Biological Control of Citrus Mealybug, *Planococcus citri* (RISSO) on Croton Shrubs Using the 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. Adults of the predator were released once on October 27, 2008 in the open field, with 50 *Cryptolaemus* adults/ Croton shrub. 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. Numbers of the associated natural enemies; *Scymnus syriacus*, *Sympherobius amicus*, *Chrysoperla carnea*, and the parasitoid, *Coccidoxenoides peregrinus* were also counted. In the second season, in 2009, no mealybug individuals *P. citri* were found on the croton shrubs.

Keywords: *Cryptolaemus montrouzieri*, Croton shrub, coccinellid predator, *Cryptolaemus*, reduction rates

INTRODUCTION

The citrus mealybug, *Planococcus citri* (Risso) (Homoptera: Pseudococcidae) is one of the most common pests in citrus, curry leaf plant, cotton, banana, coffee, cocoa, ginger, mango etc.; Rao *et al.* (2006).

Planococcus citri was found infesting the croton ornamental shrubs, *Codiaeum variegatum* (L.) at Giza governorate, associated with its hemerobiid predator; *Sympherobius amicus* Navas (Attia and El Arnaouty, 2008). *Cryptolaemus montrouzieri* Muls. (Coleoptera: Coccinellidae) is a mealybug predator, both larvae and adults attack all stages of this pest. The 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. Biological control measures against mealybugs in Egypt by 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). After 55 years from the previous work, 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 (Attia and El Arnaouty, 2007). 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 99.99, 98.85 and 94.42% for crawlers, nymphs and adults of *F. virgata*, respectively after 3 months of release (Attia and El Arnaouty, 2007). The present work aims to use this coccinellid predator to control the citrus mealybug *Planococcus citri* on the croton ornamental shrubs, C. *variegatum*.

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 premating and pre-ovipostion periods (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, 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 and were far from the first ones. 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 three times a month 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 *P. citri* (egg masses, nymphs and adults) were counted. Also, numbers of the associated natural enemies; *Scymnus syriacus*, *Sympherobius 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:

$$\text{Reduction \%} = 1 - \frac{Ta \times Cb}{Tb \times Ca} \times 100$$

Where:

Tb, Ta = Number of insects in treatment before and after treatment.

Cb, Ca = Number of insects in control before and after treatment.

Meteorological data were obtained from the nearest meteorological station at Giza during the period of study.

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 calculated, the least significant difference (LSD) test was used to separate the mean values according to Steel and Torrie (1981).

RESULTS AND DISCUSSION

Climatic conditions:

During the period of study, 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).

Mealybug population density:

Population records of *Planococcus citri* (eggs, nymphs and adults) in treatment and control are graphically illustrated on Figs. 2, 3 and 4, as well the percentages of reduction that are given on 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 figures for the control were 98.0, 1417.0 and 670.0 individuals/ 20 leaves.

As shown in Table 1 and Figs. 2, 3 and 4, after one month of release (29/11/2008), 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 figures of reduction rate were 41.5, 42.3 and 57.5% (Table 1).

After two months of release (30/12/2008), the respective mean numbers of 0.7, 20.0 and 1.0 for egg masses, nymphs and adults were recorded in treatment, opposed to the respective figures of 3.0, 145.7 and 12.3 individuals/20 leaves in the control (Figs. 2, 3 and 4). Reduction rates were 80.6, 86.5 and 91.5% for egg masses, nymphs and adults of mealybug, respectively (Table 1).

Three months later (30/1/2009), no individuals were recorded in treatment. However, 0.7, 4.0 and 2.3 individuals/ 20 leaves for egg masses, nymphs and adults, respectively were recorded in control (Figs. 2, 3 and 4). Accordingly, complete reduction was achieved for all stages of the mealybug three months after release.

