Research article

Avian Assemblage During the Development of Rice in Organic and Inorganic Rice Paddies and Its Relation to Insect Pests

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Abstract

Keywords

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pests;
insectivorous birds

Birds play a vital role in rice cultivation as organisms that help maintain the ecological balance and help eliminate pests very effectively. However, various pests at each phase of rice growth, and the use of pesticides may cause differences in the bird species found in rice paddy. The objective of this research was to explore the species of birds found in organic rice paddy and inorganic rice paddy, and during each phase of rice growth, in Doi Kaew Subdistrict, Chom Thong District, Chiang Mai Province, Thailand. The bird data was collected between April and November 2018. Insects were also collected during each growth phase of rice to investigate the relationship with the number of birds found. There were 65 species found in the survey. Most of the birds were insectivores and belonged to Order Passeriformes. Birds found in the planted area were more similar to the organic rice paddy than the inorganic rice paddy. The values of Shannon Wienner's diversity index (H'), Simpson's index (λ), and Margalef's index (D) of the planted area were at the highest level, followed by the inorganic rice paddy and organic rice paddy, respectively. Birds discovered in both paddies were statistically different ($p<0.05$), and the bird found during each phase of rice growth were statistically different ($p<0.05$). Even so, the birds that presented in each habitat were more similar to each other than other habitat types. The correlation between insectivorous birds and insect pests was positive in both rice paddy types, indicating that if there were more insect pests, there would be more birds as well.

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1. Introduction

Class Aves is very diverse in species. They are considered a beneficial natural resource that helps balance ecosystems and eliminate pests that farmers must deal with [1]. Some bird species can promote pollination and help spread plants, and also benefit as food sources or as pets [2]. Some bird species, such as chicken, goose, quail, have been adapted to become economic animals [3]. However, many species destroy crops, causing noise when living in houses, creating dirt, and may cause infections [4]. But compared to the benefits or value that birds give to humans and the environment, the various disadvantages are not so great [5]. Besides, birds are also associated with habitats; therefore, they are often used as indicators of the nature and quality of the environment. And at the same time, the surroundings can indicate the type of birds that may be found [6]. Birds are animals that have their own characteristics. They can fly, have attractive colors, and have beautiful voices. But in agriculture, some birds, such as Common Tailorbird (*Orthotomus sutorius*), Scaly-breasted Munia (*Lonchura punctulata*), and Rock Dove (*Columba livia*), have turned into species that destroy farmers' produce [7]. Rice cultivation takes place in wide-open area, which are ideal for bird territories, making it a food source for many kinds of birds. Resident birds are seen to live, forage, breed, lay eggs, and raise offspring. Then there are migratory birds that migrate to rice paddies temporarily. Furthermore, there are various mollusks, crustaceans, small mammals, and insects, including aquatic and terrestrial insects that live in rice paddies [8]. All of these take part in the complex ecological food web in the ecosystem and natural diversity in which birds are regarded as the top consumers in these natural food chains. The diversity of birds depends on different environments, including the seasons, the height above sea level, different wetland areas, or even forest or agricultural areas [9]. In the rice paddies, the essential factors that influence the type and number of birds found are cultivation methods, seasons, and monthly development periods. Variations in all these factors also affect the growth of other species that are hostile to many types of rice plants [10].

Rice cultivation can be divided into two major phases: In the first phase, the soil characteristics in the paddy are dry soil. There is no water in the rice paddy; grasses and rice stalks are the result of the previous harvest. In the second phase, water is brought into the rice paddy to prepare the soil for rice cultivation. This phase is the period of plowing and sowing rice seedlings, causing the area to become waterlogged. After rice planting, the fields undergo an obvious change and they become full of rice and various living things that are the food of birds [8]. Rice farming in some areas involves the use of chemicals to control the production of large quantities of crops. However, this is often done without considering the impact of the chemicals on natural resources and ecosystems. This rice cultivation method leads to differences in the area before and after planting rice and affects the diversity of birds and other animals [11]. Therefore, this research investigated the diversity of birds in a rice paddy in which chemicals were not used (organic cultivation) and with one in which chemicals were used (inorganic cultivation). Species and number of birds found during the process of rice cultivation were also compared. Moreover, the research involved a further look at the number of insect pests that related to the number of birds during the rice growing season. Therefore, this research was concerned with the study of the diversity of birds and their various food sources of birds in the selected area.

2. Materials and Methods

2.1 Study sites

The study was conducted in Mai Mae Tia Village, Doi Kaew Subdistrict, Chom Thong District, Chiang Mai Province, Thailand. The region has a plateau topography and foothills. There are essential rivers in the area such as the Mae Klang River, Mae Tae River, and Mae Tia River. There are also many forest areas in the Doi Inthanon National Park and Ob Luang National Park. Because the study area has many significant rivers flowing through, the villagers have a career in agriculture. The area in the village is mostly composed of rice paddies that have a ladder style with plowing to soften the soil. The high ground around the rice paddies is often dug to block the water needed for the rice plants. The USDA has approved the area of the organic rice paddies for many years. In contrast, the field of inorganic rice paddies is the area where villagers use chemicals to eliminate bothersome pests. The area around the rice paddies has a forest planted by the villagers growing nearby. Most grow longan trees. There are also ponds that the villagers use for agricultural purposes. Therefore, the study sites were determined into three areas: the organic rice paddy (18.405086, 98.645281; 0.0117 km^2) at an altitude of 298 meters above sea level; the inorganic rice paddy (18.400775, 98.651267; 0.0113 km^2) at an altitude of 298 meters above sea level; and nearby planted forest area (18.403669, 98.643250; 0.0210 km^2) at an altitude of 306 meters above sea level (Figure 1).

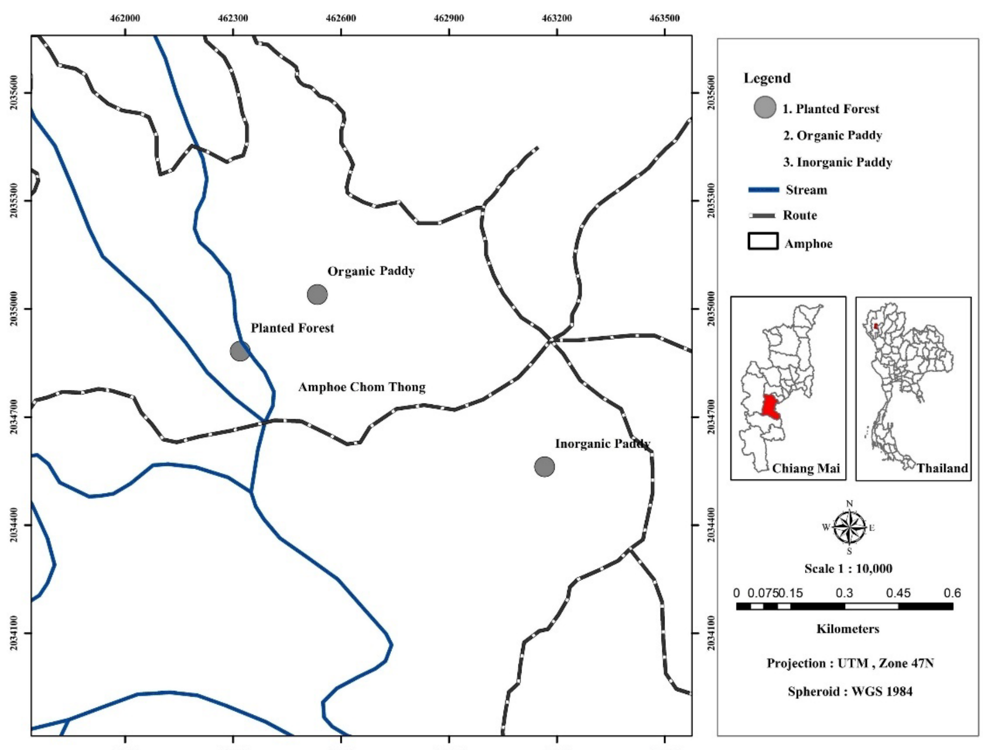

Figure 1. Study areas in Doi Kaew Subdistrict, Chom Thong District, Chiang Mai Province, Thailand

Before rice cultivation, the state of the rice paddies was an open space full of grass and remaining rice stubble from the previous harvest. No water had yet been released into the rice paddies, so the soil was dry and hard. During cultivation in the rainy season, the areas consisted of four phases: germination phase (GP), vegetative phase (VP), reproductive phase (ReP), and ripening phase (RiP). Each phase had the following conditions. Phase 1, the GP, occurred during August. It was the period in which the rice plants had a height of about 20-30 cm. The rice leaves began to germinate. The roots of the seedlings showed elongation. Inside the rice paddies, there was water to a depth of about 10-15 cm. Phase 2, the VP, occurred during September. It was the period in which the rice plants had cracked and had a height of about 40-60 cm. The rice plants had developed more leaves and more branching. The grass on the ridge was higher. Inside the rice paddies, the water was about 20-30 cm deep. Phase 3, the ReP, occurred during October. The rice plants had a height of about 70-90 cm. In this phase, the rice plants quickly transformed into rounded tree shapes and branched out. Then, the rice plants began to produce grains; they flowered, and were pollinated and then developed seeds. There was no water inside the rice paddies at this phase. Phase 4, the RiP, occurred during November. It was a period in which the rice plants were about 90-120 cm high. It was the phase in which the rice grains were yellow, indicating that they were fully ripe and ready to be harvested. The soil in the rice paddies had completely dried out.

