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Dharini SV
Department of Entomology, Geographical Information System, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Chitra N
Department of Entomology, Geographical Information System, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Sheela Venugopal
Department of Rice, Geographical Information System, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Kumaraperumal R
Department of Remote Sensing, Geographical Information System, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Corresponding Author
Chitra N
Department of Entomology, Geographical Information System, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Diversity of orthoptera in rice fields of India

Dharini SV, Chitra N, Sheela Venugopal and Kumaraperumal R

Abstract
Orthoptera collected from rice fields of Coimbatore and Bhavanisagar, India comprised Acrididae (4 species), Pyrgomorphidae (1 species), Tetrigidae (2 species), Tridactylidae (1 species), Tettigoniidae (4 species), and Gryllidae (3 species). The assemblage included herbivore (9 species), carnivores (3 species) and omnivores (3 species). *Conocephalus rentzi* Farooki and Usmani, 2018 (Tettigoniidae) is recorded for the first time in Tamil Nadu. The dominant fauna included *Oxya hyla*, *O. fuscovittata* (Acrididae) and *Metioche vittaticollis* (Gryllidae). Abundance of *Hieroglyphus banian* (Acrididae) and *Eucriotettix tricarinatus* (Tetrigidae) were observed to be minimal. Among the two places of study, the species richness, diversity and evenness of Coimbatore (α 2.34, *H'* 2.62, and J' 0.44) was higher than that of Bhavanisagar (α 2.03, *H'* 1.66, and J' 0.37). Jaccard index shows 67% of similarity between Coimbatore and Bhavanisagar.

Keywords: orthoptera, rice, India, species richness, diversity and evenness

Introduction
Rice fields contribute to richness in diversity by providing valuable habitat to many wetland species. Although wide range of taxon have been studied in this ecosystem, functional role and economic significance of Orthoptera needs further exploration. This study becomes mandatory, since Orthopteran fauna stand to be a significant element in maintaining biodiversity of arable land (Giuliano and Bogliani, 2018) [15]. Orthoptera feed on weed seeds thus offering assistance in restricting weed expansion (Ichihara *et al.*, 2014) [19] and also are the important food resources for predatory birds (Barker, 2004; Rodriguez and Bustamante, 2008; Bretagnolle *et al.*, 2010; Fasola and Cardarelli, 2014) [4, 34, 9, 32]. Grasshoppers are often considered as useful markers of healthy grasslands by contributing to the reduction in species richness and population density, thereby significantly augmenting management efficiency (Marini *et al.*, 2007) [28]. Pioneering works concentrated on taxonomy of Orthoptera in India include Kirby (1914) [23], Uvarov (1927) [40] and Chopard (1969) [11] and elsewhere (Bei-Bienko and Mishchenko, 1951 [5]; Dirsh, 1961; Hollis, 1975 [16]; Otte and Alexander, 1983) [30]. Checklisting of Orthopteran fauna in India was given by Shishodia *et al.* (2010) [38], whereas Bhowmik (1993) and Vasanth (1993) covered Western Himalayas and north-east India. Bhowmik (1985a; 1985b) [6, 7] and Shishodia (1991) [37] studied zoogeography of acridids, gryllids and tetrigids in India. However, limited studies have been undertaken Orthoptera in rice in India *viz.*, Chitra *et al.* (2000) [10] and Kandibane *et al.* (2004) [21]. Hence, the present study was undertaken to study the diversity of Orthoptera and its functional significance in rice ecosystems of Coimbatore and Bhavanisagar, Tamil Nadu, India.

Materials and Methods
Study site
Coimbatore: Coimbatore lies at 11˚1' 6" N 76˚58' 21" E at 411 meters above mean sea level along the banks of Noyyal River in northwestern Tamil Nadu. It is bordered by the Western Ghats mountain range in the West and forest range of the Nilgiris Biosphere Reserve in the North. Enriched with abundant flora and fauna, Coimbatore is included in area around the Western Ghats which is recognised as the World Heritage Site by UNESCO.

Bhavanisagar: Bhavanisagar lies at 11˚28' 8" N 77˚7' 22" E in Erode district of Tamil Nadu, India. The perennial river Cauvery forms the eastern boundary with the lower Bhavani dam constructed across the Bhavani River.

