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

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2019; 7(6): 123-127

Received: 01-09-2019
Accepted: 05-10-2019

Mohammed AA
Department of Plant Protection, Faculty of Agriculture, University Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia

A Lasady
Department of Plant Protection, Faculty of Agriculture, University Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia

Dzolkhifli Omar
Department of Plant Protection, Faculty of Agriculture, University Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia

Yusof Ibrahim
Department of Plant Protection, Faculty of Agriculture, University Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia

Rohani Ibrahim
Department of Plant Protection, Faculty of Agriculture, University Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia

Corresponding Author:
A Lasady
Department of Plant Protection, Faculty of Agriculture, University Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia

Occurrence and oviposition preference of the green lacewing *Apertochrysa* sp. (Neuroptera: Chrysopidae) on citrus and corn plants

Mohammed AA, A Lasady, Dzolkhifli Omar, Yusof Ibrahim and Rohani Ibrahim

Abstract
Field experiments to determine ovipositional preferences of *Apertochrysa* sp. were carried out in Malaysian agro ecosystem with citrus and corn plants. Although that (76%) of eggs were noticed within 1-2 m, the results showed no significant differences in ovipositional preference between the heights of citrus trees. While in corn plants 100% of eggs were observed on height 1-2 m above the ground, with highly significant differences compared with others heights. The east direction was the preferred orientation for females of *Apertochrysa* sp. to lay their eggs in citrus trees recorded (79.8%) and 66.7% in test 1 and 2 respectively. While no differences between east and west direction for females to lay their eggs in corn plants. The lower leaf surface appeared the preference place for oviposition in citrus recorded (93.7%) and corn plants (100%). The highest percentage (59.2%) from all eggs collected were recorded on corn plants aged 60 days and significantly differed with others ages.

Keywords: Ovipositional preference, green lacewing, *Apertochrysa*, chrysopidae, Malaysia

Introduction

Green lacewings as polyphagous predators can mass reared in laboratory (Syed *et al*., 2008) [31] and have been used as a powerful biological control agent against various homopterous, lepidopterous and others soft bodied insect pests in field and green house (Duelli, 2001; Cohen & Smith, 1998; Silva, 2007) [15, 11, 30].

The occurrence of green lacewings were reported to be affected by many factors some related to the host or plant selected by insects and others related to environmental factors, for instance the structure of the plant (Canard *et al*., 1984) [7], height and orientation of the plant (Ahmad, 1987) [1] or sensory contact with the leaf surface of selected plant (Dent & Walton, 1997), plant architecture (Clark & Messina, 1998; Ahmad & Ali, 1989) [10, 2], odor of plant and prey (Zhu *et al*., 2005) [35], the temperature, humidity, photoperiod and wind (Borror *et al*., 1992; Sajap, *et al*., 1997; Dent & Walton, 1997; Pappas *et al*., 2008) [28, 14, 24]. Based on these factors increasing natural enemies in the field should be designed to complement naturally occurring populations of beneficial organisms (Ridgway, 1970; Huffaker, 1974) [19].

The location of host on the plant are important for females of green lacewing to laying their eggs in order to ensure nutrition of their individuals, for instance the green lacewing *Chrysoperla carnea* can detect the location of aphids by smelling the pheromone produced from aphids (Koczorl *et al*., 2015) [20], and this sex pheromone may work as kairomone for aphidophaga (Dawson *et al*., 1987) [12]. Preferred oviposition site was also studied to determined the time-effective searching of *Chrysoperla* spp. (Keulder 2010) [21].

The host plant and ovipositional preferences of the chrysopid predators are factors which decide the effectiveness of the predators on the different host plants (Ballal & Singh, 1999) [5].

