



Survey, documentation and identification of entomofauna of cocoa, *Theobroma cacao* L. in major cocoa growing regions of South India

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Abstract: Survey, monitoring and documentation of entomofauna of cocoa was carried out in three cocoa growing states viz., Tamil Nadu, Kerala and Andhra Pradesh during 2014-2015. Results revealed that a total number of 23 species of insect pests and 13 species of natural enemies were documented and identified. Among the insect pests, 14, 2 and 7 species were sucking pests, borers and defoliators, respectively. Among the natural enemies, 7 species of predators and 6 species of parasitoids were documented and identified on different insect pests of cocoa. Among the insect pests, sucking pests were found to be predominant and maximum number of entomofauna were recorded in major coco growing areas of Tamil Nadu. From the results it was concluded that the list of entomofauna documented can enhance the knowledge on diversity of the entomofauna associated with cocoa in three different cocoa growing states. Sucking pests were found to be predominant and caused huge yield loss in Tamil Nadu and Kerala. While in Andhra Pradesh pod borer and bark eating caterpillar were found to be predominant causing severe yield loss. This information provides a base for development of location specific Integrated Pest Management module.

Keywords: Cocoa, Documentation, Identification, Insect pests, IPM, Natural enemies, Survey

INTRODUCTION

Cocoa (*Theobroma cacao* L.) is one of the greatest treasures ever discovered by man. It is the only source of chocolate and is a rich source of sensory pleasure and energy, adored by almost everyone. It is the third important beverage crop next to coffee and tea, and is the third highest traded commodity in the world. It is one of the world's most valuable crops playing an important role in socio economic life of more than 5 million households. Cocoa is cultivated worldwide over an area of 8.2 million hectares in fifty eight nations and the top five producers account for over 70 per cent of the total production (Prasannakumari *et al.*, 2012).

Globally 43.55 lakh metric tonnes of cocoa has been produced during 2014. Ivory Coast, Ghana and Indonesia are the largest cocoa producing countries with the share of 34, 24 and 14 per cent of the world total production, respectively (ICO, 2014). In India, cocoa cultivation is largely confined to southern states viz., Kerala, Karnataka, Tamil Nadu and Andhra Pradesh. Cocoa is usually planted as inter crop in coconut and arecanut plantations. India ranks eighteenth among the countries cultivating cocoa having an area of 71,000 hectares with a production of 15,000 metric tonnes and productivity of 0.2 met-

ric tonnes, of which Tamil Nadu covers an area of 24,000 hectares with a production of 1,100 metric tonnes. Kerala is leading in the production with a share of 41.72 per cent followed by Andhra Pradesh (37.08 per cent), Karnataka (13.90 per cent) and Tamil Nadu (7.28 per cent) (IHD, 2014).

Documentation of entomofauna through survey and monitoring will pave a way to understand taxonomically diversified crop pests, feeding behaviour and their biology. This information will help to formulate reliable integrated pest management module for the management of insect pests of cocoa. With this background the present investigation on survey and documentation of entomofauna of cocoa was undertaken in three states of South India viz., Tamil Nadu, Kerala and Andhra Pradesh.

MATERIALS AND METHODS

Survey and documentation of entomofauna: Survey, monitoring and documentation of entomofauna of cocoa was carried out in three cocoa growing states of South India viz., Tamil Nadu, Kerala and Andhra Pradesh. Survey was carried out in well-established and high yielding cocoa plantations in Coimbatore district of Tamil Nadu, Palakkad district of Kerala and West and East Godavari districts of Andhra Pradesh to document the entomofauna

associated with cocoa (Table 1). Entomofauna of cocoa were monitored in three farmer's holdings at Sethumadai and in coconut nursery, TNAU, Coimbatore from October, 2014 to April, 2015. Documented entomofauna were compared among the places surveyed and the results were given below.

