**ABSTRACT**

An extensive survey was carried to study the diversity of predators associated with the mealybug complex in the cassava growing districts viz., Salem, Namakkal, Erode, Tiruppur and Coimbatore of Tamil Nadu, India from January to September, 2021. The survey revealed the dominance of *Phenacoccus manihoti* Matile-Ferrero 1977 (Hemiptera: Pseudococcidae) than other mealybug species in all the surveyed districts. The incidence of *P. manihoti* ranged from 12 to 90 per cent while *Paracoccus marginatus* Williams and Granara de Willink 1992 (Hemiptera: Pseudococcidae) incidence was found to be between 8 and 54 per cent. The incidence of *Ferrisia virgata* Cockerell 1893 (Hemiptera: Pseudococcidae) was found to be very low (8-16%) compared to other mealybug species. Association of total predators with *P. manihoti* were found to be maximum (30.87%) followed by the total predators with *P. marginatus* (6.49%) whereas 0.53 per cent of total predators associated with *F. virgata*. The fourteen different predators viz., *Cryptolaemus montrouzieri* Mulsant 1853 (Coleoptera: Coccinellidae), *Menocheilus sexmaculatus* Fabricius 1781 (Coleoptera: Coccinellidae), *Anegleis cardoni* Weise 1892 (Coleoptera: Coccinellidae), *Hyperaspis maindronii* Sicard 1929 (Coleoptera: Coccinellidae), *Scymnus* spp. (Coleoptera: Coccinellidae), *Chrysoperla* spp. (Neuroptera: Chrysopidae), *Mallada* spp. (Neuroptera: Chrysopidae), *Hyperaspis* spp. (Neuroptera: Chrysopidae), *Orginal Research Article*
Keywords: Survey; predators; mealybug complex; diversity indices.

1. INTRODUCTION

Cassava, Manihot esculenta Crantz (Malpighiales: Euphorbiaceae) is an important industrial crop cultivated predominantly in the southern states of India. Cassava was relatively free from major pests though several mealybug species have been reported. The introduction of invasive papaya mealybug, Paracoccus marginatus Williams & Granara de Willink 1992 (Hemiptera: Pseudococcidae) in 2008 caused great havoc on cassava. However, the papaya mealybug was successfully managed by introducing the biological control agent, an encyrtid parasitoid, Acerophagus papayae Noyes & Schauf (Hymenoptera, Encyrtidae) during 2010. Likewise, the recent most serious biological invasion is the cassava mealybug (CMB), Phenacoccus manihoti Matile-Ferrero (Hemiptera: Pseudococcidae) on cassava which threatens the cassava cultivation.

It was reported for the first time in India on cassava at Thrissur district of Kerala during April, 2020 [1]. The CMB infestation causes curling of the leaves at the plant's growing tip, leading to the formation of bunchy tops and adventitious buds on almost all the internodes. Heavy infestation results in drying of leaves and complete defoliation. The CMB infestation ranged from 7.0% to 86.7% (per cent) in Salem and Namakkal districts of Tamil Nadu [2]. Besides, P. marginatus and P. manihoti, occurrence of striped mealybug, Ferrisia virgata Cockerell 1893 (Hemiptera: Pseudococcidae), Jack Beardsley mealybug, Pseudococcus jackbeardsiyi Gimpel and Miller 1996 (Hemiptera: Pseudococcidae), and Madeira mealybug, Phenacoccus madeirensis Green 1923 (Hemiptera: Pseudococcidae), Spherical mealybug, Nipaecoccus viridis Newstead 1894 (Hemiptera: Pseudococcidae) were also reported on cassava. Chemical-based pesticides are ineffective against cassava mealybug, which warrants eco-friendly methods involving biological control agents like A. papayae against papaya mealybug. In the above context, it is crucial to document the natural enemies associated with the mealybug complex on cassava to design biological control based management strategies. In view of the above facts, the present study was carried out to inventory the predator fauna associated with the mealybug complex on cassava and their diversity status was also documented.

2. MATERIALS AND METHODS

2.1 Survey on the Incidence of Mealybug Complex and Relative Abundance of their Associated Predators on Cassava

An extensive survey was carried out at cassava growing areas of Salem, Namakkal, Erode, Tiruppur and Coimbatore districts of Tamil Nadu to explore the incidence of different mealybug species and their associated predators on cassava. A total of twenty five cassava plants were selected at random per field and observed for the incidence of mealybug species and their associated predators.

2.1.1 Incidence of mealybug complex on cassava

The incidence of individual species among the mealybug complex on cassava was worked out by using the following formula,

\[
\text{Incidence of individual mealybug species (\%) } = \frac{\text{Number of plants affected with individual species}}{\text{Number of plants observed}} \times 100
\]

2.1.2 Relative abundance of predators associated with the mealybug complex on cassava

The relative abundance of total predators and individual predators in each location of a district was worked out by the following formulae:
Relative abundance (%) = \frac{\text{Number of predators collected in each location of a district}}{\text{Number of predators collected in all locations of a district}} \times 100

2.2 Diagnostic Characteristics of Predators Associated with the Mealybug Complex on Cassava

Adults and immature stages of the predators found during the survey were brought to the laboratory; the immature stages of predators were reared till their adult stage and preserved in 70 per cent ethanol for further identification.

The adult predators were examined under Stemi (Zeiss) 200 C microscope and photographed under a stereo zoom microscope (Leica M 205 A). The specimens were identified based on its diagnostic characteristics with the help of available literature [3-7].

2.3 Assessment of Diversity Indices

The diversity of the predators were assessed through different indices viz., Simpson’s Index of Diversity (SID), Shannon-Wiener Index (H’), Pielou’s Evenness Index (E1) and Margalef index (α).

2.3.1 Simpson’s index of diversity (SID)

Simpson’s Index of Diversity is the measure of diversity of the species. The following formula is used to work out the Index of diversity [8].

\[ D = \frac{\sum n (n-1)}{N (n-1)} \]

where, \( n \) = total number of individuals in a species, \( N \) = total number of individuals in all species

2.3.2 Shannon-wiener Index (H’)

It is an another index for measuring the diversity of the species and the Index is calculated by the following formula [9]

\[ H' = - \sum P_i \log_e(P_i) \]

where, \( P_i \) = proportion of \( i^{th} \) species, \( \log_e(P_i) \) = Natural logarithm of \( P_i \)

2.3.3 Pielou’s evenness index (E1)

Pielou’s evenness index (E1) to calculate the species evenness and the formula is as follows [10];

\[ E1 = \frac{H'}{\log_e(S)} \]

where, \( H' \) = Shannon-Wiener diversity index, \( S \) = total number of species collected

2.3.4 Margalef index (α)

It is an index is used to study the species richness and it was calculated for all the study area using the formula as follows [11]:

\[ \alpha = \frac{(S-1)}{\log_e(N)} \]

where, \( S \) = total number of species collected, \( N \) = total number of individuals in all species

The data were subjected for analysis using ‘Biodiversity Calculator’ (Al Young Studios) to understand the diversity of predators.