Green lacewing *Apertochrysa* sp. in Malaysian agro-ecosystem can play important role in Malaysian agriculture (Alasady *et al*., 2010) [4]. Good rate of prey consumption by larvae and adult of *Apertochrysa* sp., highly effects against citrus pests *Aleurodicus disperses* and *Aleurocanthus woglumi*, and against pests of corn *Rhopalosiphum maidis* and *Corcyra cephalonica* eggs and may be other Homopeterian and lepidopterian pests made it as promising polyphagous predator in Malaysia (Alasady *et al*., 2019) [3]. However, there is insufficient information on green lacewings in Malaysia.

Therefore, the present investigation was undertaken to elucidate the ovipositional preference of females of *Apertochrysa* sp. with respect to the heights, orientation, leaf surfaces and age of the plant.

Materials and Methods
Study site
The oviposition within heights, orientation, leaf surface and the effect of plant's age on the oviposition of *Apertochrysa* sp. were carried out in Malaysian agro ecosystem on citrus trees and corn plants. The monthly rainfall average was (235±100.7) mm and daily mean temperature was 31 ºC±5.6.

The oviposition preference of *Apertochrysa* sp. within the height of plant
Randomized Complete Block design (RCBD) with four replicates was used in the experiment. The citrus trees (each tree represented one replicate) and the sweet corn plants (a composite of 10 plants represented one replicate) were divided in to three parts (0-1m, 1-2m and 2-3m) above the ground. The eggs were counted and recorded at each level. The data were analyzed using analysis of variance (ANOVA) followed by LSD test.

The oviposition preference of the *Apertochrysa* sp. on orientations of plant
The RCBD with four replicates was used in the experiment. The citrus trees (Each tree as one replicate) were divided to four parts, North, South, East and West. On sweet corn only the east and west quadrants were surveyed. (Each 10 plants as one replicate). All eggs on each direction were counted and recorded and then the data of citrus was analyzed by using Analysis of Variance (ANOVA), followed by LSD test, while the T-test was used for analysis the numbers of eggs collected from the quadrants of sweet corn.

The oviposition preference of *Apertochrysa* sp. on the leaf surfaces
The placement of eggs of green lacewing on the leaf surface was tested in citrus and corn leaf by collecting the groups of leaves (Each group comprised of 100 leaves). The eggs on upper and lower surfaces were counted, recorded and then analyzed by T-test.

The effect of plant's age on the oviposition of *Apertochrysa* sp.
The area of the corn field was 17m x 28m was planted by corn plant in 10th January. RCBD with four replicates was used in experiment (Each replicate consisted of 10 plants of sweet corn). The eggs of green lacewing were collected and counted at 10, 20, 30, 40, 50, 60, 70, 80 and 90 days after plants emergence in January, February, March and April**.** The eggs which lay during the night (nocturnal) were collected at 6:45 am to 7:45 am to avoid the predation of other predators on eggs of green lacewing especially ants which normally start its activity after this time. All eggs collected were taken to laboratory for rearing and then compare for identification. The data was analyzed using ANOVA procedure. Then the means was compared by Duncan test on $P < 0.05$ (SAS Institute, 2002) [29]. Data were subjected to square-root transformation to satisfy assumptions of normality (Little and Hills, 1972) [22].

Results and discussion
The ovipositional preference of *Apertochrysa* sp. within the heights of plant
Table -I showed that 76.10% of eggs were observed in 1-2 m height in test 1, and 57.89% on height 2-3 m in test 2 within citrus trees. This distribution of eggs on citrus tree was influenced because of, firstly the shade in all heights of citrus tree can protect the eggs from direct sun exposure, secondly the random distribution of mealy bugs as prey within the citrus tree during the experiment period.

In corn plants 100% of eggs were observed in height 1-2 m with highly significant differences compared with 0-1 and 2-3 m above the ground. The 100% of eggs occurred on height (1-2 m) attributed to the behavior of females of *Apertochrysa* sp. to protect their eggs from direct exposure to sun light and lay their eggs near enough food which is available in this level especially the aphid *Rhopalosiphum maidis*.

