

BIOLOGICAL CHARACTERISTICS OF THE COCCINELLID PREDATOR *Exochomus nigromaculatus* (GOEZE) REARED ON CERTAIN APHID SPECIES UNDER LABORATORY CONDITIONS.

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ABSTRACT

Experiments were carried out in the Laboratory of Economic Entomology Department, Faculty of Agriculture, Mansoura University, during the period of March 2003 till September 2004, to study certain biological characteristics of the predator *Exochomus nigromaculatus* (Goeze) reared on *Aphis nerii* (Boyer de Fonsconlonbe), *Rhopalosiphum maidis* (Fitch) and *Macrosiphum pisi* (Harris) under laboratory conditions. The obtained results showed that the duration period of the predator larvae averages were 17.1 ± 0.4 , 13.1 ± 0.40 and 13.7 ± 0.213 days when reared on the three tested aphid species, respectively.

The averages of the total consumption during the larval stage were 482.5 ± 25.46 , 384.4 ± 12.81 and 226.2 ± 18.54 aphid individuals when this predator reared on *A. nerii*, *R. maidis* and *M. pisi*, respectively.

During the longevity period of the predator adult female, which averaged 49.00 ± 6.84 days, 54.00 ± 6.67 days and 47.80 ± 6.99 days when reared on the three tested aphid species. The predator female consumed during its longevity period an average of 2168.20 ± 333.17 , 10156 ± 148.1 and 1231.20 ± 200.43 aphid individuals when fed on *A. nerii*, *R. maidis* and *M. pisi*, respectively.

The fecundity of the predator female was 83.00 ± 2.17 , 906.00 ± 10.47 and 211.60 ± 3.20 eggs, by rearing on the three previously aphid species. During the longevity period of the predator male, which averaged 37.40 ± 1.03 , 37.60 ± 1.73 and 37.40 ± 1.08 days, when this predator reared on *A. nerii*, *R. maidis* and *M. pisi*. The predator male consumed during its longevity period an average of 926.40 ± 19.29 , 4159.00 ± 25.23 and 749.80 ± 36.95 aphid individuals.

The statistical analysis showed that there were a highly significant differences on the biological aspects of *E. nigromaculatus* larvae and adult when reared on *A. nerii*, *R. maidis* and *M. pisi*.

In conclusion, *E. nigromaculatus* (larvae and adults) could be employed as the biological control agents against *A. nerii*, *R. maidis*, and *M. pisi*, because this predator has a short developmental time, a high survival rate, a high predation efficiency and reproductive capacity.

INTRODUCTION

Coccinellid predatory insects are candidates for biological control of aphid species, jassids, whiteflies, scale insects and other soft-bodies insects on several economic crops and have been proven to consume these species commonly found as pests. Mass production of coccinellid predators in biological control programs requires huge numbers at low costs. It is desirable to choose the predator, which has short developmental time, a high survival rate and a high reproductive capacity. Genus *Exochomus* is one of the important coccinellid predators and belonging to family Coccinellidae.

Several investigators in different parts of the world studied certain biological characters of genus *Exochomus* (Fabres and Kiyindou, 1985; Ghanim and El-Adl, 1987; El-Adl *et al.*, 1987; Kiyindou and Fabres, 1987; Shao and Jin, 1987; Ghanim and El-Adl, 1988; Umeh, 1990; Kamikakiam *et al.*, 1993 & 1994; Lotfalizaden *et al.*, 2000; Ru and Makosso, 2001; Atlihan and Ozyokce, 2002; Ru and Mitsipa, 2002; Arnold and Sengonca, 2003 and Sengonca and Arnold, 2003).

Exochomus nigromaculatus (Goez) is one of the most efficient coccinellid predatory insects attacking aphid species and scale insects. However, a little previous information were found in the literature concerning its efficiency on some aphid species in Egypt or in the world (Atlihan and Ozgoko, 2002 and El-Said, 2005).

Therefore, the aim of the current study was to evaluate certain biological characteristics of *E. nigromaculatus* when reared on some aphid species under laboratory conditions.

MATERIALS AND METHODS

Experiments were carried out in the Economic Entomology Department, Faculty of Agriculture, Mansoura University, Egypt, during the period from March 2003 till September 2004 under laboratory conditions of $27.0 \pm 1^\circ\text{C}$ and $70.0 \pm 5\%$ RH. Twenty newly hatched first instar larvae of the predator *E. nigromaculatus* were introduced singly into Petri-dishes of 9 cm diameter.