3. RESULTS AND DISCUSSION

3.1 Survey on the Incidence of Mealybug Complex and Relative Abundance of their Associated Predators on Cassava

3.1.1 Incidence of mealybug complex on cassava

The survey conducted in Salem, Namakkal, Erode, Tiruppur and Coimbatore districts during January to September, 2021 revealed the occurrence of three different mealybug species viz., Phenacoccus manihoti Matile-Ferrero 1977 (Hemiptera: Pseudococcidae), Paracoccus marginatus Williams and Granara de Willink 1992 (Hemiptera: Pseudococcidae), Ferrisia virgata Cockerell 1893 (Hemiptera: Pseudococcidae) (Tables 1-5).

The mealybug species, \( P. \) manihoti was found in all the districts surveyed. The incidence of \( P. \) manihoti ranged from 16 to 86 per cent in Salem district, 12 to 90 per cent in Namakkal district 32 to 74 per cent in Erode district, 16 to 48 per cent in Tiruppur and, 32 to 76 per cent in Coimbatore district. Therefore, the incidence of \( P. \) manihoti was found to be maximum and it was ranged from 12 to 90 per cent among all the districts surveyed. The results corroborate with the results of Sampath Kumar [2] who reported 7.00 to 86.75 per cent infestation of \( P. \) manihoti in Salem and Namakkal districts during 2020.
The incidence of *P. marginatus* ranged from 18 to 42 per cent in Salem district, 24 to 34 per cent in Namakkal district and 32 to 54 per cent in Coimbatore district and revealed that the incidence of *P. marginatus* varied in different blocks of Coimbatore, Erode, Perambalur, Salem and Tiruppur districts of Tamil Nadu during the period 2011-2012. It was found that the incidence of *P. marginatus* was decreased from the period 2011 to 2021 and it might be due to the introduction of the biological control agent, an encyrtid parasitoid, *A. papayae* and abundance of different predators.

The incidence of *F. virgata* was found to be lower (8-16%) than other mealybug species and was recorded only in Anaikattilpalayam village of Namakkal district (16%) and Akkichtilpalayam village of Salem district (8%). This species was found to be very low in occurrence among the mealybug complex on cassava.

### 3.1.2 Relative abundance of predators associated with the mealybug complex on cassava

The fourteen different predators such as *Cryptolaemus montrouzieri* Mulsant 1853 (Coleoptera: Coccinellidae), *Menocheilus sexmaculatus* Fabricius 1781 (Coleoptera: Coccinellidae), *Anegleis cardoni* Weise 1892 (Coleoptera: Coccinellidae), *Hyperaspididae* *mains* Sicard 1929 (Coleoptera: Coccinellidae), *Brumoides sutralis* Fabricius 1798 (Coleoptera: Coccinellidae), *Scynmus spp.* (Coleoptera: Coccinellidae), *Chrysoperla spp.* (Neuroptera: Chrysopidae), *Mallada spp.* (Coleoptera: Coccinellidae), *Spalgis epeus* Westwood 1851 (Lepidoptera: Lycidae), *Geocoris spp.* (Hemiptera: Geocoridae), *Cardiastethus spp.* (Hemiptera: Anthocoridae), *Diacidiplosis spp.* (Diptera: Cecidomyiidae), *Oxyopes spp.* (Araneae: Oxyopidae), *Argiope spp.* (Araneae: Araneidae) were found to be associated with the mealybug complex (*P. manihoti*, *P. marginatus* and *F. virgata*) (Tables 1-5).

A total of thirteen predators viz., *H. maindroni*, *M. sexmaculatus*, *B. sutralis*, *Scynmus spp.*, *S. epeus*, *C. montrouzieri*, *Chrysoperla spp.*, *Mallada spp.*, *Geocoris spp.*, *Cardiastethus spp.*, *Diacidiplosis spp.*, *Oxyopes spp.*, *Argiope spp.* were recorded on *P. manihoti*. The relative abundance of total predators associated with *P. manihoti* ranged from 3.72 to 27.66 per cent in Salem district, 0.34 to 30.92 per cent in Namakkal district, 4.30 to 30.47 per cent in Erode district, 21.63 to 27.99 per cent in Tiruppur and 8.48 to 26.28 per cent in Coimbatore district. Among the districts surveyed, the relative abundance of total predators was found to be higher in Alampatti village of Namakkal district (30.87%) which also recorded highest (90%) incidence of *P. manihoti*.

Among the predators of *P. manihoti*, the relative abundance of individual predator, *H. maindroni* was found to be higher in Alampatti village of Namakkal district (11.74%) followed by *Diacidiplosis spp.* in Andigoundanur village of Tiruppur district (7.94%), *Mallada spp.* (6.46%) and *M. sexmaculatus* (5.06%) in Naapalaiyam village of Salem district, *S. epeus* in Kattukottai village of Salem district (3.72%), *C. montrouzieri* in TNAU Orchard of Coimbatore district (3.39%), *Chrysoperla spp.* in Devarayapuram village of Coimbatore district (3.39%), and *Scynmus spp.* in Komarayanur village of Erode district (3.25%), *Geocoris spp.* in Kannapalli village of Erode district (2.73%), *B. sutralis* in Nappalaiyam village of Salem district (2.66%), *Cardiastethus spp.* in Merkuputhur village of Erode district (1.56%), *Oxyopes spp.* (0.67%) in Alampatti village of Namakkal district, *Argiope spp.* (0.53%) in Kattukottai village of Salem district (Tables 1-5).

Therefore, the results showed that *H. maindroni* was found to be common and relatively abundant species predating *P. manihoti* among all the districts surveyed which was in accordance with [13]. Similarly, Neuenschwander and Hammond (1988) [14] reported coccinellid species under the genus *Hyperaspidis* viz., *Hyperaspidis aestimabilis* Mader 1955 (Coleoptera: Coccinellidae) and *Hyperaspidis delicatula* Mulsant 1850 (Coleoptera: Coccinellidae), *Exochomus spp.* (Coleoptera: Coccinellidae) on *P. manihoti* in Africa. A coccidiomyiid predator, *Diacidiplosis spp.* was found to be next abundant predator after *H. maindroni* during the present survey. Likewise, [15] stated that *Dicrodiplosis manihoti* Harris 1981 (Diptera: Cecidomyiidae) was the second most common predator of *P. manihoti* next to coccinellids in Nigeria.

Neuenschwander and Hammond [14] and Lohr et al., [16] reported *Chrysoperla externa* Hagen 1861 (Neuroptera: Chrysopidae),
Kalodiplosis spp. (Diptera: Cecidomyiidae), Ceraceochrysa spp. (Neuroptera: Chrysopidae), Spalgis lemolea Druce 1890 (Lepidoptera: Lyceniidae) and Sympherobius maculipennis Kimmins 1929 (Neuroptera: Hemerobiidae) as predators of P. manihoti in Africa

In India, Joshi et al., [1] reported H. maindroni, Cardiastethus spp., S. epeus and Scymnus coccivora Ramkrishna Ayyar, 1925 (Coleoptera: Coccinellidae) as predators of P. manihoti.

