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PLANT PROTECTION

Predatory potential of *Chrysoperla zastrowi sillemi* (*Esben-Peterson*) against *Planococcus citri* Risso and *Paracoccus marginatus* Williams and Granara De Willink Infesting Cocoa, *Theobroma Cacao* Linnaeus

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Abstract

Laboratory experiment was conducted to record predatory potential of different larval stages of *Chrysoperla zastrowi sillemi* against first, second, third instar nymphs of *Planococcus citri* and ovisacs, second instar nymphs and adults of *Paracoccus marginatus*. The larvae of *C. zastrowi sillemi* fed 709.80±84.56, 220.40±40.76 and 162±38.57 first, second and third instar nymphs of *P. citri* to complete their life stages, respectively. The first instar larvae of *C. zastrowi sillemi* fed 158.00±5.24, 35.00±2.73 and 23.60±2.87 first, second and third instar nymphs of *P. citri*, respectively. Among various instars of the predator, second and third instars were voracious feeder than other stages. Larvae of *C. zastrowi sillemi* fed 7.20±1.11, 410±73.14 and 58.60±7.80 ovisacs, nymphs and adults of *P. marginatus* to complete their life stages. Consumption by the first instar larvae of *C. zastrowi sillemi* was 1.40±0.55, 68.20±3.11 and 11.80±1.79 ovisacs, nymphs and adults, respectively. Among various instars of *C. z. sillemi*, second and third instars were voracious feeders. There is a greater scope for utilization of this macro entomophage in the development of integrated pest management module against sucking pests of cocoa.

Highlights

- *Chrysoperla zastrowi sillemi* a neuropteran found to be a potential predator in its second and third instar stages against cocoa mealybugs and it can be utilized in the development of the IPM module as one of the biocontrol component

Keywords: *Chrysoperla zastrowi sillemi*, *cocoa*, *Planococcus citri*, *Paracoccus marginatus*, second, third instars

Cocoa (*Theobroma cacao* L.) (Malvaceae) is one of the greatest treasurers ever discovered by man. It is the only source of chocolate and is a rich source of sensory pleasure and energy, adored by almost everyone. It is the third important beverage crop next to coffee and tea and is third highest traded commodity in the world. It is one of the world's most valuable crops playing an important role in socio economic life of more than 5 million households and affecting 25 million in poor rural areas. Cocoa is cultivated worldwide over an area of 8.2 million hectares in fifty eight nations and the top five producers account for over 70 per cent of the total production (Kumari *et al*. 2012).

Globally 43.55 lakh metric tonnes of cocoa has been produced during 2014. Ivory Coast, Ghana and Indonesia are the largest cocoa producing countries with the share of 34, 24 and 14 per cent of the world total production, respectively (ICO 2014). In India, cocoa cultivation is largely confined to southern states *viz*., Kerala, Karnataka, Tamil Nadu and Andhra Pradesh. Cocoa is usually planted as inter crop in coconut and arecanut plantations. India ranks eighteenth among the countries cultivating cocoa having an area of 71,000 hectares with a production of 15,000 metric tonnes and productivity of 0.2 metric tonnes, of which Tamil Nadu covers an area of 24,000 hectares with a production of 1,100 metric tonnes. Kerala is leading in the production with a share of 41.72% followed by Andhra Pradesh (37.08%), Karnataka (13.90%) and Tamil Nadu (7.28%) (Indian Horticulture Database, 2014).

