Birds diversity at Sabak Bernam granary of West Peninsular Malaysia

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Abstract. Paddy field ecosystem serves as critical feeding and nesting habitat for various birds, thus compensating the habitat loss and degradation of the natural ecosystem. We want to document the bird species abundance and composition at Sabak Bernam granary area, located in West Peninsular Malaysia. The species distribution pattern was known to associate with rice growing stages. Birds was observed with a week of survey in each rice growing phases using point-count method. Overall, 40 species and 23 families have been recorded from all growing phases. Ploughing phase showed the highest bird abundance (736 individuals), while, maturation phase showed the highest species richness (31 species) and reproductive phase recorded the highest species diversity (H= 2.474). Waterbirds were the most dominant family which consists of Ardeidae, Alcedinidae and Rallidae. Three migrant and one vagrant were recorded in this study. Insectivory was the most abundant guild, dominated by Pacific swallow (Hirundo tahitica). However, there were no significant differences between all feeding guilds at different phases (df=3, p>0.05). This study indicates that although several species were pest upon rice buds, many of them play a crucial role in paddy field ecosystem services, particularly for pest control, reduce weeds and scavenging on carcasses. Therefore, this man-made wetland habitat area able to harbour a great diversity of birds and indirectly give benefits to the farmers.

1. Introduction

Rice is one of the most essential staple food in Asia. Rice is the final product that can be obtained from paddy crops. Paddy is a semi-aquatic crop and has 22 species from genus Oryza, 20 of those are wild crops [1]. 520 million people in Asia eat rice as their primary source of food. Countries in Africa, the Caribbean and South America have recorded a continuous increase in the intake and consumption of rice in their population [1]. In 1998, the International Rice Research Institute (IRRI) had predicted that the demand for rice will increase up to 612 million tons’ metric in the next 12 years [2]. Apart from gastronomic resources, rice field provides essential ecosystem services, including groundwater recharge, landslide prevention, climate-change mitigation, as well as supporting biodiversity [3].

Worldwide, natural wetlands and forest habitat have been converted to paddy fields [4], which ultimately forced a lot of organisms to utilize the area. Birds are an essential component of the rice field ecosystem because of their role as predators of agricultural pest such as arthropods, and insects [5]. Waterbirds rely heavily on wetlands to carry on their daily lives such as nesting, foraging and roosting. In fact, waterbirds and migratory birds in the rice field contribute significantly to the total bird species found in Peninsular Malaysia [6]. However, birds are often considered as pests in the rice fields [7], particularly among the grain-based diet (granivore), which include sparrows and munias.
Determining the distribution pattern and habitat use of the birds could inform the land-owners and farmers on the best time to control the pest species.

A fairly wide range of literature has distinguished the bird assemblages in the rice field, including Malaysia. In Peninsular Malaysia, several studies have documented bird diversity in different paddy field areas. Munira et al. [8] recorded 67 species in the northern territories of Peninsular Malaysia, while Mohd-Taib & Kamaruddin [9] recorded 22 species of birds in the rice field in the eastern part of Peninsular Malaysia. The differences can be attributed to the geographical and geomorphological differences of the landscapes as Zainul-Abidin et al. [10] mentioned that the west coast region contained more wetland, shoreline, marshes, mangrove and agriculture than the east coast of Peninsular Malaysia. However, both studies demonstrated Ardeidae, Hirundinidae, and Columbidae as the most dominant family. However, there was inadequate information on the pattern of bird abundance and assemblages according to the rice-growing stages and water-regimes, especially in the western region of Peninsular Malaysia. Therefore, in this study, we want to distinguish the birds' diversity, based on their feeding guild in different crop stages.