2.2 Bird survey

Bird data were collected four times a month using line-transect and point-count methods during the times of 06.00-08.00 h and 15.00-18.00 h, totaling 16 times per area from April to November 2018 [12]. An observer would walk along the edge of the rice paddy ridges and study the area using binoculars to observe bird positions on the ground, and in the bushes, trees, and sky. Pictures of the birds or notes of essential characteristics of birds would also be taken. Species, numbers, locations, and behavior found were recorded. Birds were classified using a bird guide [13, 14].

2.3 Collection of insects

In each area, samples of aquatic insects were gathered from four collection points using the sweep sampling method [15], which was performed as follows. A sweep net that had a diameter of about 50 cm was used to swing around the base of the rice in the rice paddies. Aquatic insects captured were initially separated from leaf debris or large stones. Then, all specimens were put into plastic bags, and 95% alcohol was added into the bags to maintain the samples for study later on. In the laboratory, the specimens were washed with clean water and set apart from gravel, mud, leaves, debris, or rocks using a stereomicroscope because some of the aquatic insects were too small to be seen with the naked eye causing the inability to separate aquatic insects from gravel or organic debris. All insect specimens were classified using a classification guide [16]. In a similar way, samples of terrestrial insects were gathered from four collection points in each area. Specimens were collected using insect nets during every phase of rice plant growth, during the time of 08:00-09:00 h and 15.00-18.00 h, from the bases of the rice plants (approximately 5-10 cm above the ground) to the tops of the plants. All samples were classified using a dichotomous key [17, 18].

2.4 Data analysis

Analysis of the diversity of bird populations was conducted using Shannon Wienner's diversity index (H') and Simpson's index (λ). A determination of species evenness using Pielou's evenness index (J) and Margalef's index (D) was applied to measure the species richness of each study area. A quantification of the similarity distance between birds in each site and phase using Jaccard's index of similarity was performed [19]. Non-metric multidimensional scaling (NMDS) was also used to visualize the differences between bird assemblages and habitat types. This was an analysis of the ranked distances and shows the dissimilarity among habitats. The Bray-Curtis distance was used for the abundance of data. The value of stress was used to evaluate the goodness of fit of NMDS. When the value is more than 0.2, it shows a weak fit, but if the value is lower than 0.2, it shows a good fit, though some of the distance may be misleading [20]. The ANOSIM test was done to examine a statistical difference between groups [21]. The SIMPER analysis was carried out to describe each species' percentage of contribution to discriminate species between two groups using Bray-Curtis dissimilarities [22]. The relative abundance was analyzed using Pettingill's method to measure how common or how rare that bird species were found in a particular habitat [23]. Birds were sorted into five levels of abundance; level 1 rare bird (1-9% of opportunity found), level 2 uncommon bird (10-30% of opportunity found), level 3 moderately common bird (31-64% of opportunity found), level 4 common bird (65-89% of opportunity found), and level 5 abundant bird (90-100% of opportunity found) [24]. Lastly, the Pearson correlation coefficient was used to analyze the correlation between insectivorous birds and insect pests at the significance of 0.05. All data analyses were performed in R with the package "vegan" [25, 26].

3. Results and Discussion

3.1 Results

3.1.1 Species diversity and its relative abundance

From the survey of bird species found in planted forests during the rainy season, birds of 47 species from 30 families in 10 orders were found, consisting of 39 species of resident birds and eight species of migratory birds (Table 1). Among these species, 30 species of Passeriformes from 17 families were the most abundant. In the organic rice paddy, 24 species of birds from 21 families in 7 orders were found, consisting of 19 species of resident birds and five migratory bird species. Passeriformes were also found in the highest number of 12 species from 11 families. While in the inorganic rice paddy, a total of 43 species from 27 families in 9 orders were found, consisting of 35 species of resident birds and eight species of migratory birds. Twenty-one species from 14 families of Passeriformes were the most abundant (Figure 2A). The relative abundance of each bird species in each area is also shown in Table 1. The planted forest area had the highest H', λ, and D, followed by the inorganic rice paddy and the organic rice paddy, respectively. Meanwhile, the highest value of J was found in the planted forest area, followed by the organic rice paddy and the inorganic rice paddy, respectively (Figure 3). Overall, bird species found in the planted forest and the organic rice paddy were similar, while the inorganic rice paddy had slightly different species of birds (Figure 4A). The ANOSIM test showed a statistical difference in bird species assemblages among three habitats ($R = 0.7434$, $p = 0.0001$). This was confirmed by the NMDS analysis which showed a good fit and positive linear relationship between the observed dissimilarity and the ordination distance (0.1663 stress, linear fit: $r^2 = 0.783$) (Figures 5A and 6A). Table 2 shows the pairwise comparisons between habitats from the SIMPER analysis, which displays the most influential species of each pair of habitats. Species that show a high percentage of contribution are responsible for the dissimilarity between habitats. It means that these species are likely to be more abundant in one of the habitats.

Table 1. Relative abundance and percentage of composition of each species found in all habitats

Scientific Name	Common Name	Seasonal status	Guild type	Planted Forest		Organic Rice Paddy		Inorganic Rice Paddy	
				Abundance	%Composition	Abundance	%Composition	Abundance	%Composition
Order Accipitriformes; Family Accipitridea									
Elanus caeruleus	Black-winged Kite	Re	Ca			U	0.68		
Order Anseriformes; Family Anatidae									
Dendrocygna javanica	Lesser Whistling-duck	W	O	U	0.66			U	0.46
Order Bucerotiformes; Family Upupidae									
Upupa epops	Common Hoopoe	Re	Ca	M	0.83			Ra	0.08
Order Caprimulgiformes; Family Apodidae									
Apus affinis	Little Swift	Re	Ca	U	1.99			U	0.76
Cypsiurus balasiensis	Asian Palm-swift	Re	Ca	M	9.29	Co	12.61	Co	7.31
Order Charadriiformes; Family Charadriidae									
Vanellus indicus	Red-wattled Lapwing	Re	Ca	Ra	0.33	M	4.73	M	1.52
Order Charadriiformes; Family Turnicidae									
Turnix suscitator	Barred Buttonquail	Re	O	Ra	0.17				

Table 1. Relative abundance and percentage of composition of each species found in all habitats (continued)

Scientific Name	Common Name	Seasonal status	Guild type	Planted Forest		Organic Rice Paddy		Inorganic Rice Paddy	
				Abundance	%Composition	Abundance	%Composition	Abundance	%Composition
Order Columbiformes; Family Columbidae									
Columba livia	Rock Dove	Re	H	U	1.16	M	4.28		
Geopelia striata	Zebra Dove	Re	H	Co	4.64			M	1.14
Spilopelia chinensis	Spotted Dove	Re	H	Co	5.47			Co	3.81
Streptopelia tranquebarica	Red Turtle-dove	Re	H					M	2.36
Order Coraciiformes; Family Alcedinidae									
Alcedo atthis	Common Kingfisher	Re	Ca			Ra	0.23	Ra	0.08
Halcyon smyrnensis	White-breasted Kingfisher	Re	Ca	U	0.33			M	0.46
Pelargopsis amauroptera	Brown-winged Kingfisher	Re	Ca					Ra	0.08
Order Coraciiformes; Family Coraciidae									
Coracias benghalensis	Indian Roller	Re	Ca	U	0.66	M	1.13	Ra	0.08
Order Coraciiformes; Family Meropidae									
Merops orientalis	Asian Green Bee-eater	Re	Ca	Co	7.46	M	4.50	A	3.81

Table 1. Relative abundance and percentage of composition of each species found in all habitats (continued)

Scientific Name	Common Name	Seasonal status	Guild type	Planted Forest		Organic Rice Paddy		Inorganic Rice Paddy	
				Abundance	%Composition	Abundance	%Composition	Abundance	%Composition
Order Cuculiformes; Family Cuculidae									
Centropus bengalensis	Lesser Coucal	Re	Ca					Ra	0.08
Centropus sinensis	Greater Coucal	Re	Ca	M	1.33	U	0.68		
Eudynamys scolopaceus	Western Koel	Re	O	U	1.66			U	0.15
Phaenicophaeus tristis	Green-billed Malkoha	Re	Ca	U	0.33			Ra	0.08
Order Gruiformes; Family Rallidae									
Amaurornis phoenicurus	White-breasted Waterhen	Re	O					M	0.53
Order Passeriformes; Family Acrocephalidae									
Acrocephalus orientalis	Oriental Reed-warbler	W	Ca	U	0.66			Ra	0.08
Order Passeriformes; Family Aegithinidae									
Aegithina tiphia	Common Iora	Re	Ca	U	1.00			Ra	0.08

Table 1. Relative abundance and percentage of composition of each species found in all habitats (continued)

