

Research Article

Biodiversity of mealybugs, their host range and bio-control agents associated in different districts of Chhattisgarh plains

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ABSTRACT: The survey of host range of mealybugs in five districts of Chhattisgarh plain regions namely Rajnandgaon, Balod, Dhamtari, Mahasamund and Raipur districts in which 132 plant species were observed. Among these, 72 plant species belonging to 28 families were identified as hosts out of which two species were of pulses (2.78%), one oilseed (1.39%), ten vegetables (13.89%), twelve fruits (16.67%), one fibre (1.39%), one sugarcane crop (1.39%), nineteen ornamentals (26.39%), fifteen medicinal (20.83%), two forest trees (2.78%) and nine plants under weeds (12.50%). The highest number of host plants of mealybugs were recorded in the family Malvaceae and Asteraceae followed by Fabaceae, Apocynaceae, Solanaceae, Rosaceae, Amaranthaceae and Lamiaceae. Among 72 plant species, 36 species of host plants were found having low infestation, 12 species had medium infestation and 24 plant species were observed to be highly infested by mealybugs. A total of eight mealybug species namely *Ferrisia virgata* Cockerell, *Maconellicoccus hirsutus* Green, *Nipaeococcus viridis* Newstead, *Paracoccus marginatus* Williams and Granara de Willink, *Phenacoccus solenopsis* Tinsley, *Rastrococcus iceryoides* Green and seven species of their natural enemies i.e., *Cheilomenes sexmaculata*, *Brumoides suturalis*, *Scymnus* sp., *Chrysoperla* sp., spiders as a general predator and *Aenasius* sp. and *Pseudleptomastix mexicana* as parasitoid were observed during the present studies. Among the Mealybugs species, *P. solenopsis* Tinsley was noticed as the most dominant species which observed on 14 species of different host plants infested with maximum 46.66 percent.

KEY WORDS: Host plants, mealybugs, natural enemies

(Article chronicle: Received: 16-12-2018; Revised: 20-02-2019; Accepted: 15-03-2019)

INTRODUCTION

Mealybug is the common name of insects belonging to Pseudococcidae, a family constituting of unarmored scale insects found in moist, warm climates. They are considered pests as they feed on plant juices of greenhouse plants, house hold garden plants and subtropical trees (Jahn *et al.*, 2003). In recent years, mealy bug, *Maconellicoccus hirsutus* (Green) has become a serious menace to successful cultivation of different fruit crops in India. The mealybug species are widespread throughout the world. It has been found on a relatively wide variety of host plants like mango, grapevines, citrus, custard apple, sapota, cashew, pineapple and ornamentals like hibiscus, croton, ferns, cacti, gardenias and orchids etc. Besides these, mealybug infestation has also been reported in storage of tuber crops like aerial yam, elephant foot yam, colocasia, cassava etc. (Keraba, 2011). Feeding due to mealybugs, reduces plant vigour and the honeydew secreted promotes the growth of a black sooty mould that interferes with photosynthesis and affects fruit quality

(Gullan and Martin, 2009). Biological control of mealybugs has been widely studied since the early twentieth century, due to the economic importance and invasive habits of this family (McKenzie, 1967). They have a wide variety of predators, including: Coccinellids, Coleopterans, lacewings of the families Chrysopidae, Coniopterygidae and Hemerobiidae, flies of the families Cecidomyiidae and Chamaemyiidae, Anthocorids bugs, Lycaenids, lepidopterans, and Phytoseiid mites (Franco *et al.*, 2000).

In Chhattisgarh, mealybug infestation was observed on almost all crops including cereals, legumes, oilseeds, vegetables, fruits, ornamentals, medicinal and weeds. So far, no proper documentation and identification of the various species of mealybugs attacking on different plants and their related natural enemies is available, looking to the above facts the present studies were taken up, to record, identify and search for associated bio-agents for eco-friendly management of the pest.