Pests and diseases have largely contributed to declining productivity of cocoa. Cocoa is a perennial tree crop ravaged by many insect pests like sucking and borers right from the seedling stage to the fruit harvesting. The sucking pest complex includes mirid bugs, mealybugs, aphids, flatid planthoppers, cowbugs, scales *etc.* and the borers include pod and bark eating caterpillars. About 25-30% yield loss in cocoa had been attributed by cocoa mirid bug (*Sahlbergella singularis*) while, 17% is lost by cocoa pod borer (*Characoma strictigrapta*) and about 30-90% due to the black pod rot, the major disease of cocoa caused by *Phytophthora megakarya* in African countries (Uwagboe *et al*. 2012). Among the pests and disease complex, damage due to sucking pests *viz.*, tea mosquito bugs and mealybugs is major in India. Yield loss incurred due to pest problem results in the reduced income, poverty, food insecurity and loss of biodiversity. To mitigate these losses farmers are practicing chemical control, which results in the problem of 3 R'S (residue, resurgence and resistance). Hence, cocoa is an arborial crop and intercropped with coconut/arecanut/oil palm, spraying is difficult. To mitigate these disadvantages, ecofriendly practice, biological control was introduced as one of the component of integrated pest management by inoculative or inundative release of entomophages.

Among the entomophages, green lacewing, *Chrysoperla zastrowi sillemi* (Neuroptera: Chrysopidae) is a generalist predator having wide geographic distribution and occurring in multiple crop and non-crop habitats and tolerant to some of the insecticides (Bigler 1984). Adults feed on pollen, nectar and honeydew, while larvae attack a large variety of soft bodied insects including mealybugs (Principi and Canard 1984; Abd-Rabou 2008; Qureshi and Stasly 2009). These predators have high reproductive potential and are easily mass reared. Moreover lacewings have a short developmental time and low dispersal ability in targeted fields (Pappas *et al*. 2011) and are able to survive during winter unlike other entomophages form tropical or subtropical regions (Hough-Goldstein *et al*. 1993). With this background, the present investigation on predatory potential of *C. zastrowi sillemi* against cocoa mealybugs was taken up to decide which stage is more suitable for field release with maximum predatory potential and to include, *C. zastrowi sillemi* as one of the component in integrated in integrated pest management module against sucking pest complex of cocoa.

Materials and methods

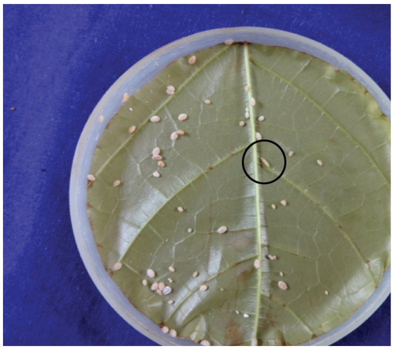
Laboratory experiment was conducted in the Department of Agricultural Entomology, TNAU, Coimbatore, India during 2014-2015 to determine the predatory potential of different larval instars of *C. zastrowi sillemi* on first, second and third instar nymphs of *P. citri* and ovisacs, second instar nymphs and adults of *P. marginatus* collected from the cocoa field located at Sethumadai, Pollachi. The insects were brought to the laboratory and maintained in the glass cages. Larvae of *C. zastrowi sillemi* were collected from the biocontrol unit, TNAU and were starved for 24 hours. Cocoa leaf was cut into circular pieces and kept inside the plastic petriplate (9 mm dia) containing solidified agar solution (3%) to maintain the turgidity of leaves (Hassanpour *et al*. 2015). Each instar of the larva of *C. zastrowi sillemi* was provided with 100 mealybugs. The respective stage of fresh mealybugs, *P. citri* (first, second and third instar) and *P. marginatus* (ovisacs, second instar and adults) were offered to each stage of predator until they reached the next instar (Figure 1). Number of prey (different stages of *P. citri* and *P. marginatus*) consumed by the grub in each instar and the total consumption during the larval period (first instar to third instar) was calculated excluding the dead mealybugs. The experiments were conducted with 10 larvae considering each one as one replication. The data were subjected to statistical analysis adopting completely randomized block design with 3 treatments and 10 replications and the mean values of treatments were separated by Least Significant Difference (LSD) (Gomez and Gomez, 1984) using AGRES ver. (7.01), Pascal International

Solutions.

