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Efficiency of *Chrysoperla mutata* (McL.) larvae as a predator of the dubas nymphs *Ommatissus lybicus* DeBerg

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Abstract:

This study was conducted to analysis the factors limiting the effectiveness of Chrysoperla mutata (MacL.) larvae as a predator of Dubas nymphs Ommatissus lybicus DeBerg, one of the most important pests on the date palm trees. The success or failure of predator in capturing prey is an indicator of its effectiveness within the predator-prey relationships, results revealed an increase of the capturing efficiency with progress of the predator age; it was 8.3% for the 1st instar larvae dealing with 5th instar of duba's nymphs, while it was 51.8% for the 3rd instar larvae. Values of specific criteria that limiting the search ability of successive larval instar were increased , the rate of speed of movement of third larval instar was 114.1 cm / min (6846 cm / h) ,that equal to 2.79 times of the movement speed of the first larval instar. The range perception was 0.12 cm equal to 3.16 times of range perception of the first instar. Accordingly, the area covered by *the successive larval instar and the chances of encounter with their prey are increased, and this is one of the important indicators of the effectiveness of the predator. The consumption time of the first, second and third instar nymph by the first larval instar was 16.5, 16.75 and 14.8 fold of the time taken by the third instar larvae, in comparing the second larval instar with the third larval instar the consumption time was 8.8 and 6.5 and 5.64 fold. The minimum number of 4^th^ nymphal instar of dubas should be consume for 100% survival was 2.44, 6.5 and 18 nymphs for 1^st^, 2^nd^ and 3^rd^ instars larvae respectively. Depending on these criteria the population density index of prey required for 100% survival for the 1^st^ instar larvae was 8.44 times more than that required for the 3^rd^ instar larvae.*

Key words: *Chrysoperla mutata* (McL.) larvae, dubas nymphs *Ommatissus lybicus* DeBerg

INTRODUCTION

Indirect studies (laboratory experiments or facts, or both) occupied an important position in measuring the efficiency of natural enemies, depending on it the equations and mathematical models that simulate the reality are designed (Kiritani, & Dempster. 1973). In the biological control aspects, these studies are concentrated on the characteristics of efficient Predator such as attack rate components (Dixon1970; Wratten, 1973) or find the relationship between predator density in the field and predatory efficiency each day in vitro (Varley, 1941). Green lacewings (Neuroptera: Chrysopidae) are natural enemies that are often used in augmentative biological control programs (Wang and Nordlund, 1994), they have high-predation efficiency, adaptation to the diversity of eco-agriculture system and pesticides tolerant (Sattar and Abro, 2011). They are successful predators of whiteflies, thrips, aphids and mites (Singh and Manoj, 2000; Zaki and Gesraha, 2001; Venkatesan et al., 2002). They also feed on the eggs and tiny larvae of the cotton bollworms (Ahmad et al., 2003). One of the important species of this family in agriculture is *Chrysoperla mutata*. The value of this predator as a biological control agent arises from the fact that each of its three larval stadia is voracious polyphagous feeders. The main factors may affect the feeding and efficiency of a predator as a biological control agent are voracity, functional response, numerical response, host preference and ability of a predator in capturing its prey besides environmental conditions (Messina &Sorenon, 2000). The present study aimed to determine the specific factors determining the attack rate of *Ch. mutata* larvae to illustrate their interaction with Dubas nymphs *Ommatissus lybicus* DeBerg, one of the most important pests on the date palm trees.

MATERIALS AND METHODS

1. Insects Rearing

Chrysoperla mutata

The adults of *Ch. mutata* were confined in transparent plastic cups (11 cm in diameter and 7.5 cm high) and supplied, via cotton swabs, with the standard artificial diet consisting of yeast, sugars, and distilled water in the ratio of 4 g: 7 g: 10 mL, respectively (Hagen and Tassan, 1970). The top of the plastic cup was covered with black muslin cloth tightened with a rubber band. The eggs laid by females on the walls of the cups and muslin cloth were harvested daily, using forceps to break the stalk beneath the egg. The eggs were placed, with the help of a camel's hair brush, singly in plastic Petri dishes (10 cm in diameter and 1.5 cm high). Each day until pupation newly hatched larvae were fed on eggs of *Ephestia cautella*.

Ephestia cautella

A colony of *E. cautella* was established using growth chamber set up at 25 ± 2°C, 60 ± 5% relative humidity and a photoperiod 16: 8 h (L:D). Artificial diet as described earlier was used for *E. cautella* maintenance (Hameed 2002). Through this method sufficient numbers of eggs were obtained to rear *Ch. mutata* continuously under laboratory condition.

