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Diversity of Hymenopteran Egg Parasitoids in Organic and Conventional Paddy Ecosystems

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ABSTRACT. *Organic farming; cultivation without chemical pesticides and fertilizers, has been known to promote the general plant diversity as well as animal diversity including many groups of animal taxa. The objectives of this study was to prepare a generic level systematic inventory of egg parasitoids, and compare the species diversity and richness between organic and conventional paddy ecosystems, which are two differently managed agroecosystems. The study also aimed to examine whether the differences in the management practices have any vital effect on the diversity of the functional groups, the hymenopteran egg parasitoids in particular, when the major physical parameters like soil, temperature and rainfall, remained constant. Altogether 40 species of egg parasitoids in 23 genera belonging to 5 families (Platygastridae, Mymaridae, Encyrtidae, Eulophidae and Trichogrammatidae) were identified in both paddy ecosystems. Out of the 40 species, 29 belong to 16 genera of family Platygastridae. The number of species found in organic and conventional ecosystems was 32 and 22, respectively. Simpson's diversity index was also higher (0.978) in organic ecosystem compared to conventional paddy ecosystem (0.878).The functional group analysis of hymenopteran egg parasitoids reflected a uniform pattern of higher functional redundancy in all the functional groups in the organic ecosystem than in the conventional ecosystem. However, egg parasitoid communities present in both ecosystems share less taxonomic similarities.*

Key words: *Conventional paddy, egg parasitoids, hymenoptera, organic paddy, Kerala*

INTRODUCTION

Many studies in the recent past have suggested that organic farming enhances the biodiversity in agricultural landscapes compared with conventional farming. Though organic system enhances species richness and abundance, its effects are likely to differ between organism groups and landscapes (Hole *et al.*, 2005; Bengtsson *et al.,* 2005).

Groups of species that perform similar roles in an ecosystem process are known as functional types or functional groups. Most of the ecosystem processes are driven by the combined biological activities of many species under same and varied functional groups (Naeem *et al.,* 1999). The functional groups assessed in this study were egg parasitoids, the group often occupying the third strata in the trophic level/food web. Egg parasitoids are organisms that both attack and complete their development within a host egg (Mills, 1994). Members

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belonging to Mymaridae and Trichogrammatidae (Chalcidoidea) and Telenominae, Teleasinae and Scelioninae of Platygastridae (Platygastroidea) are exclusively egg parasitoids (Austin *et al.*, 2005). In addition, a few species among the chalcid families like Eulophidae, Encyrtidae, Pteromalidae and Eupelmidae are also known to attack the eggs of other insects and arthropods (Noyes, 2011).

This study was aimed to prepare a generic level systematic inventory and make a comparison of species diversity and richness of egg parasitoids, between an organic and a conventional paddy ecosystem. The study also analysed the impact of the cultural/management practices on functional redundancy (number of parasitoid species within functional groups), in both the agrosystems and thus yields a better understanding on the dynamics of the egg parasitoid communities.

MATERIALS AND METHODS

Field sites

This study was conducted in Palakkad (Fig. 1), a district located in the central Kerala, a south Indian state. In Palakkad, paddy cultivated area accounts for about 60% of the net cultivated area in the district, hence Palakkad is often termed as the Rice-bowl of Kerala or the 'state granary' (Govt. of Kerala, 2011).

Site description

Organic and Conventional paddy ecosystems at Palakkad were selected that were under different cultural practices. The two study areas are situated at Chittur Taluk (Fig. 1), one of the major paddy producing regions of Palakkad. Both the study areas were in the Black soil zone (KAU, 2011). The major climatic parameters, like temperature and rainfall have been the same in both the sites.

Site 1: Conventional paddy: This site (10^0 68' N and 76^0 72' E) which was under conventional farming cultural practices, had a hybrid variety, *'Palakkadan matta', ('Jyothi')*, developed by Kerala Agricultural University, Thrissur (Kerala, India). Organophosphate pesticides (Metacid 50 EC: 500 ml in 500 l water/ha, Monocrotophos 36 EC (0.06%): 835 ml per 500 l water/ha) and Pseudomonas (1 kg/acre) were employed to control the pests. Potash (75 kg/ha), Urea (90 kg/ha) and Factomphos (90 kg/ha) were added as fertilisers. Samples were collected when the crop was in the post-flowering stage.

