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Research Article

Fauna of predaceous coccinellids (Coleoptera: Coccinellidae) associated with mealybugs (Hemiptera: Pseudococcidae) infesting horticultural crops

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ABSTRACT: Mealybugs (Hemiptera: Pseudococcidae) are highly polyphagous pests that cause serious damage especially in horticultural crops that are hard to kill by chemicals because of their protective waxy coating. Hence, relying on natural enemies like insect predators is one of the safest and most effective alternative solutions to manage these species. A total of 16 species of predatory coccinellids belonging to 13 genera and five tribes under three subfamilies viz., Coccinellinae, Chilocorinae and Scymninae were found feeding on 11 mealybug species infesting different horticultural crops of Karnataka. These include *Anegleis cardoni* (Weise), *Brumoides suturalis* (Fabricius), *Cryptolaemus montrouzieri* Mulsant, *Coccinella transversalis* Fabricius, *Cheilomenes sexmaculata* (Fab.), *Chilocorus nigrita* (Fab.), *Coelophora* sp., *Jauravia pallidula* (Motschulsky), *Harmonia octomaculata* (Fab.), *Hyperaspis maindroni* Sicard, *Nephus* sp., *Propylea* sp., *Scymnus latifolius* Poorani, *Scymnus coccivora* Ayyar, *Scymnus* sp.1 and *Scymnus* sp.2. *Scymnus coccivora* was associated with six diverse mealybug species with highest species composition (29.76%). The horticultural crop ecosystems were found to have a higher per cent species composition of predaceous coccinellids, which naturally regulates mealybug populations by devouring them. Therefore, utilizing these predatory beetles as a biological tool for the management of mealybugs has great potential.

KEYWORDS: Coccinellids, horticultural crops, mealybugs, natural enemy,

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INTRODUCTION

Coccinellids, or ladybird beetles (Coleoptera: Coccinellidae), an ecologically diverse, and species-rich group of insects, inhabit various kinds of terrestrial ecosystems. The family, Coccinellidae comprises roughly 6,000 described species from 360 genera and 42 tribes (Nedved & Kovar, 2012) with distribution in all the zoogeographic regions. These beetles have higher agricultural significance as the 90% of species are potential predators of major sucking pests of the crops (Kshitiz *et al*., 2021). In the Indian subregion, around 400 species belonging to 79 genera and 22 tribes of five subfamilies are known to occur (Poorani, 2002). While, in India, 261 predaceous coccinellids belonging to 57 genera are distributed (Omkar *et al*., 2004). In predacious coccinellids, both grubs and adults primarily feed on soft-bodied insects like aphids, mealybugs, scales and mites. The family Coccinellidae contains both generalist and specialist predators however, the generalist predators play a very crucial role in regulating pests in crop ecosystems (Pervez *et al*., 2020) and they have been intentionally dispersed over the world due to their potential for biological pest management (Michaud, 2012).

The mealybugs (Hemiptera: Pseudococcidae) are polyphagous sucking pests, hard to kill by chemicals because of their waxy coating and cause serious threats in many horticultural crops. Of the 2000 species of mealybugs 160 are considered as crop pests and often categorised into global invasive groups (Subramanian *et al.*, 2021). Natural

enemies such as predators play a crucial role in biological management because they have demonstrated their worth in preventing the spread of many homopteran pests. Hence, biological control through its natural enemies like predators is of great importance, since they have proved their value in checking many homopteran pests. The use of coccinellids in biological control programs is best exemplified by the following, *Cryptolaemus montrouzieri* (Mulsant) against *Maconellicoccus hirusutus* (Green), *Rodolia cardinalis* (Mulsant) against *Iceria purchasi* Maskell and *Planococcus citri* (Risso) (Kundoo & Khan, 2017). Differentiating the pests and natural enemies and proper identification of the predators are essential for the success of biological control programmes (Rosen, 1986). A variety of coccinellid species are commercially mass-grown as part of the IPM (Integrated Pest Management) program to aid in managing insect and mite pests (Pervez *et al*., 2020). Recognition of the predatory coccinellids that are associated with mealybugs that naturally occur in horticultural ecosystems is necessary for taking advantage of biological control and maintaining their natural order by devouring them. Hence, the present study was taken up to identify and record the potential coccinellid predators associated with different mealybug species.

