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Development and Fecundity of the Coccinellid Predator, *Cryptolaemus montrouzieri* Mulsant on Different Types of Preys

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ABSTRACT

Development and fecundity of the predator, *Cryptolaemus montrouzieri* Mulsant on different types of preys; namely, *Planococcus citri* eggs, *Ephestia kuehniella* eggs and *Schizaphis graminium* nymphs were investigated at 27±2°C and 60-70% R.H. Incubation periods averaged 4.25, 4.17 and 4.11 days in association with *P. citri* eggs, *E. kuehniella* eggs and *S. graminium* nymphs, respectively. Highest percentage of hatchability (96%) associated with *P. citri* eggs and the lowest (85%) with *S. graminium* nymphs. Developmental periods of larval stage were 20.27, 16.70 and 20.14 days when fed on *P. citri* eggs. *E. kuehniella* eggs and *S. graminium* nymphs, respectively. The respective percentages of total larval mortality were 6.00, 38.00 and 42.00%. The shortest female longevity (45.30 days) associated with *S. graminium* nymphs, while the longest (111.50 days) was with *E. kuehniella* eggs. The number of eggs deposited by a female varied according to the type of prey used. The lowest egg productivity (89.50eggs/ female) was reported for females fed on *S. graminium* nymphs and the highest (1049.70 eggs/ female) for those fed on *P. citri* eggs. The corresponding figure reported for *E. kuehniella* eggs was (695.70 eggs/ female). The longest male longevity (109.7 days) was reported for *E. kuehniella* eggs, while the shortest (46.3 days) was for *S. graminium* nymphs. Feeding on *P. citri* eggs showed an intermediate period (100.1 days). The sex ratio (males: females) reported for feeding on *E. kuehniella* eggs and *S. graminium* nymphs was 1.2:1 while on *P. citri* eggs, it became 1:1.

Key words: Development, Fecundity, *Cryptolaemus montrouzieri* Mulsant, Preys.

INTRODUCTION

Among the predators, coccinellids are of great importance, since they have proved their value in checking mealy bugs, scales, aphids, coccids, aleyrodids etc., on different plants. In fact, the interest in the biological control method itself was created with the outstanding success of the coccinellid, *Rodolia cardinalis* Muls. Following the success in the control of cottony cushion scale, *Icerya purchasi* (Mask.) with *R. cardinalis*, the interest on coccinellids had increased, resulting to the introduction of the Australian ladybird beetle *Cryptolaemus montrouzieri* Mulsunt. in many countries. Puttarudriah *et al.* (1952) ranked *C. montrouzieri* second in importance after *R. cardinalis*. It has often provided spectacular control of heavy infestations of sucking pests, especially mealy bugs and some soft scales.

For the importance of *Cryptolaemus,* many authors studied its biology on mealy bugs as its preferred preys such as Bahat, *et al.* 1983; Mani and Thontadarya 1987; Merlin *et al.* 1996; Mani and Krishnamoorthy 1997b; Baskaran *et al.*1999; Prabal and Balasubramanian 2000 and Mali and Jeevan, 2008.

Comparative development and fecundity of *C. montrouzieri* on the eggs of mealy bug; *Planococcus citri* (Risso), eggs of *Ephestia kuehniella* Zeller and nymphs of *Schizaphis graminium* (Rondani) were investigated under the laboratory conditions to evaluate the efficacy of *Ephestia* eggs as an alternative prey for mass rearing of the predator.

MATERIALS AND METHODS

Adults of *C. montrouzieri* were obtained from the "Mass rearing unit", Faculty of Agriculture, Cairo University, Giza, Egypt. It was mass multiplied on the mealy bug, *P. citri* (Risso) infesting pumpkin fruits (*Cucurbita moschata*) as described by Chacko *et al.* (1978) under laboratory conditions of 27± 2°C and 60 – 70 % R.H.

To study the effect of different preys (*P. citri* eggs, *E. kuehniella* eggs and *S. graminium* nymphs) on the development and fecundity of *C. montrouzieri,* forty newly hatched larvae were immediately isolated in the individual rearing cubic plastic boxes (2×2 × 2 cm) by the aid of small camel- hair brush. The predatory larvae were provided daily with sufficient number of the tested preys and kept at 27± 2°C and 60 – 70 % R.H. The rearing boxes were daily inspected. Molting and mortality of the larvae were recorded till emergence of adults that were sexed and confined inside the ovipositional cages. The sex – ratio was calculated in all treatments.

