RESEARCH ARTICLE

Comparision of Eurytomidae and Eupelmidae (Hymenoptera: Chalcidoidea) diversity from three rice growing zones of Tamil Nadu

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ABSTRACT

Rice inhabiting Eurytomidae and Eupelmidae (Hymenoptera; Chalcidoidea) were collected from the western zone, Cauvery delta zone and high rainfall zone of Tamil Nadu during 2015-16. Collected Eurytomidae (105 individuals) and Eupelmidae (81 individuals) comprised 8 genera and 12 species. *Neobepharata* sp. (Eurytomidae) and *Mesocomys* sp. (Eupelmidae) were the most abundant fauna among all the species observed with the relative abundance of 24.0 and 50.6 per cent respectively.

Keywords: *Diversity, Hymenopterans, Parasitoids, Eurytomidae, Eupelmidae, Rice Ecosystem.*

INTRODUCTION

Rice fields have unique characteristics that make them ideal grounds for diverse biological organisms (Heckman, 1979; Fritz *et al.,* 2011). Insect pests are a the major threat in rice production. More than 800 species of insects are known to infest rice, of which about 20 species are of economic importance (Pathak and Dhaliwal, 1981). 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). Parasitic hymenopterans especially Chlacidoids are the best alternatives to pesticides. They show greater stability to the ecosystem than any group of natural enemies of insect pests because they are capable of living and interacting at the lower host population level. To aid this means of pest control, it is essential that the diversity of parasitoids needs to be studied first (Dey *et al.,* 1999).

Eurytomidae and Eupelmidae (Hymenoptera; Chalcidoidea) are minutes, 2-3 mm usually, and often either missed in entomological collections. These Chalcidoids are generally parasitic and sometimes predaceous on Lepidoptera, Hemiptera, Diptera, Coleoptera, Neuroptera and Orthoptera (Claridge, 1959; Muesebeck & Dohanian, 1927; Morris, 1938 and Askew, 1961). A few species of Eurytomidae are also phytophagous (Varley, 1937).

The diversity of Eupelmidae and Eurytomidae associated with rice ecosystem is poorly studied and far from satisfaction especially in Tamil Nadu. Additional knowledge on diversity, taxonomy and biology is of potential practical value in rice insect pest management. Globally only 7 species each of Eupelmidae and Eurytomidae have been recorded in rice (Dey *et al*., 1999). From Tamil Nadu *Anastatus coimbatorensis* Girault alone has been recorded so far (Ramachandra Rao, 1921). Hence, to fill this void in research and considering the importance of hymenopterans, the present study was undertaken to explore the diversity of Eupelmidae and Eurytomidae in rice ecosystems of Tamil Nadu.

MATERIAL AND METHODS

Sites of collection

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

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November, 2015 in high rainfall zone and December, 2015 – January 2016, in Cauvery delta zone.

Sweep net of standard size (hoop rim 673 mm diameter and 1076 mm lenght handle) were used. Per day 30 sweeps were swept for collection. (One to and fro motion of the sweep net was considered as one sweep). Yellow pan traps @ 10 (133 mm × 195mm and 48 mm depth) were kept at canopy levels (around ½ meter high) and 20 nos were kept in ground levels at a distance of 1.5 m. These traps were half- filled with water containing a few drops of commercially available detergent (to break the surface tension) and a pinch of salt (to reduce the rate of evaporation and to prevent rotting of trapped insects).

Preservation and identification of the specimens.

The collected parasitoids were preserved in 70 per cent ethyl alcohol. The dried specimens were mounted on pointed triangular cards and studied under a Stemi (Zeiss) 2000-C and photographed under stereozoom microscope (Leica M205 A) and identified with keys of as Islam and Hayat (1986) and Narendran (1994). The identified specimens were submitted in Insect Biosystematics Laboratory, Tamil Nadu Agricultural University, Coimbatore.

