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Ecology of Birds and Insects in Organic and Conventional (In-Organic) Rice Ecosystem

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A B S T R A C T

This Investigation was undertaken in the wetlands farm of Tamil Nadu Agricultural University, Coimbatore during Thaladi season to study the ecology of birds and insects in inorganic and organic rice ecosystem, with special reference to the species abundance, diversity, richness, evenness and similarity indices. This study revealed that organic cultivation supports bird diversity and beneficial insects. However, the bird menace during maturity stage is an issue to be managed in an ecofriendly way.

Introduction

Ecosystems on earth are unique components, where organisms interact within them and also with others, and that they are characteristic to that ecosystem. Agricultural ecosystems are unique man made ecosystem on earth that acts as a habitat for various living and non living organisms. It provides food and shelter to insects, birds, spiders, crabs, frogs and rodents.

Rice is a major food crop in India, grown in an area of 81 lakh hectares (Ministry of Agriculture, 2016) covering all agro-climatic regions of the country, from uphill to flooded (low land) and semi flooded ecosystems. Rice ecosystem is an important wetland ecosystem and a variety of flora and fauna are associated with paddy cultivation. Agricultural ornithology is the study of birds in relation to agriculture. It aims at obtaining scientific information on birds in relation to agriculture and using that information for their management (Ali, 1971).

Materials and Methods

The study was conducted in Thaladi season, (01 September 2016 to 17 January 2016. Organic rice field (0.91 ha) was located in "O" block (Survey number 380 and GPS location

11°00'08.2" N, 76°55'28.7" E) of the wetlands. Inorganic field (0.89 ha) was located in "K" block (Survey number 430 and GPS location 11°00'09.8" N, 76°55'32.2" E) of Wetlands. The respective date of sowing for organic and inorganic rice was 07.09.2016 and 01.09.2016 in Thaladi season. The method of cultivation adopted was System of Rice Intensification (SRI).

The quantity of inorganic fertilizer received by inorganic field in Thaladi and was 150:50:50 kg of N: P: K respectively.

The inputs of the organic rice fields of Thaladi included enriched farm yard manure (EFYM) @ 750 kg ha^{-1}, 100 kg ha^{-1} of rock phosphate, 200 kg ha^{-1} of neem cake, 3% panchagavya spray and 12.5 t ha^{-1} of Farm yard manure (FYM).

Species diversity estimation

Species or alpha diversity of birds was quantified using Simpson's reciprocal diversity Index (SRDI) (Simpson, 1949) and Shannon-Wiener index (Shannon and Weaver, 1964).

Simpson's index for species diversity

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

$D=\Sigma n (n-1) / N (N-1)$
Simpson reciprocal index = 1 / D

Shannon-Wiener index for species diversity

Shannon-Wiener index (H') was calculated using the formula,

$H' = - \Sigma Pi \ln (Pi)$,

Margalef index for species dominance

Species dominance was calculated for the two sites using the Margalef index (Margalef, 1958) which is given as Margalef Index.

$\alpha=(S - 1) / \ln (N)$

Pielou's index for species evenness

Species evenness was calculated using the Pielou's Evenness Index (E1) (Pielou, 1966). As species richness and evenness increase, diversity also increases (Magurran, 1988). Pielou's Evenness Index,

$EI=H' / \ln(S)$

Species diversity in two fields (beta diversity) estimation

Beta diversity is a measure of how different (or similar) ranges of habitats and their associated species comparison varies (Shweta and Rajmohana, 2016).

The most widely used index for assessment of Beta diversity is Jaccard Index (JI) (Jaccard, 1912; Gianni *et al.*, 2011; Ricardo and Francisco, 2011) which is calculated using the equation,

q (for two sites) = j / (a+b-j)

All the diversity analyses were done using Microsoft Excel (2013), excel sheet calculator provided by (Klaus, 2013) and Species Diversity and Richness software by (Henderson and Seaby, 2001).

Assessment of prey (insect) diversity at various stages

The insect species were estimated by using a standard sweep net (30 x 60 cm). The insects were collected in the rice fields at intervals of

three days at one hour after the sunrise to 9 a.m. and from 3.00 p.m. to 6.30 p.m. twenty sweepings were made at random in five places of the field at random. The sweeps were made at ground vegetation above one feet height from the ground for collecting insects from crops. Collection of insects in both organic and inorganic rice fields were carried out on the same day itself.