MATERIALS AND METHODS

Surveys were conducted to collect predatory coccinellids associated with different mealybug species associated with horticultural crops of Karnataka *viz*., Kodagu, Dakshina Kannada, Udupi, Uttara Kannada, Chikkamagaluru, Shivamogga, Davanagere and Chitradurga from 2019-2021. The immature stages, *i.e.,* grubs feeding on mealybug colonies were collected and reared in the laboratory until adulthood. The adult coccinellids were preserved and labelled for taxonomic identification following standard procedures. The per cent species composition of predatory coccinellids was calculated based on number of individuals in the coccinellid species collected divided by total number of individuals of coccinellids collected during study period. The host mealybug species were slide-mounted and identified based on adult females. Habitus of coccinellid beetles associated with mealybugs was taken in the laboratory using a Leica (Leica M205C microscope attached to Leica DFC450 camera).

RESULTS AND DISCUSSION

The predatory coccinellids are extremely polyphagous and the entire dietary breadth of any of these predatory beetles is not fully realised (Weber & Lundgren, 2009), but their augmentation in cropland is very important to suppress many pests (Obrycki *et al*., 2009) including mealybugs. In the present study, a total of 16 predatory coccinellid species belonging to 13 genera and five tribes under three subfamilies were recorded predating on 11 species of mealybugs (Table 1). The subfamilies Scymninae and Coccinellinae were the diverse subfamilies collected during the survey followed by Chilocorinae. Scymninae was represented by seven species belonging to four genera of two tribes *viz*., Hyperaspdini and Scymnini as like the subfamily, Coccinellinae was represented by seven species belonging to seven genera of two tribes *viz*., Coccinellini and Sticholotidini. The subfamily Chilicorinae was represented by two species belonging to two different genera of the tribe, Chilocorini. In Coccinellinae, *Anegleis cardoni* (Weise), *Coccinella transversalis* Fab., *Cheilomenes sexmaculata* (Fab.), *Coelophora* sp., *Harmonia octomaculata* (Fab.) and *Propylea* sp. were documented while in Sticholotidini, only *Jauravia pallidula* (Motschulsky) was recorded. In Scymnini, *Cryptolaemus montrouzieri* Mulsant,