2. Method

2.1. Study area

The study site was conducted at Kampung Parit 12 Timur, Sungai Besar (3º43’38.9” N 101º03’40.8” E) in the Sabak Bernam district, North Selangor, Peninsular Malaysia (Fig. 1). It is one of the main granary areas of Peninsular Malaysia. The rice cultivation and harvesting period follow the irrigation regimes in different region. Here, the double-cropping system is practiced where rice is cultivated and harvested twice a year with four growing phases: (1) ploughing, (2) cultivation, (3) reproductive and (4) maturation. Table 1 below shows the description of each rice-growing phases.

| Phases    | Description                                                                 |
|-----------|------------------------------------------------------------------------------|
| Ploughing | Field preparation phase; involve inundation with intermediate water level (5-10 cm), weeding, improve soil structure and to create a favourable environment for the rice to grow (fertilized) |
| Cultivation | Vegetative phase; where there is gradually increased in the plant height and development of the tillers and more leaves occur |
| Reproductive | Heading and flowering phase; pollination occurs during this phase, usually occurs about 7 days |
| Maturation | Ripening phase; grain is ready to harvest. This stage usually takes about 30 days |

Table 1. Description of each rice-growing phase.

According to FAO [11], planting season in Peninsular Malaysia takes place during September-October and March-April, while the harvesting season takes place during December to March and the second season takes place during June to August each year. During the study, cultivation phase began in November due prolonged rainy season in October.
2.2. Bird sampling
The birds were surveyed between 19th October 2018 to 21st January 2019, with a week of survey in each rice-growing phases. Birds were observed using the point-count method, by two observers (W Mohd-Saleh and Rosli MZ) at five-point count stations, randomly selected at the 1km x 1km grid of the paddy field, with a minimum of 200 m distance. Observations were made in the 50-metre radius of each sampling points. Only birds that were heard, perched and did not flew from the previous station were observed using a binocular and recorded. Bird survey was conducted in two sessions; morning session started from 0700hr until 0900hr while the evening session started from 1700hr until 1900hr, during the birds were most active. Birds species identifications followed Robson [12]. Bird census includes species and abundance in each phase.

2.3. Statistical analysis
To compare species compositions between both sites, we use Euclidean distance using MVSP (Multivariate Statistical Package) version 3.13b to determine the degree of dissimilarity in species composition at different rice stages. Several diversity indices were calculated including Shannon diversity (H’), richness, evenness (eH/S) and Jaccard similarity using PAST software version 3.1.4 (Øyvind Hammer, Natural History Museum, University of Oslo). Each species was assigned to specific feeding guild (i.e. carnivore, insectivore, omnivore, granivore, frugivore, nectarivore) and significant differences between the group abundance for both sites were determined using the Mann-Whitney U test.

3. Results
A total of 1888 bird individuals, belonging to 40 species and 23 families has been recorded from all growing phases in the sampling site as shown in Appendix 1 and summarized in Table 2. The highest individuals recorded was during the ploughing phase with 736 individuals, followed by maturation phase with 449 individuals, cultivation phase with 361 individuals, and the least during reproductive phase with 342 individuals. Among all the species recorded, the maturation phase shows the highest species richness with 31 species and 17 families, where the Barn swallow (Hirundo rustica) was the
most dominant species recorded in this phase. The lowest number of species recorded was in cultivation phase with only 21 species and were dominated by House crow (*Corvus splendens*) and Barn swallow. Little egret (*Egretta garzetta*), Great egret (*Ardea alba*), White-throated kingfisher (*Halcyon smyrnensis*), Little heron (*Butorides striata*) and Black-shouldered kite (*Elanus caeruleus*) were commonly recorded throughout the sampling period. From the Euclidean distance matrix table, its shows a relatively high similarity in species composition between reproductive (cycle 3) and maturation (cycle 4) phase, with Euclidean distance of 108.2 (Table 3). A total of 20 species were shared between reproductive and maturation phase in which Barn swallow, a migratory species, was an only present during these phases. The most distant species composition was between ploughing (cycle 1) and cultivation (cycle 2) phase with a Euclidean distance of 484.5.