MATERIALS AND METHODS

The present investigation was conducted in Chhattisgarh plain regions and the Biological control laboratory of the Department of Entomology, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, (Chhattisgarh) during the 2015-16 and 2016-17. Survey of different host range of mealybugs attacking on commonly grown cereals, pulses, oilseeds, vegetables, flower, fruits, ornamental and forest trees conducted at five districts of Chhattisgarh plain regions viz. Raipur, Rajnandgaon, Balod, Dhamtari and Mahasamund. From each district, four villages were selected for observation of the various host plants of mealybugs. Nature of damage, location of occurrence and plant part infected with mealybugs were also recorded. The level of damage was calculated by placing all the host plants into three categories viz., category I – low (1 – 15% plant area damaged), category II – moderate (16 – 50% plant area damaged) and category III – high (>50% plant area damaged) (Selvaraju and Sakthivel, 2011). For identification of mealybugs, insects were collected from different parts of the plants like leaves, stems, flower and seeds. The samples consisted mostly of adult females and immature instars of mealybug. The collected samples were preserved in 70% ethanol for transporting to the laboratory. In case of natural enemies i.e., parasites, parasitoids and predators, plant parts with infested mealybugs were kept separately in cages at room temperature to facilitate emergence of natural enemies. Emerged natural enemies were also preserved in 70% ethanol solution. All the collected specimens were sent to National Bureau of Agricultural Insect Resources, Bengaluru for identification.

RESULTS AND DISCUSSION

Survey of host plants of mealybugs

The field survey of host plants of mealybugs was carried out from July, 2015 to June, 2017 in five districts of Chhattisgarh plain regions namely Rajnandgaon, Balod, Dhamtari, Mahasamund and Raipur district in which 132 plant species were observed for the survey of host range of mealybugs. A total of 72 plant species belonging to 28 plant families were identified as hosts (Table 1).

The mealybugs have a wide host range and great potential to cause damage to economically important agricultural, horticultural, ornamental and forest plants. The host range of mealybugs was sampled in twenty villages from five districts in plain region. The observed plant species were categorized into cereals, pulses, oilseed, vegetable, fruit, fibre, sugarcane, ornamental, medicinal, forest trees and weeds on the basis of economical value. In the comparative studies of host range of mealybugs in five different districts of Chhattisgarh plains

revealed that plant species such as aonla, congress grass, guava, hibiscus, mango, okra and papaya were identified as common hosts of mealybugs. They were observed in all five selected districts whereas some plant hosts were found in particular area such as cashew, chotadatura, lantana, water hyacinth observed to be infested with mealybugs in only Raipur while cow pea, jaribhaji and sunflower were recorded as host plants in Rajnandgaon district. Overall, from the present studies a total of 72 plant species belonging to 28 families were recorded as hosts for mealybugs. Among these, two species were of pulses comprising 2.78%, one oilseed (1.39%), ten vegetables (13.89%), twelve fruits (16.67%), one fibre (1.39%), one sugarcane crop (1.39%), nineteen ornamentals (26.39%), fifteen medicinal (20.83%), two forest trees (2.78%) and nine plants under weeds (12.50%) (Table 2). The highest number of host plants of mealybugs were recorded in the family Malvaceae (8 plant species) and Asteraceae (8 plant species) followed by Fabaceae (7 plant species), Apocynaceae (7 plant species), Solanaceae (5 plant species), Rosaceae (4 plant species), Amaranthaceae (3 plant species) and Lamiaceae (3 plant species). The rest of the families had just two or less than two plant species as representatives (Table 3). On the basis of level of infestation of host plant species, 36 species were found having low infestation (e.g., pigeon pea, bottle gourd, chechbhaji, tamarind, oak etc.), 12 species had medium infestation (e.g., khattabhaji, strawberry, marigold, curry leaf, akarkara etc.) and 24 plant species (e.g., tomato, brinjal, papaya, aonla, hibiscus, croton etc.) were observed to be highly infested by mealybugs (Table 4).

Species of mealybugs and their natural enemies

The samples of mealybugs collected from five districts of Chhattisgarh plains namely Rajnandgaon, Balod, Dhamtari, Mahasamund and Raipur during 2015-16 to 2016-17 under the survey program consisted mostly of adult females and immature instars along with various species of natural enemies i.e., parasites, parasitoids and predators. The collected specimens were sent to National Bureau of Agricultural Insect Resources (NBAIR), Bengaluru for identification. During the present investigations a total of eight mealybugs species namely *Ferrisia virgata* Cockerell, *Maconellicoccus hirsutus* Green, *Nipaecoccus viridis* Newstead, *Paracoccus marginatus* Williams and Granara de Willink, *Phenacoccus solenopsis* Tinsley, *Rastrococcus iceryoides* Green, *Coccidohystrix iceryoides* Green, *Saccharicoccus sacchari* Cockerell (Table 5 and Fig. 1) and seven species of their natural enemies i.e., *Cheilomenes sexmaculata*, *Brumoides suturalis* Scymnus sp., *Chrysoperla* sp., spiders, *Aenasius* sp. and *Pseudeptomastix mexicana* were recorded (Table 7 & Fig. 2). Six species of mealybugs viz. *F. virgata*, *M. hirsutus*,