Scientific Name	Common Name	Seasonal status	Guild type	Planted Forest		Organic Rice Paddy		Inorganic Rice Paddy	
				Abundance	%Composition	Abundance	%Composition	Abundance	%Composition
Order Passeriformes; Family Artamidae									
Artamus fuscus	Ashy Woodswallow	Re	Ca	Co	7.30	U	1.58	U	1.37
Order Passeriformes; Family Campephagidae									
Pericrocotus flammeus	Scarlet Minivet	Re	Ca	Ra	0.17				
Order Passeriformes; Family Chloropseidae									
Chloropsis aurifrons	Golden-fronted Leafbird	Re	O	Ra	0.17				
Order Passeriformes; Family Cisticolidae									
Orthotomus sutorius	Common Tailorbird	Re	Ca	U	1.00	U	0.90		
Prinia flaviventris	Yellow-bellied Prinia	Re	Ca					U	0.15
Order Passeriformes; Family Corvidae									
Corvus macrorhynchos	Large-billed Crow	Re	O	M	1.99	Co	2.93	Ra	0.08
Crypsirina temia	Racquet-tailed Treepie	Re	O	M	1.49				
Urocissa erythroryncha	Red-billed Blue Magpie	Re	Ca	U	1.16			U	0.15

Table 1. Relative abundance and percentage of composition of each species found in all habitats (continued)

Scientific Name	Common Name	Seasonal status	Guild type	Planted Forest		Organic Rice Paddy		Inorganic Rice Paddy	
				Abundance	**%Composition**	**Abundance**	**%Composition**	**Abundance**	**%Composition**
Order Passeriformes; Family Dicaeidae									
Dicaeum cruentatum	Scarlet-backed Flowerpecker	Re	O	Co	5.64				
Order Passeriformes; Family Dicruridae									
Dicrurus aeneus	Bronzed Drongo	Re	Ca	M	1.66			U	0.30
Dicrurus leucophaeus	Ashy Drongo	W	Ca	Ra	0.17				0.00
Dicrurus macrocercus	Black Drongo	Re	Ca	U	0.66			M	1.37
Dicrurus paradiseus	Greater Racquet-tailed Drongo	Re	Ca	U	0.33	U	1.13		
Dicrurus remifer	Lesser Racquet-tailed Drongo	Re	Ca	Ra	0.17				
Order Passeriformes; Family Estrildidae									
Lonchura punctulata	Scaly-breasted Munia	Re	H	M	4.48	M	4.73	Co	23.84
Lonchura striata	White-rumped Munia	Re	H					Co	16.76

Table 1. Relative abundance and percentage of composition of each species found in all habitats (continued)

Scientific Name	Common Name	Seasonal status	Guild type	Planted Forest		Organic Rice Paddy		Inorganic Rice Paddy	
				Abundance	%Composition	Abundance	%Composition	Abundance	%Composition
Order Passeriformes; Family Hirundinidae									
Hirundo rustica	Barn Swallow	W	O	U	1.66			M	10.66
Order Passeriformes; Family Laniidae									
Lanius cristatus	Brown Shrike	W	Ca			U	0.90	U	0.23
Order Passeriformes; Family Muscicapidae									
Kittacincla malabarica	White-rumped Shama	Re	Ca	M	1.00				
Copsychus saularis	Oriental Magpie-robin	Re	Ca	M	2.65	U	0.90	Ra	0.08
Ficedula albicilla	Red-throated Flycatcher	W	Ca	Ra	0.33				
Saxicola caprata	Pied Bushchat	Re	Ca					M	1.07
Order Passeriformes; Family Nectariniidae									
Cinnyris jugularis	Olive-backed Sunbird	Re	O	M	1.49				
Order Passeriformes; Family Passeridae									
Passer montanus	Eurasian Tree Sparrow	Re	O			M	20.05		

Table 1. Relative abundance and percentage of composition of each species found in all habitats (continued)

Scientific Name	Common Name	Seasonal status	Guild type	Planted Forest		Organic Rice Paddy		Inorganic Rice Paddy	
				Abundance	%Composition	Abundance	%Composition	Abundance	%Composition
Order Passeriformes; Family Pellorneidae									
Pellorneum ruficeps	Puff-throated Babbler	Re	Ca					U	0.15
Order Passeriformes; Family Phylloscopidae									
Phylloscopus fuscatus	Dusky Warbler	W	O	Ra	0.33				
Order Passeriformes; Family Ploceidae									
Ploceus philippinus	Baya Weaver	Re	O			U	4.05		
Order Passeriformes; Family Pycnonotidae									
Brachypodius atriceps	Black-headed Bulbul	Re	O	U	1.49				
Pycnonotus aurigaster	Sooty-headed Bulbul	Re	O	M	3.48			M	0.69
Pycnonotus blanfordi	Streak-eared Bulbul	Re	O	Co	5.31			Ra	0.08
Pycnonotus jocosus	Red-whiskered Bulbul	Re	O	Co	2.65	Ra	0.23	U	0.53

Table 1. Relative abundance and percentage of composition of each species found in all habitats (continued)

Scientific Name	Common Name	Seasonal status	Guild type	Planted Forest		Organic Rice Paddy		Inorganic Rice Paddy	
				Abundance	%Composition	Abundance	%Composition	Abundance	%Composition
Order Passeriformes; Family Sturnidae									
Acridotheres grandis	Great Myna	Re	O	M	5.14	Co	8.33	A	8.45
Acridotheres tristis	Common Myna	Re	O	M	2.32	Co	13.96	Co	6.02
Order Passeriformes; Family Timaliidae									
Mixornis gularis	Pin-striped Tit-babbler	Re	O	U	1.00				
Order Passeriformes; Family Vangidae									
Hemipus picatus	Bar-winged Flycatcher-shrike	Re	Ca					Ra	0.08
Order Pelecaniformes; Family Ardeidae									
Ardea alba	Great White Egret	W	Ca					M	1.07
Ardea intermedia	Intermediate Egret	W	Ca			M	4.50		
Ardeola bacchus	Chinese Pond-heron	W	Ca	Ra	0.17	M	4.50	Co	0.99
Bubulcus ibis	Cattle Egret	W	Ca					U	0.53
Egretta garzetta	Little Egret	W	Ca	Ra	3.32	M	2.25	M	1.83
Ixobrychus cinnamomeus	Cinnamon Bittern	Re	Ca			Ra	0.23	M	0.61

Table 1. Relative abundance and percentage of composition of each species found in all habitats (continued)

Scientific Name	Common Name	Seasonal status	Guild type	Planted Forest		Organic Rice Paddy		Inorganic Rice Paddy	
				Abundance	%Composition	Abundance	%Composition	Abundance	%Composition
Order Piciformes; Family Megalaimidae									
Psilopogon haemacephalus	Coppersmith Barbet	Re	O	M	3.32				

Re, Resident; W, Winter visitor; Ca, Carnivorous; O, Omnivorous; H, Herbivorous; A, Abundant; Co, Common; M, Moderately common; U, Uncommon; Ra, Rare

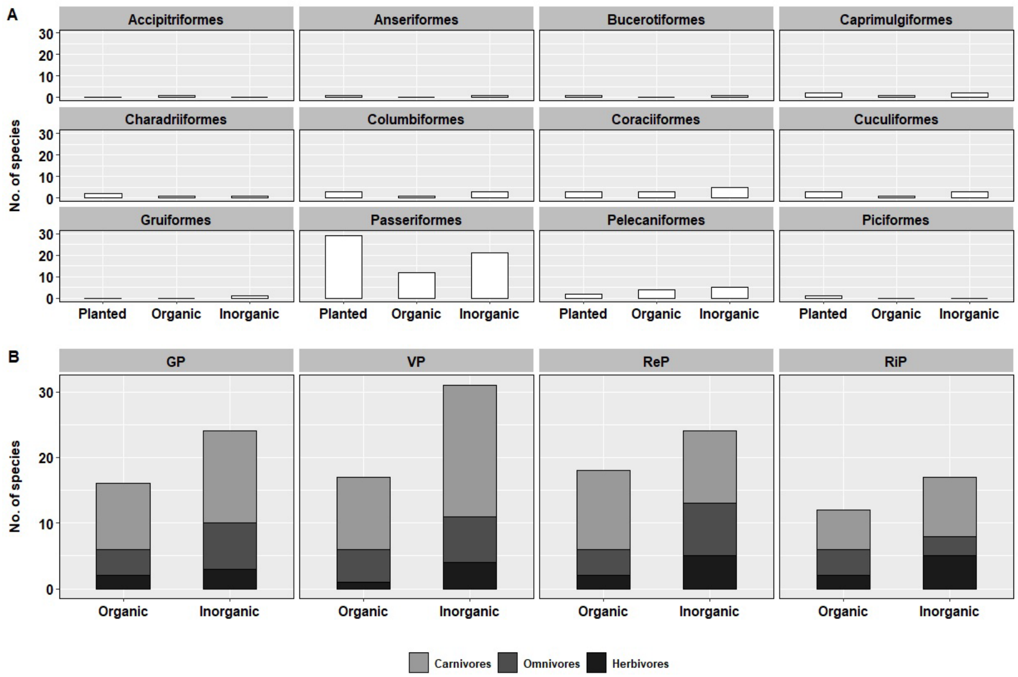

Figure 2. Number of bird species found divided by; A. Order in all study areas, B. Guild type between organic and inorganic rice paddies