**Table 2.** Number of species, families and individuals of birds in each rice-growing phase.

|                      | Ploughing phase | Cultivation phase | Reproductive phase | Maturation phase | Total |
|----------------------|-----------------|-------------------|--------------------|------------------|-------|
| Number of species    | 24              | 21                | 25                 | 31               |       |
| Number of families   | 15              | 14                | 13                 | 17               |       |
| Number of individuals| 736             | 361               | 342                | 449              | 1888  |

**Table 3.** Euclidean distance matrix for species distribution in each rice-growing phase.

|               | Ploughing | Cultivation | Reproductive | Maturation |
|---------------|-----------|-------------|--------------|------------|
| Ploughing     | 0         |             |              |            |
| Cultivation   |           | 484.53896   |              |            |
| Reproductive  |           |             | 204.99512    |            |
| Maturation    |           |             |              | 108.23585  |

Waterbirds were the most dominant family in Sabak Bernam’s rice granary field, which consists of seven species of Ardeidae (herons and egrets), two species of Alcedinidae (kingfisher) and one species of Rallidae. Little egret (*Egretta garzetta*) was the most dominant waterbirds from the Ardeidae family with 132 occurrences, followed by White-throated kingfisher (*Halcyon smyrnensis*) from the Alcedinidae family with 64 occurrences. The only raptor recorded during observation in all rice-growing phases was Black-shouldered kite (*Elanus caeruleus*) from the Accipitridae family with 36 occurrences. This raptor was among the common resident in rice granary field, often foraging for small mammals such as rats and shrews, which were known as a common pest in paddy habitat.

Shannon diversity index was the highest in the reproductive phase (2.474), followed by maturation phase (2.431), ploughing phase (2.217) and the lowest at the cultivation phase (1.675). Reproductive phase and maturation phase also showed the highest and the lowest evenness index with the value of 0.4749 and 0.2543, respectively. This indicated that no species was dominating the paddy field during the reproductive phase, unlike the cultivation phase which dominated by Pacific swallow (*Hirundo tahitica*) and Little tern (*Sternula albifrons*).

From 40 species recorded, 25 species were resident (R), 10 species were resident and migrant (R&M), 4 were migrant (M) and one species was vagrant (V). Among the migrant species, Brown shrike (*Lanius cristatus*) were frequently sighted during all phases, while Barn swallow (*Hirundo rustica*) were only observed in large number during cultivation and maturation phases. The Black-bellied Malkoha (*Phaenicophaeus diardi*), a species categorized as Near-Threatened in IUCN Red data list was present during ploughing and maturation phases. Feeding guild assemblages indicates
that insectivore was the most abundant feeding guild (33.7%), followed by omnivore (28.1%), carnivore (27.1%), frugivore (6.3%), granivore (4.4%) and the least abundant group was nectarivore (0.4%). However, there were no significant differences between all feeding guilds in all different phases (df=3, \( p > 0.05 \)). Pacific swallow was the most abundant insectivores observed during ploughing, cultivation and reproductive phases, but was not present during the maturation phase. House crow and Common myna contributed to the omnivore’s abundance in all growing phases. Waterbird group from family Ardeidae (egrets and herons) and Alcedinidae (kingfisher) contributed to the abundance of carnivore feeding guild.

Table 4. Bird diversity indices in following different growing phases.

| Index          | Ploughing | Cultivation | Reproductive | Maturation |
|----------------|-----------|-------------|--------------|------------|
| Dominance (D)  | 0.1562    | 0.3006      | 0.1297       | 0.165      |
| Shannon diversity (H) | 2.217     | 1.675       | 2.474        | 2.431      |
| Evenness       | 0.3824    | 0.2543      | 0.4749       | 0.3667     |

4. Discussions

Our study indicates that the reproductive phase and maturation phase had the highest diversity of birds and high bird species richness, respectively. Our findings were consistent with a study in Kuala Selangor where rice-growing phases promoted a greater bird species richness and abundances [13]. Waterbirds such as Little egret, Great egret and White-throated kingfisher and raptor such as Black-shouldered kite were among the common species found in rice granary areas. Just like any other paddy field, Sabak Bernam also was dominated by waterbird families which consist of seven species of Ardeidae, two species of Alcedinidae and one species of Rallidae. Insectivores were the most abundant feeding represented by Pacific swallow which was recorded during ploughing, cultivation and reproductive phases, but was not present during the maturation phase. House crow and Common myna were among the omnivores species and also known as scavengers which recorded in all growing stages, whereas carnivore feeding type was contributed by waterbird families which mainly feeds on fishes, crustaceans and molluscs. Different habitat uses and water regimes in the rice-granary field provides various food sources and suitable habitat conditions which indirectly influenced bird species assemblages.

