

**BIOLOGICAL CHARACTERISTICS AND
PREDATION EFFICIENCY OF *RODOLIA*
(=*VEDALIA*) *CARDINALIS* (MULSANT)
ON *ICERYA SEYCHELLARUM*
(WESTWOOD)**

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ABSTRACT: Biological characteristics and predation efficiency of *Rodolia* (= *Vedalia*) *cardinalis* (Mulsant) predated on *Icerya seychellarum* (Westwood) were studied under laboratory conditions of 26 ± 1 °C and 70 ± 5 % RH.

The incubation period of the eggs ranged between 5 and 7 days, with an average of 6.2 days. The durations of the four larval instars were 4.1, 4.4, 4.1 and 4.3 days, respectively. The larval developmental period of the predator lasted 16.9 days. Percent mortality during the larval stage reached 40.00. The duration of the pupal stage averaged 7.55 days with a mortality of 33.33 %. The total developmental period lasted 30.7 days on the average. Total mortality during the larval and pupal stages were 60 %. Adult female longevity recorded 27.8 days. The total eggs laid per female averaged 105.4 eggs. The adult male longevity averaged 13.0 days. The greatest number of prey was consumed by the second and third larval instars representing 11.05 and 15.09 % of the total consumed prey during the predatory stages (larvae and adults), respectively. The larval stage consumed during its developmental period an average of 18.00 preys. The adult female was more voracious than male; the corresponding consumed preys were 31.4 and 13.0 (ca. 2.42 times higher than male).

Key words: *Rodolia cardinalis*, biology, predation efficiency, *Icerya seychellarum*.

INTRODUCTION

Vidalia beetle, *Rodolia* (= *Vidalia*) *cardinalis* (Mulsant) (Coccinellidae) is responsible for the outstanding success in biological control. It was introduced into California in late 1880 to control the cottony cushion scale, *Icerya purchasi* Maskell (Margarodidae) in citrus orchards (Caltagirone and Douth, 1989). This predator was introduced to Egypt from California in 1902 to control *I. purchasi*, which was considered at that time a serious pest (Kamal, 1951). *R. cardinalis*, as a specific predator to cottony cushion scale, established and widespread all over the country. As a result, the population of *I. purchasi* has dropped to non-economic levels and it is now rare in Egypt. Vesey-Fitzgerald (1940 and 1953) mentioned that *R. cardinalis* feeds on *Icerya seychellarum* (Westwood) in the field and laboratory, but failed to become established when reared in Seychelles and Mauritius Islands.

However, massive infestations with *Icerya aegyptiaca* (Douglas) and *I. seychellarum* have occurred on various species of fruit trees and ornamental plants (Hamed and Saad, 1989).

According to Kairo and Murphy (1995), in Kenya, with few exceptions, *Rodolia* species

have a host range restricted to margarodids. Ragab (1995), in Egypt, compared the adaptation of *R. cardinalis* on *I. aegyptiaca* and *I. purchasi* to give a pattern about the capability of the predator to develop on different preys. Causton et al. (2004), in Galapagos Islands, showed that *R. cardinalis* predated on *Margarodes similes* Morrisom; a species closely related to the cottony cushion scale. Grafton – Cardwell et al. (2005), in USA, studied the effect of temperature on development of the predator under laboratory conditions.

It was noticed, in other current work, that larvae and adults of *R. cardinalis* were associated with *I. seychellarum* infested mango trees in the field. Therefore, the present investigation aimed to study biological characteristics and predation efficiency of *R. cardinalis* on *I. seychellarum* under laboratory conditions in order to give a pattern about the capability of this predator to control this pest.

MATERIALS AND METHODS

The experiment was carried out in the laboratory of Biological Control, Plant Protection Department, Faculty of

Agriculture, Zagazig University at temperature of 26 ± 1 °C and 70 ± 5 % RH.. The stock culture of *R. cardinalis* began with a lot of adults collected from *Ficus nitida* trees cultivated in Zagazig heavily infested with *I. seychellarum*. The predator was reared on different stages of *I. seychellarum* infested *Ficus nitida* leaves in Petri dishes (10 cm diameter). Preys with deposited eggs of *R. cardinalis* were transferred daily into another Petri dishes and kept till egg hatching. Fresh infested leaves were introduced as necessary to ensure that there was a fresh supply of the prey.