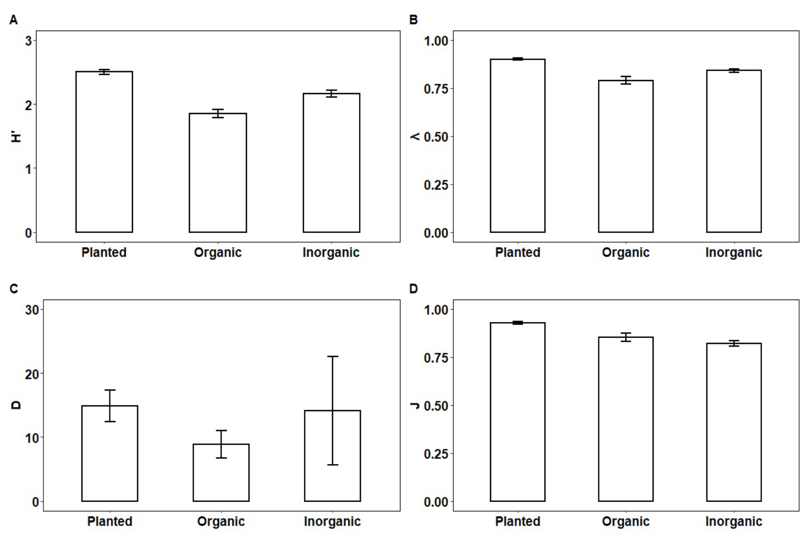

Figure 3. Mean and SE of species richness and diversity in all study areas; **A** Shannon Wienner's diversity index (H'), **B** Simpson's index (λ), **C** Species richness (D), and **D** Evenness index (J)

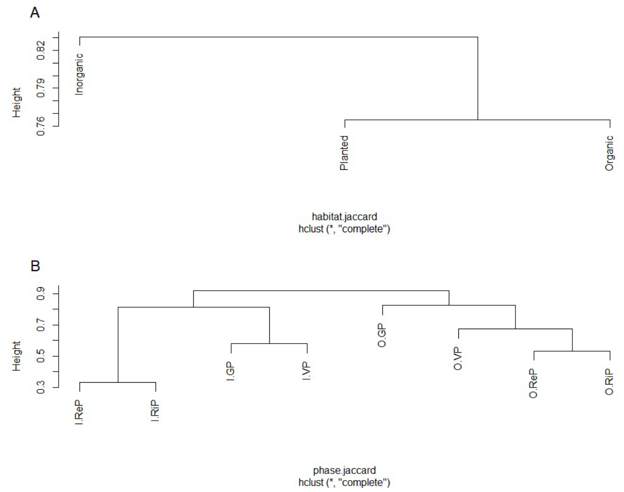

Figure 4. Jaccard's index of similarity of birds in; **A** Study sites, and **B** Rice's growth phases in organic and inorganic rice paddies

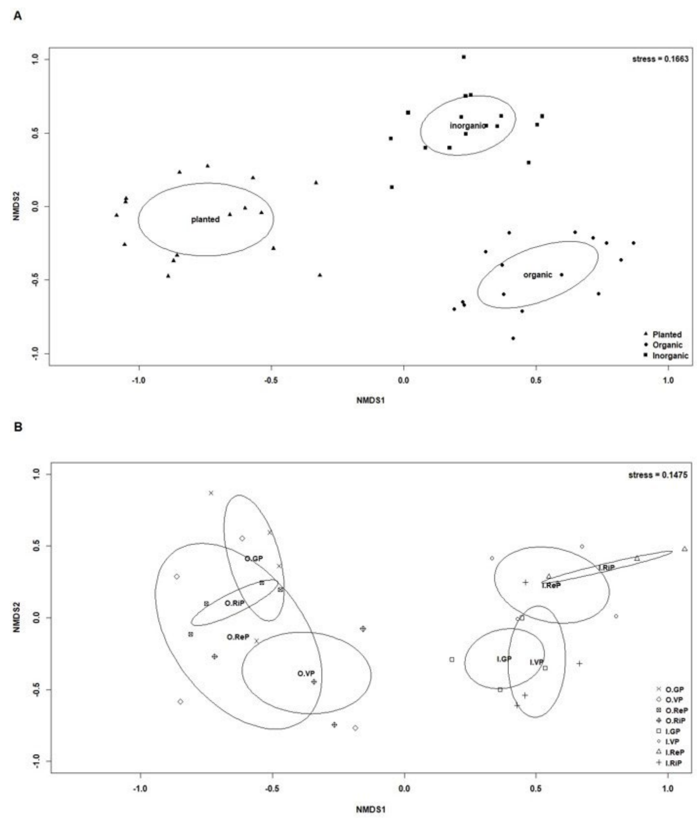

Figure 5. Non-metric multidimensional scaling (NMDS) analysis visualizing the differences between bird assemblages; **A** Habitat types, and **B** Rice's growth phases in organic and inorganic rice paddies

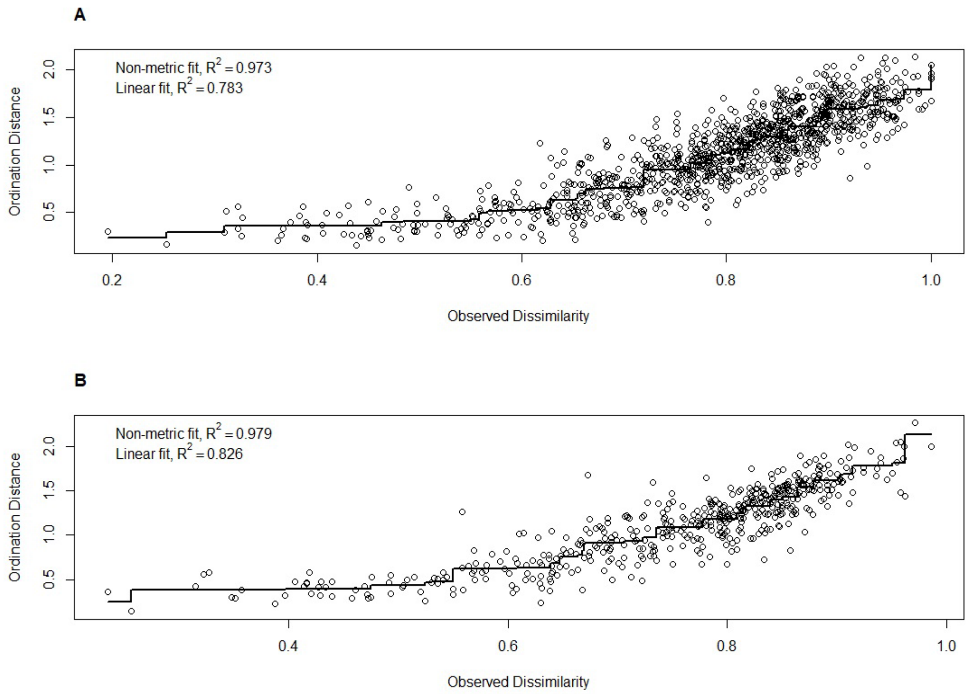

Figure 6. Plots for NMDS results showing a positive linear relationship between the observed dissimilarity and the ordination distance among; **A** Habitats, and **B** Rice growth phases

Table 2. Percentage of contribution and cumulative contribution of the most influential species for the dissimilarity between each pair of habitats (ava and avb are average abundances of habitat types)

Species	ava	avb	% Contribution	% Cumulative contribution
Planted Forest – Organic Rice Paddy				
Passer montanus	0.00	5.56	9.104490	9.104490
Pycnonotus jocosus	4.00	0.06	7.119020	16.223510
Cypsiurus balasiensis	3.50	3.50	6.695572	22.919082
Acridotheres tristis	0.88	3.88	6.031360	28.950442
Acridotheres grandis	2.56	2.31	5.004835	33.955278
Artamus fuscus	2.75	0.44	4.535320	38.490597
Merops orientalis	2.81	1.25	4.214926	42.705523
Spilopelia chinensis	2.25	0.00	3.898681	46.604204
Dicaeum cruentatum	2.13	0.00	3.764181	50.368385
Pycnonotus blanfordi	2.00	0.00	3.579778	53.948164
Lonchura punctulata	1.69	1.31	3.185106	57.133270
Geopelia striata	1.75	0.00	2.932882	60.066152
Egretta garzetta	1.25	0.63	2.688077	62.754229

Table 2. Percentage of contribution and cumulative contribution of the most influential species for the dissimilarity between each pair of habitats (ava and avb are average abundances of habitat types) (continued)