Rice granary ecosystems with different planting seasons attract various type of birds from different feeding guild to forage in these areas due to the diverse type of food presence [8]. Based on this study, the reproductive phase (third phase) had the highest diversity of birds compared to the other phases. The reproductive phase is when the paddy is most sensitive, where it undergoes heading and flowering growth stages [14]. It has attracted many birds from all feeding habits as it provides a diverse type of food from insects, fishes, small mammals, flower nectars and also grains. In the present study, this phase, however, was dominated by omnivores species such as House crow and Common myna. These species represented typical bird species whose diets included a wide variety of food items, thus enable them to persist in a wide range of habitats. Although crows were known as bird pest to several crops such as maize and wheat [15], a significant ecological role is played by these omnivorous scavengers, as their existence around rice granary field especially in rural areas will clean up the wastes such as carcasses and leftover food from nearby houses [16]. Besides omnivorous scavengers, other omnivorous species were also present in Sabak Bernam’s rice granary field during maturation phases (final phase), such as Great Bittern (waterbird), White-breasted woodswallow (forest) and Oriental-pied hornbill (Open-country).
Waterbirds and raptors were the common species found in our study. Waterbird usually inhabits damp or flooded rice granary field and eat either independently or in large flocks [6], while raptors forage generally alone. Both groups were mainly carnivorous, which consume a wide variety of animals such as small mammals, amphibians, fishes and invertebrates. Waterbird such as Little egret, Great egret and Little heron from family Ardeidae were present at all phases, and their abundance was greater during ploughing (first phase) and maturation phase. This result is in parallel with Mohd-Taib & Kamaruddin [9] where waterbird families were the most dominant during the inundation and post-harvesting stage. During ploughing phase or field preparation phase, waterbird and raptor abundance were the greatest as their preys were easily seen, exposed and available for hunt [6, 9], suggesting that this man-made habitat are equally important and valuable as natural ecosystems. Besides, Amano et al. [17] indicate that spatial and temporal variation of rice fields strongly associated with the waterbird species, thus suggesting the importance of maintaining a combination of rice fields and open water bodies to meet the habitat requirements of these species. Besides, the presence of raptors in the paddy field not only contribute to the diversity of birds but also will serve as important biological control agents which will control the abundance of rat and shrew pests.

Beside raptors, presence of insectivorous birds is also advantageous to the paddy habitat as it serves as biological control agents which control the insect pests [9]. Rice-growing phases with various environmental conditions have promoted the presence of insect’s community to this habitat [18]. Their population boom impacted the crops’ yield, due to direct damage and diseases. For example, green leafhoppers (Nephotettix spp.) cause direct damage to the paddy plants by sucking the plant’s sap and transmit the Rice tungro disease to the paddy plants [19]. Their population could be controlled with the presence of insectivores birds in the habitat. On another instance, Cattle egret (Bubulcus ibis) was observed to feed mainly on small invertebrates such as nymphs and adults of Acridid (grasshopper) in the rice field [20]. Their existence could potentially balance the abundance of insect pest in rice granary ecosystem. The high abundance of insectivorous birds during the ploughing phase and the high abundance of Pacific swallow during all growing phases except the maturation phase were also supported by Norela et al. [21], as the abundance and diversity of insects were the highest during the early stages of rice cultivation. The absence of pacific swallows during the maturation phase has been replaced by the presence of barn swallows that come to migrate, as the migration season also takes place during this phase.