Dubas bug *Ommatissus lybicus* DeBerg.

Dubas nymphs *Ommatissus lybicus* were obtained from orchards and kept in Mesh covered cages with date palm seedlings that already planted in pots under the laboratory conditions.

2. Analysis the factors limiting the effectiveness:

Efficiency of prey capturing:

Capturing efficiency of each larval instars of *Ch. mutata* to each instars of Dubas nymphs was examined by entering the larva in Petri dishes (9 × 1.5 cm) containing a number of a selected instar of Dubas nymphs. Number of the encounter cases between the larvae and nymphs and the number of successful capturing situations was recorded and then the percentage of capturing was calculated (the number of capturing / 100 encounter cases).

Time of prey consumption:

One of the most important parameter of the efficient predator is the time of prey consumption, which is the time taken by larvae in capturing the prey, consume it, and then continues to search for more prey, measuring of this time has been done by monitoring and recording the time of prey consumption in the 10 predation cases for each larval instar and each instar of dubas nymphs.

Speed of movement, range of perception and the area covered:

Searching capacity of larvae per unit time was determined by measuring the speed of movement, and the larva's range of perception which enables them to recognize their prey (Nicholson, 1933). Speed of movement was measured by tracking of 10 larvae for each instar on graph paper with recording the time taken to cut the distances. Range of perception for each larval instar (the distance between their antennas) was measured by using 20 larvae. Therefore, the area covered by larva per unit time, was estimated as products of the speed of movement and the range of perception (Nicholson, 1933)

Food requirements:

The food requirements and the effect of consumed amount on the survival and developmental rate were studied for different larval instar of the predator *Ch. mutata*. New hatched larvae (20 for each test) were placed individually in Petri dishes and provided with different numbers (1, 2, 5, and 10) of fourth instar of Dubas nymphs, the numbers of consumed nymphs were recorded daily.

Estimation of prey population density index required for survival predator larvae:

Equation of (Dixon, 1959) was used to estimate the population density index of prey required for 100% survival of predator larvae as follow:

$$P = S/Ac \times U$$

Where

P= population density index of prey

S = number of dubas nymphs required for 100% survival of the predator

Ac = area index corrected for time spent feeding.

U = number of nymphs captured per 100 encounters.

3. Data analysis:

Data were analyzed by using the Software program SPSS version 20, and Duncan multiple range test (DMRT) to compare the means in probability level of 0.05.

RESULTS AND DISCUSSION:

The success or failure of predator in capturing prey is an indicator of its effectiveness within the predator- prey relationships (Varley, & Gradwell. 1970). The results of the current study (fig.1) indicated to evolution in the efficiency of successive larval instars in capturing their prey, especially when dealing with the late stages of nymphs. The highest capturing efficiency ratio was recorded for the third larval instars (55.9 and 51.8 %) when they encountered with the fourth and fifth instar of Dubas nymphs respectively ,and this represented one capturing case /1.79 encounters cases with fourth instar nymph and 1 capturing case / 1.93 encounters cases with fifth instar nymph . Thereby they increase by 4.47 and 6.24 fold from the capturing efficiency ratio of first larval instar that reached to 12.5 % (one capturing case / 8 encounter cases with Fourth instar of nymph) and 8.3% of encountering cases with fifth instar nymph (one capturing case / 12.1 case of encountering). Results in general indicated that all larval stages have high efficiency in capturing small Dubas instar nymphs (first, 2^{nd} and 3^{ed} instar nymphs), which must be regard in release programs to ensure the survival of larval stages and increase the consumed prey. Defensive response and escape of dubas nymphs was noticed when the larvae of the predator *Ch. mutata*, contacted with them, particularly the late instar nymph, fleet response have been shown by jumping far away, which played a prominent role in the defensive behavior, as well as wax threads in the end of their body, that their number and length increase with the progress of the age, accordingly, the degree of detecting the mechanical-effects increase, (Al-Abbassi, 1987, 1988). The importance of this parameter was mentioned in the searching behavior studies of other species that could not detect their prey without a real touch, and they lost them if they were away at a few millimeters (Banks, 1957; Fleschner, 1950). It was pointed out the importance of body appendages as a defensive tool in studies of the interactions of aphids and their predators such as ladybird larvae, individuals with long appendages were more difficult predation than others that have short appendages (Kaddou, 1960). *Acyrthosiphon pisum* Individuals can escape and get rid of predation by detection the predator on distance of 4-10 mm, (Hodek, 1973).