The preference of oviposition of green lacewing varied vertically within the plant and differed from species to species, from plant to plant, and depends on the environment conditions. In this study the females of *Apertochrysa* sp. preferred to lay their eggs in any place within the citrus trees. The preferred place of these females was at height 1-2 m within the corn plants. Whereas the best height for *C. carnea* oviposition was at the height 2.26 m during the ovipository flight stage (Duelli, 1980) [16].

The vertical flight of green lacewing was studied by many researchers. Duelli (1980) [16] discovered three flights of *C. carnea*, the first flight occur shortly after emergence and this flight is not effect by wind, scent, or availability of food. The second flight is the pre-oviposition, at 6-12 m and can be influenced by vegetative' stimuli and the third flight is the oviposition flight. Sajap *et al*., (1997) [28] reported that sixty three percent of green lacewing *Glenochrysa* sp. was caught between 5-10 m, while the high altitude of *C. carnea* was 200 m (Chapman *et al*., 2004).

The ovipositional preference of *Apertochrysa* sp. within the directions of plant
Table-2 shows that the east direction differed significantly with other orientations of citrus trees in first test, recorded 79.8% of eggs collected followed by west direction 14.9%. The highest percentage of eggs 66.67 were collected from east direction in second test without significant differences with the north, south and west directions.

These results clearly show the importance of the sun light on the occurrence of eggs of *Apertochrysa* sp. The laying of high percent of eggs of *Apertochrysa* sp. on lower surface of leaf with natural shade of citrus trees at east direction can offer the best temperature and light density to the eggs until hatch. These results confirmed the findings obtained by Ahmed (1987) [1] for the *Ephestia cautella* (Lep.; Phycitidae) on date-palm orchards. The east and west directions of corn plants offered the same effect on the occurrence of eggs of *Apertochrysa* sp. which recorded 52.94% and 47.06% respectively, maybe attributed by the density of aphid *R.maidis* which release sex pheromone can play as kairmone to attract the green lacewings (Koczorl *et al*., 2015) [20].

The ovipositional preference of *Apertochrysa* sp. within the leaf of plant
Table-3 showed that 91.2% of eggs of *Apertochrysa* sp. were found on the lower leaf surface of citrus tree, which showed significant differences with the percentage of eggs found on upper leaf surface 8.8%. The females lay their eggs on the lower surface to protect the eggs from the direct effect of sun light and to protect their eggs from the natural enemies by dangling the eggs with their stalks in the air.

Table-3 also showed highly significant differences between lower and upper surface of corn leaf. 100% of eggs of *Apertochrysa* sp. were collected from lower leaf surface. The lower leaf surface of corn plant can offer a good situation to protect these eggs from direct sun light exposure especially during the mid-day when the corn leafs bend to the inside offering suitable shade for the eggs. Most green lacewing species often placed their eggs on the underside of leafs but there are exceptions to this rule (Duelli, 1984, 2001; McEwen *et al*., 2001) [17, 15, 23].

The effect of plant's age on the oviposition of *Apertochrysa* sp.

Table-4 shows that the highest number of eggs of *Apertochrysa* sp. were noticed on corn plants aged 60 days after plants emergence (14.5 eggs per replicate) which recorded the highest percentage (59.2%) from all eggs collected and significantly different with others ages, followed by 50 days (4 eggs per replicate with 16.3%) and 70 days (3.75 eggs per replicate with 15.3%) after plants emergence.

No eggs of *Apertochrysa* sp. were recorded on the plants aged 10, 20, 30 days and 90 days after plants emergence. The number of eggs increased gradually with age until the age of 60 days after plants emergence and then decreased gradually until the plants harvest at age 90 days after plants emergence. This behavior of females of *Apertochrysa* sp. to lay their eggs on specific ages of corn plants could be attributed to various reasons such as the availability of food especially the aphid *R. maidis* during the experiment time, may be due to the variation of plants odor concentrations (Zhu *et al*., 2005; Zhu *et al*., 1999) [35, 34] and may be because of the aphid pheromones (Zhu *et al*., 2005; Zhang *et al*., 2006; Hooper *et al*., 2002) [35, 33, 18].