To obtain newly emerged adults of the predator under investigation, after pupation and adult emergence of the predators, adults were paired and each couple was confined into an ovipositional glass tube of 15 cm. height and 3 cm. diameter, the opening of which was covered with a piece of thin muslin that was kept in place by rubber band. Adults were provided with sufficient number of the tested preys together with ovipositional substrate (egg masses of the mealy bug) which is important for oviposition. Inserted eggs in ovipositional substrate were collected daily and kept in cubic plastic boxes (2×2×2cm) and incubation periods of eggs were calculated. For females pre-ovipositional, ovipositional period were estimated and longevity of both females and males was calculated. Also, fecundity of the predator on the three investigated preys was recorded. The ovipositional substrate was kept daily in glass tube (15cm×3cm) for calculating the hatching rate in all treatments.

For statistical analysis, ASSISTAT program at P. of 0.05%was used.

RESULTS AND DISCUSSION

Effect of preys on egg stage

1. Incubation period

The incubation period and percentage of hatchability of *C. montrouzieri* eggs produced by females fed on the tested preys at 27± 2°C and 60-70% R.H. are presented in table (1). Data obtained showed clearly that the different preys used did not significantly affect the incubation period. It averaged 4.25 (3-6), 4.17 (3-5) and 4.11 (3-5) days when associated with the respective preys *P. citri* eggs, *E. kuehniella* eggs and *S. graminium* nymphs. In this concern, incubation periods of 3-7 days (Mali and Jeevan, 2008) and 4-6 days (Mani and Krishamoorthy, 1997a) were reported. Also, Gosalwad *et al.* (2009) reported that incubation period was 4.78 days when the predator was fed on *Maconellicoccus hirsutus*.

2. Hatching rate

Highest percentage of hatchability (96%) was associated with *P. citri* eggs and the lowest (85%) with *S. graminium* nymphs. In association with *E. kuehniella,* the rate gave an intermediate figure (88%) (Table1). In this concern, Mani and Krishamoorthy (1997a) found that viability of eggs varied from 86 to100 %.

b. Effect of preys on larval stage

The durations of the four larval instars of *C. montrouzieri* and percentage of mortality under different trophic conditions at 27± 2°C combined with 60-70% R.H. are given in table (2). Data showed that the mean duration of 1st instar of the coccinellid predator was 4.27 days when fed on *P. citri* eggs and 4.00 days on *E. kuehniella* eggs, while it was 5.40 days on *S. graminium* nymphs.

1. First larval instar

The first larval instar was significantly affected by the type of prey in association with feeding on aphid nymphs comparing with the other feeding cases that showed insignificant deviation in-between. Rate of mortality during the first stadium varied considerably according to the type of prey. The highest rate (35%) was reported for *S. graminium* nymphs and the lowest (6%) for *P. citri* eggs. *E. kuehniella* eggs showed an intermediate rate (30 %) (Table 2).

Table (1): Effect of different preys on the incubation period and hatching rate of *C. montruzieri* eggs at 27±2°C combined with 60-70%R.H.

C. montruzieri eggs	Preys			F
	P. citri eggs	*Ephestia* eggs	*S. graminium* nymphs	
Incubation period (days)	4.25 ± 0.17 a (3-6)	4.17 ± 0.49 a (3-5)	4.11 ± 0.15 a (3-5)	0.18
Hatching rate %	96a	88b	85b	24.25**

Averages have the same letter in the same row are not significantly different at 0.05%level of prob.
N = 40.

2. Second larval instar

The mean durations of the 2nd larval instar of *C. montrouzieri* were 3.51, 3.08 and 4.40 days when fed on *P. citri* eggs, *E. kuehniella* eggs and *S. graminium* nymphs, respectively (Table 2). Statistically, the second larval stadium, associated with feeding on aphid nymphs was significantly longer than those associated with other feeding cases (citrus mealy bug eggs and *Ephestia* eggs). No mortality was recorded in case of feeding on citrus mealy bug eggs, while the rate of (4%) was associated with *Ephestia* eggs.

