Menoufia J. Plant Prot., Vol. 4 February (2019): 7 - 16

THE PREDATION EFFICIENCY AND FEEDING PREFERENCE OF *COCCINELLA SEPTEMPUNCTATA* L. AND *COCCINELLA UNDECIMPUNCTATA* L. (COLEOPTERA: COCCINELLIDAE) ON SOME PREY SPECIES

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Received: Nov. 6 , 2018 Accepted: Nov. 27 , 2018

ABSTRACT: ***To enhance the strategy of the biological control of the sucking insect pests using the Ladybird Beetles (Coleoptera: Coccinellidae), it is important to understand predator–prey interactions. Hence, the predation efficiency and preference of both larvae and adult of seven-spot ladybird, Coccinella septempunctata Linnaeus and the eleven-spot ladybird, Coccinella undecimpunctata Linnaeus on four prey species i.e., the green peach aphid, Myzus persicae (Sulzer), the cotton aphid, Aphis gossypii Glover, the bird cherry-oat aphid, Rhopalosiphum padi (Linnaeus) and onion thrips, Thrips tabaci Lindeman were evaluated under laboratory conditions at varying prey densities using a clear glass jars. There were significant differences between the consumed numbers of the four different species by the two different lady beetle species. The most consumed prey by C. septempunctata was the A. gossypii followed by M. persicae then R. padi and finally T. tabaci and these results were repeated in case of C. undecimpunctata with less feeding voracious. As the grubs of C. septempunctata and C. undecimpunctata developed from 1^{st} to 4^{th} larval instars, the consumption rates from aphid species and thrips increased. The consumption rates of M. persicae, A. gossypii, R. padi and T. tabaci significantly increased with the advancement in the larval stage of the two predators. The forth larval instar of C. septempunctata and C. undecimpunctata exhibited the highest predatory potential comparing to the first, second and third larval instars. The numbers of prey eaten by adult stage or different instars of larvae of the two predators increased significantly with prey density and reaching the maximum value when 150 preys were provided compared with 50 and 100 preys.***

Key words: ***Biological control, Coccinella spp , Myzus persicae, Aphis gossypii, Rhopalosiphum padi, Thrips tabaci***

INTRODUCTION

Piercing sucking insect pests (aphids, whiteflies, leafhoppers and thrips) are cosmopolitan pests attacking a wide variety of agricultural crops and causing either directly physical damage by sucking plant juice or indirectly damage as vector transmitting plant diseases (Carter, 1990). These insects widely distributed from tropical and subtropical areas into the temperate region (Kocourek, *et al*. 1994 and Pourian *et al*., 2009). The green peach aphid, *Myzus persicae* (Sulzer) (Hemiptera: Aphididae) one of the most important piercing sucking insect pests. It's attacking over four hundred plant species in more than fifty families (Weber, 1985). The cotton aphids, *Aphis gossypii* Glover is a polyphagous insect pest with a worldwide distribution (Inaizumi, 1980 and Kocourek, *et al*. 1994). The bird cherry-oat aphid, *Rhopalosiphum padi* (Linnaeus) is one of the fourteen aphid species considered of most agricultural importance worldwide (Blackman and Eastop, 2007). It is an important insect pest of cereals, causes severe damage in cereal producing countries (Stern, 1967; Kolbe, 1973 and Mallott and Davy, 1978).

Over the past two decades the onion thrips, *T. tabaci* Lindeman has become a global pest of onion crop (Diaz-Montano *et al*., 2010). There is an urgent need to minimize the many serious problems in the environment components and biodiversity by exploring alternate measures than the intensive use of chemical synthetic insecticides such as biological control agents for management of these insects (Bellows, 2001). Predators like ladybirds can suppress the number of aphids and other piercing sucking insect pests consequently the predatory ladybird is generally considered the best candidate for bio-control of aphids and other piercing sucking insect pests (Dixon *et al*., 1995). The present study was conducted to compare the preference and predatory effect of *Coccinella septempunctata* and *Coccinella. undecimpunctata* on green peach aphids, *M. persicae*, cotton aphid, *A. gossypii,* the bird cherry-oat aphid, *R. padi* and the onion thrips, *T. tabaci* .

