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Field efficacy of *Chrysoperla zastrowi sillemi* (Esben-Petersen) against mulberry whitefly *Dialeuropora decempuncta* (Homoptera: Aleyrodidae)

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Abstract
Among different insect pests causing damage to mulberry, whitefly (*Dialeuropora decempuncta*) a Homopteran insects belonging to the family Aleyrodidae cause leaf yield loss to the tune of 24%. Because of well known negative effect of chemical pesticides and possible problem of residual toxicity to silkworm biological control of mulberry pests may prove to be an ecologically benign way of producing good quality mulberry leaf while controlling the harmful insects and pests. The Indian green lacewing, *Chrysoperla zastrowi sillemi* (Esben-Petersen) (Neuroptera: Chrysopidae) is well known generalist predator feeds on many insects like aphid mealy bug, thrips, whitefly etc. keeping all these facts in mind an experiment was undertaken to evaluate chrysoperla against mulberry whitefly. Freshly laid eggs, one day refrigerated eggs and first instar chrysopid larvae were used as treatment to evaluate its efficacy against whitefly under field conditions. Pre and post population count of whitefly/leaf was recorded before release of BCA and after 3, 7 and 10 days of second release. Among the treatment Chrysopid larvae was found to be the best with lowest population 8.28, 7.33 and 7.03/leaf respectively at 3, 7 and 10 DAR. Further population reduction at the rate of 41.69, 53.66 and 62.46% also recorded with chrysopid larvae treatment at 3, 7 and 10 DAR. Whereas population reduction with treatment of freshly laid eggs was 37.68, 52.81 and 60.84% respectively. Treatment of refrigerated eggs has provided lowest population reduction with 25.07, 38.09 and 49.84% respectively. There was significant difference between the population of whitefly compared to control with all the treatments however, among the treatments whitefly population load was only numerically different not statistically. The recorded data of the present study indicated that the whitefly populations on mulberry, in open fields, can be suppressed to some extent by the releases of *Chrysoperla zastrowi sillemi*. However, predatory action of the biocontrol agent of the present study could be characterized as more preventive than curative.

Keywords: Dialeuropora decempuncta, biological control, *Chrysoperla zastrowi sillemi*

Introduction
Mulberry (Morus spp.) constitutes exclusive food plant for the silkworm, (*Bombyx mori*). Therefore, production of superior quality mulberry foliage is of immense significance in order to make silkworm rearing a profitable venture. However, this process is often hampered due to the menace caused by insects and non-insects pests. Mulberry being a perennial and high biomass producing plant often considered a suitable host for feeding and breeding of many insect pests namely mealy bug, white fly and thrips etc. Further pests' infestation in mulberry reaches in a serious magnitude in irrigated mulberry cultivation where mulberry leaves of superior quality seem to be available throughout the year. Among several pests which causes significant damage to mulberry, whitefly (*Dialeuropora decempuncta*) a homopteran insects belonging to the family Aleyrodidae cause leaf yield loss to the tune of 24% (Bandopadhay *et al.*, 2002) [2]. The use of commercially available synthetic pesticides for controlling these insects' pests are well known and widely accepted by the sericulturists because of their prompt action against target insect pests. However, indiscriminate use of commercial pesticides has many potential harmful effects like pesticide resistance, negative effect on the non-target beneficial organisms etc. Further one has to be very much selective and judgemental while using any pesticides or insecticides for mulberry protection as the leaves are to be fed to the silkworm for cocoon production. Considering the ill effect of chemical pesticides, biological controls may prove to be an ecologically benign alternative to produce mulberry leaf while controlling the harmful insects and pests.

Augmentative as well as inoculative releases of various biocontrol agents are well known for controlling many agricultural pests and the same may be reciprocated in mulberry also.

The Indian green lacewing, *Chrysoperla zastrowi sillemi* (Esben-Petersen) (Neuroptera: Chrysopidae) popularly called as aphid lion or golden eyes is an eminent group of predators well known for its amicability to mass production and generalist feeding behaviour to use as biological control agent. Use of Chrysoperla as a generalist predator against different sucking pests like aphids, mealybugs, thrips, whiteflies (Abd-rabou *et al.*, 2008) [1] and spider mites (Than *et al.*, 1999) [8] has been well established. Host preference, diverse habit, easy mass multiplication procedure, resistance to insecticides and comparatively shorter life cycle are some of the special characteristics which made *Chrysoperla* spp. as one of the most powerful natural enemies in insect pests management. Under Indian agro-climatic conditions Chrysopid is considered to be the most efficient and widely used one referred as *Chrysoperla carnea* but to include both the population of India and Middle East the nomenclature was revised as C. *zastrowi sillemi* (Henry *et al.*, 2010) [5]. Considering the beneficial aspects of biological control measure the present study was undertaken with view to evaluate the potentiality of green lacewing in controlling whitefly in mulberry production.