3. Third larval instar

In the third larval instar, the effect of different tested preys on its duration was significant. The shortest period (2.25 days) was obtained in the case of feeding on *Ephestia* eggs and the longest (5.51days) was on citrus mealy bug eggs (Table 2). Data also showed that the highest rate of mortality (5%) associated with *S. graminium* nymphs, while no mortality was obtained on *P. citri* eggs. *Ephestia* eggs showed an intermediate rate of mortality 4.0% (Table 2).

4. Fourth larval instar

The three trophic conditions showed significant effect on the fourth larval instar. Respective durations of 6.96, 7.41 and 5.85 days were reported in association with eggs of citrus mealy bug, and *Ephestia* and wheat aphid nymphs (Table 2). In this concern, Mali and Jeevan (2008) reported that the duration of the four larval instars were in respective 4 to 7, 3 to 5, 5 to 10 and 7 to 11 days, on *M. hirsutus*. Gosalwad *et al.* (2009) reported 5.14, 3.88, 6.84 and 8.04 days as respective durations of 1st, 2nd, 3rd and 4th instars, when the larva was fed on *M. hirsutus*. Data showed that no mortality occurred during the fourth larval stadium in association with different tested preys.

Total larval period

On basis of the aforementioned data, it could be stated that the period required for the total larval development of *C. montrouzieri* was considerably influenced by the prey used. Average periods of 20.27, 16.70 and 20.14 days were reported for the total larval periods associated with the preys; *P. citri* eggs, *E. kuehniella* eggs and *S. graminium* nymphs, respectively. Statistically, significant deviations existed amng these records, excluding that between *P. citri* eggs and *S. graminium* nymphs. The grub period was extended when reared on eggs of mealy bug compared to *E. kuehniella* eggs and *S. graminium* nymphs.

Table (2): Durations (/days) and mortality (%) of various larval instars of *Cryptolaemus montruzieri* reared on different preys at 27±2°C combined with 60-70% R.H.

Immature stages of *C. montruzieri*	Prey			F
	P. citri eggs (Days)	*Ephestia* eggs (Days)	*S. graminium* nymphs (Days)	
1st instar	4.27 ± 0.01 b (3-6) (6.0)	4.00 ± 0.01 b (3-5) (30.0)	5.40 ± 0.09 a (4-6) (35.0)	19.10**
2nd instar	3.51 ± 0.02 b (3-4) (0.0)	3.08 ± 0.02 c (3-5) (4.0)	4.40 ± 0.12 a (4-5) (2.0)	47.24**
3rd instar	5.51 ± 0.08 a (5-6) (0.0)	2.25 ± 0.11c (2-4) (4.0)	4.42 ± 0.07 b (4-5) (5.0)	216.45**
4th instar	6.96 ± 0.20 a (6-7) (0.0)	7.41 ± 0.30 a (5-11) (0.0)	5.85 ± 0.11 b (5-7) (0.0)	13.58**
Total larval period	20.27 ± 0.32 a (18-23) (6.0)	16.70 ± 0.31b (14-22) (38.0)	20.14 ± 0.16 a (18-22) (42.0)	37.01**
Per pupa	2.00 ± 0.01 a (2-2)	1.36 ± 0.08 b (1-2)	2.00 ± 0.01 a (2-2)	45.38**
Pupa	8.50 ± 0.09 a (7-9)	8.00 ± 0.46 a (6-11)	7.95 ± 0.15 a (7-9)	0.97
Sex ratio	♂1 : 1♀	♂1.22 : 1♀	♂1.22 : 1♀	

Averages have the same letter in the same row are not significantly different at 0.05 % level of prob.

occurred during the first larval instar, and then decreased during the next successive stadia. Total percent of mortality among the larval individuals varied greatly according to the prey used, being 6.00, 38.00 and 42.00% when fed on *P. citri* eggs, *E. kuehniella* eggs and *S. graminium* nymphs, respectively. Thus, the lowest rate of larval mortality was reported for *P. citri* eggs and the highest for *S. graminium* nymphs.

c. Effect of preys on prepupal and pupal stage

The prepupal and pupal periods of *C. montrouzieri* lasted the averages of 2 and 8.5 days on *P. citri* eggs, respectively. Corresponding figures for *E. kuehniella* eggs were 1.36 and 8 days, opposed to the respective averages 2 and 7.95 days in in case of *S. graminium* nymphs. No significant effect was reported for the effect of different preys on the prepupal and pupal stages. Similar observations were made by earlier works such as Mani and Thontadarya, (1987) and Mani and Krishamoorthy (1997a). Mali and Jeevan (2008) reported a pupal period of 6–10 days for the same predator, while Gosalwad *et al.*, (2009) reported 8.08 days for the same stage.

