The Journal of Animal & Plant Sciences, 23(4): 2013, Page: 1019-1033
ISSN: 1018-7081

AVIAN DENSITY IN DIFFERENT HABITAT TYPS AT PAYA INDAH NATURAL WETLAND RESERVE, PENINSULAR MALAYSIA

M. N. Rajpar and M. Zakaria

Department of Recreation and Ecotourism, Faculty of Forestry, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor Darul Ehsan, Malaysia
Corresponding Author Email: rajparnawaz@gmail.com

ABSTRACT

Population monitoring is an essential tool to detect changes in avian community structure for their effective management and conservation. Present study determined bird diversity and density in five habitat types i.e., marsh swamp, lotus swamp, open water body, dryland and shrub patches using distance sampling point count method at Paya Indah Natural Wetland Reserve, Peninsular Malaysia from November, 2007 to January, 2009. Overall avian density at the reserve was 83.92 ± 4.53 birds/ha which might range from 75.40 – 93.41 birds/ha at 95% confidence interval. Highest bird density was recorded in November, 2007 (11.83 ± 1.92 birds/ha), and the lowest in April, 2008 (3.01 ± 0.45 birds/ha). Marsh Swamp habitat supported the highest avian density (i.e. 136.55 ± 21.21 birds/ha) and open water body lowest one i.e., 70.40 ± 11.14 birds/ha. Yellow-vented Bulbul – *Pycnonotus goiavier* was the most abundant bird species of Marsh Swamp (11.81 ± 1.30 birds/ha), and Dryland (13.93 ± 1.42 birds/ha), Jungle Myna – *Acridotheres tristis* (8.43 ± 2.07 birds/ha) for Open Water Body while Scaly-breasted Munia – *Lonchura punctulata* (31.52 ± 4.75 birds/ha) and Pink-necked Green Pigeon – *Treron vernans* (19.99 ± 4.52 birds/ha) was the most dominant species of Lotus Swamp and Shrub Patches, respectively. However, 26 bird species (each) of Marsh Swamp and Lotus Swamp, 20 species of Open Water Body, 28 species (each) of Dryland and Shrub Patches were not analyzed due to the small sample size (< 5 detections). Kruskal–Wallis One–Way Nonparametric ANOVA and Tukey's (HSD) test results showed that bird density of marsh swamp habitat is significantly different from shrub patches, open water body and lotus swamp habitat ($F_{4, 285}$ = 6.31, $P < 0.05$). This study highlighted that Paya Indah Natural Wetland Reserve encompasses heterogeneous vegetation that provides diversity food resources, suitable loafing, safe foraging and breeding sites for wide array of avian species.

Key words: Aves, Wetland, Habitat types, Density, diversity, Distance Sampling

INTRODUCTION

Wetlands are fringe habitats between terrestrial and aquatic ecosystems (Beury *et al*., 2008). Wetlands are highly important habitat for diverse fauna including mammals, birds, fishes, reptiles, amphibians, and aquatic invertebrates (Nelson *et al*., 2000). The importance of wetland depends on many factors namely; wetland size, connectivity to surrounding areas, diversity of vegetation, water quality, food resources and topography. The world's wetland area may range from 5.3 to 12.8 m. km (Mitsch and Gosselink, 2000). Wetlands are among the most heavily impacted and degraded habitats of all ecological systems; their degradation poses serious threats to wetland birds worldwide (Hunter *et al*, 2001; Keller *et al*, 2003; Ma *et al*, 2009). Half of the wetland areas of the world have been destroyed in past century (Fraser and Keddy, 2005; Mitsch and Day, 2006). The remaining 50% are under serious threats, and are declining locally and regionally due to diversion and damping of river flows, conversion of swamps, marshes, lakes and floodplains into agriculture fields and aquaculture ponds, eutrophication, contamination of water from agricultural fields and industries (Bernert *et al*, 1999; Brinson and Malvarez, 2002). Consequently, habitat loss and alteration causes the degradation of breeding sites, water level stabilization, sedimentation, nutrient inputs, invasion of exotic plants and animals (Davidson and Rothwell, 1993; Parish *et al*, 1987; Scott and Poole, 1989).

Malaysia is blessed with 5.19 million ha wetland resources which cover 15.65% of total land area of the country. This total area is divided into mangroves (0.63 m. ha), mudflats (0.05 m. ha), freshwater swamps (0.54 m. ha), peat swamps (1.54 m. ha), marshes (0.74 m. ha), nipa swamp (1.65 m. ha) and malaeuca swamp (0.03 m.n ha) (M.N.R. and E, 2009). A large number of avian species depend on these wetland habitats to satisfy their needs and perform other activities. They select wetland habitats based on vegetation structure and composition, food resources and microclimatic conditions that provide optimal resources for their survival. Birds are bio-indicators of wetland ecosystem, exhibit variety of techniques to utilize the wetland area and indicate ecological conditions and wetland productivity (Li and Mundkur, 2007; Seymour and Simmons, 2008; Rajpar and Zakaria, 2010).

Determining the accurate population size of different bird species inhabiting in wetland habitats is

highly important to understand the bird community structures, population status of existing species, and to evaluate the factors that cause population fluctuations of different bird species in the dwelling areas. This understanding will allows comparison of different habitats in determining the most preferable habitat for wetland birds and thus help in conservation and management actions. Avian density among different habitats such as marshes, swamps, open water bodies and adjacent areas has not been documented in Peninsular Malaysia. The objective of this study was to determine the population structure of avian species in five different wetland habitats and to understand the suitability of each habitat for avian species.

MATERIALS AND METHODS

Study Site: Paya Indah Natural Wetland Reserve is located within 101°10′ to 101°50′ longitude and 2°50′ to 3°00′ latitude, covers an area of 3050ha and indeed blessed with five different habitats i.e. marsh swamp, lotus swamp, open water body, dryland and shrub patches (Figure 1). The temperature of this wetland reserve may vary from 23 – 37 C^0, which may fluctuate from time to time depending upon rainfall pattern. The relative humidity is also changed from time to time range from 35.0% – 96.0% depending on rainfall pattern. The rainfall pattern of this study area is varied from 0 – 340mm/day. More rainy days (i.e., 24 days) occur in October and less rainy days (i.e., 10 days) in February.

Marsh Swamp is a treeless shallow water body dominated by lush growth of herbaceous plants including Water Chestnuts (*Eleocharis dulcis*), *Lepironia articulata*, Climbing Ferns (*Stenochlaena palustris*), Woolly Water Lilies (*Philydrum lanuginosum*), and Marsh Sedges (*Scleria purpurascens*). Marsh swamp provides food, cover, nesting sites and shelter for a variety of avian species and also for invertebrates, amphibians, reptiles and fishes (pers.obs.).

Lotus Swamp is shallow water body dominated by herbaceous plants that emerge above the surface of the water i.e. Lotus (*Nelumbo nucifera*), Water Lily (*N. pubescens*) and Water Chestnuts (*E. dulcis*). The edges are dominated by grasses and reed beds. Lotus swamp provides ideal habitat for aquatic invertebrates such as worms, crustaceans, and molluscs. These invertebrates are major food resource for wide array of waterbirds, fishes, amphibians and reptiles (pers.obs.).

Open Water Body is deep large lake extensively covered with Pondweeds (*Potamogeton* spp.), Bladderworts (*Utricularia* spp.), Giant Weed (*Salvinia molesta*), and along the edges dominated by Three square Bulrush (*Scirpus olneyi*), Water Chestnuts (*E. dulcis*), Marsh Sedges (*S. purpurascens*) and Common Reed (*Phragmites australis*) (pers.obs.).

Dryland is an area having scattered flowering and fruiting trees (i.e. *Cinnamonum iners*, *Melicope glabra*, *Ficus rubiginosa*, *F. benjamina*, *Syzygium grande*, *S. polyanthum*, *Caryota mitis*, *Delonix regia*, *Fragraea fragrans*) and ground is densely covered by *Imperata cylindrica*, *Cynodon dactylon*, and *Distichlis spicata* (pers.obs.).