The bottom dishes were covered with a filter paper to facilitate the predator larval movements. A known number of aphid species namely; *A. nerii*, *R. maidis* and *M. pisi* were used as a prey for the predator. A small plant leaflet was replaced daily as a food for the aphids. The devoured aphid individuals were recorded. The rest of aphids and their parts were removed from each aphid species, and consumed aphids by larvae of this predator were recorded.

The mean number of consumed aphids by this predator larvae was also calculated. Just after emergence, five couple of the beetle were introduced singly in Petri-dishes. After five days of emergence, copulation were done and then the two sexes were separated and kept singly in the dishes. The technique of rearing the adult stage was the same as in the larval stage. The daily number of the laid eggs by female during the oviposition period was counted, and the total number from female was estimated. The daily averages of food consumption during the longevity of the predators was calculated.

The data of duration period of larval stage, average of total consumption per larva, percentage of feeding capacity per larval instar, percentage of mortality per larval instar, longevity of adult stage, feeding capacity and fecundity of adult were subjected for one way analysis of variance (ANOVA), and the means separated were using Duncan's Multiple Range Test (Costat Soft, 1990).

RESULTS AND DISCUSSION

1. Rearing on *A. nerii*:

A. Predator immature stages:

Larval stage:

Data in Table 1 indicated that the duration period of the larval stage averaged 17.1 ± 0.41 days. The average of the total consumption during the four larval instars were 35.3 ± 2.42 , 75.5 ± 6.75 , 157.3 ± 6.90 and 214.4 ± 9.41 aphid individuals, respectively, and the average of the total consumption per larva was 482.5 ± 25.46 aphid individuals.

The percentages of feeding capacity for each of the four larval instars of this predator were 7.32, 15.65, 32.60 and 44.43%, respectively. Therefore, it is obvious that, the third and fourth instar larvae of this predator represent together (76.86%) the backbone in predation activity. The percentages of mortality were 30, 13, 6 and 3% during the larval instars.

Table 1. Predation efficiency and larval duration of *Exochomus nigromaculatus* reared on *Aphis nerii* under laboratory conditions.

Immature stages	Duration (days)	Daily average consumption	Average of total consumption	% of feeding capacity	% of mortality
A. larval stage					
1 st instar	3.50 ± 0.17	10.13	35.30 ± 2.42	7.32	30
2 nd instar	3.70 ± 0.15	20.37	75.50 ± 6.75	15.65	13
3 rd instar	4.50 ± 0.17	35.00	157.30 ± 6.90	32.60	6
4 th instar	5.40 ± 0.16	39.00	214.40 ± 9.41	44.43	3
Total	17.10 ± 0.41	28.00	482.5 ± 25.46	100.00	
B. Pupal stage	6.75 ± 1.5				

Pupal stage:

The pupal period lasted for an average of 6.75 ± 1.5 days.

B. Adult stage:

Female:

The predator female fed on a total average of 2168.2 ± 333.18 aphid individuals, with a daily rate of 44.25 during the longevity period of 49.00 ± 6.85 days as seen in Table 2.

The average of the pre-oviposition period was 6.60 ± 0.23 days. The predator female consumed during this period 344.80 ± 16.75 , with a daily rate of 52.13 aphid individuals. The predator female consumed during the oviposition period on average of 1627.0 ± 15.68 aphid individuals, this period lasted an average of 32.20 ± 0.55 days with a daily rate of 50.52. The number of deposited eggs per predator female averaged 83.00 ± 2.17 eggs with a daily rate of 2.57 per day. During the post-oviposition period, the female consumed 196.40 ± 11.33 aphid individuals, this period lasted an average of 7.40 ± 0.64 days, with a daily rate of 26.54. The result showed that the feeding capacity of the predator female was always higher than that of the male as the female fed on 2.34 times of *A. nerii* more than the male (Table 2).

Table 2. Longevity, feeding capacity and fecundity of the predator *Exochomus nigromaculatus* adult reared on *Aphis nerii* under laboratory conditions

	Adult Stage	Period in days	Daily average consumption	Total consumption	No. of eggs	
					Daily	Total
Female	Pre-oviposition	6.60±0.23	52.13	344.80±16.75	2.57	83±2.17
	Oviposition	32.20±0.55	50.52	1627.0±15.68		
	Post-oviposition	7.40±0.64	26.54	196.40±11.33		
	Longevity	49.00±6.85	44.25	2168.2±333.18		
Male	Longevity	37.40±1.03	24.82	926.40±19.29		

Male:

During its longevity period, which lasted for an average of 37.40 ±1.03 days (Table 2). The predator adult male consumed a total average 926.40 ±19.29 aphid individuals with daily rate of 24.82.

