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BIOLOGICAL PARAMETERS OF THE TWO COCCINELLID PREDATORS, *Exochmus nigromaculatus* (GOEZE) AND *Hippodamia convergens* GEUR. REARED ON CERTAIN APHID SPECIES UNDER CONTROLLED CONDITIONS.

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ABSTRACT

Laboratory experiments were carried out to study certain biological parameters of the two coccinellid predators, *Exochomus nigromaculatus* (Goeze) and *Hippodamia convergens* Geur. when reared on the following aphid species; *Machrosiphum pisi* (Harris) ; *Rhopalosiphum maides* (Fitch) ; *Aphis durantae* Theobald and *Aphis nerii* Boyer de Fonscolombe under controlled conditions.

The data revealed that the total developmental time from egg hatching to adult eclosion of the two coccinellid predators were differed significantly when reared on the four tested aphid species. Mortality percentage of *E. nigromaculatus* from egg hatching to adult emergence ranged from 9.70 % when fed on *M. pisi* to 15.8 % on *A. nerii*, while with *H. convergens*, it varied from 8.5 % on *M. pisi* to 17.96 % on *A. nerii*. Based on statistical analysis, the mortality percentage showed significant difference among the four aphid species. The total consumption rate per *E. nigromaculatus* larva from the four aphid species were 207.67 ± 4.53 ; 364.40 ± 7.56 ; 443.93 ± 8.45 and 400.85 ± 10.72 aphid individuals when reared on *M. pisi* ; *R. maides* ; *A. durantae* and *A. nerii*, respectively. The average numbers consumed from the four tested aphid species during larval stage of *H. convergens* were 341.58 ± 8.15 ; 569.42 ± 19.72 ; 693.15 ± 22.54 and 468.32 ± 10.89 aphid individuals when fed on *M. pisi* ; *R. maides* ; *A. durantae* and *A. nerii*, respectively. The average number of aphids consumed per larva for the two coccinellid species was also significantly different.

The aphid species have a significant effect on the longevity of adult stage of the two coccinellid predators and the fecundity of their females. The average number of eggs deposited per *E. nigromaculatus* female was 322.45 ± 8.75 ; 280.45 ± 6.30; 253.86 ± 4.65 and 171.62 ± 5.24 eggs when reared on *M. pisi*; *R. maides* ; *A. durantae* and *A. nerii*, respectively. While that was 650.48 ± 12.85 ; 596.78 ± 9.43 ; 542.78 ± 9.3 and 211.51 ± 5.10 eggs when the *H. convergens* females fed on *M. pisi* ; *R. maides* ; *A. durantae* and *A. nerii*, respectively. The statistical analysis showed that the aphid species have a highly significant effect on the female fecundity. It can be recommended that the coccinellid predators used as biological control agents against the four aphid species tested.

INTODUCTION

Many authors supported the use of safe alternative control methods such as biological control in some cases. Predators as one of the major groups of natural enemies play a noticeable role against different insect pests. (Hafez, 1994 ; Ahmed *et al.*, 2001). Predators belonging to family Coccinellidae, comprise one of the most active groups of predatory species, that feed on different sucking pests including aphids, whiteflies, jassids and

mites as well as other soft bodied insects. This family gained the interest of many investigators as important group of predators in the biological control of insect pests attacking different crop plants (Hodek *et al.*, 1972 ; Hodek, 1973).

The efficiency of the coccinellid predator *Exochomus nigromaculatus* (Goeze) and *Hippodamia convergens* Geur. as a biological control agent has been studied by few number of investigators in different parts of the world (Hammalainen *et al.*,1975 ; Selim, 1977; Tassan, 1982; Ghanim and El-Adl, 1987; Kanika-Kiamfu *et al.*, 1994; Atlihan and Ozgoke, 2002; Saleh, 2005).

The existence of *E. nigromaculatus* in many citrus species, ornamental plants and field crops attracted our attention especially as few previous studies had been carried out on its predacious efficiency from the literature it is obvious that *H. convergens* exits in a wide rang of plantations such as field crops vegetable plants and orchards (Kring and Gilstrap, 1986; Lind, 1988; Rodriguez and Miller, 1995; Hafez and El-Khayat, 1996; EL-Habi *et al.*, 2000 ; Hafez, 2001; Cardos and Lazzari, 2003; Prasifka *et al.*, 2004). Therefore, this investigation was undertaken to investigate the duration and feeding capacity of different stages as well as female fecundity of these two predators under controlled conditions.