The time of the prey consumption has been decreased with progress of the predator age (table 1). This parameter for the first larval instar dealing with first, second and third instar nymph was 16.5, 16.75 and 14.8 fold of the time taken by the third instar larvae, and it was 8.8 and 6.5 and 5.64 fold when comparing the second larval instar with the third larval instar. The consumption time is a part of searching time; so the chances of the later instar larvae in searching and encountering the prey is bigger than the early stages.

The results (table 2) indicated to increase values of specific criteria that limiting of the search ability of successive larval instar , the rate of speed of movement of third larval instar was 114.1 cm / min (6846 cm / h) ,that equal to 2.79 times of the speed movement of the first larval instar. The range perception was 0.12 cm equal to 3.16 times of range perception of the first instar.

Accordingly, the area covered by the successive larval instar and the chances of encounter with their prey are increased, and this is one of the important indicators of the effectiveness of the predator.

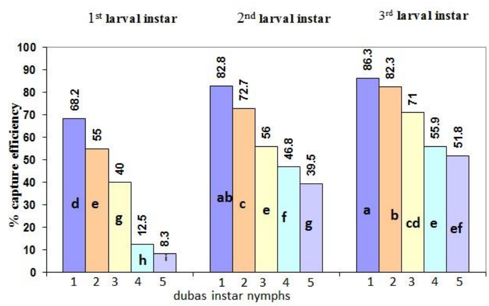
Study of food requirements for larval instars revealed that larval development is completed despite of decreasing of food consumption (Table 3), and clear acceleration was occurred with an increase rate of consumed food. The development of the first larval stage was required 2.44 fourth instar nymphs by developmental time 2.44 days, and 100% of survival rate. Developmental time of this instar was decreased to 2.05 days at rate consumption of 5.54 nymphs of Dubas. 100% survival of the second larval instar was required to consume 6.5 nymphs and 3.25 days of developmental time. The third larval stage has requested 18 nymphs of Dubas and the instar completed its development within the time period of 3.8 days. The duration of this instar was decreased to 3.05 days when larvae fed on 26.5 nymphs. In similar studies ladybird larvae *Coccinella septempunctata* L. are completed their development in spite of decreasing amount of consumed food to 44% (Hodek, 1973), Sundby, (1966) mentioned the possibility of larvae of this species to complete their development even when they fed on one-third of normal values.

Survival rate of predator depends on the number of consumed prey within a certain time. This is determined by efficiency of larvae in capturing their preys, the abundance of prey and the total covered area of their searching.

The prey population density index of Dubas nymphs needed to survival of the first instar larvae was equivalent to 8.44 times of those needed by the third instar (Table 4). It should be noted that capturing efficiency that were used in the calculations of index were based on the observations recorded for individuals of newly hatched larvae but the developmental age will be accompanied by the development of the capturing efficiency; and this making requirements of the population density of prey close to that needs of the second larvae, and this is true for the second instar also.

Predation components mentioned above are used in the calculation the number of the prey of the lime aphid *Eucallipterus tiliae* that can be consumed and removed from the field by the Predator *Adalia bipunctata* within a certain time, which indicates to the importance of these criteria's in the expression of the real results of the predation and field control (Wratten, 1973).

In accordance with the hypothesis of Volterra, (1931) and Nicholson, (1933) any animal must find the things it seeks, by movements which, until they are influenced by the qualities of object sought, are random with respect to it, Fleschner,(1950) in his study on searching capacity of *Chrysoperla carnea* larvae has been noted that the larvae must be touch their prey in order to respond to its presence; it can therefore be said that they move at random with respect to their prey. Through random search a number of encounters between prey and predator are occurred proportional to the population densities of the two species (Varley, 1941) thereby consuming of prey is achieved. The encounters Increase when prey consistent with the Predator in response to environmental conditions that is making them adjacent (Hodek, 1973), this has been observed in the presence of each of nymphs Dubas and larvae of the predator in the shadow areas between the folds of leaflet, at the heart of palm away from the influence of direct sunlight. Based on laboratory observations, the high effectiveness of larval stages with small instars nymph lead to greater consumption of prey, and great survival and development of the predator. In spite of the high potential of survival of larvae in scarce nutrition conditions, but it needs a certain number of prey during a given time, and to search for those numbers, they will cover certain areas increases with low density of prey and decreases with high prey density that making their presence confined in severe infestation areas. The nature of occurrence of this predator was subjected to movement and distribution of their adults associated with abundant of honey dew secretions as food and attractive. The abundance of these secretions linked with density of Dubas nymphs and their feeding activity, which increase with the successive instar nymph.



The same letters mean there are no significant differences between means according to Duncan test ($P \leq 0.05$).