Shrub Patches are dense patches of *Melastoma malabathricum*, *Dillenia suffruticosa*, and saplings of *Acacia auriculiformis and A. mangium*. The ground is densely covered by Cogon Grass (*I. cylindrica*), Climbing Fern (*S. palustris*), Fern Tree (*Gleichenia linearis*) and Giant Weed (*S. molesta*) (pers.obs.).

Bird Surveys: Avian surveys were carried out for employing distance sampling point count method to examine the avian density in five habitats namely marsh swamp, lotus swamp, open water body, dryland and shrub patches for 16 consecutive months from November, 2007 to January, 2009. Distance-sampling point count method is easier and more efficient way to conduct avian surveys to determine densities from sighting data of wildlife (Bibby *et al*., 1992; Codesido and Bilenca, 2000; Buckland *et al*., 2004). This method involves the visual and auditory detection of birds with fixed or variable radius plots, and it provides important information on species abundance, diversity and density among different habitats (Verner and Ritter, 1985; Mills *et al*., 2000). It adjusts counts for delectability, which allows the estimation of absolute density and abundance of wild animals, including birds (Marques *et al*., 2007). A total of 110 point count stations, 300 m apart from each other were established with in Marsh Swamp (25 stations), Lotus Swamp (23 stations), Open Water Body (20 stations), Dryland (22 stations) and Shrub Patches (20 stations) (Figure 2). Surveys were conducted early in the morning from 0730 hrs to 1100 hrs. All bird species seen or heard at each point count station were recorded for 10 minutes at 360^0. Bird census was avoided under extreme weather conditions due to possible adverse effect on avian distribution and abundance. The methodology was followed as described by Bibby *et al.* (2000), Buckland *et al.* (2004), Marques *et al*. (2007), Aborn (2007), Lee and Marsden (2008), and Nadeau *et al.* (2008).

Data Analysis: The distance software Version 5.0 by Buckland *et al.* (2004) was used to determine the avian density among five habitats. The key to distance sampling is to use the distribution of the observed distances to estimate the "detection function," $g(y)$, the probability of detecting a bird at distance y. This function can then be used to estimate the average probability of detecting a bird given that it is within w of the point,

denoted *Pa*. Given an estimate of *Pa*, bird density can be estimated as

$$\hat{D} = \frac{1}{a}\sum_{i=1}^{n}\frac{1}{\hat{P}_a(\mathbf{z}_i)}$$

(Where *a* = size of the covered region, *n* = number of birds seen, and *P*ˆ *a* (**z***i*) = the estimated probability) of detecting the *i*th bird given that it is within *w* = mean perpendicular distance of sighted birds at point and has the covariate values **z***i*.

The results were compared employing One-Way Analysis of Variance (ANOVA) and Tukey's (HSD) test (Analytical Software, version 8.1) by McGraw-Hill (2008), in order to investigate the significant difference in bird density among five habitats.

RESULTS

A total of 13,872 bird individuals of 100 species and 38 families were recorded, of which 6,086 bird observations (43.87% of all detections) from 84 species and 37 families, were recorded in the marsh swamp, 1,097 bird observations (7.90%) from 57 bird species and 30 families recorded in the lotus swamp, 1,545 bird observations (11.14%) that belong to 55 bird species and 33 families were recorded in the open water body, 3,212 bird observations (i.e. 23.15% of all detections) of 75 species and 35 families were detected in the dryland and 1,932 bird observations (i.e. 13.92% of all detections) representing 68 bird species and 33 families were detected in the shrub patches habitat by applying the point count method.

The density analysis showed that bird density at Paya Indah Natural Wetland Reserve was 83.92 ± 4.53 birds/ha, ranging from 75.40 – 93.41 birds/ha at 95% confidence interval. The five highest bird densities were recorded during migratory season, i.e. November, 2007 (11.83 ± 1.92 birds/ha) followed by January, 2008 (11.10 ± 1.11 birds/ha), January, 2009 (10.34 ± 1.44 birds/ha) and December, 2007 (9.99 ± 1.19 birds/ha) (Table 1). In contrast, the five lowest bird densities were recorded during non-migratory season such as in May, 2008 (3.82 ± 0.65 birds/ha), August, 2008 (3.54 ± 0.66 birds/ha), June, 2008 (3.31 ± 0.40 birds/ha), July, 2008 (3.04 ± 0.56 birds/ha) and April, 2008 (3.01 ± 0.45 birds/ha) (Table 1).

Bird Density Based on Habitats: The bird density in all five habitats was separately examined to understand the population size of different bird species in each habitat. Highest bird density was recorded in marsh swamp, i.e. 136.55 ± 21.21 birds/ha, followed by lotus swamp, (95.42 ± 6.96 birds/ha), shrub patches (86.47 ±8.36 birds/ha), dry land (75.22 ± 7.09 birds/ha) and open water body (70.40 ± 11.14 birds/ha) (Table 2).

Bird Density in Marsh Swamp: Yellow-vented Bulbul - *Pycnonotus goiavier* (11.81 ± 1.30 birds/ha), Peaceful Dove - *Geopelia striata* (10.03 ± 1.68 birds/ha), Pink-necked Green Pigeon - *Treron vernans* (8.91 ± 1.37 birds/ha), Purple Swamphen - *Porphyrio porphyrio* (7.94 ± 1.36 birds/ha) and Scaly-breasted Munia - *Gallirallus striatus* (7.93 ± 3.84 birds/ha) were five most dominant species in marsh swamp habitat. Pintail Snipes - *Gallinago stenura* (0.30 ± 0.10 birds/ha), Olive-winged Bulbul - *Pycnonotus plumosus* (0.29 ± 0.18 birds/ha), Common Tailorbird - *Orthotomus sutorius* (0.26 ± 0.11 birds/ha), Black-crowned Nightheron - *Nycticorax nycticorax* (0.23 ± 0.14 birds/ha) and Grey Heron - *Ardea cinerea* (0.11 ± 0.06 birds/ha) were the rarest five bird species with low densities. Needless to say, 26 bird species were not analyzed due to the small sample size (< 5 detections) (Table 3).

Bird Density in Lotus Swamp: The results showed that Scaly-breasted Munia - *Lonchura punctulata* (31.52 ± 4.75 birds/ha), Red Junglefowl - *Gallus gallus* (11.88 ± 4.86 birds/ha), Pied Fantail - *Rhipidura javanica* (7.85 ± 2.73 birds/ha), Eurasian Tree Sparrow - *Passer montanus* (3.51 ± 1.75 birds/ha) and Blue-tailed Bee-eater - *Merops philippinus* (3.01 ± 0.68 birds/ha) were the five most dominant bird species in this habitat. Conversely, White-browed Crake - *Porzana cinerea* (0.46 ± 0.32 birds/ha), Jungle Myna - *Acridotheres fuscus* (0.39 ± 0.16 birds/ha), Pheasant-tailed Jacana - *Hydrophasianus chirurgus* (0.35 ± 0.23 birds/ha), Common Flameback - *Dinopium javanense* (0.32 ± 0.11 birds/ha) and Baya Weaver - *Ploceus philippinus* (0.31 ± 0.17 birds/ha) were the rarest species in the lotus swamp habitat. However, the density of 26 bird species was not analyzed due to very low detections (< 5 observations) (Table 4).

Bird Density in Open Water Body: The five highest densities in the open water body habitat were recorded for Jungle Myna – *Acridotheres tristis* (8.43 ± 2.07 birds/ha) followed by Yellow–vented Bulbul – *Pycnonotus goiavier* (8.17 ± 2.92 birds/ha), Lesser Whistling Duck – *Dendrocygna javanica* (7.72 ± 4.17 birds/ha), Spotted Dove – *Streptopelia chinensis* (5.56 ± 1.58 birds/ha), and Baya Weaver - *Ploceus philippinus* (5.44 ± 2.71 birds/ha). In contrast, the five lowest bird densities in the open water body area was noted in Lesser Coucal - *Centropus bengalensis* (0.45 ± 0.23 birds/ha), Red Junglefowl - *Gallus gallus* (0.40 ± 0.17 birds/ha), Green Iora - *Aegithina virdissima* (0.32 ± 0.20 birds/ha), Purple Swamphen - *Porphyrio porphyrio* (0.30 ± 0.10 birds/ha) and Black-naped Oriole - *Oriolus chinensis* (0.27 ± 0.12 birds/ha). Nevertheless, the density of 20 bird species was not analyzed due to the small sample size (< 5 detections) (Table 5).

