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Diversity and Relative Abundance of Insect Pests and Natural Enemies in Organic Rice

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A study was conducted to decipher diversity and relative abundance of insect pests, hemipteran predators and hymenopteran parasitoids in organic rice transplanted at the research farm of the Indian Institute of Rice Research, Rajendranagar, Hyderabad during *Rabi*, 2020. Yellow pan traps, visual count, yellow sticky traps, sweep net and D-net methods were used for collecting insect specimens. A total of 543 insect pest individuals belonging to 12 families, 678 Hemipteran predators belonging to 9 families and 2193 parasitoids of 10 families were collected. The most abundant families among insect pests, predators and parasitoids were Cicadellidae, Miridae and Eulophidae with a relative abundance of 32.41, 81.56 and 72.55%, respectively. Shannon weiner

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index of insect pests, predators and parasitoids was 1.81, 0.72 and 0.99 respectively. Further, Margelef diversity index of insect pests, predators and parasitoids was 1.75, 1.23 and 1.43, respectively. Furthermore, the Pielou's eveness index was 0.73, 0.33 and 0.40, respectively. Visual count for pests, yellow sticky traps for predators and parasitoids were adjudged the most effective methods of collection.

Keywords: Organic rice; insect diversity; relative abundance; Margelef diversity index; Pielou's eveness index.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is an important staple crop worldwide, cultivated in regions with warm climates and ample moisture, predominantly in subtropical areas. Globally, it is cultivated in more than hundred countries, covering a total harvested area of approximately 158 million hectares and yielding more than 700 million tonnes annually (equivalent to 470 million tonnes of milled rice). Asia alone accounts for nearly 640 million tonnes, constituting 90% of global production. Yields vary widely, from less than 1 tonne per hectare in challenging rainfed conditions to over 10 tonnes per hectare in intensive irrigated systems in temperate regions. In the financial year 2023, India achieved a record production of over 135 million metric tons of rice [1].

Conventional rice cultivation has often accomplished high yields and stable crop production, but has been heavily dependent on continuous and excessive inputs of chemical pesticides, which lead to pest resistance, resurgence, pesticide residue, ground water contamination and risk to human health and animal habitats [2] [3]. The increasing awareness of these harmful effects of intensive chemical use in agriculture has led to a global shift towards organic farming [4]. Organic farms typically exhibit higher levels of biological diversity compared to conventional farms reliant on chemical inputs. This diversity supports varied biological communities, encompassing insect pests, natural predators, and weeds [5]. Among the biotic factors that regulate the population dynamics of insect pests, the predators and parasitoids serve the key mortality factors of pets. If there is an increase in the pest population, is simultaneously followed by an increase in the natural enemy population (numerical response) and increase in feeding power (functional response) [6]. This approach underscores the importance of biological control methods in organic farming, emphasizing sustainability and reduced reliance on synthetic pesticides. Hence, the current study was conducted to quantify the diversity and relative abundance of insect pests along with their hemipteran and hymenopteran natural enemies in organic rice ecosystem.

2. MATERIALS AND METHODS

The experiment was conducted at the research fields of Indian Institute of Rice Research, Rajendranagar, Hyderabad during *Rabi*, 2020. The rice variety BPT 5204 (Samba Mahsuri) was raised in 900 square meters plots, with three replications. The main field was well-puddled, and 25-day-old seedlings were transplanted at a spacing of 20 cm x 10 cm. In a nursery of 10 sq. m area, 5kg rice husk + 5kg vermicompost were applied. In the main field, 18 kg neem cake + 900 kg FYM per plot were applied. Observations on abundance of insect pests and natural enemies in the field were recorded at 30, 45, 60, 90, and 120 days after transplanting (DAT) during morning hours when insects were inactive. Various collection methods such as yellow pan traps (YST) (3 traps per plot), visual counts (VC) and collections from randomly selected 20 hills in 1 m² quadrats (5 quadrats per plot), sweep netting (SN) across plots (five sweeps at five points), yellow sticky traps (YST) (5 traps per plot), and D-Net for collection of aquatic insects were used. Collected insects were categorized into orders and families. Hemipteran and Hymenoptera families were identified using respective keys [7] [8]. Statistical analyses included calculations of the Shannon-Wiener diversity index, Margalef's species richness index, and Pielou's evenness index using PAST (Paleontological Statistics Tool) version 4.03 software (https://past.en.lo4d.com/windows#google_vignette). Additionally, the relative abundance (RA) of each family was computed using the formula:

$$\text{Relative abundance (\%)} = n_i \times 100 / N,$$

where N represents the total number of individuals across all families, and ni denotes the number of individuals in the i^{th} family.

