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Cumulative effects of insecticides on generalist predators and parasitoid population in cocoa ecosystem

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Cocoa (*Theobroma cacao* L.) is a small understorey tree endemic to the low land rainforests of the Amazon basin (Wood and Lass, 1985). Pests and diseases are the main constraints in cocoa production. Tea mosquito bugs known as mirids or plant bugs are serious pests of cocoa world wide (Entwistle, 1972). In India, cocoa is attacked by three species of tea mosquito bug *viz*., *Helopeltis antonii* Signoret, *H. bradyi* Waterhouse and *H. theivora* Waterhouse (Sundararaju, 1996). Among this, *H. bradyi* is the most predominant species attacking cocoa (CPCRI, 2011). It is a polyphagous sap sucking insect and both the nymphs and adults suck the sap from all parts of the cocoa plant. Salivary secretions are injected into the plant tissue which causes lesions on the cocoa pods, cherelles and flushing shoots. Estimates of crop loss attributed to damage by *Helopeltis* sp. are variable and depend on factors such as management practices, locality, climate and the plant and insect species involved. Chemical insecticides predominate in the management of tea mosquito bug. A number of predators and parasitoids have been reported against *Helopeltis* spp. by several workers. They include ants, spiders and reduvid bugs (Ambika and Abraham, 1979; Devasahayam and Nair, 1986; Sudararaju, 1996). Information on the effects of insecticides on predators and parasitoids in cocoa ecosystem is very limited. Therefore the present study was undertaken to assess the species composition and cumulative effects of insecticides spray on predator and parasitoid population occurring in cocoa ecosystem.

Experiments were carried out at ICAR-Central Plantation Crops Research Institute, Regional Station, Vittal, Karnataka, India (12^{0}15' N latitude and 75^{0}25' E longitude) during 2012-2013. The field experiments were laid in randomized block design, with six treatments and three replications, each treatment covering 450 cocoa trees. The impact of insecticide spray on predatory fauna in cocoa ecosystem was assessed as suggested by Waage (1992).

Total predator population existing under its peak period of abundance was recorded. Eight trees were selected from each replication in random and 10 branches per tree from all the four sides were tapped gently over 30 cm^2 card board and counted immediately. The effects of insecticides on the parasitoid, *Telenomous* sp. and their seasonal activity on tea mosquito bug were also investigated. The cocoa plant parts (shoots, petioles, midribs and panicles) containing eggs of tea mosquito bug were collected at monthly intervals and counted under stereoscopic zoom microscope. They were treated with carbendazim 0.1 per cent solution for ten minutes to prevent fungal infection. The treated samples were dried and placed in a plastic container completely wrapped with a black paper to record the emergence of parasitoid and the per cent egg parasitisation.

Predatory ants associated with cocoa plantations and their effect on tea mosquito bug population was assessed. Observations were recorded on insecticide treated plots and untreated plots. The indices for assessing abundance of

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predatory ants *O. smaragdina* were made based on the quick examination of individual cocoa tree (Way and Khoo, 1991), as given below:

(i) A few: Less than 20 workers per tree, no trails; very few or bugs: no nests, (ii) Moderate: >20-50 *O. smaragdina*, (iii) Common: >50-500 *O. smaragdina,* usually some distinct trails on the tree trunk or canopy but rarely on ground, (iv) Abundant: >500-1000 *O. smaragdina,* well defined trails in canopy and occasionally on trunk and along ground, (v) Very abundant: >1000 *O. smaragdina* or with strong trails; interconnecting in ants colonized and not colonized plots or virtually all trees across their canopies and or along the ground.

Cocoa cherelles infested by tea mosquito bug were recorded before spray and one month after every spray from the randomly selected tagged trees (8 trees per replication). The data was subjected to arc sine transformation prior to analysis and the treatment mean were compared by DMRT (Gomez and Gomez, 1984) analysis using AGRES.

The predators and parasitoids recorded in cocoa garden are given in Table 1. It constituted seven species of spiders (*Camaricus* sp., *Plexippus* sp., *Oxyopes* sp., *Strigoplus* sp., *Hyllus* sp., *Angaeus* sp. *Phidippus* sp.), eight species of ants, Black ant (*Paratrechina* sp.), Asian weaver ant (*Oecophylla smaragdina*), crazy ant (*Anoplolepis gracilipes)* carpenter ant (*Camponotus* sp.,), cocktail ant (*Crematogaster* spp.) and long horned crazy ant (*Paratrechina longicornis*), three species of Heteropteran predatory bugs (*Camphylomma* sp., *Geocoris* sp. and *Sphedanolestes* sp.) and one egg parasitoid (*Telenomous* sp.). One month after third spray, their relative abundance were computed and given in Table 2. The lowest population of spiders were observed in Lambda-cyhalothrin 5 EC (0.003%) 0.6 mL L^{-1} treated plot (0.13 numbers per branch) followed by Bifenthrin 10 EC (0.008%) 0.8 mL L^{-1} treated plots (0.16) treated plots but, not significantly different. On the other hand, in Chlorantraniliprole 18.5SC (0.009%) 0.5 mL L^{-1} treated plots had significantly highest population of spiders (0.19) which was on par with untreated check (0.25). Similar to spiders the heteropteran bugs like reduvids, geocorid and mirid population was lower in the insecticide treated plot compared to untreated check.

