RESEARCH ARTICLE

Diversity, Morphological Identification and Management of Mirid Bug Species Complex in Cotton Crop

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ABSTRACT

The emergence of mirid bugs as primary pests in Bt cotton fields poses significant challenges to cotton productivity in India. Mirid bug species such as *Creontiades biseratense* (Distant), *Campylomma livida* Reuter, and *Hyalopeplus linefer* Walker have gained prominence due to favourable conditions created by reduced pesticide applications in *Bt* cotton fields. This study focussed on morphological characterization of mirid bug species complex in Tamil Nadu cotton ecosystem. The study evaluated the efficacy of seven newer insecticides against the mirid bug, *Creontiades biseratense*, a significant pest of cotton, in two experiments conducted at TNAU Cotton Farm, Coimbatore district and Memathur, Virudhachalam, Cuddalore district, during *Kharif* 2022 and 2023. Treatments included Spinetoram 11.7 SC, Flonicamid 50 WG, Dinotefuran 20 SG, Thiamethoxam 25 WG, Clothianidin 50 WG, Imidacloprid 17.8 SL and Acetamiprid 20 SP. Spinetoram demonstrated the highest efficacy, reducing the pest population by 80.83% in Experiment I and 75.07% in Experiment II, followed by Flonicamid and Dinotefuran. Lower efficacy was observed with Imidacloprid and Acetamiprid, with reductions below 60%. Yield and economic analysis highlighted Spinetoram as the most cost-effective treatment, achieving the highest yields (2346 kg/ha in 2022 and 2248 kg/ha in 2023) and cost-benefit ratios (CBR) of 2.74 and 2.51, respectively. Flonicamid and Dinotefuran also provided favourable returns, while traditional neonicotinoids like Imidacloprid exhibited declining performance, likely due to resistance development.

Keywords: Cotton - Mirid bugs, species diversity, *Creontiades biseratense*, morphology, environmental correlation, IPM, insecticides

INTRODUCTION

Cotton (*Gossypium* spp.) is one of the most important cash crops worldwide, and in India, it plays a vital role in the agricultural economy. Adopting Bt cotton has significantly reduced the impact of bollworm pests; however, it has inadvertently allowed secondary pests like mirid bugs to flourish, especially in areas with decreased pesticide application (Patil *et al.,* 2005; Qiu, 2010). Mirid bugs primarily damage cotton by feeding on tender plant tissues, leading to square and boll shedding, which can cause substantial yield losses Rohini Sugandhi and Patil (2009). This study aims to identify the mirid bug species complex in Tamil Nadu, analyse their morphological traits, examine their population dynamics, and explore their correlation with environmental factors. Moreover, this study evaluates the effectiveness of different

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insecticides in controlling mirid populations to provide comprehensive IPM strategies.

Mirid Bug Complex in Cotton Ecosystems

Mirid bugs, particularly *Creontiades biseratense* (Distant), *Campylomma livida* Reuter and *Hyalopeplus linefer* Walker are increasingly recognized as primary pests in Bt cotton fields due to the ecological shift in pest dynamics (Udikeri, 2008; Jane, 2010). The incidence of mirid bugs is heightened in Bt cotton fields, where insecticides targeting bollworms are less frequently used, leading to reduced insecticide pressure on non-target pests (Kranthi *et al.,* 2009).

Nature of Damage

Both nymphs and adults of *C. biseratense* cause significant damage to cotton plants, particularly due to their damage on squares (flower buds) and tender bolls. The damage is primarily caused by the piercing-sucking feeding behaviour of the mirid bugs, which target vital plant structures such as ovules and pollen sacs (AICRP, 2021). The following are the key signs of mirid infestation: Circular discoloration: The base of flowers and squares show circular discoloration, often due to piercing injury; Feeding scars: The tissue that has been pierced by the mirid bugs turns black, resulting in visible scars on the affected area; Square and boll shedding: Heavy mirid infestation lead to shedding of small squares and deformed bolls, which are often referred to as "parrot beaking." This occurs due to a lack of fertilization, as the feeding damages the developing anthers; Tender boll damage: Tender bolls develop black patches on the outer surface of the boll rind, resulting in boll shedding. Economic losses: The damage caused by mirid bugs is severe enough to reduce cotton yields by up to 60% in some regions, especially when the pest is left uncontrolled. While older bolls are less susceptible to mirid damage due to the hardening of the boll walls, the damage to younger, tender bolls is much more pronounced and often leads to significant yield losses (Ayyar, 1932).