3. RESULTS AND DISCUSSION

In the current study, a total of 543 individuals of insect pests belonging to 12 families of 6 orders were recorded (Table 1). Relative abundance of Cicadellidae was highest (32.41%) followed by Delphacidae (22.10%) and Pentatomodae (13.63%). Sweep net was effective in collecting majority of pest taxa (34%) followed by visual count (32%) and yellow sticky trap (28%) (Fig. 1A). Sweep net and yellow sticky trap collected 8 families each (Fig. 2A). A field study assessed the effect of organic manures on the incidence of insect pests of rice and reported that organically manured plots showed significant ($P<0.05$) decrease in gall midge (6.61-9.25 per cent) and leaf folder (11.75-13.46 per cent) incidence compared with the check (12.94 per cent and 22.70 per cent, respectively) [9]. Lowest incidence of leaf folder, brown plant hopper (BPH) and whorl maggot in organic plots compared to both purely inorganic and combination of organic and inorganic nitrogen fertilizer sources. Percent increase of leaf folder, BPH and whorl maggot was 220.00, 326.76 and 147.72 per cent in purely nitrogen fertilizer source treatment [10]. In a study, report included 34 species of insects. Out of which 11 were pests including plant hoppers, leaf hoppers, bugs and others belonged to orders Lepidoptera, Thysanoptera (rice thrips) and Coleoptera [11].

In the present study, a total 678 specimens of hemipteran predators belonging to 9 families were collected. Relative abundance of Miridae was highest (81.56%) followed by Pentatomidae (11.21%) (Table 2). Yellow sticky traps were very effective means of collection of Hemipteran predators (50%) followed by visual counting (41.74%) (Fig. 1B); however, more diverse families were collected in the D-net method (5 families) (Fig. 2B). A total of 12 families of Hymenopteran parasitoids, added up to 2193 number of individuals were collected. Relative abundance of Eulophidae was highest (72.55%) followed by Trichogrammatidae (9.35%) and Scelionidae (8.53) (Table 3). Yellow sticky traps were proved most effective for the collection of parasitoids (90%) followed by yellow pan traps (6%) (Fig. 1C); however, in yellow pan traps 10 families were recorded (Fig. 2C). Diversity indices of pests, Hemipteran predators and Hymenopteran parasitoids are presented in Table 4.

Parasitoid average abundance was significantly higher on organically managed rice (25.38 ± 6.85) than in conventionally managed areas (8.41 ± 3.40). The most abundant families in rice crop were Platygastridae, Mymaridae, Encyrtidae, Eulophidae and Trichogrammatidae. [12]. In an account of study, nine parasitoid species were recorded including 3 egg parasitoids (*Trichogramma chilonis, Trichogramma japonicum*, and *Telenomus* sp.), 3 larval parasitoids (*Stenobracon nicevillei, Bracon sp., and Cotesia* sp.), and 3 pupal parasitoids (*Tetrastichus* sp., *Brachymeria* sp., and *Xanthopimpla* sp.). Results revealed that natural parasitism by these parasitoids was significantly higher in organic than conventional rice [13]. Bio-agents such as *T. japonicum* and *T. chilonis* have proven effectiveness against pests like stem borers and leaf folders [14]. A report documented 3,184 Hymenopteran parasitoids, 2,038 individuals in the Non cut subarea and 1,146 in the Cut subarea of organically grown rice and identified 458 morphospecies distributed in 24 families. Mymaridae was the most abundant family with 914 individuals followed by Platygastridae with 550 individuals and Encyrtidae with 333 and Eulophidae was the richest in both subareas. A total of 198 morphospecies were shared between the subareas, including Platygastridae (40), Eulophidae (36), and Mymaridae (21), which were the families with the highest number of shared species. The Morisita index (0.78) identified three groupings, indicating a similarity that was related to the three phases of rice growth and development: seedling, vegetative and post-harvest [15]. Altogether 40 species of egg parasitoids in 23 genera belonging to 5 families (Platygastridae, Mymaridae, Encyrtidae, Eulophidae and Trichogrammatidae). Out of these, 29 belonged to 16 genera of family Platygastridae while 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) [16]. An increased population of natural enemies (Hymenopteran parasitoids) of leaf folder viz., *Apanteles* spp, *Brachymeria* spp, *Goniozus* spp, *Macrocentres* spp and *Elasmus* spp. were recorded in the *Pseudomonas* treated plots under field conditions [17]. It is concluded that the yellow sticky traps [18] and yellow pan traps [19] are highly effective in attracting many herbivorous hemipterans, and hymenopteran parasitoids, making them ideal for sampling and studying these insects.