Measurement of diversity

Relative abundance (Magurran 1988), alpha diversity *viz*., Simpson's index (Simpson 1949), Shannon-Wiener Index (Shannon & Wiener 1949), Margalef richness index (Margalef 1958) and Pielou's Evenness Index (Pielou 1966) and beta diversity using Jaccard Index (Jaccard 1912) were calculated using an online software Biodiversity Calculator (https://www.alyoung.com/labs/biodiversity_calculator.html).

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 was 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 the 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.

RESULTS AND DISCUSSION

Eupelmidae

Eupelminae is of interest because of the unique adaptation of the sclerites and muscles of the mesothorax for jumping. This peculiar mechanism was first noticed by Walsh and Riley (1869) when they published a description of what was later called the "back-rolling wonder"(Clausen, 1927). Duet o this jumping behaviour eupelmines often die in a contorted state with the head and gaster reflexed upwards and often nearly meeting over the thorax. The middle legs are often held in front of the head after death which is very much useful while sorting them from assorted samples.

Table 1. Comparison of Eupelmidae and Eurytomidae collected from three rice growing zones of Tamil Nadu

Species	Zones						Total			
	Western		Cauvery Delta		High Rainfall					
	No.	%	No.	%	No.	%	No.	%	F	P
Eupelmidae										
Anastatus sp.	4	20.0	0	0.0	5	11.9	9	11.1	1.82	0.17
Eupelmus sp.	0	0.0	0	0.0	8	19.0	8	9.9	2.92	0.06
Mesocomys sp.	9	45.0	11	57.9	21	50.0	41	50.6	1.32	0.27
Neanastatus sp. 1	0	0.0	0	0.0	1	2.4	1	1.2	1.00	0.37
Neanastatus sp. 2	6	30.0	7	36.8	5	11.9	18	22.2	0.02	0.97
Neanastatus sp. 3	1	5.0	1	5.3	2	4.8	4	4.9	0.16	0.82
Total No. collected	20	-	19	-	42	-	81	-		-
Species Number	04	-	03	-	06	-	06	-		
Eurytomidae										
Bruchophagus sp.	0	0.0	0	0.0	11	16.4	11	8.8	4.60	0.01
Eurytoma sp 1	14	35.9	8	42.1	7	10.4	29	23.2	0.79	0.45
Eurytoma sp 2	0	0.0	0	0.0	16	23.9	16	12.8	4.50	0.01
Eurytoma sp 3	9	23.1	5	26.3	5	7.5	19	15.2	0.53	0.58
Neobepharata sp.	4	10.3	0	0.0	26	38.8	30	24.0	5.10	0.00
Tetramesa sp.	12	30.8	6	31.6	2	3.0	20		2.34	0.10
Total No. collected	39	-	19	-	67	-	105	-		-
Species Number	04	-	03	-	06	-	06	-		

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

A total of 81 eupelmid individuals belonging to two sub families *viz*., Eupelminae and Neanastatinae were collected in the present study. Under the sub family Eupelminae, three species were collected *viz., Anastatus* sp., *Eupelmus* sp. and *Mesocomys* sp. Under the subfamily Neanastatinae, three different species of *Neanastatus* were collected. All the 6 species were collected from high rainfall zone, three from Cauvery delta zone and four from the western zone. *Mesocomys* sp. was the most abundant species in the rice ecosystem having a relative abundance of 50.6 per cent. No significant difference between the zones for eupelmids was obtained in the ANOVA test (Table 1). Seven species of Eupelmidae were reported worldwide and only, three are from India *viz*., *Anastatus coimbatorensis* Girault, *Neanastatus grallarius* (Masi.) and *Neanatatus* sp. (Dey *et al.,* 1999).