Materials and Method

Selection of Mulberry Garden

Established garden of S1635 a popular mulberry variety for Eastern and North-eastern India is selected for the present study. All the standard agronomic practices were followed while maintaining the garden and study was undertaken 45 days after pruning of the plants from the base.

Raising of *Chrysoperla zastrowi sillemi*

Mass production technique of Chrysoperla sp. consists of two consecutive stages namely production of common rice moth (*Corcyra cephalonica*) eggs and rearing of *Chrysoperla Zastrowi sillemi* by using the eggs as food.

Production of *Corcyra* eggs

For rearing of *Chrysoperla* or green lace wing, common rice moth (*Corcyra cephalonica)* eggs were produced by following standard procedure. 2.5 kgs of half grinded wheat, 75gm of ground nut powder, 5gm of yeast and 1 pinch of streptomycin was mixed thoroughly and placed in plastic basins. To this Corcyra eggs were sprinkled through sprinkler tube. Basins were covered with gada cloth and tied with rubber band. The media left undisturbed for 30-40 days for moth emergence.

After 30-40 days, the emerged moths were collected in test tube and placed in a plastic buckets one side fitted with iron mesh, tied with a cotton swab dipped in 50% honey solution using galvanized iron (GI) wire and mouth of the plastic bucket was covered with centrally holed 3 layered newspaper using rubber band. After moth collection, the hole of the newspaper was sealed with a thick paper using cello tape. The bucket was kept in plastic basin with a newspaper placed in and left for egg laying undisturbed. After 24hrs of egg laying, the eggs were collected using flat brush. The scales of the moth were removed by slight rubbing the cotton swab on egg surface. The collected eggs were treated with ultraviolet (UV) rays for 1 hour for sterilization and kept in fridge as a food for *Chrysoperla* multiplication.

Production of *Chrysoperla* sp.

Freshly hatched larvae reared individually with UV treated *Corcyra* eggs in glass vials plugged with cotton. After 10 - 12days the larva turns into cocoon in glass vials for pupation. The adult emerges out of pupa in 8-10 days depending on the climatic conditions. Afterwards emerged out adults were transferred to oviposition containers/plastic jars and cover with perforated brown paper and tied by rubber band for egg laying and. Feed for the adults were provided with two cotton swabs one dipped in water and the other with 50% honey solution with a pinch of protein mixture (Protein X: Yeast extract: Honey: Sucrose) in the ratio of 1:1:1:1 and 1-2 brush castor pollen grains into the container. Eggs were collected after each two days alternately while transferring the adults into another container. The female adults lay eggs for 15-30 days depending on the climatic conditions.

Treatment protocol

Freshly laid eggs, one day refrigerated eggs and first instar chrysopid larvae were released at the rate of 20 eggs and 20 larvae/block containing 20 plants in a complete randomised block design. A total of 2 releases were made at 7 days interval. The pre-count and post count data of whiteflies/leaf were recorded before the release and after the release at an interval of 3, 7 and 10-days respectively. The population was recorded from 5 randomly selected plants in three leaves top, middle and bottom from each replication. Leaves from the individual plants were plucked kept in polybag, labelled and brought into laboratory for counting of population. The number of whiteflies was calculated on per leaf basis.

Results and Discussion

The data on Pre-count of whitefly on the day just before imposing treatment was in the range of 10.51 to 13.86. The pre-treatment population of whitefly was homogenous as there was no statistical difference in the counts of insects on mulberry plants for various treatments in the experimental field. (Table 1).

Table 1: Effect of *Chrysoperla zastrowi sillemi* on mulberry whitefly population

Treatments	Number of whiteflies/ leaf						
	Pre-count	3 DAR	PROC	7 DAR	PROC	10 DAR	Proc
Chrysoperla Larvae (T_1)	10.51	8.28	41.69	7.33	53.66	7.03	62.46
Refrigerated eggs (T_2)	12.76	10.64	25.07	9.66	38.90	9.39	49.84
Fresh eggs (T_3)	10.88	8.85	37.68	7.46	52.81	7.33	60.84
Control (T_4)	13.86	14.20	-	15.81	-	18.72	-
S.Em±	1.41	0.84	-	1.52	-	0.92	-
CD @ 5%	NS	2.52	-	4.58	-	2.76	-

DAR= Day after release, PROC= Population reduction over control

All the Biological control release treatments showed significant differences (p<0.05) with the control since population count in control was significantly higher14.20/leaf (Table 1) when compared to the treatments. The lowest population 8.28/ leaf was recorded in Chrysoperla Larvae (T1) which was followed by Fresh eggs (T3) 8.85 and (T2) Refrigerated eggs 10.64 in 3 days after release. Further population reduction over control was found to be maximum

41.69% in T1. However, the mean population of whiteflies between the treatments (8.28, 8.85, and 10.64/leaf) after the 3rd day of releases were not statistically different.