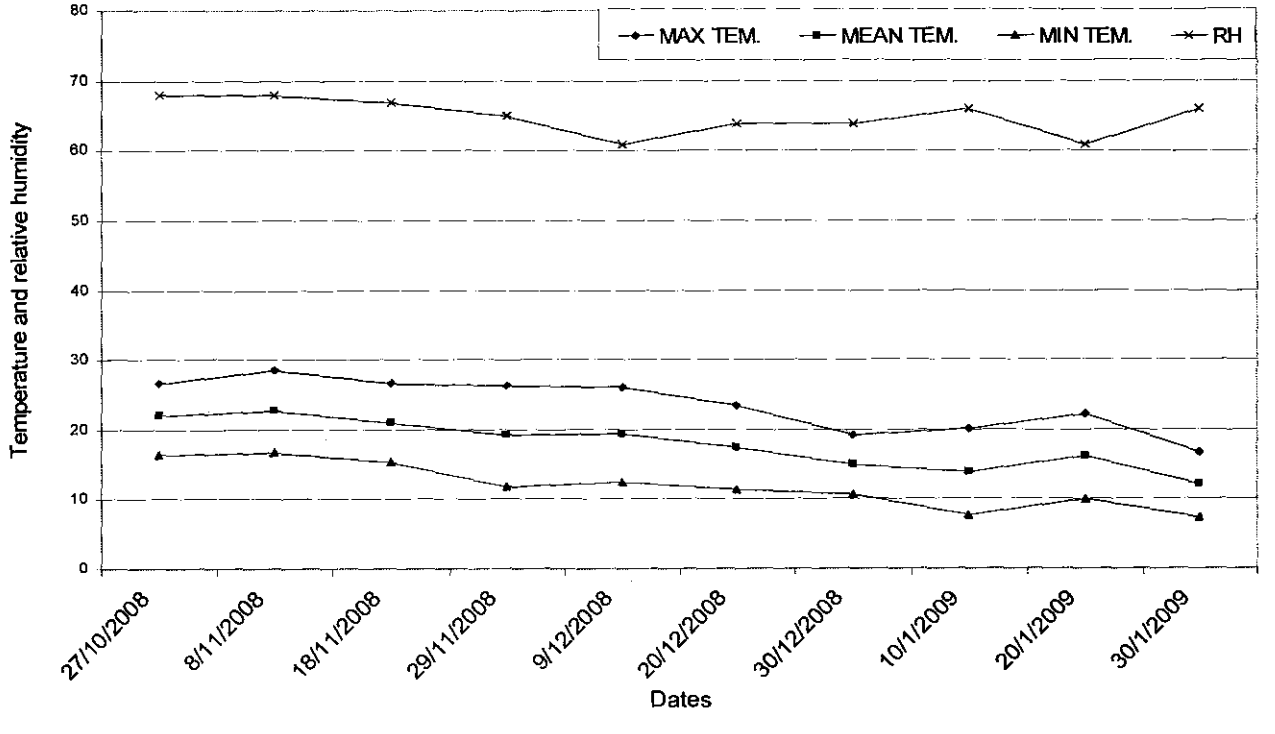

Fig. (1) : Temperatures and relative humidity at Giza governorate during the period of investigation.

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

Date	Treatments	Egg masses		Nymphs		Adults	
		Mean number	Reduction (%)	Mean number	Reduction (%)	Mean number	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.

