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Species Diversity and Feeding Guilds of Birds in Paya Indah Wetland Reserve, Peninsular Malaysia

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Abstract: The objective of this study was to examine the bird species diversity and feeding guilds in Paya Indah Wetland Reserve, Peninsular, Malaysia. Distance sampling-point count method was used to survey the bird species. A total of 13872 birds belonging to 100 species and 38 families were recorded. The results show that *Treron vernans* (12.42%), *Pycnonotus goiavier* (12.13%), *Geopelia striata* (7.58%), *Porphyrio porphyrio* (6.87%) and *Streptopelia chinensis* (6.33%) were the most dominant species in the area. The Ardeidae was the most dominant family with nine species and sixteen families were rarest only with one species each. The highest bird diversity was observed in Marsh swamp (Shannon's $N_1 = 27.16$), while the lowest was in Patchy shrubland (Shannon's $N_1 = 22.51$). The highest bird species richness was observed in Marsh swamp (Margalef's $R_1 = 9.52$), while the lowest was observed in open water bodies (Margalef's $R_1 = 7.35$). The evenness of individuals among the species was higher in Marsh swamps (Pielou $J = 0.71$) and lower in Patchy shrubland (Pielou $J = 0.67$). Analysis of variance and Tukey (HSD) tests showed that bird species among habitats is significantly different ($F_4, 495 = 8.82$ $p < 0.0001$). Feeding guilds indicated that insectivore was the most dominant group (37%), while Carnivore/Insectivore and Granivore were the least dominant groups (3% each) in all five habitats. This study clearly indicated that Paya Indah Wetland Reserve is highly important in providing food resources, shelter, nesting and roosting sites for wide range of bird species.

Key words: Wetland birds, diversity, richness, feeding guilds, habitat

INTRODUCTION

The total area of natural wetlands in Malaysia is estimated about 3.5 to 4.0 million ha or 10% of the total land area. This total area of Malaysian wetlands is divided into 0.6 million ha of mangrove, 0.15 million ha of open water, 0.05 million ha of marsh and 2.7 to 3.2 million ha of freshwater peat swamp forest. In Peninsular Malaysia, wetlands are found in the States of Pahang (2.5%), Selangor (1.1%), Johor (1.1%), Perak (1%) and Terengganu (0.8%) (Aik, 2002).

Wetlands are widely recognized as fragile ecosystems with diverse attributes including a distinctive avifauna (Burger, 1985). It has been estimated that freshwater wetlands hold more than 40% of bird species of the entire world and 12% of all animal species. Wetlands are highly important because they serve as critical breeding, staging and wintering grounds for wide array of globally important bird species (Kristen and Brander, 2004).

Approximately 460 native and 215 migratory bird species occurred in Malaysia. Many of them are endemic to Malaysia and show distinct habitat preferences. Almost, 24% of migratory bird species

utilized freshwater wetland areas such as swamp forest, peat swamp forest, rivers and lakes systems, while 30% preferred to use coastal wetlands such as mangrove and inter tidal mudflats (Medway and Wells, 1976).

Point counts are widely used as indices of bird diversity and abundance and to assess habitat relationship and population response to environmental changes or managements (Thompson, 2002; Mathew *et al.*, 2006). The species richness and relative abundance of birds depend upon wetland characteristics such as size, water level, quality of water, availability and distribution of food resources, presence of suitable roosting and nursery sites (Wiens, 1989). Moreover, variation in habitat condition may also cause changes in relative abundance of bird species composition (Garcia *et al.*, 1997; Caziani and Derlindati, 2000).

However, to date no detail studies have been done to examine the species richness and feeding guilds of birds in freshwater wetlands of Malaysia. Very little is known on the ecological roles of birds related to the freshwater wetland ecosystem; i.e., what would happen to them when their habitat is altered and whether their populations are increased or decreased. However, it is important to examine which species need the different types of habitats within the wetland areas before the effects of their changes on the species can be understood. Therefore, the main objective of this study was to describe the bird species diversity and feeding guilds based on habitat types in Paya Indah Wetland Reserve, Peninsular Malaysia.

MATERIALS AND METHODS

Study Site

Paya Indah (beautiful swamp) Wetland Reserve is encompassing of 3050 ha which consists of peat swamps and large ex-tin mining lakes. The study area lies adjacent to Malaysia's administrative capital of Putrajaya within the quadrant of 101° 10' to 101° 50' longitude and 2° 50' and 3° 00' latitude. Paya Indah has diverse topography, vegetative features and climate with splendid natural setting which directly affect the occurrence and distribution of bird species.

The research area was divided into five major habitats based on existing conditions and vegetation structure namely; (1) Marsh swamp, (2) Lotus swamp, (3) Open water body, (4) Terrestrial area and (5) Patchy shrubland.