About eight different predators, C. montrouzieri, B. suturalis, M. sexmaculatus, A. cardoni, S. epeus, Chrysoperla spp., Mallada spp., Oxyopes spp. were recorded on P. marginatus. The relative abundance of total predators associated with P. marginatus ranged from 5.45 to 18.42 per cent in Salem district, 7.96 to 10.01 per cent in Namakkal district and 9.32 to 20.34 per cent in Coimbatore district. Among the districts surveyed, the total predators associated with P. marginatus were found to be higher in Kumarapalayam village of Coimbatore district (20.34%) which also recorded 54 per cent incidence of P. marginatus (Tables 1, 2 & 5).

Among the predators of P. marginatus, the relative abundance of C. montrouzieri was found to be higher in Pudur village of Salem district (6.49%) and S. epeus (5.39%) followed by Chrysoperla spp. (4.24%), Mallada spp. (3.39%), in Kumarapalayam village of Coimbatore district, B. suturalis in Alampilayam village of Coimbatore district (2.54%), A. cardoni in Pudur village of Salem district (2.13%), M. sexmaculatus in Kalkurichi village of Namakkal district (2.01%) and Oxyopes spp. in Panaimadal village of Salem district (0.53%) (Tables 1, 2 & 5).

Mastoi et al., [17] also documented A. cardoni, B. suturalis, Chilocorus nigrita Fabricius 1798 (Coleoptera: Coccinellidae), C. montrouzieri, Nephus quadrimaculatus Herbst 1783 (Coleoptera: Coccinellidae), Chrysoperla carnea Stephens 1836 (Neuroptera: Chrysopidae), Scymnus spp., S. epeus, Cyrtopeltis spp. (Hemiptera: Miridae) as predators of P. marginatus in Malaysia. The predatory spiders, Oxyopes spp. was found feeding on various sucking pests including P. marginatus [18].

However, S. epeus was the only predator found associated with F. virgata in Analakkipalayam village of Namakkal district (0.67%) and Akkichettipalayam village of Salem district (0.53%) (Tables 1, 2) whereas Mani and Krishnamoorthy, [19] documented S. coccivora, Mallada boninensis Okamoto (Neuroptera: Chrysopidae), B. suturalis, S. epeus and M. sexmaculatus as predators of F. virgata in India.

3.2 Diagnostic Characteristics of Predators Associated with the Mealybug Complex on Cassava

Based on the available literatures, the adult predators were identified and its diagnostic characteristics were described below:

3.2.1 Hyperaspis maindroni Sicard 1929 (Coleoptera: Coccinellidae)

Oval body with orange yellow coloured head and pronotum. Trident shaped stripes found on the pale cream coloured elytra (Plate 1a).

3.2.2 Menochelius sexmaculatus Fabricius 1781 (Coleoptera: Coccinellidae)

Body is yellowish brown colour with a pair of transverse black coloured band on pronotum, longitudinal blackish band on the mid dorsal line of elytra junction, three pairs of zig-zag patch found on the elytra viz., small inverted V-shaped anterior patch, W-shaped middle patch and nearly rounded posterior patch (Plate 1b).

3.2.3 Cryptolaemus montrouzieri Mulsant 1853 (Coleoptera: Coccinellidae)

Adult having orange coloured head, pronotum and blackish elytra with orange apices (Plate1c).

3.2.4 Brumoides suturalis Fabricius 1798 (Coleoptera: Coccinellidae)

Oval shaped body with yellowish brown pronotum. Three longitudinal black stripes present on the yellow elytra, two stripes on the sides of elytra and another one is found along the mid dorsal line of elytra junction, not touching posterior end of the body (Plate1d).

3.2.5 Anegleis cardoni Weise 1892 (Coleoptera: Coccinellidae)

The beetle is having yellow coloured elytra found with one black median stripe at the junction of elytra, one inwardly curved anterior stripe, outwardly curved posterior stripe and small rounded black spot on each elytron (Plate1e).
Table 1. Occurrence of the mealybug complex and their predators in Salem district, Tamil Nadu, India (January-September, 2021)