MATERIALS AND METHODS

The predation efficiency of adult stage and different larval instars of two ladybird beetles: *C. septempunctata* and *C. undecimpunctata* was studied under laboratory conditions on adults of each of *Myzus persicae*, *Aphis gossypii*, *Rhopalosiphum padi* and *Thrips tabaci* using a series of experiments using a clear glass jars (20 × 15 cm) which were covered with a fine mesh for aeration and to prevent escaping of predators and preys. The experiments were done at 25°C ± 2°C with a photoperiod of 14:10 (L:D) h.

The prey species:

The four preys which were used in this study (*M. persicae*, *A. gossypii*, *R. padi* and *T. tabaci*) were obtained from the culture maintained in the laboratory for experimentation. Each of *M. persicae*, *A. gossypii* were provided in glass jars with fresh tomato leaves for feeding. While, *R. padi* was provided with fresh wheat seedlings and *T. tabaci* was provided with fresh leek leaves. After 24 hours the jars were checked for counting unconsumed aphids.

The predators:

Aphidophagous lady beetle species, which were known to be abundant and were found together feeding on aphid species and in the same habitats, were chosen for the present study. Each individual of the different instars and adults of the predators was provided with one of the following prey densities: 50, 100 and 150 individuals/one glass jar. One day old for the different four instars and two-day-old for adult stage of the two predators were used for all experiments and these instars were starved for 12 h before use by placing them with the hosts on the jars.

The experiments were replicated five times for each instar of the two predators. The estimation of the predatory effect of the predators was based on the number of consumed individuals by the predator. Five more glass jars (for each prey density) were used as control. In these jars, there were the same numbers of preys per jar but in the absence of the predator.

The obtained results were subjected to the analysis of variance test (ANOVA) as randomized complete blocks design, and the least significant differences (LSD) at 5% level were determined using a computer program (Costat, 2008).

RESULTS AND DISCUSSION

Feeding potential of adult stage and different larval instars of the two ladybird beetles; *C. septempunctata* and *C. undecimpunctata:*

Results in (Tables 1-6) cleared that the feeding potential of adult stage and

different larval instars of the two ladybird beetles; *C. septempunctata* and *C. undecimpunctata* under laboratory conditions was significantly dependent on prey species, prey density and predator-stage. There were significant differences between the consumed numbers of the four different species; *M. persicae*, *A. gossypii*, *R. padi* and *T. tabaci* by the two different lady beetle species. The most consumed prey by *C. undecimpunctata* was the cotton aphids, *A. gossypii* (with general consumption means of 13.16±1.51, 17.56±1.73 and 23.88±2.37 individual/day in 50, 100, 150 prey density) followed by *M. persicae* (8.2±0.99, 10.4±1.13 and 13.48±1.5 in 50, 100, 150 prey density) then *R. padi* (6.2±0.71, 7.68±0.68 and 10.92±1.05 in 50, 100, 150 prey density) and finally *T. tabaci* (3.8±0.48, 4.5±0.67 and 6.35±0.85 in 50, 100, 150 prey density).

Table (1): Voracity (number of prey eaten ± SE) of *Coccinella undecimpunctata* stages provided with 50 individuals of four preys under laboratory conditions

Prey	1st instar larvae	2nd instar larvae	3rd instar larvae	4th instar larvae	Adult stages	General mean
R. padi	2.4±0.51[ab]	3.4±0.93[b]	6.8±1.24[c]	9.8±1.16[c]	8.6±0.81[bc]	6.2±0.71[c]
A.gossypii	3.2±0.58[a]	7.6±0.93[a]	15±1.41[a]	21.2±1.98[a]	18.8±1.93[a]	13.16±1.51[a]
M.persicae	1.8±0.37[b]	4±0.71[b]	10.2±0.86[b]	13.6±1.29[b]	11.4±0.93[b]	8.2±0.99[b]
T. tabaci	1.2±0.37[b]	2.4±0.51[b]	3.6±0.51[d]	4.6±0.68[d]	7.2±0.73[c]	3.8±0.48[d]
F values	3.318	8.274	20.969	26.386	18.437	15.858
L.S.D. 5%	1.4062	2.3606	3.194	4.0777	3.6101	2.8033

Means in each column followed by different letters are significantly different at $P < 0.05$

Table (2): Voracity (number of eaten prey ± SE) of *Coccinella undecimpunctata* stages provided with 100 individuals of four preys under laboratory conditions