Species	ava	avb	% Contribution	% Cumulative contribution
Columba livia	0.44	1.19	2.366758	65.120987
Pycnonotus aurigaster	1.31	0.00	2.268105	67.389092
Vanellus indicus	0.13	1.31	2.262188	69.651280
Ardeola bacchus	0.06	1.25	2.202941	71.854222
Planted Forest – Inorganic Rice Paddy				
Lonchura punctulata	1.69	19.56	17.391363	17.391363
Lonchura striata	0.00	13.75	12.160608	29.551971
Hirundo rustica	0.63	8.75	7.449379	37.001350
Acridotheres grandis	2.56	6.94	5.530827	42.532177
Cypsiurus balasiensis	3.50	6.00	5.447247	47.979424
Acridotheres tristis	0.88	4.94	4.561072	52.540496
Pycnonotus jocosus	4.00	0.44	4.229056	56.769552
Egretta garzetta	1.25	1.50	3.045129	59.814681
Artamus fuscus	2.75	1.13	2.969265	62.783946
Spilopelia chinensis	2.25	3.13	2.905680	65.689625
Merops orientalis	2.81	3.13	2.494024	68.183649
Dicaeum cruentatum	2.13	0.00	2.361253	70.544902
Organic Rice Paddy – Inorganic Rice Paddy				
Lonchura punctulata	1.31	19.56	19.696335	19.69633502
Lonchura striata	0.00	13.75	13.398039	33.09437386
Hirundo rustica	0.00	8.75	7.802361	40.89673514
Passer montanus	5.56	0.00	6.684239	47.58097428
Organic Rice Paddy – Inorganic Rice Paddy				
Acridotheres grandis	2.31	6.94	6.584069	54.16504357
Cypsiurus balasiensis	3.50	6.00	6.542293	60.70733677
Acridotheres tristis	3.88	4.94	4.027889	64.73522529
Spilopelia chinensis	0.00	3.13	3.248691	67.98391614
Merops orientalis	1.25	3.13	2.806461	70.79037727

3.1.2 Species and number of birds in each growth phase of the rice

Twenty-four species and 43 species of birds were found in the organic rice paddy and the inorganic rice paddy, respectively. According to the types of bird diet, the birds could be divided into three groups, which were herbivorous birds, carnivorous birds, and omnivorous birds (Figure 2B).

3.1.3 Species diversity, evenness, and similarity of birds in each growth phase of the rice

In the organic rice paddy, the GP had the highest diversity of birds (H' and λ), followed by the RiP, the ReP, and the VP. In the inorganic rice paddy, the VP had the highest diversity of birds (H' and λ), followed by the GP, the ReP, and the RiP. In the organic rice paddy, the GP had the highest value of the evenness index (J), followed by the ReP, the RiP, and the VP. In the inorganic rice paddy, it was found that the GP had the highest value of the evenness index, followed by the VP, the ReP, and the RiP, respectively. The species richness (D) in the organic rice paddy had the highest value in the GP, followed by the VP, the RiP, and the ReP, respectively. Meanwhile, the inorganic rice paddy showed the top D in the VP, followed by the ReP, the RiP, and the GP, respectively (Figure 7). When considering the similarities of birds found in the organic and inorganic rice paddies by the rice growth phases, it was found that the resemblance of birds was quite distinct between the rice paddies in the two areas. For each rice paddy, the last two phases of rice growth had the most similarities of birds (Figure 4B). The ANOSIM test presented the statistical difference in bird species assembly among habitats and rice growth (R = 0.7106, p = 0.0001). The NMDS analysis supported this difference by showing a good fit and positive linear relationship between the observed dissimilarity and the ordination distance (0.1475 stress, linear fit: r^2 = 0.826) (Figures 5B and 6B). Table 3 indicates the percentage contribution of the most critical species between each pair of the rice growth phase of the organic rice paddy and the inorganic rice paddy from the SIMPER analysis. Those species with a high percentage are more representative in one of the two phases.

3.1.4 Survey of insects on the growth phases of the rice

Ten orders of insects were found during the growth phases of the rice. There were 11 families containing insect pests namely Coccinellidae, Cecidomyiidae, Clecidomyiidae, Alydidae, Coreidae, Cicadelliodae, Eucleidae, Hypsidae, Pyralidae, Syntomide, and Acrididae. The number of insects discovered in organic and inorganic rice paddies is shown in Table 4.

3.1.5 The correlation between insectivorous birds and insect pests

When considering the relation of the number of insectivorous birds and the number of insect pests in the organic rice paddy in all four phases, it was found that carnivorous birds and insect pests were strongly positively correlated, $r(2) = .68$, $p = .32$. Whilst, in the inorganic rice paddy, both variables were also strongly positively correlated, $r(2) = .62$, $p = .38$ (Figure 8). This means that the change of either variable was correlated to the change of another variable in the same direction or both types of paddies. If there are a large number of insect pests, there will also be a large number of predatory birds. However, the Lesser Whistling Duck was not included in the analysis as it was not eating insects.

3.2 Discussion

The study area is an agricultural area comprising rice paddies and patchy planted forests, where variations in site characteristics can also affect bird diversity in the study area. Many species of birds may have intrinsic habitats within the planted forests or on the edges between planted forests and rice paddies. In addition, during the rainy season, which is the farming season, disturbances caused by farmers can cause birds to take shelter in nearby forest patches. Therefore, the study also initially investigated birds in the nearby planted forest to see differences in bird species found in the study area. It was found that bird species living in the three study sites were similar and they were mostly

Table 3. Percentage of contribution and cumulative contribution of the most influential species for the dissimilarity between each pair of phases of rice growth of the organic rice paddy and the inorganic rice paddy (ava and avb are average abundances of phase types)

Species	ava	avb	% Contribution	% Cumulative contribution
O.GP_O.VP				
Passer montanus	0.00	10.50	21.004013	21.004013
Acridotheres tristis	5.75	0.75	11.207869	32.211882
Ploceus philippinus	4.50	0.00	10.464061	42.675943
Cypsiurus balasiensis	0.00	5.75	10.268411	52.944354
Acridotheres grandis	2.50	4.25	7.613181	60.557535
Vanellus indicus	2.75	0.75	5.795052	66.352588
Ardeola bacchus	3.25	1.25	5.295233	71.647821
O.GP_O.ReP				
Ploceus philippinus	4.50	0.00	14.040070	14.040070
Passer montanus	0.00	4.00	10.761075	24.801145
Acridotheres tristis	5.75	4.25	9.075188	33.876333
Ardeola bacchus	3.25	0.50	8.494973	42.371306
Cypsiurus balasiensis	0.00	2.50	7.730621	50.101928
Vanellus indicus	2.75	0.25	7.704093	57.806021
Acridotheres grandis	2.50	0.75	6.405206	64.211227
Lonchura punctulata	1.75	1.75	6.198513	70.409740
O.GP_O.RiP				
Passer montanus	0.00	7.75	18.266979	18.266979
Cypsiurus balasiensis	0.00	5.75	13.632229	31.899207
Ploceus philippinus	4.50	0.00	11.601376	43.500584
Ardeola bacchus	3.25	0.00	7.986447	51.487031
Vanellus indicus	2.75	1.50	7.088501	58.575532
Columba livia	0.75	3.00	6.444851	65.020383
Ardea intermedia	1.00	2.75	5.088996	70.109380
O.GP_I.GP				
Cypsiurus balasiensis	0.00	5.50	12.178538	12.178538
Ploceus philippinus	4.50	0.00	10.429727	22.608265
Lonchura punctulata	1.75	4.50	10.251514	32.859779
Ardeola bacchus	3.25	0.00	7.202575	40.062354
Acridotheres grandis	2.50	5.25	6.701115	46.763468
Vanellus indicus	2.75	0.75	5.922885	52.686354
Egretta garzetta	1.00	3.25	5.826289	58.512643

Table 3. Percentage of contribution and cumulative contribution of the most influential species for the dissimilarity between each pair of phases of rice growth of the organic rice paddy and the inorganic rice paddy (ava and avb are average abundances of phase types) (continued)

Species	ava	avb	% Contribution	% Cumulative contribution
Acridotheres tristis	5.75	4.25	5.140036	63.652679
Merops orientalis	0.25	2.25	4.660275	68.312955
Spilopelia chinensis	0.00	1.25	2.968722	71.281677
O.GP_I.VP				
Lonchura punctulata	1.75	16.25	18.707106	18.707106
Lonchura striata	0.00	10.00	13.335876	32.042982
Cypsiurus balasiensis	0.00	6.00	7.504044	39.547027
Acridotheres grandis	2.50	8.00	7.167866	46.714893
Ploceus philippinus	4.50	0.00	6.059371	52.774263
Merops orientalis	0.25	3.50	4.506188	57.280451
Vanellus indicus	2.75	2.75	3.813445	61.093896
Acridotheres tristis	5.75	4.75	3.515014	64.608910
Ardeola bacchus	3.25	1.00	2.926701	67.535610
Artamus fuscus	0.00	2.50	2.918152	70.453762
O.GP_I.ReP				
Lonchura punctulata	1.75	27.50	23.929905	23.929905
Lonchura striata	0.00	17.50	16.041446	39.971351
Hirundo rustica	0.00	15.00	12.919553	52.890904
Cypsiurus balasiensis	0.00	7.50	7.221355	60.112259
Acridotheres grandis	2.50	6.00	4.323247	64.435506
Merops orientalis	0.25	4.75	4.261485	68.696991
Spilopelia chinensis	0.00	4.50	4.255817	72.952808
O.GP_I.RiP				
Lonchura punctulata	1.75	30.00	22.745905	22.745905
Lonchura striata	0.00	27.50	21.859773	44.605678
Hirundo rustica	0.00	20.00	16.061465	60.667143
Streptopelia tranquebarica	0.00	6.50	5.161163	65.828306
Acridotheres grandis	2.50	8.50	4.715219	70.543524
O.VP_O.ReP				
Passer montanus	10.50	4.00	25.371187	25.371187
Acridotheres tristis	0.75	4.25	12.119940	37.491126
Acridotheres grandis	4.25	0.75	9.385318	46.876444
Cypsiurus balasiensis	5.75	2.50	7.442460	54.318905
Lonchura punctulata	0.50	1.75	6.221434	60.540339
Merops orientalis	1.75	1.25	5.861953	66.402292
Artamus fuscus	1.75	0.00	5.096924	71.499216