Marsh Swamp

About 85% of marsh swamp areas are covered with water and 15% with terrestrial area. Marsh swamps densely covered with aquatic plants namely *Eleocharis dulcis*, *Lepironia articulata*, *Stenochlaena palustris*, *Philydrum lamuginosum*, *Scirpus* sp., *Carex* sp., *Sagittaria latifolia*, *Elodea* sp., *Phragmites karka*, *Nymphaea rubra*, *Nymphaea Pubescens*, *Nelumbo nucifera*, *Scleria purpurascens*, *Panicum repens*, *Gleichenia linearis*, *Lycopodium cernuum* and scattered trees such as *Acacia auriculiformis*, *A. mangium*, *Macaranga lanrius*, *Peltophorum pterocarpum*, *Cinnamomum iners*, *Melicope glabra* and *Melastoma malabathrium*. These areas are shallow in water depth and rich in food resources such as fishes, amphibians, insects, snails and invertebrates larvae.

Lotus Swamp

About 90% of lotus swamp areas are covered by water and 10% by terrestrial land. Lotus swamps are extensively covered with *Nelumbo nucifera*, *N. nouchali*, *N. pubescens*, *Eleocharis dulcis*, *Elodea canadensis*, *Lepironia articulata*, *Phragmites karka* reeds and *Typha angustifolia*. The land is covered with *Acacia auriculiformis* and *A. mangium*.

Open Water Body

About 90% of the area is covered by water and 10% by terrestrial land. Open water bodies mostly covered with emergent vegetation such as *Nymphaea odorata*, *Potamogeton* sp., *Eleocharis*

dulcis, *Myriophyllum spicatum*, *Salvinia molesta*, *Utricularia aurea*, *Scirpus holschoenus*, *S. sylvaticus*, *S. californicus*, *S. mucronatus*, *S. maritimus* and along the edges *Eleocharis dulcis*, *Lepironia articulata*, *Phylidrum languginosum*, *Scleria purpurascens*, *Scirpus* sp., *Carex* sp., *Sagittaria latifolia* and *Elodea* sp. Open water bodies are rich in invertebrates, amphibians and fishes.

Terrestrial Area

About 85% of the area is covered with scattered trees and grasses and 15% by small ditches or somewhere stagnant water ponds. The most dominant tree species are *Mimusops elengi*, *Fragraea fragrans*, *Cassia fistula*, *Tectona* sp., *Albizia julibrissin*, *Syzygium* sp., *Delonix regia*, *Samanea saman*, *Acacia auriculiformis*, *A. mangium*, *Melicope glabra*, *Melastoma malabathricum*, *Ficus* sp. and the ground is extensively covered with Bald grass *Imperata cylindrica*, *Cynodon dactylon*, *Wedelia trilobata*, *Nephrolepis acutifolia*, *Artocarpus altilis*, *Asystasia gangetica*, *Peltophorum pterocarpum*, *Plumeria obtuse*, *Asystasia gangetica* and *Passiflora caerulea*.

Patchy Shrubland

About 85% of the area is covered with dense vegetation and 15% covered by scattered trees and aquatic vegetation. Patchy Shrublands are mainly cluster and patches of shrubs and small trees between pools, mound hills and along the pathways. The dominant plant species are *Acacia auriculiformis*, *A. mangium*, *Fragraea fragrans*, *Delonix regia*, *Alstonia scholaris*, *Samanea saman*, *Macaranga lanrius*, *Ficus rubiginosa*, *F. benjamina*, *F. fistulosa*, *Lagerstroemia speciosa*, *Melastoma malabathricum*, *Wedelia trilobata*, *Nephrolepis acutifolia* and *Asystasia gangetica*.

Observations

Bird surveys were carried out at Paya Indah Wetland Reserve by using distance sampling-point count method to determine species diversity and feeding guilds of different bird species within November 2007 to January 2009. Sixty one point count stations 300 m apart from each other were established within the study area. The main objective of using 300 m interval distance apart between points was to avoid detecting the same birds at more than one station. Each point count station was surveyed fifteen consecutive times at monthly interval to achieve reliable diversity estimate because the replication of point count stations increased precision and provides reliable results (Petit *et al.*, 1995; Smith *et al.*, 1993). The survey was done early in the morning from 7:30 to 11:00 am. The methodology was followed as described by Buckland *et al.* (2004), Blonde *et al.* (1981) and Bibby *et al.* (2002).

The detection of birds within each point count station was done for 10 min. Ten minute enables to detect many species of birds with minimal efforts and disturbance. Ten minutes point counts provide more reliable results as compared to shorter time because more species are usually detected and efficiency declined substantially after 10 min (Jiménez, 2000; Gutzwiller, 1991; Smith *et al.*, 1993; Dawson *et al.*, 1995; Lynch, 1995; Petit *et al.*, 1995; Lee and Marsden, 2008). During each point count survey we recorded species and number of individuals detected by sight or sound.

