https://doi.org/10.33307/entomon.v44i3.458
ENTOMON 44(3): 173-182 (2019)
Article No. ent. 44302

Comparative studies of mymarid diversity from three different zones of paddy ecosystem in Tamil Nadu, India

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ABSTRACT: Surveys were conducted to explore the mymarid fauna from three different rice growing zones *viz.,* western zone, Cauvery delta zone and high rainfall zone in Tamil Nadu during 2015-16. In the present study, 92 mymarid parasitoids comprising of 8 species under 7 genera *viz., Anagrus* sp., *Anaphes* sp., *Camptoptera* sp., *Dicopus longipes* (Subba Rao), *Lymaenon delhiensis* Narayanan and Subba Rao, *Lymaenon munnarus* Mani and Saraswat, *Mymar pulchellum* Curtis and *Ptilomymar dictyon* Hayat and Anis were collected. Alpha and beta diversity were computed for the three zones and the diversity indices (Simpson's index, Shannon-Wiener index, Pielou's index) revealed high rainfall zone as the most diverse zone, while Cauvery delta zone being the least diverse. *Dicopus longipes* is found to the predominant species in rice ecosystem**.** Jaccard's index of species similarity comparison revealed 42.5 per cent similarity between western and Cauvery delta zones and 62.5 per cent similarity between high rainfall and Cauvery delta zones and 62.5 per cent similarity between high rainfall and western zones. Correspondence analysis and Bray-curtis cluster analysis were also done to understand the diversity assemblage of the mymarids that were collected.

KEY WORDS: Parasitoids, Mymaridae, rice, ecosystem

INTRODUCTION

Rice (*Oryza sativa* L.), is an annual grass native to Asia. Rice fields, together with the associated irrigation ponds, ditches and ridges often constitute the traditional landscape in rural environments and are a key ecosystem of Asia (Kiritani, 2009). Tamil Nadu is one of the leading rice growing states in India, has been cultivating rice from time immemorial as this state is endowed with all favourable climatic conditions for paddy crop. Rice fields harbour a rich and varied fauna than any other agricultural crop (Heckman, 1979; Fritz *et al.,* 2011). The fauna is dominated by micro, meso and macro arthropods inhabiting the soil, water and vegetation sub-habitats of the rice fields. The different communities of terrestrial arthropods in the rice field include pests, their natural enemies (predators and parasitoids) and other neutral insects that inhabit or visit the vegetation as tourists (Heong *et al*., 1991). Insect pests are reported as the major threat to its production. More than 800 species of insects are known to infest rice, of which about 20 species are of economic importance. The overall losses due to insect pest damage in rice are estimated as 25 per cent (Pathak and Dhaliwal, 1981; Dale, 1994).

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Farmers generally rely on insecticides to combat pest problems of rice. Indiscriminate use of insecticides resulted in the loss of biodiversity of beneficial organisms like parasitic hymenopterans (Dudley *et al.,* 2005). Reducing the mortality of parasitic hymenopterans caused by insecticides is essential for greater sustainability in rice pest management (Heong and Hardy, 2009; Gurr *et al*., 2011). If the use of insecticides is to be reduced through Integrated Pest Management, then the consequent reduction in pest control has to be augmented in some way and no doubt, parasitic hymenopterans especially mymarids are the best alternatives to pesticides. They show greater stability to ecosystem than any group of natural enemies of insect pests because they are capable of living and interacting at lower host population level. To aid of pest control, it is essential that the diversity of mymarids needs to be studied (Yoshimoto, 1975).

Mymaridae are internal primary parasitoids of insect eggs (Huber, 1986), particularly Auchenorrhyncha whose eggs are concealed/ embedded within plant tissues, under bark, and in soil. Pupation occurs inside the host egg. Some species have been successful in biological control programs (Clausen, 1978). Diversity of mymarids associated with rice ecosystem is inadequately studied in Tamil Nadu. Hence, the present study was undertaken to explore the diversity of mymarid fauna in rice ecosystems of Tamil Nadu.