The collected insects were curated and preserved as per Johnson and Triplehorn (2005) and was identified as per the taxonomic keys of Sheperd *et al.,* (1992) and with reference collections of Insect Biosystematics laboratory, Department of Agricultural Entomology, TNAU, Coimbatore.

Diversity of insects prey species at different stages of rice were assessed by using Shannon Wiener index and Simpson reciprocal index, dominance of insects by Margalef index, Evenness by Pielou's index and beta diversity by Jaccard similarity index. All the analyses were done using Microsoft Excel (2013), PAST software (Hammer *et al.,* 2001) and Species Diversity and Richness software by (Henderson and Seaby, 2001).

Results and Discussion

The study recorded a total of 26 species in inorganic rice ecosystem as compared to 25 species in organic rice ecosystem. However, with respect to number of birds, organic ecosystem recorded 29.69% higher bird population compared to inorganic system. Maturity stage attracted more birds than other crop stages in both organic and inorganic rice. Red Wattled Lapwing, Egret, White Browed Wagtail, Indian Pond Heron, Common Sandpiper were dominant in organic rice and Red Wattled Lapwing, Egret, Indian Pond Heron, Common Myna, Black Drongo were dominant in inorganic rice. Species diversity by Shannon Wiener index, Simpson reciprocal index was high in birds of organic rice ecosystem, when compared to inorganic rice ecosystem. In insects, diversity was high inorganic rice ecosystem. The species recorded in the organic and inorganic rice ecosystem were mentioned in table 1 and 2 for birds and insects respectively.

Shannon Wiener diversity index

Shannon Wiener index is the basic and fundamental indicator of species diversity and richness. In Shannon Wiener calculation, higher the value obtained, higher is the diversity. In inorganic rice, the diversity of birds in Thaladi ranged from 0.947 to 1.990. An overall analysis revealed that the bird diversity was less in post-harvest and active tillering stage (Table 3). The diversity of insects was high in panicle initiation stage in both organic and inorganic rice ecosystem. Bakar and Khan (2016) also recorded maximum Margalef index value at tillering stage and active tillering stage. It is due to attraction of insects towards panicles.

Simpson reciprocal diversity index

Simpson's reciprocal index is a simple mathematical measure that characterizes species diversity in a community. More diversity of birds was occurred in nursery stage of organic and inorganic rice. Diversity of insects was higher in tillering stages of inorganic rice and panicle initiation stages of rice. The insects like sucking and sap feeding insects such as grasshopper, yellow stem borer and rice hispa were recorded high in the tillering stages (Table 4). This was due to increase in the canopy and insect may attract towards the new growing tillers. Similar results were also recorded by Wilby (2006) wherein the maximum Simpson diversity was recorded in tillering stage of rice.