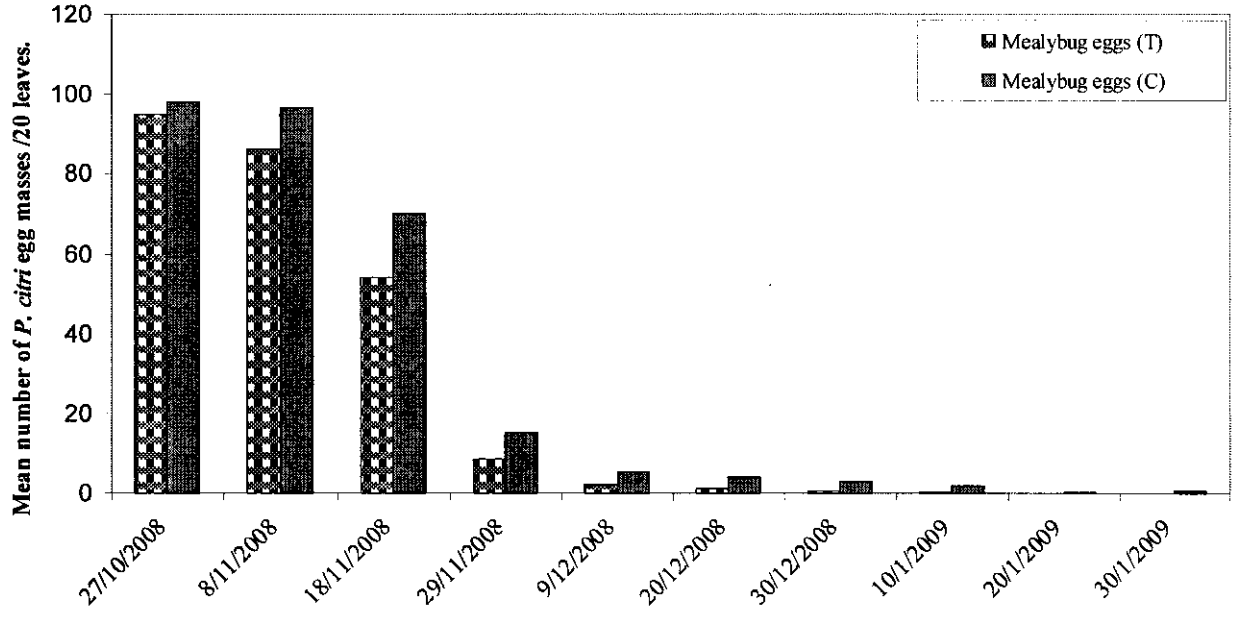

Fig. (2): Mean number of Planococcus citri egg masses per 20 leaves of croton shrubs in treatment(T) and control(C) at Giza governorate, Egypt.

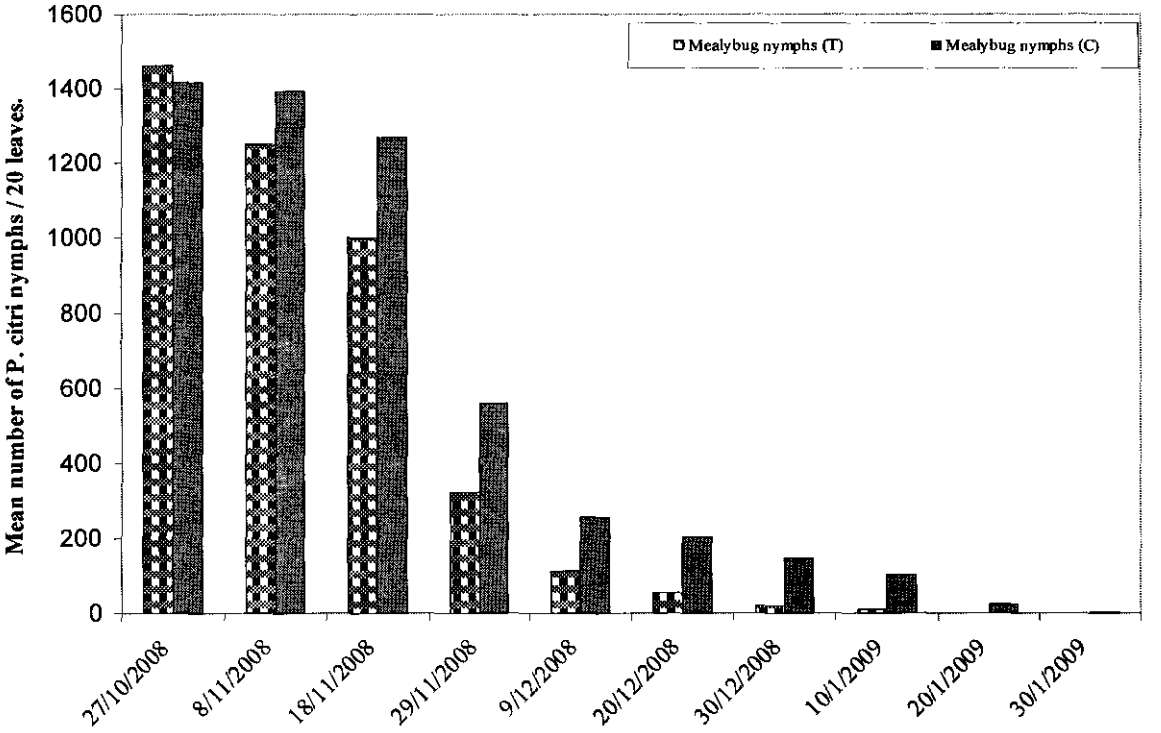

Fig. (3): Mean number of *Planococcus citri* nymphs per 20 leaves of croton shrubs in treatment(T) and control(C) at Giza governorate, Egypt.