Sampling methods

The Orthopteran fauna were collected from the rice fields of Tamil Nadu Agricultural University (TNAU), Coimbatore and Agricultural Research Station (ARS), Bhavanisagar. The collected specimens were killed with chloroform (99.8%) and subsequently pinned and labelled. The dry preserved specimens were deposited in the TNAU Insect Museum. Imaging of the specimens were taken with Leica M205C through LAS X Application Suite montage software and Nikon D3100. Identification of fauna was carried out following the works of Kirby (1914) [23], Chopard (1969) [11] and Farooki and Usmani (2018) [14]. Relative abundance (percent) of families belonging to order Orthoptera and functional groups of Orthoptera from rice fields of Coimbatore and Bhavanisagar was calculated in MS Excel using the following formula,

Relative abundance (%) = (Number of individuals of one species / Number of individuals of all species) x 100

Biodiversity indices *viz.*, Margalef's index of Species Richness (α) (Margalef, 1958) [27], Shannon-Wiener Index of Diversity (*H'*) (Shannon and Wiener, 1949) [36] and Peilou's Evenness index (Peilou, 1966) were calculated for Orthopteran fauna with https://www.alyoung.com/labs/biodiversity_calculator.html.

Further, Berger-Parker Dominance index (May, 1975) [29], Jaccard index of Similarity (Jaccard, 1912) [20], and Sorenson's Similarity index (Sorenson, 1948) were also calculated.

Results and Discussion

This study revealed the presence of Pyrgomorphidae (1 species), Tetrigidae (2 species), Tridactylidae (1 species), Tettigoniidae (4 species), and Gryllidae (3 species). (Tab. 1; Fig. 1). It was observed that *Oxya hyla, Oxya fuscovittata and Metioche vittaticollis* were found to be the most dominant while *Hieroglyphus banian* and *Eucriotettix tricarinatus* were the least recorded fauna. The order of dominance of the Orthoptera was Acrididae (39%) > Gryllidae (29%) > Tettigoniidae (15%), Tetrigidae (7%) > Pygrgomorphidae and Tridactylidae (Fig. 2). The functional diversity of Orthoptera in rice comprised herbivores Acrididae (4 species), Pyrgomorphidae, Tetrigidae, Tridactylidae and Tettigoniidae (1 species each), Tetrigidae carnivores (3 species) and omnivores (2 species) and the functional role of *Conocephalus rentzi* remains undetermined (Table 2; Fig. 3). The occurrence of herbivores (59%) were found to be the maximum followed by carnivores (29%) and omnivores (12%). The herbivorous nature of *Oxya fuscovittata, O. hyla, H. banian, Trilophidia annulata, Atractomorpha crenulata, Paratettix scaber, Eucriotettix tricarinatus, Xya japonica,* and *Phaneroptera gracilis* has been previously reported in rice by Ayyar (1940) [1], Ballard (1921) [2], Banu and Kushawa (1974); Chitra *et al.* (2000) [10]. Similarly, the omnivorous nature of *Conocephalus longipennis* and *C. maculatus* were reported to feed on mature grains by making vertical cuts on leaf blades and also feed on adults of leaf and plant hoppers, eggs and immature stages of stem borers and leaf folders (Pitkin, 1980; Manley, 1985) [33, 26]. In addition being herbivorous they were reported to be predatory as well (Chitra *et al.*, 2000) [10] *Metioche bicolor, M. vittaticollis,* and *O. indicus* documented as predators in the present study which is also confirmed by the reports of Rubia and Shepard (1987) [35] and Kraker (1996) [24] who have highlighted that M. *vittaticollis* were efficient predators of eggs of leaf folders and nymphs of hopper pests of rice.

The herbivores in the present study gradually increased in numbers from tillering to panicle initiation. However, when crop matured to harvesting stage, the abundance of herbivores considerably lesser comparatively (Fig. 4). Lanjar *et al.* (2002) [25] reported that three weeks after transplanting rice crop, nymphal activity of grasshoppers reached maximum and adult infestation lasts till crop maturity. Carnivores gradually increased during tillering stage and almost the same population prevailed till maturity. During phases of active tillering and early panicle initiation, de Kraker (1999) [12] noticed egg and larval peaks of leaf folders in rice. Omnivores attained the maximum numbers during crop maturity. Khan (2013) [22] reported that habitats influence the population dynamics of pests and predators in rice. Habitat, crop growth stages and cultivation practices in rice significantly contribute to the diversity of insect communities (Hurlbert *et al*., 1989) [17] further confirm our results.