| Location          | Variety          | Age of the crop (months) | Mealybug species observed | Incidence of mealybug species (%) | Predators observed                   | Relative abundance of individual predator (%) | Relative abundance of total predators (%) |
|-------------------|------------------|--------------------------|---------------------------|-----------------------------------|---------------------------------------|-----------------------------------------------|-------------------------------------------|
| Nappalaiyam      | MVD-1            | 6                        | *P. manihoti*             | 86                                | *B. sutralis*                          | 2.66                                          | 27.66                                     |
|                  |                  |                          |                           |                                   | *H. maindroni*                        | 6.45                                          |                                          |
|                  |                  |                          |                           |                                   | *M. sexmaculatus*                      | 5.06                                          |                                          |
|                  |                  |                          |                           |                                   | *Scymnus spp.*                         | 2.19                                          |                                          |
|                  |                  |                          |                           |                                   | *Chrysoperla spp.*                     | 1.60                                          |                                          |
|                  |                  |                          |                           |                                   | *Mallada spp.*                         | 6.46                                          |                                          |
|                  |                  |                          |                           |                                   | *S. epeus*                             | 2.13                                          |                                          |
|                  |                  |                          |                           |                                   | *Diadiplosis spp.*                     | 1.13                                          |                                          |
|                  |                  |                          |                           |                                   | *B. sutralis*                          | 1.06                                          | 9.57                                      |
|                  |                  |                          |                           |                                   | *H. maindroni*                         | 3.19                                          |                                          |
|                  |                  |                          |                           |                                   | *M. sexmaculatus*                      | 2.13                                          |                                          |
|                  |                  |                          |                           |                                   | *Scymnus spp.*                         | 1.13                                          |                                          |
|                  |                  |                          |                           |                                   | *Mallada spp.*                         | 2.13                                          |                                          |
|                  |                  |                          |                           |                                   | *B. sutralis*                          | 1.13                                          | 6.45                                      |
|                  |                  |                          |                           |                                   | *H. maindroni*                         | 1.60                                          |                                          |
|                  |                  |                          |                           |                                   | *M. sexmaculatus*                      | 1.60                                          |                                          |
|                  |                  |                          |                           |                                   | *Scymnus spp.*                         | 0.53                                          | 3.72                                      |
|                  |                  |                          |                           |                                   | *B. sutralis*                          | 0.53                                          |                                          |
|                  |                  |                          |                           |                                   | *H. maindroni*                         | 1.06                                          |                                          |
|                  |                  |                          |                           |                                   | *M. sexmaculatus*                      | 2.13                                          |                                          |
|                  |                  |                          |                           |                                   | *Chrysoperla spp.*                     | 1.13                                          |                                          |
|                  |                  |                          |                           |                                   | *S. epeus*                             | 4.26                                          |                                          |
| Pillukurichi      | MVD-1            | 7                        | *P. manihoti*             | 53                                | *B. sutralis*                          | 1.06                                          | 9.57                                      |
|                  |                  |                          |                           |                                   | *H. maindroni*                         | 3.19                                          |                                          |
|                  |                  |                          |                           |                                   | *M. sexmaculatus*                      | 2.13                                          |                                          |
|                  |                  |                          |                           |                                   | *Scymnus spp.*                         | 1.13                                          |                                          |
|                  |                  |                          |                           |                                   | *Diadiplosis spp.*                     | 1.13                                          |                                          |
|                  |                  |                          |                           |                                   | *B. sutralis*                          | 1.06                                          |                                          |
|                  |                  |                          |                           |                                   | *H. maindroni*                         | 3.19                                          |                                          |
|                  |                  |                          |                           |                                   | *M. sexmaculatus*                      | 2.13                                          |                                          |
|                  |                  |                          |                           |                                   | *Scymnus spp.*                         | 1.13                                          |                                          |
|                  |                  |                          |                           |                                   | *Mallada spp.*                         | 2.13                                          |                                          |
|                  |                  |                          |                           |                                   | *B. sutralis*                          | 1.13                                          | 6.45                                      |
|                  |                  |                          |                           |                                   | *H. maindroni*                         | 1.60                                          |                                          |
|                  |                  |                          |                           |                                   | *M. sexmaculatus*                      | 1.60                                          |                                          |
|                  |                  |                          |                           |                                   | *Scymnus spp.*                         | 0.53                                          | 3.72                                      |
|                  |                  |                          |                           |                                   | *B. sutralis*                          | 0.53                                          |                                          |
| Chokkanathapuram  | MVD-1            | 10                       | *P. manihoti*             | 48                                | *B. sutralis*                          | 1.13                                          | 6.45                                      |
|                  |                  |                          |                           |                                   | *H. maindroni*                         | 1.60                                          |                                          |
|                  |                  |                          |                           |                                   | *M. sexmaculatus*                      | 1.60                                          |                                          |
|                  |                  |                          |                           |                                   | *Scymnus spp.*                         | 0.53                                          | 3.72                                      |
|                  |                  |                          |                           |                                   | *B. sutralis*                          | 0.53                                          |                                          |
|                  |                  |                          |                           |                                   | *H. maindroni*                         | 1.06                                          |                                          |
|                  |                  |                          |                           |                                   | *M. sexmaculatus*                      | 2.13                                          |                                          |
|                  |                  |                          |                           |                                   | *Chrysoperla spp.*                     | 1.13                                          |                                          |
|                  |                  |                          |                           |                                   | *S. epeus*                             | 4.26                                          |                                          |
| Alagapuram        | White Thailand   | 3                        | *P. manihoti*             | 16                                | *B. sutralis*                          | 1.06                                          | 5.85                                      |
|                  |                  |                          |                           |                                   | *H. maindroni*                         | 1.60                                          |                                          |
|                  |                  |                          |                           |                                   | *M. sexmaculatus*                      | 0.53                                          |                                          |
|                  |                  |                          |                           |                                   | *S. epeus*                             | 2.66                                          |                                          |
|                  |                  |                          |                           |                                   | *B. sutralis*                          | 1.60                                          | 4.79                                      |
|                  |                  |                          |                           |                                   | *H. maindroni*                         | 1.06                                          |                                          |
|                  |                  |                          |                           |                                   | *M. sexmaculatus*                      | 1.06                                          |                                          |
|                  |                  |                          |                           |                                   | *Chrysoperla spp.*                     | 1.06                                          |                                          |
|                  |                  |                          |                           |                                   | *C. montrouzier*                       | 6.49                                          | 18.42                                     |
| Poolampatti       | White Thailand   | 6                        | *P. manihoti*             | 40                                | *B. sutralis*                          | 1.06                                          | 5.85                                      |
|                  |                  |                          |                           |                                   | *H. maindroni*                         | 1.60                                          |                                          |
|                  |                  |                          |                           |                                   | *M. sexmaculatus*                      | 0.53                                          |                                          |
|                  |                  |                          |                           |                                   | *S. epeus*                             | 2.66                                          |                                          |
|                  |                  |                          |                           |                                   | *B. sutralis*                          | 1.60                                          | 4.79                                      |
|                  |                  |                          |                           |                                   | *H. maindroni*                         | 1.06                                          |                                          |
|                  |                  |                          |                           |                                   | *M. sexmaculatus*                      | 1.06                                          |                                          |
|                  |                  |                          |                           |                                   | *Chrysoperla spp.*                     | 1.06                                          |                                          |
| Ramanujapuram     | White Thailand   | 4                        | *P. manihoti*             | 36                                | *B. sutralis*                          | 1.06                                          | 4.79                                      |
|                  |                  |                          |                           |                                   | *H. maindroni*                         | 1.06                                          |                                          |
|                  |                  |                          |                           |                                   | *M. sexmaculatus*                      | 1.06                                          |                                          |
|                  |                  |                          |                           |                                   | *Chrysoperla spp.*                     | 1.06                                          |                                          |
|                  |                  |                          |                           |                                   | *C. montrouzier*                       | 6.49                                          | 18.42                                     |
|                  |                  |                          |                           |                                   | *M. sexmaculatus*                      | 1.06                                          |                                          |
|                  |                  |                          |                           |                                   | *B. sutralis*                          | 1.80                                          |                                          |
|                  |                  |                          |                           |                                   | *A. cardoni*                           | 2.13                                          |                                          |
|                  |                  |                          |                           |                                   | *Chrysoperla spp.*                     | 2.66                                          |                                          |
|                  |                  |                          |                           |                                   | *S. epeus*                             | 4.26                                          |                                          |
| Pudur             | White Thailand   | 10                       | *P. marginatus*           | 42                                | *B. sutralis*                          | 2.66                                          | 18.42                                     |
|                  |                  |                          |                           |                                   | *H. maindroni*                         | 1.80                                          |                                          |
|                  |                  |                          |                           |                                   | *M. sexmaculatus*                      | 2.13                                          |                                          |
|                  |                  |                          |                           |                                   | *Chrysoperla spp.*                     | 2.66                                          |                                          |
|                  |                  |                          |                           |                                   | *S. epeus*                             | 4.26                                          |                                          |
| Location              | Variety         | Age of the crop (months) | Mealybug species observed | Incidence of mealybug species (%) | Predators observed | Relative abundance of individual predator (%) | Relative abundance of total predators (%) |
|-----------------------|-----------------|--------------------------|---------------------------|-----------------------------------|--------------------|---------------------------------------------|------------------------------------------|
| Panaimadal            | White Thailand  | 9                        | P. marginatus             | 32                                | C. montrouzieri   | 3.19                                        | 10.11                                    |
|                       |                 |                          |                           |                                   | A. cardoni        | 1.06                                        |                                          |
|                       |                 |                          |                           |                                   | Chrysoperla spp. | 2.13                                        |                                          |
|                       |                 |                          |                           |                                   | Oxyopes spp.      | 0.53                                        |                                          |
|                       |                 |                          |                           |                                   | S. epeus          | 3.19                                        |                                          |
| Akkichettipalayam     | H-226           | 8                        | P. marginatus             | 36                                | C. montrouzieri   | 2.26                                        | 5.45                                     |
|                       |                 |                          |                           |                                   | A. cardoni        | 0.53                                        |                                          |
|                       |                 |                          |                           |                                   | S. epeus          | 1.60                                        |                                          |
|                       |                 |                          |                           |                                   | S. epeus          | 0.53                                        |                                          |
| Narasingapuram        | White Thailand  | 9                        | P. marginatus             | 8                                 | F. virgata        | 0.53                                        | 0.53                                     |
|                       |                 |                          |                           |                                   | S. epeus          | 0.53                                        |                                          |
|                       |                 |                          |                           |                                   | S. epeus          | 0.53                                        |                                          |
| Kattukottai           | Sree Jaya       | 7                        | P. manihoti               | 46                                | Argiope spp.      | 0.53                                        | 7.45                                     |
|                       |                 |                          |                           |                                   | H. maindroni      | 1.06                                        |                                          |
|                       |                 |                          |                           |                                   | S. epeus          | 3.72                                        |                                          |
|                       |                 |                          |                           |                                   | Mallada spp       | 1.06                                        |                                          |
| Manivizhundhan        | Kunguma Rose    | 8                        | P. manihoti               | 16                                | -                 | -                                           | -                                        |
|                       |                 |                          |                           |                                   | -                 | -                                           | -                                        |