Table 3. Percentage of contribution and cumulative contribution of the most influential species for the dissimilarity between each pair of phases of rice growth of the organic rice paddy and the inorganic rice paddy (ava and avb are average abundances of phase types) (continued)

Species	ava	avb	% Contribution	% Cumulative contribution
O.VP_O.RiP				
Passer montanus	10.50	7.75	24.362276	24.362276
Cypsiurus balasiensis	5.75	5.75	11.775794	36.138070
Acridotheres tristis	0.75	4.75	10.975941	47.114011
Acridotheres grandis	4.25	1.75	8.952724	56.066735
Columba livia	0.00	3.00	7.819695	63.886430
Ardea intermedia	0.75	2.75	5.643474	69.529905
Vanellus indicus	0.75	1.50	4.970958	74.500863
O.VP_I.GP				
Passer montanus	10.50	0.00	20.943687	20.943687
Lonchura punctulata	0.50	4.50	10.135146	31.078833
Cypsiurus balasiensis	5.75	5.50	9.761267	40.840101
Acridotheres grandis	4.25	5.25	9.656526	50.496627
Acridotheres tristis	0.75	4.25	7.440193	57.936820
Egretta garzetta	0.75	3.25	6.644600	64.581420
Artamus fuscus	1.75	1.00	3.926555	68.507975
Spilopelia chinensis	0.00	1.25	2.912133	71.420108
O.VP_I.VP				
Lonchura punctulata	0.50	16.25	19.694285	19.694285
Lonchura striata	0.00	10.00	12.790039	32.484323
Passer montanus	10.50	0.00	12.549724	45.034047
Acridotheres grandis	4.25	8.00	7.543889	52.577936
Cypsiurus balasiensis	5.75	6.00	6.875008	59.452944
Acridotheres tristis	0.75	4.75	4.910683	64.363627
Vanellus indicus	0.75	2.75	3.104859	67.468486
Artamus fuscus	1.75	2.50	3.035996	70.504482
O.VP_I.ReP				
Lonchura punctulata	0.50	27.50	24.599129	24.599129
Lonchura striata	0.00	17.50	15.669300	40.268429
Hirundo rustica	0.00	15.00	12.622045	52.890474
Passer montanus	10.50	0.00	9.053047	61.943521
Cypsiurus balasiensis	5.75	7.50	5.904049	67.847570
Acridotheres tristis	0.75	6.00	5.112281	72.959852
O.VP_I.RiP				
Lonchura punctulata	0.50	30.00	22.816340	22.816340
Lonchura striata	0.00	27.50	20.936119	43.752459

Table 3. Percentage of contribution and cumulative contribution of the most influential species for the dissimilarity between each pair of phases of rice growth of the organic rice paddy and the inorganic rice paddy (ava and avb are average abundances of phase types) (continued)

Species	ava	avb	% Contribution	% Cumulative contribution
Hirundo rustica	0.00	20.00	15.382002	59.134462
Passer montanus	10.50	0.00	7.729173	66.863635
Streptopelia tranquebarica	0.00	6.50	4.943146	71.806781
O.ReP_O.RiP				
Passer montanus	4.00	7.75	26.127932	26.127932
Cypsiurus balasiensis	2.50	5.75	10.516966	36.644898
Columba livia	1.00	3.00	9.524316	46.169214
Acridotheres tristis	4.25	4.75	9.052223	55.221437
Ardea intermedia	0.50	2.75	7.366426	62.587864
Lonchura punctulata	1.75	1.25	6.566414	69.154277
Merops orientalis	1.25	1.75	6.015871	75.170149
O.ReP_I.GP				
Lonchura punctulata	1.75	4.50	11.738017	11.738017
Acridotheres grandis	0.75	5.25	11.234686	22.972703
Passer montanus	4.00	0.00	9.372790	32.345493
Cypsiurus balasiensis	2.50	5.50	8.750399	41.095892
Egretta garzetta	0.75	3.25	7.359039	48.454931
Acridotheres tristis	4.25	4.25	7.177669	55.632600
Merops orientalis	1.25	2.25	5.024896	60.657495
Spilopelia chinensis	0.00	1.25	3.423790	64.081286
Ixobrychus cinnamomeus	0.00	1.25	3.359626	67.440912
Columba livia	1.00	0.00	2.756342	70.197254
O.ReP_I.VP				
Lonchura punctulata	1.75	16.25	19.218859	19.218859
Lonchura striata	0.00	10.00	13.787173	33.006032
Acridotheres grandis	0.75	8.00	9.742284	42.748316
Cypsiurus balasiensis	2.50	6.00	6.198795	48.947110
Passer montanus	4.00	0.00	5.158507	54.105617
Acridotheres tristis	4.25	4.75	4.308571	58.414188
Merops orientalis	1.25	3.50	3.960795	62.374982
Vanellus indicus	0.25	2.75	3.591869	65.966851
Artamus fuscus	0.00	2.50	2.985731	68.952582
Ardea alba	0.00	2.25	2.861995	71.814577

Table 3. Percentage of contribution and cumulative contribution of the most influential species for the dissimilarity between each pair of phases of rice growth of the organic rice paddy and the inorganic rice paddy (ava and avb are average abundances of phase types) (continued)

Species	ava	avb	% Contribution	% Cumulative contribution
O.ReP_I.ReP				
Lonchura punctulata	1.75	27.50	25.083463	25.083463
Lonchura striata	0.00	17.50	16.826662	41.910125
Hirundo rustica	0.00	15.00	13.503878	55.414003
Cypsiurus balasiensis	2.50	7.50	6.219149	61.633152
Acridotheres grandis	0.75	6.00	5.315562	66.948715
Spilopelia chinensis	0.00	4.50	4.472238	71.420953
O.ReP_I.RiP				
Lonchura punctulata	1.75	30.00	23.228354	23.228354
Lonchura striata	0.00	27.50	22.335828	45.564182
Hirundo rustica	0.00	20.00	16.419572	61.983754
Acridotheres grandis	0.75	8.50	6.228276	68.212030
Streptopelia tranquebarica	0.00	6.50	5.273592	73.485622
O.RiP_I.GP				
Passer montanus	7.75	0.00	16.795730	16.795730
Lonchura punctulata	1.25	4.50	10.400838	27.196569
Cypsiurus balasiensis	5.75	5.50	9.477186	36.673755
Acridotheres grandis	1.75	5.25	7.681517	44.355271
Egretta garzetta	0.00	3.25	7.182982	51.538253
Columba livia	3.00	0.00	6.374329	57.912582
Ardea intermedia	2.75	0.00	6.265117	64.177700
Vanellus indicus	1.50	0.75	3.938622	68.116322
Acridotheres tristis	4.75	4.25	3.840987	71.957308
O.RiP_I.VP				
Lonchura punctulata	1.25	16.25	18.770039	18.770039
Lonchura striata	0.00	10.00	12.898518	31.668556
Passer montanus	7.75	0.00	9.620107	41.288663
Acridotheres grandis	1.75	8.00	7.848636	49.137299
Cypsiurus balasiensis	5.75	6.00	5.889815	55.027114
Columba livia	3.00	0.00	3.675676	58.702790
Egretta garzetta	0.00	2.75	3.569650	62.272440
Ardea intermedia	2.75	0.00	3.519708	65.792148
Acridotheres tristis	4.75	4.75	3.017884	68.810032
Artamus fuscus	0.00	2.50	2.839348	71.649381

Table 3. Percentage of contribution and cumulative contribution of the most influential species for the dissimilarity between each pair of phases of rice growth of the organic rice paddy and the inorganic rice paddy (ava and avb are average abundances of phase types) (continued)

Species	ava	avb	% Contribution	% Cumulative contribution
O.RiP_I.ReP				
Lonchura punctulata	1.25	27.50	24.294716	24.294716
Lonchura striata	0.00	17.50	15.981594	40.276310
Hirundo rustica	0.00	15.00	12.899958	53.176268
Passer montanus	7.75	0.00	6.966640	60.142908
Cypsiurus balasiensis	5.75	7.50	4.997135	65.140043
Acridotheres grandis	1.75	6.00	4.619704	69.759747
Spilopelia chinensis	0.00	4.50	4.235187	73.994934
O.RiP_I.RiP				
Lonchura punctulata	1.25	30.00	22.629351	22.629351
Lonchura striata	0.00	27.50	21.376286	44.005637
Hirundo rustica	0.00	20.00	15.700984	59.706621
Passer montanus	7.75	0.00	5.940381	65.647001
Acridotheres grandis	1.75	8.50	5.177524	70.824526
I.GP_I.VP				
Lonchura punctulata	4.50	16.25	21.063390	21.063390
Lonchura striata	0.00	10.00	16.969839	38.033229
Cypsiurus balasiensis	5.50	6.00	7.211324	45.244553
Acridotheres grandis	5.25	8.00	4.575722	49.820275
Egretta garzetta	3.25	2.75	4.509279	54.329554
Acridotheres tristis	4.25	4.75	3.966655	58.296208
Vanellus indicus	0.75	2.75	3.947774	62.243983
Artamus fuscus	1.00	2.50	3.917276	66.161259
Apus affinis	0.50	2.00	3.457979	69.619237
Ardea alba	0.50	2.25	3.179678	72.798915
I.GP_I.ReP				
Lonchura punctulata	4.50	27.50	24.220513	24.220513
Lonchura striata	0.00	17.50	18.201338	42.421852
Hirundo rustica	0.00	15.00	14.714871	57.136722
Cypsiurus balasiensis	5.50	7.50	5.003353	62.140075
Acridotheres tristis	4.25	6.00	4.219229	66.359304
Spilopelia chinensis	1.25	4.50	4.132057	70.491361
I.GP_I.RiP				
Lonchura striata	0.00	27.50	23.786547	23.786547
Lonchura punctulata	4.50	30.00	22.318847	46.105393
Hirundo rustica	0.00	20.00	17.467419	63.572812

