Indian Journal of Entomology, 81(4): 000-000 (2019) DoI No.:

DIVERSITY OF HYMENOPTERA IN COFFEE IN TAMIL NADU

K. R. Manikandan*, M. Muthuswami, N. Chitra**, C. Chinniah and M. Ananthan*****

Department of Agricultural Entomology,
Agriculture College and Research Institute, Madurai 625104;
**Coimbatore 641003
***Directorate of Open and Distance Learning,
Tamil Nadu Agricultural University, Coimbatore 641003
*Email: manibscagri@gmail.com (corresponding author)

ABSTRACT

A total of 2334 hymenopterans of 24 families under 14 superfamilies were collected in the coffee ecosystem at Horticultural Research Station, Thadiyankudisai, Dindigul, Tamil Nadu. The hymenopteran diversity comprised predominantly Ichneumonidae (14.7%) followed by Diapriidae (13.4%), Platygastridae (13.0%), Braconidae (12.0%) and Scelionidae (11.3%). Ceraphronidae, Eulophidae, Ampulicidae, Figitidae (0.7%) and Eupelmidae (0.6%) were observed to be the least in diversity.

Key words: Coffee, Hymenoptera, diversity, parasitoids, Ichneumonidae, Diapriidae, Platygastridae, Braconidae, Scelionidae, diversity indices

Hymenoptera is the third largest insect order, comprising over 1,50,000 species (Janke et al., 2013). Collectively, Hymenoptera are the most important group because they act as pollinators of wild and cultivated flowering plants, natural enemies (predator and parasitoids) of destructive insects and as makers of honey (Taye et al., 2017). Many environmental and social problems result from the overuse of insecticides (Wei and Yu, 1998). Indiscriminate usage of pesticides causes the loss of biodiversity of beneficial organisms. Recently, biodiversity in agricultural land has received growing attention (Dudley et al., 2005). Coffee is the most important perennial beverage with national productivity of 765 kg/ha while it is 519 kg/ha in Tamil Nadu (Central Coffee Research Institute (CCRI, 2018)). More than 100 insects had been recorded as pests in coffee (Le Pelley, 1968). Hymenoptera from the coffee ecosystem has been of least concern comparatively in the past creating a void in biological control of the coffee pests. In the study area of Thadiyankudisai, coffee is cultivated in an area of 13,436 ha, and insect pests are a major constraint in achieving higher yield. Basic study on hymenopteran diversity is a prerequisite for the success of any biological control and IPM, and hence the present study.

MATERIALS AND METHODS

The hymenopteran diversity in coffee ecosystem at Horticultural Research Station, Thadiyankudisai (10.29°N, 77.71°E 1098 masl) was studied from January to December, 2018. Thadiyankudisai region has a winter (from December to February), summer (from March to May), south west monsoon (SWM) (from June to August) and north east monsoon (NEM) (from September to November) seasons. Coffee is inter cropped with silver oak, pepper, avocado, mandarin orange, macadamia nut, Indian coral tree, silk cotton, jack and banana. Need based application of chlorpyriphos and quinalphos in recommended doses is the common plant protection measure followed here. Sampling was taken at weekly intervals with yellow pan traps (30cm dai) (@ 20 traps/ plot of 10x 10 m) at four points. The traps were filled with water along with a few drops of detergent (soap oil) and pinch of salt. The hymenopterans were filtered with a fine mesh filter after 24 hr. Relative abundance of the hymenopterans during the prevailing four seasons was recorded.

The collected specimens were preserved in 70% ethyl alcohol. Specimens were also mounted on pointed triangular cards and studied under a stereozoom microscope (Stemi- Zeiss DV4) and photographed in stereozoom microscope (Leica M205C). These were identified following the keys by Narendran and Achterberg (2016). Further, identification was confirmed by Dr. A. Rameshkumar (Chalcidoidea), Dr. K. Rajmohana (Platygastroidea), Ms. Nabasri Basak (Chalcididae) and Mr. Arnab Mandi (Formicidae) of the Zoological Survey of India, Kolkata. The parasitoid collections were deposited at the Insect Biosystematics laboratory, Department of Agricultural Entomology,

Tamil Nadu Agricultural University, Coimbatore. The hymenopterans diversity was quantified based on indices of species richness (α) (Margalef, 1958), species diversity: Shannon-Wiener Index (H') (Shannon and Wiener, 1949) Simpson's Index Diversity (SID) (Simpson, 1949) and species evenness (EI) (Pielou, 1966) with biodiversity calculator. https://www.alyoung.com/labs/biodiversity_calculator.html.

