

Host plant diversity of *Planococcus citri* and *Planococcus lilacinus* in horticultural ecosystem and their associated natural enemies

Comment [M1]: Where ? you should have to specify your study area

ABSTRACT

The mealybugs, *Planococcus* spp. (Hemiptera: Pseudococcidae) are highly polyphagous and are of great economic importance as noxious pests on many horticultural plants worldwide. Surveys were conducted to study the diversity of host plants of *P. citri* and *P. lilacinus* in different horticultural ecosystems of Karnataka along with their associated natural enemies. The citrus mealybug, *P. citri* was found feeding on 34 host plants and was found parasitized and predated by 23 natural enemies (11 parasitoids and 12 predators). The highest number hosts were recorded in ornamental plants (13) followed by fruit crops (11). The cacao mealybug, *P. lilacinus* was predominant on 10 horticultural crops and were found associated with six natural enemies (three parasitoids and three predators). The highest number hosts were recorded from fruit crops (five) followed by ornamental (four).

Comment [M2]: When did the study conducted?

Comment [M3]: The study indicated that.....

Comment [M4]: What is your conclusion/s and recommanation/s

Keywords: Mealybugs, Pseudococcidae, horticultural crops, predator, parasitoids

1. INTRODUCTION

Mealybugs (Hemiptera: Pseudococcidae) are highly polyphagous and are of great economic importance as serious sucking pests on many fruit crops, vegetable crops, plantation and as well as ornamental crops [1,2]. Mealybugs feed plant sap by inserting their stylets and inflict direct damage to crops by sucking sap from trunk, buds, roots, leaves, shoots, nodes, flower and fruits. They also inject toxic substance into plants leading chlorosis, deformation of leaf, stunting, early fruit drop and in severe case death of the plant [3]. Mealybugs live in protected areas such as cracks and crevices of the bark and inside the fruit bunch, underside of leaves, at the base of leaf petioles and most of the stages of mealybugs are covered with a white mealy or wax coating. Inappropriate and recurrent use of insecticides for mealybug control results in resistance and deleterious effects on humans and the environment. While, the natural enemies like predators and parasitoids play a key role in suppression of mealybugs in natural ecosystem without any non-target effects. On several occasions, insecticides do not reach and biological suppression of mealybug species by natural enemies provide a good control [4].

Planococcus sp. is highly polyphagous has been reported on over 200 host-plant species belonging to 191 genera and 82 families, and can damage many agricultural and horticultural crops. It is also known to transmit some plant virus diseases [5] like *Cacao swollen shoot virus*. This species causes damage, especially in fruit trees and ornamental plants. Mealybug being sessile insects and are more amenable to biological control in horticultural ecosystems. Hence, the present study was undertaken to understand the diversity of host plants of *P. citri* and *P. lilacinus* and its associated natural enemies.

2. MATERIAL AND METHODS

Extensive surveys were conducted to identify the host plant diversity of mealybug species viz., *P. citri* and *P. lilacinus* on different horticultural ecosystems of Karnataka along with their natural enemies during 2019 - 2021. Mealybugs were collected from leaves, branches, fruits and roots of host plants. Host plants of mealybugs were categorised on the basis of plant category viz., fruit crops, plantation crops, ornamental plants, spice crops, flower crops, vegetables and medicinal plants. Each sample was assigned with a number which corresponded to the collection data. Host plants were identified based on their local name, flowers, inflorescence, fruits and field images. The collected mealybugs were stored in vials (2.5ml) containing 70 % ethanol and used for preparation of slides for morphological identification. The host mealybug species were slide mounted using standard mounting procedure [6] and identified based on key morphological characters of adult female using keys developed by McKenzie [7] and Williams [8]. The grubs feeding on mealybug colonies and parasitized mummies were collected and reared in laboratory until adulthood and were preserved, labelled and identified.

Comment [M5]: How you collected and kept samples for further examinations in laboratory ?

Comment [M6]: Which magnification lens were used?
From which locations? ,
Indicate the procedures you have used.

Comment [M7]: Data storage, and Analytic approaches were not indicated /

3. RESULTS AND DISCUSSION

The citrus mealybug, *P. citri* is a serious pest and reported to infest on 34 horticultural crops. The highest number of host plants (13 plants) was recorded in ornamental plants (acalypha, asparagus, areca palm, balsam, bottle palm, croton, four o' clock plant, ixora, jungle geranium, oleander, red ginger plant, royal palm and yellow trumpet bush) followed by fruit crops (12 plants) viz., banana, butter fruit, bread fruit, citrus, custard apple, fig, guava, mango pomegranate, rose apple, mulberry and water apple. While, three species in spices (cardamom, ginger and black pepper) and two in medicinal plants (mexican mint and tulsi), plantation crops (coffee and cocoa) and vegetable crops (cucumber and ivy gourd) were recorded as hosts for *P. citri* in Karnataka (Table 1). The previous studies reported citrus, curry leaf, coffee, cocoa, ginger, cotton, banana, and mango as host plants for *P. citri* [9]. However, as a polyphagous sucking pest, *P. citri* may infest much more horticultural crops based on the ecology and climate of the region.