Morphological identification of entomofauna: Entomofauna observed during survey and monitoring were collected and brought to the Department of Agricultural Entomology, Centre Plant Protection Studies, TNAU, Coimbatore. Soft bodied insects were preserved in 70 per cent ethanol and other entomofauna were card mounted or pinned. The specimens were identified morphologically by the well known taxonomists *viz.*, Dr. C.A. Viraktamath, Dr. S. Manickavasagam, Dr. M. Ganeshkumar, Dr. N. Chitra and by comparing the specimens in the Biosystematics Laboratory, Department of Agricultural Entomology, TNAU, Coimbatore. The diversity of entomofauna documented in the three states was compared and species richness was analyzed. Economically important pests and natural enemies associated with cocoa in different locations were documented.

RESULTS AND DISCUSSION

Survey and documentation of entomofauna: From the results of present study on survey and monitoring of entomofauna of cocoa in the farmer's holdings and coconut nursery, the observed entomofauna were cate-

gorized into two groups *viz.*, insect pests and natural enemies. A total number of 23 species of insect pests and 13 species of natural enemies were documented. Among the insect pests, 14, 2 and 7 species were grouped under sucking pests, borers and defoliators, respectively. Among the natural enemies, 7 species of predators and 6 species of parasitoids were documented on different insect pests of cocoa (Table 2).

Among the sucking pests, two species of tea mosquito bugs, five species of mealybugs, two species of aphids, three species of plant hoppers, one species of scale insect and one species of cowbug were found to suck the sap from different parts of cocoa *viz.*, leaves, tender shoots, flowers, flower cushions, cherelles and pods. Bark eating caterpillar and pod borer were the two borers found to infest different parts of cocoa tree. Among the two borers, bark eating caterpillar occurred regularly and caused upto 40 per cent damage to cocoa trees. Four species of hairy caterpillars, one species of bagworm, one species of ash weevil and one species of grasshopper were the defoliators found feeding on cocoa leaves (Table 2).

Among the tea mosquito bugs, *Helopeltis bradyi* was noticed in Tamil Nadu, Kerala and Andhra Pradesh, whereas, *H. antonii* was found in Tamil Nadu and Kerala. Among the farmer's holdings surveyed, *H. bradyi* was found to be the predominant species over *H. antonii*. Among the mealybugs documented, *Planococcus citri* and *Paracoccus marginatus* were docu-

Table 1. Details of farm holdings surveyed and monitored for the documentation of entomofauna of cocoa during 2014-2015

S. No.	Location	Name of the farmer/ farm	Address of the farmer/farm	Age of the plantation
I	Tamil Nadu			
1		VJ. Jayaraj	Sethumadai,	10 years
2	Sethumadai	VJ. Prasad	Pollachi taluk,	15 years
3		Rajaram	Coimbatore district	10 years
4	Coimbatore	Coconut nursery	TNAU, Coimbatore	4 years
II	Kerala			
5	Chamanampathy	T.S. Asokan	Chamanampathy, Palakkad district	15 years
III	Andhra Pradesh			
6		A. S. Pratap	Naguldenipadu, Eluru	17 years
7		Gopinathreddy	Singarayapalem, T. Narasapuram	21 years
8		Thirumurthirao	Singarayapalem, T. Narasapuram	13 years
9		Rajanbabu	Vijaya gardens, Eluru	20 years
10		Gopalakrishanan	Pedavegi, Eluru	17 years
11		GP Rao	Eluru	18 years
12		Sathish	Vundrajavaram, Eluru	18 years
13		Shivananda	Savaram, Eluru	18 years
14	West Godavari	Ravi Prasad	Savaram, Tanuku	6 years
15		Ramakrishanaraju	Velayaduru, Tanuku	13 years
16		Muraliraju	Velayaduru, Tanuku	19 years
17		Narayanaraju	Velayaduru, Tanuku	17 years
18		Sremannarayanrao	Velayaduru, Tanuku	19 years
19		Shankararao	Bapiraju gudam, Eluru	20 years
20		Hari Mohan	Kunchum padi, Eluru	22 years
21		Krishnabhaskar	Badarada, Eluru	20 years
22		Subbaraju	Lakshampuram, Eluru	15 years
23	East Godavari	Madhusudanrao	Vearavaram, Rajhamandry	14 years

Table 2. Documentation of entomofauna of cocoa during 2014-2015.