Prey	1st instar larvae	2nd instar larvae	3rd instar larvae	4th instar larvae	Adult stages	General mean
R. padi	3.6±0.51[b]	5.2±0.86[c]	8.4±0.51[c]	11.4±1.17[c]	9.8±1.02[c]	7.68±0.68[c]
A. gossypii	6.2±1.07[a]	10.8±0.86[a]	21.2±2.35[a]	24.6±2.2[a]	25±2.17[a]	17.56±1.73[a]
M.persicae	2.8±0.58[b]	6.6±0.98[b]	12±1.41[b]	16.2±1.8[b]	14.4±0.87[b]	10.4±1.13[b]
T. tabaci	1.4±0.75[c]	2.2±0.58[d]	4.6±0.81[d]	5.8±0.86[d]	9.4±1.03[c]	4.5±0.67[d]
F values	7.072	18.379	23.885	24.863	27.914	23.304
L.S.D. 5%	2.2733	2.4993	4.36	4.7874	4.1216	3.2022

Means in each column followed by different are significantly different at $P < 0.05$ (LSD test).

Table (3): Voracity (number of eaten prey ± SE) of *Coccinella undecimpunctata* stages provided with 150 individuals of four preys under laboratory conditions:

Prey	1st instar larvae	2nd instar larvae	3rd instar larvae	4th instar larvae	Adult stages	General mean
R. padi	4.2±0.86 b	8±0.89 b	11.2±1.39 c	16.2±1.69 c	15±1.52 bc	10.92±1.05 b
A. gossypii	9.6±1.29 a	14.4±1.4 a	24.8±2.65 a	36.6±2.25 a	34±3.7 a	23.88±2.37 a
M.persicae	4±0.84 b	7.8±1.11 b	17.6±1.7 b	22±2.24 b	16±1.7 b	13.48±1.5 b
T. tabaci	2.2±0.58 b	3.4±0.75 c	5.8±0.66 d	7.8±1.02 d	12.2±1.93 c	6.35±0.85 c
F values	11.876	17.988	21.91	42.195	17.425	22.857
L.S.D. 5%	2.7802	3.201	5.2529	5.5967	7.1325	4.3736

Means in each column followed by different letters are significantly different at $P < 0.05$

Table (4): Voracity (number of eaten prey ± SE) of *Coccinella septempunctata* stages provided with 50 individuals of four preys under laboratory conditions.

Prey	1st instar larvae	2nd instar larvae	3rd instar larvae	4th instar larvae	Adult stages	General mean
R. padi	2.6±0.68 b	4±1.58 b	10.2±1.4 c	17±3.1 c	12±1.58 c	9.16±1.3 c
A. gossypii	4.6±0.81 ab	11±1.14 a	25.6±3.93 a	40.6±5.24 a	32±5.17 a	22.76±3.12 a
M.persicae	5.6±0.75 a	11.6±1.44 a	18.2±2.56 b	23.8±2.97 b	17.4±1.94 b	15.32±1.53 b
T. tabaci	1.6±0.68 b	3±0.84 b	3.8±0.97 d	5±1.4 d	8.8±1.46 d	4.44±0.66 c
F values	6.231	17.988	14.462	18.796	12.011	17.78
L.S.D. 5%	2.1928	3.201	7.477	10.3213	8.8809	5.2791

Means in each column followed by different letters are significantly different at $P < 0.05$

Table (5): Voracity (number of eaten prey ± SE) of *Coccinella septempunctata* stages provided with 100 individuals of four preys under laboratory conditions.

Prey	1st instar larvae	2nd instar larvae	3rd instar larvae	4th instar larvae	Adult stages	General mean
R. padi	4.2±0.37 b	8.4±0.82 bc	15.4±1.8 c	19.6±1.44 c	14.2±1.53 c	12.36±1.23 c
A. gossypii	7.6±1.08 a	15.6±1.96 a	35.6±2.78 a	51.4±4.26 a	37.6±2.48 a	29.56±3.42 a
M.persicae	5.4±0.87 ab	10.8±1.24 b	23±2.39 b	30.2±3.1 b	23.8±2.58 b	18.64±2.08 b
T. tabaci	1.4±0.6 c	2.2±0.73 c	5.2±0.86 d	8.6±1.3 d	13.2±1.46 d	6.12±1 d
F values	11.036	18.818	37.602	42.356	29.685	21.673
L.S.D. 5%	2.3319	3.851	6.5438	8.4024	6.2312	6.029

Means in each column followed by different letters are significantly different at $P < 0.05$

Table (6): Voracity (number of eaten prey ± SE) of *Coccinella septempunctata* stages provided with 150 individuals of four preys under laboratory conditions.