2. Rearing on *R. maidis*:

A. Predator immature stages:

Larval stage:

Results presented in Table 3 illustrate the duration period of the larval stage averaged 13.70±0.30 days. The average of the total consumption during the four larval instar were 25.70 ±2.04, 45.30 ±2.18, 95.70 ±4.23 and 201.70 ±11.58 aphid individuals, respectively and the average of the total consumption per larva was 384.40 ±12.81 aphid individuals. The percentages of feeding capacity for each of the four larval instars of this predator were 6.98, 12.29, 25.98 and 54.75%, respectively. Therefore, it may be obvious that the third and fourth instar larval of this predator represent together (80.73%) the backbone in predation activity. The percentages of mortality were 15, 7, 2 and 2% during the larval instars.

Table 3. Predation efficiency and larval duration of *Exochomus nigromaculatus* reared on *Rhopalosiphum maidis* under laboratory conditions.

Immature stages	Duration (days)	Daily average consumption	Average of total consumption	% of feeding capacity	% of mortality
A. larval stage					
1 st instar	2.70±0.15	9.51	25.70±2.04	6.98	15
2 nd instar	2.70±0.15	16.77	45.30±2.18	12.29	7
3 rd instar	3.60±0.16	26.58	95.70±4.23	25.98	2
4 th instar	4.70±0.15	42.91	201.7±11.58	54.75	2
Total	13.70±0.30	26.89	368.4±12.81	100	
B. Pupal stage	5.82±0.75				

Pupal stage:

As clearly shown in Table 3, the pupal period lasted for an average of 5.82 ±0.75 days.

B. Predator adult stage:

Female:

The predator female fed on a total average of 10156±148.11 aphid individuals, with a daily rate of 188.07 during the longevity period of 54.00 ±6.67% days as seen in Table 4. The average of the pre-oviposition period was 7.00 ±0.00 days. The predator female consumed during this period 1641 ±5.89 with a daily rate of 234.42 aphid individuals. The predator female consumed during the oviposition period an average of 7099 ±22.57 aphid individuals, this period lasted an average of 32.20 ±0.55 days with a daily rate of 220.46. The number of deposited eggs per predator female averaged 906.00 ±10.47 eggs with a daily rate of 5.61 per day.

During the post-oviposition period, the female consumed 1416 ± 9.81 aphid individuals, this period lasted an average of 12.00 ± 0.51 days with a daily rate of 118.00. The results showed that the feeding capacity of the predator female was always higher than that of the male as the female fed on 2.44 times of *R. maidis* more than the male (Table 4).

Male:

During its longevity period, which lasted for an average of 37.60 ± 1.72 days (Table 4). The predator adult male consumed a total average 4159 ± 25.23 aphid individuals with daily rate of 110.61.

Table 4. Longevity, feeding capacity and fecundity of the predator *Exochomus nigromaculatus* adult reared on *Rhopalosiphum maidis* under laboratory conditions

Adult Stage	Period in days	Daily average consumption	Total consumption	No. of eggs	
				Daily	Total
Female	Pre-oviposition	7.00±0.00	234.42a	1641.0±5.89	
	Oviposition	32.20±0.55	220.46	7009.0±22.57	
	Post-oviposition	12.00±0.51	118.00	1416.0±9.81	5.61
	Longevity	54.00±6.67	188.07	10156±148.11	906±10.47
Male	Longevity	37.60±1.72	110.61	4159.0±25.23	

3. Rearing on *M. pisi*:

A. Predator immature stages:

Larval stage:

Data in Table 5 indicated that the duration period of the larval stage, which averaged 13.70 ± 0.213 days. The average of the total consumption during the four larval instars were 17.50 ± 0.92, 31.80 ± 1.72, 61.42 ± 2.23 and 115.50 ± 2.12 aphid individuals, respectively and the average of the total consumption per larva was 226.20 ± 18.54. The percentages of feeding capacity for each of the four larval instars of this predator were 7.74, 14.06, 27.14 and 51.06%, respectively. Therefore, it may be obvious that the third and fourth instar larvae of this predator represent together (78.22%) the backbone in predation activity. The percentages of mortality were 20, 10, 3 and 2% during the larval four instars successively.

Pupal stage:

The pupal period lasted for an average of 6.02 ± 1.20 days.

Table 5. Predation efficiency and larval duration of *Exochomus nigromaculatus* reared on *M. pisi* under laboratory conditions.