MATERIALS AND METHODS

Sites of collection: The survey was carried out in the paddy fields during 2015-16 in three different agro climatic zones of Tamil Nadu *viz.,* western zone (District representation: Coimbatore at, Paddy Breeding Station, Coimbatore, 427 m, 10° 59' 43.24'' N 76° 54' 59.22'' E), Cauvery delta zone (District representation: Thiruvarur at, Krishi Vigyan Kendra, Needamangalam, 26 m, 10° 46' 23.93'' N 79° 25' 0.96'' E) and high rainfall zone (District representation: Kanyakumari at Agricultural Research Station, Thirupathisaram, 17 m, 8° 12' 16.70'' N 77° 26' 57.84'' E). Collections were made for 20 consecutive days in each zone to provide the same weightage as well as minimize chances of variations in collection. The sampling time is decided based on the rice growing season and the stages of the crop *i.e.,* 20 days during August-September, 2015 in western zone, October-November, 2015 in high rainfall zone and December, 2015 – January 2016, in Cauvery delta zone.

Methods of collection: A total of three different gadgets *viz.,* sweep net, yellow pan trap kept at ground level and yellow pan trap erected at canopy levels were used. All the three gadgets were employed continuously for 20 days.

Sweep Net: The portable round sweep net (673 mm mouth diameter and a 1076 mm long aluminum handle) is employed in the present study. Sweeping of vegetation was as random as possible from ground level to the height of the crop. One to and fro motion of the sweep net was considered as one sweep. Thirty sweeps were made half an hour per day in the early morning and late evening hours.

Yellow pan traps kept at ground level: Yellow pan traps are shallow trays of 133 mm × 195mm and 48 mm deep with bright yellow colour. The traps were filled (3/4) with water, a few drops of liquid detergent (to break the surface tension) and a pinch of salt (to reduce the rate of evaporation and to prevent rotting of trapped insects). Twenty yellow pan traps were placed at ground level in each site on the bunds with 1.5 m distance each. The traps were serviced after 24 hours.

Yellow pan traps erected canopy level: Ten erected yellow pan traps per site were installed at the crop canopy with a help of polyvinyl chloride pipes. Rests of the protocol were followed as mentioned previously.

Preservation and identification of the specimens: The collected parasitoids were preserved in 70% ethyl alcohol. The dried specimens were mounted on pointed triangular cards and studied under a Stemi (Zeiss) 2000-C and Photographed under Leica M 205-A stereo zoom microscopes and identified through appropriate keys.

Measurement of diversity:

Relative Density: Relative density of the species was calculated by the formula, Relative Density (%) = (Number of individuals of one species / Number of individuals of all species) X 100.

Alpha Diversity: Alpha diversity of the zones was quantified using Simpson's diversity Index (*SDI*) Shannon-Wiener index (*H'*), Margalef Index (α) and Pielou's Evenness Index (*E1*).

Simpson's Index: Simpson's diversity index is a measure of diversity which takes into account the number of species present, as well as the relative abundance of each species. It is calculated using the formula, $D = \Sigma n\ (n-1)/\ N(N-1)$ where n = total number of organisms of a particular species and N = total number of organisms of all species (Simpson 1949). Subtracting the value of Simpson's diversity index from 1, gives Simpson's Index of Diversity (SID). The value of the index ranges from 0 to 1, the greater the value the greater the sample diversity.

Shannon-Wiener Index: Shannon-Wiener index (*H'*) is another diversity index and is as follows: $H' = -\ \Sigma\ Pi\ \ln(Pi)$, where $Pi = S / N$; S = number of individuals of one species, N = total number of all individuals in the sample, ln = logarithm to base e (Shannon & Wiener 1949). The higher the value of *H'*, the higher the diversity.

Margalef Index: Species richness was calculated for the three zones using the Margalef index which is given as Margalef Index, $\alpha = (S - 1) / \ln(N)$; S = total number of species,

N = total number of individuals in the sample (Margalef 1958).