Table 1. Host plants of mealybugs recorded in plain regions of Chhattisgarh during 2015-16 and 2016-17 on the basis of plant category and infestation level

Sl.No.	Common name	Botanical name	Family	Plant category	Infestation level
01.	Soybean	<i>G. max</i>	Fabaceae	<i>Pulse</i>	M
02.	Pigeon pea	<i>C. cajan</i>	Fabaceae	---	L
03.	Sunflower	<i>H. annuus</i>	Asteraceae	<i>Oilseed</i>	L
04.	Tomato	<i>S. lycopersicum</i>	Solanaceae	<i>Vegetable</i>	H
05.	Brinjal	<i>S. melongena</i>	Solanaceae	---	H
06.	Cow pea	<i>V. unguiculata</i>	Fabaceae	---	L
07.	Potato	<i>S. tuberosum</i>	Solanaceae	---	H
08.	Okra	<i>A. esculentus</i>	Malvaceae	---	H
09.	Bottle gourd	<i>L. siceraria</i>	Cucurbitaceae	---	L
10.	Khattabhaji	<i>H. cannabinus</i>	Malvaceae	---	M
11.	Jaribhaji	<i>A. dubius</i>	Amaranthaceae	---	M
12.	Chechbhaji	<i>C. actutangulas</i>	Malvaceae	---	L
13.	Kanda bhaji	<i>Ipomia sp.</i>	Convolvulaceae	---	L
14.	Cashew	<i>A. occidentale</i>	Anacardiaceae	<i>Fruit</i>	M
15.	Apple	<i>M. domestica</i>	Rosaceae	---	L
16.	Strawberry	<i>F. ananassa</i>	Rosaceae	---	M
17.	Guava	<i>P. guajava</i>	Myrtaceae	---	H
18.	Ber	<i>Z. mauritiana</i>	Rhamnaceae	---	L
19.	Papaya	<i>C. papaya</i>	Caricaceae	---	H
20.	Mango	<i>M. indica</i>	Anacardiaceae	---	L
21.	Tamarind	<i>T. indica</i>	Fabaceae	---	L
22.	Aonla	<i>E. officinalis</i>	Euphorbiaceae	---	H
23.	Citrus	<i>C. vlemom</i>	Rutaceae	---	L
24.	Custard apple	<i>A. squamosa</i>	Annonaceae	---	H
25.	Pomegranate	<i>P. granatum</i>	Punicaceae	---	L
26.	Cotton	<i>Gossypium sp.</i>	Malvaceae	<i>Fibre</i>	H
27.	Sugarcane	<i>S. officinarum</i>	Poaceae	<i>Sugar</i>	L
28.	Temple tree	<i>P. alba</i>	Apocynaceae	<i>Ornamental</i>	L
29.	Hibiscus	<i>Hibiscus sp.</i>	Malvaceae	---	H
30.	Marigold	<i>T. erecta</i>	Asteraceae	---	M
31.	Kaner	<i>Nerium sp.</i>	Apocynaceae	---	L
32.	Satpatia	<i>A. scholaris</i>	Apocynaceae	---	L
33.	Croton	<i>C. variegatum</i>	Euphorbiaceae	---	H
34.	Periwinkle	<i>C. roseus</i>	Apocynaceae	---	L
35.	Dumb cane	<i>D. spp.</i>	Araceae	---	L
36.	Mani plant	<i>S. podophyllum</i>	Araceae	---	H
37.	Rose	<i>Rosa sp.</i>	Rosaceae	---	L
38.	China rose	<i>R. chinensis</i>	<i>Rosaceae</i>	---	H
39.	Phlox	<i>Phlox sp.</i>	<i>Polemoniaceae</i>	---	L
40.	Hollyhock	<i>A. rosea</i>	<i>Malvaceae</i>	---	L
41.	Verbena	<i>V. officinalis</i>	<i>Verbenaceae</i>	---	L
42.	Candy tuff	<i>I. sempervirens</i>	Brassicaceae	---	L