Table 2. Occurrence of the mealybug complex and their predators in Namakkal district, Tamil Nadu, India (January-September, 2021)
| Location     | Variety    | Age of the crop (months) | Mealybug species observed | Incidence of mealybug species (%) | Predators observed | Relative abundance of individual predator (%) | Relative abundance of total predators (%) |
|--------------|------------|--------------------------|---------------------------|-----------------------------------|--------------------|---------------------------------------------|------------------------------------------|
| Alampatti    | MVD-1      | 6                        | P. manihoti               | 90                                | B. sutralis        | 2.07                                        | 30.92                                    |
|              |            |                          |                           |                                    | H. mainndroni      | 11.74                                       |                                          |
|              |            |                          |                           |                                    | M. sexmaculatus    | 3.69                                        |                                          |
|              |            |                          |                           |                                    | Scymnus spp.       | 2.01                                        |                                          |
|              |            |                          |                           |                                    | Mallada spp.       | 1.01                                        |                                          |
|              |            |                          |                           |                                    | Oxyopes spp.       | 0.67                                        |                                          |
|              |            |                          |                           |                                    | Cardiastethus spp. | 1.34                                        |                                          |
|              |            |                          |                           |                                    | Geocoris spp.      | 1.68                                        |                                          |
|              |            |                          |                           |                                    | Diadiplosis spp.   | 6.71                                        |                                          |
|              |            |                          |                           |                                    | Scymnus spp.       | 1.34                                        | 14.43                                    |
|              |            |                          |                           |                                    | Mallada spp.       | 1.34                                        |                                          |
|              |            |                          |                           |                                    | S. epeus           | 1.34                                        |                                          |
|              |            |                          |                           |                                    | Geocoris spp.      | 1.01                                        |                                          |
|              |            |                          |                           |                                    | B. sutralis        | 1.01                                        | 1.69                                     |
|              |            |                          |                           |                                    | M. sexmaculatus    | 0.34                                        |                                          |
|              |            |                          |                           |                                    | Mallada spp.       | 0.34                                        |                                          |
|              |            |                          |                           |                                    | S. epeus           | 0.34                                        |                                          |
|              |            |                          |                           |                                    | C. montrouzieri    | 1.34                                        |                                          |
|              |            |                          |                           |                                    | B. sutralis        | 1.34                                        | 18.12                                    |
|              |            |                          |                           |                                    | M. exmaculatus     | 4.03                                        |                                          |
|              |            |                          |                           |                                    | H. mainndroni      | 1.34                                        |                                          |
|              |            |                          |                           |                                    | Scymnus spp.       | 1.01                                        |                                          |
|              |            |                          |                           |                                    | Chrysoperla spp.   | 1.68                                        |                                          |
|              |            |                          |                           |                                    | Mallada spp.       | 0.67                                        |                                          |
|              |            |                          |                           |                                    | Geocoris spp.      | 2.01                                        |                                          |
|              |            |                          |                           |                                    | Diadiplosis spp.   | 6.04                                        |                                          |
|              |            |                          |                           |                                    | Scymnus spp.       | 1.01                                        |                                          |
|              |            |                          |                           |                                    | Mallada spp.       | 1.68                                        |                                          |
|              |            |                          |                           |                                    | S. epeus           | 2.01                                        |                                          |
|              |            |                          |                           |                                    | Geocoris spp.      | 1.01                                        |                                          |
|              |            |                          |                           |                                    | B. sutralis        | 1.01                                        | 1.69                                     |
|              |            |                          |                           |                                    | M. sexmaculatus    | 0.34                                        |                                          |
|              |            |                          |                           |                                    | Mallada spp.       | 0.34                                        |                                          |
|              |            |                          |                           |                                    | S. epeus           | 0.34                                        |                                          |
|              |            |                          |                           |                                    | C. montrouzieri    | 1.34                                        | 7.96                                     |
|              |            |                          |                           |                                    | B. sutralis        | 0.67                                        |                                          |
|              |            |                          |                           |                                    | M. exmaculatus     | 1.68                                        |                                          |
|              |            |                          |                           |                                    | A. cardoni         | 1.68                                        |                                          |
|              |            |                          |                           |                                    | Mallada spp.       | 1.68                                        |                                          |
|              |            |                          |                           |                                    | S. epeus           | 2.01                                        |                                          |
|              |            |                          |                           |                                    | S. epeus           | 0.67                                        | 0.67                                     |
| Location       | Variety | Age of the crop (months) | Mealybug species observed | Incidence of mealybug species (%) | Predators observed | Relative abundance of individual predator (%) | Relative abundance of total predators (%) |
|----------------|---------|--------------------------|---------------------------|-----------------------------------|--------------------|-----------------------------------------------|-------------------------------------------|
| Kalkurichi     | MVD-1   | 12                       | P. marginatus             | 26                                | C. montrouzieri    | 2.68                                          | 10.01                                     |
|                |         |                          |                           |                                   | M. sexmaculatus     | 2.01                                          |                                           |
|                |         |                          |                           |                                   | A. cardoni         | 1.34                                          |                                           |
|                |         |                          |                           |                                   | Chrysopera spp.    | 1.01                                          |                                           |
|                |         |                          |                           |                                   | Mallada spp.       | 0.67                                          |                                           |
|                |         |                          |                           |                                   | S. epeus           | 2.30                                          |                                           |
| Usivellai      | 6       |                          | F. virgata                | 12                                | C. montrouzieri    | 2.01                                          | 8.47                                      |
|                |         |                          |                           |                                   | M. sexmaculatus     | 1.01                                          |                                           |
|                |         |                          |                           |                                   | Scymnus spp.       | 1.01                                          |                                           |
|                |         |                          |                           |                                   | Chrysopera spp.    | 0.76                                          |                                           |
|                |         |                          |                           |                                   | Mallada spp.       | 1.67                                          |                                           |
|                |         |                          |                           |                                   | S. epeus           | 2.01                                          |                                           |