Bird Density in Dryland: The highest bird densities were detected in five species, namely Yellow-vented

Bulbuls - *Pycnonotus goiavier* (13.93 ± 1.42 birds/ha), followed by Pink-necked Green Pigeon - *Treron vernans* (10.66 ± 2.55 birds/ha), Scaly-breasted Munia - *Lonchura punctulata* (7.93 ± 2.37 birds/ha), Peaceful Dove - *Geopelia striata* (7.74 ± 1.26 birds/ha) and Common Myna - *Acridotheres tristis* (6.41 ± 2.26 birds/ha) in the dryland. On the contrary, the lowest bird densities were noted in Common Flameback - *Dinopium javanense* (0.38 ± 0.16 birds/ha), Red Junglefowl - *Gallus gallus* (0.34 ± 0.13 birds/ha), Black-shouldered Kite - *Elanus caeruleus* (0.27 ± 0.14 birds/ha), Purple Heron - *Ardea purpurea* (0.27 ± 0.13 birds/ha) and Greater Coucal - *Centropus sinensis* (0.25 ± 0.15 birds/ha) in the dryland habitat. Needless to say, the density of 28 bird species was also not analyzed due to the small sample size (< 5 detections) (Table 6).

Bird Density in Shrub Patches: The density analysis for the shrub patches habitat revealed that Pink-necked Green Pigeon - *Treron vernans* (19.99 ± 4.52 birds/ha), Scaly-breasted Munia - *Lonchura punctulata* (17.18 ± 5.21 birds/ha), Peaceful Dove - *Geopelia striata* (11.18 ± 2.83 birds/ha), Black-headed Munia - *Lonchura malacca* (7.96 ± 2.67 birds/ha) and Dollar Bird - *Eurystomus orientalis* (7.88 ± 2.99 birds/ha) was the most dominant bird species in this habitat. Whereas, Pied Triller - *Lalage nigra* (0.33 ± 0.11 birds/ha), Common Iora - *Aegithina tiphia* (0.31 ± 0.15 birds/ha), Blue-tailed Bee-eater - *Merops philippinus* (0.28 ± 0.16 birds/ha), Large-billed Crow - *Corvus macrorhynchos* (0.23 ± 0.11 birds/ha) and Purple Heron - *Ardea purpurea* (0.19 ± 0.09 birds/ha) were the five rarest species in this habitat. However, 28 bird species were not analyzed due to the small sample size (< 5 detections) (Table 7).

Comparison of Bird Density among Five Habitats: The significant difference of bird density among five habitats (i.e. marsh swamp, lotus swamp, open water body, dryland and shrub patches) of Paya Indah Wetland Reserve was determined employing Kruskal–Wallis One–Way Nonparametric AOVA and Tukey's (HSD) test. Kruskal–Wallis One–Way Nonparametric AOVA and Tukey's (HSD) test results showed that bird density of marsh swamp habitat is significantly different from shrub patches, open water body and lotus swamp habitat ($F_{4,\ 285} = 6.31$, $P < 0.05$). However, bird density of marsh swamp was not significantly different from dryland habitat. The bird density of shrub patches, open water body and lotus swamp habitat was not statistically significant (Table 8 and Appendix 1).

Table 1: Month-wise bird density at Paya Indah Natural Wetland Reserve, Peninsular Malaysia

Rank	Months	Density/ha	Density at 95% confidence interval (Density/ha)
1	November, 2007	11.83 ± 1.92	8.61 – 16.26
2	January, 2008	11.10 ± 1.11	9.10 – 13.53
3	January, 2009	10.34 ± 1.44	9.84 – 15.32
4	December, 2007	9.99 ± 1.19	7.89 – 12.65
5	December, 2008	8.56 ± 1.21	7.44 – 14.85
6	November, 2008	7.12 ± 1.05	6.86 – 10.19
7	February, 2008	6.08 ± 0.59	5.00 – 7.39
8	March, 2008	5.49 ± 0.45	4.66 – 6.45
9	October, 2008	5.02 ± 0.88	4.60 – 7.56
10	September, 2008	3.94 ± 0.72	3.10 – 5.42
11	May, 2008	3.82 ± 0.65	3.08 – 4.73
12	August, 2008	3.54 ± 0.66	2.65 – 6.68
13	June, 2008	3.31 ± 0.40	2.61 – 4.20
14	July, 2008	3.04 ± 0.56	2.85 – 5.89
15	April, 2008	3.01 ± 0.45	2.33 – 3.89

Table 2: Ranking of bird density in different habitats at Paya Indah Natural Wetland Reserve, Peninsular Malaysia

Habitat Name	Density (birds/ha)	Density at 95% confidence interval (birds/ha)
Marsh Swamp	136.55 ± 21.21	95.81 – 194.61
Lotus Swamp	95.42 ± 6.96	82.15 – 110.82
Shrub Patches	86.47 ±8.36	70.26 – 106.43
Dryland	75.22 ± 7.09	62.42 – 90.65
Open Water Body	70.40 ± 11.14	48.29 – 102.64
Overall	83.92 ± 4.53	75.40 – 93.41

Table 3: Ranking of bird density in Marsh Swamp habitat at Paya Indah Natural Wetland Reserve, Peninsular Malaysia