43.	Goldenrod	<i>S. virgaurea</i>	Asteraceae	---	L
44.	Champa	<i>M. champaca</i>	Magnoliaceae	---	L
45.	<i>Amaranthus</i> garden plants	<i>Amaranthus sp.</i>	<i>Amaranthaceae</i>	---	H
46.	Chrysanthemum	<i>Chrysanthemum sp.</i>	Asteraceae	---	L
47.	Adusa	<i>A. vasica</i>	Acanthaceae	Medicinal	L
48.	Bhringraj	<i>W. chinensis</i>	Asteraceae	---	H
49.	Bawachi	<i>P. corlifolia</i>	Fabaceae	---	H
50.	Tulsi	<i>O. tenuiflorum</i>	Lamiaceae	---	H
51.	Samandersokh	<i>A. nervosa</i>	Convolvulaceae	---	H
52.	Ashwagandha	<i>W. somniferous</i>	Solanaceae	---	H
53.	<i>Sarpagandha</i>	<i>R. serpentina</i>	<i>Apocynaceae</i>	---	L
54.	Chui mui	<i>M. pudica</i>	Mimosaceae	---	H
55.	<i>Patchouli</i>	<i>P. cablin</i>	Lamiaceae	---	M
56.	<i>Nirgundi</i>	<i>Vnegundo</i>	Lamiaceae	---	H
57.	Kasturibhindi	<i>A. moschatus</i>	Malvaceae	---	H
58.	Betelvine	<i>P. betel</i>	<i>Piperaceae</i>	---	M
59.	Curry leaf	<i>M. koenigii</i>	Rutaceae	---	M
60.	Gudmar	<i>G. sylvestre</i>	Apocynaceae	---	M
61.	Akarkara	<i>S. acmella</i>	Asteraceae	---	M
62.	Chirchita	<i>A. aspera</i>	Amaranthaceae	Weed	L
63.	Congress grass	<i>P. hysterophorus</i>	Asteraceae	---	H
64.	Lantana	<i>L. camara</i>	Verbenaceae	---	L
65.	Aak/ Madar	<i>C. gigantea</i>	Apocynaceae	---	L
66.	Dhoob grass	<i>C. dactylon</i>	Poaceae	---	L
67.	Baryara	<i>S. acuta</i>	Malvaceae	---	H
68.	Chirpoti	<i>P. minima</i>	Solanaceae	---	L
69.	Chotadhatara	<i>X. strumarium</i>	Asteraceae	---	L
70.	Water hyacinth	<i>E. crassipes</i>	Pontederiaceae	---	L
71.	Black babool	<i>A. nilotica</i>	Fabaceae	Forest tree	L
72.	Karanj	<i>P. pinnata</i>	Fabaceae	---	L

(L- Low infestation level, M- Medium infestation level, H- High infestation level)

Table 2. Host plants of mealybugs recorded on the basis of different plant category

Sl. No.	Plant category	No. of host plants	Name of host plants
01.	Pulse	02 (2.78%)	Soybean, Pigeon pea
02.	Oilseed	01 (1.39%)	Sunflower
03.	Vegetable	10 (13.89%)	Tomato, Brinjal, Cow pea, Potato, Okra, Bottle gourd, Khattabhaji, Jaribhaji, Chechbhaji, Kanda bhaji
04.	Fruit	12 (16.67%)	Cashew, Apple, Strawberry, Guava, Ber, Papaya, Mango, Tamarind, Aonla, Citrus, Custard apple, Pomegranate
05.	Fibre	01 (1.39%)	Cotton
06.	Sugarcane	01 (1.39%)	Sugarcane

07.	Ornamentals	19 (26.39%)	Temple tree, Hibiscus, Marigold, Kaner, Satpatia, Croton, Periwinkle, Dumb cane, Mani plant, Rose, China rose, Phlox, Hollyhock, Verbena, Candy tuff, Goldenrod, Champa, Amaranthus garden plants, Chrysanthemum
08.	Medicinals	15 (20.83%)	Adusa, Bhringraj, Bawachi, Tulsi, Samandersokh, Ashwagandha, Sarpagandha, Chui mui, Patchouli, Nirgundi, Kasturibhindi, Betelvine, Curry leaf, Gudmar, Akarkara
09.	Weeds	09 (12.50%)	Chirchita, Congress grass, Lantana, Aak/ Madar, Dhoob grass, Baryara, Chirpoti, Chotadhatura, Water hyacinth
10.	Forest trees	02 (2.78%)	Karanj, Black babool
	Total	72	