The relative abundance (%) of waterbird species was determined by using expression:

$$\text{Relative abundance(\%)} = \frac{n}{N} \times 100$$

where, n is numbers of particular recorded bird and N is total recorded bird species.

The study area was divided into five major habitats based on existing conditions and vegetation structure namely, (1) Lotus swamp, (2) Marsh swamp, (3) Open water body, (4) Terrestrial area and (5) Patchy shrubland. Species diversity, species richness and evenness were determined in study area

and within five habitats by using standard Species Diversity Indices method (Henderson and Seaby, 2007; Ludwig and Reynolds, 1988) to examine the variability of bird species among five habitats. The trophic structure was also determined in study area and within five habitats based on observed foraging behavior of bird species during the surveys.

RESULTS AND DISCUSSION

A total of 13872 individuals of 100 species of birds that represented 38 families were detected within November 2007 to January 2009. The results shows that the five most dominant bird species were *Treron vernans* (12.420%), *Pycnonotus goiavier* (12.132%), *Geopelia striata* (7.583%), *Porphyrio porphyrio* (6.877%) and *Streptopelia chinensis* (6.336%). The most rare bird species were *Haliastur indus*, *Circus aeruginosus*, *Haliaeetus leucogaster*, *Treron curvirostra*, *Clamator coromandus*, *Eudynamis scolopacea*, *Dicrurus leucophaeus*, *Emberiza aureola*, *Prinia rufescens*, *Nectarinia sperata*, *Picumnus innominatus*, *Phylloscopus inornatus* and *Gallirallus striatus* (each 0.007%) (Appendix 1).

The six most dominant families based on number of species detected were Ardeidae (9 species), Sylviidae (7 species), Nectariniidae (7 species), Rallidae (7 species), Columbidae (6 species) and Cuculidae (6 species). The least dominant families were Charadriidae, Coraciidae, Dicruridae, Emberizidae, Hirundinidae, Jacanidae, Motacillidae, Muscicapidae, Oriolidae, Pachycephalidae, Ploceidae, Passeridae, Podicipedidae, Rhipiduridae, Turdidae and Turnicidae with only one species each. However, the three most dominant families with highest number of observations were Columbidae (3721 observations; 26.823%), Pycnonotidae (1696 observations; 12.226%), Rallidae (1485 observations; 10.70%) and the rarest families were Dicruridae and Emberizidae (one observation each; 0.007% each) (Table 1; Appendix 2).

The bird species diversity, richness and evenness in different habitats were determined using species Diversity indices method (Henderson and Seaby, 2007; Ludwig and Reynolds, 1988). The highest bird diversity was observed in Marsh swamp and lowest in Patchy shrubland (Shannon diversity index $N_1 = 27.16$ and $N_1 = 22.51$, respectively; Table 2). The highest bird species richness was also observed in Marsh swamp (Margalef's Richness Index $R_1 = 9.52$) while the lowest was observed in Open water bodies (Margalef's Richness Index $R_1 = 7.35$). The distribution of individuals among the species was higher in Marsh Swamps and lower in Patchy Shrubland (Pielou J Evenness = 0.71 and 0.67, respectively) (Table 2; Appendix 3).

Bird species diversity comparison among five habitats was also determined by using ANOVA and Tukey's (HSD) comparison test. The result showed that bird species diversity among the five habitats was significantly different ($F_4, 495 = 8.82$ $p < 0.0001$) (Table 3).

The bird species were divided into eight feeding guilds based on observed foraging behaviours and habitat use during the 15 consecutive month's surveys. The results clearly showed that the Insectivore was the most dominant group of birds (37.0%) as compared to Omnivore (19.0%), Carnivore/Insectivore/Pisicivore (17.0%), Frugivore/Insectivore (8.0%), Nectarivore/Insectivore (7.0%), Granivore/Insectivore (6.0%), Carnivore/Insectivore and Granivore (3.0% each) in Paya Indah Wetland Reserve (Table 4).

Composition of feeding guild based on habitats was also determined to examine the importance of the habitats for different groups. The results showed that Insectivore was the most dominant group of birds as compared to other feeding guilds in all habitat types. The least dominant guild in all habitat types was the Carnivore/Insectivore (Table 5).