Table 3. Percentage of contribution and cumulative contribution of the most influential species for the dissimilarity between each pair of phases of rice growth of the organic rice paddy and the inorganic rice paddy (ava and avb are average abundances of phase types) (continued)

Species	ava	avb	% Contribution	% Cumulative contribution
Streptopelia tranquebarica	0.00	6.50	5.616089	69.188902
Cypsiurus balasiensis	5.50	5.00	4.397932	73.586834
I.VP_I.ReP				
Hirundo rustica	0.00	15.00	17.092358	17.092358
Lonchura punctulata	16.25	27.50	15.259418	32.351776
Lonchura striata	10.00	17.50	10.539353	42.891129
Cypsiurus balasiensis	6.00	7.50	5.506326	48.397455
Spilopelia chinensis	0.75	4.50	5.022602	53.420056
Acridotheres tristis	4.75	6.00	4.677948	58.098004
Acridotheres grandis	8.00	6.00	3.952987	62.050991
Dicrurus macrocercus	0.00	3.25	3.915665	65.966656
Egretta garzetta	2.75	0.00	3.326856	69.293512
Artamus fuscus	2.50	1.00	2.888168	72.181680
I.VP_I.RiP				
Hirundo rustica	0.00	20.00	19.672727	19.672727
Lonchura striata	10.00	27.50	16.989820	36.662547
Lonchura punctulata	16.25	30.00	15.022193	51.684740
Streptopelia tranquebarica	0.00	6.50	6.337791	58.022530
Spilopelia chinensis	0.75	6.00	5.111915	63.134445
Cypsiurus balasiensis	6.00	5.00	4.963155	68.097600
Acridotheres tristis	4.75	4.75	2.995528	71.093128
I.ReP_I.RiP				
Hirundo rustica	15.00	20.00	21.590161	21.590161
Lonchura striata	17.50	27.50	14.099470	35.689631
Lonchura punctulata	27.50	30.00	9.204147	44.893778
Spilopelia chinensis	4.50	6.00	8.160005	53.053783
Streptopelia tranquebarica	1.25	6.50	7.466588	60.520371
Cypsiurus balasiensis	7.50	5.00	7.352564	67.872935
Acridotheres tristis	6.00	4.75	5.397772	73.270707

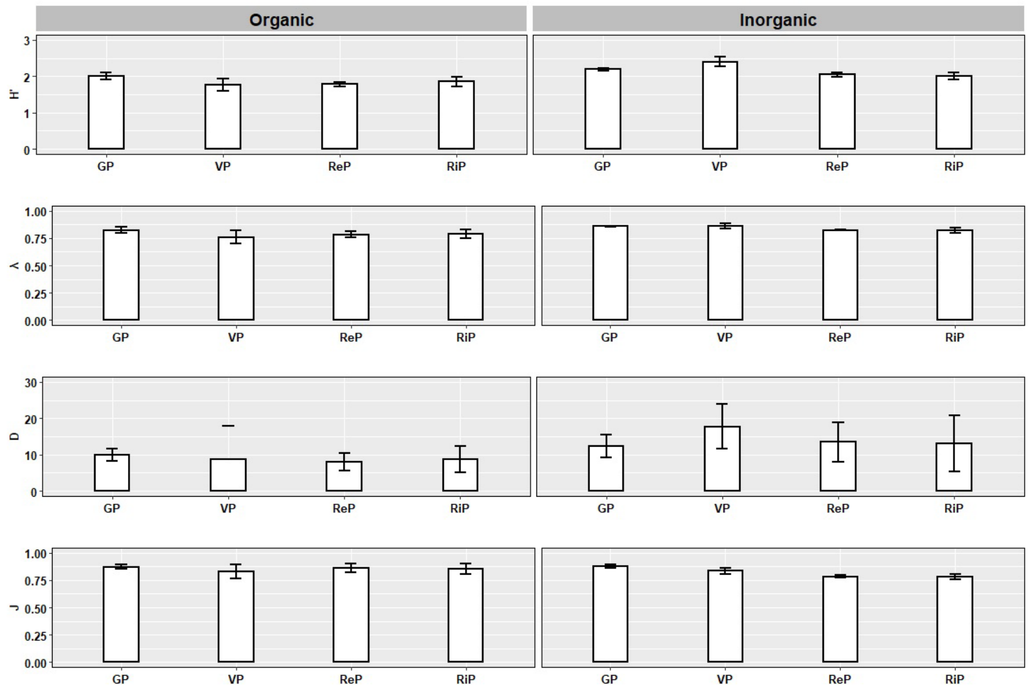

Figure 7. Mean and SE comparison of species richness and diversity of birds among all rice growth phases; **A** Shannon Wienner's diversity index (H'), **B** Simpson's index (λ), **C** Species richness (D), and **D** Evenness index (J)

Table 4. Number of insects found in each growth phase of rice in organic and inorganic rice paddies

Order	Family	No. of Individuals							
		Organic Rice Paddy				Inorganic Rice Paddy			
		GP	VP	ReP	RiP	GP	VP	ReP	RiP
Coleoptera	Carabidae			9	3			1	2
	Chrysomelidae				4			3	
	Coccinellidae*			10	12	7		4	3
	Dytiscidae	8							
	Hydrophilidae	17	6						
	Limnichidae	4							
Diptera	Cecidomyiidae*			4	2			5	1
	Ceratopogonidae	9	10			65	70		
	Chironomidae	30	39			107	126		
	Clecidomyiidae*	8					7		
	Culicidae	12	30			86	90		
	Ephydridae	2							
	Psychodidae		17				13		
	Sciomyzidae	1							
	Tipulidae					24			
Epemeroptera	Betidae	120	172			27	8		
	Caenidae	33	90						
Hemiptera	Alydidae*	9			5		3	2	
	Bolostomatidae					6			
	Coreidae*	4		2		3	4		3
	Corixidae	22					24		

Table 4. Number of insects found in each growth phase of rice in organic and inorganic rice paddies (continued)

Order	Family	No. of Individuals							
		Organic Rice Paddy				Inorganic Rice Paddy			
		GP	VP	ReP	RiP	GP	VP	ReP	RiP
Hemiptera	Gerridae	1	4				3		
	Naucoridae	19	24						
	Notonectidae	37	36			7	3		
	Veliidae	5	6						
Homoptera	Cicadelliodae*		12				8		
Lepidopetera	Crambidae		3						
	Eucleidae*			3	4				
	Hypsidae*			2	3				
	Pyralidae*						10	7	
	Syntomide*				4			4	
Megaloptera	Corydalidae	1							
Odonata	Chlorocyphidae	10	11						
	Coenagrionidae	4							
	Corduliidae	19					5		
	Gomphidae		9			12	7		
	Libellulidae			15	14				
	Protoneuridae	3	5						
Orthoptera	Acrididae*		20	12	20	12	23	29	20
Trichoptera	Lepdidistomatidae						8		

* Insect pests of rice

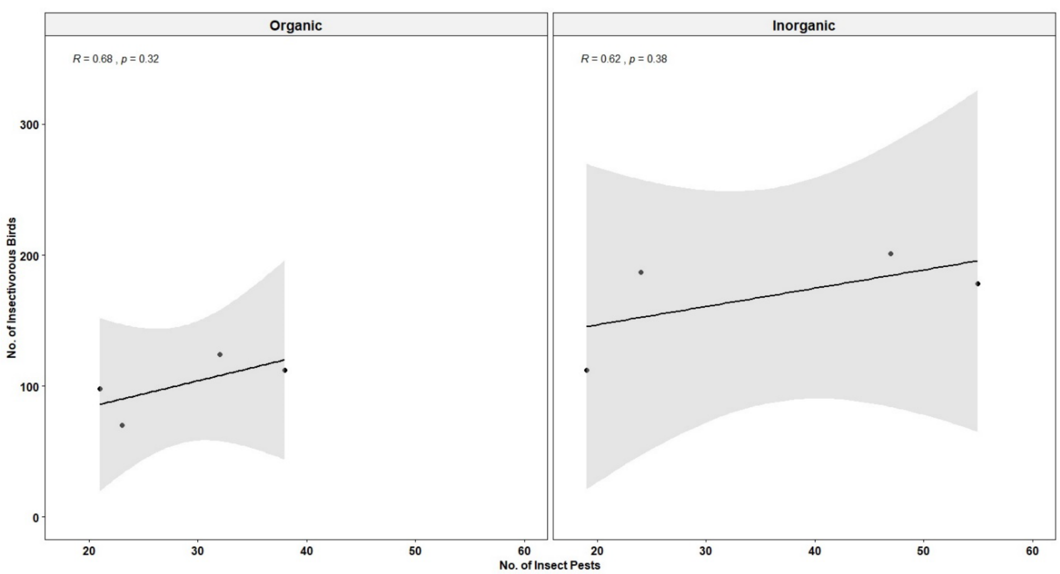

Figure 8. Pearson correlation coefficient between the number of insectivorous birds and the number of insect pests in organic and inorganic rice paddies