Table 3. List of families of host plants of mealybugs and associated plant species recorded in Chhattisgarh plain region

Sl. No.	Family	Number of plant species	Name of plant species
01.	Acanthaceae	1	Adusa
02.	Amaranthaceae	3	Chirchita, Jaribhaji, Amaranthus garden plants
03.	Anacardiaceae	2	Cashew, Mango
04.	Annonaceae	1	Custard apple
05.	Apocynaceae	7	Aak, Gudmar, Periwinkle, Satpatia, Kaner, Temple tree, Sarpagandha
06.	Araceae	2	Dumb cane, Mani plant
07.	Asteraceae	8	Chotadhatura, Congress grass, Akarkara, Bhringraj, Marigold, Goldenrod, Sunflower, Chrysanthemum
08.	Brassicaceae	1	Candy tuff
09.	Caricaceae	1	Papaya
10.	Convolvulaceae	2	Kanda bhaji, Samandersokh
11.	Cucurbitaceae	1	Bottle gourd
12.	Euphorbiaceae	2	Croton, Aonla,
13.	Fabaceae	7	Black babool, Karanj, Bawachi, Tamarind, Cow pea, Soybean, Pigeon pea
14.	Lamiaceae	3	Tulsi, Patchouli, Nirgundi
15.	Magnoliaceae	1	Champa
16.	Malvaceae	8	Baryara, Kasturibhindi, Okra, Khattabhaji, Chechbhaji, Cotton, Hibiscus, Hollyhock
17.	Mimosaceae	1	Chui mui
18.	Myrtaceae	1	Guava
19.	Piperaceae	1	Betelvine
20.	Poaceae	2	Dhoob grass, Sugarcane
21.	Polemoniaceae	1	Phlox
22.	Pontederiaceae	1	Water hyacinth
23.	Rhamnaceae	1	Ber
24.	Punicaceae	1	Pomegranate
25.	Rosaceae	4	Rose, China rose, Apple, Strawberry
26.	Rutaceae	2	Curry leaf, Citrus
27.	Solanaceae	5	Tomato, Brinjal, Potato, Chirpoti, Ashwagandha
28.	Verbenaceae	2	Lantana, Verbena
	Total	72	

Table 4. Host plants of mealybugs categorized on the basis of level of Infestation

Sl.No.	Level of Infestation	Number of host plants	Name of host plants
01.	Category I - Low (1 – 15% plant area damaged)	34	Pigeon pea, Sunflower, Cow pea, Bottle gourd, Chechbhaji, Kanda bhaji, Apple, Ber, Tamarind, Citrus, Pomegranate, Sugarcane, Temple tree, Kaner, Satpatia, Periwinkle, Dumb cane, Rose, Phlox, Hollyhock, Verbena, Candy tuff, Goldenrod, Champa, Chrysanthemum, Adusa, Sarpagandha, Aak/ Madar, Dhooob grass, Chirpoti, Chotadhatura, Water hyacinth, Black babool, Karanj
02.	Category II - Medium (16 – 50% plant area damaged)	14	Khattabhaji, Jaribhaji, Strawberry, Cashew, Marigold, Patchouli, Betelvine, Curry leaf, Gudmar, Akarkara, Mango, Chirchita, Lantana, Croton
03.	Category III - High (>50% plant area damaged)	24	Tomato, Brinjal, Potato, Okra, China rose, Hibiscus, Cotton, Custard apple, Papaya, Guava, Baryara, Congress grass, Chui mui, Nurgundi, Kasturibhindi, Bhringraj, Ashwagandha, Bawachi, Tulsi, Samandersokh, Amaranthus garden plants, Mani plant
	Total	72	







N. viridis, *P. marginatus*, *P. solenopsis*, *R. iceryoides* and two species of natural enemies viz. *B. suturalis*, *P. mexicana* were identified by NBAIR, Bengaluru. Muthulingam (2011) identified eight different species of mealybugs and among them six were identified up to species level. Identified species were *P. solenopsis*, *Planococcus citri*, *F. virgata*, *P. marginatus*, *M. hirsutus* and *Dysmicoccus neobrevipes*. Nebie *et al.* (2016) also identified two mealybug species in mango trees infested by *Icerya aegyptiaca* Douglas (Hemiptera: Monophlebidae) and *F. virgata* Cockerell (Hemiptera: Pseudococcidae).