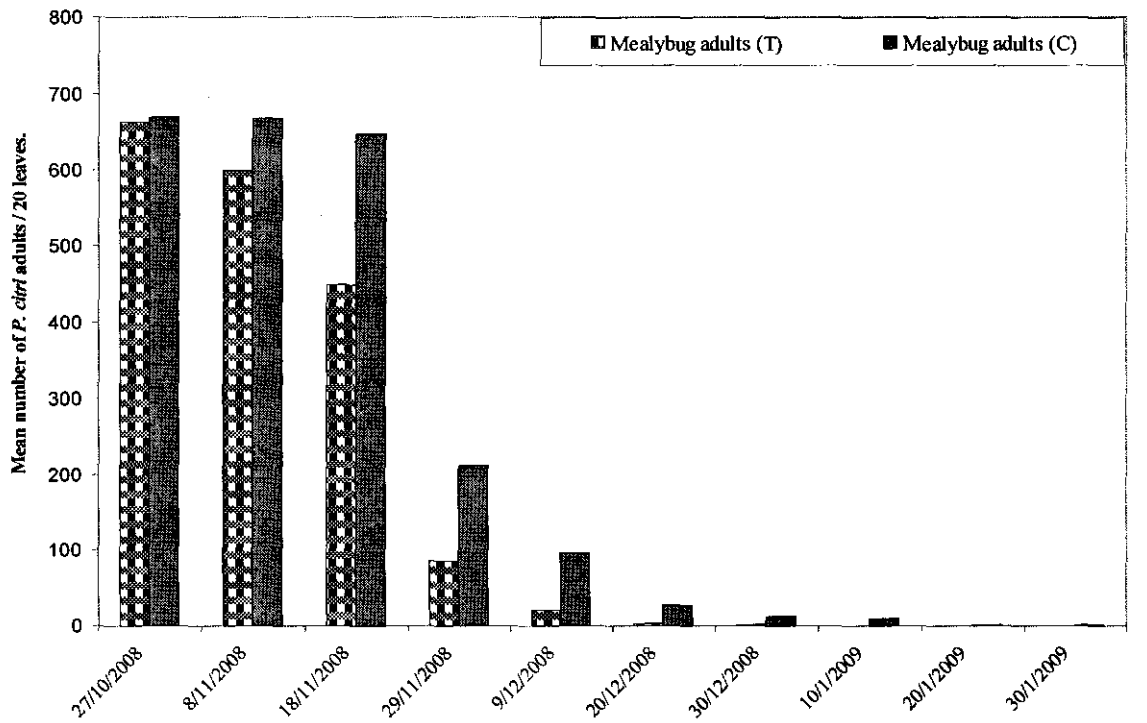

Fig. (4): Mean number of *Planococcus citri* adults per 20 leaves of of croton shrubs in treatment(T) and control(C) at Giza governorate, Egypt.

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.* Attia and El-arnaouty (2007) showed that the same predator was able to reduce the population of the same pest ; reduction rates reached to 75.01 and 67.62% for nymphs and adults, respectively after two months of release, and to the respective rates of 89.3 and 95.4% in the 11th week after release. Moreover, the present data were in agreement with the observations of Srinivasan and Sundara-Babo (1989), who found that the maximum effect of this predator against the mealybug, *Maconillicoccus hirsutus* on grapes was observed six weeks after the initial release, with 64.3% reduction when 10 predators were released per vine. The present data was also supported by the study of Mani (1988), who reported that, *C. montrouzieri* succeeded to suppress the population of the grape vine mealy bug *Maconellicoccus hirsutus*; the release of 1000-1500 adults predator/ acre gave an effective control within two months. Mangoud, (2006) 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.

Existence of C. montrouzieri after being released

- *Cryptolaemus* eggs

As shown on Fig. 5, the greatest number of *Cryptolaemus* eggs was observed after 10 days of release, when 12.0 eggs/ 20 leaves were recorded. 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.

- *Cryptolaemus* larvae

Great counts of *C. montrouzieri* larvae were recorded during the period from 10 to 40 days after release; the greatest figure 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. 5). In this concern Mani *et al.* (1990) recorded that the mean population of *Cryptolaemus* grubs ranged from 6.1 to 15.2 per plant.