Monitoring bird species diversity is very important to describe the community structure and make comparisons among the different habitats (Goldsmith, 1975; Everett, 1978; Rafe *et al.*, 1985; Robertson and Liley, 1998). Paya Indah Wetland Reserve has diverse vegetation and habitats. The vegetation diversity and richness directly affect species diversity and richness of birds, because it

Table 1: Ranking of bird families according to No. of species detected in Paya Indah Wetland Reserve, Peninsular Malaysia

Family name	No. of species	Total No. of observations	Percentage
Ardeidae	9	616	4.440
Sylviidae	7	102	0.735
Nectariniidae	7	84	0.605
Rallidae	7	1485	10.705
Columbidae	6	3721	26.823
Cuculidae	6	170	1.225
Accipitridae	5	24	0.173
Sturnidae	5	1333	9.609
Picidae	4	78	0.566
Estrildidae	3	637	4.591
Aegithinidae	2	227	1.636
Alcedinidae	2	334	2.407
Anatidae	2	337	2.429
Campophagidae	2	80	0.576
Caprimulgidae	2	24	0.173
Cisticolidae	3	189	1.362
Corvidae	2	50	0.360
Laniidae	2	163	1.175
Meropidae	2	386	2.782
Phasianidae	2	88	0.634
Pycnonotidae	2	1696	12.226
Scolopacidae	2	37	0.266
Charadriidae	1	261	1.881
Coraciidae	1	40	0.288
Dicruridae	1	1	0.007
Emberizidae	1	1	0.007
Hirundinidae	1	353	2.544
Jacaniidae	1	7	0.050
Motacillidae	1	257	1.825
Muscicapidae	1	14	0.100
Oriolidae	1	178	1.283
Pachycephalidae	1	8	0.057
Ploceidae	1	378	2.724
Passeridae	1	112	0.807
Podicipedidae	1	11	0.079
Rhipiduridae	1	167	1.203
Turdidae	1	203	1.463
Turnicidae	1	20	0.144

Table 2: Diversity of bird species according to habitat type in Paya Indah Wetland Reserve

Name of habitat	No. of species (n _i)	No. of observations	Shannon's diversity index (N _i)	Margalef's richness index (R _i)	Pielou J evenness
Marsh swamp	84	6086	27.16	9.52	0.71
Lotus swamp	57	1097	25.72	8.00	0.70
Open water body	55	1545	24.20	7.35	0.69
Terrestrial area	75	3212	23.95	9.16	0.68
Patchy shrubland	68	1932	22.51	8.85	0.67

Table 3: Comparison of bird species among habitats (Tukey's HSD)

Habitat type	Mean value
Marsh swamp	0.587a
Lotus swamp	0.545ab
Open water body	1.072bc
Terrestrial area	0.828bc
Patchy shrubland	0.699c

Values having the same letter(s) are not significant

provides heterogeneous and suitable sites for foraging, nesting and roosting (Karr and Roth, 1971; Cody, 1981; Canterbury *et al.*, 1999; Soderstrom and Part, 1999). This study also showed that

Table 4: Classification of feeding guilds based on foraging behaviors in Paya Indah Wetland Reserve

Trophic structure	No. of species	Percentage
Carnivore/insectivore	3	3
Carnivore/insectivore/piscivore	17	17
Frugivore/insectivore	8	8
Granivore	3	3
Granivore/insectivore	6	6
Insectivore	37	37
Nectarivore/insectivore	7	7
Omnivore	19	19
Total species	100	100

Table 5: Feeding guilds of bird species according to habitat types

Feeding guild	Marsh swamp	Lotus swamp	Open water body	Terrestrial area	Patchy shrubland
	------(%)-----				
Carnivore/Insectivore	3.57	0.00	3.63	4.00	2.94
Carnivore/Insectivore/Piscivore	16.66	15.78	14.54	10.66	8.82
Frugivore/Insectivore	8.33	10.52	7.27	8.00	10.29
Granivore	3.57	3.50	5.45	4.00	4.41
Granivore/Insectivore	7.14	7.01	7.27	8.00	5.88
Insectivore	34.52	36.84	34.54	37.33	41.17
Nectarivore/Insectivore	5.95	7.01	1.81	9.33	7.35
Omnivore	20.23	19.29	25.45	18.66	19.11
Total No. of species	84.00	57.00	55.00	75.00	68.00

bird species diversity and feeding guilds are significantly different among habitats. We recorded 13872 birds belonging to 100 species and 38 families. We also recorded 84 species in marsh swamp, 57 species in lotus swamp, 68 species in patchy shrubland, 75 species in terrestrial area and 55 species in open water body.

The results showed that Marsh swamp is highly attractive for different bird species as compared to other habitats since it provides heterogeneous habitats that attracted high diversity of birds through offering shelter, abundant food, suitable nesting and safe roosting sites for different groups of birds (Macdonald, 1977). The main reason for the difference in habitat preference by bird species could be due to different vegetation types (Weller, 1978) and abundant food resources (Puttick, 1984) such as insects, fishes, frogs, lizards, mouse and vegetable matter. However, other factors such as weather (rainfall), social interactions and predators (Caldwell, 1986; Butler and Vennesland, 2000; Rivers, 2000) such as *Aviceda leuphotes*, *Accipiter* sp., *Circus aeruginosus*, *Varanus salvator*, *Varanus goulgii*, *Python reticulatus*, *Ophiophagus hamah* and *Naja naja* may also affect the distribution, foraging, nesting and roosting behaviour of bird species (Kerbs, 1978; Baldassarre and Bolen, 1994; Haukos *et al.*, 1998).