Table.1 List of birds recorded

Common name	Scientific name	Family	Order
Indian Pond Heron	*Ardeola grayii* (Sykes) 1832	Ardeidae	Pelecaniformes
White Browed Wagtail	*Motacilla maderaspatensis* (Gmelin) 1789	Motacillidae	Passeriformes
Little Egret	*Egretta garzetta* (Linnaeus) 1766	Ardeidae	Pelecaniformes
Darter	*Plotus anhinga* (Linnaeus) 1766	Anhingidae	Suliformes
Cattle Egret	*Bubulcus ibis* (Linnaeus) 1758	Ardeidae	Pelecaniformes
White Breasted Waterhen	*Amaurornis phoenicurus (*Pennant*) 1769*	Rallidae	Gruiformes
Purple Moorhen	*Porphyrio poliocephalus* (Latham) 1801	Rallidae	Gruiformes
Bronze Winged Jacana	*Metopidius indicus* (Latham) 1790	Jacanidae	Charadriiformes
Red Wattled Lapwing	*Vanellus indicus* (Boddaert) 1783	Charadriidae	Charadriiformes
Grey Wagtail	*Motacilla cinerea* (Tunstall) 1771	Motacillidae	Passeriformes
Blue Rock Pigeon	*Columba livia* (Gmelin) 1789	Columbidae	Columbiformes
House Crow	*Corvus splendens* (Vieillot) 1817	Corvidae	Passeriformes
Common Myna	*Acridotheres tristis* (Linnaeus) 1758	sturnidae	Passeriformes
Black Drongo	*Dicrurus macrocercus* (Vieillot) 1817	Dicruridae	Passeriformes
Black Kite	*Milvus migrans* (Boddaert) 1783	Accipitridae	Accipitriformes
Spotted Owlet	*Athene brama* (Temminck) 1821	Strigidae	Strigiformes
Green Shank	*Tringa nebularia* (Gunnerus) 1767	Scolopacidae	Charadriiformes
Indian Roller	Coracias benghalensis (Linnaeus) 1758	Coraciidae	Coraciiformes
Common Sandpiper	*Acititis hypoleucos* (Linnaeus) 1758	Scolopacidae	Charadriiformes
White Throated Kingfisher	*Halcyon smyrnensis* (Linnaeus) 1758	Alcedinidae	Coraciiformes
Brahminy Kite	*Haliaster Indus* (Boddaert) 1783	Accipitridae	Accipitriformes
Blue Tailed Bee Eater	Merops philippinus (Linnaeus) 1766	Meropidae	Coraciiformes
Eurasian White Collared Dove	Streptopelia decaocto (Frivaldszky) 1838	Columbidae	Columbiformes
White Throated Kingfisher	*Halcyon smyrnensis* (Linnaeus) 1758	Alcedinidae	Coraciiformes
Asian Open Bill Stork	Anastomus oscitans (Boddaert) 1783	Ciconiidae	Ciconiiformes
Spotted Munia	Lonchura punctulata (Linnaeus) 1758	Estrildidae	Passeriformes
Tricolored Munia	Lonchura Malacca (Linnaeus) 1766	Estrildidae	Passeriformes
Common Parakeet	Psittacara holochlorus (Sclater) 1859	Psittacoidae	Psittaciformes
Peafowl	*Pavo cristatus* (Linnaeus) 1758	Phasianidae	Galliformes
Whimbrel	Numenius phaeopus (Linnaeus) 1758	Scolopacidae	Charadriiformes

Table.2 List of insects recorded

Common name	Scientific name	Order	Family
Dragon fly	*Sympetrum flaveolum* (Selys, 1854)	Odonata	Coenagrionidae
Yellow stem borer	*Scirpophaga incertulas* (Walker, 1863)	Lepidoptera	Crambidae
Brown plant hopper	*Nilaparvata lugens* (Stal, 1854)	Hemiptera	Delphacidae
Green leafhopper	*Nephotetix virescens* (Distant, 1908)	Hemiptera	Cicadellidae
Rice hispa	*Dicladispa armigera* (Oliver) 1808	Coleoptera	Chrysomelidae
Rice leaf folder	*Cnaphalocrocis medinalis* (Guenee, 1859)	Lepidoptera	Crambidae
Rice caseworm	*Nymphula depunctalis* (Guenee) 1854	Lepidoptera	Pyrallidae
Swarming caterpillar	*Spodoptera mauritia* (Boisduval) 1833	Lepidoptera	Noctuidae
Cutworm	*Spodoptera litura* (Fabricius, 1775)	Lepidoptera	Noctuidae
Grasshopper	*Atractomorpha lata* (Mochulsky, 1866)	Orthoptera	Pyrgomorphidae
Damsel fly	*Agriocnemis pygmaea* (Rambur, 1842)	Odonata	Coenagrionidae
Ant	*Solenopsis geminate* (Fabricius, 1804)	Hymenoptera	Formicidae
Rice bugs	*Leptocorisa oratoria* (Fabricius, 1764)	Hemiptera	Alydidae
Stink bugs	*Nezara viridula* (Linnaeus, 1758)	Hemiptera	Pentatomidae

Table.3 Shannon Wiener diversity index

Stages of rice	Birds		Insects	
	Inorganic	Organic	Inorganic	Organic
Nursery	1.990	1.713	1.321	1.082
Transplanted	1.823	1.642	1.376	1.079
Tillering	0.947	1.556	1.846	1.073
Active tillering	1.282	1.567	1.151	1.798
Panicle Initiation	1.541	1.608	1.938	1.870
Maturity	1.845	1.912	1.832	1.717
Post harvest	1.008	0.800	NA	NA

Table.4 Simpson reciprocal index for birds in rice ecosystem

Stages of rice	Birds		Insects	
	Inorganic	Organic	Inorganic	Organic
Nursery	5.571	3.845	5.600	4.000
Transplanted	3.531	4.062	5.056	4.200
Tillering	1.750	3.134	8.053	3.391
Active tillering	2.323	3.332	1.940	4.612
Panicle Initiation	4.005	5.150	7.101	7.373
Maturity	5.121	5.741	5.637	5.563
Post harvest	2.260	2.030	NA	NA