Rank	Common Name	Scientific Name	Density (birds/ha)	Density at 95% confidence interval (birds/ha)
1	Yellow-vented Bulbul	*Pycnonotus goiavier*	11.81 ± 1.30	9.43 – 14.87
2	Peaceful Dove	*Geopelia striata*	10.03 ± 1.68	7.15 –14.07
3	Pink-necked Green Pigeon	*Treron vernans*	8.91 ± 1.37	6.54 – 12.13
4	Purple Swamphen	*Porphyrio porphyrio*	7.94 ± 1.36	5.59 – 11.29
5	Scaly-breasted Munia	*Lonchura punctulata*	7.93 ± 3.84	3.14 – 20.03
6	White-headed Munia	*Lonchura maja*	7.55 ± 3.77	2.69 – 23.05
7	Rufous-tailed Tailorbird	*Orthotomus sericeus*	7.54 ± 4.35	1.90 – 29.91
8	Black-headed Munia	*Lonchura malacca*	6.63 ± 2.89	1.98 – 22.20
9	Eurasian Tree Sparrow	*Passer montanus*	6.25 ± 1.77	2.97 – 13.12
10	Baya Weaver	*Ploceus philippinus*	5.90 ± 1.50	3.55 – 9.80
11	Spotted Dove	*Streptopelia chinensis*	5.49 ± 1.33	3.39 – 8.89
12	Yellow Bittern	*Ixobrychus sinensis*	5.07 ± 1.13	3.24 – 7.92
13	Pacific Swallow	*Hirundo tahitica*	4.74 ± 1.04	1.05 – 21.49
14	White-breasted Waterhen	*Amaurornis phoenicurus*	4.68 ± 0.83	3.29 – 6.66
15	Red-wattled Lapwing	*Vanellus indicus*	3.97 ± 1.13	2.21 – 7.11
16	Philippine Glossy Starling	*Aplonis panayensis*	3.77 ± 1.47	1.76 – 8.05
17	Richard's Pipit	*Anthus richardi*	2.72 ± 1.08	1.19 – 6.22
18	Common Flameback	*Dinopium javanense*	2.67 ± 0.89	1.34 – 5.34
19	Black-naped Oriole	*Oriolus chinesis*	2.60 ± 0.78	1.44 – 4.70
20	Jungle Myna	*Acridotheres fuscus*	2.11 ± 0.38	1.46 – 3.05
21	White-browed Crake	*Porzana cinererea*	2.05 ± 0.98	0.73 – 5.75
22	Oriental Reed Warbler	*Acrocephalus orientalis*	1.96 ± 0.54	1.13 – 3.41
23	Pied Triller	*Lalage nigra*	1.76 ± 0.70	0.80 – 3.90
24	Pied Fantail	*Rhipidura javanica*	1.72 ± 0.32	1.93 – 2.49
25	Little Bronze Cuckoo	*Chrysoccyx minutillus*	1.70 ± 1.10	0.28 – 10.47
26	White-throated Kingfisher	*Halcyon smyrnensis*	1.66 ± 0.37	1.06 – 2.62
27	Little Heron	*Butorides striatus*	1.56 ± 0.97	0.45 – 5.34
28	Orange-breasted Green Pigeon	*Treron bicincta*	1.54 ± 0.61	0.69 – 3.42
29	Lesser Whistling Duck	*Dendrocygna javanica*	1.52 ± 0.59	0.63 – 3.64
30	Common Iora	*Aegithina tiphia*	1.46 ± 0.49	0.75 – 2.86
31	Schrenck's Bittern	*Ixobrychus eurhythmus*	1.44 ± 0.89	0.37 – 5.59
32	Yellow-bellied Prinia	*Prinia flaviventris*	1.27 ± 0.19	0.95 – 1.71
33	Cotton Pygmy Goose	*Nettapus coromandelianus*	1.21 ± 0.90	0.32 – 15.14
34	Green Iora	*Aegithina virdissima*	1.13 ± 0.16	0.86 – 1.49
35	Blue-tailed Bee-eater	*Merops philippinus*	1.12 ± 0.49	0.48 – 2.60
36	Brown Shrike	*Lanius cristatus*	1.04 ± 0.19	0.72 – 1.49
37	Plaintive Cuckoo	*Cacomantis merulinus*	0.97 ± 0.40	0.42 – 2.24
38	White-vented Myna	*Acridotheres grandis*	0.93 ± 0.25	0.53 – 1.64
39	Ashy Tailorbird	*Orthotomus ruficeps*	0.85 ± 0.55	0.23 – 3.11
40	Little Green Pigeon	*Treron olax*	0.84 ± 0.35	0.34 – 2.15
41	Oriental Magpie Robin	*Copsychus saularis*	0.83 ± 0.14	0.59 – 1.16
42	Common Moorhen	*Gallinula chloropus*	0.83 ± 0.18	0.53 – 1.29
43	Large-billed Crow	*Corvus macrorhynchos*	0.74 ± 0.42	0.23 – 2.43
44	Lesser Coucal	*Centropus bengalensis*	0.71 ± 0.20	0.40 – 1.26
45	Blue-throated Bee-eater	*Merops philippinus*	0.67 ± 0.22	0.32 – 1.38
46	Purple Heron	*Ardea pupurea*	0.61 ± 0.17	0.35 – 1.04
47	Cinnamon Bittern	*Ixorbychus cinnamoneus*	0.53 ± 0.12	0.34 – 0.83
48	Olive-backed Sunbird	*Nectarinia jugularis*	0.46 ± 0.30	0.13 – 1.62
49	Common Myna	*Acridotheres tristis*	0.45 ± 0.22	0.35 – 0.60
50	Zitting Cisticola	*Cisticola juncidis*	0.43 ± 0.31	0.08 – 2.38
51	Barred Button Quail	*Turnix suscitator*	0.41 ± 0.25	0.10 – 1.60
52	Brown-throated Sunbird	*Anthreptes malacensis*	0.33 ± 0.17	0.11 – 1.03
53	Red Junglefowl	*Gallus gallus*	0.32 ± 0.14	0.13 – 0.76
54	Pintail Snipe	*Gallinago stenura*	0.30 ± 0.10	0.14 – 0.64

55	Olive-winged Bulbul	*Pycnonotus plumosus*	0.29 ± 0.18	0.08 – 1.13
56	Common Tailorbird	*Orthotomus sutorius*	0.26 ± 0.11	0.09 – 0.71
57	Black-crowned Nightheron	*Nycticorax nycticorax*	0.23 ± 0.14	0.05 – 1.07
58	Grey Heron	*Ardea cinerea*	0.11 ± 0.06	0.03 – 0.40
59	Black-shoulder Kite	*Elanus caeruleus*	–	–
60	Dollar Bird	*Eurystomus orientalis*	–	–
61	Great Egret	*Egretta albus*	–	–
62	Greater Coucal	*Centropus sinensis*	–	–
63	Little Egret	*Egretta garzetta*	–	–
64	Mangrove Whistler	*Pachycephala grisola*	–	–
65	Plain Sunbird	*Anthreptes simpplex*	–	–
66	Water Cock	*Gallicerx cinerea*	–	–
67	Ballion's Crake	*Porzana pusilla*	–	–
68	Black-throated Sunbird	*Aethopyga saturata*	–	–
69	Savanna Nightjar	*Caprimulgus affinis*	–	–
70	Asian Brown Flycatcher	*Muscicapa dauurica*	–	–
71	Common Kingfisher	*Alcedo atthis*	–	–
72	Hill Myna	*Gracula religosa*	–	–
73	Large-tailed Nightjar	*Caprimulgus macrurus*	–	–
74	Little Grebe	*Tachybaptus ruficollis*	–	–
75	Long-tailed Shrike	*Lanius schach*	–	–
76	Ashy Drongo	*Dicrurus leucophaeus*	–	–
77	Black Baza	*Aviceda leuphotes*	–	–
78	Blue-breasted Quail	*Coturnix chinensis*	–	–
79	House Crow	*Corvus splendens*	–	–
80	Inornate Warbler	*Phylloscopus inornatus*	–	–
81	Little Spiderhunter	*Arachnothera longirostra*	–	–
82	Pheasant-tailed Jacana	*Hydrophasianus chirurgus*	–	–
83	Rusty-rumped Warbler	*Locustella certhiola*	–	–
84	Speckled Piculet	*Picumnus innominatus*	–	–

Table 4: Ranking of bird density in Lotus Swamp habitat at Paya Indah Natural Wetland Reserve, Peninsular Malaysia

Rank	Common Name	Scientific Name	Density (birds/ha)	Density at 95% Confidence Interval (birds/ha)
1	Scaly-breasted Munia	*Lonchura punctulata*	31.52 ± 4.75	6.57 – 151.26
2	Red Junglefowl	*Gallus gallus*	11.88 ± 4.86	1.84 – 76.74
3	Pied Fantail	*Rhipidura javanica*	7.85 ± 2.73	3.73 – 16.49
4	Pacific Swallow	*Hirundo tahitica*	4.79 ± 1.64	1.20 – 18.59
5	Eurasian Tree Sparrow	*Passer montanus*	3.51 ± 1.75	1.15 – 10.72
6	Blue-tailed Bee-eater	*Merops philippinus*	3.01 ± 0.68	1.91 – 4.76
7	Yellow Bittern	*Ixobrychus sinensis*	2.79 ± 0.85	1.46 – 5.34
8	Brown Shrike	*Lanius cristatus*	2.63 ± 1.15	1.03 – 6.68
9	Green Iora	*Aegithina virdissima*	2.38 ± 0.93	1.01 – 5.60
10	White-breasted Waterhen	*Amaurornis phoenicurus*	2.19 ± 0.54	1.29 – 3.72
11	Orange-breasted Green Pigeon	*Treron bicincta*	2.11 ± 1.18	0.51 – 8.76
12	Yellow-bellied Prinia	*Prinia flaviventris*	2.04 ± 0.66	0.98 – 4.25
13	White-throated Kingfisher	*Halcyon smyrnensis*	2.04 ± 0.56	1.15 – 3.62
14	Pink-necked Green Pigeon	*Treron vernans*	1.95 ± 0.29	1.45 – 2.62
15	Black-napped Oriole	*Oriolus chinensis*	1.82 ± 0.84	0.69 – 4.75
16	Purple Heron	*Ardea pupurea*	1.55 ± 0.54	0.69 – 3.46
17	Yellow-vented Bulbul	*Pycnonotus goiavier*	1.42 ± 0.22	1.03 – 1.95
18	Red-wattled Lapwing	*Vanellus indicus*	1.32 ± 0.55	0.52 – 3.32
19	Oriental Magpie Robin	*Copsychus saularis*	1.20 ± 0.61	0.41 – 3.49
20	Spotted Dove	*Streptopelia chinensis*	1.11 ± 0.28	0.66 – 1.87
21	Peaceful Dove	*Geopelia striata*	1.11 ± 0.21	0.75 – 1.64
22	Purple Swamphen	*Porphyrio porphyrio*	1.01 ± 0.37	0.50 – 2.07