Pielou's Evenness Index: Species evenness was calculated using the Pielou's Evenness Index (*E1*). Pielou's Evenness Index, $E1=H'/\ln(S)$; H' = Shannon-Wiener diversity index, S = total number of species in the sample (Pielou 1966). As species richness and evenness increase, diversity also increases (Magurran 1988).

Beta Diversity: Beta diversity is a measure of how different (or similar) ranges of habitats are in terms of the variety of species found in them. The most widely used index for assessment of Beta diversity is Jaccard Index (JI) (Jaccard 1912), which is calculated using the equation: JI (for two sites) = $j / (a+b-j)$, where j = the number of species common to both sites A and B,

a = the number of species in site A and b = the number of species in site B. We assumed the data to be normally distributed and adopted parametric statistics for comparing the sites.

Statistical analysis: The statistical test ANOVA was also used to check whether there was any significant difference in the collections from three zones. The data on population number were transformed into X+0.5 square root before statistical analysis. The mean individuals caught from three different zones were analyzed by adopting Randomized block design (RBD) to find least significant difference (LSD). Critical difference (CD) values were calculated at five per cent probability level. All these statistical analyses were done using Microsoft Excel 2016 version and Agres software version 3.01. The multivariate analyses were carried out using PRIMER 7 (Clarke and Gorley, 2015)

RESULTS

In the present study, a total of 92 mymarid individuals comprising of 8 species under 7 genera *viz., Anagrus* sp., *Anaphes* sp., *Camptoptera* sp., *Dicopus longipes* (Subba Rao), *Lymaenon delhiensis* Narayanan and Subba Rao, *Lymaenon munnarus* Mani and Saraswat, *Mymar pulchellum* Curtis and *Ptilomymar dictyon* Hayat and Anis were collected. The host details of the 08 species of mymarids are tabulated (Table. 1).

Dicopus longipes (Subba Rao) is found to the predominant species in paddy ecosystem with a relative abundance of 33.7 per cent. Five species of mymarids were collected from western zone and Cauvery delta zone each whereas 8 species were collected from high rainfall zone. *Anagrus* sp., *Anaphes* sp., and *M. pulchellum* were found in all the three zones. *Lymaenon munnarus* was collected only from high rainfall zone, whereas *D.*

Table 1. Host details of Mymaridae collected in the present study

Parasitoid	Host	Reference
Anagrus sp.	Eggs of Cercopidae, Tingidae, and Odonata (Zygoptera), Cicadellidae and Delphacidae	Lin *et al.,* 2007
Anaphes sp.	Eggs of Curculionidae and Chrysomelidae; also from Argidae, Brenthidae, Byrrhidae, phydridae, Gerridae, Miridae, Tephritidae and Tipulidae	Lin *et al.,* 2007
Camptoptera sp.	Eggs of Scolytidae and Buprestidae, and possibly Cicadellidae, Aleyrodidae and Thripidae	Lin *et al.,* 2007
Dicopus longipes (Subba Rao)	Hemiptera: Diaspididae (*Fiorinia fioriniae* and *Unaspis euonymi*)	Lin *et al.,* 2007
Lymaenon delhiensis Narayanan & Subba Rao	Unknown	-
Lymaenon munnarus (Mani & Saraswat)	Eggs of *Cofana spectra* (Distant), *Nephotettix nigropictus* (Stal); *N. virescens* (Distant)	Zeya and Hayat, 1995
Mymar pulchellum Curtis	Unknown	–
Ptilomymar dictyon Hayat and Anis	Unknown. Probably an aquatic insect because *Ptilomymar* spp. are almost collected with yellow pan traps set on or beside running or standing water	Lin *et al.,* 2007

longipes, and *Comptoptera* sp., were collected from both Cauvery delta and high rainfall zones. *Lymaenon delhinensis* and *P. dictyon* were common to western and high rainfall zones. A significant difference is observed via ANOVA in the occurrence of *D. longipes*, *L. munnarus* and *M. pulchellum* between the zones (Table 2).