MATERIALS AND METHODS

Experiments were carried out at the laboratory of Economic Entomology Department, Faculty of Agriculture, Mansoura University under 25 ± 2 °C and 70 ± 5.0 % R.H. . Four aphid species,namely, *Macrosiphum pisi* (Harris), *Rhopalosiphum maides* (Fitch), *Aphis durantae,* Theobald and *Aphis nerii* Boyer de Fonscolombe were used as preys for the two coccinellid predators, *Exochomus nigromaculatus* (Goeze) and *Hippodamia convergens* Geur. The predators and the prey individuals were obtained from a maintained culture in the Insectary.

A . Larval experiments :

Newly hatched predator larvae from the two coccinellids were put individually in a Petri-dish (10 cm. diameter) with a filter paper on its bottom. Twenty replicates from each were reared on four aphid species. Known surplus numbers of prey species were offered and the devoured individuals were replaced daily. Attacked prey individuals were counted and recorded daily throughout the periods of the larval instars.

B . Adult experiments :

After emergence from the pupae, each predator adults were sexed and then introduced singly into a Petri-dish . Known numbers of the four aphids were offered daily on a plant leaflet to each predator. Counting and removing the un-devoured aphids in each Petri-dish were practiced before introducing the new aphid individuals. After five days of emergence, copulation took place and the two sexes were immediately separated and kept singly in the dishes. Daily numbers of laid eggs per predator female during its ovipositional period was counted. In addition, the total number of

eggs laid per predator female was estimated. The daily averages of prey consumption throughout adults longevities were calculated.

C . Data analysis :

Data for the developmental time of immature stages mortality, pre-oviposition, oviposition, post-oviposition periods, fecundity, male longevity, consumption rate of the two coccinellid predators reared on the tested aphid species were subjected for one way analysis of variance (ANOVA), and the means were separated using Duncan's Multiple Range Test (CoHort Software, 2004).

RESULTS AND DISCUSSION

1. Developmental time of immature stage :

A . *Exochomus nigromaculatus*

Data in Table (1) indicated that the incubation period of *E. nigromaculatus* varied from 4.52 ± 0.38 to 5.32 ± 0.48 days with significant difference among the four tested aphid species. Considering the developmental time of larval instars, the shortest developmental time was obtained when larvae reared on *M. pisi* (13.56±1.42 days), while the longest time was recorded on *A. nerii* (18.43±1.67 days). The developmental of larval instars showed a significant variation among the four aphid species (Table 1). Among the tested aphid species, there were significant differences between developmental times of pupal stage. The longest time was observed with *A. nerii*, while the shortest time was obtained with *M. pisi*. The total developmental time (from egg hatching to adult eclosion) was ranged from 23.02 ± 1.8 days by rearing on *M. pisi* to 30.22± 2.9 days by feeding on *A. nerii* with significantly differed. Mortality percentage from egg to adult ranged from 9.70 % when reared on *M. pisi* to 15.80 % with *A. nerii*. There were significant variations among the four tested aphid species. These findings agree with that of Lotfalizadeh *et al.* (2000) who found that the larval stage period was 20.97 days and the pupal period lasted 6.13 days when reared on *P. vovae*.

B . *Hippodamia convergens*

The ANOVA indicated that there were statistically significant differences concerning egg incubation of *H. covergens* (Table1). Developmental time of larval instars were significantly shorter by feeding on *M. pisi* than the other aphid species. While the longest time was addressed when larvae reared on *A.nerii*. Based on statistical analysis, the duration of pupal stage showed a significant difference among the four aphid species. The total developmental time (from egg hatching to adult emergence) was significant difference between the four tested aphid species (Table 1). Mortality percentage of this predator varied from 8.5% when larvae fed on *M. pisi* to 17.96 % on *A. nerii*. Based on statistical analysis, the mortality percentage showed significant difference among the four aphid species. Similar results were found by Lind (1988) who reported that the duration of *H. convergens* lasted 5.0 , 20.0 and 5.0 days for the eggs, larval and pupal stages, respectively when fed on aphids. Mohammed (2001) found that the

average period of *H. tridecimpunctata* larvae was lasted 9.24 ± 1.01 days when reared on *Aphis craccivora* at 27.2 °C and 63.68 % R.H. .The average incubation period of *H. tredecimpunctata* eggs was 4.4 ± 0.22 days. The durations of larval and pupal stages were 16.47 ± 0.17 and 8.6 ± 0.19 days. Bahy EL-Din, (2006) recorded that the average of duration periods of *H. convergns* lasted 4.32 ±12.0 ; 8.84 ± 0.27 and 4.36 ± 0.11 days for the eggs ; larval and pupal stages, respectively when the larvae of this predator fed on the 4 th nymphal instar of *A. craccivora*.