Table 3. Occurrence of the mealybug complex and their predators in Erode district, Tamil Nadu, India (January-September, 2021)

| Location       | Variety | Age of the crop (months) | Mealybug species observed | Incidence of mealybug species (%) | Predators observed | Relative abundance of individual predator (%) | Relative abundance of total predators (%) |
|----------------|---------|--------------------------|---------------------------|-----------------------------------|--------------------|-----------------------------------------------|-------------------------------------------|
| Merkuputhur    | MVD-1   | 5                        | P. manihoti               | 74                                | B. suturalis       | 1.56                                          | 32.47                                     |
|                |         |                          |                           |                                   | H. maindroni       | 10.94                                         |                                           |
|                |         |                          |                           |                                   | M. sexmaculatus     | 4.69                                          |                                           |
|                |         |                          |                           |                                   | Chrysopera spp.    | 1.95                                          |                                           |
|                |         |                          |                           |                                   | Mallada spp.       | 2.34                                          |                                           |
|                |         |                          |                           |                                   | S. epeus           | 0.79                                          |                                           |
|                |         |                          |                           |                                   | Cardiastethus spp. | 1.56                                          |                                           |
|                |         |                          |                           |                                   | Geocoris spp.      | 1.56                                          |                                           |
|                |         |                          |                           |                                   | Diadiplosis spp.   | 5.08                                          |                                           |
| Kannapalli     | MVD-1   | 8                        | P. manihoti               | 64                                | B. suturalis       | 1.17                                          | 19.53                                     |
|                |         |                          |                           |                                   | H. maindroni       | 3.91                                          |                                           |
|                |         |                          |                           |                                   | M. sexmaculatus     | 3.13                                          |                                           |
|                |         |                          |                           |                                   | Mallada spp.       | 2.56                                          |                                           |
| Location     | Variety | Age of the crop (months) | Mealybug species observed | Incidence of mealybug species (%) | Predators observed             | Relative abundance of individual predator (%) | Relative abundance of total predators (%) |
|--------------|---------|--------------------------|---------------------------|-----------------------------------|-------------------------------|-----------------------------------------------|---------------------------------------------|
| Guruvareddiyur | MVD-1   | 6                        | P. manihoti               | 62                                | S. epeus                       | 1.73                                          | 15.63                                       |
|              |         |                          |                           |                                   | Cardiastethus spp.             | 0.78                                          |                                             |
|              |         |                          |                           |                                   | Geocoris spp.                  | 2.73                                          |                                             |
|              |         |                          |                           |                                   | Diadiplosis spp.               | 3.52                                          |                                             |
|              |         |                          |                           |                                   | B. sustralis                   | 0.78                                          |                                             |
|              |         |                          |                           |                                   | H. maindroni                   | 3.13                                          |                                             |
|              |         |                          |                           |                                   | M. sexmaculatus                | 2.34                                          |                                             |
|              |         |                          |                           |                                   | Scymnus spp.                   | 1.18                                          |                                             |
|              |         |                          |                           |                                   | Chrysoperla spp.               | 1.17                                          |                                             |
|              |         |                          |                           |                                   | Mallada spp.                   | 1.95                                          |                                             |
|              |         |                          |                           |                                   | S. epeus                       | 1.17                                          |                                             |
|              |         |                          |                           |                                   | Geocoris spp.                  | 0.78                                          |                                             |
|              |         |                          |                           |                                   | Diadiplosis spp.               | 3.13                                          |                                             |
| Komarayanur  | MVD-1   | 5                        | P. manihoti               | 67                                | C. montrouzieri                | 0.78                                          | 24.61                                       |
|              |         |                          |                           |                                   | H. maindroni                   | 4.19                                          |                                             |
|              |         |                          |                           |                                   | M. sexmaculatus                | 3.13                                          |                                             |
|              |         |                          |                           |                                   | Scymnus spp.                   | 3.23                                          |                                             |
|              |         |                          |                           |                                   | Chrysoperla spp.               | 1.56                                          |                                             |
|              |         |                          |                           |                                   | Mallada spp.                   | 3.52                                          |                                             |
|              |         |                          |                           |                                   | S. epeus                       | 2.73                                          |                                             |
|              |         |                          |                           |                                   | Geocoris spp.                  | 0.78                                          |                                             |
| Annamadu     | MVD-1   | 6                        | P. manihoti               | 50                                | Diadiplosis spp.               | 4.69                                          |                                             |
|              |         |                          |                           |                                   | C. montrouzieri                | 0.78                                          | 5.37                                        |
|              |         |                          |                           |                                   | H. maindroni                   | 2.34                                          |                                             |
|              |         |                          |                           |                                   | M. sexmaculatus                | 1.17                                          |                                             |
|              |         |                          |                           |                                   | Mallada spp.                   | 1.08                                          |                                             |
|              |         |                          |                           |                                   | B. sustralis                   | 0.39                                          |                                             |
|              |         |                          |                           |                                   | H. maindroni                   | 1.56                                          |                                             |
|              |         |                          |                           |                                   | M. sexmaculatus                | 0.48                                          |                                             |
|              |         |                          |                           |                                   | Scymnus spp.                   | 0.79                                          |                                             |
|              |         |                          |                           |                                   | Chrysoperla spp.               | 1.17                                          |                                             |
| YTP-2        | MVD-1   | 6                        | P. manihoti               | 32                                |                               |                                               |                                             |