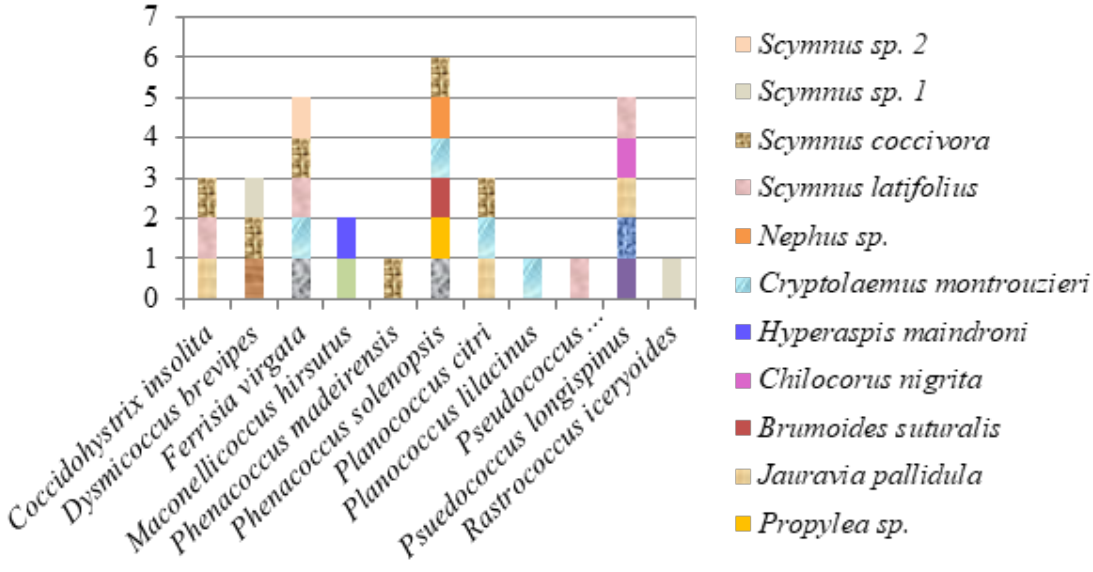


Figure 1. Association of mealybug species with predatory coccinellids.

