 1995.The effects of different components of an artificial food on adult green lacewing *(Chrysoperla carnea)* fecundity and longevity. Entomologia Experimentalis et Applicata **77,** 343-346.

Menezes LCCR, Rossi MN, Reigada C. 2005. Consequences of refuge for the functional response of *Dermestes ater* (Coleoptera: Dermestidae) to *Musca domestica* (Diptera: Muscidae). Population Ecology **47,** 213-219.

Nakahira K, Nakahara R, Arakawa R. 2005. Effect of temperature on development, survival, and adult body size of two green lacewings, *Mallada desjardinsi* and *Chrysoperla nipponensis* (Neuroptera: Chrysopidae). Applied Entomology and Zoology **40(4),** 615-620.

Nehrae SK, Deotale VY, Deotale R, Dawane PN. 2004. Biology and predator's potential of *Mallada boninensis* (Okamoto) against sucking pests. Journal of Soils and Crops **14(2),** 427-432.

Pappas ML, Broufas GD, Koveos DS. 2007. Effects of various prey species on development, survival and reproduction of the predatory lacewing *Dichochrysa prasina* (Neuroptera: Chrysopidae). Biological Control **43,** 163-170.

Patel AG, Yadav DN, Patel RC. 1988. Improvement in mass rearing technique of green lacewing *Chrysopa scelestes* Banks (Neuroptera: Chrysopidae). Gujarat Agricultural University. Research Journal **14,** 1- 4.

Perdikis DC, Lykouressis DP. 2002. Life table and biological characteristics of *Macrolophus* pygmaeus when feeding on Myzus persicae and Trialeurodes vaporariorum. Entomologia. Experimentalis et Applicata **102,** 261-272.

Petersen MK, Hunter MS. 2002. Ovipositional preference and larval–early adult performance of two generalist lacewing predators of aphids in pecans. Biological Control **25,** 101-109.

Prasad YK. 1989. The role of natural enemies in controlling *icerya purchas* in south Australia. Entomophaga **34(3),** 391-395.

Principi MM, Carnard M. 1984. Feeding habits. In: Canard M, Semeria Y, New TR Ed. Biology of Chrysopidae, The Hague, The Netherlands: Dr. W. Junk Publishers p. 76-92.

Ramani S. 2000. Fortuitous introduction of an aphelinid parasitoid of the spiraling whitefly, *Aleurodicus dispersus* (Russell) (Homoptera: Aleyrodidae) into Lakshadweep Islands with notes on host plants and other natural enemies. Biological Control **14,** 55-60.

Shah VH. 2012. Feeding potential and insecticidal safety evaluation of Chrysoperla sp. (carnea-group). Master thesis, Division of Entomology, Indian Agricultural Research Institute. New Delhi. India P. 19-26.

Shivankar VJ, Singh S. 1998. Management of insect pests in citrus. National Research Center for Citrus. Technical Bulletin No. **3,** 99.

Silva. 2007. Predators of aphids in cacao plantations in Brazil: Effectiveness in biological control and mechanisms of coexistence. PhD Thesis, University of Michigan. USA.

Silva PS, Albuquerque GS, Tauber, CA, Tauber MJ. 2007. Life history of a widespread Neotropical predator, *Chrysopodes (Chrysopodes) lineafrons* (Neuroptera: Chrysopidae). Biological Control **41,** 33-41.

Singh SP, Jalali SK, Bhumannavar BS, Bakthavatsalam N, Pushpalatha NA. 1994a. Production and use of chrysopid predators. Project Directorate of Biological Control, Indian Council of Agricultural Research, Technical Bulletin 10, Bangalore.

Singh SP, Bhumannavar BS, Jalali SK, Bakthavatsalam N, Pushpalatha NA. 1994b. Chrysopids and Trichogrammatids. Strain Selection and Utilization. Project Directorate of Biological Control, Indian Council of Agricultural Research, Technical bulletin 9, Bangalore.

Song YH, Heong KL. 1997. Changes in searching responses with temperature of *Cyrtorhinus lividipennis* Reuter (Hemiptera: Miridae) on the eggs of the brown planthopper, *Nilaparvata lugens* (Stal.) (Homoptera: Delphacidae). Population Ecology **39(2),** 201-206.

Uddin J, Holliday NJ, MacKay PA. 2005. Rearing Lacewings, *Chrysoperla carnea* and *Chrysopa oculata* (Neuroptera: Chrysopidae), on prepupae of alfalfa leaf cutting Bee, *Megachile rotundata* (Hymenoptera: Megachilidae). In: Proceedings of the Entomological Society of Manitoba, Volume **61.**

Ulhaq MM, Sattar A, Salihah Z, Farid A, Usman A, Khattak SUK. 2006. Effect of different artificial diets on the biology of adult green lacewing (*Chrysoperla carnea*) Stephens.Songkanakarin. Journal of Science and Technology **28(1),** 1-8.

Zaki FN, Gesraha MA. 2001. Production of the green lacewing *Chrysoperla caranea* (Steph.) (Neuroptera: Chrysopidae) reared on semi-artificial diet based on the algae, *Chlorella vulgaris*. Journal of Applied Entomology **125,** 97-98.

Zheng Y, Daane KM, Hagen KS, Mittler TE. 1993. Influence of larval food consumption on the fecundity of the lacewing *Chrysoperla carnea* Entomologia. Experimentalis et Applicata **67,** 9-14.