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Table 4. Occurrence of the mealybug complex and their predators in Tiruppur district, Tamil Nadu, India (January-September, 2021)

| Location                  | Variety | Age of the crop (months) | Mealybug species observed | Incidence of mealybug species (%) | Predators observed | Relative abundance of individual predator (%) | Relative abundance of total predators (%) |
|---------------------------|---------|--------------------------|---------------------------|----------------------------------|--------------------|-----------------------------------------------|------------------------------------------|
| Madathukulam (Field.1)   | Kollam 16 | 3                        | *P. manihoti*             | 48                               | *B. sutralis*      | 2.59                                          | 24.99                                    |
|                           |         |                          |                           |                                  | *H. maindroni*     | 3.17                                          |                                          |
|                           |         |                          |                           |                                  | *M. sexmaculatus*  | 4.76                                          |                                          |
|                           |         |                          |                           |                                  | *Mallada spp.*     | 6.35                                          |                                          |
|                           |         |                          |                           |                                  | *S. epeus*         | 2.59                                          |                                          |
|                           |         |                          |                           |                                  | *Diadiplosis spp.* | 4.76                                          |                                          |
| Vedapatti                 | Kollam 16 | 9                        | *P. manihoti*             | 46                               | *H. maindroni*     | 5.76                                          | 25.39                                    |
|                           |         |                          |                           |                                  | *B. sutralis*      | 2.17                                          |                                          |
|                           |         |                          |                           |                                  | *M. sexmaculatus*  | 3.18                                          |                                          |
|                           |         |                          |                           |                                  | *Mallada spp.*     | 6.36                                          |                                          |
|                           |         |                          |                           |                                  | *S. epeus*         | 1.59                                          |                                          |
|                           |         |                          |                           |                                  | *Diadiplosis spp.* | 6.35                                          |                                          |
| Madathukulam (Field.2)   | Kollam 16 | 3                        | *P. manihoti*             | 76                               | *H. maindroni*     | 4.17                                          | 21.63                                    |
|                           |         |                          |                           |                                  | *B. sutralis*      | 1.59                                          |                                          |
|                           |         |                          |                           |                                  | *M. sexmaculatus*  | 4.76                                          |                                          |
|                           |         |                          |                           |                                  | *Scymnus spp.*     | 1.59                                          |                                          |
|                           |         |                          |                           |                                  | *Mallada spp.*     | 3.17                                          |                                          |
|                           |         |                          |                           |                                  | *Diadiplosis spp.* | 6.35                                          |                                          |
| Andigoundanur            | Kolaraman | 4                        | *P. manihoti*             | 16                               | *H. maindroni*     | 7.76                                          | 27.99                                    |
|                           |         |                          |                           |                                  | *M. sexmaculatus*  | 4.94                                          |                                          |
|                           |         |                          |                           |                                  | *Scymnus spp.*     | 1.59                                          |                                          |
|                           |         |                          |                           |                                  | *Mallada spp.*     | 2.59                                          |                                          |
|                           |         |                          |                           |                                  | *Chrysoperla spp.* | 3.17                                          |                                          |
|                           |         |                          |                           |                                  | *Diadiplosis spp.* | 7.94                                          |                                          |
Table 5. Occurrence of the mealybug complex and their predators in Coimbatore district, Tamil Nadu, India (January-September, 2021)

| Location          | Variety | Age of the crop | Mealybug species observed | Mealybug incidence (%) | Predator species observed  | Relative abundance of individual predator (%) | Relative abundance of total predators (%) |
|-------------------|---------|-----------------|---------------------------|-------------------------|---------------------------|-----------------------------------------------|------------------------------------------|
| Aalampalayam      | MVD-1   | 4               | *P. marginatus*           | 52                      | *C. montrouzieri*         | 4.24                                          | 16.10                                    |
|                   |         |                 |                           |                         | *B. sutralis*             | 2.54                                          |                                          |
|                   |         |                 |                           |                         | *M. sexmaculatus*         | 1.69                                          |                                          |
|                   |         |                 |                           |                         | *A. cardoni*              | 0.86                                          |                                          |
|                   |         |                 |                           |                         | *Chrysoperla spp.*        | 1.69                                          |                                          |
|                   |         |                 |                           |                         | *Mallada spp.*            | 2.54                                          |                                          |
|                   |         |                 |                           |                         | *S. epeus*                | 2.54                                          |                                          |
|                   |         |                 |                           |                         | *C. montrouzieri*         | 5.93                                          | 20.34                                    |
|                   |         |                 |                           |                         | *B. sutralis*             | 1.69                                          |                                          |
|                   |         |                 |                           |                         | *M. sexmaculatus*         | 1.69                                          |                                          |
|                   |         |                 |                           |                         | *Chrysoperla spp.*        | 4.24                                          |                                          |
|                   |         |                 |                           |                         | *Mallada spp.*            | 3.39                                          |                                          |
|                   |         |                 |                           |                         | *S. epeus*                | 3.40                                          |                                          |
| Kumarapalayam     | MVD-1   | 4               | *P. marginatus*           | 54                      | *C. montrouzieri*         | 5.93                                          | 20.34                                    |
|                   |         |                 |                           |                         | *B. sutralis*             | 1.69                                          |                                          |
|                   |         |                 |                           |                         | *M. sexmaculatus*         | 1.69                                          |                                          |
|                   |         |                 |                           |                         | *Chrysoperla spp.*        | 4.24                                          |                                          |
|                   |         |                 |                           |                         | *Mallada spp.*            | 3.39                                          |                                          |
|                   |         |                 |                           |                         | *S. epeus*                | 3.40                                          |                                          |
| Devarayapuram     | Kollam 16| 3               | *P. manihoti*             | 76                      | *B. sutralis*             | 1.69                                          | 26.28                                    |
|                   |         |                 |                           |                         | *H. maindroni*            | 6.78                                          |                                          |
|                   |         |                 |                           |                         | *M. sexmaculatus*         | 3.39                                          |                                          |
|                   |         |                 |                           |                         | *Scymnus spp.*            | 3.39                                          |                                          |
|                   |         |                 |                           |                         | *Chrysoperla spp.*        | 3.39                                          |                                          |
|                   |         |                 |                           |                         | *S. epeus*                | 3.40                                          |                                          |
| Insectary, TNAU   | YTP-2   | 4               | *P. manihoti*             | 32                      | *C. montrouzieri*         | 2.54                                          | 8.48                                     |
|                   |         |                 |                           |                         | *M. sexmaculatus*         | 2.54                                          |                                          |
|                   |         |                 |                           |                         | *Chrysoperla spp.*        | 0.85                                          |                                          |
|                   |         |                 |                           |                         | *Mallada spp.*            | 0.86                                          |                                          |
|                   |         |                 |                           |                         | *S. epeus*                | 1.69                                          |                                          |
|                   |         |                 |                           |                         | *C. montrouzieri*         | 3.69                                          | 19.48                                    |
|                   |         |                 |                           |                         | *B. sutralis*             | 0.85                                          |                                          |
|                   |         |                 |                           |                         | *M. sexmaculatus*         | 2.54                                          |                                          |
|                   |         |                 |                           |                         | *H. maindroni*            | 8.17                                          |                                          |
|                   |         |                 |                           |                         | *Scymnus spp.*            | 1.69                                          |                                          |
|                   |         |                 |                           |                         | *Mallada spp.*            | 0.85                                          |                                          |
|                   |         |                 |                           |                         | *S. epeus*                | 1.69                                          |                                          |
| TNAU Orchard      | YTP-2   | 8               | *P. manihoti*             | 56                      | *C. montrouzieri*         | 2.54                                          | 9.32                                     |
|                   |         |                 |                           |                         | *B. sutralis*             | 0.85                                          |                                          |
|                   |         |                 |                           |                         | *M. sexmaculatus*         | 2.54                                          |                                          |
|                   |         |                 |                           |                         | *H. maindroni*            | 8.17                                          |                                          |
|                   |         |                 |                           |                         | *Scymnus spp.*            | 1.69                                          |                                          |
|                   |         |                 |                           |                         | *Mallada spp.*            | 0.85                                          |                                          |
|                   |         |                 |                           |                         | *S. epeus*                | 1.69                                          |                                          |
| Thenkarai         | Kolaraman| 9               | *P. marginatus*           | 40                      | *C. montrouzieri*         | 2.54                                          | 9.32                                     |
|                   |         |                 |                           |                         | *M. sexmaculatus*         | 1.69                                          |                                          |
|                   |         |                 |                           |                         | *A. cardoni*              | 0.85                                          |                                          |
|                   |         |                 |                           |                         | *Mallada spp.*            | 1.69                                          |                                          |
|                   |         |                 |                           |                         | *S. epeus*                | 2.54                                          |                                          |
3.2.6 *Scymnus* spp. (Coleoptera: Coccinellidae)

