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PJBS

ISSN 1028-8880

**Pakistan
Journal of Biological Sciences**

ANSI*net*

Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Biological Control of Citrus Mealybug, *Planococcus citri* (Risso) using Coccinellid Predator, *Cryptolaemus montrouzieri* Muls.

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Abstract: The coccinellid predator, *Cryptolaemus montrouzieri* Mulsant (Coleoptera: Coccinellidae) was used to control the citrus mealybug, *Planococcus citri* (Risso) (Homoptera: Pseudococcidae) on the croton ornamental shrubs, *Codiaeum variegatum* L. at Giza governorate, Egypt. *Cryptolaemus montrouzieri* Mulsant, 50 adults/Croton shrub, were released once on October 27, 2008 in the open field. Obtained results indicated that percentages of reduction among the egg masses, nymphs and adults of *P. citri*, one month after releasing the predator reached to 41.5, 42.3 and 57.5%, respectively. Two months later, the corresponding rates were 80.6, 86.5 and 91.5%. Finally, after three months of releasing the predator, reduction rates reached to 100% for all stages of the pest. The associated natural enemies in the field were consisted of three predaceous insects and one parasitic species. The insect predators secured were the hemerobiid predator, *Symphorobius amicus* Navas; the coccinellid predator, *Scymnus syriacus* (Mars.) and the chrysopid predator, *Chrysoperla carnea* (Stephens). The parasitic species was the encyrtid, *Coccidoxenoides peregrinus* (Timberlake). The aforementioned natural enemies were found feeding on the citrus mealybug, *Planococcus citri* infesting croton shrubs. In the second season, 2009 there is no mealybug, *P. citri* individuals were found on the croton shrubs.

Key words: Biological control, citrus mealybug, *Planococcus citri*, coccinellid predator, *Cryptolaemus montrouzieri*

INTRODUCTION

The citrus mealybug, *Planococcus citri* (Risso) (Homoptera: Pseudococcidae) is a serious pest of a wide variety of economically important plants (Cox, 1981) as well as on greenhouse ornamentals (Hennekam *et al.*, 1987).

Chemical control of the citrus mealybug is difficult because of the waxy material which covers eggs and adult females (Dean *et al.*, 1971). As well as the rising cost of chemical control and damage caused by over-use and the environmental pollution. The trend now is to control this pest using biological control. Predators are the important biological agents used to control this mealybug pest in many countries.

Cryptolaemus montrouzieri Muls. (Coleoptera: Coccinellidae) is a mealybug predator, both larvae and adults attack all stages of mealybug, *Planococcus citri* (Risso). This predator is most effective in high infestations, but with the scarcity of food, it feeds on soft scale insects and aphids. According to Mani and Thontadarya (1987), this coccinellid grub consumed a total of 900-1500 *Maconellicoccus hirsutus* (Green) eggs during its development. Mani (1988) in India,

reported that, *C. montrouzieri* succeeded to suppress the population of the grape vine mealybug, *Maconellicoccus hirsutus*; the release of 1000-1500 adults predator/acre gave an effective control within two months. Srinivasan and Babo (1989) in India, found that the maximum effect of this predator against the mealybug, *Maconellicoccus hirsutus* on grapes was observed at six weeks after the initial release, with 64.3% reduction when 10 predators were released per vine. In India, Mami *et al.* (1990) reported that the population of the mealybug *Ferrisia virgata* (Ckll.) in guava orchards was controlled within 50 days after releasing *Cryptolaemus montrouzieri*. Mealybug is one of the most common pests in citrus, curry leaf plant, cotton, banana, coffee, cocoa, inger, mango etc. (Rao *et al.*, 2006). Mangoud (2006) in Germany, mentioned that the percent reduction of *P. citri* in the releasing plot by *C. montrouzieri* increased gradually from 0.7 in the beginning of the trial to 7.0, 13.7, 26.3, 45.1 and 74.0% in the following five months, respectively.