The data on predatory potential of C. *zastrowisillemi* evaluated against *Dialeuropora decempuncta* in mulberry plants after 7 days of release revealed significantly lower population of whiteflies on Chrysoperla released plants than untreated control. Plants released with chrysopid larvae (T1) recorded with a significantly lower population of whiteflies at 7 DAR, than in the control ($p<0.05$). Mean population of 7.33 whiteflies/ leaf was recorded in plants released with chrysoperla larvae whereas population of 7.46 and 9.66 whiteflies/leaf was recorded on plants released with fresh (T3) and refrigerated eggs (T2) respectively. All these release treatments were statistically superior ($p<0.05$) to untreated control (15.81 whiteflies/leaf) in reducing the whitefly population. Further maximum population reduction over control was recorded with respect to treatment of chrysopid larvae (53.66%) when compared to egg release.

At 10 days after bio-control agent release significantly lower population of whiteflies was observed on the released plants than the control. Once again, the plants released with bio-control agent was recorded significantly lower whitefly population than untreated control ($p<0.05$). At 10 DAR a mean white fly population of 7.03/leaf was recorded in plants released with chrysoperla larvae, whereas the number of whitefly insects recorded per leaf was 7.33 and 9.39, where plants were treated with fresh (T3) and refrigerated eggs (T2). Further, all three release treatments were not statistically different but they were significantly better ($p<0.05$) than untreated control where in whitefly population of 18.72/leaf was recorded. Similar to the earlier observations, 10 DAR with chrysopid larvae provided maximum protection (62.46%) than control.

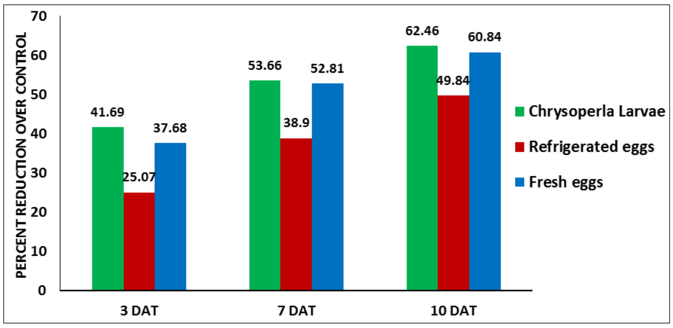

Fig 1: Percent reduction of whitefly population in mulberry

The present study indicates that the releasing of larvae rather than eggs in mulberry plant responded well for getting a good suppression of whitefly (*Dialeuropora decempuncta*). Earlier study of Easterbrook *et al*., 2006 [3] indicated that *C. carnea* is effective in open field than in protected crops and found that the aphid infestation, was significantly reduced at the releasing rate of eight larvae/strawberry plant in open field experiments. Chrysoperla larvae known to feed on almost all instar of whitefly nymph, eggs with most preferably on adult of whitefly thereby disrupting all life stages of Whitefly. Our finding also corroborates with the findings of (Rehman *et al.*, 2020) [7] as they reported very strong negative correlation with increase in chrysoperla causing decrease in whitefly *Bemisia tabaci* population in tomato. The present findings can also be substantiated by the findings of (Nair *et al.*, 2020) [6] where in three releases of chrysopid larvae @ 4, 5, and 6 grubs/ plant have brought down over all *Bemisia tabaci* population considerably in tomato with respect to untreated control population without significant difference between the treatments. Present results also coincide with (Zaki *et al.*,1999) [9] who found that *C. carnea* induced highly significant reduction of *A. gossypii* and *B. tabaci* at different releasing rates on various vegetable crops. Further efficacy of *Chrysoperla carnea* larvae at the rate of 0.75 and 1 lakhs/ha. released 43 days after cotton seed sowing reported to be reduced population of leaf hoppers, thrips, aphids and whiteflies and bollworm *H. armigera* with seed yield increase (Hanumantharaya *et al.*, 2008) [4].

One of the main concerns on success of biocontrol agents against crop pests is association of abiotic factors and its influence on the performance of the same under field condition. Therefore, it is imperative to use these biological agents Innudatively, i.e., their repeated applications are very much essential to have a proper impact of the bioagent in crop pest management. Further, releasing rate of bioagent should also be optimal because over estimated release rate may also increase the implementation cost of biological control programme and may not always improve the pest control proportionately. One more important factor is the timing of biological intervention that has relatively more impact on pest control than the release rate. The timing of release should always be in synchrony with the presence of pest population load in the field for proper establishment of the bio agents in field conditions.

The results of this study showed that *Chrysoperla* sp. can be used to control mulberry whitefly under field conditions. Further it was also evident from the study that release of larvae instead of eggs can be of more effective as chrysopid larvae released plants has significantly a smaller number of whiteflies compared to others. However, predatory action of the biocontrol agent of the present study could be characterized as more preventive than curative.

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