d. Effect of preys on adult stage

1- Female

Egg laying activity of *C. montrouzieri* females that fed on different preys at 27 ± 2°C and 60-70% R. H. was recorded in table (3). Longest female longevity (111.50 days) was found at *E. kuehniella* eggs, followed by *P. citri* eggs (104.50 days) and lastly by *S. graminium* nymphs (45.3days). Shortest ovipositional period (34.3 days) and lowest egg productivity (89.5eggs/female) associated with the shortest longevity was reported for females fed on *S. graminium* nymphs. However, for *P. citri* eggs, the female deposited the greatest number of eggs (1049.70/ female), which was significantly greater than that reported for *E. kuehniella* eggs and *S. graminium* nymphs. They deposited during an ovipositional period of 97.9 days, which appeared significantly longer than that reported for *S. graminium* nymphs (34.3 days).
Accordingly, the daily rate of reproduction/ female differed significantly according to the preys used. Average rates of 10.68, 6.70 and 2.69eggs were recorded in case of feeding on *P. citri* eggs, *E. kuehniella* eggs and *S. graminium* nymphs, respectively. Thus, the highest rate was associated with *P. citri* eggs, and the lowest with *S. graminium* nymphs.

In association with the two tested preys, *P. citri* eggs and *S. graminium* nymphs, the weekly rate of deposited eggs attained its highest value during the second and the third week of ovipositional period, respectively (Figs. 1 and 2;mx.) while that in case of feeding on *Ephestia* eggs, the highest rate was recorded during the sixth week of the ovipositional period, (Fig. 3).

This rate after attaining its highest level fluctuated in various patterns according to the associated prey, during the successive weeks till the end of the ovipositional period (Figs. 1, 2 and 3).

Survival rates of the females, recorded under various feeding conditions, showed that all the females deposited eggs during the first week of the ovipositional period, but their survival rates varied during the successive weeks according to the type of prey. On *E. kuehniella* eggs, the rate remained 100% for eight weeks of the ovipositional period, while it was 93.33% in case of *P. citri* eggs of the females survived to sixth week. On *S. graminium* nymphs, only 83% of the females survived to the second week of ovipositional period. In the successive weeks, these rates decreased in different patterns. The lowest survival rate was reported for females fed on *S. graminium* nymphs, while the highest was associated with *E. kuehniella* eggs. Females fed on *P. citri* eggs showed intermediate survival rates.

Table (3): Effect of the prey on the adult activities of *C. montrouzieri* at 27±2°C and 60-70%R.H.

Biological characters	prey			F value
Adult stage	*P. citri* eggs	*E. kuehniella* eggs	*S. graminium* nymphs	
a. Female				
Preoviposition	6.60 ± 0.16^{b} (6-7)	7.00 ± 0.29^{b} (6-9)	11.00 ± 0.33^{a} (10-12)	78.35**
Oviposition	97.90 ± 5.19b (58-133)	104.40 ± 7.88^{a} (59-146)	34.30 ± 3.91^{c} (24-40)	43.08**
longevity	104.50± 5.18^{a} (64-140)	111.50± 7.88 ^{a} (65- 152)	45.30 ± 3.84^{b} (34-50)	38.24**
Fecundity/ female	1049.70± 53.04^{a} (621-1202)	695.70± 66.27^{b} (353-952)	89.50 ± 7.39^{c} (65-128)	97.42**
Rate of reprod. /fem./day	10.68 ± 0.14^{a} (10.25-11.23)	6.70 ± 0.45^{b} (3.84-8.22)	2.69 ± 0.11^{c} (2-3.2)	198.36**
b. Male longevity	100.10 ± 4.80 a(64-135)	109.70 ± 8.09^{a} (66-148)	46.30 ± 3.90^{b} (34-56)	33.76***

Averages have the same letters in the same row are not significantly different at 0.05 % level of prob.