Comment [M8]: Make subtitles for both hosts and enemies. Foreexample 3.1. Host
3.2 . enemies

Natural control through predators and parasitoids are efficient means of management of sucking pests like mealybugs. However, the diversity and potential of the naturally associated predators and parasitoids needs to be assessed in a structured way. A total of 23 natural enemies were found associated with *P. citri* on different host plants, which includes 11 parasitoids and 12 predators. Of the six families of hymenopteran parasitoids recorded in association with *P. citri*, family Encyrtidae was the diverse comprising five different species (*Aenasius arizonensis*, *Anagyrus* sp., *Gyranusoidea* sp., *Leptomastix tsukumiensis* and *Leptomastix* sp.). Two species were recorded in Aphelinidae (*Promuscidea unfasciiventris* and *Coccophagus* sp.), one species in Signihoridae (*Chartocerus* sp.), and one each unidentified parasitoids species in Pteromalidae, Braconidae and Chalcididae. The associated predators were identified to belong to five different orders (Coleoptera, Diptera, Hymenoptera, Hemiptera and Lepidoptera). Coleoptera identified to be the diverse group associated with the *P. citri*. In Coleoptera, four species of Coccinellidae (*Cryptolaemus montrouzieri*, *Cybocephalus nipponicus*, *Jauravia pallidula* and *Scymnus (Pullus) coccivora*) were found preying on *P. citri* in different host plants. Whereas, *Acletoxenus* sp., *Cacoxenus perspicax*, *Paragus* sp. and *Triommata coccidivora*, were recorded in the order Diptera and *Chrysoperla* sp. and *Micromus* sp.

were recorded in the order Neuroptera. One species each was recorded in Lepidoptera (*Spalgus epius*) and Hemiptera (*Blaptostethus* sp.) found predated on *P. citri* (Table 2). The diversity and natural suppression potential of these natural enemies may vary with the host plant, geography and climatic conditions. *Planococcus citri* was noticed to be attacked by more than 20 natural enemies in citrus, guava, grape, ber, sapota, pomegranate and custard apple [10]. While, Mahfoudhi and Dhouibi recorded different encyrtid parasitoids (*Anagyrus pneumococci*, *Leptomastix dactylic*, *Leptomastidea abnormis* and *Coccidoxenoides peregrinus*) and predators (*Rhyzobius lophanthae* and *Scymnus* sp.) found feeding on *P. citri* [11]. One each of Dipteran, Coleopteran and Lepidopteran predators along with 12 hymenopteran parasitoids were recorded on *P. citri* in cocoa [12]. Ten hymenopteran parasitoid species were recovered in association with *P. citri* on citrus in Queensland [13]. Predators belong to Coleoptera (17 species), Diptera (03 species), Neuroptera (03 species) and 22 parasitoids were recorded associated with mealybugs of Turkey [14]. Natural enemies are potential for the control of pests like mealybugs, Mani and Krishnamoorthy also reported decline in *P. citri* population on acid lime when *C. montrouzieri* released @ 2500 adults/acre [15].

Planococcus lilacinus is an emerging pest and was reported to infest 10 different horticultural crops during the survey. Fruit crops recorded to be the diverse host plants comprising five different species (fig, custard apple, guava, star fruit and soursop). While four species of ornamental plants (ornamental areca palm, balsam, croton and mussaenda) and in plantation crops, cocoa is also found to be the hosts for *P. lilacinus* (table 1). As like, Mani *et al.* reported cocoa, guava, ber, citrus, cashew, pomegranate, guava, black pepper, coffee, sapota and custard apple as hosts for the mealybug, *P. lilacinus* [10].