Table (1): Duration (in days)[a] (means ±SD) of the developmental stages of two coccinellid predators reared on certain aphid species under controlled conditions.

Predator species	Prey species	Incubation period	Larval instars					Pupal stage	Total of immature stages	Mortality %
			1st	2nd	3rd	4th	Total			
E. nigromaculatus	*M. pisi*	4.52± 0.38 C	2.46± 0.36 b	2.10± 0.31d	3.52± 0.62c	5.48± 0.85 d	13.56± 1.42 C	5.94± 0.46d	23.02± 1.8 C	9.70 c
	R. maides	4.96± 0.42 ab	2.96± 0.41 a	2.42± 0.37C	3.96± 0.85b	6.27± 1.54 c	15.61± 1.95 bc	6.27± 0.52 c	26.94± 1.96 b	11.50 bc
	A. durantae	5.32± 0.48 a	3.21± 0.52 a	2.64± 0.41b	4.25± 0.96a	6.97± 1.98 b	17.07± 2.10 ab	6.54± 0.61b	28.93± 2.7 ab	12.8 b
	A. nerii	4.58± 0.32 bc	3.4± 0.25 a	2.95± 0.21a	4.36± 0.24a	7.75± 0.46 a	18.43± 1.67 a	7.21± 0.64 a	30.22± 2.9 a	15.80 a
H. convergens	*M. pisi*	3.96± 0.21 b	2.17± 0.36 d	1.53± 0.24d	2.10± 0.35d	3.42± 0.51 d	9.22± 1.02 C	5.47± 0.35d	18.65± 1.62 C	8.5 c
	R. maides	4.22± 0.24 b	2.85± 041 C	1.92± 0.35C	2.53± 0.52c	3.83± 0.63 C	11.13± 1.26 bc	5.86± 0.41 c	21.21± 1.75 b	10.35 c
	A. durantae	4.35± 0.26 b	3.10± 0.50 b	2.05± 0.42b	2.67± 0.46b	4.35± 0.90 b	12.17± 1.06 b	5.98± 0.51b	22.50± 1.94 b	13.75 b
	A. nerii	5.82± 0.50 a	3.75± 0.61a	2.58± 0.46a	3.42± 0.82a	6.57± 0.97 a	16.32± 1.62 a	6.96± 0.85 a	29.30± 2.10 a	17.96 a

[a] **Means followed by the same letter in a column for each coccinellid predator are not significantly different at the 1 % level of probability (Duncan's Multiple Range Test).**

2. Feeding capacity:

A . *Exochomus nigromaculatus*

Data in Table (2) show the consumption period rate of *E. nigromaculatus* larval instars when reared on four aphid species. The average number of aphids consumed during first instar larvae varied from 14.61± 0.50 individuals of *M. pisi* to 27.35 ± 1.26 individuals of *A. durantae*. Consumption percentage differed between 5.28 % on *A. nerii* to 7.04 % on *A. pisi*. There were apparent differences in average numbers of the four consumed aphid species and consumption percentage by the second instar larvae. In addition, the same trend was obtained with the third and fourth instars larvae. The total consumption rate from the four aphid species by the larval stage of *E. nigromaculatus* showed significant difference. Concerning to the food preference for predator larvae among tested aphid species, *A. durantae* came first, followed by *A. nerii*, *R. maids* and *M. pisi*. The average number of consumed aphid per larvae was also significantly different.

B . *Hippodamia convergens*

The consumption rate of *H. convergens* larval instars is given in Table (2). Based on ANOVA analysis, there were considerable differences among the fourth instars larvae concerning the average numbers of consumed aphid per larva. Larvae of this predator during the fourth larval instars consumed an average of 341.58 ±8.15 ; 569.42 ± 19.72 ; 693. 15 ±22.54 and 468.32 ± 10.89 individuals from *M. pisi* ; *R. maides* ; *A. durantae* and *A. nerii*, respectively. Data also revealed that the highest numbers of consumed aphid species by larvae were 693.15 ± 22.54 individuals from *A. durantae*, while the lowest numbers were obtained on *M. pisi* (Table 2). Our results are in general agreement with those addressed by Campbell and Cone (1999) who found that the larvae of *H. convergens* consumed an average of 318 adults of the damson hop aphid, *Rhordon humuli* during its development at 20°C. Cardos and Lazzari (2003) found that the predator *H. convergens* especially in the fourth larval instars showed highest consumption capacity on nymphs of aphid, *Cinara* spp. Bahy EL-Din (2006) recorded that the *H. convergens* larvae consumed an average of 340.25 ± 3.79 fourth nymphal instar of *A. craccivora* during its larval stage.

