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Biological control of *Aulacaspis tubercularis* and *Kilifia acuminata* infested mango trees by *Chrysoperla carnea* (Neuroptera: Chrysopidae)

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Abstract

The current study was carried out to evaluate the efficacy of *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) against *Aulacaspis tubercularis* (Newstead) and *Kilifia acuminata* (Signoret) (Hemiptera: Diaspididae and Coccidae) infested mango trees (*Mangifera indica* L.) in Faculty of Agriculture-Cairo University-Giza Governorate by double release, 50 individuals of 2nd larval instar of *C. carnea* for each release and counts were recorded at 15, 30 and 45 days, post-treatment. Results indicated that in the first release, there was an effective reduction percentage in the population of both scale insects in autumn. The mean reduction percentages 45 days after treatment in *A. tubercularis* were 86.08, 78.40 and 76.07%, respectively. While, in *K. acuminata*, the mean reduction percentages were 81.48, 77.78 and 75%, respectively. In the second release, in spring, the mean reduction percentages 45 days after treatment in *A. tubercularis* were 81.48, 77.78, and 75%, respectively. However, in *K. acuminata*, the mean reduction percentages 45 days after treatment were 84.37, 66.6 and 75.1%, respectively. *C. carnea* has proven to be a highly efficient biocontrol agent against scale insects *A.tubercularis* and *K. acuminata*.

Introduction

The mango trees *Mangifera indica* L. (Family: Anacardiaceae), are one of the most widespread tropical fruits in Egypt after citrus and grapes in terms of production, marketing, and consumption due to their exotic flavor and delicious taste, as well as high nutritional value and high yield (Kawiz, 1999 and Radwan, 2003). Moreover, the cultivation of mangoes is a significant contributor to Egypt's economy, with a primary focus on eight Governorates in the Nile Delta (Hashem, 2021). Mango trees are susceptible to various insect pests, including the white mango scale, *Aulacaspis tubercularis* (Newstead) (Hemiptera: Diaspididae), and *Kilifia acuminata* (Signoret) (Hemiptera: Coccidae), the first is a hard scale insect but the second is a soft scale insect. They cause much damage as it has pipette-piercing mouth parts, they suck plant sap from different parts of plants such as shoots, twigs, leaves, and fruits of mango trees causing momentous damage. This mechanism confused the plant physiology and led to plant weakness, which became endangered infesting by secondary infestation with other insects. High infestation levels caused serious damage such as early leaves drop and reduced yield of mango orchards (Elwan, 1990; Kwaiz, 1999 and Nada *et al.*,1990). These insects cause reduced mango production and decrease the quantity and quality of fruits (Elwan *et al*., 2005; Kwaiz, 2009; Fita, 2014 and Fita *et al*., 2023). It has three annual generations in Sharkia Governorate (Hassan *et al.*, 2012), while Amer *et al.* (2017) recorded that *A. tubercularis* had three or four peaks in Qaliobiya Governorate.

K. acuminata infested mango trees, causing serious damage to leaves and fruits. It secretes dew on leaves which reduces photosynthesis on leaves (Badawy *et al.*, 2000; El-Dash *et al.*,2002 and Hassan *et al*., 2012). It is crucial to manage pests effectively while also prioritizing environmental preservation through reduced pesticide use. Therefore, implementing a biological control approach to enhance the impact of natural enemies is essential in integrated pest management. The green lacewing *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) has become an increasingly popular biological control agent for agricultural insect pests in integrated management (I.P.M.) programs. Its ability to be easily mass-produced (El-Arnaouty, 1991) and its broad tolerance to many insecticides, particularly during the larval and cocoon stages, give it an advantage over other natural enemies (Medina *et al*., 2001; Chen and Liu, 2002 and Badawy *et al*., 2006). The larvae of *C. carnea* are known for their voracious appetite for soft-bodied arthropods, including aphids, whiteflies, thrips, mealybugs, scale insects, Leafhoppers, and eggs and small larvae of Coleoptera and Lepidoptera (Ulhaq *et al.,* 2006; El-Hawary *et al.,* 2010; Abd-Rabou *et al.*,2012; Khan *et al*.,2015; Rugno *et al*., 2019; El-Dessouki *and* Korish, 2023 and Ismail *et al*., 2023).

The primary objective of this research was to assess the potential of *C. carnea* larvae as a biological control agent against various life stages of two scale insects, *A. tubercularis* and *K. acminata* infested mango trees.