Among mealybug species identified, *P. solenopsis* Tinsley was noticed as the most dominant species observed on 14 different host plants with 46.66 percent infestation followed by *R. iceryoides* Green in six host plants with 20 percent, *P. marginatus* Williams and Granara de Willink infesting five host plants with 16.66 percent infestation, *N. viridis* Newstead recorded on three host plants with 10 percent infestation, *F. virgata* Cockerell, *M. hirsutus*, *C. iceryoides* and *S. sacchari* attacked only on a single host plant with 3.33 percent infestation (Table 5). Since, species of host plants namely cotton, china rose, hibiscus and karanj were observed during the survey, it was noticed that two different species of mealybugs were attacking on a single host plant at a time such as cotton infested by *P. solenopsis*, *F. virgata* and *R. iceryoides*, china rose infested by *P. solenopsis* and *P. marginatus*, Hibiscus by *P. solenopsis* and *P. marginatus* and karanj infested by *P. solenopsis* by an unidentified mealybug species (Table 6). Nagrare *et al.* (2014) carried out twenty-six random surveys that recorded five mealybug species as minor pests of cotton in India i.e. *N. viridis*, *F. virgata*,

M. hirsutus, *R. iceryoides* and *P. tamarindus*. Among these species, *N. viridis* was found to be next most widely distributed mealybug species after *P. solenopsis*. Sahu (2014) reported mealybugs on aonla causing heavy damage by sucking the sap of leaves, fruits and young shoots of plants at Agro-forestry farm of IGKV, Raipur (Chattisgarh).

Among natural enemies of mealybugs, *C. sexmaculata*, *B. suturalis*, *Scymnus* sp. and *Chrysoperla* sp., spiders as a predators and *A. bambawalei*, *P. mexicana* as parasitoids were observed during the survey. The data on field survey represented that *C. sexmaculata* was associated with four species of mealybugs namely *P. solenopsis*, *P. marginatus*, *M. hirsutus* and *Rastrococcus iceryoides*. Similarly, *B. suturalis* was recorded on two species of mealybugs such as *P. Marginatus* and *P. solenopsis*. *Scymnus* species was observed associated with three species of mealybugs namely *N. viridis*, *P. solenopsis* and *P. marginatus*. *Chrysoperla* sp. was seen attacking only on a single species of unidentified mealybug of aonla, *E. officinalis*. Spiders were observed on two species of mealybugs i.e., *P. solenopsis* and *P. marginatus*. *A. bambawalei* and *P. mexicana* was found parasitization *P. solenopsis* and *P. marginatus*, respectively (Table 7). Neetan and Aggarwal (2011) recorded different natural enemies from mealy bug colonies which included four coccinellid predators, one parasitoid and one *Chrysoperla* species. Walton and Pringle (2014) recorded natural enemies of mealybug, *Planococcus ficus* Signoret were predatory beetle, *Nephus* sp. and the parasitoids, *Coccidoxenoides perminutus* Girault, *Anagyrus* sp. and

Table 5. List of mealybugs species with their host plants recorded from various districts of Chhattisgarh plains