Fifty newly hatched larvae were kept individually in Petri dishes (7 cm diameter). The dishes were provided with filter papers in their bottoms to absorb condensed water and to facilitate the movement of the predator larvae. The predator larvae were reared on gravid females of *I. seychellarum* that were collected daily from *Ficus nitida*. The prey was carefully examined to be free from any predators. Certain number of the prey was introduced daily into the Petri dishes. The predator larvae were daily inspected using a binocular microscope. Moulting dates and consumed prey were recorded. Durations of larval and

pupal stages as well as mortality were considered.

After pupation and emergence of the predator adults, females and males were sexually distinguished. Seven pairs of newly emerged adults were confined each in a Petri dish as previously described in case of larval rearing. Adequate numbers of the prey were offered day after day. After copulation, adult females and males were kept singly, each in a Petri dish. Number of laid eggs per female, the incubation period of eggs, longevity of each female and male and consumed prey were recorded. The obtained data were statistically analyzed according to Snedecor and Cochran (1987).

RESULTS AND DISCUSSION

Biological Characteristics of *Rodolia cardinalis* (Mulsant) Predated on *Icerya seychellarum* (Westwood)

Data presented in Table (1) showed that the incubation period of the eggs of *R. cardinalis* ranged from 5 to 7 days, with an average of 6.2 days. The egg mortality was not considered. Ragab (1995) mentioned that the incubation period of the eggs at a temperature

Table 1 : Developmental periods, mortality, longevity and fecundity of *Rodolia* (= *Vidalia*) *cardinalis* (Mulsant) predated on *Icerya seychellarum* (Westwood) under laboratory conditions (Temp. $26 \pm 1^\circ\text{C}$ and RH $70 \pm 5\%$).

Biological characteristics	Numbers of		Developmental periods (in days)		% Mortality	Fecundity / Female	
	Initial	Surviving	Range	Mean		Range	Mean
Egg stage	Not considered	50	5 - 7	6.2 ± 0.17			
Larval stage							
1 st instar	50	47	3 - 6	4.1 ± 0.24	6.00		
2 nd instar	47	43	3 - 6	4.4 ± 0.22	8.51		
3 rd instar	43	38	3 - 5	4.1 ± 0.16	11.63		
4 th instar	38	30	3 - 7	4.3 ± 0.30	21.05		
Total larval Stage	50	30	14 - 20	16.9 ± 0.37	40.00		
Pupal stage	30	20	4 - 10	7.6 ± 0.43	33.33		
Larvae - adult	50	20	22 - 28	24.5 ± 0.44	60.00		
Total developmental period			28 - 35	30.7 ± 0.43			
Female longevity		13	12 - 37	27.8 ± 4.53		64 - 138	105.4 ± 15.14
Male longevity		7	9 - 18	13.0 ± 1.64			

of 25 °C and 60 % RH lasted 3 to 5 days, with an averages of 4.04 and 4.16 days when females predated on *I. purchasi* and *I. aegyptiaca*, respectively.

The larval stage duration of the predator ranged between 14 and 20 days, with an average of 16.9 days (Table 1). The duration of the four larval instars averaged 4.1, 4.4, 4.1 and 4.3 days, respectively. These results are in agreement with those of Hamed and Saad (1989) who found that the larval stage period averaged 16.5 days, when the predator reared on *I. seychellarum*. According to Ragab (1995), the duration of larval development of *R. cardinalis* differed when feed upon *I. purchasi* and *I. aegyptiaca*. He added that development of the predator, reared on *I. aegyptiaca* was relatively faster than that fed on *I. purchasi*.

Mortality percentages during the first, second, third and fourth larval instars were 6.00, 8.51, 11.63 and 21.05, respectively (Table 1). The total larval mortality was 40.00 %. Kuwana (1922) in Japan, revealed that the larval mortality was 27 % when *R. cardinalis* was reared on *I. purchasi*. Ragab (1995)

mentioned that the larval mortalities of the predator were 40 and 3.44 % in association with *I. purchasi* and *I. aegyptiaca*, respectively.