Materials and methods

1. Rearing of the predator *Chrysoperla carnea*:

Adults of *C. carnea* were placed in plastic boxes 20×15×6 cm covered with black muslin for deposited eggs, semi-artificial diet (4g yeast extract, 8g honey and 4cm distilled water) drops were provided on tape stacked on the muslin for adults nutrition. The deposited eggs were collected daily, and the boxes were changed three times per week. The eggs of *C. Carnea* were kept in plastic boxes until hatching, the hatched larvae were supplied by eggs of the grain moth *Sitotroga cerealella* as a food source Eggs of *S. cerealella* were obtained from the mass production Unit of *S. cerealella* eggs, bollworm Research Department, Plant Protection Research Institute, Agricultural Research Center , Dokki, Giza, Egypt.

2. Experimental design:

This experiment was conducted in the Faculty of Agriculture, Cairo University Giza Governorate of 31st October 2022, with a corresponding temperature of an average of 30°C and 55% (RH.). The experiment involved selecting 30-year-old mango trees that were heavily infested with *A. tubercularis* and *K. acminata* which had not been treated with insecticides for two years before the study. The treatments consisted of replicating 5 leaves 5 times for each release, where two releases of the 2nd larval instar of *C. carnea* with 50 larvae per treatment were carried out. During the first release in Autumn *C. carnea* larvae were delicately placed on the infested leaves using a fine camel brush. With second release in spring, the treatments were repeated with 50 larvae/ treatment.

3. Sampling procedures:

Following the treatment, counts were conducted at intervals of 15, 30, and 45 days. The samples were stored in polyethylene bags and promptly transported to the laboratory for examination. Various life stages of the insects were identified (Living specimens) in order to determine the percentage decrease in the population.

4. Statistical analysis:

The reduction in population percentages of *A. tubercularis* and *K. acuminata at* various stages relative to the initial count before treatment was calculated according to Stafford and Summers (1963) equation.

$$R = \frac{\text{Pre-treatment count} - \text{Post-treatment counts}}{\text{Pre-treatment counts}} \times 100$$

The results were analyzed utilizing the Cost as a computer program to calculate the" F value" and Least Significant Difference (L.S.D.) between treatments (Two releases) of second larval instars of *C. carnea*.

Results and discussion

Biological control of *Aulacaspis tubercularis* and *Klifia acuminata* infesting mango trees by releasing of 2nd larval instar of *Chrysoperla carnea*:

1. The first releasing of 2nd larval instar of *Chrysoperla carnea*:

The study involved the release of the 2nd larval instar of *C. carnea* to feed on *A. tubercularis* and *K. acuminata* in different stages infesting mango trees in Faculty of Agriculture-Cairo University in October 2022.

The data displayed in Table (1) and depicted in Figure (1), indicated that there was a significant decrease in the total population of *A. tubercularis* and *K. acuminata* were recorded after 45 days after treatment with 80.18 % and 78.09 %, respectively, followed by the 2nd post count with 71.12 % and 55.54 % respectively then the 1st post count with 47.49 % and 46.68 % respectively. Statistical analysis also indicated a significant disparity between 1st count and both 2nd and 3rd count in *A. tubercularis* and *K. acuminata* with F value = 23.99 and L.S.D.= 14.96±4.87 in *A. tubercularis* while, *in K. acuminata was* F value 22.30 and L.S.D.=14.89 ± 4.85.

Table (1): Reduction percentages of *Aulacaspis tubercularis* and *Klifia acuminata* infestation under first release of 2nd larval instar of *Chrysoperla carnea*.

Sampling dates	*Aulacaspis tubercularis* df= (2,6)				*Kilifia acuminata* df= (2,6)			
	Nymphs	Adults	Gravid females	Total mean reduction	Nymphs	Adults	Gravid females	Total mean reduction
1st count	56.1	45.27	41.10	47.49±4.470b(C)	51.85	44.44	43.75	46.68± 2.59b(C)
2nd count	76.02	69.82	67.48	71.12±2.55b(AB)	64.2	55.56	46.87	55.54± 5.00b(BC)
3rd count	86.08	78.40	76.07	80.18±3.02a(A)	81.48	77.78	75.00	78.09± 1.88a(A)
F value	23.99**				22.30**			
P	0.001				0.002			
L.S.D.	14.96±4.87				14.89±4.85			
Total mean	62.68±8.66				59.99± 7.75			
$F_{df(5,12)}$value	24.64***							
P	0.000							
L.S.D	13.71±4.08							