Sl. No.	Name of mealybug species	Name of the host plants
01.	<i>Ferrisia virgate</i> Cockerell 	Guava (<i>Psidium guajava</i>)
02.	<i>Maconellicoccus hirsutus</i> Green 	Soybean (<i>Glycine max</i>)
03.	<i>Nipaeococcu sviridis</i> Newstead 	Tulsi (<i>Ocimum tenuiflorum</i>), Babool (<i>Acasia nilotica</i>), Ber (<i>Ziziphus mauritiana</i>)
04.	<i>Paracoccus marginatus</i> Williams and Granara de Willink 	Marigold (<i>Tagetes erecta</i>), Amaranthus plant (<i>Amaranthus sp.</i>), Sarpagandha (<i>Rauwolfia serpentina</i>), Papaya (<i>Carica papaya</i>), Croton (<i>Codiaeum variegatum</i>)
05.	<i>Phenacoccus solenopsis</i> Tinsley 	Okra (<i>Abelmoschus esculentus</i>), Lantana (<i>Lantana camara</i>), Aak (<i>Calotropis gigantea</i>), Brinjal (<i>Solanum melongena</i>), Hibiscus (<i>Hibiscus sp.</i>), Khat-tabhaji (<i>Hibiscus cannabinus</i>), Kasturibhindi (<i>Abelmoschus moschatus</i>), Tomato (<i>Solanum lycopersicum</i>), Chrysanthemum (<i>Chrysanthemum sp.</i>), Congress grass (<i>Parthenium hysterophorus</i>), Baryara (<i>Sidaacuta</i>), Chirpoti (<i>Physalis minima</i>), Chotadatura (<i>Xanthium strumarium</i>), Chirchita (<i>Achyranthus aspera</i>), Ashwagandha (<i>Withania somniferous</i>)
06.	<i>Rastrococcus iceryoides</i> Green 	Curry leaf (<i>Murraya koenigii</i>), Bewachi (<i>Psoralea corlifolia</i>), Citrus (<i>Citrus lemon</i>), Cotton (<i>Gossypium sp.</i>), Ram aonla, Mango (<i>Mangifera indica</i>)






07	<p><i>Coccidohystrix iceryoides</i> Green</p> 	Brinjal (<i>Solanum melongena</i>)
08	<p><i>Saccharicoccus sacchari</i> Cockerell</p> 	Sugarcane (<i>Saccharum officinarum</i>)

Table 6. Name of host plants of mealybugs infested by two different species observed during survey program

S.N.	Name of host plants	Botanical name	Associated mealybug species
01.	Cotton	<i>Gossypium sp.</i>	<i>Phenacoccus solenopsis</i>
			<i>Ferrisia virgata</i>
			<i>Rastrococcus iceryoides</i>
02.	China rose	<i>Rosa chinensis</i>	<i>Phenacoccus solenopsis</i>
			<i>Paracoccus marginatus</i>
03.	Hibiscus	<i>Hibiscus sp.</i>	<i>Phenacoccus solenopsis</i>
			<i>Paracoccus marginatus</i>
04.	Karanj	<i>Pongamia pinnata</i>	<i>Phenacoccus solenopsis</i>
			Unidentified sp.

Table 7. Natural enemies on various species of mealybugs observed during 2015-16 and 2016-17

Name of natural enemies	Name of mealybug species	Name of host plants of mealybugs
<u>Predators</u>		
<p><i>Cheilomenes sexmaculata</i></p> 	<i>Phenacoccus solenopsis</i>	Hibiscus, Okra, Ashwagandha, Parthenium
	<i>Paracoccus marginatus</i>	Amaranthus garden plants
	<i>Ferrisia virgata</i>	Guava
	<i>Rastrococcus iceryoides</i>	Cotton
<p><i>Brumoidessuturalis</i></p> 	<i>P. solenopsis</i>	Ashwagandha, Hibiscus
	<i>P. marginatus</i>	Amaranthus garden plants

<p><i>Scymnus</i> spp.</p> 	<i>P. solenopsis</i>	Ashwagandha, Hibiscus
	<i>P. marginatus</i>	Amaranthus garden plants
	<i>N. viridis</i>	Tulsi
<p><i>Chrysoperla</i> sp.</p> 	Unidentified	Aonla
<p>Spiders</p> 	<i>P. solenopsis</i>	Ashwagandha, Hibiscus
	<i>P. marginatus</i>	Amaranthes garden plants
Parasitoids		
<p><i>Aenasius bambawalei</i></p> 	<i>P. solenopsis</i>	Hibiscus, Ashwagandha, Lantana, Okra, Kasturi bhindi, Brinjal, Congress grass
<p><i>Pseudleptomastix mexicana</i></p> 	<i>P. marginatus</i>	Amaranthus garden plants

Leptomastix dactylopii Howard.

ACKNOWLEDGEMENT

The authors are thankful to Dr. V. K. Dubey, Head, Department of Entomology, and I. G. K. V. Raipur for encouragements, useful suggestion and providing necessary facilities to conduct the experiment and special thankful to Dr.

Sunil Joshi, Principal Scientist, NBAIR, Bangalore, for the identification of mealybugs and their related natural enemies.

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