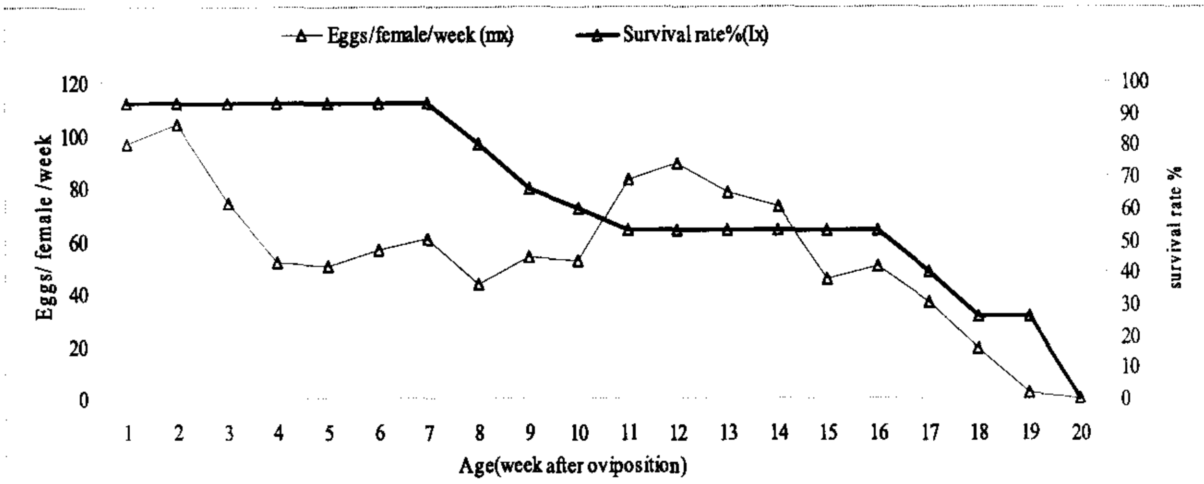

Fig. (1): Survival rate % (Ix) and specific fecundity (mx) curves of *C. montrouzieri* reared on *P. citri* eggs at 27°C and 60-70%R.H.

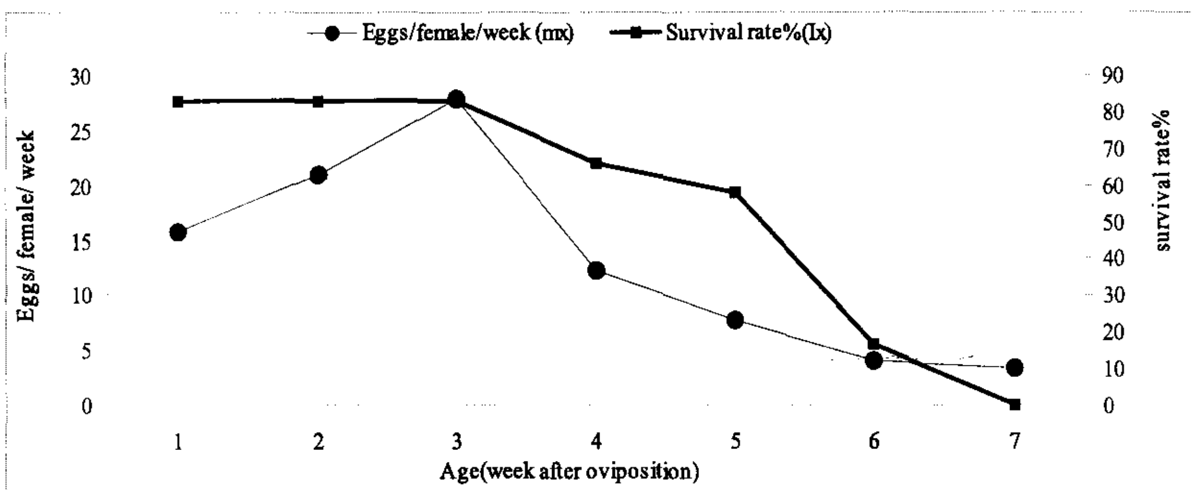

Fig. (2): Survival rate% (Ix) and specific fecundity (mx) curves of *C. montrouzieri* reared on *S. graminium* nymphs at 27°C and 60-70%R.H.