In Egypt, biological control measures against mealybugs using *C. montrouzieri* started in 1926. It was reared and distributed on a limited scale as its rearing was time consuming. Even though, the insect feeds freely on various species of mealybugs and the expenses involved

for its continuous breeding and feeding made it very costly. Thus, due to its low reproductive potential, slow spreading, the necessary protection to stand our winter condition and the annual release of new colonies, the work on this predator species was abandoned (Kamal, 1951). In 2006, a second trial to introduce this coccinellid predator from France to Egypt to be reared in the *Chrysopa* Mass Production laboratory, Faculty of Agriculture, Cairo University, was carried out and to be used against mealybugs in Egypt. Releasing *C. montrouzieri* against the striped mealybug, *Ferrisia virgata* gave a positive effect in reduction of the mealybug population, the percent of reduction reached to 100.0, 98.9 and 94.4% for crawlers, nymphs and adults of *F. virgata*, respectively after 3 months of release (Attia and El Arnaouty, 2007).

Planococcus citri was found infesting the croton ornamental shrubs, *Codiaeum variegatum* L. at Giza governorate, associated with its hemerobiid predator; *Symphorobius amicus* Navas. The present work aims to use this coccinellid predator, *C. montrouzieri* Muls. to control the citrus mealybug, *Planococcus citri*.

MATERIALS AND METHODS

Mass culture of *Cryptolaemus montrouzieri*: Adults of *C. montrouzieri* were obtained from the Mass rearing unit, Faculty of Agriculture, Cairo University. It was mass multiplied on the mealybug, *Planococcus citri* (Risso) infesting pumpkin fruits (*Cucurbita moschata*) as described by Chacko *et al.* (1978) under laboratory conditions of 26±2°C and 60-70% R.H. Each breeding cage yielded 100-200 beetles. The beetles were collected from the breeding cages with an aspirator, released in a plastic jar (14×11.5 cm) and fed on 50% honey solution. Twenty-day old adults were used for release after completing their pre-mating and pre-oviposition periods as recommended by Tirumala and David (1958).

Six shrubs of croton, 20 years old, 2.5-3.0 m height and 2.0 m width, highly infested by citrus mealybug, *P. citri* grown in Orman garden located at Giza governorate, in Egypt were chosen for this study. The shrubs of croton were divided into two groups, 1st one (3 replicate shrubs) was treated with the predator, while the latter one (3 replicate shrubs) was left untreated as a control. The ratio of release was 50 adults of predator per one croton shrubs. Release was made once (inoculation release) in the early morning of October, 27, 2008. Sampling was carried out every ten days starting from Oct. 27, 2008 (just prior to release) up to January, 30, 2009. Each sample consisted of 20 leaves per croton shrub. Samples were transferred to the laboratory for examination under a stereo-microscope. Number of egg masses, nymphs and adults of *P. citri* were counted. Also, numbers of the associated natural enemies; *Scymnus syriacus*, *Symphorobius amicus*, *Chrysoperla carnea* and the parasitoid, *Coccidoxenoides peregrinus* were also counted.

Percentage of reduction in the mealybug population was calculated using the formula of Henderson and Tilton (1955) as follows:

$$\text{Reduction (\%)} = 1 - \frac{T_a \times C_b}{T_b \times C_a}$$

Where:

T_b and T_a: No. of insects in treatment before and after treatment

C_b and C_a: No. of insects in control before and after treatment

Maximum temperature ranged from 16.7-28.6°C., while minimum temperature ranged from 7.4-16.7°C. The associated mean relative humidity ranged from 61-68% (Fig. 1).

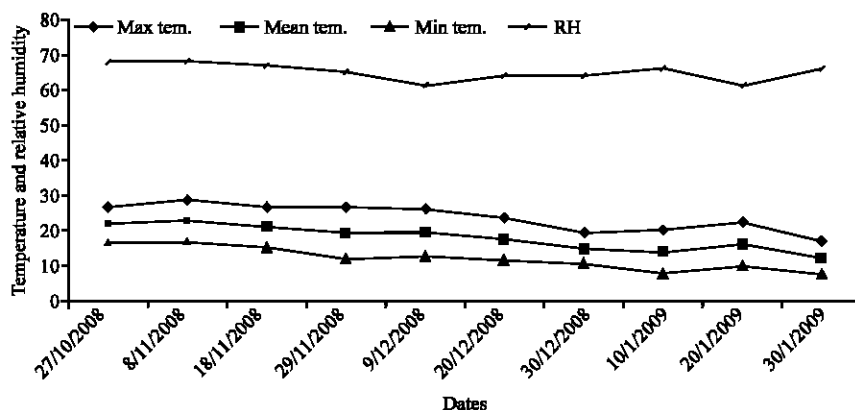


Fig. 1: Temperatures and relative humidity at Giza governorate during the period of investigation