Adult having dark brown elytra with pubescence and testaceous brown apices (Plate1f).

3.2.7 *Chrysoperla* spp. (Neuroptera: Chrysopidae)

Adult having yellow median thoracic band on the thorax and a pair of net like wings. The pseudomedian vein (PSM) met with imago (im) and pterostigma found on the apex of the wings (Plate1g).

3.2.8 *Mallada* spp. (Neuroptera: Chrysopidae)

Short and ovate imago, Subcosta (Sc) and radial vein (R) are widely separated on the forewings and narrow in hindwings (Plate1h).

3.2.9 *Spalgis* epeus Westwood 1851 (Lepidoptera: Lycaenidae)

The adult is having whitish-grey wings with thin black stripes on the inner side of the wings (Plate1i).

3.2.10 *Diadiplosis* spp. (Diptera: Cecidomyiidae)

Antenna is having 12 flagellomeres and presence of strap like adult abdominal sclerites. Radial vein (R1) joins Costa (C) and forked Cubitus Anal vein (Cu A) present on the wings (Plate1j).

3.2.11 *Geocoris* spp. (Hemiptera: Geocoridae)

Body is broadly oval and having wide head with bulging eyes and four segmented antenna (Plate1k).

3.2.12 *Cardiastethus* spp. (Hemiptera: Anthocoridae)

Body is generally elongate oval and brown in colour. Dark brown antenna and hemelytra is paler than head and pronotum (Plate1l).

3.2.13 *Oxyopes* spp. (Araneae: Oxyopidae)

Light brown coloured body with elongated opisthosoma having long spines on its legs (Plate1m).

3.2.14 *Argiope* spp. (Araneae: Araneidae)

Brown coloured body having pentagonal opisthosoma (Plate1n).

3.3 Assessment of Diversity Indices

Diversity indices form a significant part in the investigation of biodiversity and the indices will help us to study the diversity, richness and evenness of the species. The diversity of the predators associated with the mealybug complex in cassava were assessed through diversity indices viz., Simpson’s Index of Diversity (SID), Shannon’s Weiner’s Diversity (H’), Pielou’s evenness value (E1) and Margalef’s Index (α) and the results were presented in Fig. 1.

3.3.1 Simpson’s index of diversity (SID)

SID is a measure of diversity which takes into account the number of species present, as well as the relative abundance of each species. The present investigation revealed highest species diversity in Namakkal district as indicated by its SID value (0.90) and lowest diversity in Tiruppur district (0.75).

3.3.2 Shannon’s Weiner’s diversity (H’)

H’ is also a measure of diversity and analysis of the predator diversity indicated higher H’ in Namakkal district (3.32) and lower H’ value in Tiruppur district (1.54). Considering the SID and H’, it was evident that the species diversity was maximum in Namakkal district and minimum in Tiruppur district.

3.3.3 Pielou’s evenness value (E1)

Among all the districts surveyed, Namakkal district recorded maximum evenness value of 0.94 and Tiruppur district recorded minimum evenness pattern (0.79).

3.3.4 Margalef’s index (α)

Margalef’s index of species richness was high in Namakkal district (1.93) and low in Tiruppur district (1.67).

From the present studies, it can be concluded that the predators of mealybug complex were well distributed throughout the cassava ecosystem of surveyed districts and especially in Namakkal district as it had higher species diversity, richness and evenness. This results correlates with reports of Magurran [20] who explained that the species diversity increases with increase in species richness and species evenness. This might be due to minimum use of chemical pesticides or prevailing environmental condition which was congenial for the development and multiplication of predators or it may be due to the relative abundance of prey population in Namakkal district.
Plate 1a. *Hyperaspis maindroni*
- Orange yellow head and pronotum
- Trident shaped marking

Plate 1b. *Menochilus sexmaculatus*
- Transverse band on the pronotum
- Inverted V-shaped patch
- Inverted W-shaped patch
- Rounded patch
- Mid dorsal line

Plate 1c. *Cryptolaemus montrouzieri*
- Orange coloured head and pronotum
- Blackish elytra
- Orange colour apex

Plate 1d. *Brumus sutralis*
- Yellowish brown pronotum
- Black longitudinal stripe
- Stripes not touching posterior end

Plate 1e. *Aneileis cardoni*
- Anteriorly curved stripe
- Median stripe
- Posteriorly curved stripe
- Rounded black spot

Plate 1f. *Scymnus spp.*
- Pubescence on elytra
- Testaceous brown apex
Plate 1g. *Chrysoperla* spp.

Plate 1h. *Mallada* spp.

Plate 1i. *S. epeus*

Plate 1j. *Diadiplosis* spp.

Plate 1k. *Geocoris* spp.

Plate 1l. *Cardiastethus* spp.
Plate 1m. *Oxyopes* spp.  
Plate 1n. *Argiope* spp.

**Plate 1. Predators associated with the mealybug complex on cassava**

**Fig. 1. Diversity of predators in cassava growing districts of Tamil Nadu, India**

**4. CONCLUSION**

Our investigations revealed the prevalence of several predators associated with the mealybug complex on cassava. Further research on the predatory potential and then standardization of the mass culturing protocol for the most predominant predators will pave for designing indigenous natural enemies based biological control strategy for managing the mealybug complex on cassava.

**DISCLAIMER**

The products used for this research are commonly and predominantly used products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the product because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

**ETHICAL APPROVAL**

As per international standard or university standard ethical approval has been collected and preserved by the authors.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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