RESULTS AND DISCUSSION

A total of 2,334 number of hymenopterans of 24 families under 14 superfamilies were collected in the coffee ecosystem at Thadiyankudisai, Tamil Nadu. Amongst these, the superfamily Chalicidoidea was the most diverse with seven families. The others include Ichneumonoidea, Chrysidoidea, Platygastroidea, Apoidea (2 families each), Cynipoidea, Ceraphronoidea, Evanioidea, Tiphioidea, Vespoidea, Tenthredinoidea, Diaprioidea, Pompiloidea and Formicoidea (1 family each) (Table 1). The analysis of indices of species richness during the four seasons revealed that the species richness (α) was the highest during NEM (3.86) followed by summer season (3.76), winter season (3.49) and SWM (3.48). The species diversity ranged from 0.88 to 0.91 with lesser variation as per SID and as well as by H' (range 2.44 to 2.62). The evenness was the maximum during SWM (0.85) followed by winter (0.82) and summer (0.80). Minimum evenness was observed during the NEM (0.76) (Table 2).

Among the different families, characteristically Platygastridae (25.8%), Scelionidae (24.5%) and Diapriidae (23.2%) were more abundant during winter season, while Ichneumonidae were dominant during summer (17.4%) and NEM (19.8%), Diapriidae during SWM (27.1%). The overall higher abundance during all the four seasons was of Ichneumonidae and Diapriidae (Table 3). The collected hymenoptera were classified based on the functional role in the coffee ecosystem. The feeding guild comprised predator cum pollinator (5 families), parasitoids (18 families) and herbivore (1 family).

Table 1. Relative abundance of hymenoptera in coffee at Thadiyankudisai

Superfamily	Family	Relative abundance	
		No.	(%)
Apoidea	Sphecidae	39	1.7
	Ampulicidae	16	0.7
Pompiloidea	Pompilidae	18	0.8
Formicoidea	Formicidae	69	3.0
Vespoidea	Vespidae	121	5.2
Ichneumonoidea	Braconidae	280	12.0
	Ichneumonidae	343	14.7
Ceraphronoidea	Ceraphronidae	16	0.7
Chalcidoidea	Encyrtidae	90	3.9
	Pteromalidae	34	1.5
	Mymaridae	61	2.6
	Eulophidae	17	0.7
	Eupelmidae	15	0.6
	Chalcididae	72	3.1
	Trichogrammatidae	21	0.9
Evanioidea	Evaniidae	40	1.7
Chrysidoidea	Dryinidae	49	2.1
	Bethylidae	41	1.8
Diaprioidea	Diapriidae	313	13.4
Platygastroidea	Platygastridae	304	13.0
	Scelionidae	264	11.3
Cynipoidea	Figitidae	17	0.7
Tiphioidea	Tiphiidae	72	3.1
Tenthredinoidea	Tenthredinidae	22	0.9
	Total	2334	100.0

Ichneumonidae (52.92%) and Formicidae (32.73%) were found to be dominant in the coffee estates of Indonesia (Hasnah et al., 2019). The parasitoids of the Ichneumonidae were also the most dominant family in organic and inorganic coffee plantations (Hamdi et al., 2015). Banks et al. (2013) reported that a total of 66 hymenopteran were collected in yellow pan tap during dry and rainy season in Costa Rican coffee agroecosystem the hymenopteran family in dry season viz., Apidae, Crabronidae, Halictidae, Pompilidae and Vespidae were recorded, in rainy season viz., Crabronidae, Evaniidae, Halictidae, Pompilidae, Tiphiidae and Vespidae. During the dry season there was no difference in overall hymenopteran abundance or richness between coffee farms that were adjacent to

Table 2. Diversity indices of hymenopteran families in coffee at Thadiyankudisai

Seasons	Diversity indices			
	Margalef index (α)	Simpson's Index of Diversity (SID)	Shannon-Wiener Index (H')	Pielou's index (EI) of Evenness
Winter	3.49	0.90	2.62	0.82
Summer	3.76	0.89	2.54	0.80
South West Monsoon	3.48	0.91	2.71	0.85
North East Monsoon	3.86	0.88	2.44	0.76

Table 3. Seasonal abundance of Hymenoptera in coffee (Thadiyankudisai)