Table.5 Margalef index for birds in rice ecosystem

Stages of rice	Birds		Insects	
	Inorganic	Organic	Inorganic	Organic
Nursery	3.253	2.405	1.443	0.962
Transplanted	2.868	1.865	1.137	1.028
Tillering	1.491	2.191	2.076	0.780
Active tillering	1.438	1.889	2.184	2.156
Panicle Initiation	1.300	0.831	2.199	1.764
Maturity	2.580	1.656	1.967	1.123
Post harvest	0.724	0.539	NA	NA

Table.6 Pielou's Evenness index for birds in rice ecosystem

Stages of rice	Birds		Insects	
	Inorganic	Organic	Inorganic	Organic
Nursery	0.776	0.689	0.953	0.875
Transplanted	0.658	0.685	0.993	0.941
Tillering	0.487	0.649	0.949	0.918
Active tillering	0.583	0.631	0.524	0.568
Panicle Initiation	0.792	0.999	0.882	0.822
Maturity	0.665	0.797	0.796	0.870
Post harvest	0.727	0.728	NA	NA

Table.7 Jaccard index of similarity coefficient for birds in organic and inorganic rice ecosystem

Stages of rice	Birds		Insects	
	Jaccard index value	Similarity percentage	Jaccard index value	Similarity percentage
Nursery	0.316	31.57	0.750	75.000
Transplanted	0.500	50.00	0.400	40.000
Tillering	0.286	28.57	0.250	25.000
Active tillering	0.500	50.00	0.583	58.333
Panicle Initiation	0.333	33.33	0.600	60.000
Maturity	0.688	68.75	0.600	60.000
Post harvest	0.750	75.00	NA	NA

Plates

Spotted Munia
Lonchurapunctulata

Red wattled lapwing
Vanellusindicus

Indian roller
Coraciasbenghalensis

Grey wagtail
Motacillacinerea

Little egret
Egrettagarzetta

Blue rock pigeon
Columba livia

Blue tailed bee eater
Meropsphilippinus

Tricoloured Munia
Lonchura Malacca

House crow
Corvus splendens

Black kite
Milvusmigrans

White Breasted Waterhen
Amaurornis phoenicurus

Whimbrel
Numeniusphaeopus

Asian open bill stork
Anastomusoscitans

Cattle egret
Bubulcus ibis

Indian pond heron
Ardeolagrayii

Common parakeet
Psittacaraholochlorus

Common Sandpiper
Acititishypoleucos

Common Myna
Acridotheres tristis

Rice leaf folder

Damsel fly

Rice stem borer

Rice bug

Insect box

Margalef index

Species richness was high in organic rice field compared to inorganic rice. The nursery stages of inorganic rice recorded highest species richness, which however decreased in the later stages and finally increasing in the maturity stage.

The sparse count recorded on birds such as Brahminy Kite, Bronze Winged Jacana, Open Billed Stork, and Whimbrel has resulted in lesser Margalef Index values.

The Margalef index for species richness, revealed that the highest species richness was in tillering stage of organic rice and panicle initiation stage of inorganic rice (Table 5). Bakar and Khan (2016) also recorded maximum Margalef index value at tillering stage and active tillering stage.

Pielou's evenness index

Pielou's evenness index is the measure of evenness of the organisms. From the results, birds has maximum evenness index occurred in panicle initiation stage in organic rice of Thaladi season (0.999). Insects have high evenness in transplanted stage of both organic and inorganic rice ecosystem (Table 6).

Jaccard index of similarity coefficient

Jaccard index is the measure of similarity between two ecosystems. From the results of Jaccard index, it was observed that the similarity coefficient between organic and inorganic rice ranged from 28.57 to 75 % for Thaladi (Table 7). Highest similarity of species (75%) was recorded in post-harvest stage, where in little egret, blue rock pigeon and black drongo were the common bird

species in both inorganic and organic fields. This was followed by maturity stage (68.75%). Lowest similarity was observed in tillering stage (28.57%), followed by nursery stage (31.57%). Similar results of highest evenness were recorded in transplanting (seedling) stage of rice by Bakar and Khan (2016). This is due to the even occurrence of insects in the rice fields.

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