Site 2: Organic paddy: This site (10^0 69' N and 76^0 72' E) was maintained as organic paddy system. Traditional variety '*Navara*', medicinal rice was used. No chemical pesticides or synthetic fertilizers were applied in this field; the farm manures were used to supply the nutrients. Samples were collected when the crop was in the flowering stage. The site has been an organic one for more than five years.

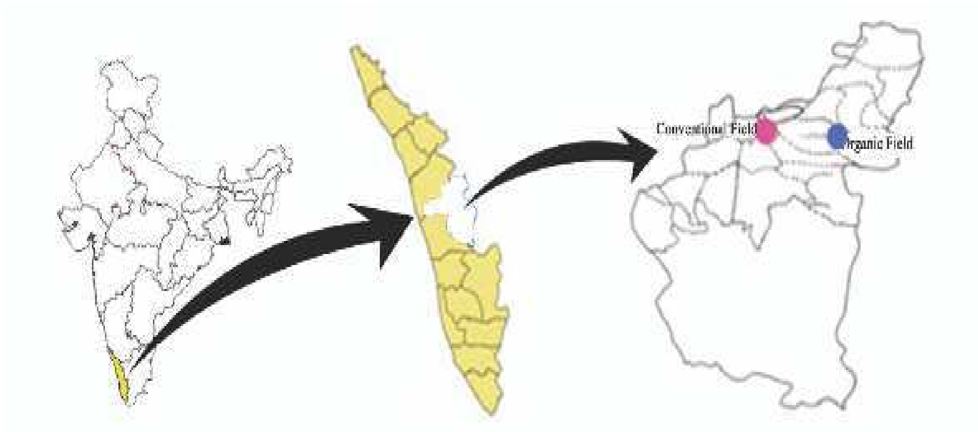

Fig. 1. The study sites, Chittur Taluk (Palakkad, Kerala)

Insect sampling

Malaise traps are widely used for catching flying insects (Ganho & Marinoni, 2003), especially dipteran and hymenopteran insects (Selfa *et al.*, 2003). Since Malaise trap collections are essentially standardized (Mason & Bordera, 2008), the data could be used for meaningful statistical analyses. This study employed malaise traps (Fig. 2) for collecting insects. Two malaise traps were installed in these sites, for 3 weeks duration, from Feb-April, 2011. The trap was emptied only once a week, thus generating 3 subsets of data replicates from both the fields.

The insects were preserved in 70% alcohol. HMDS (hexamethyldisalicylate) was employed as the drying agent. The dried specimens were mounted on pointed triangular cards and studied under Olympus SZ 61 and Leica M 205-A stereomicroscopes, at a magnification of 60 to 160X.

Fig. 2. A Malaise trap set in the paddy field

Identification of egg parasitoids

Families that are exclusively egg parasitoids like Mymaridae and Trichogrammatidae (Chalcidoidea) and 3 subfamilies of Platygastridae (Scelioninae, Telenominae and Teleasinae) were identified and sorted to morpho-species level. In Encyrtidae, only the exclusive egg parasitoid genus *Ooencyrtus* was considered for this study.

Egg parasitoids collected were identified with the help of available taxonomic keys to the genera of different families. Genera under superfamily Chalcidoidea except Mymaridae were identified using a dichotomous key used by Subba Rao & Hayat (1985). Mymarid genera were identified using key to Australian Mymaridae by Lin *et al.* (2007) and Platygastroid genera were identified with the help of Masner (1976) as well as the interactive key by Rajmohana *et al.* (2011).

Species richness and diversity of egg parasitoids in organic and conventional paddy ecosystems

All the 3 series of samples collected from individual sites were pooled together to create a single large sample providing the most comprehensive description of the parasitoid community structure at each site.