Statistical analysis: Data were analyzed by multivariable analysis (ANOVA), with three replicates according to Snedecor and Cochran (1980) using Mstat-C program. When significant differences ($p < 0.05$) were found, the Least Significant Difference (LSD) test was used to separate the mean values according to Steel and Torrie (1981).

RESULTS AND DISCUSSION

Mealybug population density: The population of eggs, nymphs and adults of *Planococcus citri* and percentages of reduction are given in Table 1.

Just prior to release the predator (27/10/2008), the mean records of egg masses, nymphs and adults of the mealybug were 95.0, 1462.3 and 663.3 individuals/20 leaves in treatment. The corresponding values for the untreated treatment (control) were 98.0, 1417.0 and 670.0 individuals/20 leaves.

After one month of release, the population decreased gradually to record mean numbers of 8.7 egg masses, 322.0 nymphs and 86.3 adults/20 leaves in treatments. The corresponding values of reduction rate were 41.5, 42.3 and 57.5% (Table 1).

After two months of release, the respective mean numbers were 0.7, 20.0 and 1.0 for egg masses, nymphs and adults were recorded in treatment, opposed to the respective values of 3.0, 145.7 and 12.3 individuals/20 leaves in the control. Reduction rates reached to 80.6, 86.5 and 91.5% for egg masses, nymphs and adults of mealybug, respectively (Table 1).

At three months of release, no individuals were recorded in treated croton shrubs with predator. However, 0.7, 4.0 and 2.3 individuals/20 leaves for egg masses, nymphs and adults, respectively were recorded in control. Accordingly, complete reduction was achieved for all stages of the mealybug three months after release.

These results are in accordance with those of Mani (1988) in India, who reported that, *C. montrouzieri* succeeded to suppress the population of the grape vine mealybug, *Maconellicoccus hirsutus* within two months. In India, Mani *et al.* (1990) reported that the population of the mealybug *Ferrisia virgata* (Ckll.) in guava orchards was controlled within 50 days after releasing *Cryptolaemus montrouzieri*. Mangoud (2006) in Germany, mentioned that the reduction percent of *P. citri* in the releasing plots by *C. montrouzieri* increased gradually up to five months, respectively. Attia and El-arnaouty (2007) in Egypt showed that the *Cryptolaemus montrouzieri* was able to reduce the population of the striped mealybug. Reduction rates reached to 75.01 and 67.62% for nymphs and adults, respectively after two months of release.

Existence of *C. montrouzieri* after being released

***C. montrouzieri* eggs:** As shown on Fig. 2, the greatest number of *Cryptolaemus* eggs (12.0 eggs/20 leaves) was observed after 10 days of release. However, it ranged from 8.3 to 12.0 eggs/20 leaves during the first month of release, opposed to the respective ranges of 2.3-6.0 eggs/20 leaves and 0.0-3.0 eggs/20 leaves during the second and third months of release.

Table 1: Number and reduction% of egg masses, nymphs and adults of *Planococcus citri* population before and after releasing the coccinellid predator, *Cryptolaemus montrouzieri* (Muls.) on croton ornamental shrubs, *Codiaeum variegatum* L. at Giza governorate, Egypt