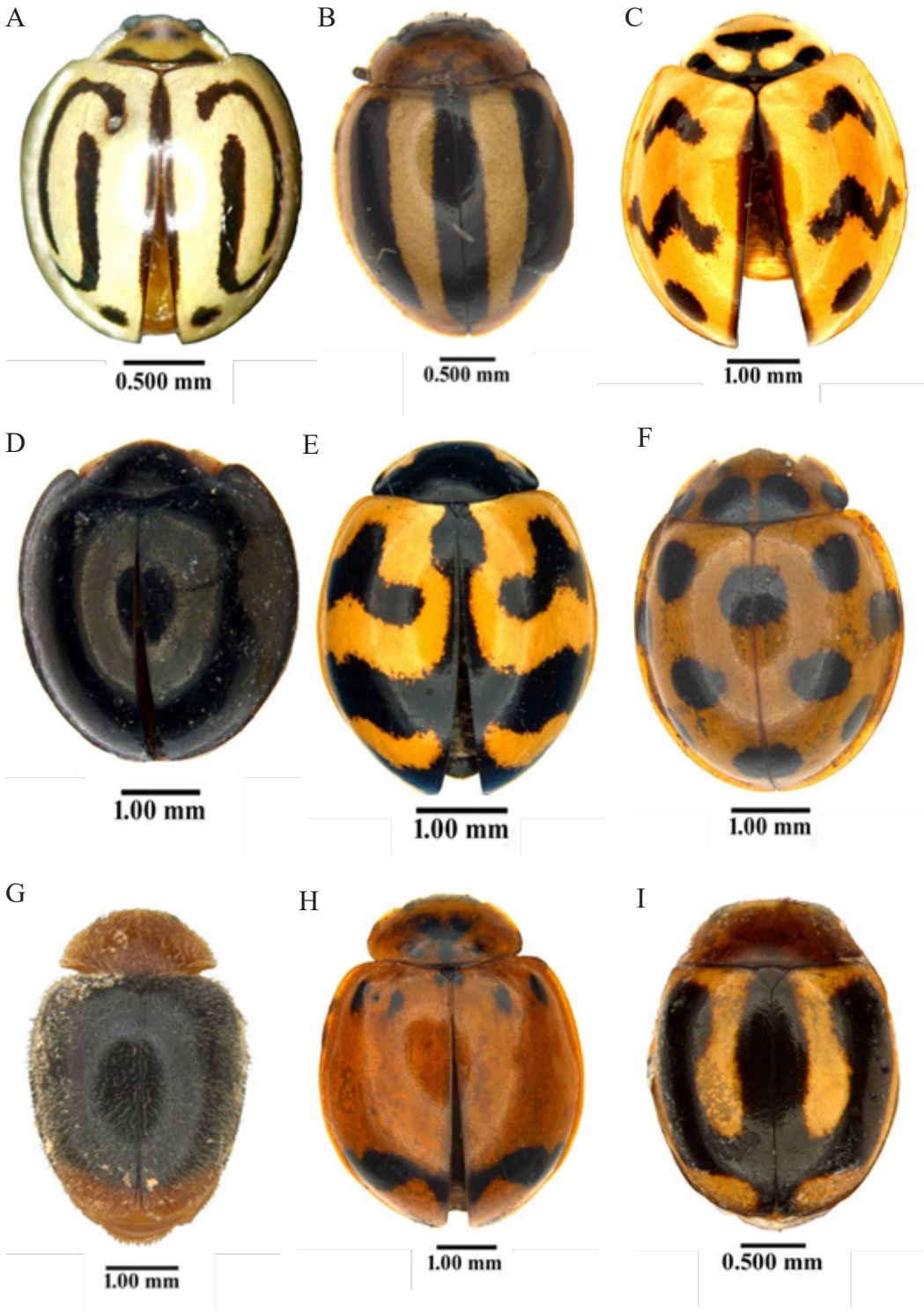


Figure 2. Predatory coccinellids; A) *Anegleis cardoni;* B) *Brumoides suturalis;* C) *Cheilomenes sexmaculata;* D) *Chilocorus nigrita;* E) *Coccinella transversalis;* F) *Coelophora sp.;* G) *Cryptolaemus montrouzieri;* H) *Harmonia octomaculata;*I) *Hyperaspis maindroni.*

Nephus sp., *Scymnus* (*Pullus*) *latifolius* Poorani, *Scymnus* (*Pullus*) *coccivora* Ayyar, *Scymnus* (*Pullus*) sp.1 and *Scymnus* (*Pullus*) sp.2. were recorded. However, in Hyperaspidini, only *Hyperaspis maindroni* Sicard was documented. *Brumoides suturalis* (Fab.) and *Chilocorus nigrita* (Fab.) were recorded under the tribe Chilocorini as predators of Pseudococcidae infesting various horticultural crops (Table 1, Figures 1 and 2).

These coccinellids were found predating on 11 mealybug species *viz*., *Coccidohytrix insolita* (Green) *Dysmicoccus brevipes* (Cockerell), *Ferrisia virgata* (Cockerell, *Maconellicoccus hirsutus* (Green), *Phenacoccus solenopsis* Tinsley, *Phenacoccus madeirensis* Green, *Planococcus citri* (Risso), *Planococcus lilacinus* (Cockerell), *Psuedococcus longispinus* (Targioni Tozzetti), *Pseudococcus jackbeardsleyi*