Entomofauna	Common name	Scientific name	Family	Order	TN	KL	AP	Total
A. Insect pests	Tea mosquito bugs	<i>Helopeltis bradyi</i> Waterhouse	Miridae	Hemiptera	✓	✓	✓	
		<i>H. antonii</i> Signoret	Miridae	Hemiptera	✓	✓	-	
		<i>Planococcus citri</i> Risso	Pseudococcidae	Hemiptera	✓	✓	✓	
		<i>Paracoccus marginatus</i> Williams and Granara de Willink	Pseudococcidae	Hemiptera	✓	✓	✓	
	Mealybugs	<i>Pseudococcus longispinus</i> (Targioni-Tozzetti)	Pseudococcidae	Hemiptera	-	-	✓	
		<i>Rastrococcus iceryoides</i> (Green)	Pseudococcidae	Hemiptera	✓	-	-	
		<i>Dysmicoccus brevipes</i> (Cockerell)	Pseudococcidae	Hemiptera	✓	-	-	14
	Aphids	<i>Aphis gossypii</i> Glover	Aphididae	Hemiptera	✓	-	✓	
		<i>Toxoptera aurantii</i> (Boyer De Fonscolombe)	Aphididae	Hemiptera	✓	✓	-	
		<i>Pochazia</i> sp.	Ricaniidae	Hemiptera	✓	-	-	
	Planthoppers	<i>Eurybrachis tomentosa</i> Fabricius	Eurybrachidae	Hemiptera	✓	-	-	
		<i>Proutista moesta</i> (Westwood)	Derbidae	Hemiptera	✓	-	-	
	Scales	<i>Icerya aegyptiaca</i> (Douglas)	Monophlebidae	Hemiptera	✓	-	-	
	Cowbugs	<i>Telingana</i> sp.	Membracidae	Hemiptera	✓	-	-	
	Pod borer	<i>Dichrocrocis punctiferalis</i> (Guenee)	Crambidae	Lepidoptera	✓	✓	-	02
Borers	Bark eating caterpillar	<i>Inderbala</i> sp.	Cossidae	Lepidoptera	✓	✓	✓	
		<i>Dasychira moerens</i> Felder	Lymantriidae	Lepidoptera	✓	-	-	
		<i>Euproctis fraterna</i> (Moore)	Lymantriidae	Lepidoptera	✓	-	-	07
Defoliators	Hairy caterpillars	<i>Olene mendosa</i> Hubner	Lymantriidae	Lepidoptera	✓	-	-	
	Unidentified	Unidentified	Totricidae	Lepidoptera	✓	-	-	