Table 1. List of predators and parasitoids recorded in cocoa ecosystem

I. Predators	**Family**
a. Spiders	
Camaricus spp.	Thomicidae
Plexippus sp.	Salticidae
Oxyopes sp.	Oxyopidae
Strigoplus sp.	Thomicidae
Hyllus sp.	Salticidae
Angaeus sp.	Thomicidae
Phidippus sp.	Salticidae
b. Ants	
Black ant (*Paratrechina* sp.)	Formicidae
Asian Weaver ant (*Oecophylla smaragdina*)	Formicidae
Crazy ant (*Anoplolepis gracilipes*)	Formicidae
Carpenter ant (*Camponotus* sp.)	Formicidae
Cocktail ant (*Crematogaster* spp.)	Formicidae
Longhorn crazy ant (*Paratrechina longicornis*)	Formicidae
c. Bugs	
Campylomma sp.	Miridae
Geocoris sp.	Geocoridae
Sphedanolestes sp.	Reduviidae
II. Parasitoid	
Telenomous sp.	Scelionidae

The results showed that the predatory bug population was significantly lower in Lambda-cyhalothrin 5 EC (0.003%) 0.6 mL L^{-1} treated plots (0.12) followed by Imidacloprid 17.8 SL (0.004%) 0.25 mL L^{-1} (0.17) treated plots, however, it was on par with each other. Whereas, in untreated check and Chlorantraniliprole 18.5 SC (0.009%) 0.5 mL L^{-1} treated plots had significantly highest number of heteropteran predatory bugs of 0.37 and 0.35, respectively (Table 2). Although the predators like spiders and reduvids were predominant than other groups, the occurrence of spiders was seen in all the sample trees than heteropteran bugs.

The predominant occurrence of spiders is in concurrence with reports of Basu Choudhuri (1982) and Devasahayam and Nair (1986) whereas, the predatory bugs were observed rarely, feeding on the plant tissues at some stages of their life cycle (Hardin *et al.,* 1995). The *Campylomma* sp. of bugs

Table 2. Effect of insecticides spray on population of predators in cocoa ecosystem

Treatments	Dose ($mL\ L^{-1}$ or $g\ L^{-1}$)	Predator population (No. per shoot)	
		Spiders	Heteropteran bugs
Thiamethoxam 25 WG (0.005%)	0.20	0.17 [b]	0.25[b]
Imidacloprid 17.8 SL (0.004%)	0.25	0.18 [b]	0.17[cd]
Chlorantraniliprole 18.5 SC (0.009%)	0.50	0.19 [ab]	0.35[a]
Lambda-cyhalothrin 5 EC (0.003%)	0.60	0.13 [b]	0.12[d]
Bifenthrin 10 EC (0.008%)	0.80	0.16 [b]	0.19[cd]
Untreated check	-	0.25 [a]	0.37[a]
CD (5%)	-	0.064	0.064

Mean followed by common letter are not significantly different at 5% level by DMRT

Table 3. Effect of insecticides spray on egg parasitoids in cocoa

Treatments	Dose ($mL\ L^{-1}$ or $g\ L^{-1}$)	Percentage parasitisation on tea mosquito bug
Thiamethoxam 25 WG (0.005%)	0.20	3.7[d]
Imidacloprid 17.8 SL (0.004%)	0.25	3.8[c]
Chlorantraniliprole 18.5 SC (0.009%)	0.50	4.3[b]
Lambda-cyhalothrin 5 EC (0.003%)	0.60	3.5[e]
Bifenthrin 10 EC (0.008%)	0.80	3.7[d]
Untreated check	-	4.8[a]
CD (5%)	-	0.06

Mean followed by common letter are not significantly different at 5% level by DMRT

were reported as predator of insect eggs (IIE, 1990). They appeared to be general polyphagous predators but not key predators of tea mosquito bug.