Table 1. Methods of collection of pests of rice and relative abundance of families in organic rice

Order	Families	Number of individuals	Method/s of collection	Relative abundance (%)
Lepidoptera	Crambidae	52	SN, VC	9.58
	Hespiriidae	1	VC	0.18
	Nymphalidae	2	SN	0.37
	Arctiidae	3	SN, VC	0.55
Orthoptera	Acrididae	72	SN	13.26
Hemiptera	Delphacidae	120	YPT, VC,YST,DN	22.10
	Cicadellidae	176	YPT, SN, VC,YST	32.41
	Pentatomidae	74	SN, VC	13.63
	Alydidae	24	SN, VC	4.42
Coleoptera	Chrysomelidae	6	SN, VC	1.10
Diptera	Cecidomyiidae	1	YST	0.18
Thysanoptera	Thripidae	12	YPT	2.21
	Total	**543**		

(SN- Sweep Net; VC- Visual Count method; DN- D-Net Collection; YPT- Yellow Pan Trap; YST- Yellow Sticky Trap)

Table 2. Methods of collection of Hemipteran predators and relative abundance of families in organic rice

Families	Number of individuals	Method/s of collection	Relative abundance (%)
Miridae	553	VC, YST,DN	81.56
Pentatomidae	76	SN, VC,YST	11.21
Geocoridae	8	YPT, SN	1.18
Veliidae	13	DN	1.92
Mesoveliidae	16	DN	2.36
Corixidae	6	DN	0.88
Gerridae	1	DN	0.15
Nebidae	3	SN, VC,YST	0.44
Saldidae	2	YPT	0.29
Total	**678**		

(SN- Sweep Net; VC- Visual Count method; DN- D-Net Collection; YPT- Yellow Pan Trap; YST- Yellow Sticky Trap)

Table 3. Methods of collection of Hymenopteran parasitoids and relative abundance of families in organic rice

Families	Number of individuals	Method/s of collection	Relative abundance (%)
Eulophidae	1591	YPT,VC,YST	72.55
Scelionidae	187	YPT,YST	8.53
Trichogrammatidae	205	YPT,YST	9.35
Braconidae	6	YPT,SN,YST	0.27
Ichneumonidae	15	SN,YST	0.68
Diapriidae	10	YPT	0.46
Mymaridae	154	YPT,YST	7.02
Dryinidae	11	VC	0.50
Platygastridae	7	YPT	0.32
Torymidae	4	YPT	0.18
Ceraphronidae	2	YPT	0.09
Chalcididae	1	YPT	0.05
Total	**2193**		

(SN- Sweep Net; VC- Visual Count method; DN- D-Net Collection; YPT- Yellow Pan Trap; YST- Yellow Sticky Trap)

Table 4. Diversity indices

Indices	Insect pests	Hemipteran predators	Hymenopteran parasitoids
Shannon weiner index	1.81	0.72	0.99
Margelef diversity index	1.75	1.23	1.43
Pielou's eveness index	0.73	0.33	0.40

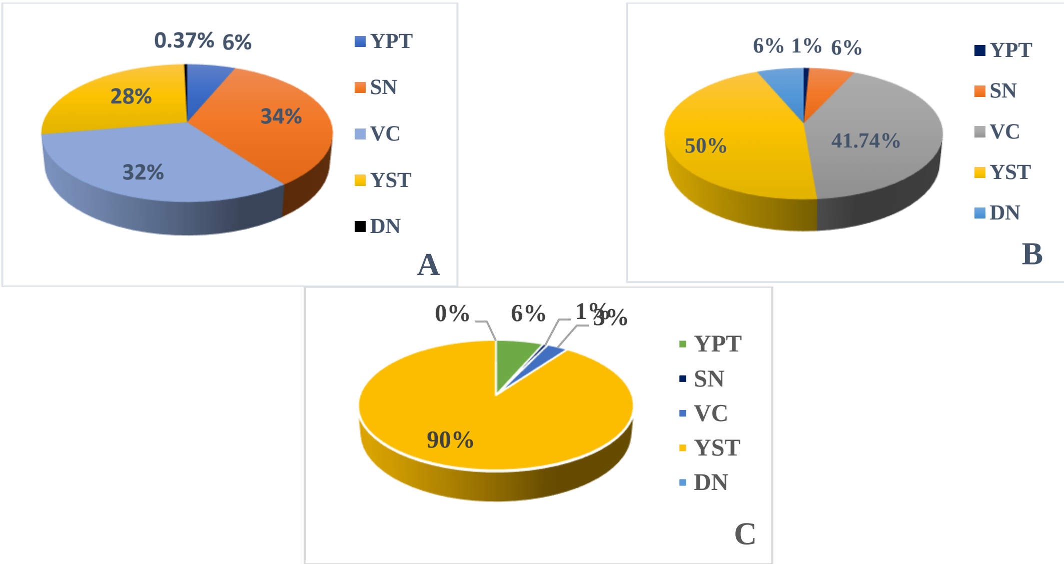

Fig. 1. Percent contribution of methods of collection to number of individuals Pests (A), Hemipteran predators (B), Hymenopteran parasitoids (C) in organic rice