Table 2: Mean numbers consumed (±SD) and percentage from different aphid species during larval instars of two coccinellid predators under controlled conditions.

Predator species	Prey species	Larval instars								Total
		1st		2nd		3rd		4th		
		No.	%	No.	%	No.	%	No.	%	
E. nigromaculatus	*M. Pisi*	14.61± 0.50 C	7.04a	21.48± 1.38 C	10.33 a	54.42± 2.50 d	26.21 a	117.16± 3.41 d	56.42 c	207.67± 4.53 d
	R. maides	21.79± 0.90 b	5.98 b	35.45± 1.50 b	9.73 a	78.49± 3.62 b	21.54 b	228.67± 4.96 C	62.75 b	364.40± 7.56 C
	A. durantae	27.35± 1.26 a	6.16 b	44.22± 2.50 a	9.96 a	89.17± 4.18 a	20.09 c	283.19± 5.78 a	63.79 b	443.93± 8.45 a
	A. nerii	21.15± 1.75 b	5.28c	34.93± 2.04 b	8.71 b	68.71± 3.25 C	17.14 d	276.06± 5.76 b	68.87 a	400.85± 10.72 b
H. convergens	*M. pisi*	18.99± 0.82 d	5.56 c	34.61± 1.65 d	10.13 a	55.59± 2.40 d	16.27 b	232.39± 5.78 d	68.04 a	341.58± 8.15 d
	R. maides	36.74± 2.30 C	6.45 b	55.45± 4.50 b	9.74 ab	88.56± 6.22 C	15.55bc	388.67± 10.53 b	68.26 a	569.42± 19.72 b
	A. durantae	48.04± 5.37 a	6.64 b	62.87± 6.75 a	9.07 b	103.04± 10.72 a	14.87 c	481.20±2 0.19 a	69.42 a	693.15± 22.54 a
	A. nerii	40.37± 3.96 b	8.62a	48.09± 3.79 C	10.27 a	98.33± 8.56 b	21.00 a	281.53± 15.67 C	60.11 b	468.32± 10.89 C

[a] **Means followed by the same letter in a column for each coccinellid predator are not significantly different at the 1 % level of probability (Duncan's Multiple Range Test).**

3. Longevity and fecundity of adult stage :

A. *Exochomus nigromaculatus*

Data in Table (3) and Figure (1) showed that the mean male longevity of this predator was significantly longer when fed on *A. nerii*, than when reared on *A. durantai* , *R. maids* and shortest on *M. pisi*. Concerning the female, there were significant differences in the total longevity periods of *E. nigromaculatus* when reared on the tested aphid species (Table 3). Also, the aphid species have a significant effect on female fecundity. The highest numbers of eggs were obtained when females fed on *M. pisi* followed by *R. maides* and *A. durantae*, while the lowest numbers were achieved on *A. nerii*

(Table 3 and Figure 1). Remzi and Bora (2002) indicated that the total number of eggs per female was 428.5 which lasted 75.3 days. Whereas Saleh (2005) recorded that the number of eggs were 310.75 ± 11.64 eggs during the oviposition period which lasted 32.85 ± 2.97 days.

B . *Hippodamia convergens* :

Male longevity of *H. convergens* reared on *A. nerii* were significantly longer than males fed on *A. durantae* ; *R. maides* and *M. pisi*, respectively. Pre-oviposition period of female ranged from 5.51± 0.62 days on *M. pisi* to 8.75 ± 1.05 days on *A. nerii*. The ANOVA indicated that prey species have insignificant effects on the duration of oviposition period (Table 3). Post-oviposition period ranged from 6.35 ± 0.71 days when females reared on *M. pisi* to 15.73 ± 1.26 days on *A. nerii*. The total longevity of *H. covergens* females varied from 40.53 ± 3.42 days to 55.44 ± 4.05 days and appear to influenced by aphid species. When *M. pisi* individuals were offered for females, higher oviposition rate was obtained rather than the other three tested aphid species (Table 3 and Figure 2). Rodriguez and Miller (1995) showed that when *H. convergens* fed on *Acyrthosiphon pisum*, the fecundity of female was 344 eggs, being fewer than those recorded in the present study. Hafez (2001) found that the female of *H. convergens* deposited an average of 306.2 ± 38.66 (173-538) eggs throughout an ovipositional period of 40.38 ± 3.27 (26-56) days. Our results are in agreement with those addressed by Bahy El-Din (2006).