resident birds in the study area. The presence of planted forest nearby is unlikely to affect the abundance of birds in the rice paddies. The planted forest area of Mai Mae Tia Village, Doi Kaew Subdistrict, Chom Thong District in Chiang Mai Province is an open area with a deciduous forest that is more suitable for the line-transect surveying than point-count surveying because the former method is appropriate for the areas with a low density of birds and are easily accessible so that the recording of bird data can be done and researchers can cover the areas quickly. The designated point-count survey is for complex and dense habitats [27]. During the rainy season, most incoming birds in all three study areas are resident birds and some migratory birds that use the spaces for nesting and breeding, such as White-vented Myna, Oriental Magpie Robin, Chinese Pond Heron, Streak-eared Bulbul. They fly to the tall trees because, during this period, crops such as longan begin to bear fruit [28]. Rice cultivation is started in surrounding rice paddies resulting in birds finding food in the planted forest and nearby areas [29]. The Passeriformes is the most observed bird since it has the highest number of species found in Thailand, and most of them are residents. Their breeding season is between April and June [14].

The rice paddies are essential to birds because birds can use rice paddies for many activities, such as shelters, breeding grounds, and food sources [30]. Some species are considered migratory birds because they come to Thailand in September, not in the breeding season, and migrate back from March to April, resulting in finding a small number of migratory birds during the rice-planting period. While passage migrants are usually found in Thailand at the beginning of August and migrate back in around March to May, some species may live in Thailand during the cold season [13]. At the time of the study, the rice paddies may have been suitable for some migratory birds due to the areas being a junction in which birds could make use of. September is when the rice paddies are waterlogged areas and is the beginning of the VP of rice growth. Thus, birds, both residents, and migrants, make use of the rice paddies more than other months. The Red-billed Blue Magpies can be seen all year round. They feed on insects and like to live in small groups in the scrub forests or sparse forest areas, often shouting as they begin to feed. Sometimes, they come down to forage on the ground, in the niche of the stone or the decaying wood. The Eurasian Tree Sparrows are also very common. They are usually seen in pairs or small groups. They can eat a variety of food, mainly seeds, but sometimes eat invertebrates [31]. Their habitat is found in agricultural areas where they build nests in trees [13]. The conditions of the study areas are rice terraces. Even before the rice planting during the summer, the fields is arid. But the surrounding areas have a pond and grassy areas with seeds which can be food for those common species.

In the forested area, eight resident species of birds are commonly abundant, such as Oriental Magpie-robin, Asian Green Bee-eater, and Streak-eared Bulbul. Eleven resident species are moderately abundant. Twenty-eight species (20 residents and eight migrants) are uncommonly abundant. Some migratory birds may come sooner around July to August [32], such as Red-throated Flycatcher, Little Egret, and Barn Swallow, but the number of populations is found to be small. During the survey period, some days it rained all day, no birds were found to use the agricultural areas. And that was the period in which the farmers came to do more activities in the rice paddies after the paddies had been abandoned over the summer. Therefore, when there were more stimuli to disturb the birds, we could not find a variety of birds. However, we found more than double the number of individuals of some species in the summer, especially Eurasian Tree Sparrows that were nesting in the rice paddies and more likely to be found in groups than in the summer as well [33]. This may be due to the general wetland area having been waterlogged in the rainy season, resulting in the area being suitable as a habitat, and the abundant food sources were on the rise, making the birds dispersed more in other wetlands. Therefore, the birds in the rainy season were less dense than at other times. The season does affect the species and number of birds in the area [34]. Moreover, some physical factors such as rainfall and temperature are inversely proportional to species presence, meaning that the number of species and individuals decreased [35].

There were more bird species found in the inorganic rice paddy than in the organic rice paddy. It was observed that the number of species found was different since the beginning of the study. This may be a result of external factors involved, such as the presence of food and water sources nearby, construction sites, road traffic, which made it difficult to determine the causes of different in species in the two types of rice paddies. However, what is evident from this study is that the number of bird species was greatly reduced in inorganic rice paddies after the VP due to the use of chemicals. While in the organic rice paddy, the number of species found in each rice stage differed only slightly. In the GP, there was an area with a lot of water. Some insects were both terrestrial and aquatic. Most of the birds that made use of the area were usually insectivorous such as Baya Weaver, Cinnamon Bittern, Black-winged Kite. The ReP was the most common period for migratory birds. Because this period was the second half of rice growth, various insects being present caused both resident and migratory birds to find food in the areas. Birds found in the RiP were mostly common residential birds. The common migratory bird was Intermediate Egret, which migrates from the north in cold weather and descends to the south with the warm weather in early November, which is the same period as the study [36]. Therefore, many insectivorous and granivorous birds can be seen in this ReP because many insects were resident and the rice grains had started to grow long [37].

In the organic rice paddy, the GP has the highest value of diversity index (H' and λ), species richness, and evenness. Since it was during the period of rice planting and the rice paddy still had water, making the birds that ate aquatic animals or small reptiles were likely to be found, such as Red-wattled Lapwing and Common Myna. It is followed by the RiP, which was the harvesting period when there was no more water in the rice paddy. Farmers came to use the area more than before. At this time, there were more disturbances from the outside environment, from both humans and animals, which resulted in a low number of birds found in this range. Besides, the weather was not favorable for the livelihood of birds. In this period, the Intermediate Egret was the only migratory species found. With the diversity of birds ranked in third place, the ReP was the period in which the rice grains began to yield, and the rice leaves began to grow, resulting in insects that were pests that ate rice leaves, such as grasshoppers and various aphids. Some migratory birds that eat insects and small aquatic animals entered the area, eg., Ardeidae. The VP has the lowest value of the diversity index. Although more species and numbers of birds were found in this phase than in the RiP, we found one species, Eurasian Tree Sparrow, which has a very high number of individuals. Other species were few in numbers, which kept the overall diversity to a minimum.

In the inorganic rice paddy, the VP had the highest value of diversity index. The rice paddy in this period was still waterlogged and many small aquatic creatures were present, and the rice leaves had begun to grow, resulting in more pests that ate the rice leaves. The birds that entered the area mainly fed on insects and small aquatic animals [38]. The GP followed it. We found only one species of water bird: Lesser Whistling Duck, and very few species of migratory birds [39]. The diversity index of the ReP ranked third. In this period, the water was taken out of the area, and the rice grains began yielding. Therefore, there was spraying of chemicals in the rice paddy to get rid of pests, causing the food of the birds to decrease, resulting in fewer birds found in the area [40]. Another possible reason is that this phase, unlike GP and VP, the lack of waterlogging resulted in a decrease in the number of birds that fed on small aquatic animals. The RiP had the lowest value of the diversity index. Since the rice paddy began to dry and the rice was ready to be harvested, most of the birds found were resident birds that ate insects and grains. However, the birds were disturbed by humans who had come to check on the rice more often than other periods. Weeds are sprayed so that the rice is ready before the harvest, which causes the number of birds to decrease [41].

The relationship between the number of insectivorous birds and the number of insect pests in the organic rice paddy had a high level of relevance [38]. Since the surveyed area was chemical-free, a high number of insect pests came into the rice paddy. The birds that made use of the field at each phase of rice growth may be different, but at every stage, there were more predatory birds that used the area than herbivores. This indicates that birds can help get rid of insects and pests without the use of chemicals during rice growth [42]. The use of chemicals, aside from being harmful to humans, causes the destruction of ecosystems and adversely affects soil and water [43]. Encouraging farmers to turn to organic farming can result in more excellent benefits for the ecosystem [44]. As for the inorganic rice paddy, the relationship between the number of insectivorous birds, and the number of insect pests had a moderate level of relevance [38]. In this area, chemicals were used in rice production, which decreased the number of pests in the area [45]. So, the birds found in each phase were different. Predatory birds were dominant, while, in some phases, herbivorous birds were more common. When there were a lot of insects, the number of birds also increased. During the spraying of chemicals, the ReP and the RiP were periods in which there were fewer insect pests. The number of birds, therefore, decreased too. During these periods, most of the birds found were herbivores or granivorous birds.

4. Conclusions

Most of the birds discovered in the survey were in Order Passeriformes and were carnivores, especially the insectivores. The species found in the planted forest were more similar to those found in the organic rice paddy than the inorganic rice paddy. However, the birds observed in both rice paddies were quite different. The Shannon Wiener's diversity index, Simpson's index, and species richness were in the same direction. The types of birds detected in each phase of rice growth were similar within each variety of habitat. The number of insectivorous birds showed positive correlation with the number of insect pests. This showed that birds, especially insectivorous birds, played an essential role in both organic and inorganic rice paddies.

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