Entomofauna	Common name	Scientific name	Family	Order	TN	KL	AP	Total
	Bagworm	Unidentified	Psychidae	Lepidoptera	✓	-	-	
	Ash weevil	<i>Mylocerus</i> sp.	Curculionidae	Coleoptera	✓	-	-	
	Grasshopper	<i>Diabolocatantops</i> sp.	Acrididae	Orthoptera	✓	-	-	
B. Natural enemies			Insect pests					23
	Lady bird beetle	<i>Cheilomenus sexmaculata</i> (Fabricius)	Coccinellidae	Coleoptera	✓	-	✓	
	Australian lady bird beetle	<i>Cryptolaemus montrouzieri</i> Mulsant	Coccinellidae	Coleoptera	✓	-	✓	
	Oriental apefly	<i>Spalgis epeus</i> (Westwood)	Lycanidae	Lepidoptera	✓	✓	✓	
Predators	Chrysopa	<i>Chrysoperla zastrowi sillemi</i> (Eshben-Peterson)	Chrysopidae	Neuroptera	✓	✓	✓	07
	Preying mantid	<i>Humbertiella</i> sp.	Liturgusidae	Dictyoptera	✓	-	-	
	Syrphid	Unidentified	Syrphidae	Diptera	✓	-	-	
	Spider	<i>Argiope anasuja</i> Thorell	Arenidae	Araneae	✓	-	-	
	Aphelinids (mealybug parasitoid)	<i>Promusidea un fasciati ventris</i> Girault	Aphelinidae	Hymenoptera	✓	-	-	
	Encyrtids (mealybug parasitoid)	<i>Leptomastix tsukumiensis</i> Tachikawa	Encyrtidae	Hymenoptera	✓	-	-	
Parasitoids	Encyrtids (mealybug parasitoid)	<i>Aenasius</i> sp.	Encyrtidae	Hymenoptera	✓	-	-	06
	Encyrtids (mealybug parasitoid)	Unidentified	Encyrtidae	Hymenoptera	-	-	✓	
	Encyrtids (mealybug parasitoid)	<i>Acerophagus papayae</i>	Encyrtidae	Hymenoptera	✓	-	-	
	Eurytomids (hairy caterpillar parasitoid)	Unidentified	Eurytomidae	Hymenoptera	✓	-	-	
			Natural enemies					13
			Total entomofauna					36

TN: Tamil Nadu; KL: Kerala; AP: Andhra Pradesh

mented in all the three states, whereas, *Pseudococcus longispinus* was observed only in Andhra Pradesh. *Rastrococcus iceryoides* and *Dysmicoccus brevipes* were documented only in Tamil Nadu (Table 2). Among the aphids, *Aphis gossypii* was documented in Tamil Nadu and Andhra Pradesh, whereas, *Toxoptera aurantii* was observed in Kerala and Tamil Nadu. All the planthoppers, scales, cowbugs, defoliators, bagworms, ash weevils and grasshoppers were observed only in Tamil Nadu, whereas, pod borer was recorded in

Kerala and Tamil Nadu. Bark eating caterpillar was recorded as a major pest in all the three cocoa growing states (Table 2).

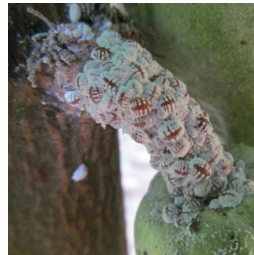
Thirteen species of natural enemies *viz.*, seven species of predators and six species of parasitoids were documented. Among the seven predators, two species of coccinellids, one species of lycaenid, one species of chrysopid, one species of liturgusid, one species of syrphid and one species of arenid were found to be associated with cocoa pests. Out of six parasitoids



Helopeltis bradyi



H. antonii



Planococcus citri



Paracoccus marginatus



Pseudococcus longispinus



Rastrococcus iceryoides



Dysmicoccus brevipes



Toxoptera aurantii



Aphis gossypii



Nymph of *Pochazia* sp.



Adult of *Pochazia* sp.



Eurybrachis tomentosa



Proutista moesta



Icerya aegyptiaca



Telingana sp.



Larva of *D. punctiferalis*



Pupa of *D. punctiferalis*



Adult of *D. punctiferalis*



Larva of *Inderbala* sp.