- *Cryptolaemus* adults

It is too difficult to count adults, number 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 figures of 1.3 and 0.3 individuals/ 20 leaves (Fig.5). 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 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.

- The population of *Sympherobius amicus*

Data on Fig. 6 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 – 0.7 and 2.3 – 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 figures in the control were 0.7 – 3.7, 6.7- 16.3 and 15.0 – 40.3 / 20 leaves.

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 numbers 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.7 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 figures 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. 8 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 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 mean ranges of *Chrysoperla* eggs were 1.3 – 2.0 and 6.0 – 22.7 in treatment and control, respectively. Ranges of corresponding figures 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. 9 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.

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). In the second season, in 2009. There is no mealybug individuals *P. citri* was found on the croton shrubs.

In Egypt, the newly reclaimed cultivated areas of vineyards suffer from the absence of the predators where the population of the vine mealybug, *p. ficus* has increased and causes a great problem (Attia, 2003). Therefore, rearing and releasing of *C. montrouzieri* in the vineyards may help in regulating the population of the vine mealybugs.

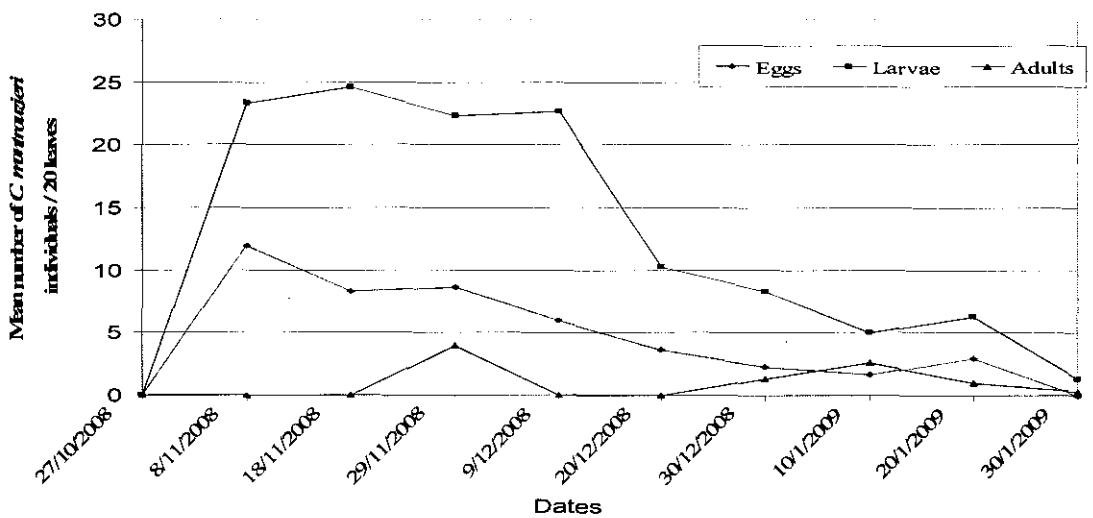

Fig. (5): Mean number of Cryptolaemus montrouzieri individuals per 20 leaves of croton shrubs at Giza, Egypt.