The pupal stage averaged 7.6 days, with a range of 4 to 10 days (Table 1). According to Ragab (1995), the means of pupal durations were 5.91 and 6.44 days when the predator was reared during the larval stage on *I. purchasi* and *I. aegyptiaca*, respectively.

The pupal mortality was 33.33 % (Table 1). Kuwana (1922) stated that the pupal mortality was 47 % when *R. cardinalis* was reared on *I. purchasi*.

As indicated in Table (1), the total developmental period lasted 28 to 35 days, with an average of 30.7 days. The total mortality during larval and pupal stages of the predator reached 60 %. Hamed and Saad (1989) reported that the total developmental periods of the predator were 21.9 and 22.3 days on *I. aegyptiaca* and *I. seychellarum*, respectively. Hamed and Saad (1989) mentioned that during the larval and pupal stages high of mortality percentages (44 and 62 %) were recorded in association with *I. aegyptiaca* and *I. seychellarum*, respectively.

Adult female longevity averaged 27.8 days, with a range of 12 to 37 days. The adult male longevity ranged between 9 and 18 days, with an average of 13.0 days. Kuwana (1922) showed that when *R. cardinalis* was fed on *I. purchasi* the life span of females and males were 40 and 23 days in spring and 23 and 13 days in summer, respectively. The present results disagree with the findings of Hamed and Saad (1989) who mentioned that the longevity of females and males fed on *I. seychellarum* averaged 12.8 and 8.8 days, respectively. According to Ragab (1995), females of *R. cardinalis* lived longer with an average of 31.54 and 37.11 days when fed on *I. purchasi* and *I. aegyptiaca*, respectively. The males longevity were 25.73 and 32.00 days on the aforementioned preys, respectively.

The number of deposited eggs per predator female during its longevity averaged 105.4 ± 15.14 eggs, with a range of 64 to 138 eggs. Kuwana (1922) reported that the female of *R. cardinalis* fed on *I. purchasi* deposited as many as 5.4 eggs per day in summer, while in spring and autumn, sometimes, only one egg was laid per day.

The obtained results are in disagreement with the findings of Hamed and Saad (1989) who found that the average egg output of females fed on *I. aegyptiaca* and *I. seychellarum* were 33.4 and 19.8, respectively. On the contrary, Ragab (1995) indicated that the average of total number of eggs laid by the females of *R. cardinalis* throughout the oviposition period was not affected by the type of prey consumed by these females.

Predation Efficiency

Larvae

As shown in Table (2), the consumption averages during the different larval instars of the predator were 3.00, 4.45, 6.00 and 4.55 preys for the 1st, 2nd, 3rd and 4th instars, respectively. Also data showed that the 2nd and 3rd larval instars consumed the highest percentages of preys (11.05 and 15.09 %, respectively). The numbers of consumed preys during different larval instars ranged between 13 and 28 preys, with an average of 18.0 ± 0.84 preys that represent a 45.01 % of the total consumed preys. The larva consumed between 0.72 and 1.56 preys daily, with an average of 1.07 ± 0.04 preys (Table 2).

Table 2: Predation efficiency of *Rodolia* (= *Vedalia*) *cardinalis* (Mulsant) larvae and adults predated on *Icerya seychellarum* (Westwood) under laboratory conditions (Temp. $26 \pm 1^\circ\text{C}$ and RH $70 \pm 5\%$).

Biological characteristics	Number of daily consumed prey		Total number of consumed prey		% Consumption
	Range	Mean	Range	Mean	
1. Larval stage					
1 st instar	0.25 - 1.70	0.78 ± 0.87	1 - 6	3.00 ± 0.30	8.36
2 nd instar	0.50 - 2.25	1.05 ± 0.10	2 - 9	4.45 ± 0.37	11.05
3 rd instar	1.00 - 2.00	1.45 ± 0.08	4 - 9	6.00 ± 0.25	15.09
4 th instar	0.25 - 2.20	1.05 ± 0.11	1 - 11	4.55 ± 0.61	10.51
Total larval stage	0.72 - 1.56	1.07 ± 0.04	13 - 28	18.00 ± 0.84	45.01
2. Adult stage					
Female	1.03 - 1.65	1.30 ± 0.12	17 - 38	31.40 ± 3.70	37.47
Males	0.50 - 1.85	0.97 ± 0.23	5 - 24	13.00 ± 3.54	17.52