Table 1: The mean ± SD and percentage of eggs occurrence of *Apertochrysa* sp. within the heights of citrus orchard and corn plant

Elevations	N	Test 1 on citrus orchards 31-8-2007 A		Test 2 on citrus orchards 03-09-2007 B		N	Corn plant C	
		Mean of eggs number ± SD	% of eggs occurrence	Mean of eggs number ± SD	% of eggs occurrence		Mean of eggs number± SD	% of eggs occurrence
0-1 m	4	6.5±11.7	23.00	5.75±10.2	40.35	40	0.0 b	0.0
1-2 m	4	21.5±24.2	76.10	0.25±0.5	1.000	40	9.2±6.0a	100%
2-3 m	4	0.25±0.5	0.88	8.25±9.0	57.89	40	0.0 b	0.0

Within the same column, the data followed by the same letter are not significantly different on $P = 0.05$, d.f = 2, 6 $(F = 1.63)^{A}$, $(F = 0.838)^{B}$, $(F = 57.7, LSD = 2.47)^{C}$.

Table 2: The mean ± SD and percentage of eggs occurrence of *Apertochrysa* sp. within the orientations of citrus orchard and corn plant

Orientations	N	Test 1 on citrus orchards 31-8-2007 A		Test 2 on citrus orchards 03-09-2007 B		N	Corn plant C	
		Mean number of eggs ± SD	% of eggs occurrence	Mean number of eggs ± SD	% of eggs occurrence		Mean number of eggs ± SD	% of eggs occurrence
North	4	0.75±0.9b	2.63	4.0±7.3	28.07		-	-
South	4	0.75 ±1.5b	2.63	0.5±0.58	3.50		-	-
East	4	22.75±16.4a	79.82	9.5±11.0	66.67	40	9±10.5	52.94%
West	4	4.25 ± 4.9b	14.91	0.25±0.5	1.75	40	8±34.0	47.06%

Within the same column, the data followed by the same letter are not significantly different on $P = 0.05$, $(d.f = 3, 9, F = 7.02, LSD = 5.63)^{A}$, $(d.f = 3, 9, F = 1.4)^{B}$, $(d.f = 6, t_{cal} = 0.28)^{C}$.

Table 3: The mean ± SD and percentage of eggs occurrence of *Apertochrysa* sp. within the leaf surface of citrus orchards and corn plants

surface		Citrus orchards A		Corn plants B	
	N	Mean number of eggs ± SD	% of eggs occurrence	Mean number of eggs ± SD	% of eggs occurrence
Upper	99	9 ± 5b	8.8	0.0 ± 0.0b	0.0
lower	99	93.7 ± 47.8a	91.2	103.7 ± 59.5a	100

Within the same column, the data followed by the same letter are not significa-ntly different on $P = 0.05$, $(d.f = 4, t_{cal} = 5.3)^{A}$, $(d.f = 4, t_{cal} = 3)^{B}$.

Table 4: The mean ± SD and the percentage of occurrence of eggs of *Apertochrysa* sp. within different ages of corn plants

Age of plants	N	Mean of eggs ± SD/replicate	% of eggs occurrence
10 days	40	0 ± 0 c	0
20 days	40	0 ± 0 c	0
30 days	40	0 ± 0 c	0
40 days	40	1.75 ± 1.7 c	7.1
50 days	40	4 ± 4.97 b	16.3
60 days	40	14.5±4.43 a	59.2
70 days	40	3.75 ±3 b	15.3
80 days	40	0.5 ± 1 c	2.0
90 days	40	0 ± 0 c	0

Within the same column, the data followed by the same letter are not significantly different on $P = 0.05$, (d.f = 8, 24, F = 17.98, L.S.D = 1.61).