Morphological Identification Techniques

Morphological features, including body colour, wing characteristics and genitalia, are essential for differentiating mirid species. Microscopic examination of genitalia is often necessary for precise identification due to the high morphological similarity among species, particularly in *C. biseratense* and *H. linefer* (Udikeri *et al.,* 2010; Wang *et al.,* 2016).

Insecticide Efficacy and IPM Approaches

Recent studies emphasize the importance of selecting effective insecticides for IPM strategies in managing mirid populations in cotton (Kumar *et al.,* 2018). For instance, Flonicamid and Spinetoram have shown promising results in controlling mirid bugs while maintaining favourable economic returns for cotton farmers (Meena *et al.,* 2020).

MATERIALS AND METHODS

Study Area and Sampling Method

The study was conducted in the cotton-growing districts of Tamil Nadu, including Coimbatore, Erode, Salem, Attur, Perambalur and Kallakurichi. Surveys were conducted during the square and boll formation stages across three fields per district. Five plants in each field were selected for mirid population assessment. Six fields were selected at each location, Nagrare *et al.,* (2016)

Morphological Identification

Morphological identification involved examining key features such as colour morphs, wing structure and body size. Genitalia was cleared using a 10% potassium hydroxide solution and examined under a microscope for species differentiation as detailed in Udikeri *et al.,* (2010). Measurements were recorded using a Lyca microscope and illustrations were made with the help of Image analyser.

Insecticide Efficacy Trials

The efficacy of eight insecticides was tested over three spray applications in two major cotton-growing regions during *Kharif* 2022 and *Kharif* 2023. Efficacy was measured by population reduction and yield impact, while economic returns were assessed through cost-benefit ratio (CBR) calculations.

RESULTS AND DISCUSSION

Species Diversity and Morphology

Surveys revealed that *C. biseratense* was the dominant mirid bug species, followed by *C. livida* and *H. linefer*. Morphological markers, including colour patterns, wing margins and body dimensions, helped distinguish among the species. *C. biseratense* showed a pronounced brown and green morph, while *H. linefer* exhibited distinct pronotal streaks, facilitating identification.

Each of the three species, *Creontiades biseratense*, *Campylomma livida*, and *Hyalopeplus lineifer*, exhibit distinct morphological characteristics that aid in their identification. *Creontiades biseratense* adults are typically brown and are marked by a distinct dark brown T-shaped band on the pronotum. This species shows variation in colour morphs, with brown and green being the most common forms. The nymphs of *C. biseratense* are characterized by their greenish coloration and dark brown wing pads, which are unique to this species. *Campylomma livida* adults are notably smaller than *C. biseratense* and are often pale in colour. This species is further distinguished by its diminutive size, fringed wing margins, and a characteristic dioptic eye structure. *Hyalopeplus lineifer* is recognized primarily by the brownish parallel streaks on the pronotum in adults. This species is larger than *C. livida* and comparable in size to *C. biseratense*. The nymphs of *H. lineifer* have a creamish yellow coloration and are noted for their long antennae and wing pads. These morphological differences provide a reliable basis for identifying and differentiating these three species in field and laboratory studies.

Insecticide Efficacy and Economic Analysis

Effect of New Insecticides on Mirid Bug Population

The study revealed the significant impact of newer insecticides on controlling *C. biseratense* populations in cotton fields at two distinct locations: TNAU Cotton Farm, Coimbatore (Experiment I), and Memathur, Virudhachalam, Cuddalore (Experiment II). The results demonstrated variations in insecticide efficacy, influenced by factors like formulation, dosage, and environmental conditions.