Date of counting	Treatments	Egg masses		Nymphs		Adults	
		No.	Reduction (%)	No.	Reduction (%)	No.	Reduction (%)
27/10/2008	Treated	95.0±4.1	-	1462.3±264.9	-	663.3±86.1	-
	Control	98.0±13.9		1417.0±62.3		670.0±21.6	
80/11/2008	Treated	86.0±4.3	17.0±2.1 f	1250.0±187.1	19.4±7.2 g	600.0±81.7	9.0±4.6 f
	Control	96.7±14.3		1394.3±74.8		668.0±48.1	
18/11/2008	Treated	54.0±4.3	18.2±13.9 ef	1000.0±81.7	32.6±6.6 f	450.0±40.8	28.2±9.6 e
	Control	70.0±8.2		1262.7±93.6		648.3±18.4	
29/11/2008	Treated	8.7±1.3	41.5±7.1 de	322.0±27.0	42.3±6.9 ef	86.3±16.5	57.5±9.5 d
	Control	15.3±2.1		559.3±42.9		213.3±4.7	
09/12/2008	Treated	2.3±0.5	54.9±1.9 cd	110.0±4.1	56.7±4.7 e	20.0±4.1	78.3±4.5 c
	Control	5.3±1.3		253.7±4.5		96.3±1.3	
20/12/2008	Treated	1.3±0.5	65.4±7.2 cd	55.0±7.1	73.2±2.3 d	3.0±0.8	89.0±1.8 c
	Control	4.0±0.8		203.0±6.2		27.7±1.7	
30/12/2008	Treated	0.7±0.5	80.6±10.8 bc	20.0±4.1	86.5±1.8 c	1.0±0.0	91.5±1.0 bc
	Control	3.0±0.8		145.7±13.8		12.3±1.9	
10/01/2009	Treated	0.3±0.5	86.1±13.9 ab	9.0±0.8	91.1±1.3 bc	0.3±0.5	95.9±4.1 ab
	Control	2.0±0.0		101.3±2.6		9.7±0.5	
20/01/2009	Treated	0.0±0.0	100.0±0.0 a	0.7±0.5	97.2±1.5 ab	0.0±0.0	100.0±0.0 a
	Control	0.3±0.5		25.3±1.3		1.0±0.0	
30/01/2009	Treated	0.0±0.0	100.0±0.0 a	0.0±0.0	100.0±0.0 a	0.0±0.0	100.0±0.0 a
	Control	0.7±0.9		4.0±0.8		2.3±0.5	

Means followed by the same letter in the same column are not significantly ($p > 0.05$) different

C. montrouzieri larvae: The highest counts of *C. montrouzieri* larvae were recorded during the period from 10 to 40 days after release; the greatest values reached to 24.7 larvae/20 leaves after 20 days of release. However, the mean numbers of *Cryptolaemus* larvae decreased to 10.3, 8.3, 5.0, 6.3 and 1.3 individuals/20 leaves after 50, 60, 70, 80 and 90 days of release, respectively (Fig. 2). In this concern, Mani *et al.* (1990) recorded that the mean population of *Cryptolaemus* grubs ranged from 6.1 to 15.2 plant⁻¹.

C. montrouzieri adults: It is too difficult to count adults owing to its mobility. However, a mean number of 4.0 adults/20 leaves was recorded after one month of release. After two and three months, counts decreased to the

respective values of 1.3 and 0.3 individuals/20 leaves (Fig. 2). In this concern, Mani *et al.* (1990) reported that no predators were detected after the 50th day of release, as complete control was achieved.

The associated natural enemies located in the field: The associated natural enemies which were found in the field consisted of three predaceous insects and one parasitic species. The insect predators secured were the hemerobiid predator, *Sympherobius amicus* Navas; the coccinellid predator, *Scymnus syriacus* (Mars.) and the chrysopid predator, *Chrysoperla carnea* (Stephens). The parasitic species was the encyrtid, *Coccidoxenoides peregrinus* (Timberlake). The aforementioned natural enemies were found feeding on the citrus mealybug, *Planococcus citri* infesting croton shrubs.