Larva of *D. moerens*

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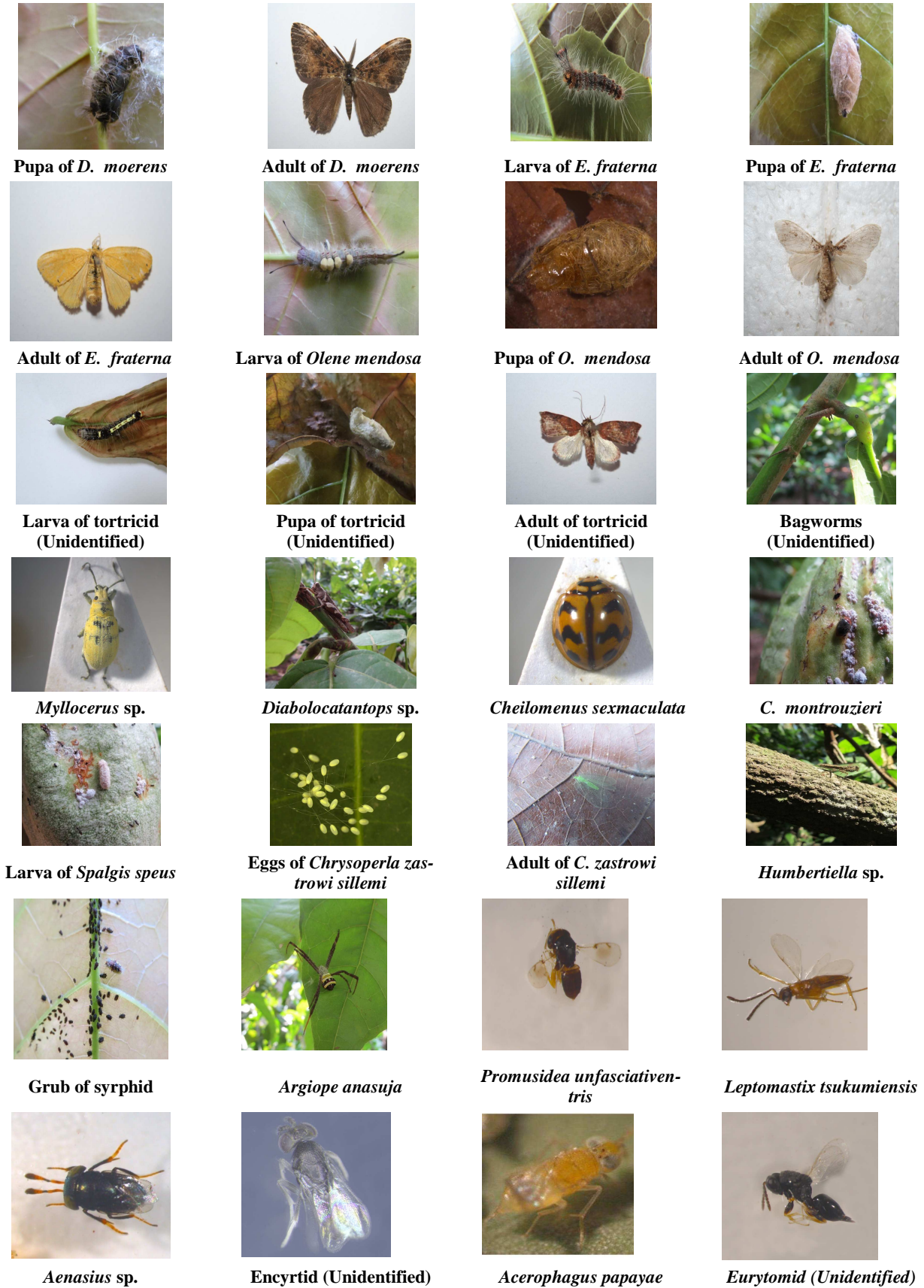


Fig.1. Morphological identification of entomofauna of cocoa.

documented, four species of encyrtids and one species of aphelinid parasitized mealybug, *P. citri* and a eurytomid parasitoid was documented on hairy caterpillar, *Dasychira moerens* (Table 2).