Alpha Diversity/Simpson's Diversity Index (SDI) and Beta Diversity/the Jaccard index (JI) were used to analyse the data. SDI is a measure of diversity which takes into account the number of species present, as well as the relative abundance of each species. SDI 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.

As species richness and evenness increase, diversity also increases (Magurran, 1988). The value of '*D*' ranges between 0 and 1. With this index, 1 represents infinite diversity and 0, no diversity. There is no necessity to have the taxonomic identify of all the species, provided they can be distinguished from each other.

Beta or differentiation diversity is a measure of how different (or similar) ranges of habitats or samples are in terms of the variety of species found in them (Magurran, 1988). The most widely used index is JI, which is calculated using the equation: $C_J=j/(a+b-j)$, where j=the number of species common to both sites *a*=the number of species in site A and *b*=the number of species in site B.

Functional group analysis

There are a variety of approaches for defining functional groups, which reflect the ecological question being addressed and the state of knowledge of focus organisms (Hooper *et al.*, 2002). Each parasitoid species in this study has been assigned to one of the functional groups according to host range. Broad host ranges of the parasitoids were compiled from literature, as given in Table 1. This study classified the egg parasitoids into 5 functional groups. Thus, each species was categorized as one among the egg parasitoid of - Lepidoptera (LP), Hemiptera (HP), Orthoptera (OP), Coleoptera (CP) or spiders (SP). Data from the 3 samplings of 1 week duration from each study site were combined and used to calculate the average number of parasitoid species per functional group per farm (referred to as functional group species richness).

Table 1. Hymenopteran egg parasitoid recorded and their functional group in organic and conventionally grown rice

No.	Family	Genus	Functional group	Reference
1	Trichogrammatidae	*Trichogramma*	LP	Noyes, 2011
2	Eulophidae	*Tetrastrichus*	LP	Noyes, 2011
3	Encyrtidae	*Ooencyrtus*	HP	Noyes, 2011
4	Mymaridae	*Mymar*	HP	Huber, 1997
		Gonatocerus	HP	Huber, 1997
		Anagrus	HP	Huber, 1997
		Polynema	HP	Huber, 1997
5	Platygastridae	*Scelio*	HP	Rajmohana *et al.* 2011
		Ceratobaeus	SP	Rajmohana *et al.* 2011
		Telenomus	LP, HP	Rajmohana *et al.* 2011
		Trimorus	CP	Rajmohana *et al.* 2011
		Baryconus	OP	Rajmohana *et al.* 2011
		Gryon	HP	Rajmohana *et al.* 2011
		Macroteleia	OP	Rajmohana *et al.* 2011
		Cremastobaeus	OP?	Rajmohana *et al.* 2011
		Trissolcus	HP	Rajmohana *et al.* 2011
		Platyscelio	OP	Rajmohana *et al.* 2011
		Habroteleia	OP	Masner, 1976
		Opisthacantha	OP	Rajmohana *et al.* 2011
		Probaryconus	OP?	Rajmohana *et al.* 2011
		Palpoteleia	OP?	Rajmohana *et al.* 2011
		Psix	HP	Rajmohana *et al.* 2011
		Xenomerus	CP	Rajmohana *et al.* 2011

LP-Lepidoptera, HP-Hemiptera, OP-Orthoptera, CP-Coleoptera or SP-spider

RESULTS AND DISCUSSION

Generic level systematic inventory of egg parasitoids in organic and conventional paddy ecosystems

Total of 40 species under 23 genera belonging to 5 families (Platygastridae, Mymaridae, Encyrtidae, Eulophidae and Trichogrammatidae) were found as egg parasitoids in both paddy ecosystems. Among them, the family Platygastridae (Superfamily Platygastroidea) stands highest in species diversity with 29 species under 16 genera. Mymaridae (Superfamily Chalcidoidea) stands second highest in diversity with 4 genera and 8 species. Eulophidae, Encyrtidae and Trichogrammatidae also have their representation with one genus each. Genus *Telenomus* Haliday with 8 species topped the list while many other genera were represented only by single species (Fig. 3).