Immature stages	Duration (days)	Daily average consumption	Average of total consumption	% of feeding capacity	% of mortality
A. larval stage					
1 st instar	2.60 ± 0.16	6.73	17.50 ± 0.92	7.74	20
2 nd instar	2.80 ± 0.13	11.35	31.80 ± 1.72	14.06	10
3 rd instar	3.70 ± 0.15	16.59	61.40 ± 2.33	27.14	3
4 th instar	4.60 ± 0.16	25.10	115.5 ± 2.12	51.06	2
Total	13.7 ± 0.21	16.51	226.2 ± 18.54	100	
B. Pupal stage	6.02 ± 1.20				

B. Predator adult stage:

Female:

The predator female fed on a total average of 1231.20 ± 200.43 aphid individuals with a daily rate of 25.75 during the longevity period of 47.80 ± 6.993 days as seen in Table 6. The average of the pre-oviposition period was 6.40 ± 0.23 days. The predator female consumed during this period 186.80 ± 6.53 , with a daily rate of 29.18 aphid individuals. The predator female consumed during the oviposition period an average of 31.60 ± 0.48 days with a daily rate of 30.18. The number of deposited eggs per predator female averaged 211.60 ± 3.19 eggs with a daily rate of 6.74 per day. During the post-oviposition period the female consumed 90.40 ± 11.15 aphid individuals this period lasted an average of 6.4 ± 0.82 days with a daily rate of 14.12. The results showed that the feeding capacity of the predator female was always higher than of the male as the female feed on 1.64 times of *M. pisi* more than the male (Table 6).

Table 6. Longevity, feeding capacity and fecundity of the predator *Exochomus nigromaculatus* adult reared on *Macrosiphum pisi* under laboratory conditions

	Adult Stage	Period in days	Daily average consumption	Total consumption	No. of eggs	
					Daily	Total
Female	Pre-oviposition	6.40 ± 0.23	29.18	186.8 ± 6.54	6.74	211.6 \pm 3.19
	Oviposition	31.60 ± 0.48	30.18	954.0 ± 4.43		
	Post-oviposition	6.40 ± 0.83	14.13	90.4 ± 11.15		
	Longevity	47.80 ± 6.99	25.75	1231.2 ± 200.43		
Male	Longevity	37.40 ± 1.08	20.04	749.8 ± 36.95		

Male:

During the longevity period, which lasted an average 37.40 ± 1.07 days (Table 6), the predator adult male consumed a total average 749.80 ± 36.95 aphid individuals with a daily rate of 20.04.

These findings agree with those obtained by some authors such as (Altihan and Ozgekle, 2002) in Turkey mentioned that the development of *E. nigromaculatus* from egg to adult ranged from 22.40 days at 20°C to 10.60 days at 35°C and they added that the longevity of this predator declined significantly with increasing temperature ranging from 120.70 days at 20°C to 46.60 days at 35°C (Ramzi and Bora, 2002) in Turkey indicated that the total number of eggs per female was 428.50, which lasted 75.30 days when this predator reared on *Hyalopterus pruni* Fabr, while El-Said (2005) recorded the average numbers of eggs per female was 310.75 ± 11.64 eggs during the oviposition period, which lasted 32.85 ± 2.97 days. In our study, we found that the average number of eggs per female when reared on *A. nerii*, *R. maidis* and *M. pisi* was 83.0 ± 2.16 , 90.6 ± 10.47 and 211.6 ± 3.19 , respectively, during oviposition periods 32.2 ± 0.55 , 32.2 ± 0.55 and 31.6 ± 0.48 days, respectively.

Data in Tables 7 and 8 showed that the effect of three aphid species on certain biological characteristics of the predator *E. nigromaculatus*. It can be seen from these tables that the statistical analysis showed that there was a highly significant difference on the biological aspects of *E. nigromaculatus* larvae and adult when reared on *A. nerii*, *R. maidis* and *M. pisi*.

The data indicated that the duration period of the larval stage was the shortest when the predator larvae fed on *M. pisi*, and *R. maidis*, while the duration period of the larval stage was the longest when this predator larval reared on the *A. nerii* (Table 7). The results in Table 8 assured that the egg productivity of the female predator was the highest with the feeding on *R. maidis* followed by *M. pisi* and *A. nerii*, that mainly due to contents of the aphid species.

In conclusion, *E. nigromaculatus* (larvae and adults) could be employed as the biological control agents against *A. nerii*, *R. maidis*, and *M. pisi*, because this predator has short developmental time, a high survival rate, a high predation efficiency and reproductive capacity.