We determine the relative importance of different habitats for foraging of wetland dependent and non-wetland dependent bird species. We observed that wetland dependent birds such as ducks, grebes and geese used open water bodies with shallow water depth particularly to forage on seeds and vegetable matter namely *Myriophyllum spicatum*, *Ceratophyllum demersum*, *Elodea* sp. and *Potamogeton* sp. Swamphens, moorhens and crakes used marsh swamps and lotus swamps to feed on soft shoots, stems, herbs, seed of reeds and rushes such as *Eleocharis dulcis*, *Nelumbo nucifera* and *Myriophyllum spicatum*. They also feed on small vertebrates such as tadpoles, fishes and invertebrates such as larvae of insects. Bitterns and herons hide in thick vegetation of *Eleocharis dulcis*, *Scleria purpurascens*, *Lepironia articulate* and *Phragmites karaka* in shallow water to catch variety of aquatic insects, nektons, pleustones, tadpoles and fishes. Egrets were often running with raised wing to chase their prey in shallow water mostly on amphibians, fish and insects. Jacanas picked snails, insects and invertebrates by walking slowly on the leaves of water lilies. Waterhens and water cocks frequently used wet moist soil in shallow water and along the edges of water bodies to probe in mud on variety of food items such as worms, insects and adjacent terrestrial areas especially covered with *Scleria purpurascens* and *Panicum repens* grasses to forage on seeds and vegetable matter. Kingfishers used variety of habitats to hunt on fishes and insects and often perched on trees along the edge of lakes and

adjacent lakes areas. Other species such as plovers, snipes and sandpipers used wet grounds (soft soil of muddy shorelines) for probing or picking up food items such as worms and insects. The edges preference feeding may be explained in term of higher level of prey availability and easy to catch prey as was also reported by McIver and Odum (1988). Such types of foraging behavior in birds have also been reported by Hancock (1999), Oglvie and Rose (2002), Pringle (1985), Clary (2007), Pranty *et al.* (2000), Ali and Daniel (1983), John *et al.* (1986) and Fry and Fry (1992).

The study shows further that the guild Insectivore which comprised of terrestrial, arboreal foliage gleaning, bark gleaning and sallying insectivores was the most dominant group of birds as compared to other feeding guilds namely Omnivore, Carnivore/Insectivore/Piscivore, Frugivore/Insectivore, Nectarivore/Insectivore, Granivore/Insectivore, Granivore and Carnivore/Insectivore. However, the feeding guilds also differ from habitat to habitat. The diverse vegetation has had strong and pervasive effect on avian species distribution. This could be due to the richness and heterogeneity of the emergent vegetation (e.g., *Eleocharis dulcis*, *Nelumbo mucifera*, *Salvinia molesta*, *Scleria purpurascens*), submerged vegetation (e.g., *Myriophyllum spicatum*, *Potamogeton illionensis*, *Eleocharis radicans*, *Creatophyllum demersum*, *Elodea* sp.), herbaceous plants (e.g., *Cyperus* sp. *Juncus effeuses*, *Panicum repens*, *Scirpus atrovirens*, *Phragmites karka*), shrubs (e.g., *Melastoma malabathricum*) and fruiting trees (e.g., *Fagaa fragrances*, *Syzygium* sp., *Ficus fistulosa*, *F. maclellandi*, *F. benjamina*, *Cinnamomum iners*, *Melicope glabra*). The diversity of flora subsequently affected the abundance and diversity of birds, insects, amphibians, fishes, reptiles and small mammals. Fruiting trees frequently provide fruits that attracted Frugivore/Insectivore and Omnivore birds such as pigeons, bulbuls, orioles, mynas and starlings. Flowering trees such as *Lagestroemia speciosa*, *Dillenia grandifolia*, *Dillenia suffruticosa* and *Cassia fistula* have also been observed to attract Nectarivore/Insectivore birds such as sunbirds and spiderhunters. The abundance of insects, amphibians, reptiles and small mammals has also attracted waders and raptors.

CONCLUSION

Based on these results it is concluded that Paya Indah Wetland Reserve provides various types of habitats especially in terms of vegetation and food resources. This area provides optimal combination of resources that allows bird species to fullfill their biological needs such as food, water (for swimming as well as for drinking), cover (for protection from predators and weather) and rest (including protection from natural and human disturbance). All primary feeding guilds Carnivore-/Insectivore/Piscivore, Frugivore/Insectivore, Grainivore/Insectivore, Insectivore, Nectarivore/Insectivore and Omnivore are present in the area. Therefore, the wetland area should be declared as bird sanctuary to protect particularly the wetland dependent birds.