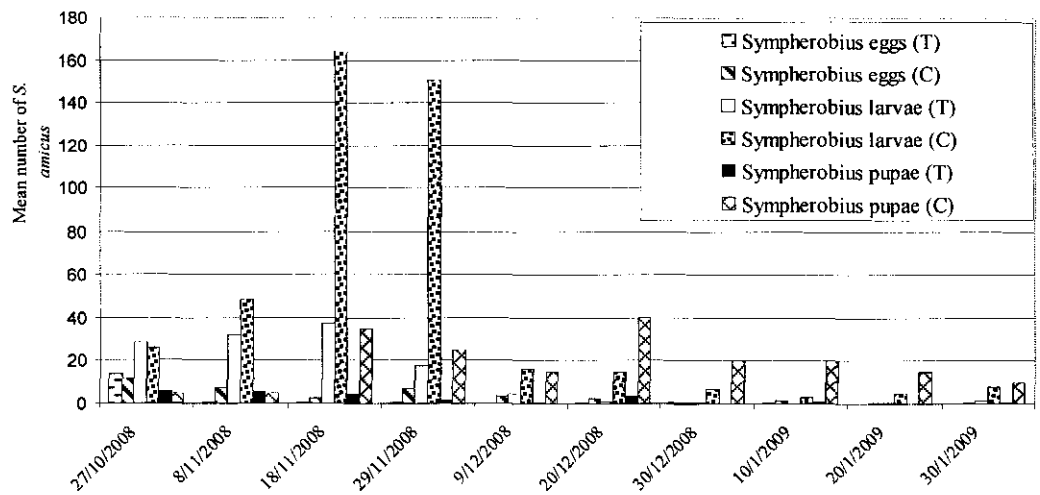

Fig. (6): Mean number of *Sympherobius amicus* individuals per 20 leaves of croton shrubs in treatment(T) and control (C) at Giza governorate, Egypt.

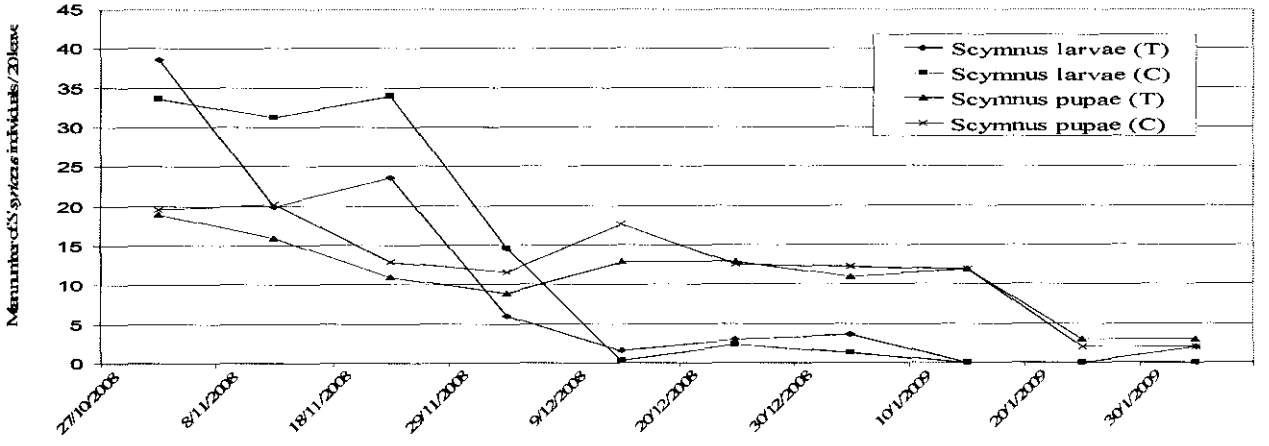

Fig. (7): Mean number of *Scymnus syriacus* individuals per 20 leaves of croton shrubs in treatment(T) and control(C) at Giza governorate, Egypt.

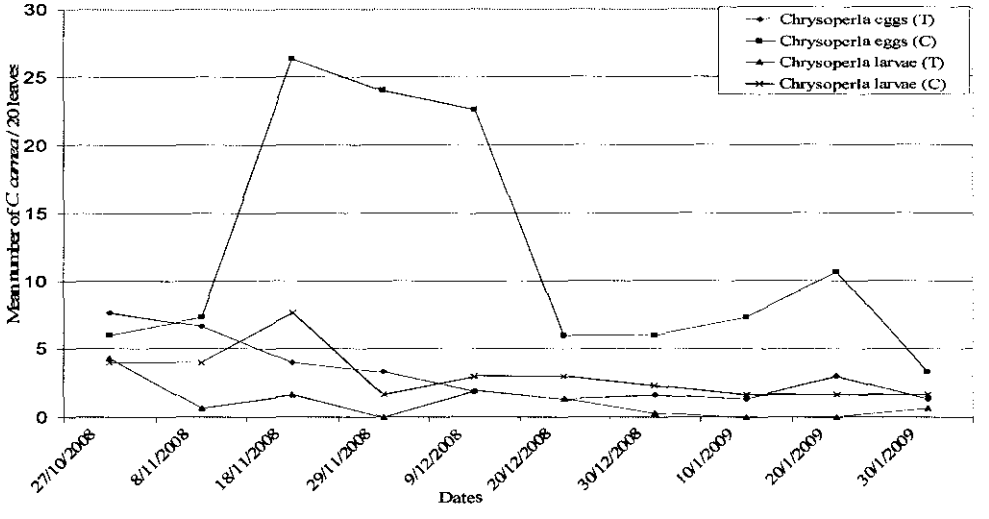

Fig. (8): Mean number of *Chrysoperla carnea* individuals per 20 leaves of croton shrubs in treatment(T) and control(C) at Giza governorate, Egypt.