Adults

Data presented in Table (2) showed that the predator adult female consumed an average of 31.40 ± 3.70 preys, with a daily rate of 1.30 ± 0.12 preys. The predator adult male fed on an average of 13.00 ± 3.54 preys, with a daily rate of 0.97 ± 0.23 preys. The female and male consumed 37.47 and 17.52 %, respectively, of the total consumed prey by the predator. The adult female was more voracious than male as it consumed a greater number of prey individuals ca. 2.42 times higher than that consumed by the male.

On basis of the previously discussed results, it could be concluded that *R. cardinalis* has a considerable role for controlling *I. seychellarum* because this predator has a long longevity as well as a highly predation efficiency on *I. seychellarum*.

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الخصائص البيولوجية والكفاءة الافتراضية لخفساء الفيداليا
على البق الدقيقي *Icerya seychellarum*

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أجريت تلك الدراسة للتعرف على الخصائص البيولوجية والكفاءة الافتراضية لخفساء الفيداليا *Rodolia cardinalis* (Mulsant) على البق الدقيقي *Icerya seychellarum* (Westwood) تحت درجة حرارة ٢٦ ± ١ درجة مئوية ورطوبة نسبية ٧٠ ± ٥%. أوضحت النتائج ما يلي:

تراوحت فترة حضانة البيض بين ٥ إلى ٧ أيام بمتوسط ٦,٢٠ ± ٠,١٧ يوم. متوسط الأعمار اليرقية الأول والثاني والثالث والرابع ٤,١٠ ± ٠,٢٤، ٤,٤٠ ± ٠,٢٢، ٤,١٠ ± ٠,١٦، ٤,٣٠ ± ٠,٣٠ يوماً على التوالي. كان متوسط الطور اليرقي ١٦,٩٠ ± ٠,٣٧ يوم. وصلت نسبة الموت في الطور اليرقي إلى ٤٠%.

أستغرق طور العنقاء ٧,٦ ± ٠,٤٣ يوم بنسبة موت ٣٣,٣٣%. استغرقت الفترة من البيض إلى خروج الحشرات الكاملة ٣٠,٧ ± ٠,٤٣ يوم في المتوسط وسجلت نسبة ٦٠,٠٠% موت كلي خلال طوري اليرقة والعنقاء. متوسط طول عمر الحشرة الكاملة الأنثى ٢٧,٨٠ ± ٤,٥٣ يوم وضعت خلالها الأنثى ١٠٥,٤ ± ١٥,١٤ بيضة في المتوسط بينما عاشت الذكور ١٣,٠٠ ± ١,٦٤ يوم في المتوسط.

أستهلك العدد الأكبر من الضحية بواسطة العمرين اليرقيين الثاني والثالث بما يعادل ١١,٠٥ و ١٥,٠٩% من العدد الكلي للضحية المستهلكة خلال طوري اليرقة والحشرة الكاملة. متوسط ما تستهلكه اليرقة خلال فترة نموها ١٨,٠٠ ± ٠,٨٤ ضحية. متوسط ما تستهلكه الأنثى خلال فترة حياتها ٣١,٤٠ ± ٣,٧٠ ضحية، بينما استهلك الذكر خلال حياته ١٣,٠٠ ± ٣,٥٤. تعتبر الإناث هي الأكثر فعالية حيث تفترس العدد الأكبر من الضحية وبما يوازي ٢,٤٢ مرة مقارنة بما يفترسه الذكر مع الأخذ في الاعتبار أن طول حياة هذا المفترس المرتبطة بتغذيته على هذا النوع من البق الدقيقي يجعله ذو أثر فعال في استخدامه ضمن برامج مكافحة المتكاملة للسيطرة على هذه الآفة الخطيرة واسعة الانتشار.