Results

Results of the laboratory experiment on predatory potential of *C. zastrowi sillemi* on *P. citri* revealed that larvae of *C. zastrowi sillemi* fed 709.80±84.56, 220.40±40.76 and 162±38.57 first, second and third instar nymphs of *P. citri* to complete their life stages. The first instar larva of *C. zastrowi sillemi* fed 158.00±5.24, 35.00±2.73 and 23.60±2.87 first, second and third instar nymphs of *P. citri*, respectively. Among various instars of the predator, second and third instars were voracious and consumed 224.40±4.14, 69.20±3.27, 41.00±3.16 and 326.60±2.96, 116.20 ±6.45 and 97.40±2.05 first, second and third instar nymphs of *P. citri*, respectively (Table 1).

I insatr preadtor on *Planococcus citri*



II instar predator on *P. citri*

III insatr on *P. citri*

III insatr on *Paracoccus marginatus*

Different instars of *C. zastrowi sillemi* on *Paracoccus marginatus*

Fig. 1: Laboratory experiment on predatory potetnial of *C. zastrowi sillemi* on cocoamealybugs (round circle indicates different instars of the predator)

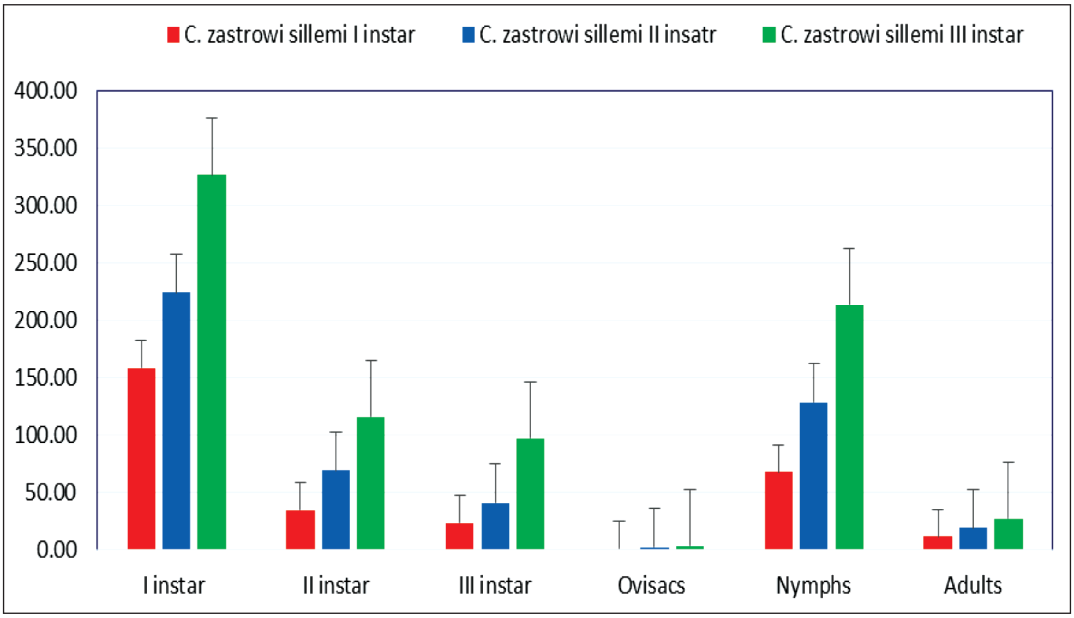


Fig. 2: Feeding potential of *C. zastrowi sillemi* (first, second and third instars) on *P. citri* (first, second and third instar) and *P. marginatus* (Ovisacs, Nymphs and adults)

Table 1: Predatory potential of *Chrysoperla zastrowi sillemi* (first, second and third instars) on *Planococcus citri* (first, second and third instar) and *Paracoccus marginatus* (ovisacs, nymphs and adults)