Conclusion

The ovipositional preference and occurrence of eggs of females of *Apertochrysa* sp. affected by many factors like heights, directions of plant, surface of leaf and the age of plant and the effect of these factors vary from plant to plant. The east direction of plant and the lower leaf surface appeared the preferred place for oviposition. It seems the ovipositional preference of females of *Apertochrysa* sp. within the plant is affected mainly by availability of food and sunlight. The occurrence of eggs of *Apertochrysa* sp. within the age of corn plants can be affected by availability of food and odor of plant.

References

1. Ahmad TR. Effect of pheromone trap design and placement on capture of almond moth *Cadra cautella* (Lep.: Pyralidae). J Econ Entomol. 1987; 80:897-900.
2. Ahmad TR, Ali MA. Effect of plant type cover and pheromone concentration on movement of codling moth *Cydia pomonella* (L.) (Lep.: Olethreutidae). J Appli. Entomol. 1989; 108:312-316.
3. Alasady MAA, Omar DB, Ibrahim YB, Ibrahim RB. Effects of preys on survival, development, sex ratio and number of consumption victims of Apertochrysa sp. at laboratory conditions. J Biodi Envi Sci. 2019; 14(6):252-261.
4. Alasady MAA, Omar DB, Ibrahim YB, Ibrahim RB. Life table of the green lacewing *Apertochrysa* sp. (Neuroptera: Chrysopidae) reared on the rice moth *Corcyra cephalonica* (Lepidoptera: Pyralidae). Int J Agric Biol. 2010; 12:266-270.
5. Ballal, CR, Singh SP. Host plant-mediated orientational and ovipositional behavior of three species of Chrysopids (Neuroptera: Chrysopidae). Biol Cont. 1999; 16:47-53.
6. Bigler F. Biological control by chrysopids: integration with pesticides, In: Biology of Chrysopidae, ed. M. Canard, Y. Semeria and T.R. New, Dr. Junk W Publishers. The Hague/ The Netherlands, 1984, 233-245.
7. Canard M, Semeria Y, New TR. Biology of Chrysopidae. Dr. Junk W Publishers. The Hague/ The Netherlands, 1984.
8. Chapman, JW, Reynolds DR, Smith AD. Vertical-looking radar: a new tool for monitoring high-altitude insect migration. Bioscience. 2003; 53**:**503-511.
9. Chapman JW, Reynolds DR, Brooks SJ, Smith AD, Woiwod IP**.** Seasonal variation in the migration strategies of the green lacewing *Chrysoperla carnea* species complex. Ecol Entomol. 2006; 31:378-388.
10. Clark TL, Messina FJ. Foraging behavior of lacewing larvae (Neuroptera: Chrysopidae) on plants with divergent architectures. J Insect Behav. 1998; 11:303-317.
11. Cohen AC, Smith LK. A New concept in artificial diets for *Chrysoperla rufilabris*: The efficacy of solid diets. Biol Cont. 1998; 13:49-54.
12. Dawson GW, Griffiths DC, Janes NF, Mudd A, Pickett JA, Wadhams LJ *et al*, Identification of an aphid sex pheromone. *Nature*. 1987; 325:614-616.
13. Dean GJ, Satasook C. Response of *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) to some potential attractants. Bull Entomol Res. 1983; 73:619-624.
14. Dent TR, Walton MP. Methods in ecological and agricultural entomology. Cab international, U.K., Cambridge University Press, 1997, 400.
15. Duelli P. Lacewings in field crops. In: Lacewings in the crop environment, ed. P.K. McEwen, TR New, Whittington AE. (ed). Cambridge: Cambridge University Press, 2001, 158-171.
16. Duelli P. Preovipository Migration flights in the green lacewing, *Chrysopa carnea* (Planipennia, Chrysopidae). Behav Ecol Sociobiol. 1980; 7:239-246.
17. Duelli P. Flight, dispersal, migration. In: Biology of Chrysopidae (ed) Canard M, Semeria Y, New TR. Dr. W. Junk Publishers. The Hague/ The Netherlands, 1984, 110-116.