Prey	1st instar larvae	2nd instar larvae	3rd instar larvae	4th instar larvae	Adult stages	General mean
R. padi	6.4±1.03[b]	10±1.3[b]	20.8±1.56[b]	30.2±1.83[b]	20±1.82[bc]	17.48±1.84[b]
A. gossypii	9.4±1.17[a]	19.6±1.81[a]	42.6±2.79[a]	55.4±3.16[a]	38.4±2.46[a]	33.08±3.5[a]
M.persicae	5.6±0.93[b]	12±1.58[b]	26.4±2.42[b]	32.8±2.91[b]	26.4±2.01[b]	20.64±2.24[b]
T. tabaci	1.8±0.66[c]	3±0.71[c]	8.4±1.5[c]	10.8±1.98[c]	17.2±1.69[c]	8.24±1.28[c]
F values	10.523	23.429	43.967	51.948	21.842	18.897
L.S.D. 5%	2.8912	4.2292	6.416	7.5962	6.0445	6.6283

Means in each column followed by different letters are significantly different at P < 0.05

The seven-spot ladybird, *C. septempunctata* behaved aggressively and their feeding was more voracious on these preys whereas the general means of consumed individuals of *A. gossypii* reach 22.76±3.12, 29.56±3.42 and 33.08±3.5 individuals/day. While these means recorded 15.32±1.53, 18.64±2.08 and 20.64±2.24 individuals/day for *M. persicae* and 9.16±1.3, 12.36±1.23 and 17.48±1.84 individuals/day for *R. padi*. The least preferable prey species for *C. septempunctata* was *T. tabaci* which recorded 4.44±0.66, 6.12±1 and 8.24±1.28 individual/day in 50, 100, 150 prey density, respectively.

Feeding potential of the two ladybird beetles predators was significantly dependent on prey species. Similar observations were recorded by Singh and Singh (1993, 1994) who reported that larvae of ladybird beetle *(C. septempunctata)* behaved aggressively and their feeding was voracious on aphids. Other studies reported that *C. septempunctata* is considered a potent predator for many aphid species (Hagen, 1987; Omkar and Srivastava, 2003 ; Kalushkov and Hodek, 2004). The differences in the numbers of prey individuals consumed by the two lady beetle species may be due to the size of prey (Finlayson, *et al.* 2010). The smallest insect that has been tested in this work was a cotton aphids followed by green peach aphids and finally the bird cherry-oat aphid. Also the consumed numbers of preys may be affected by nutritional suitability of prey (Houck , 1991 and Roger *et al*. 2001), or chemical deterrence (Nishida and Fukami 1989).

Effect of larval instars of *the two predators* on prey consumption :

As the grubs of *C. septempunctata* and *C. undecimpunctata* developed from 1st to 4th larval instars, the mean consumption of individuals of its hosts from aphid species and thrips increased and its feeding potential was significantly prey and predator-stage dependent (Tables 7 & 8). The consumption individuals of *M. persicae*, *A. gossypii*, *R. padi* and *T. tabaci* significantly increased with the advancement in the larval stage of the predator from instar to the following other. The forth larval instar of *C. septempunctata* and *C. undecimpunctata* exhibited the highest predatory potential comparing to the first, second and third larval instars. Obtained results (fourth instar fed voraciously) are in agreement with the results of Dixon *et al.* (1997), Dixon (2000), Singh and Singh (1993, 1994),

Srivastiva *et al*. (1987) and Solangi, *et al*. (2007) who stated that the number of aphids consumed per day per larva varied from 1st to 4th instar and they reported that among all larval stages, 4th instar was difficult to provide enough aphids to satisfy their voracious appetites. Ali and Rizvi (2007) and Arshad *et al*. (2017) found that adults of *Coccinella septempunctata* consumed more aphids than grubs.

Table (7): Means of consumed individuals of four prey species (*R. padi*, *A. gossypii*, *M. persicae* and *T. tabaci*) by *C. undecimpunctata*:

Instars	Prey density		
	50 preys	100 preys	150 preys
1st larvae	2.15±0.27[c]	3.5±0.53[b]	5±0.76[c]
2nd larvae	4.35±0.58[c]	6.2±0.81[b]	8.4±1.02[c]
3rd larvae	8.9±1.09[b]	11.55±1.56[a]	14.85±1.82[b]
4th larvae	12.3±1.5[a]	14.5±1.74[a]	20.65±2.56[a]
Adult	11.5±1.17[ab]	14.65±1.57[a]	19.3±2.25[ab]
F values	18.754	14.190	13.947
L.S.D.5%	2.8806	3.7439	5.1092

Means in each column followed by different letters are significantly different at $P < 0.05$.