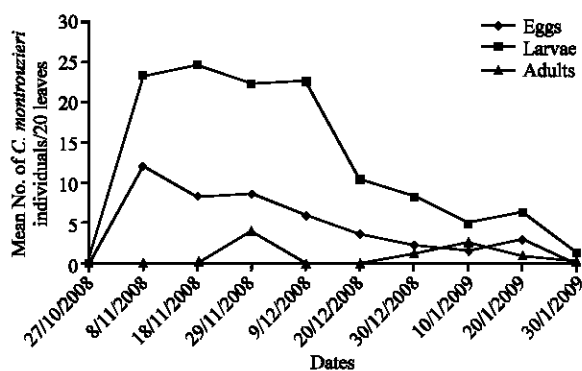


Fig. 2: Mean number of *Cryptolaemus montrouzieri* individuals per 20 leaves of croton shrubs at Giza governorate, Egypt

The population of *Sympherobius amicus*: Data on Fig. 3 represent the population of eggs, larvae and pupae of *Sympherobius* in treatment and control.

During the first month of release, the mean number of *Sympherobius* eggs ranged from 0.3 to 0.7 and from 2.3 to 7.3 eggs/20 leaves in treatment and control, respectively. The respective ranges of its larvae were 17.7-32.0 and 48.7-164.0 larvae/20 leaves, opposed to the respective ranges of 1.7-5.3 and 5.0-35.0 for pupae/20 leaves.

During the second month of release, respective ranges of *Sympherobius* eggs, larvae and pupae in the treatment were 0.0-0.3, 0.3-4.7 and 0.0-3.3 / 20 leaves. The corresponding values in the control were 0.7-3.7, 6.7- 16.3 and 15.0-40.3 / 20 leaves.

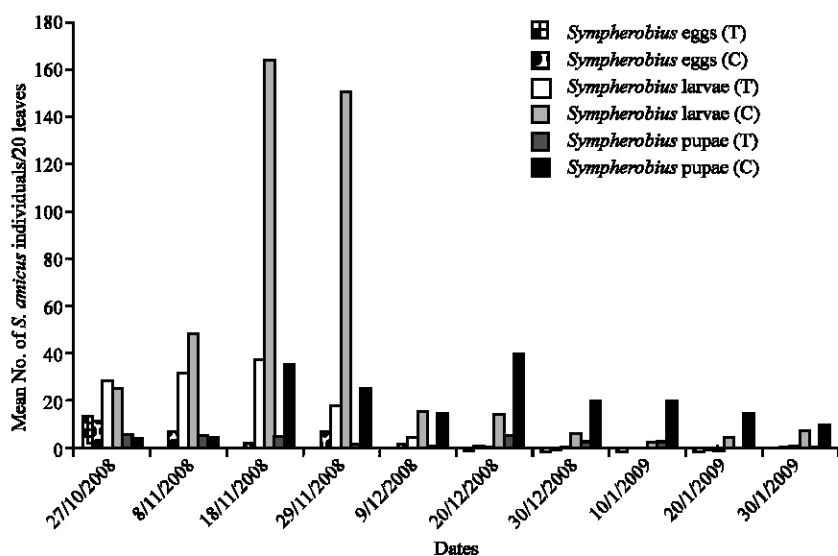


Fig. 3: Mean number of *Sympherobius amicus* individuals per 20 leaves of croton shrubs in treatment(T) and control(C) at Giza governorate, Egypt