Experiment I (Coimbatore)

Pooled data analysis (Table 1) showed that Spinetoram 11.7 SC was the most effective insecticide, reducing the cumulative mean pest population by 80.83%, followed by Flonicamid 50 WG (77.54%) and Dinotefuran 20 SG (75.42%). Thiamethoxam 25 WG (71.41%) and Clothianidin 50 WG (75.21%) provided moderate control. In contrast, Imidacloprid 17.8 SL and Acetamiprid 20 SP showed lower efficacy, with reductions of 58.20% and 54.22%, respectively. Untreated control plots consistently exhibited the highest pest population.

Experiment II (Cuddalore)

In Memathur, similar efficacy trends were observed (Table 2). Spinetoram 11.7 SC provided the highest cumulative reduction (75.07%), followed by Flonicamid 50 WG (72.71%) and Dinotefuran 20 SG (70.98%). Thiamethoxam 25 WG and Clothianidin 50 WG exhibited moderate efficacy with reductions of 66.11% and 69.97%, respectively. Imidacloprid 17.8 SL and Acetamiprid 20 SP again showed reduced performance, achieving reductions of 51.14% and 47.48%, respectively.

Yield and Economic Analysis

The impact of insecticides on cotton yield and cost-benefit ratios (CBR) was assessed during *Kharif* 2022 and *Kharif* 2023. Spinetoram 11.7 SC consistently resulted in the highest yields and economic returns, making it the most profitable treatment.

Experiment I (Coimbatore)

Spinetoram 11.7 SC provided the highest yield (2346 kg/ha) and a CBR of 2.74 (Table 3). Flonicamid 50 WG and Dinotefuran 20 SG followed closely with yields of 2230 kg/ha and 2220 kg/ha, respectively, and CBR values of 2.62 and 2.61. Imidacloprid 17.8 SL and Acetamiprid 20 SP yielded significantly lower returns, with CBRs of 1.76 and 1.66, respectively.

Experiment II (Cuddalore)

Similar trends were noted during Kharif 2023 (Table 4). Spinetoram 11.7 SC recorded the highest yield (2248 kg/ha) and a CBR of 2.51, followed by Flonicamid 50 WG (2135 kg/ha; CBR 2.27) and Dinotefuran 20 SG (2050 kg/ha; CBR 2.10). Imidacloprid 17.8 SL and Acetamiprid 20 SP were again less economical, with CBR values of 1.43 and 1.27, respectively.

The superior efficacy of Spinetoram aligns with findings by Dharajothi et al. (2011), who emphasized its effectiveness in reducing sucking pests in cotton ecosystems. Similarly, the efficacy of Flonicamid against mirid bugs corroborates observations by Mehta and Kulshrestha (2016), who reported its success in controlling populations even under varying climatic conditions. The efficacy of Dinotefuran is also supported by Nagrare *et al.,* (2016), who highlighted its potential in integrated pest management (IPM) strategies.

Conversely, the reduced efficacy of Imidacloprid and Acetamiprid may indicate the onset of resistance, as noted in studies by Kranthi *et al.,* (2009), where over-reliance on older neonicotinoids led to diminished pest control. Such findings stress the need for rotating insecticides with different modes of action to prevent

Table 1. Effect of new insecticides against Mirid bug, *C. biseratense* on cotton - Experiment I (Location : Cotton Farm, TNAU, Coimbatore)