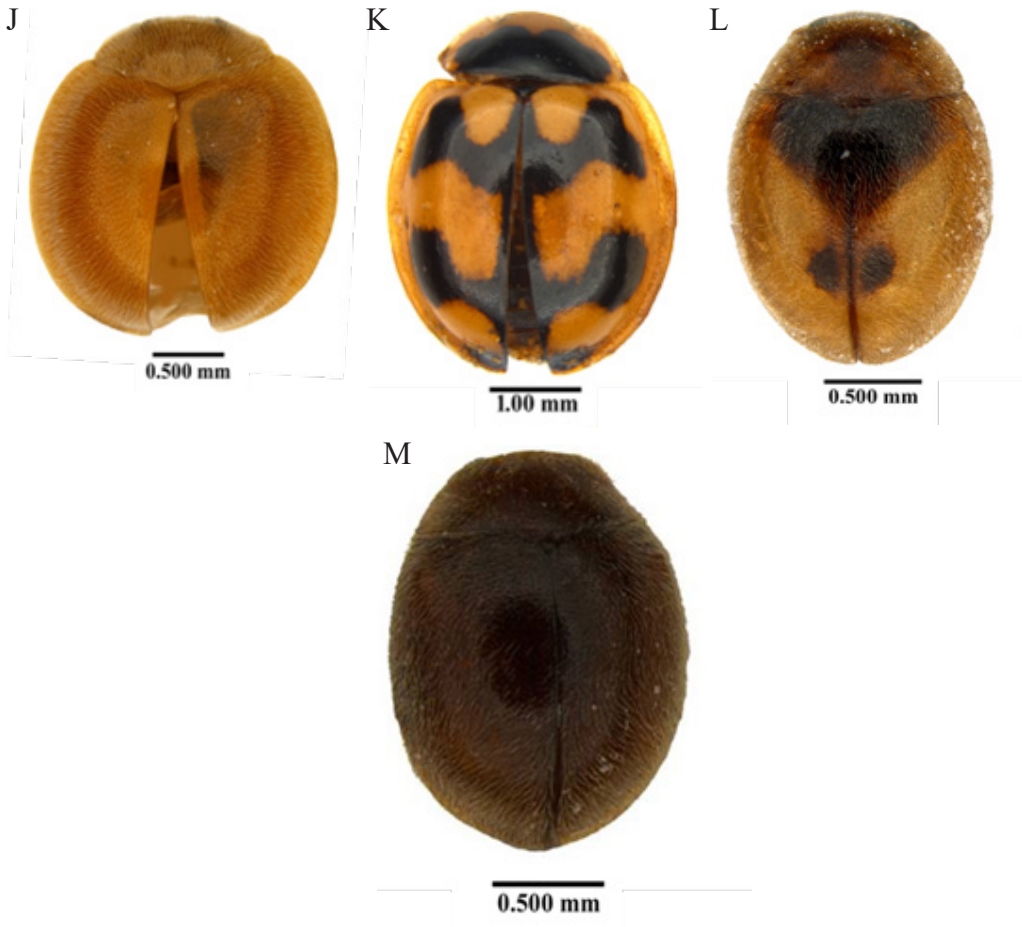


Figure 2 (cont'd.). Predatory coccinellids: J) *Jauravia pallidula;* K) *Propylea* sp.; L) *Scymnus (Pullus) coccivora;* M) *Scymnus (Pullus) latifolius.*

Gimpel and Miller and *Rastrococcus iceryoides* (Green) on various horticultural crops during study period (Table 1).

The highest per cent composition of coccinellid predators was recorded in subfamily Scymninae (75%) belonging to two tribes *viz*., Hyperaspidini and Scymnini, trailed by subfamily Coccinellinae (21.43%) belonging to two tribes *viz*., Coccinellini and Sticholotidini. The lowest percentage was recorded from the subfamily Chilocorinae (3.57%) belonging to the single tribe Chilocorini (Table 1).

The subfamily Scymninae and Coccinellinae were the diverse subfamilies collected during the survey followed by Chilocorinae. The highest percentage composition of coccinellid predators was recorded in the subfamily Scymninae. Scymninae was represented by seven species belonging to four genera of two tribes *viz*., Hyperaspdini (7.14%) and Scymnini (67.86%), the subfamily, Coccinellinae was represented by seven species belonging to seven genera of two tribes *viz*., Coccinellini (11.90%) and Sticholotidini (9.52%). The lowest subfamily composition was recorded in Chilocorinae and was represented by two species belonging to two different genera of the tribe, Chilocorini (3.57%). In Coccinellinae, *A. cardoni C. transversalis*, *C. sexmaculata*, *Coelophora* sp., *H. octomaculata* and *Propylea* sp. were documented while in Sticholotidini, only *J. pallidula* was recorded. In Scymnini, *C. montrouzieri*, *Nephus* sp., *S. latifolius*, *S. coccivora*, *Scymnus* sp. 1 and *Scymnus* sp. 2. were recorded. However, in Hyperaspidini, only *H. maindroni* was documented. *Brumoides suturalis* and *C. nigrita* were recorded under the tribe Chilocorini as predators of Pseudococcidae infesting various horticultural crops (Table 1).