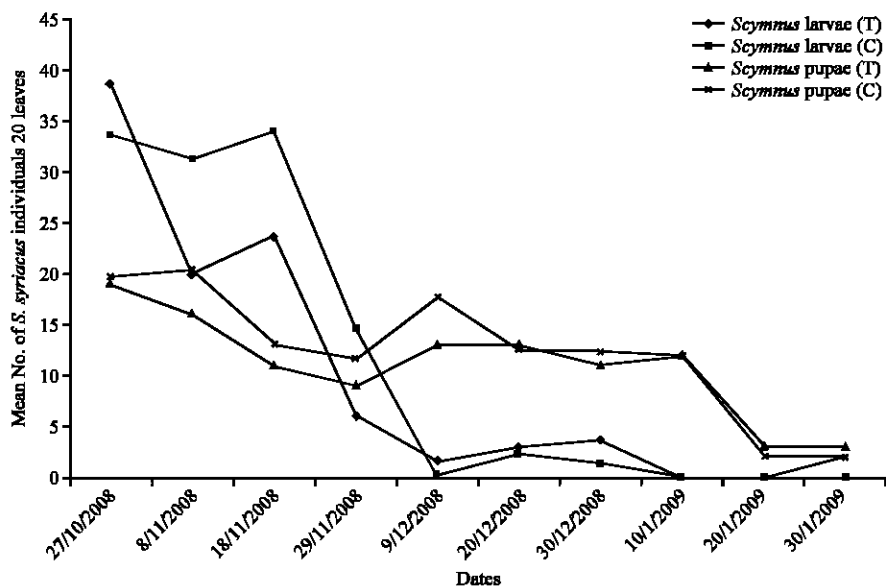


Fig. 4: Mean number of *Scymnus syriacus* individuals per 20 leaves of croton shrubs in treatment(T) and control(C) at Giza governorate, Egypt

During the third month of release, the mean number of *Sympherobius* eggs in treatment and control ranged from 0.0 to 0.3 and from 0.7 to 1.7 individuals/20 leaves, respectively opposed to the respective ranges 0.0-1.3 and 3.0-8.0 larvae/20 leaves. On the other hand, the *Sympherobius* pupae ranged from 0.0 to 1.0 and from 10.0 to 40.0 pupae/20 leaves in treatment and control, respectively.

It is noticed that number of predator in the control was comparatively higher than in the treatment. This phenomenon may be attributed to the scarcity of mealybug individuals in the treated shrubs from one side and to the cannibalistic behavior of *Cryptolaemus* individuals in case of prey depletion from the other side.

The population of *Scymnus syriacus*: Data on Fig. 4 showed that during the first month of release, the population of *Scymnus* larvae ranged from 6.0 to 35.0 and from 14.7 to 34.0 individuals/20 leaves in treatment and control, respectively. On other hand, the population of *Scymnus* pupae ranged from 9.0 to 16.0 and from 11.7 to 20.3 individuals/20 leaves in treatment and control, respectively.

During the second month of release, the population of *Scymnus syriacus* larvae ranged from 1.7 to 3.7 and from 0.3 to 2.3 individuals/20 leaves in treatment and control, respectively. The corresponding values of pupae were 11.0-13.0 and 12.3-17.7 individuals/20 leaves.

During the third month of release, *Scymnus* larvae population ranged from 0.0-2.0 and 0.7 individuals/20

leaves in treatment and control, respectively opposed to the ranges of 3.0-12.0 and 2.0-12.0 for pupae.

The population of *Chrysoperla carnea*: Data on Fig. 5 indicated that during the first month of release, the population of *Chrysoperla* eggs ranged from 3.3 to 6.7 and from 7.3 to 26.3 eggs/20 leaves in treatment and control, respectively. On the other hand, the population of *Chrysoperla* larvae ranged from 0.0 to 1.7 and from 1.7 to 7.7 larvae/20 leaves in treatment and control, respectively.

During the second month of release, the ranges of *Chrysoperla* eggs were 1.3-2.0 and 6.0-22.7 in treatment and control, respectively. Ranges of corresponding values of larvae were 0.3-2.0 and 2.3-3.0 larvae/20 leaves.

During the third month of release, the mean number of *Chrysoperla* eggs ranged from 1.3 to 3.0 and from 3.3 to 10.7 eggs/20 leaves in treatment and control, respectively. The corresponding ranges of *Chrysoperla* larvae were 0.0-0.7 and 1.7-1.7 larvae/20 leaves.

The population of the encyrtid parasitoid, *Coccidoxenoides peregrinus*: The encyrtid parasitoid, *Coccidoxenoides peregrinus* was recorded as an endoparasitoid species on citrus mealybug, *P. citri* on croton shrubs.

Data on Fig. 6 showed that during the first month of release, ranges of the parasitoid's mummies were 50.7-110.7, 118.3-134 individuals/20 leaves in treatment and control, respectively.