Table 3: Longevity (in days)[a] and fecundity of the two coccinellid predatory insects reare on four aphid species under controlled conditions.

Predator species	Aphid species	Female longevity				Male longevity	Female fecundity	
		Pre-oviposition	Oviposition	Post-oviposition	Total		Daily	Total
E. nigromaculatus	*M. pisi*	7.65± 0.96 b	29.56± 1.98 c	5.32± 1.05 c	42.53± 3.78 d	35.68± 2.46 d	10.91a	322.45±8.75 a
	R. maides	8.93± 1.0231 a	31.56± 2.75 b	6.85± 1.62 b	47.34± 3.81 c	38.56± 3.95 c	8.89 b	280.45±6.30 b
	A. durantae	8.98± 1.05 a	33.82± 4.27 a	7.57± 0.83 b	50.37± 5.86 b	40.16± 4.62 b	7.51c	253.86±4.65 c
	A. nerii	8.51± 1.21 ab	30.75± 5.17 b	16.84± 1.15 a	56.10± 6.75 a	44.16± 3.78 a	5.58 d	171.62±5.24 d
H. convergens	*M. pisi*	5.51± 0.62 b	28.67± 2.10 d	6.35± 0.71 d	40.53± 3.42 d	31.21± 2.14 d	22.69 a	650.48±12.85 a
	R. maides	6.73± 0.83 b	32.56± 2.56 b	7.34± 0.91 c	46.63± 4.75 c	35.85± 2.69 c	18.33 b	596.78±9.43 b
	A. durantae	7.24± 0.91 b	35.28± 3.20 a	9.62± 1.20 b	52.14± 3.62 b	41.57± 2.93 b	15.38 c	542.78±9.30 c
	A. nerii	8.75± 1.05 a	30.96± 2.95 c	15.73± 1.26 a	55.44± 4.05 a	45.72± 3.16 a	6.83 d	211.51±5.10 d

[a] **Means followed by the same letter in a column for each coccinellid predator are not significantly different at the 1 % level of probability (Duncan`s Multiple Range Test).**

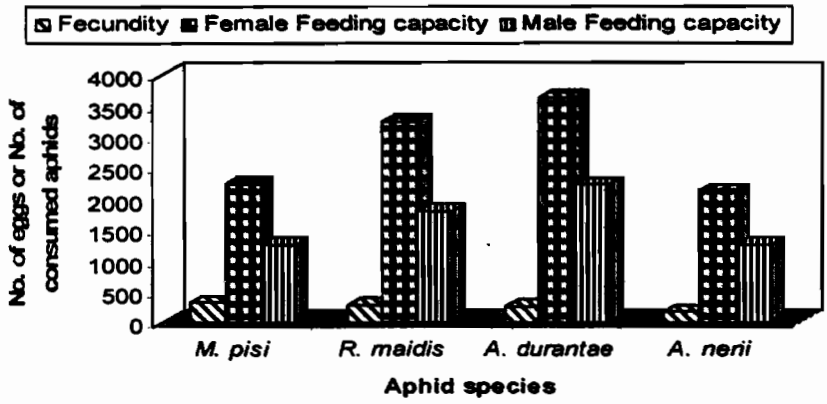

Fig. (1) : Feeding capacity and fecundity of *E. nigromaculatus* adults reared on four aphid species under controlled conditios.