23	Common Moorhen	*Gallinula chloropus*	0.96 ± 0.27	0.54 – 1.68
24	Blue-throated Bee-eater	*Merops viridis*	0.94 ± 0.51	0.28 – 3.31
25	Common Myna	*Acridotheres tristis*	0.87 ± 0.35	0.38 – 1.99
26	Plaintive Cuckoo	*Cacomantis merulinus*	0.71 ± 0.34	0.26 – 1.90
27	Ballion's Crake	*Porzana pusilla*	0.67 ± 0.21	0.34 – 1.32
28	White-vented Myna	*Acridotheres grandis*	0.59 ± 0.36	0.16 – 2.16
29	White-browed Crake	*Porzana cinererea*	0.46 ± 0.32	0.09 – 2.38
30	Jungle Myna	*Acridotheres fuscus*	0.39 ± 0.16	0.17 – 0.93
31	Pheasant-tailed Jacana	*Hydrophasianus chirurgus*	0.35 ± 0.23	0.09 – 1.40
32	Common Flameback	*Dinopium javanense*	0.32 ± 0.11	0.15 – 0.70
33	Baya Weaver	*Ploceus philippinus*	0.31 ± 0.17	0.09 – 1.07
34	Ashy Tailorbird	*Orthotomus ruficeps*	–	–
35	Grey Heron	*Ardea cinerea*	–	–
36	Common Iora	*Aegithina tiphia*	–	–
37	Little Heron	*Butorides striatus*	–	–
38	Brown-throated Sunbird	*Anthreptes malacensis*	–	–
39	Common Tailorbird	*Orthotomus sutorius*	–	–
40	Little Bronze Cuckoo	*Chrysoccyx minutillus*	–	–
41	Asian Brown Flycatcher	*Muscicapa dauurica*	–	–
42	Little Grebe	*Tachybaptus ruficollis*	–	–
43	Common Sandpiper	*Tringa. hypoleucos*	–	–
44	Rufous woodpecker	*Celeus brachyurus*	–	–
45	Richard's Pipit	*Anthus richardi*	–	–
46	Oriental Reed Warbler	*Acrocephalus orientalis*	–	–
47	Olive-backed Sunbird	*Nectarinia jugularis*	–	–
48	Cotton Pygmy Goose	*Nettapus coromandelianus*	–	–
49	Little Green Pigeon	*Treron olax*	–	–
50	Barred Button Quail	*Turnix suscitator*	–	–
51	Water Cock	*Gallicerx cinerea*	–	–
52	Common Kingfisher	*Alcedo atthis*	–	–
53	Long-tailed Shrike	*Lanius schach*	–	–
54	Little Spiderhunter	*Arachnothera longirostra*	–	–
55	Rusty-rumped Warbler	*Locustella certhiola*	–	–
56	Thick-billed Green Pigeon	*Treron curvirostra*	–	–
57	Copper-throated Sunbird	*Nectarinia calcostetha*	–	–

Table 5: Ranking of bird density in Open Water Body habitat at Paya Indah Natural Wetland Reserve, Peninsular Malaysia

Rank	Common Name	Scientific Name	Density (birds/ha)	Density at 95% Confidence Interval (birds/ha)
1	Jungle Myna	*Acridotheres tristis*	8.43 ± 2.07	5.13 – 13.85
2	Yellow-vented Bulbul	*Pycnonotus goiavier*	8.17 ± 2.92	4.09 – 16.33
3	Lesser Whistling Duck	*Dendrocygna javanica*	7.72 ± 4.17	1.72 – 34.08
4	Spotted Dove	*Streptopelia chinensis*	5.56 ± 1.58	3.15 – 9.82
5	Baya Weaver	*Ploceus philippinus*	5.44 ± 2.71	1.41 – 21.03
6	Cotton Pygmy Goose	*Nettapus coromandelianus*	4.37 ± 1.73	1.63 – 11.75
7	Pacific Swallow	*Hirundo tahitica*	4.11 ± 1.37	0.70 – 24.41
8	Scaly-breasted Munia	*Lonchura punctulata*	3.94 ± 1.72	1.66 – 9.36
9	Pink-necked Green Pigeon	*Treron vernans*	3.61 ± 0.96	1.95 – 6.68
10	Blue-tailed Bee-eater	*Merops philippinus*	3.57 ± 1.05	1.10 – 11.57
11	Yellow-bellied Prinia	*Prinia flaviventris*	2.53 ± 0.94	1.09 – 5.85
12	Zitting Cisticola	*Cisticola juncidis*	2.36 ± 1.25	0.65 – 8.60
13	Oriental Magpie Robin	*Copsychus saularis*	2.31 ± 1.08	0.63 – 8.40
14	Yellow Bittern	*Ixobrychus sinensis*	2.19 ± 0.73	1.09 – 4.50
15	White-breasted Waterhen	*Amaurornis phoenicurus*	2.15 ± 0.83	1.00 – 4.64
16	Peaceful Dove	*Geopelia striata*	2.04 ± 0.51	1.24 – 3.34

17	Red-wattled Lapwing	*Vanellus indicus*	2.03 ± 0.56	1.17 – 3.54
18	White-vented Myna	*Acridotheres grandis*	2.00 ± 0.99	0.53 – 7.58
19	Philippine Glossy Starling	*Aplonis panayensis*	1.89 ± 0.58	0.36 – 9.83
20	Large-billed Crow	*Corvus macrorhynchos*	1.33 ± 0.37	0.64 – 49.27
21	Common Moorhen	*Gallinula chloropus*	1.19 ± 0.59	0.10 – 14.24
22	Common Iora	*Aegithina tiphia*	0.94 ± 0.24	0.07 – 12.06
23	White-throated Kingfisher	*Halcyon smyrnensis*	0.93 ± 0.28	0.50 – 1.73
24	Common Myna	*Acridotheres tristis*	0.91 ± 0.18	0.61 – 1.37
25	Richard's Pipit	*Anthus richardi*	0.84 ± 0.22	0.50 – 1.43
26	Pied Triller	*Lalage nigra*	0.83 ± 0.26	0.15 – 4.43
27	Little Grebe	*Tachybaptus ruficollis*	0.78 ± 0.46	0.15 – 4.09
28	Pied Fantail	*Rhipidura javanica*	0.72 ± 0.32	0.28 – 1.89
29	Purple Heron	*Ardea pupurea*	0.71 ± 0.28	0.31 – 1.63
30	Cinnamon Bittern	*Ixorbychus cinnamoneus*	0.60 ± 0.25	0.23 – 1.56
31	Brown Shrike	*Lanius cristatus*	0.54 ± 0.21	0.20 – 1.46
32	Lesser Coucal	*Centropus bengalensis*	0.45 ± 0.23	0.12 – 1.73
33	Red Junglefowl	*Gallus gallus*	0.40 ± 0.17	0.06 – 2.55
34	Green Iora	*Aegithina virdissima*	0.32 ± 0.20	0.08 – 1.34
35	Purple Swamphen	*Porphyrio porphyrio*	0.30 ± 0.10	0.15 – 1.58
36	Black-naped Oriole	*Oriolus chinesis*	0.27 ± 0.12	0.12 – 0.67
37	Common Flameback	*Dinopium javanense*	–	–
38	Common Tailorbird	*Orthotomus sutorius*	–	–
39	Water Cock	*Gallicerx cinerea*	–	–
40	Black-headed Munia	*Lonchura malacca*	–	–
41	House Crow	*Corvus splendens*	–	–
42	Ashy Minivet	*Pericrocotus divaricatus*	–	–
43	Little Bronze Cuckoo	*Chrysoccyx minutillus*	–	–
44	Olive-backed Sunbird	*Nectarinia jugularis*	–	–
45	Pintail Snipe	*Gallinago stenura*	–	–
46	Greater Coucal	*Centropus sinensis*	–	–
47	Blue-breasted Quail	*Coturnix chinensis*	–	–
48	Eurasian Tree Sparrow	*Passer montanus*	–	–
49	Grey Heron	*Ardea cinerea*	–	–
50	Oriental Reed Warbler	*Acrocephalus orientalis*	–	–
51	Schrenck's Bittern	*Ixobrychus eurhythmus*	–	–
52	Mangrove Whistler	*Pachycephala grisola*	–	–
53	Savanna Nightjar	*Caprimulgus affinis*	–	–
54	Large-tailed Nightjar	*Caprimulgus macrurus*	–	–
55	Black Baza	*Aviceda leuphotes*	–	–