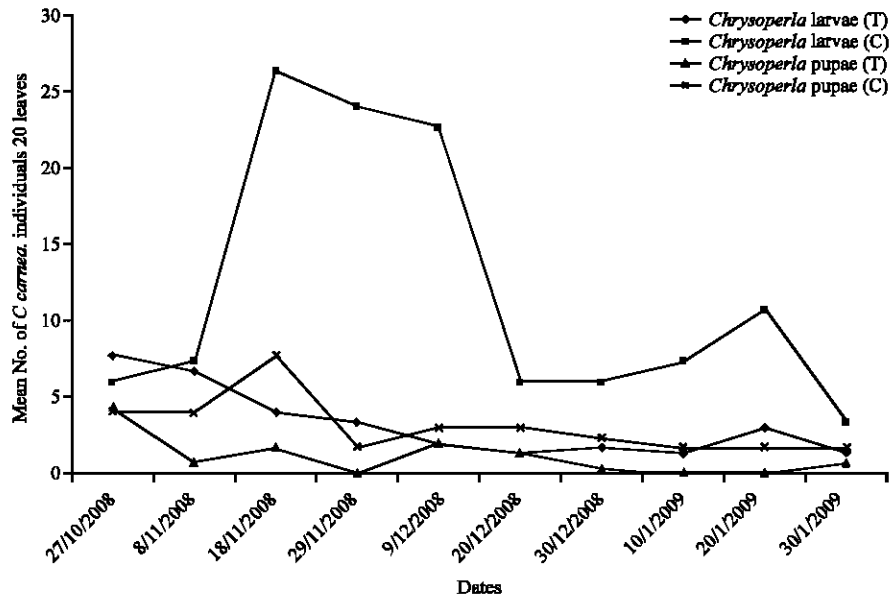


Fig. 5: Mean number of *Chrysoperla carnea* individuals per 20 leaves of croton shrubs in treatment(T) and control(C) at Giza governorate, Egypt

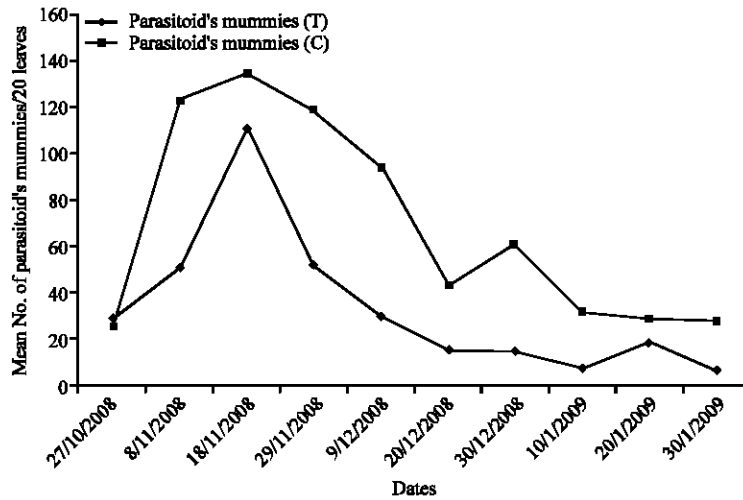


Fig. 6: Mean number of parasitoid's mummies and adults per 20 leaves of croton shrubs in treatment(T) and control(C) at Giza governorate, Egypt

During the second month of release, the mean number of parasitoid's mummies ranged from 15.0 to 29 and from 43.3 to 93.3 individuals/20 leaves in treatment and control, respectively.

During the third month of release, ranges of the parasitoid's mummies were 6.3-18.0 and 27.3-31.7 individuals/20 leaves, in treatment and control, respectively. These results are in agreement with the findings of Mani (1988).

From the all previous results, it could be concluded that, the reduction of mealybug population was due to

the effect of the predator *C. montrouzieri*, together with the associated natural enemies located in the field. The *C. montrouzieri* predator had highly predation capacity on mealybug *P. citri* at a short period (70 days). As the coccinellid *C. montrouzieri* Mulsant known as Australian mealybug destroyer because both its adults and grubs feed extensively on all stages of the mealybug but the larvae are more voracious feeders. In the second season, in 2009. There is no mealybug individual's, *P. citri* was found on the croton shrubs.

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