Among the predators, oriental apefly and chrysopa were recorded in all the three states, while, lady bird beetles were documented in Andhra Pradesh and Tamil Nadu. Preying mantids, syrphids and spiders were observed only in Tamil Nadu. Except an encyrtid parasitoid observed in Andhra Pradesh, all other parasitoids were observed in Tamil Nadu (Table 2). Prasannakumari *et al.* (2012) also reported that red borer (*Zeuzera coffeae*), tea mosquito bug (*Helopeltis antonii*), mealybugs (*Planococcus lilacinus*), ash weevil (*Myllocerus* sp.), cockchafer beetle (*Leucopholis* sp.), red banded thrips and storage pests (*Corcyra cephalonica*) were the major pests on cocoa in Kerala, Andhra Pradesh, Tamil Nadu and Karnataka regions in India.

Among the insect pests documented, sucking pests were found to be predominant. This might be due to the congenial tree environment with high temperature and low humidity prevailing in the cocoa ecosystem for the development of sucking pests. The results are in accordance with the findings of Jamunadevi (2010) who has reported that the highest number of aphids and mealybugs were present in aonla ecosystem in Tamil Nadu.

P. citri, *P. marginatus*, *P. longispinus*, *R. iceryoides* and *D. brevipes* were the five different mealybugs documented during survey. Strickland (1951), Dale (1962), and Attafuah *et al.* (1963) also reported more than 20 species of mealybugs infesting cocoa in West Africa. Among them, *P. citri*, *P. lilacinus*, *P. njalensis*, *Ferrisia virgata* and *Pseudococcus adonidum* were found to be major (Prasannakumari *et al.*, 2012) and associated with swollen shoot viral disease of cocoa.

H. bradyi and *H. antonii* were documented in the cocoa plantations surveyed. Among the tea mosquito bugs observed, *H. bradyi* was found to be predominant over *H. antonii*. This observation is in line with Sundararaju (1996) who found that out of 31 specimens collected from cocoa, 30 were of *H. bradyi* and only one was *H. antonii*. Leston (1970) also reported 3 groups of the cocoa capsids causing damage to cocoa in Tamil Nadu.

Dasychira moerens, *Euproctis fraterna*, *Olene mendosa*, torticid (unidentified), psychid (unidentified), *Myllocerus* sp. and *Diabolocatanops* sp. were the defoliators documented in cocoa. Alibert and Les (1951), Szent-Ivanyi (1964) and Smith (1965) also reported 56 genera of beetles and 147 species of lepidopterans to be associated with cocoa in West Africa.

During the survey, *Cheilomenus sexmaculata*, *Cryptolaemus montrouzieri*, *Spalgis epeus*, *Chrysoperla zastrowi sillemi*, *Humbertiella* sp., syrphid (unidentified) and *Argiope anasuja* were documented as major predators and *Promusidea unfauciiventris*, *Leptomastix tsukumienensis*, *Aenasius* sp., encyrtid parasitoid (unidentified), *Acerophagus papayae* and eurytomid (unidentified)

were documented as parasitoids in cocoa ecosystem to know the species diversity of natural enemies and for the development of IPM module using these biocontrol agents. Similar results were reported by Boukhris-Bouhachem (2011) who has recorded 16 natural enemies on citrus aphids in Tunisia. Among them, coccinellids (*Coccinella septempunctata*, *Scymnus subvillosus*, *Adalia bipunctata*, *Chilocorus bipustulatus* and *Hippodamia variegata*) were the predominant predators, followed by a cecidomyiid (*Aphidoletes aphidimyza*), a chrysopid (*Chrysoperla carnea*) and a syrphid (*Episyrphus balteata*). According to Boukhris-Bouhachem (2011), parasitoids viz., *Aphidius matriariae*, *A. colemani*, *Ephedrus persicae*, *Lysiphlebus fabarum*, *L. testaceipes*, *Praon volucre*, *Trioxys angelicae* and *Diaeretiella rapae* played significant role in reducing citrus aphid population.

Morphological identification of entomofauna : Results of morphological identification of entomofauna of cocoa to study the identifying the species diversity revealed that the two species of tea mosquito bugs were identified as *Helopeltis bradyi* Waterhouse (Plate 18) and *H. antonii* (Miridae: Hemiptera) based on the key given by Stonedahl (1991) as detailed below.