The mealybug, *P. lilacinus* is recent emerging pest of many fruit crops, plantation crops and ornamental plants. Three parasitoids and three predators were recorded as natural enemies for this mealybug during the course of study. The parasitoids were identified to belong to two orders, Hymenoptera (two species) and Diptera (one species). The two hymenopteran parasitoids recorded were *Anagyrus* sp., *Gyranusoidea* sp. of the family Encyrtidae while, the dipteran parasitoid was *Megaselia* sp. belongs to family Phoridae. One species each of Coleoptera, Neuroptera and Lepidoptera recorded as predators. The coleopteran predator was *Cryptolaemus montrouzieri* (Coccinellidae), the neuropteran predator was *Chrysoperla* sp. (Chrysopidae) and lepidopteran predator was *Spalgus epius* (Lycaenidae) (table 2). The lepidopteran predator, *Spalgus epius* was a common predator to many mealybugs and was previously recorded by Devasahayam *et al.* on *P. citri* and *P. lilacinus* [16]. While, Mani recorded three parasitoids (*Aprostocetus pupureus*, *Leptomastix dactylopii*, *Tetracnemoidea indica*) and six predators (*Brumus* sp., *Cryptolaemus montrouzieri*, *Scymnus coccivora*, *Triommato coccidivora*, *Spalgis epius* and *Cacoxenus perspicax*) feeding on *P. lilacinus* [17]. The most important predators of *P. lilacinus* are *Spalgis epius* and *Platynaspis stictica* [18]. Diversity of natural enemies may vary with the mealybug host plant, three species of natural enemies (*Spalgis epius*, *Triommata coccidivora* and *Pullus pallidicollis*) were encountered in coffee plants infested with *P. lilacinus* [19]. Better understanding on the host diversity, mealybug pest and the associated natural enemies are necessary for the current scenario. Identifying the diversity of natural enemies and their potential in controlling the mealybugs are vital, as the chemical suppression of the pest may not work properly due to mealy coating.

Table 1. Number of host plants infested with mealybugs on the basis of plant category

Sl. No.	Plant category	Name and no. of host plants	
		<i>P. citri</i>	<i>P. lilacinus</i>

1.	Fruit crops	Banana, Butter fruit, Bread fruit, Citrus, Custard apple, Fig, Guava, Mango Pomegranate, Mulberry, Rose apple, Water apple	11 (32.35%)	Fig, Custard apple, Guava, Star fruit, Soursop	5 (50%)
2.	Medicinals	Mexican mint, Tulsi,	3 (8.82%)	-	-
3.	Ornamentals	Acalypha, Asparagus, Areca palm, Balsam, Bottle palm, Croton, Four o' clock plant, Ixora, Jungle geranium, Oleander, Red ginger, Royal palm, Yellow trumpet bush	13 (38.23%)	Areca palm, Balsam, Croton, Mussaenda	4 (40%)
4.	Plantation crops	Coffee, Cocoa	2 (5.89%)	Cocoa	1 (10%)
5.	Spices	Cardamom, Ginger, Black pepper	3 (8.82%)	-	-
6.	Vegetables	Cucumber, Ivy gourd	2 (5.89%)	-	-
Total no. of host plants		-	34	-	10

Table 2. Diversity of natural enemies associated with *Planococcus* spp.

Order	Family	Species	
		<i>Planococcus citri</i>	<i>Planococcus lilacinus</i>
Parasitoids			
Hymenoptera	Encyrtidae	<i>Aenasius arizonensis</i> (Girault), <i>Anagyrus</i> sp., <i>Gyranusoidea</i> sp., <i>Leptomastix tsukumiensis</i> Tachikawa, <i>Leptomastix</i> sp.	<i>Anagyrus</i> sp., <i>Gyranusoidea</i> sp.
		Signiphoridae	<i>Chartocerus</i> sp.
		Aphelinidae	<i>Coccophagus</i> sp.
		Eriaporidae	<i>Promuscidea unfasciiventris</i> Girault
		Pteromalidae	Unidentified
	Chalcididae	Unidentified	
	Braconidae	Unidentified	
	Diptera	Phoridae	<i>Megaselia</i> sp.
Predator			
Coleoptera	Coccinellidae	<i>Cryptolaemus montrouzieri</i> Mulsant, <i>Jauravia pallidula</i> (Motschulsky), <i>Scymnus coccivora</i> Ayyar, <i>Cybocephalus nipponicus</i>	<i>Cryptolaemus montrouzieri</i> Mulsant
Diptera	Drosophilidae	<i>Cacoxenus perspicax</i> (Knab) and <i>Acletoxenus</i> sp.	
	Cecidomyiidae	<i>Triommata coccidivora</i> (Felt)	
	Syrphidae	<i>Paragus</i> sp.	
Lepidoptera	Lycaenidae	<i>Spalgus epius</i> (Westwood)	<i>Spalgus epius</i> (Westwood)

Neuroptera	Chrysopidae	<i>Chrysoperla</i> sp. and <i>Micromus</i> sp.	<i>Chrysoperla</i> sp.
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4. CONCLUSION

The citrus mealybug, *P. citri* was found feeding on 34 host plants and was found parasitized and predated by 23 natural enemies. The cacao mealybug, *P. lilacinus* was predominant on 10 horticultural crops and were found associated with six natural enemies.

Comment [M9]: Based on your own findings please write recommendation/s

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Comment [M10]: Old

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Comment [M11]: Old

Comment [M12]: Too old reference

Comment [M13]: Too old