Besides insectivorous waterbirds, carnivorous waterbirds also have an important role in controlling the pest population of paddy plants. The Golden apple snails (Pomacea canaliculata), one of the aquatic gastropod molluscs were a crucial invasive pest species which causes considerable losses in rice production in Malaysia [22]. Various techniques were conducted to control this pest species, including biological and chemical approaches [22, 23]. However, the use of the chemical in controlling this invasive pest will have negative impacts on the farmer’s health [23]. Therefore, using a biological control method would suggest a better approach in controlling the gastropods. Asian openbill (Anastomus oscitans) was among the storks in Malaysia, which utilize the paddy habitat as their foraging, roosting and even nesting [10]. This species has a potentially significant ecological role as a biological control agent, especially in the paddy field to control the population of Golden apple snails. According to Zainul-Abidin et al. [10], their presence was highly associated with the abundance of the snails, especially during the rice-growing stages when the paddy field was flooded. However, Asian openbill was absence during our study, due to the low infestation of this invasive species in our study area.

The presence of migratory birds also influenced by the abundance and diversity of bird in rice granary. It plays a crucial role for both native and migratory birds as nursing area, foraging grounds and stop-over areas during the migratory season which occurs from September to March every year [6, 25]. Three migratory birds were recorded in Sabak Bernam, which is Brown shrike (Lanius cristatus), Tiger shrike (Lanius tigris) and Barn swallow (Hirundo rustica). These migrant species utilize rice field habitat as it provides plenty types of food and suitable place for them to stay during the migratory season which protect them from extreme weather conditions [24, 25]. According to Munira et al. [6],
the number of raptors will increase during the migratory season. However, in our study, only one resident raptor species was present, which is the Black-shouldered kite (Elanus caeruleus). The Great bittern (Botaurus stellaris), a vagrant species was present in our study during the maturation phase. This species is known to utilize paddy field as their nesting sites. According to Longoni [26], part of the Great bittern population in Italy was completely dependent on rice field besides living in the reed beds. However, this species was recorded only once throughout the observation, particularly in the maturation phase when the paddy plants were high and dense. We are sure, there are many more of these species in the Sabak Bernam’s rice granary fields but were not seen during the observation as this species is secretive, solitary and shy [27].

5. Conclusion
The presence of various bird species in rice granary field in Sabak Bernam indicates that this habitat supports a high diversity of birds. Different rice growing phases harbour a wide range of bird species from various feeding guilds due to the availability of food resources such as arthropods, amphibians, grains and small mammals especially rat pest. Presence of carnivorous and insectivorous birds was particularly significant as a biological control agent, which indirectly will reduce the use of pesticide to control the common insect and mollusc pests in paddy ecosystem, thus producing crop yields that are safe from excessive contamination of pesticides.

Appendix

Appendix 1. List of bird species and their relative abundance in each phase.