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APPENDIX

Appendix 1: Number of observations of bird species in Paya Indah Wetland Reserve, Peninsular Malaysia

Species name	Scientific name	Total observations	Observations (%)
Pink-necked green pigeon	<i>Treron vernans</i>	1723	12.420
Yellow-vented bulbul	<i>Pycnonotus goiavier</i>	1683	12.132
Peaceful dove	<i>Geopelia striata</i>	1052	7.583
Purple swamphen	<i>Porphyrio porphyrio</i>	954	6.877
Spotted dove	<i>Streptopelia chinensis</i>	879	6.336

Appendix 1: Continued

Species name	Scientific name	Total observations	Observations (%)
Jungle myna	<i>Acridotheres fuscus</i>	571	4.116
Common myna	<i>Acridotheres tristis</i>	454	3.272
Scaly-breasted munia	<i>Lonchura punctulata</i>	410	2.955
Baya weaver	<i>Ploceus philippinus</i>	378	2.724
White-breasted waterhen	<i>Amaurornis phoenicurus</i>	376	2.710
Pacific swallow	<i>Hirundo tahitica</i>	353	2.544
Blue-tailed bee-eater	<i>Merops philippinus</i>	349	2.515
White-throated kingfisher	<i>Halcyon smyrneusis</i>	330	2.378
Purple heron	<i>Ardea purpurea</i>	269	1.939
Red-wattled lapwing	<i>Vanellus indicus</i>	261	1.881
Richard's pipit	<i>Anthus richardi</i>	257	1.852
Yellow bittern	<i>Ixobrychus sineusis</i>	246	1.773
Lesser whistling duck	<i>Dendrocygna javanica</i>	244	1.758
Black-headed munia	<i>Lonchura malacca</i>	214	1.542
Oriental magpie robin	<i>Copsychus saularis</i>	203	1.463
Philippine glossy starling	<i>Aplonis panayensis</i>	194	1.398
Black-naped oriole	<i>Oriolus chinensis</i>	178	1.283
Yellow-bellied prinia	<i>Prinia flaviventris</i>	175	1.261
Pied fantail	<i>Rhipidura javanica</i>	167	1.203
Green iora	<i>Aegithina viridissima</i>	164	1.182
Brown shrike	<i>Lanius cristatus</i>	160	1.153
Eurasian tree sparrow	<i>Passer montanus</i>	112	0.807
White-vented myna	<i>Acridotheres grandis</i>	108	0.778
Lesser coucal	<i>Centropus bengalensis</i>	106	0.764
Common moorhen	<i>Gallinula chloropus</i>	97	0.699
Cotton pygmy goose	<i>Nettion coromandelianus</i>	93	0.670
Red junglefowl	<i>Gallus gallus</i>	82	0.591
Common flameback	<i>Dinopium javanense</i>	68	0.490
Common iora	<i>Aegithina tiphia</i>	63	0.454
Pied triller	<i>Lalage nigra</i>	55	0.396
Orange-breasted green pigeon	<i>Treron bicincta</i>	55	0.396
Dollar bird	<i>Eurystomus orientalis</i>	40	0.288
Cinnamon bittern	<i>Ixobrychus cinnamomeus</i>	38	0.273
Blue-throated bee-eater	<i>Merops viridis</i>	37	0.266
Oriental reed warbler	<i>Acrocephalus orientalis</i>	35	0.252
Pintail snipe	<i>Gallinago stenura</i>	32	0.230
White-browed crane	<i>Porzana cinerea</i>	31	0.223
Large-billed crow	<i>Corvus macrorhynchos</i>	29	0.209
Common tailorbird	<i>Orthotomus sutorius</i>	29	0.209
Brown-throated sunbird	<i>Anthreptes malacensis</i>	28	0.207
Plaintive cuckoo	<i>Cacomantis merulinus</i>	27	0.194
Ashy minivet	<i>Pericrocotus divaricatus</i>	25	0.180
Ashy tailorbird	<i>Orthotomus ruficeps</i>	25	0.180
Olive-backed sunbird	<i>Nectarinia jugularis</i>	23	0.165
Little heron	<i>Butorides striatus</i>	23	0.165
House crow	<i>Corvus splendens</i>	21	0.151
Little bronze cuckoo	<i>Chrysococcyx minutillus</i>	20	0.144
Barred button quail	<i>Turnix suscitator</i>	20	0.144
Plain sunbird	<i>Anthreptes simplex</i>	18	0.129
Black-shouldered kite	<i>Elanus caeruleus</i>	17	0.122
Greater Coucal	<i>Centropus sineusis</i>	15	0.108
Asian brown flycatcher	<i>Muscicapa dauurica</i>	14	0.100
Ballion's crane	<i>Porzana pusilla</i>	14	0.100
White-headed munia	<i>Lonchura maja</i>	13	0.093
Olive-winged bulbul	<i>Pycnonotus plumosus</i>	13	0.093
Zitting cisticola	<i>Cisticola juncidis</i>	13	0.093
Black-crowned nightheron	<i>Nycticorax nycticorax</i>	13	0.093
Large-tailed nightjar	<i>Caprimulgus macrurus</i>	12	0.085
Savauna nightjar	<i>Caprimulgus affinis</i>	12	0.085
Grey heron	<i>Ardea cinerea</i>	12	0.085
Water cock	<i>Gallixer cinerea</i>	12	0.085
Little green pigeon	<i>Treron olax</i>	11	0.079