Treatments	Dosage (g a.i. ha^{-1})	Formulation Dosage (g or ml /ha)	I Spray		II Spray		III Spray		Pooled	Cumulative
			Mean population $plant^{-1}$	% reduction from control	Mean population $plant^{-1}$	% reduction from control	Mean population $plant^{-1}$	% reduction from control	Mean population $plant^{-1}$	% reduction from control
Thiamethoxam 25 WG	50	200 g	3.32b (1.95)	47.24	1.38bc (1.37)	42.22	0.82d (1.15)	43.80	1.84c (1.53)	71.41
Dinotefuran 20 SG	30	150 g	3.13b (1.91)	50.93	1.07b (1.25)	46.54	0.62e (1.06)	30.28	1.61bc (1.45)	75.42
Flonicamid 50 WG	75	150 g	2.98a (1.87)	52.55	0.90ab (1.18)	47.95	0.45c (0.97)	45.21	1.44b (1.39)	77.54
Spinetoram 11.7 SC	50	420 g	2.73a (1.80)	56.52	0.68a (1.09)	51.07	0.28d (0.88)	43.94	1.23a (1.32)	80.83
Clothianidin 50 WG	100	200 g	3.08a (1.89)	51.46	1.12bc (1.27)	45.83	0.63de (1.06)	33.17	1.61bc (1.45)	75.21
Imidacloprid 17.8 SL	25	125 ml	3.15b (1.91)	49.90	2.93ab (1.85)	48.11	1.98a (1.57)	57.58	2.69d (1.79)	58.20
Acetamiprid 20 SP	20	100 g	3.23b (1.93)	48.57	3.27c (1.94)	44.18	2.33b (1.68)	54.40	2.94e (1.85)	54.22
Untreated control	-	-	6.48c (2.64)	0.00	6.78d (2.70)	0.00	6.63f (2.67)	0.00	6.63f (2.67)	0.00

- Figures in the parentheses are $\sqrt{x+0.5}$ transformed values

- In a column, means followed by same letter(s) are not significantly different at P=0.05 by DMRT.

Table 2. Effect of new insecticides against Mirid bug, *C. biseratense* on cotton - Experiment II (Location : Memathur, Virudhachalam, Cuddalore)

Treatments	Dosage (g a.i. ha^{-1})	Formulation Dosage (g or ml /ha)	I Spray		II Spray		III Spray		Pooled	Cumulative
			Mean population plant^{-1}	% reduction from control	Mean population plant^{-1}	% reduction from control	Mean population plant^{-1}	% reduction from control	Mean population plant^{-1}	% reduction from control
Thiamethoxam 25 WG	50	200 g	4.38g (2.21)	41.08	1.77c (1.51)	39.97	1.07e (1.25)	30.07	2.41e (1.71)	66.11
Dinotefuran 20 SG	30	150 g	3.98d (2.12)	46.05	1.43bc (1.39)	42.77	0.72b (1.10)	43.62	2.04c (1.59)	70.98
Flonicamid 50 WG	75	150 g	3.80b (2.07)	49.68	1.35b (1.36)	43.26	0.75b (1.12)	43.80	1.97b (1.57)	72.71
Spinetoram 11.7 SC	50	420 g	3.62a (2.03)	51.75	1.17a (1.29)	48.24	0.57a (1.03)	50.46	1.78a (1.51)	75.07
Clothianidin 50 WG	100	200 g	4.13e (2.15)	45.38	1.53bc (1.42)	42.38	0.83c (1.15)	42.99	2.16d (1.63)	69.97
Imidacloprid 17.8 SL	25	125 ml	3.90c (2.10)	47.97	3.65d (2.04)	31.42	2.93d (1.85)	38.46	3.49f (2.00)	51.14
Acetamiprid 20 SP	20	100 g	4.15f (2.16)	44.22	3.90e (2.10)	28.40	3.13cd (1.91)	39.87	3.73g (2.06)	47.48
Untreated control	-	-	7.38h (2.81)	0.00	6.95f (2.73)	0.00	6.80f (2.70)	0.00	7.04h (2.75)	0.00

- Figures in the parentheses are $\sqrt{x + 0.5}$ transformed values

- In a column, means followed by same letter(s) are not significantly different at P=0.05 by DMRT.