Table 2. Comparison of Mymaridae collected from three paddy growing zones of Tamil Nadu

Species	Zones						Total			
	Western		Cauvery Delta		High Rainfall					
	No.	%	No.	%	No.	%	No.	%	F	P
Anagrus sp.	1	6.6	2	4.8	1	2.7	4	4.4	1.66	0.84
Anaphes sp.	1	6.6	3	7.3	6	16.7	10	10.8	1.86	0.16
Camptoptera sp.	0	0.0	5	12.1	1	2.7	6	6.5	2.97	0.05
Dicopus longipes	0	0.0	22	53.6	9	25.0	31	33.7	9.48	0.00
Lymaenon delhiensis	4	26.7	0	0.0	4	11.1	8	8.7	1.40	0.24
Lymaenon munnarus	0	0.0	0	0.0	8	22.2	8	8.7	2.92	0.00
Mymar pulchellum	2	13.3	9	21.9	5	13.8	16	17.4	3.34	0.04
Ptilomymar dictyon	7	46.7	0	0.0	2	5.5	9	9.8	2.58	0.08
Total No. collected	15	-	41	-	36	-	92	-	-	
Species Number	05	-	05	-	08	-	06	-		

%- Relative Density, No.- Total number of individuals collected, F-Value, P-Value

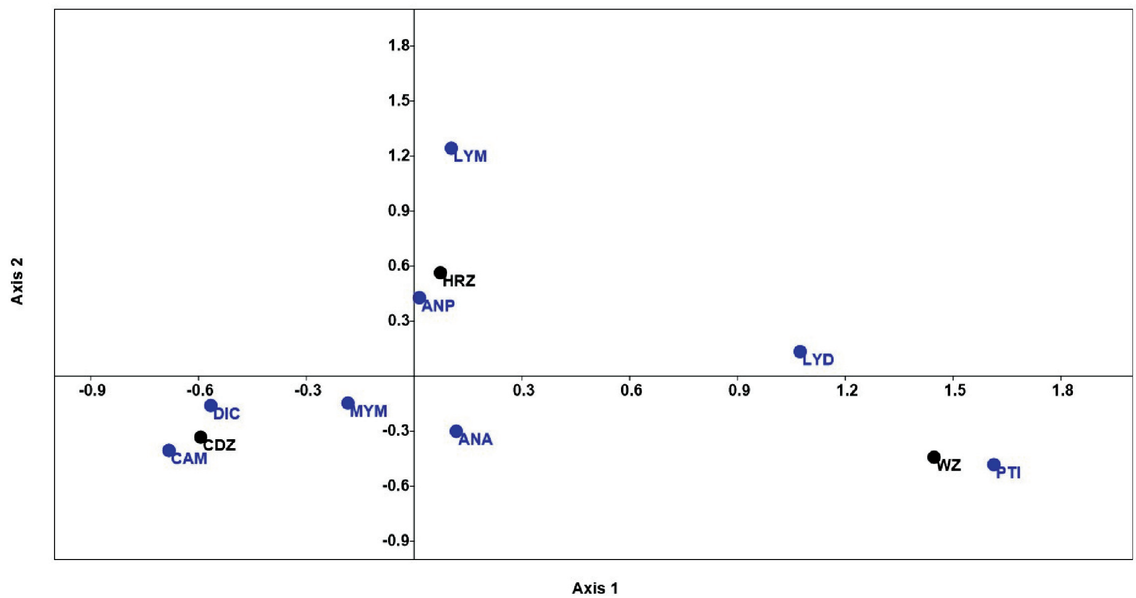

Fig. 1. Correspondence Analysis of mymarid species from three different zones in Tamil Nadu [WZ – Western Zone; CDZ – Cauvery Delta Zone; HRZ – High Rainfall Zone; ANA - *Anagrus*; ANP - *Anaphes*; CAM - *Camptoptera*; DIC - *Dicopus longipes*; LYD - *Lymaenon delhiensis*; LYM - *Lymaenon munnarus*; MYM - *Mymar pulchellum*; PTI - *Ptilomymar dictyon*]