Species richness and diversity of egg parasitoids in organic and conventional paddy ecosystems

Enhanced natural enemy abundance has been reported in several studies of organic systems (Fuller *et al.,* 2005). In this study, a total of 20 genera and 32 species under 5 families of hymenopteran egg parasitoids were recorded in organic paddy, where as only 22 species under 16 genera were identified in conventional paddy (Fig. 3). Usage of agrochemicals can be an accountable factor responsible for the comparatively lower species of egg parasitoids richness in the conventional paddy ecosystem.

Diversity indices

The species under all the egg parasitoid genera were sorted into morphospecies/ Recognizable Taxonomic Units and the individuals were counted for computing the diversity, similarity and richness indices.

The SDI was used for calculating the species richness and evenness between the sites. The indices were 0.977 and 0.898 for organic paddy and conventional paddy respectively. The value near to 1 indicates a high species diversity and richness of egg parasitoids. This inturn denotes that differences in cultural practices have little influence in the diversity and richness of egg parasitoids, one of the groups occupying the third trophic level in the food web. It can be assumed that eggs parasitoids are not severely affected by the practice of pesticide application in conventional farming. This may be due to the concealed sites of the host eggs or the presence of differential egg coverings like scales and hairs rendering protection to eggs from direct exposure to insecticide applications. Some insecticides fail to penetrate the host egg-chorion (Plewka *et al.,* 1975), while adverse effects of some insecticides on egg parasitoids seem to be much less compared to that on larval parasitoids (Preetha *et al.,* 2010).

The observed JI value of 0.358 means that only 35% of similarity exists between the communities of egg parasitoids among both the ecosystems.

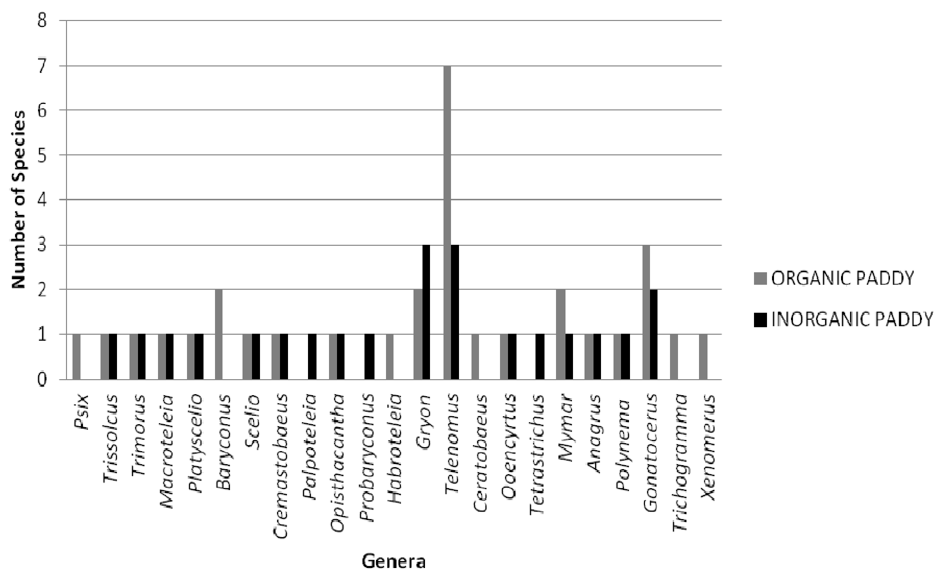

Fig. 3. Species diversity and richness of egg parasitoids in organic and conventional paddy ecosystems in Chittur during Feb-April 2011

Functional group redundancy

The functional group analysis of the egg parasitoids reflected a uniform pattern regarding all the groups (Fig. 4). As per the result of this analysis, the number of parasitoid species within all the 5 functional groups considered is higher in the organic farm, than that in the conventional one. This finding is very well in line with the result of a similar study in the recent by Macfadyen *et al.* (2011), in Southwest England, which also reported that the larger number of species within the functional groups in an organic system can render an increased temporal stability in parasitism rates.