A mean number of 2.10 ± 0.75 eupelmids were collected per day from high rainfall zone and for the western zone and Cauvery delta zone, it was 1.00 ± 0.29 and 0.95 ± 0.35, respectively. The Simpson's index of Diversity was the highest for high rainfall zone (0.69), followed by western zone (0.59) and Cauvery delta zone (0.55) (Table 2). A similar trend was observed in Shannon-Wiener index also, for western, Cauvery delta and high rainfall zones having values of 0.51, 0.36 and 0.60, respectively. The values of Margalef index for the three zones revealed that maximum richness (1.33) was accounted for high rainfall zone followed by western zone (1.00) and Cauvery delta zone (0.67). The species evenness was maximum for the western zone (0.37) and for the Cauvery delta zone and high rainfall zone, it was 0.33. Comparison of species similarities using the Jaccard's index between the three sites taken in pairs, reveals 75 per cent similarity between western and Cauvery delta zones and 50 per cent similarity between high rainfall and Cauvery delta zones and 66 per cent similarity between high rainfall and western zones.

Table 2. Diversity indices of Eupelmidae and Eurytomidae from three rice growing zones of Tamil Nadu

Zones	**Mean No. of Eupelmidae collected/day**	**Std. Error**	**SID**	***H'***	α	***E1***	β **%**
Western	1.00 (1.13)	0.29	0.59	0.51	1.00	0.37	W and C – 75
Cauvery Delta	0.95 (1.10)	0.35	0.55	0.36	0.67	0.33	C and H - 50
High Rainfall	2.10 (1.41)	0.75	0.69	0.60	1.33	0.33	H and W – 66
S.ED	0.20	-	-	-	-	-	-
CD (p=0.05)	0.41	-	-	-	-	-	-
Zones	**Mean No. of Eurytomidae collected/day**	**Std. Error**	**SID**	***H'***	α	***E1***	β **%**
Western	1.55 $(1.24)^{ab}$	0.57	0.73	0.56	0.82	0.40	W and C – 75
Cauvery Delta	0.95 $(1.08)^{b}$	0.37	0.69	0.47	0.68	0.43	C and H - 50
High Rainfall	3.35 $(1.64)^{a}$	1.11	0.75	0.67	1.18	0.37	H and W – 66
S.ED	0.26	-	-	-	-	-	-
CD (p=0.05)	0.53	-	-	-	-	-	-

*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

Eurytomidae

A total of 105 eurytomid individuals were collected in the present study that represents 4 genera and 6 species *viz., Bruchophagus* sp., three different species under the genera *Eurytoma*, *Neobepharata* sp. and *Tetramesa* sp. Table 1 reveals that *Neobepharata* sp. was the predominant species in the rice ecosystem having a relative abundance of 24.0 per cent. A total of 4 species were collected from the western zone, 3 from Cauvery delta zone and 6 from high rainfall zone. Species such as *Eurytoma* sp 1 and sp 3. and *Tetramesa* sp. were obtained from all the three zones. *Burchophagus* sp. and *Eurytoma* sp 2 were found only from high rainfall zone. *Neobepharata* sp. was found common to western zone and high rainfall zone. The ANOVA test results indicated a significant difference between the zones for *Bruchophagus* sp., *Eurytoma* sp 2 and *Neobepharata* sp. So far, only 7 species of Eurytomidae were reported from rice ecosystems around the world of which only 3 species are from India *viz*., *Eurytoma anilensis* Ashmead, *Eurytoma setitibia* Gahan and *Eutytoma* sp. (Dey *et al*., 1999).