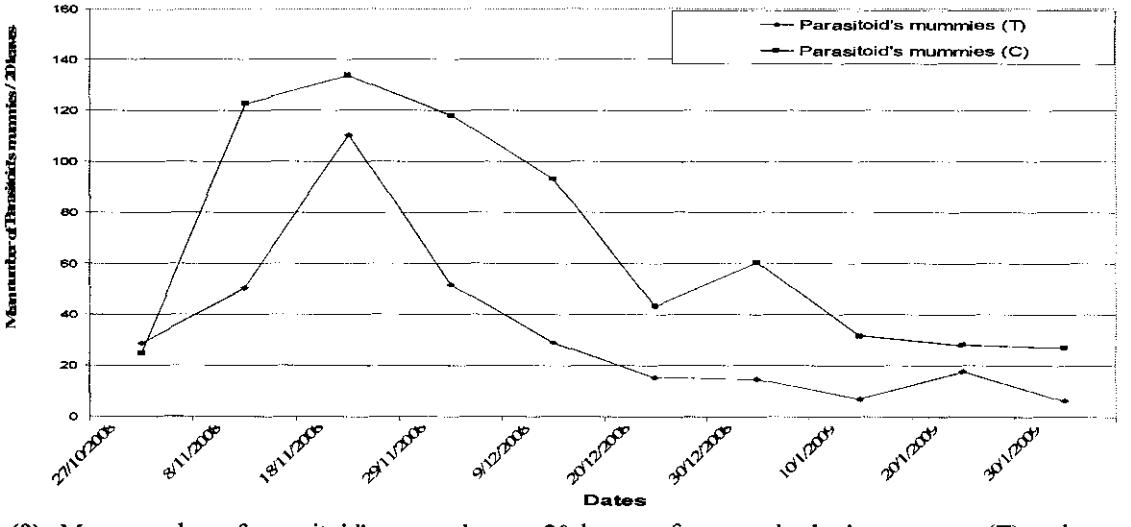

Fig. (9): Mean number of parasitoid's mummies per 20 leaves of croton shrubs in treatment (T) and control(C) at Giza governorate, Egypt.

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المكافحة الحيوية لبق الموالح الدقيقى على شجيرات الكروتون باستخدام المفترس كريبتوليمس مونترويوزيرى *Cryptolaemus montrouzieri* Muls.

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تم إستخدام المفترس كريتوليمس مونترويوزيرى *Cryptolaemus montrouzieri* Muls. فى المكافحة الحيويه لبق الموالح الدقيقى على شجيرات الكروتون. حيث تم إطلاق المفترس فى حديقة الأورمان (محافظة الجيزة) فى نهاية شهر اكتوبر ٢٠٠٨ بمعدل ٥٠ فرد من المفترس/شجيره، كما تم عمل حصر للأعداء الحيوية المصاحبة للأفه على شجيرات الكروتون (مفترس السكيمنس، مفترس السيمفروبيس، مفترس أسد المن ، وطفيل كوكسيدواوكسيدونس)

وقد اوضحت النتائج المتحصل عليها إنخفاض فى تعداد كلا من كتل البيض والحوريات والحشرات الكاملة لبق الموالح الدقيقى. وقد قدرت نسبة الخفض بعد شهر من إطلاق المفترس بمتوسط ٤١,٥ % ، ٤٢,٣ % و ٥٧,٥ % لكل ٢٠ ورقة نبات على التوالى وقد لوحظت زيادة فى نسبة انخفاض كتل البيض والحوريات والحشرات الكامله لبق الموالح الدقيقى ٨٠,٦ %، ٨٦,٥ % و ٩١,٥ % على التوالى بعد شهرين من الاطلاق. وقد أوضحت النتائج المتحصل عليها إنخفاض نسبة الأصابه ببق الموالح الدقيقى بأطواره االمختلفه (البيض، الحوريات، الحشرات الكامله) إلى ١٠٠ % بعد ٣ شهور من الاطلاق.