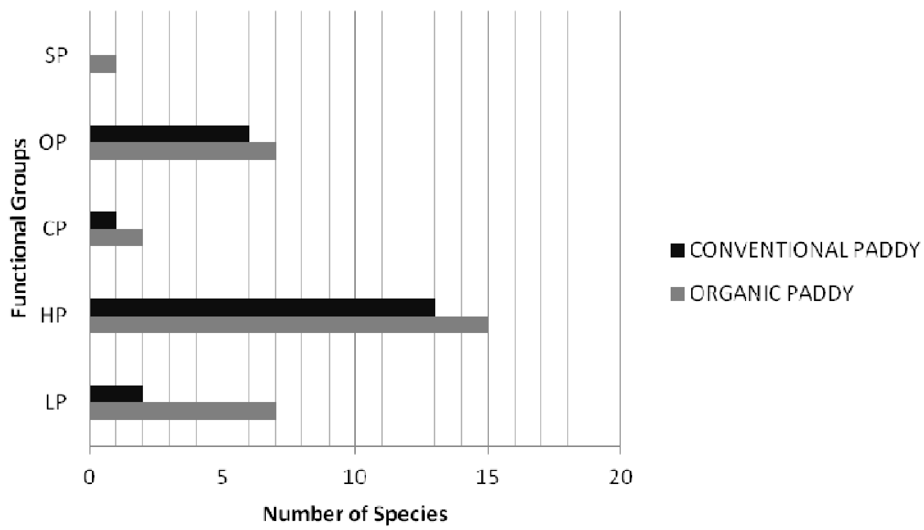

Fig. 4. Functional group redundancy of egg parasitoids in organic and conventional paddy ecosystems in Chittur during Feb-April 2011

CONCLUSIONS

The organic paddy ecosystem contained more species of hymenopteran egg parasitoids than the conventional paddy, as supported by the higher value of the SDI (0.978>0.878). Since a higher species richness and diversity reflects a healthier and a more stable state of an ecosystem, it can be concluded that the organic paddy ecosystem is a much more stable and healthier ecosystem than that of the conventional one. However, since SDI is near to 1 in both cases, it appears that the differences in cultural practices have practically no profound influence over the species richness of egg parasitoids. It was also found that the community of hymenopteran egg parasitoids in organic and conventional paddy ecosystems are taxonomically not very similar. In the light of the above study it can also be concluded that the functional redundancy of the species in all the functional groups of hymenopteran egg parasitoids is uniformly higher in organic paddy compared with that of the conventional paddy ecosystem.

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REFERENCES

Austin, A.D., Johnson, N.F. and Downton, M. (2005). Systematics, evolution, and biology of Scelionid and platygastrid wasps. Annu. Rev. Entomol. *50*, 553-82.

Bengtsson, J., Ahnstrom, J. and Weibull, A.C. (2005). The effects of organic agriculture on biodiversity and abundance: a meta-analysis. J. Appl. Ecol. *42*, 261-269. doi:10.1111/j.1365-2664.2005.01005.x.

Fuller, R.J., Norton, L.R., Feber, R.E., Johnson**, P.**J. and Chamberlain, D.E. (2005). Benefits of organic farming to biodiversity vary among taxa. Biol. Lett. *1*, 431-34.

Ganho, N.G. and Marinoni, R.C. (2003). Fauna de Coleoptera no Parque Estadual de Vila Velha, Ponta Grossa, Parana, Brasil. Abundancia e riqueza das familias capturadas atraves de armadilhas malaise. Revta Bras. Zool*.* *20*, 727-736.