Table (8): Means of consumed individuals of four prey species (*R. padi*, *A. gossypii*, *M. persicae* and *T. tabaci*) by *C. septempunctata*

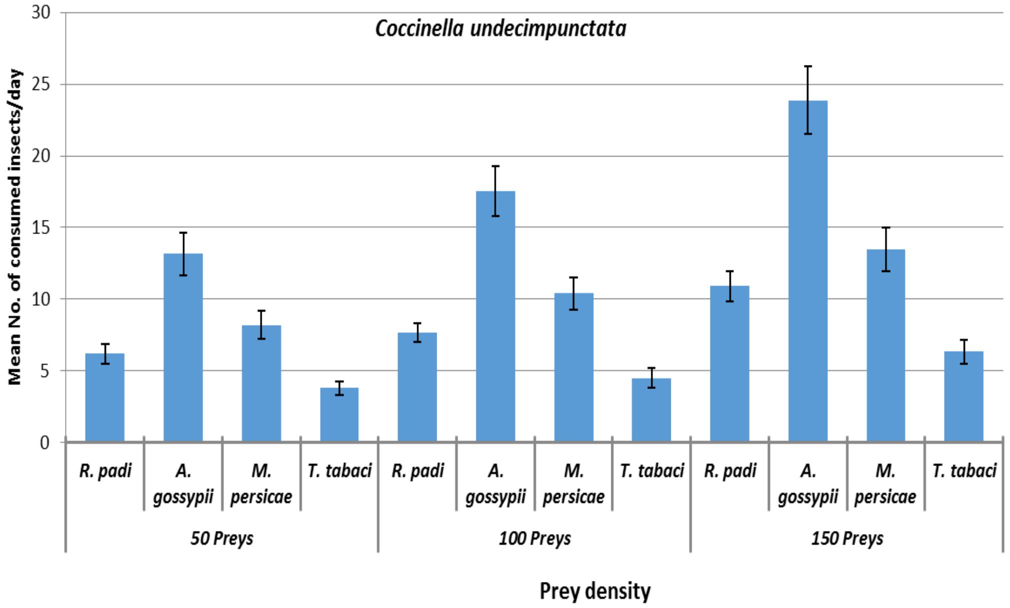
Instars	Prey density		
	50 preys	100 preys	150 preys
1st larvae	3.6±0.49[c]	4.65±0.63[c]	5.8±.76[c]
2nd larvae	7.4±1.02[c]	9.25±1.25[c]	11.15±1.5[c]
3rd larvae	14.45±2.2[b]	19.8±2.72[b]	24.55±2.99[b]
4th larvae	21.6±3.35[a]	27.45±3.85[a]	32.3±3.81[a]
Adult	17.55±2.45[ab]	22.2±2.44[ab]	25.5±2.09[ab]
F values	11.586	14.779	19.674
L.S.D. 5%	6.0677	6.8909	6.9491

Means in each column followed by different letters are significantly different at $P < 0.05$

Effect of prey density on the consumption rates of *C. septempunctata* and *C. undecimpunctata:*

The number of prey eaten by different instars of larvae of *C. septempunctata* and *C. undecimpunctata* and/or adult stage increased significantly with prey density (Fig. 1) reaching the maximum value when 150 preys were provided (for one jar).

At higher prey densities encounters rates are more frequent and consequently predators consume considerably more than the minimum required, this fact may be explain the increase in number of prey individuals consumed with increasing density. Obtained results are in agreement with published results in this manner (Ali, *et al.,* 1994, Omkar and Pervez, 2004, Bahy El-Din, 2006 and Cabral, *et al*. 2009).