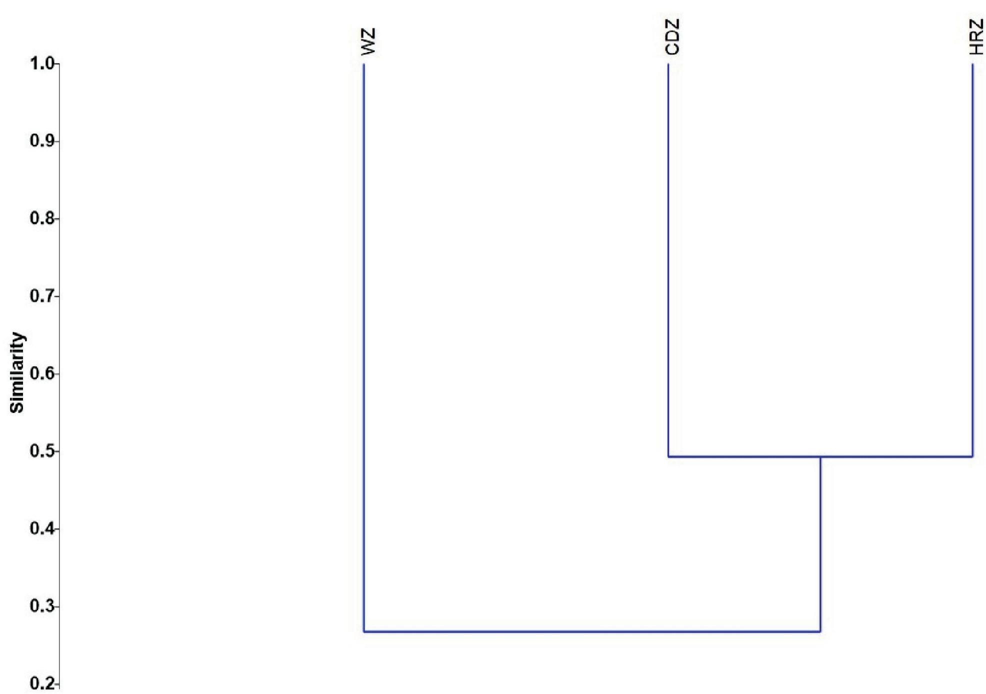

Fig. 2. Bray-curtis cluster anlaysis [WZ – Western Zone; CDZ – Cauvery Delta Zone; HRZ – High Rainfall Zone