Table 8. Effect of three aphid species on certain biological characteristics of *Exochomus nigromaculatus* adult under laboratory condition.

	Female													Male			
	Pre-oviposition			Oviposition				Post-oviposition			Longevity			Longevity			
	Period in days	Dailt average consum.	Total consum.	Period in days	Dailt average consum.	Total consum.	No. of eggs		Period in days	Dailt average consum.	Total consum.	Period in days	Dailt average consum.	Total consum.	Period in days	Dailt average consum.	Total consum.
						Daily	Total										
<i>A. nerii</i>	6.6±0.231 a	52.13 b	3.44.8±16.75 b	32.2±0.55 a	50.52 b	1627±15.68 b	2.57 b	83±2.17 c	7.40±0.64 b	26.54 b	196.4±11.33 b	49.0±6.85 b	44.25 b	2186.2±333.18 b	37.4±1.03 a	24.82 b	926.4±19.29
<i>R. maidis</i>	7.0 ± 0.00 a	234.42 a	1641±5.89 a	32.20±0.55 a	220.46 a	7099±22.57 a	5.61 a	906±10.47 a	12.0±0.51 a	118.0 a	1416±9.81 a	54.0±6.67 a	188.07 a	10156±148.11 a	37.6±1.72 a	110.61 a	4159±25.23 a
<i>M. pisi</i>	6.40±0.231 a	29.18 c	186.8±6.536 c	31.60±0.48 a	30.18 c	954±4.43 c	6.74 a	211.6±3.19 b	6.40±0.83 b	14.13 c	90.40±11.15 c	47.8±6.99 b	25.75 c	1231.2±200.44 c	37.4±1.08 a	20.04 c	749.8±36.95 c

Average followed by the same letter for each aphid species are not significant different at 1% level of probability (Duncan's Multiple Range Test).

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لخصائص البيولوجية لمفترس أبوالعيد *Exochomus nigromaculatus*
المربي على بعض أنواع المن تحت الظروف المعملية
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تم عمل تجارب معملية بقسم الحشرات الاقتصادية بكلية الزراعة جامعة المنصورة في الفترة من مارس ٢٠٠٣ حتى سبتمبر ٢٠٠٤ لدراسة بعض الخصائص البيولوجية لمفترس *E. nigromaculatus* عند تربيته على ثلاثة أنواع من المن *Aphis nerii*, *Macrosiphum pisi*, *Ropalosiphum maidis* تحت الظروف المعملية.

وقد أوضحت النتائج أن متوسط عمر يرقة المفترس كانت حوالي ١٧,١ ، ١٢,١ ، ١٢,٧ يوم عند تربيته على هذه الأنواع على التوالي. وكان متوسط تغذية اليرقة في هذه الفترة هو ٤٨٢,٥ ، ٣٨٤,٤ ، ٢٢٦,٢ فرد من المن وذلك عند تربيته على كلا من *M. pisi*, *R. maidis*, *A. nerii* على التوالي. وقد وصل متوسط عمر الأنثى إلى حوالي ٤٩ ، ٥٤ ، ٤٧,٨ يوما عند التربية على أنواع المن السابقة. وتم تغذية الأنثى خلال تلك الفترة على حوالي ٢١٦٨ ، ١٢٣١ ، ١٦٤١ فرد من المن. كما أكدت النتائج أن معدل وضع البيض للأنثى الواحدة هو ٨٣ ، ٩٠٦ ، ٢١١ بيضة وذلك عند التربية على أنواع المن المختبرة *M. pisi*, *R. maidis*, *A. nerii*. كما أظهرت النتائج فترة حياة الذكر استمرت ٣٧,٤ ، ٣٧,٦ ، ٣٧,٤ يوما عند التغذية على أنواع المن المختبرة وكان متوسط تغذية الذكر على حوالي ٩٢٦,٤ ، ٤١٥٩ ، ٧٤٩ فرد من المن. وقد أظهر التحليل الإحصائي أن هناك إختلاف معنوي مابين الخصائص البيولوجية لليرقات والحشرات الكاملة لهذا المفترس عند التربية على أنواع المن الثلاثة.

ويمكن التوصية باستخدام هذا المفترس في مجال مكافحة البيولوجية ضد هذه الأنواع الثلاثة من المن بنجاح وذلك لأن هذا المفترس دورة حياته قصيرة ومتعدد الأجيال وطول فترة حياة الحشرة الكاملة وقدرتها الإفتراسية والتناسلية عالية.