The highest per cent species composition of coccinellid predators was recorded in *S. coccivora* (29.76%), trailed by *C. montrouzieri* (15.48%), *J. pallidula* and *S. latifolius* each with 9.52% and *H. maindroni* with 7.14%, *Scymnus* sp. 2 and *Nephus* sp. each with 4.76%, *C. sexmaculata* and *Scymnus* sp. 1 each with 3.57 %, *B. suturalis*, *C. transversalis* and *Propylea* sp. each with 2.38 %. The lower per cent of 1.19 was recorded from *A. cardoni*, *C. nigrita*, *Coelophora* sp. and *H. octomaculata* (Table 1).

The mealybug, *P. solenopsis* was associated with highest number of predators (six) *viz*., *B. suturalis*, *C. montrouzieri*, *C. sexmaculata*, *S. coccivora*, *Nephus* sp. and *Propylea* sp. (Figure 2), which was followed by mealybug species

Table 1. Per cent species composition of predatory coccinellids associated with mealybug species on different host plants

Sub family	Tribe	Coccinellid species	Species composition (%)	Mealybug species	Host plants
Coccinellinae (21.43%)	Coccinellini	1. *Anegleis cardoni* (Weise)	1.19	*Psuedococcus longispinus*	Sweet potato
		2. *Coccinella transversalis* Fabricius	2.38	*Maconellicoccus hirsutus*	Hibiscus
		3.*Cheilomenes sexmaculata* (Fabricius)	3.57	*Ferrisia virgata*	Mexican rose
				Phenacoccus solenopsis	Tomato
		4. *Coelophora* sp.	1.19	*Psuedococcus longispinus*	Coconut
		5. *Harmonia octomaculata* (Fabricius)	1.19	*Dysmicoccus brevipes*	Guava
		6. *Propylea* sp.	2.38	*Phenacoccus solenopsis*	China aster
	Sticholotidini	7. *Jauravia pallidula* (Motschulsky)	9.52	*Psuedococcus longispinus*	Coconut,Arecanut
				Planococcus citri	Sapota
				Coccidohystrix insolita	Hibiscus
Chilocorinae (3.57%)	Chilocorini	8. *Brumoides suturalis* (Fabricius)	2.38	*Phenacoccus solenopsis*	Marigold
		9. *Chilocorus nigrita* (Fabricius)	1.19	*Psuedococcus longispinus*	Jasmine
Scymninae (75%)	Hyperaspidini	10. *Hyperaspis maindroni* Sicard	7.14	*Maconellicoccus hirsutus*	Hibiscus
	Scymnini	11. *Cryptolaemus montrouzieri* Mulsant	15.48	*Planococcus citri*	Ixora
				Planococcus lilacinus	Cocoa
				Ferrisia virgata	Guava
				Phenacoccus solenopsis	Hibiscus
		12. *Nephus* sp.	4.76	*Phenacoccus solenopsis*	Hibiscus
		13. *Scymnus latifolius* Poorani	9.52	*Ferrisia virgata*	Pepper
				Psuedococcus longispinus	Sweet potato
				Pseudococcus jackbeardsleyi	Peace lily
				Coccidohystrix insolita	Brinjal
		14. *Scymnus coccivora* Ayyar	29.76	*Ferrisia virgata*	Butterfly pea
				Coccidohystrix insolita	Hibiscus
				Planococcus citri	Mulberry, Pepper
				Phenacoccus solenopsis	Okra
				Phenacoccus madeirensis	Acalypha
				Dysmicoccus brevipes	Guava
		15. *Scymnus* sp.1	3.57	*Dysmicoccus brevipes*	Jackfruit
				Rastrococcus iceryoides	Mango
		16. *Scymnus* sp.2	4.76	*Ferrisia virgata*	Cocoa