Table 6: Ranking of bird density in Dryland habitat at Paya Indah Natural Wetland Reserve, Peninsular Malaysia

Rank	Common Name	Scientific Name	Density (birds/ha)	Density at 95% confidence interval (birds/ha)
1	Yellow-vented Bulbul	*Pycnonotus goiavier*	13.93 ± 1.42	11.27 – 17.21
2	Pink-necked Green Pigeon	*Treron vernans*	10.66 ± 2.55	6.46 – 17.57
3	Scaly-breasted Munia	*Lonchura punctulata*	7.93 ± 2.37	3.56 – 17.67
4	Peaceful Dove	*Geopelia striata*	7.74 ± 1.26	5.51 – 10.86
5	Common Myna	*Acridotheres tristis*	6.41 ± 2.26	3.22 – 12.75
6	Spotted Dove	*Streptopelia chinensis*	5.57 ± 1.57	3.16 – 9.80
7	Baya Weaver	*Ploceus philippinus*	4.88 ± 1.27	2.59 – 9.20
8	Eurasian Tree Sparrow	*Passer montanus*	4.78 ± 1.29	1.67 – 13.64
9	Ashy Tailorbird	*Ploceus philippinus*	4.35 ± 1.61	0.91 – 20.72
10	Philippine Glossy Starling	*Aplonis panayensis*	3.67 ± 1.12	0.14 – 99.10
11	White-headed Munia	*Lonchura maja*	3.47 ± 1.27	1.89 – 9.51
12	Pied Fantail	*Rhipidura javanica*	3.34 ± 1.08	1.02 – 10.98

13	Richard's Pipit	*Anthus richardi*	3.34 ± 1.38	1.43 – 7.82
14	Jungle Myna	*Acridotheres fuscus*	3.33 ± 1.06	1.79 – 6.20
15	Blue-throated Bee-eater	*Merops viridis*	2.98 ± 1.18	0.49 – 18.27
16	Little Bronze Cuckoo	*Chrysoccyx minutillus*	2.85 ± 1.49	0.14 – 58.71
17	Black-headed Munia	*Lonchura malacca*	2.44 ± 1.19	0.94 – 6.33
18	Blue-tailed Bee-eater	*Merops philippinus*	2.17 ± 0.51	1.33 – 3.54
19	White-breasted Waterhen	*Amaurornis phoenicurus*	2.13 ± 0.49	1.32 – 3.44
20	Red-wattled Lapwing	*Vanellus indicus*	2.12 ± 0.87	0.96 – 4.68
21	Oriental Magpie Robin	*Copsychus saularis*	2.04 ± 0.59	1.11 – 3.75
22	Yellow-bellied Prinia	*Prinia flaviventris*	1.96 ± 0.65	1.01 – 3.78
23	Dollar Bird	*Eurystomus orientalis*	1.91 ± 1.19	0.44 – 8.31
24	House Crow	*Corvus splendens*	1.76 ± 0.56	1.02 – 9.35
25	Ashy Minivet	*Pericrocotus divaricatus*	1.56 ± 0.91	0.06 – 39.80
26	White-throated Kingfisher	*Halcyon smyrnensis*	1.52 ± 0.70	0.63 – 3.67
27	Common Iora	*Aegithina tiphia*	1.33 ± 0.50	0.62 – 2.86
28	Savanna Nightjar	*Caprimulgus affinis*	1.33 ± 1.29	0.15 – 11.97
29	Barred Button Quail	*Turnix suscitator*	1.31 ± 0.90	0.34 – 5.08
30	Pintail Snipe	*Gallinago stenura*	1.26 ± 0.52	0.54 – 2.94
31	White-vented Myna	*Acridotheres grandis*	1.22 ± 0.35	0.69 – 2.19
32	Plain Sunbird	*Anthreptes simpplex*	1.10 ± 0.87	0.15 – 8.26
33	Brown Shrike	*Lanius cristatus*	1.08 ± 0.24	0.69 – 1.69
34	Pied Triller	*Lalage nigra*	1.00 ± 0.27	0.57 – 1.76
35	Black-naped Oriole	*Oriolus chinesis*	0.97 ± 0.28	0.53 – 1.75
36	Green Iora	*Aegithina virdissima*	0.93 ± 0.25	0.54 – 1.59
37	Lesser Coucal	*Centropus bengalensis*	0.82 ± 0.27	0.42 – 1.61
38	Lesser Whistling Duck	*Dendrocygna javanica*	0.73 ± 0.30	0.01 – 38.58
39	Yellow Bittern	*Ixobrychus sinensis*	0.73 ± 0.37	0.32 – 1.70
40	Brown-throated Sunbird	*Anthreptes malacensis*	0.71 ± 0.32	0.28 – 1.82
41	Common Tailorbird	*Orthotomus sutorius*	0.62 ± 0.25	0.13 – 3.05
42	Purple Swamphen	*Porphyrio porphyrio*	0.54 ± 0.29	0.17 – 1.76
43	Common Flameback	*Dinopium javanense*	0.38 ± 0.16	0.16 – 0.90
44	Red Junglefowl	*Gallus gallus*	0.34 ± 0.13	0.16 – 0.74
45	Black-shouldered Kite	*Elanus caeruleus*	0.27 ± 0.14	0.09 – 0.82
46	Purple Heron	*Ardea purpurea*	0.27 ± 0.13	0.14 – 0.50
47	Greater Coucal	*Centropus sinensis*	0.25 ± 0.15	0.60 – 0.98
48	Hill Myna	*Gracula religosa*	–	–
49	Olive-winged Bulbul	*Pycnonotus plumosus*	–	–
50	Pacific Swallow	*Hirundo tahitica*	–	–
51	Asian Brown Flycatcher	*Muscicapa dauurica*	–	–
52	Common Sandpiper	*Tringa. hypoleucos*	–	–
53	Olive-backed Sunbird	*Nectarinia jugularis*	–	–
54	Black Baza	*Aviceda leuphotes*	–	–
55	Cinnamon Bittern	*Ixorbychus cinnamoneus*	–	–
56	Greater Flameback	*Chrysocolaptes lucidus*	–	–
57	Large-billed Crow	*Corvus macrorhynchos*	–	–
58	Large-tailed Nightjar	*Caprimulgus macrurus*	–	–
59	Little Spiderhunter	*Arachnothera longirostra*	–	–
60	Orange-breasted Green Pigeon	*Treron bicincta*	–	–
61	Water Cock	*Gallicerx cinerea*	–	–
62	Black-throated Sunbird	*Aethopyga saturata*	–	–
63	Blue-breasted Quail	*Coturnix chinensis*	–	–
64	Brahminy Kite	*Haliastur indus*	–	–
65	Chestnut-winged Cuckoo	*Clamator coromandus*	–	–
66	Common Asian Koel	*Eudynamys scolopacea*	–	–
67	Common Kingfisher	*Alcedo atthis*	–	–
68	Copper-throated Sunbird	*Nectarinia calcostetha*	–	–
69	Mangrove Whistler	*Pachycephala grisola*	–	–
70	Plaintive Cuckoo	*Cacomantis merulinus*	–	–
71	Purple-throated Sunbird	*Nectarinia sperata*	–	–