Govt. of Kerala. (2011). Palakkad [online]. [Accessed on 6.09.2011]. Available at http://www.palakkad.nic.in/

Hooper, D.U., Solan, M., Symstad, A., Diaz, S., Gessner, M.A. and Buchman, N. (2002). Species diversity, functional diversity, and ecosystem functioning. In Biodiversity and ecosystem functioning: synthesis and perspectives, M. Loreau, S. Naeem & P. Inchausti (eds) pp. 195-208. New York, NY: Oxford University Press.

Hole, D.G., Perkins, A.J., Wilson, J.D., Alexander, I.H., Grice, F. and Evans, A.D. (2005). Does organic farming benefit biodiversity? Biol. Conserv. *122*, 113-130. doi:10.1016/j.biocon.2004.07.018.

Huber, J.T. (1997). *Chapter 14. Mymaridae. in* Gibson, G.A.P., Huber, J.T. and Woolley, J.B. *Annotated keys to the genera of Nearctic Chalcidoidea (Hymenoptera).* NRC Research Press, Ottawa. Pp. 499–530.

Kerala Agricultural University (2011). Rice Info. Genetic Database on rice [online]. [Accessed on 15.08.2011]. Available at http://kaubic.in/rice%20info/html/kau.html

Lin, N., Huber, J.T. and LaSalle, J. (2007). Australian genera of Mymaridae (Hymenoptera: Insecta). Zootaxa *1596*, 1-111.

Macfadyen, S., Craze, P.G., Polaszek, A., Achterberg, K.V. and Memmott, J. (2011). Parasitoid diversity reduces the variability in pest control services across time on farms. Proc. R. Soc. B. published online before print March 30. doi: 10.1098/rspb.2010.2673.

Magurran, E.A. (1988). Ecological Diversity and its Measurement. Croom Helm*,* Australia. 179pp.

Masner, L. (1976). Revisionary notes and keys to world genera of Scelionidae (Hymenoptera: Proctotrupoidea). Mem. Entomol. Soc. Can. *113*, 1-54.

Mason, M. and Bordera, S. (2008). Effectiveness of two sampling methods used for collecting Ichneumonidae (Hymenoptera) in Cabaneros national park (Spain). Eur. J. Entomol. *105*, 879-888.

Mills, N.J. (1994). Parasitoid guilds: defining the structure of the parasitoid communities of endopterygote insect hosts. Environ Entomol. *23*, 1066-1983.

Naeem, S., Chapin, T., Costanza, R., Ehrlich, P., Golley, F.B., Hooper, D., Lawton, J.H., O'Neil, R., Mooney, H., Sala, O., Symstad, A. and Tilman, D. (1999). Biodiversity and Ecosystem Functioning. Ecological Issues. *4*, 1-12.

Noyes, J.S. (2011). Universal Chalcidoidea data base [online]. [Accessed on 06.09.2011]. Available at
http://www.nhm.ac.uk/research-curation/research/projects/chalcidoids/database/ .

Plewka, T., Kot, J. and Krukierek, T. (1975). Effect of insecticides on the longevity and fecundity of *Trichogramma evanescens* (Hymenoptera: Trichogrammatidae). Pol. Ecol. Stud. *1*, 197- 210.

Preetha, G. , Manoharan, T., Stanley, J., Kuttalam S. (2010). Impact of Chloronicotinyl insecticide, imidacloprid on egg, egg-larval and larval parasitoids under Laboratory conditions. J. Plant Protection Res. *50(4),* 535-540.

Rajmohana, K., Bijoy, C. and Radhakrishnan, C. (2011). Interactive identification system for the common genera for the Platygastrid egg parasitoids of rice ecosystem of Kerala (India) [online]. [Accessed on 15.08.2011]. Available at at
http://zsi.gov.in/right_menu/IIS/index.html .

Selfa J., Motilla F., Ribes A., Rosello J. and Dominguez A. (2003). Abundancia de los ordenes de insectos en cuatro sistemas agronomicos mediterraneos. Phytoma Esp. *151*, 24-30.

Subba Rao, B.R. and Hayat, M. (1985). The Chalcidoidea (Insecta: Hymenoptera) of India and the adjacent countries. Orient. Insects. *19*, 163-310.

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