Fig. (1) Capture efficiency of *Chrysoperla mutata* larvae to dubas instar nymphs

Table (1) Average of time (minute) taken by *Chrysoperla mutata* larvae in consumption of Dubas nymph instars

Instars larvae	Dubas Nymph instars				
	1st	2nd	3rd	4th	5th
1st	**± 1.18 a D 16.3**	**30.16 ±12.7a CD**	**± 12.24 a C 50**	**±10.6a B 82.5**	**±15.27a A 133**
2nd	**± 1.6 b C 8.72**	**±2.09 b C 11.65**	**19 ±1.4 b C**	**40.3 ±9.5 b B**	**A ± 7.6 b 61**
3rd	**0.41 c C 0.99±**	**1.8 ±0.45 b C**	**± 0.34c C 3.4**	**13.6 ±2.6 c B**	**A ±2.6 c 17.8**

The same small letters mean there is no significant difference between means in the same column; the same capital letters mean there is no significant difference between means of the raw according to Duncan test ($P \leq 0.05$).

Table (2) The range perception, speed of movement and area covered per minute for different instar larvae of *Chrysoperla mutata*

Instars larvae	Range of perception(cm.)	Speed of movement(cm/min)	Area covered(cm^2)/min
1st	0.038 a	40.9± 12.59 a	1.55
2nd	0.059 b	65± 8 a	*3.83*
3rd	0.12 c	114.1 ± 36.15 b	*13.7*

The same letters mean there are no significant differences between means according to Duncan test ($P \leq 0.05$).

Table (3) Effect of number of dubas nymph (4th instar) provided each day upon percentage survival and duration of each instar of *Chrysoperla mutata*

Instar larvae	Number of dubas nymph provided each day	Survival (%)	Number of nymphs eaten	Average duration of instar(days)
1st	1	100	2.44 ± 0.5	2.44 ± 0.5
	2	*100*	3.91± 0.82	2.3± 0.48
	5	*100*	4.73 ± 0.79	2.15 ± 0.36
	10	*100*	5.54 ± 0.59	2.05 ± 0.22
2nd	*1*	*95*	3.45 ± 0.83	3.45 ± 0.83
	2	*100*	6.5 ± 1.44	3.25 ± 0.72
	5	*100*	12.19 ± 3.1	2.65± 0.67
	10	*100*	18.26 ± 7.5	2.2 ± 0.41
3rd	*1*	*89.47*	5.9 ± 1.6	5.9 ± 1.6
	2	*95*	10.8 ± 1.4	5.4 ± 0.7
	5	*100*	18 ± 4.73	3.8± 1
	10	*100*	26.5 ± 3.4	3.05 ± 0.39

Table (4) Estimated index of the population density of prey required for 100% survival of*Chrysoperla mutate*

Instar larvae	Number of dubas nymphs captured per 100 encounter (U)	Number of dubas nymphs required for 100%survival (S)	Percentage of time spent searching	Area index corrected for time spent feeding (Ac)	Prey population index(S/U× Ac)	Prey population index ratio
1st	*12.5*	2.44	94.3	0.51	0.38	8.44
2nd	*46.8*	*6.5*	94.4	1.69	0.082	1.82
3rd	*55.9*	*18*	95.5	7.16	0.045	1

REFERENCES

1. Ahmad, M., B. Fatima, G.Z. Khan, asrullah, and A. Salam. 2003. Field managements of insect pests of cotton through augmentation of parasitoids and predators. Asian J. Plant Sci. 2: 563- 565.
2. Al-Abbassi, S. H. 1987. Jumping mechanism of Dubas bug *Ommatissus binotatus lybicus* DeBerg. (Homoptera: Tropiduchidae). J. Agr. Wat. Reco. Res. 6 (1): 29-38.
3. Al-Abbassi, S. H. 1988. Biology of *Ommatissus binotatus lybicus* DeBerg. (Homoptera: Tropiduchidae) under laboratory conditions. Date Palm Journal 2: 412-423.
4. Banks, C. J. 1957. The behavior of individual Coccinellid larvae on plants. Br. J. Anim. Behav. 5: 12-24.
5. Dixon, A. F. G. 1959. An experimental study of the searching behavior of the predatory coccinellid beetle *Adalia decempunctata* (L.). J. Anim. Ecol. 28: 259-281.
6. Dixon, A. F. G. 1970. Factors limiting the effectiveness of the coccinellid beetle, *Adalia bipunctata* (L.), as a predator of the sycamore aphid, *Drepanosiphum platanoides* (SCHR). J. Anim. Ecol. 39: 739-751.
7. Finney, G. L. 1948. Culturing *Chrysopa californica* and obtaining eggs for field distribution. J. Econ. Entomol., 41: 719-721.
8. Fleschner, C. A. 1950. Studies on searching capacity of the larvae of three predators of the citrus red mite. Hilgardia, 20: 233-265.
9. Hagen, K. S. & R. L. Tassan. 1970. The influence of food Wheast® and related *Saccharomyces fragilis* yeast products on the fecundity of *Chrysopa carnea*. Can. Entomol. 102: 806-811.
10. Hameed, A.A., 2002. Field and laboratory studies for using Bracon hebetor for controlling *Ephestia cautella* and *Earias*