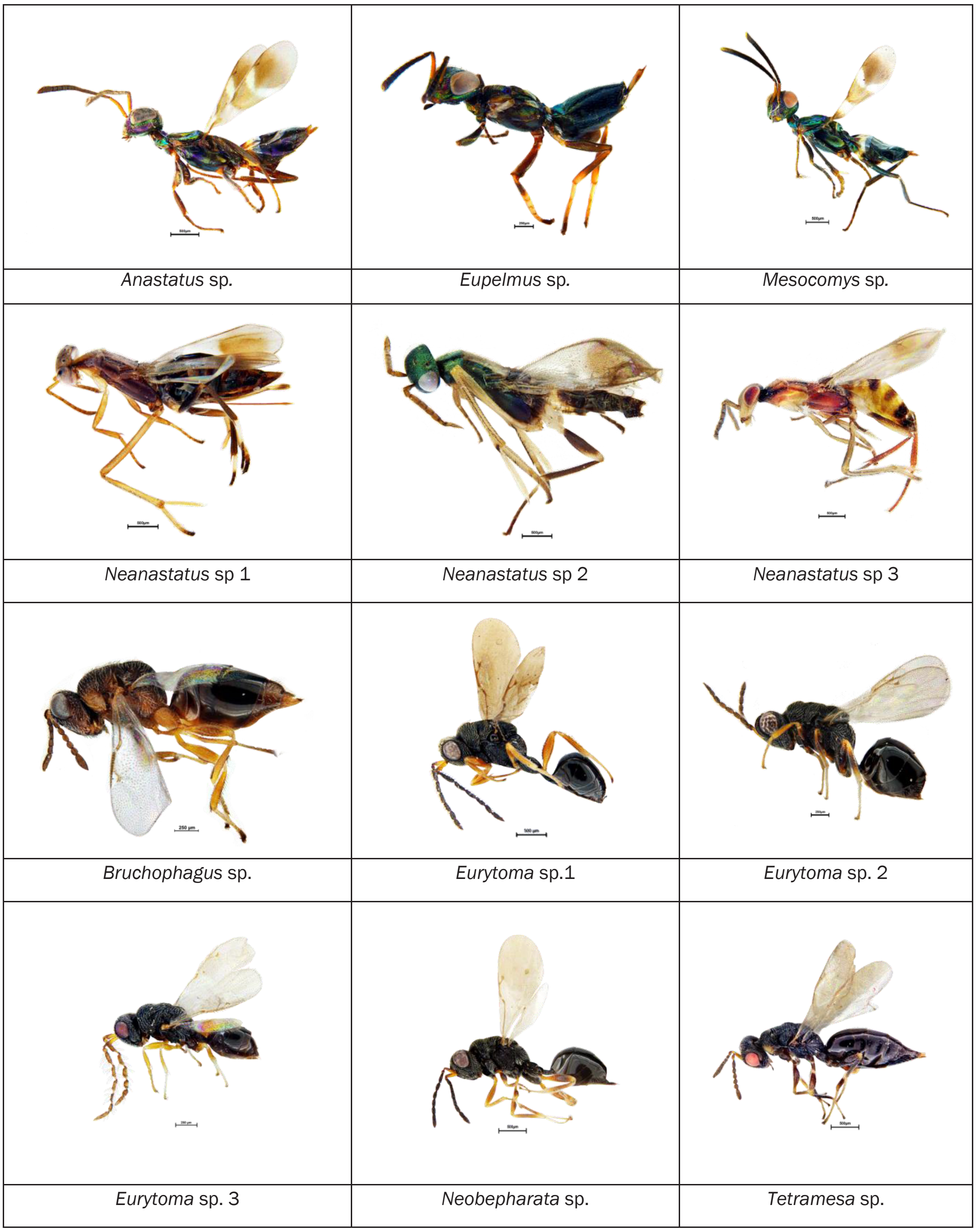
Table 3. Eupelmidae and Eurytomidae collected in the study along with their host

Parasitoid	Host	Reference
Eupelmidae		
Anastatus sp.	Pentatomidae Acrididae	Stahl *et al.* (2019) Ramachandra Rao (1921)
Eupelmus sp.	Chrysomelidae	Cortesero and Monge (1994)
Mesocomys sp.	Bombycoidea	Van den Berg (1970)
Neanastatus sp.1 *Neanastatus* sp. 2 *Neanastatus* sp. 3	Cecidomyiidae	Kobayashi *et al.* (1990)
Eurytomidae		
Bruchophagus sp.	Sesbania seeds	Batiste (1967)
Eurytoma sp. 1 *Eurytoma* sp. 2 *Eurytoma* sp. 3	Ephydridae Braconidae Hesperiidae	Narendran *et al.* (2006) Gates and Delvare (2008) Narendran (2001)
Neobepharata sp.	Acrididae	Menon *et al.* (2016)
Tetramesa sp.	Poaceae	Goolsby and Moran (2009)