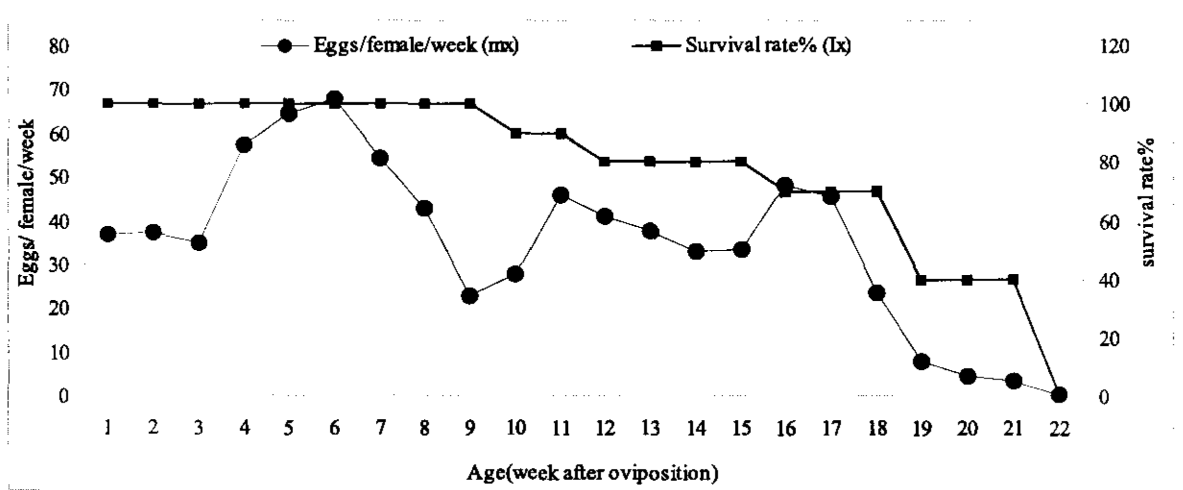

Fig. (3): Survival rate% (Ix) and specific fecundity (mx) curves of *C. montrouzieri* reared on *Ephestia* eggs at 27°C and 60-70%R.H.

Mali and Jeevan (2008) reported that the ovipositional period of C. montrouzieri lasted 54 to 83 days, during which the female laid 476.2 eggs when fed on *M. hirsutus*. Mani and Thontadarya (1987) recorded that the female longevity averaged 61.40 days, with a mean fecundity of 210.52 eggs on *M. hirsutus*. For the same predator, Mani and Krishamoorthy (1997a) stated that pre-ovipositional and ovipositional periods ranged from 5 to 7 days and 45 to 68 days, respectively. A single adult female laid about 200 eggs. The longevity of adult varied from 52 to 80 days. Gosalwad *et al.* (2009) recorded that the pre-ovipositional and ovipositional periods were 7.90, 67.10 and 9.00, 68.00 on *M. hirsutus* and *P. solenopsis*, respectively. According to them, the female adult longevity was 77.44, 72.38 on *M. hirsutus* and *P. solenopsis*, respectively and the fecundity was 478.20 and 460.42. On *P. citri*, Al- Khateeb and Raie (2001) reported that the average longevity of females was 70.6 days.

2. **Male**

Under the three trophic conditions, the longest male longevity (109.7 days) was recorded on *E. kuehniella* eggs, while the shortest (46.3 days) was found on *S. graminium* nymphs. In association with *P. citri* eggs, intermediate longevity (100.1/days) was recorded (Table3). Statistically, significant deviations existed between those longevities. In this concern, Mani and Thontadarya (1987) reported longevity of 55.9 days when fed on *M. hirsutus*. Gosalwad *et al.* (2009) reported that the longevity was 80.49 and 74.44 days for males fed on *M. hirsutus* and *P. solenopsis*, respectively. Al – Khateeb and Raie (2001) recorded a period of 76.40 days when fed on *P. citri*

Sex ratio

In association with the two tested preys *E. kuehniella* eggs and *S. graminium* nymphs, the sex ratio was1♀:1.2♂at 27±2°C and 60-70% R.H. In case of *P. citri* eggs, this ratio was 1♀:1♂ (Table 2). In this concern, Mani and Krishamoorthy (1997a) found that the male to female ratio was equal, while, Baskaran *et al.*, (1999) recorded that the sex ratio (males: females) with *P. citri* was 1:1.75.