Nymphal stage	Feeding potential* (Mean ± SD)					
	Planococcus citri			*Paracoccus marginatus*		
	I instar	II instar	III instar	Ovisacs	Nymphs	Adults
Grub (Instar)						
I instar	158.80 ± 5.24[c]	35.00 ± 2.73[c]	23.60 ±2.87[c]	1.40 ± 0.55[c]	68.20 ± 3.11[c]	11.80 ± 1.79[c]
II instar	224.40 ± 4.14[b]	69.20 ± 3.27[b]	41.00 ± 3.16[b]	2.20 ± 0.45[b]	128.80 ± 2.77[b]	19.40 ± 2.88[b]
III instar	326.60 ± 2.96[a]	116.20 ± 6.45[a]	97.40 ± 2.05[a]	3.60 ± 0.55[a]	213.80 ± 8.84[a]	27.40 ± 3.13[a]
Mean	**364.06±54.63**			**158.60±27.35**		
Total	709.80 ± 84.56	220.40 ± 40.76	162 ± 38.57	7.20 ± 1.11	410 ± 73.14	58.60 ± 7.80
S. Ed	2.67	2.82	1.93	0.32	3.57	1.68
CD (P=0.05)	5.81	6.15	4.21	0.71	7.77	3.67

*Mean of 5 replications

In a column, means followed by common letter(s) are not significantly different by LSD

Regarding *P. marginatus* the larvae of *C. zastrowi sillemi* fed 7.20±1.11, 410± 73.14 and 58.60±7.80 ovisacs, nymphs and adults of *P. marginatus* to complete their life stages. Consumption by the first instar larva of *C. zastrowi sillemi* was 1.40±0.55, 68.20±3.11 and 11.80±1.79 ovisacs, nymphs and adults, respectively.

Among various instars of *C. zastrowi sillemi,* second and third instars were voracious and consumed 2.20±0.45, 128.80±2.77, 19.40±2.88 and 3.60±0.55, 213.80±8.84 and 27.40±3.13 ovisacs, nymphs and adults of *P. marginatus,* respectively (Table 1).

Discussion

As the age of the host (mealybug) increased (first instar, second instar, third instar of *P. citri* and ovisacs, second instar and adults of *P. marginatus*) the number consumed by the predator decreased and more number of first instar (Figure 2) were consumed due to its smaller size, more fragility so that less handling time needed for the consumption.

In contrast, as the age of the predator increased, the consumption also increased and found to be more with the third instar larva of *C. zastrowi sillemi* due to its more capability to handle the prey in less time. It was also found in other predators such as *Adalia decempunctata* (L.) (Coleoptera: Coccinellidae), *Mallada basalis* (Walker) (Neuroptera: Chrysopidae) and *Macrolophus pygmaeus* (Rambur) (Hemiptera: Miridae) (Dixon, 1959; Fantinou *et al.* 2008; Cheng *et al.* 2009). Gradual increase in the feeding rate of older grubs might be due to their increased nutritional requirement.

Among all the instars of the predator, second and third instars were found to be more active and consumed at higher rate (Figure 2), irrespective of the prey. While comparing the consumption rate, it was found to be low for *P. marginatus* than *P. citri*. This might be due to its more waxy webbing in *P. marginatus* than the *P. citri* and there by more handling time was required for consumption of a single individual host. These results are in line with the findings of Suganthy and Sakthivel (2012).

The results were also in line with the findings of Aravind *et al.* (2012) who studied the predatory potential of *C. z. sillemi* against two tailed mealybug, *Ferrisia virgata* and revealed that the consumption rate was found to be more with the third instar (140.41 mealybugs) followed by second instar (41.66). Klingen *et al.* (1996) and Sablon *et al.* (2013) found that third instar lacewing larvae were more voracious, as their prey consumption was 4 times higher than that of the two first instars against colorado potato beetle larva and aphids, respectively.

Conclusion

From the results it was concluded that second and third instars of *C. z. sillemi* were found to be voracious against the cocoa mealybugs (*P. citri* and *P. marginatus*). There is a greater scope for utilization of this macro entomophage in the development of integrated pest management module against the sucking pests of cocoa, as one of the important biocontrol component.

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