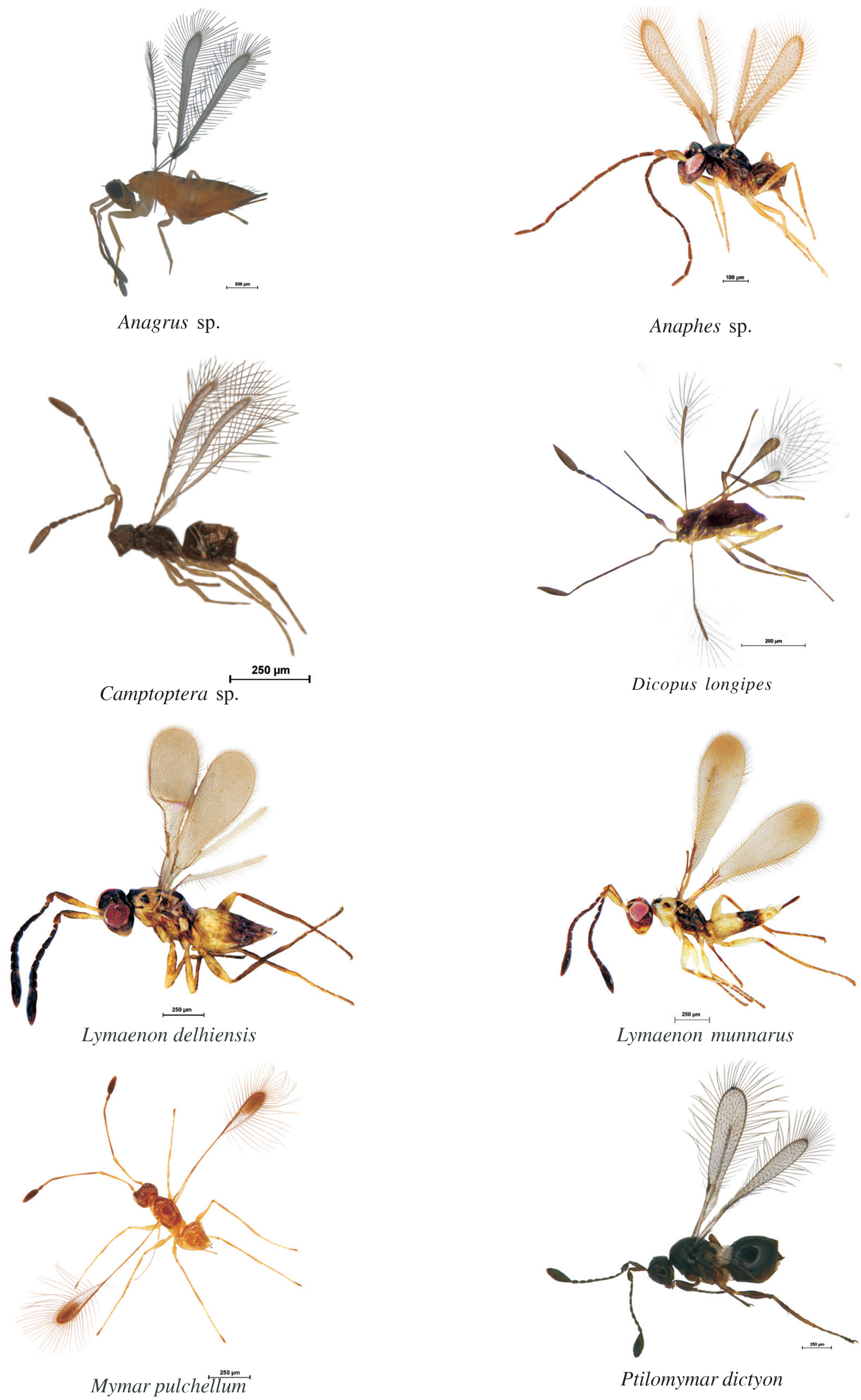

Plate 1. Eight species of Mymaridae collected from three paddy growing zones of Tamil Nadu

Table 3. Diversity indices of Mymaridae from three paddy growing zones of Tamil Nadu

Zones	Mean No. of Mymaridae collected/day	Std. Error	SID	*H'*	α	*E1*	β %
Western	0.75 (1.06)[b]	± 0.20	0.73	0.58	1.47	0.36	W and C – 42.8
Cauvery Delta	2.05 (1.47)[a]	± 0.46	0.65	0.54	1.07	0.33	C and H - 62.5
High Rainfall	1.80 (1.40)[ab]	± 0.42	0.84	0.80	1.95	0.38	H and W – 62.5
S.ED	0.17	-	-	-	-	-	-
CD (p=0.05)	0.35	-	-	-	-	-	-

Figures in parentheses are square root transformed values; In a column, means followed by a common letter(s) are not significantly different by LSD (p=0.05).
SID- Simpson's Index of Diversity, *H'*- Shannon-Wiener Index, α- Margalef index,
E1- Pielou's index, β-Beta diversity (Jaccard Index).
W- Western Zone, C- Cauvery Delta Zone, H- High Rainfall Zone

A mean of 2.05 ± 0.46 mymarids was collected per day from Cauvery delta zone whereas, and from western and high rainfall zones it was 0.75 ± 0.20 and 1.80 ± 0.83, respectively (Table 3). The Simpson's index of diversity was the highest for high rainfall zone (0.84), followed by western zone (0.73) and Cauvery delta zone (0.65). Similar trend was observed in Shannon-Wiener index also, for Western, Cauvery delta and High rainfall zones with values of 0.58, 0.54 and 0.80, respectively. Maximum species richness (1.95) was found in High rainfall zone followed by western zone (1.47) and Cauvery delta zone (1.07), as revealed by Margalef index. The species evenness was recorded maximum in High rainfall zone (0.38) followed by Western zone (0.36) and Cauvery delta zone (0.33).