72	Rufescent Prinia	*Prinia rufescens*	–	–
73	Western Marsh Harrier	*Circus aeruginosus*	–	–
74	Yellow-breasted Bunting	*Emberiza aureola*	–	–
75	Zitting Cisticola	*Cisticola juncidis*	–	–

Table 7: Ranking of bird density in Shrub Patches habitat at Paya Indah Natural Wetland Reserve, Peninsular Malaysia

Rank	Common Name	Scientific Name	Density (birds/ha)	Density at 95% confidence interval (birds/ha)
1	Pink-necked Green Pigeon	*Treron vernans*	19.99 ± 4.52	12.60 – 31.74
2	Scaly-breasted Munia	*Lonchura punctulata*	17.18 ± 5.21	2.92 – 100.98
3	Peaceful Dove	*Geopelia striata*	11.18 ± 2.83	7.17 – 17.43
4	Black-headed Munia	*Lonchura malacca*	7.96 ± 2.67	1.54 – 41.14
5	Dollar Bird	*Eurystomus orientalis*	7.88 ± 2.99	2.30 – 26.94
6	Pacific Swallow	*Hirundo tahitica*	7.70 ± 2.84	3.62 – 16.36
7	Baya Weaver	*Ploceus philippinus*	6.66 ± 2.63	2.71 – 16.40
8	Yellow-vented Bulbul	*Ploceus philippinus*	3.24 ± 0.47	2.43 – 4.33
9	Orange-breasted Green Pigeon	*Treron bicincta*	2.80 ± 1.27	0.19 – 8.61
10	Ashy Minivet	*Pericrocotus divaricatus*	2.46 ± 1.55	0.59 – 10.24
11	Large-tailed Nightjar	*Caprimulgus macrurus*	2.35 ± 1.58	0.57 – 9.70
12	Brown-throated Sunbird	*Anthreptes malacensis*	2.14 ± 1.23	0.14 – 32.99
13	Oriental Reed Warbler	*Acrocephalus orientalis*	1.91 ± 1.04	0.61 – 5.95
14	Brown Shrike	*Lanius cristatus*	1.80 ± 0.94	0.66 – 4.89
15	Oriental Magpie Robin	*Copsychus saularis*	1.72 ± 1.14	0.49 – 6.02
16	Yellow-bellied Prinia	*Prinia flaviventris*	1.87 ± 0.67	0.90 – 3.89
17	Philippine Glossy Starling	*Aplonis panayensis*	1.54 ± 0.57	0.70 – 3.38
18	Yellow Bittern	*Ixobrychus sinensis*	1.37 ± 0.69	0.39 – 4.87
19	Spotted Dove	*Streptopelia chinensis*	1.14 ± 0.25	0.74 – 1.76
20	Richard's Pipit	*Anthus richardi*	1.11 ± 0.36	0.57 – 2.16
21	Lesser Coucal	*Centropus bengalensis*	1.00 ± 0.25	0.59 – 1.67
22	Pied Fantail	*Rhipidura javanica*	0.93 ± 0.22	0.58 – 1.49
23	Jungle Myna	*Acridotheres fuscus*	0.90 ± 0.31	0.46 – 1.76
24	Common Tailorbird	*Orthotomus sutorius*	0.86 ± 0.46	0.29 – 2.60
25	Black-napped Oriole	*Oriolus chinensis*	0.73 ± 0.16	0.47 – 1.13
26	White-throated Kingfisher	*Halcyon smyrnensis*	0.73 ± 0.17	0.45 – 1.18
27	Common Flameback	*Dinopium javanense*	0.55 ± 0.21	0.24 – 1.26
28	Green Iora	*Aegithina virdissima*	0.50 ± 0.12	0.31 – 0.81
29	Asian Brown Flycatcher	*Muscicapa dauurica*	0.47 ± 0.31	0.12 – 1.93
30	Red-wattled Lapwing	*Vanellus indicus*	0.46 ± 0.15	0.31 – 0.69
31	Purple Swamphen	*Porphyrio porphyrio*	0.45 ± 0.18	0.20 – 1.01
32	White-breasted Waterhen	*Amaurornis phoenicurus*	0.42 ± 0.10	0.26 – 0.68
33	Common Myna	*Acridotheres tristis*	0.35 ± 0.20	0.23 – 0.54
34	White-vented Myna	*Acridotheres grandis*	0.35 ± 0.14	0.11 – 1.10
35	Barred Button Quail	*Turnix suscitator*	0.34 ± 0.20	0.21 – 1.60
36	Red Junglefowl	*Gallus gallus*	0.33 ± 0.11	0.18 – 0.63
37	Pied Triller	*Lalage nigra*	0.33 ± 0.11	0.16 – 0.67
38	Common Iora	*Aegithina tiphia*	0.31 ± 0.15	0.11 – 0.87
39	Blue-tailed Bee-eater	*Merops philippinus*	0.28 ± 0.16	0.19 – 0.43
40	Large-billed Crow	*Corvus macrorhynchos*	0.23 ± 0.11	0.06 – 0.97
41	Purple Heron	*Ardea purpurea*	0.19 ± 0.09	0.06 – 0.56
42	Rufous woodpecker	*Celeus brachyurus*	–	–
43	Olive-backed Sunbird	*Nectarinia jugularis*	–	–
44	Little Bronze Cuckoo	*Chrysoccyx minutillus*	–	–
45	Greater Coucal	*Centropus sinensis*	–	–
46	Savanna Nightjar	*Caprimulgus affinis*	–	–
47	Olive-winged Bulbul	*Pycnonotus plumosus*	–	–
48	Blue-throated Bee-eater	*Merops viridis*	–	–

49	Arctic Warbler	*Phylloscopus borealis*	–	–
50	Zitting Cisticola	*Cisticola juncidis*	–	–
51	White-browed Crake	*Porzana cinerea*	–	–
52	Water Cock	*Gallicerx cinerea*	–	–
53	Mangrove Whistler	*Pachycephala grisola*	–	–
54	Little Green Pigeon	*Treron olax*	–	–
55	Common Moorhen	*Gallinula chloropus*	–	–
56	Cinnamon Bittern	*Ixorbychus cinnamoneus*	–	–
57	Blue-breasted Quail	*Coturnix chinensis*	–	–
58	Black-throated Sunbird	*Aethopyga saturata*	–	–
59	White-bellied Sea Eagle	*Haliaeetus leucogaster*	–	–
60	Slaty-breasted Crake	*Gallirallus striatus*	–	–
61	Rusty-rumped Warbler	*Locustella certhiola*	–	–
62	Plaintive Cuckoo	*Cacomantis merulinus*	–	–
63	Pintail Snipe	*Gallinago stenura*	–	–
64	Little Spiderhunter	*Arachnothera longirostra*	–	–
65	Greater Flameback	*Chrysocolaptes lucidus*	–	–
66	Copper-throated Sunbird	*Nectarinia calcostetha*	–	–
67	Black-shouldered Kite	*Elanus caeruleus*	–	–
68	Ashy Tailorbird	*Orthotomus ruficeps*	–	–

Table 8: Comparison of bird density in marsh swamp, lotus swamp, open water body, dryland and shrub patches at Paya Indah Wetland Reserve, Peninsular Malaysia

Habitat Name	Mean Density
Marsh Swamp	183.28 a
Dryland	162.80 ab
Shrub Patches	130.67 b
Open Water Body	130.07 b
Lotus Swamp	120.67 b

(The mean values in columns with same letter are not significant at P = 0.05, Tukey's HSD test; Critical Value, 43.71).