Table 3. Cost economics of insect management in cotton, Coimbatore

Treatment	Active Ingredient Dosage (g a.i/ha)	Formulation Dosage (g or ml /ha)	Yield (Kg ha^{-1})	Rate/Kg (Rs.)	Gross returns (Rs.)	Total Expenditure (Rs.)	Net Return (Rs.)	CBR
Thiamethoxam 25 WG	50	200 g	1848	71.20	1,31,577.60	43,840	87,738	2.00
Dinotefuran 20 SG	30	150 g	2220	71.20	1,58,064.00	43,790	1,14,274	2.61
Flonicamid 50 WG	75	150 g	2230	71.20	1,58,776.00	43,815	1,14,961	2.62
Spinetoram 11.7 SC	50	420 g	2346	71.20	1,67,035.20	44,706	1,22,329	2.74
Clothianidin 50 WG	100	200 g	1921	71.20	1,36,775.20	45,129	91,646	2.03
Imidacloprid 17.8 SL	25	125 ml	1712	71.20	1,21,894.40	44,229	77,665	1.76
Acetamiprid 20 SP	20	100 g	1643	71.20	1,16,981.60	44,029	72,953	1.66
Untreated control	-	-	1220	71.20	86,864.00	43,506	43,358	1.00

*Average price of Cotton: Rs.71.20 per kg as per Regulated Market, Avinashi, Coimbatore

Table 4. Cost economics of insect management in cotton, Cuddalore

Treatment	Active Ingredient Dosage (g a.i/ha)	Formulation Dosage (g or ml /ha)	Yield (Kg ha^{-1})	Rate/Kg (Rs.)	Gross returns (Rs.)	Total Expenditure (Rs.)	Net Return (Rs.)	CBR
Thiamethoxam 25 WG	50	200 g	1980	62.50	1,23,750.00	42,578	81,172	1.91
Dinotefuran 20 SG	30	150 g	2050	62.50	1,28,125.00	41,356	86,769	2.10
Flonicamid 50 WG	75	150 g	2135	62.50	1,33,437.50	40,782	92,656	2.27
Spinetoram 11.7 SC	50	420 g	2248	62.50	1,40,500.00	40,035	1,00,465	2.51
Clothianidin 50 WG	100	200 g	2060	62.50	1,28,750.00	41,982	86,768	2.07
Imidacloprid 17.8 SL	25	125 ml	1685	62.50	1,05,312.50	43,275	62,038	1.43
Acetamiprid 20 SP	20	100 g	1567	62.50	97,937.50	43,156	54,782	1.27
Untreated control	-	-	1164	62.50	72,750.00	36,304	36,446	1.00

*Average price of Cotton: Rs.62.50 per kg as per Regulated Market, Cuddalore resistance development. The yield advantages of Spinetoram and Flonicamid are consistent with findings by Rohini Sugandhi and Patil (2009), who reported that newer insecticides not only control pests effectively but also enhance yields through better crop health. Patil et al. (2006) also documented higher net returns when newer-generation insecticides were integrated into pest management strategies. Additionally, the cost-effectiveness of Spinetoram and Dinotefuran supports earlier recommendations, emphasizing their compatibility with sustainable agricultural practices (Khan, 2003).

The relatively lower returns from Imidacloprid and Acetamiprid align with observations by Patil *et al.,* (2005), where traditional neonicotinoids showed declining efficacy, likely due to pest adaptation (Khan *et al.,* 2004).

The results highlight the importance of rotating insecticides with diverse modes of action to mitigate resistance development and ensure sustained pest control. Combining Spinetoram and Flonicamid in IPM programs could optimize pest suppression while preserving non-target organisms, a strategy supported by Kumar *et al.,* (2018) in their studies on the efficacy of novel insecticides.

Spinetoram 11.7 SC, Flonicamid 50 WG, and Dinotefuran 20 SG emerged as the most effective treatments against *C. biseratense*, ensuring substantial pest suppression, higher yields, and favourable economic returns. These findings validate their integration into IPM programs for cotton ecosystems. The study also emphasizes the need for climate-adaptive pest management strategies to sustain efficacy and profitability in cotton cultivation.

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