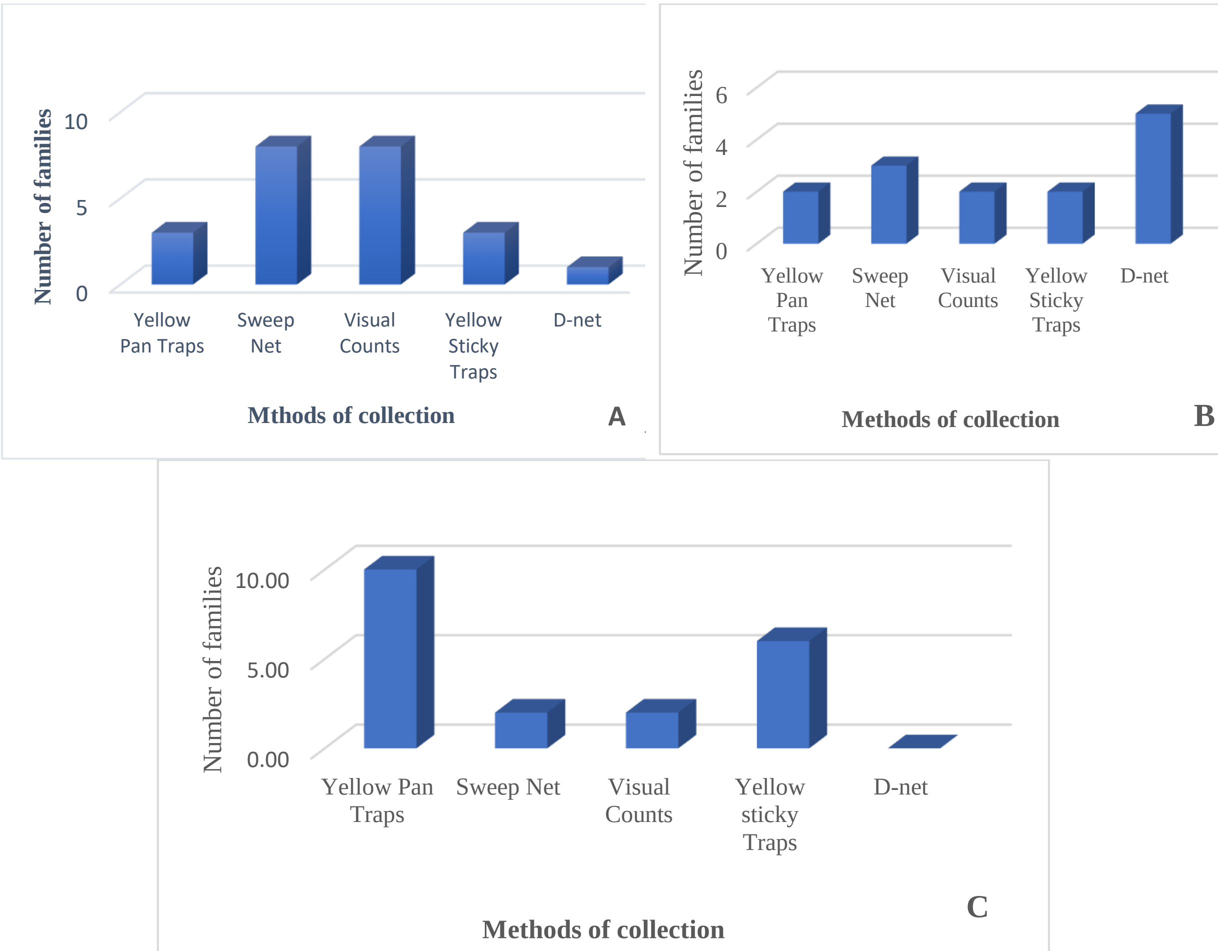

Fig. 2. Number of families in each method of collection (A) Pests (B) Hemipteran predators (C) Hymenopteran parasitoids in organic rice

4. CONCLUSION

The present study, shown that organic rice supported rich diversity and abundance of natural enemies of Hemiptera and Hymenoptera which could be an approach for conservation of natural enemies for natural regulation of pests, which in turn reduces usage of chemical pesticides. This study also evaluated and concluded that visual count and yellow sticky traps are the effective methods of collection for pests and predators and parasitoids, respectively, which are could be utilized in the sampling programmes of pest management.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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