viz., *P. longispinus* (*C. nigrita*, *A. cardoni*, *J. pallidula*, *S. latifolius*, *Coelophora* sp.) and *F. virgata* (*C. montrouzieri*, *C. sexmaculata*, *S. latifolius*, *S. coccivora*, *Scymnus* sp. 2) with five predators, respectively. The mealybugs *viz*., *C. insolita* (*J. pallidula*, *S. latifolius*, *S. coccivora*), *D. brevipes* (*H. octomaculata*, *S. coccivora*, *Scymnus* sp. 1) and *P. citri* (*C. montrouzieri*, *J. pallidula*, *S. coccivora*) with three predators, respectively. The mealybug, *M. hirsutus* was associated with two predators *viz*., *C. transversalis* and *H. maindroni*. *The lowest of one predator species was associated with mealybugs viz., P. madeirensis* (*S. coccivora*)*, P. lilacinus* (*C. montrouzieri*)*, P. jackbeardsleyi* (*S. latifolius*) and *R. iceryoides* (*Scymnus* sp. 1).

In the present study, the highest per cent composition of coccinellid predators was recorded in the subfamily Scymninae and species, *S. coccivora* and *C. montrouzieri*. These predatory coccinellid species can be used to manage

various mealybug species and their conservation and augmentation within the croplands may help to suppress these sucking pest outbreaks (van Emden & Harrington, 2007; Lundgren, 2009; Obrycki *et al.,* 2009). Their diversity varies according to the geography of the region. As per the records of Ponnusamy *et al*. (2019) a total of 15 species of coccinellids belonging to ten genera and three tribes under the subfamily Coccinellinae were found predating on soft-bodied sucking pests on various hosts in the Terai region of West Bengal. However, Sajan *et al*. (2019) recorded fourteen different species of Coccinellinae belonging to nine different genera and one tribe (Coccinellini) at fields of Nepal Agricultural Research Council, Khumaltar, Lalitpur and Thangjam *et al.* (2020) documented, 19 species of coccinellids belonging to 11 genera were found to predate on sucking pests of king chilli in Assam.

Predatory coccinellids show diversity between various cropping systems and host mealybug species. *Brumoides sutarilis, C. montrouzieri* and *H. maindroni* were reported predating *C. insolita* on brinjal (Krishnamoorthy & Mani, 1996). While, *Brumoides lineatus, B. suturalis*, *C. sexmaculata*, *N. regularis* and *S. coccivora* were found predating on *Phenacoccus solani* infesting various host plants (Tanwar *et al*., 2007; Gautam *et al*., 2009; Ram & Saini, 2010). As well, eight species of coccinellids *viz*., *H. maindroni, B. suturalis, S. coccivora, N. regularis, C. septempunctata, C. sexmaculata, Adonia variegata* and *Illeis* sp. found predacious on solenopsis mealybug, *P. solenopsis* (Suroshe *et al*., 2013) and *S. coccivora, N. regularis, B. suturalis, Hippodamia variegata, C. sexmaculata* and *C. septempunctata* were found associated with *P. solenopsis* infesting cotton and other host plants (Kedar *et al*., 2011). While Sankar *et al*. (2011) documented, the incidence of *H. maindroni* on *P. solenopsis*. Though they are generalist predators, their documentation is restricted to a few major pest species of mealybugs, which may be due to the studies being more focused on a few mealybugs which are much more notorious than the others. However, *B. suturalis, C. septempunctata, Hippodamia variegata, Menochilus sexmaculatus* and *H. maindroni* predate on different mealybug species (Ali *et al.*, 2014; Jalilvand *et al.,* 2014). The present study provides detailed information about the predaceous coccinellid fauna associated with various mealybug species infesting horticultural crops in Karnataka. The horticultural crop ecosystems were found to have higher species richness of coccinellids and were found predating on different mealybug species. There are standard rearing methods for a few predatory coccinellid species which can be modified to rear the native predators. Therefore, utilizing these predatory beetles as a biological tool for the management of mealy bugs has great potential. These coccinellid species can be multiplied and supplied to the farmers as a part of Integrated Pest Management (IPM) based management strategies, especially against mealybugs and also other sucking pests. These will also reduce the use of chemical pesticides and help conserve the natural enemy fauna in the horticultural ecosystem, which are essential for biological diversity and ecological sustainability.

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