The effect of insecticides treatment on parasitoid *Telenomous* sp. (Table 3) revealed that the Lambda-cyhalothrin 5EC (0.003%) 0.6 $mL\ L^{-1}$ treated plots had significantly lower parasitisation (3.5%) whereas, in Chlorantraniliprole 18.5 SC (0.009%) 0.5 $mL\ L^{-1}$ treated plot had significantly highest parasitisation of 4.3 per cent as compared to untreated check (4.8%). Highest per cent of parasitisation (10.5%) was observed in the month of December followed by during February (8.8%). The results indicated that the per cent parasitisation

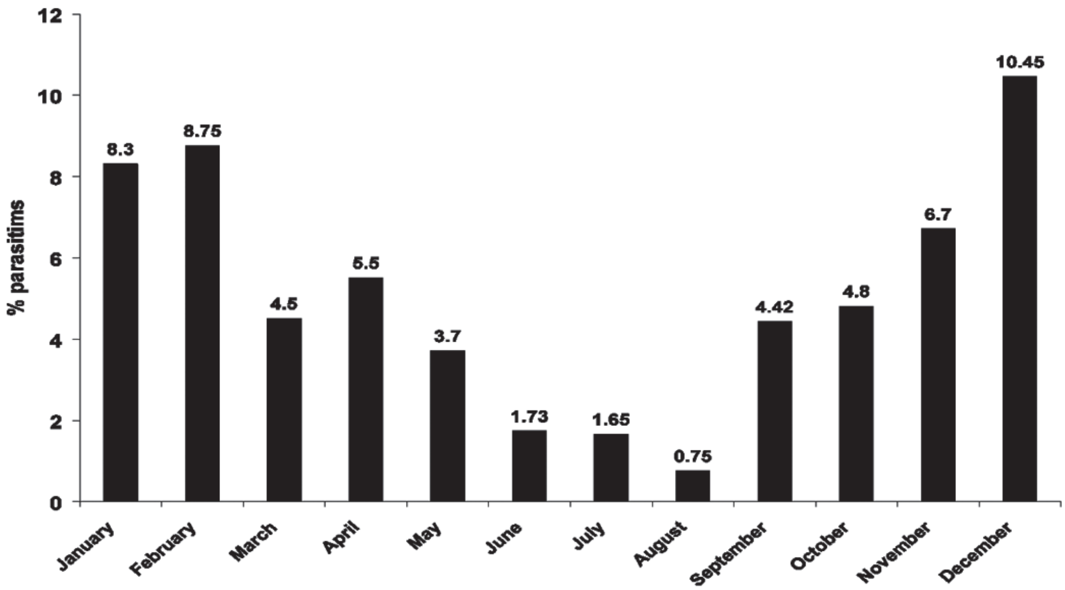

Fig. 1. Natural parasitisation by *Telenomous* sp. on tea mosquito bug in cocoa

Table 4. Effect of insecticides on colonization of red ant, *O. smaragdina* and infestation of *Helopeltis* spp. in cocoa

Treatments	Number of *O. smaragdina* observed*	Per cent damage by tea mosquito bug
Thiamethoxam 25 WG (0.005%)	<20	3.3 [a]
Imidacloprid 17.8 SL (0.004%)	<20	4.5 [c]
Chlorantraniliprole 18.5 SC (0.009%)	<20	6.5 [d]
Lambda-cyhalothrin 5 EC (0.003%)	<20	3.8 [b]
Bifenthrin 10 EC (0.008%)	<20	3.7 [b]
Untreated check with colonization of red ants	>500-1000	3.3 [a]
Untreated check without colonization of red ants	>20	25.7 [e]
CD (5 %)		0.08

*<20: a few, >500-1000: Abundant: Mean followed by common letter are not significantly different at 5% level by DMRT

were high during winter and it was low during summer (March to May) and during monsoon (June to October) (Fig. 1).

The effect of insecticides on the colonisation of red ants, *O. smaragdina* revealed that the colonisation was abundant (>500 to 1000) in the untreated plots and it was a few (<20) in all the insecticide treated plots (Table 4). The per cent damage by tea mosquito bug was significantly lower (3.3%) in the red ants colonized cocoa trees without insecticide spray compared to untreated check without colonisation of red ants (25.7%). Tea mosquito bug infestation was significantly very low, wherever the population of red ants was high. Similar observations were made by Chin *et al*. (1988); Peng *et al*. (1995) and Wijetunga *et al.* (2003). Hussain *et al*. (2012) tested the toxicity of some new insecticides *viz*., spinosad, lufenuron, flubendiamide, chlorantraniliprole, emamectin benzoate and imidacloprid against immature and adult stages of *Trichogramma chilonis* Ishii (Hymenoptera: Trichogrammitidae) under laboratory conditions. After eight days parasitism by *T. chilonis,* chlorantraniliprole resulted in maximum emergence of *T. chilonis* and did not show significant difference with lufenuron and emamectin benzoate. These findings suggested that the chlorantraniliprole is found to be safer to natural enemies. The effective management of tea mosquito bug involves proper intercultural operations like shade management, timely pruning, water management during summer and nutrient management. Further investigations are required to explore the associated natural biocontrol agents.

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