***** and ** indicate significance at 1% &5% , respectively.**

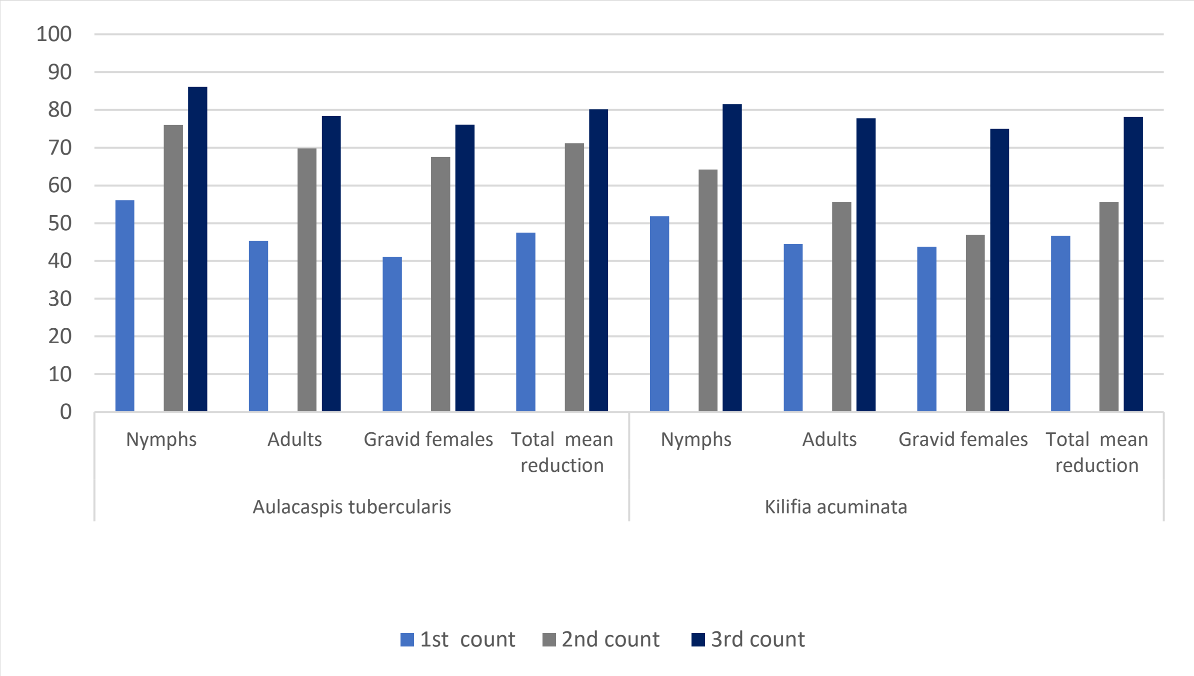

Figure (1): Reduction percentages of of *Aulacaspis tubercularis* and *Klifia acuminata* infestation under first release of 2nd larval instar of *Chrysoperla carnea*.

2. The second releasing of 2nd larval instar of *Chrysoperla carnea*:

The second release of the second larval stage of *C. carne*a to feed on *A. tubercularis* and *K. acminata* at different stages infesting mango trees in Faculty of Agriculture- Cairo University was conducted in March 2023. The data shown in Table (2) and depicted in Figure (2), indicated that the total population decreased to 48.78 % and 50.77 % respectively, after 15 days from treatment then it gradually increased to reach 60.57 % and 66.07 % respectively, after 30 days and then reached 78.09 % and 75.36 %, respectively, after 45 days post-treatment, it became evident that there were notable variances and significant differences between 1st count and both 2nd and 3rd counts.

Table (2): Reduction percentages of *Aulacaspis tubercularis* and *Klifia acuminata* infestation under second release of 2nd larval instar of *Chrysoperla carnea*.

Sampling dates	*Aulacaspis tubercularis* df= (2,6)				*Kilifia acuminata* df=(2,6)			
	Nymphs	Adults	Gravid females	Total mean reduction	Nymphs	Adults	Gravid females	Total mean reduction
1st count	51.85	47.62	46.87	48.78±1.55c(C)	52.1	50.10	50.10	50.77±0 .67a(BC)
2nd count	60.49	55.56	65.62	60.57±2.90b(BC)	69.1	66.60	62.50	66.07± 1.92b(AB)
3rd count	81.48	77.78	75.00	78.09±1.88aA	84.37	66.60	75.10	75.36± 5.13a(A)
F value	45.432***				15.18**			
P	0.000				0.005			
L.S.D.	9.498±3.09				13.84±4.51			
Total mean	68.64±68.64				65.38± 8.38			
$F_{df(5,12)}$value	15.63***							
P	0.000							
L.S. D	15.74±4.68							