Base of hind femur with broad pale band, distal region usually fuscous; length of antennal segment I much greater than posterior width of pronotum (ratio: males, 1.50:1-1.85:1; females, 1.45:1-1.60:1); lobal sclerite with limited scattered tubercles at apex only; sclerotized rings of genital chamber fused posteriorly.

Basal third and apex of hind femur mostly fuscous, middle section pale with fuscous spots or mottling; length of antennal segment I slightly greater than posterior width of pronotum (ratio: males, 1.20:1- 1.45:1; females, 1.05:1-1.30:1); lobal sclerite with dense distribution of tubercles distally, usually extending proximally along outer margin to near median level of sclerite; sclerotized rings of genital chamber not fused posteriorly.

Five species of mealybugs were morphologically identified as *Planococcus citri* Risso, *Paracoccus marginatus* Williams and Granara de Willink, *Pseudococcus longispinus* (Targioni-Tozzetti), *Dysmicoccus brevipes* (Cockerell) and *Rastrococcus iceryoides* (Green) (Pseudococcidae: Hemiptera). Two species of Aphids were identified morphologically as *Toxoptera aurantii* (Boyer De Fonscolombe) and *Aphis gossypii* Glover (Aphididae: Hemiptera), three species of Planthoppers as *Pochazia* sp. (Ricaniidae: Hemiptera), *Eurybrachis tomentosa* Fabricius (Eurybrachidae: Hemiptera) and *Proutista moesta* (Westwood) (Derbidae: Hemiptera), one species of Scale insect as *Icerya aegyptiaca* (Douglas) (Monophlebidae: Hemiptera) and one species of Cowbug/Tree hopper as *Telingana* sp. (Membracidae: Hemiptera) (Fig.1).

Among the borers, Pod borer was identified morphologically as *Dichocrocis punctiferalis* (Guenee) (Crambidae:

Lepidoptera) and Bark eating caterpillar as *Indarbela* sp. (Cossidae: Lepidoptera). The Defoliators viz., Hairy caterpillars were identified as *Dasychira moerens* Felder (Lymantriidae: Lepidoptera), *Euproctis fraterna* (Moore) (Lymantriidae: Lepidoptera), *Olene mendosa* Hubner (Lymantriidae: Lepidoptera) and Tortricid (unidentified) (Tortricidae: Lepidoptera). While, Ash weevils were identified as *Myloccerus* sp. (Curculionidae: Coleoptera), bagworm as Psychid (unidentified) (Psychidae: Lepidoptera) and Grasshopper as *Diabolocatantops* sp. (Acrididae: Orthoptera) (Fig.1).

The predators of insect pests of cocoa were morphologically identified as *Cheilomenus sexmaculata* (Fabricius) (Coccinellidae: Coleoptera), *Cryptolaemus montrouzieri* Mulsant (Coccinellidae: Coleoptera), *Spalgis epeus* (Westwood) (Crambidae: Lepidoptera), *Chrysoperla zastrowi sillemi* (Chrysopidae: Neuroptera), *Humbertiella* sp. (Liturgusidae: Dictyoptera), syrphids (unidentified) (Syrphidae: Diptera) and *Argiope anasuja* (Araneidae: Araneae) (Fig.1).

Parasitoids on mealybugs and Hairy caterpillars were morphologically identified as *Promusidea unfauciventrif* Girault (Aphelinidae: Hymenoptera), *Lepitomastix tsukumiensis* Tachikawa (Encyrtidae: Hymenoptera), *Aenasius* sp. (Encyrtidae: Hymenoptera), encyrtid parasitoid (unidentified) (Encyrtidae: Hymenoptera), *Acerophagus papayae* (Encyrtidae: Hymenoptera) and eurytomid parasitoid (unidentified) (Eurytomidae: Hymenoptera), respectively (Fig.1)

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