Appendix 1: Continued

Species name	Scientific name	Total observations	Observations (%)
Little grebe	<i>Tachybaptus ruficollis</i>	11	0.079
Mangrove whistler	<i>Pachycephala grisola</i>	8	0.057
Pheasant-tailed jacana	<i>Hydrophasianus chirurgus</i>	7	0.050
Schrenck's bittern	<i>Ixobrychus eurhythmus</i>	7	0.050
Black-throated sunbird	<i>Aethopyga saturata</i>	6	0.043
Blue-breasted quail	<i>Coturnix chinensis</i>	6	0.043
Rufous woodpecker	<i>Celeus brachyurus</i>	6	0.043
Hill Myna	<i>Gracula religiosa</i>	6	0.043
Rufous-tailed tailorbird	<i>Orthotomus sericeus</i>	6	0.043
Little spiderhunter	<i>Arachnothera longirostra</i>	5	0.036
Common sandpiper	<i>Tringa hypoleucos</i>	5	0.036
Black baza	<i>Aviceda leuphotes</i>	4	0.028
Common kingfisher	<i>Alcedo atthis</i>	4	0.028
Great egret	<i>Chasmerodius albus</i>	4	0.028
Little egret	<i>Egretta garzetta</i>	4	0.028
Long-tailed shrike	<i>Lanius schach</i>	3	0.021
Copper-throated sunbird	<i>Nectarinia calcostetha</i>	3	0.021
Greater Yellow-nape	<i>Picus flavinucha</i>	3	0.021
Arctic warbler	<i>Phylloscopus borealis</i>	3	0.021
Rusty-rumped warbler	<i>Locustella certhiola</i>	3	0.021
Brahminy kite	<i>Haliastur indus</i>	1	0.007
Western marsh harrier	<i>Circus aeruginosus</i>	1	0.007
White-bellied fish eagle	<i>Haliaeetus leucogaster</i>	1	0.007
Thick-billed green pigeon	<i>Tyreron curvirostra</i>	1	0.007
Chestnut-winged cuckoo	<i>Clamator coromandus</i>	1	0.007
Common koel	<i>Eudynamis scolopacea</i>	1	0.007
Ashy drongo	<i>Dicrurus leucophaeus</i>	1	0.007
Yellow-breasted bunting	<i>Emberiza aureola</i>	1	0.007
Rufescent prinia	<i>Prinia rufesceus</i>	1	0.007
Purple-throated sunbird	<i>Nectarinia sperata</i>	1	0.007
Speckled piculet	<i>Picumnus innominatus</i>	1	0.007
Inornate warbler	<i>Phylloscopus inornatus</i>	1	0.007
Slaty-breasted crane	<i>Gallirallus striatus</i>	1	0.007

Appendix 2: Classification of bird species according to family in Paya Indah Wetland Reserve

Family name	Species name	Scientific name
Accipitridae	Black-shoulder kite	<i>Elanus caeruleus</i>
	Black baza	<i>Aviceda leuphotes</i>
	Brahminy kite	<i>Haliastur indus</i>
	Western marsh harrier	<i>Circus aeruginosus</i>
	White-bellied sea eagle	<i>Haliaeetus leucogaster</i>
Aegithinidae	Common iora	<i>Aegithina tiphia</i>
	Green iora	<i>Aegithina viridissima</i>
Alcinidae	White-throated kingfisher	<i>Halcyon smyrnensis</i>
	Common kingfisher	<i>Alcedo atthis</i>
Anatidae	Lesser whistling duck	<i>Dendrocygna javanica</i>
	Cotton pygmy goose	<i>Nettion coromandelianus</i>
Ardeidae	Yellow bittern	<i>Ixobrychus sineusis</i>
	Purple heron	<i>Ardea purpurea</i>
	Cinnamon bittern	<i>Ixobrychus cinnamomeus</i>
	Little heron	<i>Butorides striatus</i>
	Schrenck's bittern	<i>Ixobrychus eurhythmus</i>
	Great egret	<i>Chasmerodius albus</i>
	Little egret	<i>Egretta garzetta</i>
	Black-crowned night heron	<i>Nycticorax nycticorax</i>
	Grey heron	<i>Ardea cinerea</i>
Campophagidae	Ashy minivet	<i>Pericrocotus divaricatus</i>
	Pied triller	<i>Lalage nigra</i>
Caprimulgidae	Large-tailed nightjar	<i>Caprimulgus macrurus</i>
	Savauna nightjar	<i>Caprimulgus affinis</i>
Charadriidae	Red-wattled lapwing	<i>Vanellus indicus</i>