18. Hooper AM, Donato B, Woodcock CM, Park JH, Paul RL, Boo KS *et al*. Characterization of (1r,4s,4ar,7s,7ar)-dihydronepetalactol as a semiochemical for lacewings, including *Chrysopa* spp. and *Peyerimhoffina gracilis.* J Chem Ecol. 2002; 28:849-864.
19. Huffaker CB. Biological Control (eds.), New York: Plenum Press, 1974, 3-15.
20. Koczor S, Szentkirályi F, Pickett JA, Birkett MA, Tóth M. Aphid sex pheromone compounds interfere with attraction of common green lacewings to floral bait._J Chem Ecol. 2015; 41:550-556.
21. Keulder R. Oviposition site preference of lacewings in maize ecosystems and the effect of Bt maize on *Chrysoperla pudica* (Neuroptera: Chrysopidae). Master thesis. School of Environmental Sciences and Development North-West University South Africa, 2010.
22. Little TM, Hills FJ. Statistical methods in Agricultural research. USA: University of California Press. 1972, 242.
23. McEwen P, New TR, Whittington AE. Lacewings in the crop environment, (eds). Cambridge: Cambridge University Press, 2001.
24. Pappas ML, Broufas GD, Koveos DS. Effect of relative humidity on development, survival and reproduction of the predatory lacewing *Dichochrysa prasina* (Neuroptera: Chrysopidae). Biol Cont. 2008; 46:234-241.
25. Ridgway RL. Control of bollworm and tobacco budworm through conservation and augmentation of predaceous insects, Proc. Tall Timbers Conf. ecol. anim. Contr. Habitat Manage. Tallahassee. 1969; 2:127-144.
26. Rosenheim JA, Wilhoit LR, Armer CA. Influence of intraguild predation among generalist insect predators on the suppression of an herbivore population. Oecologia. 1993; 96:439-49.
27. Ruberson JR, Tauber CA, Tauber MJ. Developmental effects of host and temperature on Telenomus app. (Hymenoptera; Scelionidae) parasitizing chrysopid eggs. Biol Cont. 1995; 5:245-250.
28. Sajap AS, Maeto K, Fukuyama K, Ahmad FBH, Wahab AY. Chrysopidae attraction to floral fragrance chemicals and its vertical distribution in a Malaysian lowland tropical forest. Malays Appl Biol. 1997; 26:75-80.
29. SAS Institute. SAS/STAT._ 9. 1. 3. User's Guide. SAS Institute Inc. USA: Cary, NC. 2002.
30. Silva. Predators of aphids in cacao plantations in Brazil: effectiveness in biological control and mechanisms of coexistence, PhD Thesis, University of Michigan, East Lansing, Michigan, 2007.
31. Syed AN, AShfaq M, Ahmad S. Comparative effect of various diets on development of *Chrysopela carnea* (Neuroptera: Chrysopidae). Int J Agric Biol. 2008; 10:728-730.
32. Ulhaq MM, Sattar A, Salihah Z, Farid A, Usman A, Khattak SUK. Effect of different artificial diets on the biology of adult green lacewing (*Chrysoperla carnea*) Stephens. Songkanakarin. J Sci Technol. 2006; 28:1-8.
33. Zhang QH, Sheng M, Chen G, Aldrich JR, Chauhan KR. Iridodial: a powerful attractant for the green lacewing, *Chrysopa septempunctata* (Neuroptera: Chrysopidae). Naturwissenschaften. 2006; 93:461-465.

34. Zhu J, Cosse AA, Obrycki JJ, BooK S, Baker TC. Olfactory reactions of the twelve-spotted lady beetle, *Coleomegilla maculate* and the green lacewing, *Chrysoperla carnea* to semiochemicals released from their prey and host plant: electroantennogram and behavioral responses. J Chem Ecol. 1999; 25:1163-1177.
35. Zhu J, Obrycki JJ, Ochieng SA, Baker TC, Pickett JA, Smiley D. Attraction of two lacewing species to volatiles produced by host plants and aphid prey. Naturwissenschaften. 2005; 92:277-281.