Further, when the two sampling locations are compared, it exhibited variations in case of carnivore populations. Rice fields of Bhavanisagar showed no carnivore populations during our study. However, populations of omnivores and herbivores do not reveal significant differences in their diversity in both locations. Diversity index (*H'*), species richness (α) and evenness (J') showed higher values for Coimbatore (2.62, 2.34 and 0.44) than Bhavanisagar (1.66, 2.03 and 0.37) (Table 3). Jaccard's and Sorenson's Similarity index exhibits a similarity of 67 per cent and 80per cent in the distribution of Orthopteran fauna from the rice fields of Coimbatore and Bhavanisagar respectively.

Berger- Parker Dominance index values for Bhavanisagar (D= 0.36) was higher than that of Coimbatore (D= 0.17). Though relative abundance of Genus *Oxya* and *Metioche* were higher than others in Coimbatore dominance index of Coimbatore is low. This is in accordance with the statement of Hurd *et al.* (1971) [18] *i.e.*, dominance of one species cause ample effects in another species in a more stable ecosystem. Our results revealed that growth stages of rice, cropping practices and habitats greatly influence the distribution of Orthopteran fauna.

Table 1: Relative abundance of Orthopteran species in rice

S. No.	Family and Scientific name	Relative abundance (%)
I.	Acrididae	
	Oxya fuscovittata (Marschall, 1836)	15.40*
	Oxya hyla (Serville, 1831)	19.10*
	Trilophidia annulata (Thunberg, 1815)	3.29
	Hieroglyphus banian (Fabricius, 1798)	0.62^
II.	Pyrgomorphidae	
	Atractomorpha crenulata (Fabricius, 1793)	5.34
III.	Tetrigidae	
	Eucriotettix tricarinatus (Bolivar, 1887)	2.05^
	Paratettix scaber (Thunberg, 1815)	5.95
IV.	Tridactylidae	
	Xya japonica (Haan, 1844)	5.54
V.	Tettigoniidae	
	Conocephalus longipennis (Haan, 1843)	2.46
	Conocephalus maculatus (Le Guillou, 1841)	3.90
	Conocephalus rentzi (Farooki and Usmani, 2018)	6.98
	Phaneroptera gracilis (Burmeister, 1838)	2.46
VI.	Gryllidae	
	Metioche bicolor (Stal, 1861)	6.78
	Metioche vittaticollis (Stal, 1861)	13.97*
	Oecanthus indicus (Saussure, 1878)	6.16

* Dominant species; ^ least abundant species

Table 2: Functional groups of Orthoptera from the rice fields

S. No.	Functional group	Family / Genus
1.	Herbivores	Acrididae : *Oxya* (2 species), *Trilophidia* (1 species), and *Hieroglyphus* (1 species) Pyrgomorphidae: *Atractomorpha* (1 species) Tetrigidae: *Eucriotettix* (1 species) and *Paratettix* (1 species) Tridactylidae: *Xya* (1 species) Tettigoniidae: *Phaneroptera* (1 species)
2.	Carnivores	Gryllidae: *Metioche* (2 species) and *Oecanthus* (1 species)
3.	Omnivores	Tettigoniidae: *Conocephalus* (2 species)
4.	Undetermined	Tettigoniidae: *Conocephalus rentzi*

Table 3: Indices of Dominance, Species Richness, Diversity, and Similarity for Orthopteran fauna collected from the rice fields of Coimbatore and Bhavanisagar

Place of Collection	Berger- Parker Dominance Index (d)	Shannon-Wiener Index of Diversit (H')	Margelef's Index of Species Richnes (α)	Peilou's Evenness Index (J')	Jaccard Index of Similarity (Sj)	Sorenson's Similarity Index (Ss)
Coimbatore	0.17	2.62	2.34	0.44	0.67	0.80
Bhavanisagar	0.36	1.66	2.03	0.37		