Super family	Family	Winter		Summer		SWM		NEM	
		No.	%	No.	%	No.	%	No.	%
Apoidea	Sphecidae	9	2.3	15	3.9	12	3.1	3	0.8
	Ampulicidae	6	1.6	5	1.3	3	0.8	2	0.5
Pompiloidea	Pompilidae	7	1.8	3	0.8	7	1.8	1	0.3
Formicoidea	Formicidae	16	4.2	12	3.1	25	6.5	16	4.2
Vespoidea	Vespidae	32	8.3	33	8.6	34	8.9	22	5.7
Ichneumonoidea	Braconidae	96	25.0	63	16.4	67	17.4	54	14.1
	Ichneumonidae	97	25.3	67	17.4	103	26.8	76	19.8
Ceraphronoidea	Ceraphronidae	3	0.8	2	0.5	9	2.3	2	0.5
Chalcidoidea	Encyrtidae	65	16.9	4	1.0	19	4.9	2	0.5
	Pteromalidae	9	2.3	3	0.8	18	4.7	4	1.0
	Mymaridae	26	6.8	6	1.6	22	5.7	7	1.8
	Eulophidae	6	1.6	4	1.0	4	1.0	3	0.8
	Eupelmidae	2	0.5	3	0.8	9	2.3	1	0.3
	Chalcididae	25	6.5	16	4.2	26	6.8	5	1.3
	Trichogrammatidae	2	0.5	12	3.1	6	1.6	1	0.3
Evanioidea	Evaniidae	15	3.9	1	0.3	17	4.4	7	1.8
Chrysidoidea	Dryinidae	16	4.2	11	2.9	12	3.1	10	2.6
	Bethylidae	14	3.6	5	1.3	12	3.1	10	2.6
Diaprioidea	Diapriidae	89	23.2	63	16.4	104	27.1	57	14.8
Platygastroidea	Platygastridae	99	25.8	58	15.1	96	25.0	51	13.3
	Scelionidae	94	24.5	55	14.3	75	19.5	40	10.4
Cynipoidea	Figitidae	6	1.6	1	0.3	8	2.1	2	0.5
Tiphioidea	Tiphiidae	27	7.0	5	1.3	36	9.4	4	1.0
Tenthredinoidea	Tenthredinidae	6	1.6	5	1.3	7	1.8	4	1.0
	Total	767		452		731		384	

%- Relative abundance, No- Total number of individuals collected, SWM- south west monsoon, NEM- north east monsoon

forest and those that were isolated from forest. There were no differences in hymenopteran abundance or richness between coffee and forest for both rainy season and dry season. Similarly, there were no differences in bee abundance or richness between coffee and forest habitats neither for rainy season nor dry season.

Farms isolated from forest habitat may support some Hymenoptera during the rainy season equally as well as farms adjacent to forest habitat since increased sunlight and ground cover within coffee farms may provide resources for pollinators and parasitoids throughout the months following the mass-flowering of the coffee crop (Priess et al., 2007). Banks et al. (2014) the mean number of hymenopteran visitors varies seasonally in each type of farm, suggesting that there may be times when the Tarrazú coffee farms undergo a pollinator deficit. As pollinator dynamics in coffee agro-ecosystems are driven by the availability of total flowering resources (Jha and Vandermeer, 2010; Karanja et al., 2010; Peters et al., 2013). Wijayanti et al. (2019) reported that the abundance of predator and parasitoid insects visitors on coffee flowers are also influenced by the distance to *Crotalaria juncea*. The relationship between the distance of *C. juncea* and the abundance of predator and parasitics insects visitors on coffee flowers showed a negative correlation (r = -0.336).

In the present study it is evident that the abundance of beneficial functional groups of Hymenopter are high irrespective of the plant protection measure taken (which has not been considered in this study). Further, seasonal occurrence of different groups of parasitoids may be attributed to different host insects occurring in this ecosystem with multiple crops. Considering the importance of the beneficial impact of the Hymenoptera in this ecosystem, further research can be focused on insect pest specific parasitoid study with amenable methods for more multiplication of the natural enemies to be included in ecologically safe pest management programmes in coffee ecosystems.

ACKNOWLEDGEMENTS

The financial assistance from the School of Post Graduate Studies, Tamil Nadu Agricultural University, Coimbatore is gratefully acknowledged. Hymenoptera identification by Dr. A. Rameshkumar (Chalcidoidea), Dr. K. Rajmohana (Platygastroidea), Ms. Nabasri Basak (Chalcididae) and Mr. Arnab Mandi (Formicidae) is gratefully acknowledged.