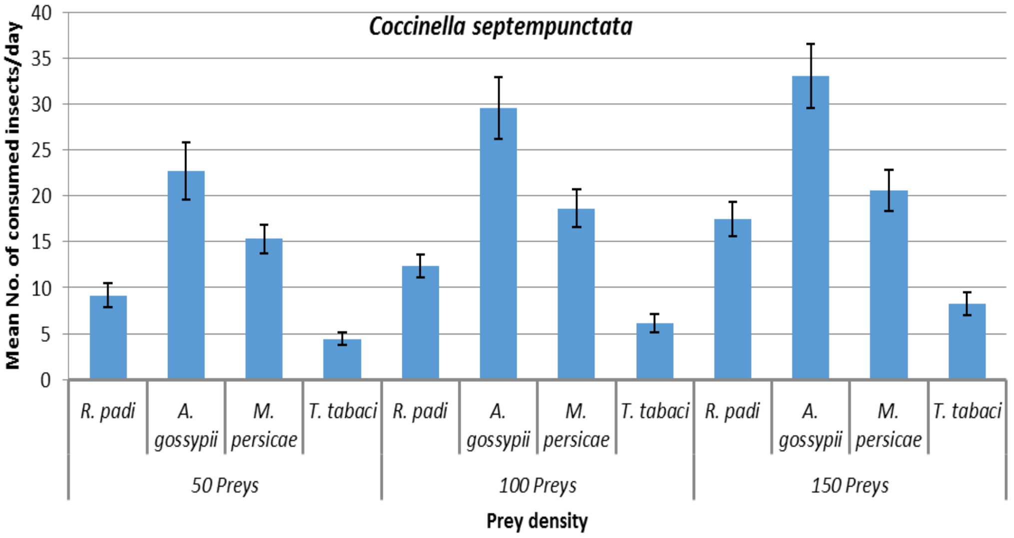


Fig. (1): Voracity (number of prey eaten ± SE) of *C. undecimpunctata* and *C. septempunctata* stages fed on three densities (number of provided preys) of four prey species under laboratory conditions

Conclusion:

In general, using of such natural enemies (*C. septempunctata* and *C. undecimpunctata*) in IPM programs can be useful with other safe alternative control methods. This will decrease the application of harmful pesticides and allow these natural enemies to do their role successfully in the field. Also, it was observed that *C. septempunctata* consumed large numbers of prey comparing to *C. undecimpunctata* in all trails in despite of the similarity in feeding behavior of both predators (devouring the entire body of the prey). Also, the obtained results reveal to the clear preference of the two predators for the aphid species than *thrips tabaci.*

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الكفاءة الافتراسية والتفضيل الغذائى لحشرتي أبوالعيد ذو السبع نقاط *Coccinella septempunctata* وأبوالعيد ذو الاحدي عشر نقطة *Coccinella undecimpunctata* علي بعض أنواع الفرائس

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تم إختيار الكفاءة والتفضيل الافتراسي لكلا من اليرقات والحشرات البالغة للمفترسين أبوالعيد ذو السبع نقاط *Coccinella septempunctata* وأبوالعيد ذو الاحدي عشر نقطة *Coccinella undecimpunctata* علي كل من حشرات مّن الخوخ الأخضر *Myzus persicae* ومّن القطن *Aphis gossypii* ومّن الشوفان *Rhopalosiphum padi* وتربس البصل *Thrips tabaci* تحت ظروف المعمل وذلك تحت كثافات مختلفة للفرائس الحشرية.

وقد وجد أن هناك فروق معنوية بين الافراد التي تم افتراسها للأنواع الاربعة بالنسبة للمفترسين الحشريين وكانت أكثر انواع الفرائس تفضيلا بالنسبة للمفترس أبو العيد ذو الاحدي عشر نقطة هي حشرة مّن القطن يليها حشرة مّن الخوخ الأخضر ثم مّن الشوفان وأخيرا تربس البصل. هذه النتائج تكررت مع المفترس أبوالعيد ذو السبع نقاط ولكنه كان أكثر إفتراسا وشراهة في التغذية من المفترس أبو العيد ذو الاحدي عشر نقطة. وأيضا تم اختبار الكفاءة الإفتراسية للأعمار المختلفة للمفترسيين الحشريين وقد وجد أن هناك إختلافات معنوية بين الأربع أعمار يرقية في قدرتها الإفتراسية للمفترسات الأربع حيث تزيد القدرة الإفتراسية مع تقدم اليرقة في العمر وأكثر الأعمار إفتراسا هو العمر الرابع لليرقة. ووجد أيضا أن كثافة الفرائس بالنسبة لوحدة الحجم تؤدي الي إختلافات في قدرة المفترس حيث تزيد القدرة الإفتراسية بزيادة كثافة الفريسة.

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