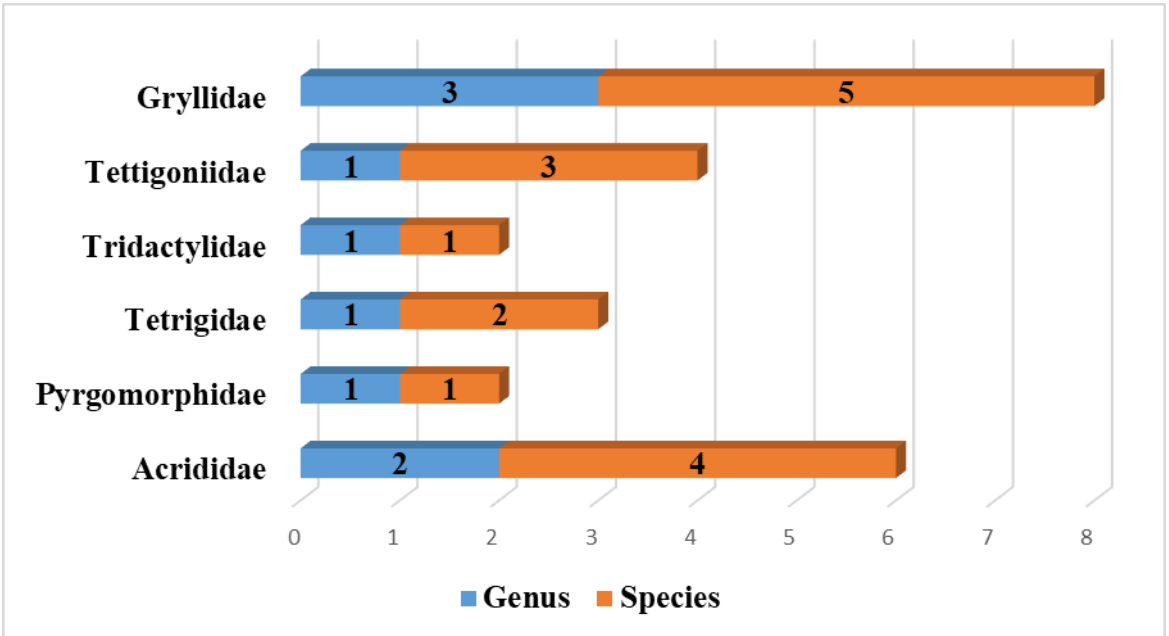

Fig 1: Diversity of Orthoptera in rice ecosystem

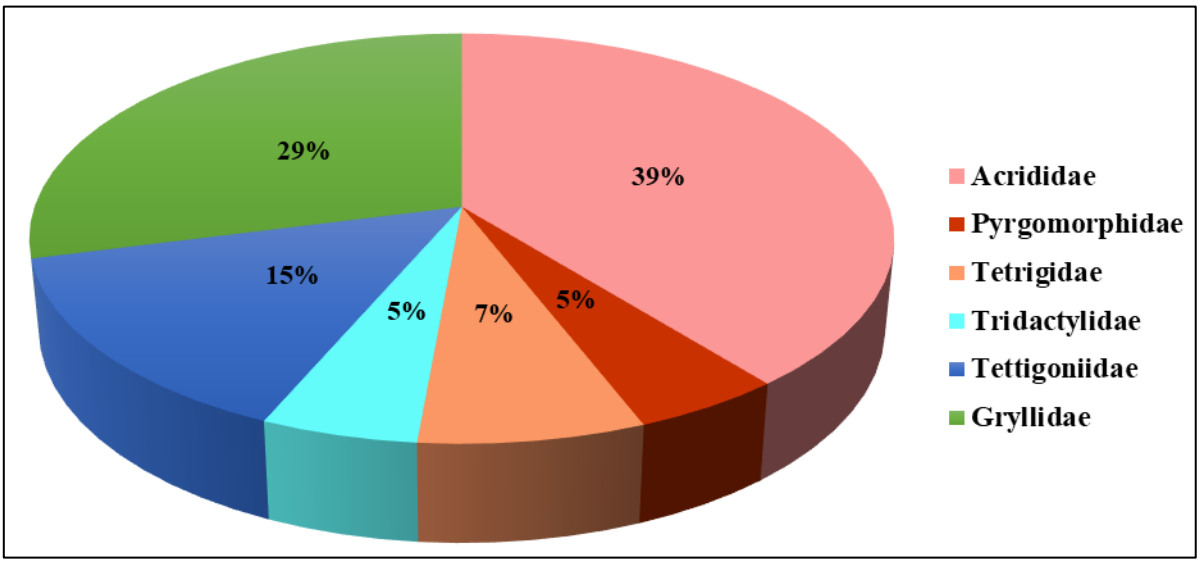

Fig 2: Relative abundance of Orthopteran families in rice

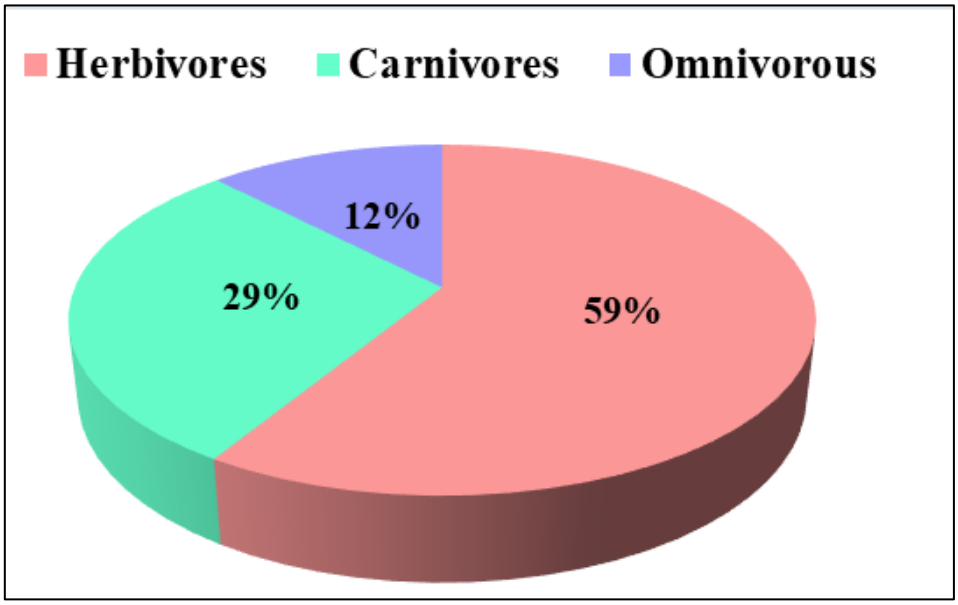

Fig 3: Functional Diversity of Orthoptera in rice fields

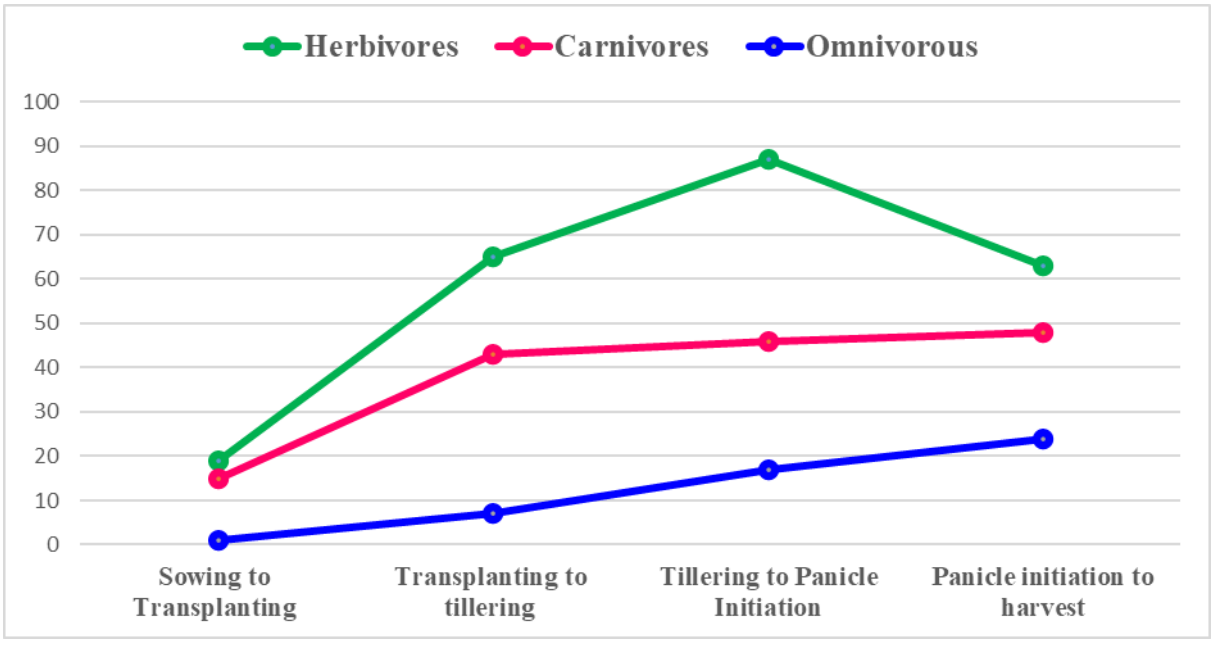

Fig 4: Relative abundance of functional groups (herbivores, carnivores, and omnivores) of Orthoptera across different growth stages of rice

Conclusion

Rice ecosystem is a hub of many arthropod species. There is a greater diversity of Orthopteran fauna in the rice fields of India. Grasshoppers are economically significant component in rice cultivation both as pests and predators on pests. Therefore, more studies in progress on population dynamics of pestiferous grasshoppers and pest-predatory potential of predatory Orthopterans may be taken as future prospects of this study.

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