insulana . M.Sc. Thesis, College of Agriculture / Baghdad University. Baghdad/Iraq.

11. Hodek, I. 1973. Biology of Coccinellidae. Academia, Prague.
12. Kaddou, I. K. 1960. The feeding behaviour of *Hipodamia quinquesignata* (Kirby) larvae. Univ. Calif. Publ. Entomol. 16: 181-230.
13. Kiritani, K. & J. P. Dempster. 1973. Different approaches to the quantitative evaluation of natural enemies. Ecol. 10: 323-330.
14. Messina F.J., and S. Sorenon. 2000. Effectiveness of Lacewing Larvae in reducing Russian wheat aphid population on susceptible and resistant wheat. *Biological Control*, , 21(1): 19-26.
15. Morrison, R. K., V. S. House and R. L. Ridgway. 1975. Improved rearing unit for larvae of common green lacewing. J. Econ. Entomol. 68: 821-822.
16. Nicholson, A. J. 1933. The balance of animal populations J. Anim. Ecol. 2: 131-178.
17. Sattar, M., and G.H. Abro. 2011. Mass rearing of *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) adults for integrated pest management Programs. Pakistan. J. Zool. 43(3): 483-487.
18. Singh, N.N., and K. Manoj. 2000.Potentiality of *Chrysoperla carnea* in suppression of mustard aphid population. Indian J. Entomol. 62: 323-326.
19. Sundby, R. A. 1966. A comparative study of the efficiency of three predatory insects *Coccinella septempunctata* L. (Coleoptera, Coccinellidae), *Chrysopa carnea* St. (Neuroptera, Chrysopidae) and *Syrphus ribesii* L. (Diptera, Syrphidae) at two different temperatures. Entomophaga, 11: 395-404.
20. Tauber, M. J. & C. A. Tauber. 2000. Commercialization of predators: recent lessons from green lacewings (Neuroptera:

Chrysopidae: Chrysoperla). American Entomologist, Vol. 46(1): 26-38.

21. Tauber, M. J., & C. A. Tauber. 1975. Criteria for selecting *Chrysopa carnea* biotypes for biological control: Adult dietary requirements. Can. Entomol. 107: 589-595.
22. Turnbull, A. L. 1956. Spider predators of the spruce budworm, *Christoneura fumiferana* (Clem.) at Lillooet, B. C. Canada. Proc. 8th Pacif. Sci. Congr. III A: 1579-1594.
23. Varley, G. C. 1941. On the search for hosts and the eggs distribution of some chalcid parasites of the knapweed gall-fly. Parasitology 33: 47-66.
24. Varley, G. C., G. R. Gradwell. 1970. Recent advances in insect population dynamics. A. Rev. Entomol., 15: 1-24.
25. Volterra, V. 1931. Variations and fluctuations of the number of individuals in animal species living together. In Chapman, R. N., Animal Ecology. New York
26. Wang, R., and D. A. Nordlund. 1994. Use of *Chrysoperla* spp. (Neuroptera: Chrysopidae) in augmentative release programmes for control of arthropod pests. Biocontrol News and Information 15:51N-57N.
27. Wratten, S. D. 1973. The effectiveness of the *Coccinella beetle*, *Adalia bipunctata* (L.) as a predator of the lime aphid, *Eucallipterus tiliae* L. J. Anim. Ecol. 42: 785-802.
28. Venkatesan, T., S.P. Singh, S.K.Jalali, and S. Joshi. 2002. Evaluation of predatory efficiency of *Chrysoperla carnea* (Stephens) reared on artificial diet against tobacco aphid, *Myzus persicae* (Sulzer) in comparison with other predators. J. Entomol. Res. 26: 193-196.
29. Zaki, F.N., and Gesraha, M.A. 2001. Production of the green lacewing, *Chrysoperla carnea* (Steph.) (Neuroptera: Chrysopidae*)* reared on semi-artificial diet based on algae, *Chlorella vulgaris*. J. Appl. Entomol. 125: 97-98.