DISCUSSION

Daniel *et al.* (2017) obtained similar results by conducting experiments to assess the diversity of pteromalids of paddy ecosystems in Tamil Nadu. The species composition among elevation zones can indicate how community structure changes with biotic and abiotic environmental pressures (Shmida and Wilson 1985; Condit *et al.,* 2002). Studies on the effect of elevation on species diversity of taxa such as spiders (Sebastian *et al.,* 2005), moths (Axmacher and Fiedler 2008), paper wasps (Kumar *et al.,* 2008) and ants (Smith *et al.,* 2014) reported that species diversity decreased with increase in altitude. However, according to Janzen (1976), diversity of parasitic Hymenoptera is not as proportionately reduced by elevation as in other insect groups, a fact that is in supports to results of present study. A similar study conducted by Shweta and Rajmohana (2016) to assess the diversity of members belonging to the subfamily Scelioninae also declared that the elevation did not have any major effect on the overall diversity patterns. Similar trend was observed for Shannon- Wiener index also.

Jaccard's index of species similarity comparison revealed that 42.8 per cent similarity between Western and Cauvery delta zones and 62.5 per cent similarity between High rainfall and Cauvery delta zones and 62.5 per cent similarity between High rainfall and Western zones. The elevational diversity gradient (EDG) in ecology proposes that species richness tends to increase as elevation increases, up to a certain point creating "diversity bulge" at moderate elevations (McCain and Grytnes, 2010). The elevation dealt with the present study is ranged from 17-427 m, in this range, species diversity and richness is not showed any correlation *i.e.,* species diversity and richness were not proportional with elevation. Daniel and Ramaraju (2017) were assessed the diversity of Chalcididae among three paddy growing tracts of Tamil Nadu and concluded that there was no correlation between elevation and species richness.

Studies on the altitudinal variation of parasitic Hymenoptera assemblages in an Australian subtropical rainforest by Hall *et al.* (2015), didn't find any distinct assemblage at each altitude, at the morphospecies level, whereas, clear separation between 'upland' and 'lowland' assemblages. The area under cultivation turns out to be a very important factor with respect to abundance and species density in paddy fields (Wilby *et al.* 2006).

The correspondence analysis of species of mymarids were done for three different paddy growing zones (Western Zone, Cauvery Delta Zone and High rainfall Zone) of Tamil Nadu. The contribution of *Dicopus longipes* (DIC), *Camptoptera* (CAM) and *Mymar pulchellum* (MYM) were observed more towards CD zone whereas the contribution of *Anaphes* (ANP) and *Lymaenon munnarus* (LYM) were observed more towards HR zone. The western zone got outlier due to the contribution of *Ptilomymar dictyon* (PTI) and *Lymaenon delhiensis* (LYD). Similarly, the western zone got outlier in Bray-curtis cluster anlaysis (Fig. 2) where the similarity of the site is less than 30% with the remaining selected study sites. In contrast, a cluster was formed between CDZ and HRZ with 50% similarity based on the observed species abundance (Fig.1).

This study reveals the diversity of mymarids of three different paddy ecosystems of Tamil Nadu, where the High rainfall zone is the most diverse and the Cauvery delta zone being the least. The reasons for the significant changes in diversity of parasitoids and their host insects are to be further studied.

ACKNOWLEDGMENTS

Thanks are due to Ministry of Minority Affairs, Government of India for the financial grants through Maulana Azad National Fellowship. Third author is grateful to Dr. Kailash Chandra, Director, Zoological Survey of India, Kolkata for providing facilities and support.

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(Received May 31, 2019; revised ms accepted August 30, 2019; published September 30, 2019)