REFERENCES

Banks J E, Hannon L, Hanson P, Dietsch T, Castro S, Urena N, Chandler M. 2013. Effects of proximity to forest habitat on hymenoptera diversity in a Costa Rican coffee agroecosystem. Pan-Pacific Entomology 89: 60-68.

Banks J E, Hannon L M, Dietsch T V, Chandler M. 2014. Effects of seasonality and farm proximity to forest on Hymenoptera in Tarrazú coffee farms. International Journal of Biodiversity Science, Ecosystem Services and Management 10(2): 128-132.

Central Coffee Research Centre. 2018. Database on Coffee. Market Research and Intelligence Unit, Central Coffee Research Institute, Coffee Research Station, Chikmagalur. 119 pp.

Dudley N, Baldock D, Nasi R, Stolton S. 2005. Measuring biodiversity and sustainable management in forests and agricultural landscapes. Philosophical Transactions of the Royal Society of London B: Biological Sciences 360(1454): 457-470.

Hasnah, Alfian Rusdy, Muhammad Sayuthi, Susanna, Auliani. 2019. The diversity of arthropods at the Arabica coffee plantation in Atang Junket village, Aceh Tengah district, Indonesia. International Journal of Engineering Research and Advanced Technology 5(2): 46-52.

Hamdi S, Sapdi, Husni. 2015. The composition and community structure of Hymenoptera parasitoid between organically and conventionally managed coffee gardens in Central Aceh District. Journal Floratek 10(2): 44-51.

https://www.alyoung.com/labs/biodiversity_calculator.html (accessed on 10.05.2019)

Janke A, Klopfstein S, Vilhelmsen L, Heraty J H, Sharkey M, Ronquist F. 2013. The Hymenopteran Tree of Life: Evidence from Protein-Coding Genes and Objectively Aligned Ribosomal Data. PLoS ONE 8(8): 69344.

Jha S, Vandermeer J H. 2010. Impacts of coffee agroforestry management on tropical bee communities. Biological Conservation 143: 1423-1431.

Karanja R H N, Njoroge G N, Gikungu M W, Newton L E. 2010. Bee interactions with wild flora around organic and conventional coffee farms in Kiambu district, Central Kenya. Journal of Pollination Ecology 2: 7-12.

Le Pelley R H. 1968. Pests of Coffee. Longmans, Green and Co. Ltd, London. 590p.

Margalef R. 1958. Temporal succession and spatial heterogeneity in phytoplankton In: Perspectives in Marine Biology. University of California Press, Berkeley, pp. 323-347.

Narendran T C, Achterberg C. 2016. Revision of the family Chalcididae (Hymenoptera, Chalcidoidea) from Vietnam, with the description of 13 new species. Zoo Keys 576: 1-202.

Peters V E, Carroll C R, Cooper R J, Greenberg R, Solis M. 2013. The contribution of plant species with a steady-state flowering phenology to native bee conservation and bee pollination services. Insect Conservation and Diversity 6: 45-56.

Pielou E C. 1966. The measurement of diversity in different types of biological collections. Journal of Theoretical Biology 13: 131-144.

Priess J A, Mimler M, Klein A M, Schwarze S, Tscharntke T, Steffan Dewenter I. 2007. Linking deforestation scenarios to pollination services and economic returns in coffee agroforestry systems. Ecological Applications 17(2): pp.407-417.

Shannon C E, Wiener W. 1949. The Mathematical Theory of Communication. University of Illinois Press, Urbana. 177pp.

Simpson E H. 1949. Measurement of species diversity. Nature 163: 688.

Taye R R, Bathari M, Borkataki S, Rahman A. 2017. Diversity of Hymenopteran predators and parasitoids in Assam Agricultural University Campus, Jorhat. Journal of Entomology and Zoology Studies 5(6): 2420-2423.

Wijayanti R, Arniputri B, Puspitarini N, Dwiyatno M H. 2019. The effect of *Crotalaria juncea* plant in coffee ecosystem to the diversity and abundance of predators and parasitoids insects. In IOP Conference Series: Earth and Environmental Science, Indonesia. 2018. p.1.

Wei J N, Yu X W. 1998. A preliminary study on the diversity and control evaluation of natural enemies of coffee stem borers, *Xylotrechus quardripes* and *Acalolepta cervirus* (Coleoptera: Cerambycidae) in Simao region, Yunnan province. Chinese Biodiversity 6(4): 248-252.

(Manuscript Received: May, 2019; Revised: November, 2019;
Accepted: November, 2019; Online Published: November, 2019)