In conclusion, all the previous data concerning with the effect of the prey on the bio-cycle of *C. montrouzieri* indicated that eggs of *P. citri* were the most adequate prey for *C. montrouzieri* as the adult female deposited the greatest number of eggs (1049.7 eggs/female), coincident with the highest daily rate of reproduction (10.86 eggs / day/female). On this prey, the adult female also lived a comparatively long longevity (104.5 days), of which 97.9 days was reported as an ovipositional period. On the other hand, the larval stage lasted 20.27 days coinciding with a lowest rate of mortality (6.0%). However, by feeding on *E. kuehniella* eggs although the larval stage lasted 16.70 days, the rate of larval mortality was higher (38.0%). In addition, the females reared on this prey produced lower amount of eggs (695.7eggs/ female), throughout an ovipositional period of 104.4 days which was longer than that reported for *P. citri* eggs. The daily rate of reproduction was represented by (6.7 eggs/ female). It was lower than that reported for *P. citri* eggs. By using *S. graminium* nymphs as a prey, adult female lived shorter (45.30 days) and produced a fewer amount of eggs (89.50 eggs), in a shortest ovipositional period (34.30 days). Moreover, the larval duration occupied a comparatively longer period (20.14 days) and the larval mortality was represented by the highest rate (42%).

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الملخص العربى

تطور وكفاءة وضع البيض لمفترس أبو العيد ***Cryptolaemus montrouzieri* Mulsant** على أنواع مختلفة من الفرائس

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درست فترات تطور وكفاءة وضع البيض للمفترس *Cryptolaemus montrouzieri* Mulsant على أنواع مختلفة من الفرائس مثل بيض بق الموالح الدقيقى وبيض الافستيا وحوريات المن تحت الظروف المعملية 27±2°C& R.H. 60-70% . أظهرت النتائج أن أقل فترة حضانة للبيض (4,11 يوم) عند التربية على حوريات من القمح وأطول فتره كانت عند التربية على بيض بق الموالح الدقيقى (4,25 يوم). كما أشارت النتائج الى ارتفاع نسبة الفقس لبيض الإناث المتغذية على بيض بق الموالح الدقيقى مقارنة بكل من بيض الإفستيا وحوريات من القمح، حيث كانت 96، 88 و85% على التوالى. سّجلت أقصر فترة نمو لإجمالي مدة الطور اليرقى فى حالة التغذية على بيض الإفستيا (16,70 يوم) ، وأطولها (20,27 يوم) عند التغذية على بيض بق الموالح الدقيقى. سجلت أقل نسبة موت خلال الطور اليرقى (6%) بالتغذية على بيض بق الموالح وأعلى نسبة (42%) لحوريات المن. سجلت هذه النسبة أعلى معدلاتها خلال العمر اليرقى الأول حيث كانت30، 6، 35 % عند التغذية على بيض بق الموالح الدقيقى ، بيض الإفستيا وحوريات المن على التوالي. أظهرت الفرائس تأثيرا غير معنويا على طول فترة طور العذراء حيث كانت 8,50، 8,00 و7,95 يوما فى حالة التغذية على بيض بق الموالح الدقيقى ،بيض الافستيا وحوريات من القمح على التوالى. تشير النتائج إلى ان متوسط مدة حياة الذكر والأنثى بالتغذية على بيض بق الموالح الدقيقى 100,1 ، 104 يوما وبالتغذية على بيض الإفستيا 109,7، 111.5 يوما، وقد سجلت أقصر مدة لحياة كل منهما بالتغذية على حوريات من القمح بمتوسط 46,3 ،45.3 يوم بالترتيب. سجلت أقصر فترة م اقبل وضع البيض (6,6 يوم) فى حالة التغذية على بيض بق الموالح الدقيقى وأطول فترة (11 يوما) على حوريات مَن القمح و فترة وضع البيض للمفترس (97,9، 104,4 و34,3 يوم) بالتغذية على بيض بق الموالح الدقيقى، بيض ألإفستيا وحوريات من القمح على التوالى. سجل أكبر معدل لوضع البيض لأنثى المفترس عند تغذيتها على بيض بق الموالح الدقيقى وأقل معدل عند التغذية على حوريات من القمح، حيث كانت المتوسطات 1049,70، 695,70 و89,50 بيضة بمتوسط يومي 10,69، 6,70 و2,69 بيضة عند تربية المفترس على بق الموالح الدقيقى، بيض الإفستيا و حوريات مَنْ القمح على التوالي.

كلمات مفتاحية: تطور، كفاءة وضع البيض، *Cryptolaemus montrouzieri* Mulsant، فرائس.