***** & ** indicate significance at 1% &5%, respectively.**

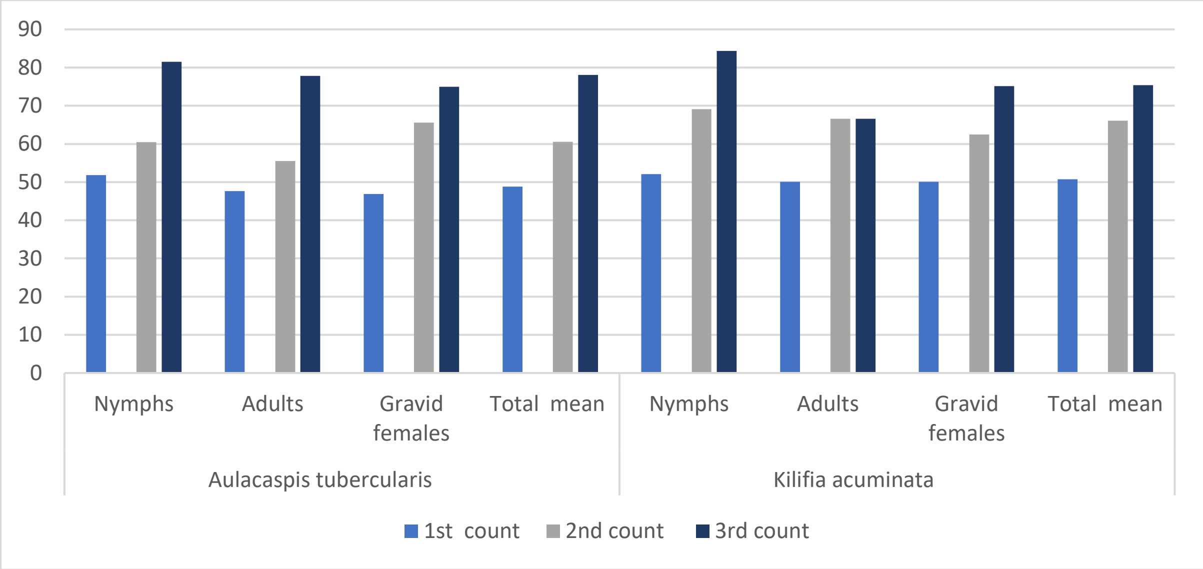

Figure (2): Reduction percentages of ***Aulacaspis tubercularis*** **and** ***Klifia acuminata*** infestation under second release **of 2nd larval instar of** ***Chrysoperla carnea*****.**

The findings displayed in Tables (1 and 2) indicated that the decrease in population was most significant among nymphs compared to adults and ovipositing females during two releases and the three subsequent counts post-treatment. This could be attributed to the fact that nymphs, particularly the 1st instar (Crawlers) have not developed their protective scales yet making them less vulnerable to predation by *C. carnea* larvae. In contrast, adult females and ovipositing females have already developed or secreted their scales. The numbers of released *C. carnea* larvae were positively correlated with reduction percentages, with the third treatment exhibiting higher reduction percentages compared to the other two treatments. The results from the two releases are compatible with the findings of multiple researchers. El-Sahn and Gaber (2012) found that *C. carnea* is highly effective as a biological control agent against *Planococcus citri*, (Risso) (Hemiptera: Pseudococcidae) consuming approximately 194.86 nymphs/ larvae at different stages. Additionally, **Helmy (2014)** conducted research in Egypt and observed that the predator led to the greatest reduction (84.97%) in the total population of *Saissetia oleae* (Olivier) (Hemiptera: Coccidae) in the1st post treatment and the highest reduction (32.94%) in the 2nd post treatment of the total population of *Hemiberlesia lataniae* (Signoret) (Hemiptera: Diaspididae) in March at Giza Governorate.

Similarly, El-Zahi (2017) reported that 3rd instar larvae of *C. carnea* were the most voracious feeder compared to 1st and 2nd instar larvae and consumed 673.3+ 6.38, 2756.3+20.10, 326.9+5.07 and115.2+3.45 insects of aphid, 1st, 2nd and 3rd instar nymphs of the mealybug *Phenacoccus solenosis* Tinsley (Hemiptera: Pseudococcidae), respectively. First instar nymphs of the mealybug were significantly the most consumed prey. In the same line, Helmy *et al*. (2020) reported that *C. carnea* has been identified as a highly efficient biocontrol agent against both diaspidid insects *Parlatoria proteus* (Curtis) and *Fiorinia phoenicis* (Balachowsky) (Hemiptera: Diaspididae). The predator achieved the greatest decrease (82.50%) in the overall population of *P. proteus* during the 3rd post-treatment period and the highest reduction (69.99%) in the total population of *F. phoenicis* during the 2nd post treatment period in October at Giza Governorate.

It is evident that *C. carnea* is a highly efficient biocontrol agent for diapsid insects *A. tubercularis* and *K. acuminata,* making it a suitable candidate for inclusion in I.P.M. programs.

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