A mean of 3.35 ± 1.11, 1.55 ± 0.57 and 0.95 ± 0.37 eurytomids per day was collected per day form high rainfall, western and Cauvery delta zones, respectively (Table 2). The Simpson's index of Diversity was the highest for high rainfall zone (0.75), followed by the western zone (0.73) and Cauvery delta zone (0.69). Similar trend was observed in Shannon-Wiener index also for western, Cauvery delta and high rainfall zones with values of 0.56, 0.47 and 0.67, respectively. The values of Margalef index for the three zones revealed that maximum richness (1.18) was accounted for high rainfall zone followed by western zone (0.82) and Cauvery delta zone (0.68). The species evenness was maximum for Cauvery delta zone (0.43), whereas the western zone and high rainfall zone recorded 0.40 and 0.33, respectively. Comparison of species similarities using the Jaccard's index in between the three sites taken in pairs; revealed 75 per cent similarity between western zone and Cauvery delta zone, 50 per cent similarity between high rainfall zone and Cauvery delta zone and 66 per cent similarity between high rainfall zone and western zone. All the eupelmids and eurytomids that were collected are presented in Fig. 1. The host details of all the collected eurytomids and eupelmids are tabulated (Table. 3).

Daniel *et al.* (2017; 2019b) obtained similar results by conducting experiments to assess the diversity of pteromalids and Braconid of rice ecosystems in Tamil Nadu. The species composition among elevational 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 & 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 support of our results. 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 all diversity patterns. 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 in this work ranged from 17-427 m which was not very high. So taking into account the scale and extent of elevational gradients, it can be said that species diversity and richness have not show any correlation i.e. species diversity and richness were not proportional to that of elevation. Daniel and Ramaraju (2017) assessed the diversity of chalcididae among three rice growing tracts of Tamil Nadu and concluded that there was no correlation between elevation and species richness. This fact supports our present study.

Studies on the altitudinal variation of parasitic Hymenoptera assemblages in an Australian sub-tropical rainforest by Hall *et al.* (2015) did not record any distinct assemblage at each altitude, at the morphospecies level, even though there was a clear separation between 'upland' and 'lowland' assemblages. To detect minute changes in species assemblages, species-level sorting is found to give the best result (Grimbacher *et al.,* 2008). The area under cultivation turns out to be a very important factor with respect to abundance and species density in rice fields (Wilby *et al.,* 2006). The number of species in a habitat increases with increase in area (Gotelli and Graves, 1996). Only few studies have demonstrated the importance of different varieties in attracting the natural enemies (Scutareanu *et al.,* 1997; De Moraes *et al.,* 1998; Thaler, 1999; Kessler and Baldwin, 2001; Lou *et al.,* 2005; Rasmann *et al.,* 2005 and Daniel *et al.,* 2019a). Lack of success in biological control programs has often been caused by the high mortality of parasitoids due to climatic extremes (Daniel *et al.,* 2019c). Therefore, more researches like this should be encouraged to understand



Anastatus sp. | *Eupelmus* sp. | *Mesocomys* sp.

Neanastatus sp 1 | *Neanastatus* sp 2 | *Neanastatus* sp 3

Bruchophagus sp. | *Eurytoma* sp.1 | *Eurytoma* sp. 2

Eurytoma sp. 3 | *Neobepharata* sp. | *Tetramesa* sp.

Figure 1. Eupelmidae and Eurytomidae from three rice growing zones of Tamil Nadu

the underpinnings between varietal preferences, climatic conditions and parasitoid diversity.

CONCLUSION

This study reveals the diversity of Eupelmidae and Eurytomidae of three different rice ecosystems of Tamil Nadu. The reasons for the significant changes in the diversity of these parasitoids and their host insects are to be further studied. There is much scope for research to be take on these aspects.

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