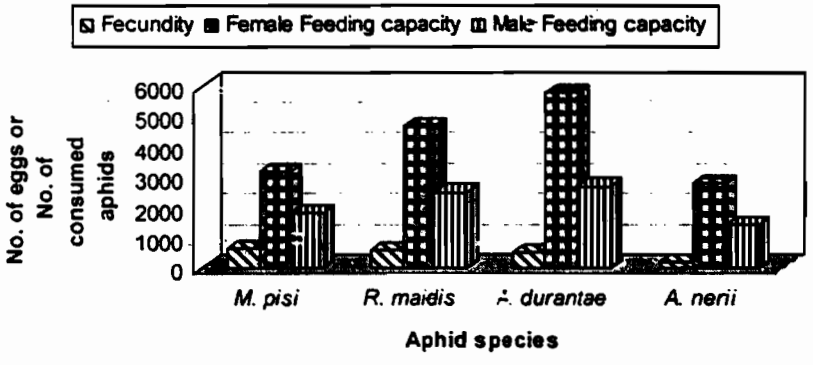

Fig. (2) : Feeding capacity and fecundity of *H. covergens* adults reared on four aphid species under controlled conditios.

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المقاييس البيولوجية لمفترسى أبو العيد *Exochmus nigromaculatus* و *Hippodamia convergens* عند تربيتهما علي بعض أنواع من حشرات المنّ تحت درجات حرارة ثابتة

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أجريت دراسات معملية لدراسة بعض الخصائص البيولوجية لمفترسى أبو العيد *E. nigromaculatus* ; *H. convergens* عند تربيتهما علي أربعة أنواع من المن هى منّ البسلة ــ منّ الذرة ــ منّ الدورانتا ــ و منّ التفلة تحت درجة حرارة ثابتة

اوضحت النتائج أن فترة النمو من فقس البيض حتى خروج الحشرات الكاملة لمفترس ابو العيد *E. nigromaculatus* اختلفت معنويا عند تربيتها على الاربعة أنواع من المنّ المختبرة وكانت النسبة المئوية للموت من فقس البيض و حتي خروج الحشرات الكاملة للنوع *E. nigromaculatus* تراوحت بين ٩,٧ % عند تغذيتها علي حشرة من البسلة بينما كانت ١٥,٨ % عند التغذية علي من التفلة بينما بالنسبة للنوع *H. convergens* اختلفت هذه النسبة من ٨,٥ % عند التغذية علي منّ البسلة إلي ١٧,٩٦ % عند التغذية علي منّ التفلة ولقد أوضحت نتائج التحليل الإحصائي أن هناك اختلافات معنوية واضحة بين النسب المئوية للموت عند التربية علي الأربعة أنواع من المنّ المختبرة . و لقد بلغ معدل التغذية الكلي ليرقة المفترس *E. nigromaculatus* هو ٢٠٧,٦٧ ± ٤,٥٣ , ٣٦٤,٤ ± ٧,٥٦ , ٤٤٣,٩٣ ± ٨,٤٥ , ٤٠٠,٨٥ ± ١٠,٧٢ فردا من المنّ عند تربية هذا المفترس علي منّ البسلة ومنّ الذرة و منّ الدورانتا و منّ التفلة علي التوالي , و بلغ متوسط الأعداد المستهلكة من المنّ ليرقة المفترس *H. convergens* ٣٤١,٥٨ ± ٨,١٥ , ٥٦٩,٤٢ ± ١٩,٧٢ , ٦٩٣,١٥ ± ٢٢,٥٤ , ٤٦٨,٣٢ ± ١٠,٨٩ فردا من المنّ عند تغذيته علي منّ البسلة ومنّ الذرة و من الدورانتا و من التفلة على التوالي . أظهر التحليل الإحصائي أن هناك اختلافات معنوية واضحة في المنّ المستهلك لكلا المفترسين عند التغذية علي الأربعة أنواع من المن المختبرة. أيضا وجد تأثير لأنواع المنّ الأربعة علي طول فترة حياة الحشرات الكاملة و كفائتها التناسلية لكل من المفترسين حيث كان متوسط عدد البيض الذي وضعته أنثي المفترس *E. nigromaculatus* ٣٢٢,٤٥ ± ٨,٧٥ , ٢٨٠,٤٥ ± ٦,٣ , ٢٥٣,٨٦ ± ٤,٦٥ , ١٧١,٦٢ ± ٥,٢٤ بيضة عند تغذيته علي منّ البسلة و منّ الذرة و منّ الدورانتا و منّ التفلة علي التوالي . و لقد أوضحت نتائج التحليل الإحصائي أن هناك فروق معنوية واضحة لتأثير أنواع المنّ الأربعة المختبرة علي الكفاءة التناسلية لكلا المفترسين و أشارت نتائج الدراسة أن كلا من مفترسي أبو العيد يمكن استخدامهما كعنصر من عناصر المكافحة الحيوية لمكافحة أنواع المنّ السابق الذكر .