Appendix 1: Kruskal–Wallis One–Way Nonparametric ANOVA test results of bird density comparison in five habitats at Paya Indah Wetland Reserve, Peninsular Malaysia

DF	SS	MS	F	P
4	162481	40620.3	6.31	0.0001
285	1834713	6437.6		
289	1997194			

Figure 1: Location map of Paya Indah Natural Wetland Reserve, Selangor Peninsular Malaysia

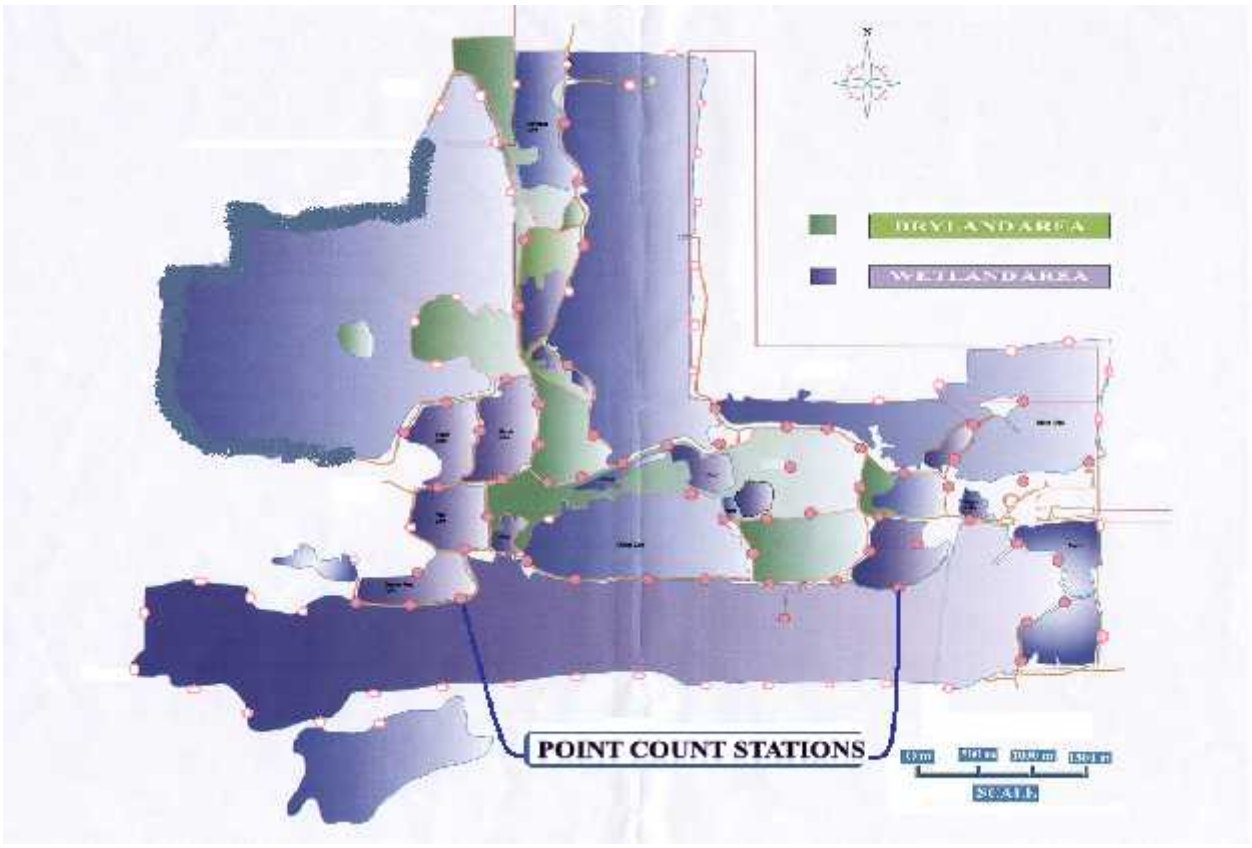

Figure 2: Location of count stations at Paya Indah Natural Wetland Reserve, Selangor Peninsular Malaysia.

DISCUSSION

Birds are highly mobile creatures that often exhibit distinct association with particular habitat (Seymour and Simmons, 2008). Monitoring the avian density among different habitats provide information about population variation in particular habitats (Desante *et al*., 2005). A total of 100 bird species were recorded in the study area including 84 species in marsh swamp, 57 species in lotus swamp, 65 species in shrub patches, 75 species in dryland and 55 species in open water body which indicated that Paya Indah Natural Wetland Reserve is a suitable habitat and frequently utilized by diverse avian species. Furthermore, data analysis indicated that bird density varied in different habitats depending on vegetation structure and composition, availability of food resources, occurrence of suitable foraging, nesting and chick rearing sites, and also surrounded landscape.

Vegetation composition of this natural wetland reserve comprises trees, shrubs, grasses, emergent and submerged vegetation, reeds, sedges, ferns and herbs. The heterogeneity of vegetation has created various layers such as canopy layer, shrub layer and ground vegetation layer, i.e. grasses and aquatic vegetation (emergent and submerged vegetation) that attracted wide array of avian species. The canopy layer of the wetland reserve is sparsely distributed along the edges of water bodies and somewhere dense stands of trees and shrubs in the dryland. Furthermore, the shrubs occupy the vegetation below five meters height under trees and along the banks of lakes, while the ground layer consists of herbaceous plants, such as grasses, reed beds of sedges and emergent vegetation. Diversity of vegetation structure and composition gives physical configuration characteristic to wetland habitats and attract diversity of bird species (Soderstrom and Part, 1999; Canterbury *et al*, 2000; Rajpar and Zakaria, 2010), because vegetative structure and composition is a primary proximate factor that determines where and how birds use resources, affecting habitat selection, influenced the species abundance, distribution, diversity and density (Rotenberry, 1985; Bloack and Brennan, 1993).

Most importantly, this study revealed that marsh swamp habitat supported higher bird density as compared to other habitats. This is probably due to richness and diversity of vegetation of emergent vegetation (Water Chestnuts, Marsh Sedges, Water Lilies, Water-Milfoils, and Bulrushes), availability of abundant food sources (invertebrates, vegetable matter, fishes, amphibians, reptiles, and mammals), shelter from harsh weather and predators, suitable nesting and chick rearing sites as reported by earlier studies (Elphick and Oring, 1998; Colwell and Taft, 2000; Zakaria *et al*. 2009). Emergent

vegetation presumably acts as an ultimate factor, as it provides food, nesting sites and cover for swamphen, crakes, moorhens, warblers and prinias. The grasses along the edges of marshes offer nesting grounds for ducks, waterhens, and water cocks. This indicated that avian species select habitats that provide an optimal combination of resources to allow them to perform multiple activities such as foraging, breeding, roosting and nesting. It has been reported that marshes support the highest avian diversity than other wetland types and are the most important natural mechanism for maintaining water quality to support avifaunal diversity to fulfil their daily requirements and reproduction (Weller, 1994, & 1999; Zakaria *et al*, 2009).

The avian density and diversity is associated with the availability of food, habitat condition and safe breeding sites (Paracuellos, 2006; Aynalem and Bekele, 2008) and also abiotic factors such as soil, temperature and relative humidity (Jaksic, 2004; Lagos *et al*., 2008). These factors in turn affect the wetland dependent communities as well as the ecosystem attribute such as species richness, distribution and density (Burkert *et al*., 2004). In addition, weather and climate conditions also play significant role in avian population affecting their breeding and wintering grounds, availability of food resources directly and indirectly (Sillett *et al*., 2000; Both and Visser, 2001). Furthermore, the arrival and departure of migratory bird species also influences avian species abundance and food resources (Gaston *et al*., 2000; Corcoran, 2005).

Conclusion: This study highlighted that Paya Indah Natural Wetland Reserve encompasses heterogeneous vegetation that offer different habitats and food resources for wide array of avian species. Furthermore, this study also revealed that marsh swamp habitat attracted higher bird density as compared to lotus swamp, open water body, dryland and shrubs patches. This is due to richness of food resources such as fishes, amphibians, aquatic invertebrates and diversity of emergent vegetation such as *E. dulcis, L. articulata, S. palustris, P. lanuginosum,* and *S. purpurascens* that provide ideal foraging, nesting and chick rearing sites, and also cover from predators and harsh weather.

Acknowledgements: The authors would like to thank Department of Wildlife and National Parks, Peninsular Malaysia to conduct this research study at Paya Indah Natural Wetland Reserve. This research was partially funded by Fundamental Grant Research Scheme 01-10-07-291FR and Forestry Sector Research Division Project, Pakistan Forest Institute, Peshawar Pakistan.

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