| Family            | Scientific name       | Common name                  | I  | II | III | IV | FG | RES | IUCN |
|-------------------|-----------------------|------------------------------|----|----|-----|----|----|-----|------|
| Accipitridae      | Elanus caeruleus      | Black-shouldered kite        | 14 | 10 | 3   | 9  | C  | R   | LC   |
| Aegithinidae      | Aegithina tiphia      | Common iora                  | 0  | 0  | 0   | 1  | I  | R   | LC   |
| Alcedinidae       | Alcedo atthis         | Common kingfisher            | 1  | 0  | 0   | 1  | C  | R   | LC   |
| Alcedinidae       | Halcyon smyrnensis    | White-throated kingfisher    | 26 | 11 | 15  | 12 | C  | R   | LC   |
| Ardeidae          | Ixobrychus sinensis   | Yellow bittern               | 0  | 0  | 0   | 1  | C  | R,M | LC   |
| Ardeidae          | Egretta garzetta      | Little egret                 | 96 | 5  | 5   | 26 | C  | R,M | LC   |
| Ardeidae          | Ardea alba            | Great egret                  | 22 | 6  | 2   | 20 | C  | R,M | LC   |
| Ardeidae          | Butorides striata     | Little heron                 | 7  | 3  | 1   | 1  | C  | R,M | LC   |
| Ardeidae          | Nycticorax ncticorax  | Black-crowned night heron    | 0  | 0  | 22  | 0  | C  | R   | LC   |
| Ardeidae          | Bubulcus ibis         | Cattle egret                 | 0  | 1  | 0   | 2  | I  | R,M | LC   |
| Ardeidae          | Botaurs stellaris     | Great bittern                | 0  | 0  | 0   | 1  | O  | V   | LC   |
| Artamidae         | Artamus leucorynchus  | White-breasted woodswallow   | 0  | 0  | 0   | 10 | O  | R   | LC   |
| Bucerotidae       | Anthracoceros albirostris | Oriental pied-hornbill | 0  | 0  | 0   | 1  | O  | R   | LC   |
| Columbidae        | Geopelia striata      | Zebra dove                   | 3  | 6  | 10  | 5  | G  | R   | LC   |
| Columbidae        | Spilopelia chinensis  | Spotted dove                 | 4  | 2  | 2   | 18 | G  | R   | LC   |
| Columbidae        | Columba livia         | Rock pigeon                  | 5  | 0  | 4   | 7  | G  | R   | LC   |
| Corvidae          | Corvus splendens      | House crow                   | 117| 15 | 86  | 65 | O  | R   | LC   |
| Cuculidae         | Centropus bengalensis | Lesser coucal                | 0  | 0  | 0   | 2  | I  | R   | LC   |
| Cuculidae         | Eudynamys scolopaceus | Asian koel                   | 1  | 2  | 7   | 2  | F  | R,M | LC   |
| Cuculidae         | Phaenicophaeus diardi | Black-bellied malkoha        | 2  | 0  | 0   | 1  | O  | R   | NT   |
| Family    | Scientific Name                          | Common Name                  | Feeding Guild | Residency Status | IUCN Status |
|-----------|------------------------------------------|------------------------------|---------------|------------------|-------------|
| Estrildidae | *Lonchura leucogastra*                  | White-bellied munia         | F             | R,M              | LC          |
| Hirundinidae | *Hirundo tahitica*                     | Pacific swallow             | I             | R                | LC          |
| Hirundinidae | *Hirundo rustica*                      | Barn swallow                | R,M           | I                | LC          |
| Laniidae   | *Lanius cristatus*                      | Brown shrike                | C             | M                | LC          |
| Laniidae   | *Lanius tigrinus*                       | Tiger shrike                | C             | M                | LC          |
| Laridae    | *Sturnula albifrons*                    | Little tern                 | N             | M                | LC          |
| Meropidae  | *Merops philippinus*                    | Blue-tailed bee-eater       | I             | R,M              | LC          |
| Muscicapidae | *Muscicapa daurica*                | Asian brown flycatcher      | R             | I                | LC          |
| Nectariniida | *Cinnyris jugularis*               | Olive-backed sunbird        | N             | R                | LC          |
| Nectariniida | *Anthreptes malacensis*           | Brown-throated sunbird     | N             | R                | LC          |
| Oriolida   | *Oriolus chinensis*                    | Black-naped oriole          | F             | R,M              | LC          |
| Paridae    | *Passer major*                         | Great tit                   | R             | I                | LC          |
| Passerida  | *Passer montanus*                      | Eurasian tree-sparrow       | R             | I                | LC          |
| Passerida  | *Passer domesticus*                   | House sparrow               | G             | R                | LC          |
| Pycnonotoidea | *Pycnonotus goiavier*         | Yellow-vented bulbul        | F             | R                | LC          |
| Rallidae   | *Amaurornis phoenicuicaris*           | White-breasted waterhen     | R             | I                | LC          |
| Sturnidae  | *Acridotheres tristis*                 | Common myna                 | O             | R,M              | LC          |
| Sturnidae  | *Aplonis panayensis*                   | Asian glossy starling      | F             | R                | LC          |
| Sturnidae  | *Acridotheres fuscus*                  | Jungle myna                 | O             | R                | LC          |
| Turdidae   | *Copsychus saularis*                   | Oriental magpie-robin       | R             | I                | LC          |

Note: Growing phases: I=ploughing phase; II=cultivation phase; III=vegetation phase; IV=maturation phase. FG: Feeding Guild status; I=insectivore; C=carinivore; F=frugivore; N=nectarivore; G=granivore; O=omnivore. RES: Residency status; R=residence; M=migrant; R,M=resident and migrant. IUCN status: LC=least concern; NT=near threatened.

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