Appendix 2: Continued

Family name	Species name	Scientific name
Cisticolidae	Yellow-bellied prinia	<i>Prinia flaviventris</i>
	Rufescent prinia	<i>Prinia rufesceus</i>
	Zitting cisticola	<i>Cisticola juncidis</i>
Columbidae	Pink-necked green pigeon	<i>Treron vernans</i>
	Peaceful dove	<i>Geopelia striata</i>
	Spotted dove	<i>Streptopelia chinensis</i>
	Little green pigeon	<i>Treron olax</i>
	Thick-billed green pigeon	<i>Treron curvirostra</i>
	Orange-breasted green pigeon	<i>Treron bicincta</i>
	Dollar bird	<i>Eurystomus orientalis</i>
Coraciidae	Dollar bird	<i>Eurystomus orientalis</i>
Corvidae	House crow	<i>Corvus splendens</i>
	Large-billed crow	<i>Corvus macrorhynchos</i>
Cuculidae	Plaintive cuckoo	<i>Cacomantis merulinus</i>
	Greater coucal	<i>Centropus sinensis</i>
	Little bronzone cuckoo	<i>Chrysococcyx minutillus</i>
	Common asian koel	<i>Eudynamis scolopacea</i>
	Chesnut-winged cuckoo	<i>Clamator coromandus</i>
	Lesser coucal	<i>Centropus bengalensis</i>
	Ashy drongo	<i>Dicrurus leucophaeus</i>
Dicruridae	Ashy drongo	<i>Dicrurus leucophaeus</i>
Emberizidae	Yellow-breasted bunting	<i>Emberiza aureola</i>
Estrildidae	Black-headed munia	<i>Lonchura malacca</i>
	Scaly-breasted munia	<i>Lonchura punctulata</i>
	White-headed munia	<i>Lonchura maja</i>
Hirundinidae	Pacific swallow	<i>Hirundo tahitica</i>
Jacaniidae	Pheasant-tailed jacana	<i>Hydrophasianus chirurgus</i>
Laniidae	Brown shrike	<i>Lanius cristatus</i>
	Long-tailed shrike	<i>Lanius schach</i>
Meropidae	Blue-tailed bee-eater	<i>Merops philippinus</i>
	Blue-throated bee-eater	<i>Merops viridis</i>
Motacillidae	Richard's pipit	<i>Anthus richardi</i>
Muscicapidae	Asian brown flycatcher	<i>Muscicapa dauurica</i>
Nectariniidae	Brown-throated sunbird	<i>Anthreptes malaccensis</i>
	Plain sunbird	<i>Anthreptes simplex</i>
	Copper-throated sunbird	<i>Nectarinia calcostetha</i>
	Olive-backed sunbird	<i>Nectarinia jugularis</i>
	Little spiderhunter	<i>Arachnothera longirostra</i>
	Purple-throated sunbird	<i>Nectarinia sperata</i>
	Black-throated sunbird	<i>Aethopyga saturata</i>
	Black-naped oriole	<i>Oriolus chinensis</i>
	Mangrove whistler	<i>Pachycephala grisola</i>
	Baya weaver	<i>Ploceus philippinus</i>
Passeridae	Eurasian tree sparrow	<i>Passer montanus</i>
Phasianidae	Red jungle-fowl	<i>Gallus gallus</i>
	Blue-breasted quail	<i>Coturnix chinensis</i>
Picidae	Common flameback	<i>Dinopium javanense</i>
	Rufous woodpecker	<i>Celeus brachyurus</i>
	Greater flameback	<i>Chrysocolaptes leucurus</i>
	Speckled piculet	<i>Picumnus innominatus</i>
Podicipedidae	Little grebe	<i>Tachybaptus ruficollis</i>
Pycnonotidae	Yellow-vented bulbul	<i>Pycnonotus goiavier</i>
	Olive-winged bulbul	<i>Pycnonotus plumosus</i>
Rallidae	Purple swamphen	<i>Porphyrio porphyrio</i>
	White-breasted waterhen	<i>Amaurornis phoenicurus</i>
	Common moorhen	<i>Gallinula chloropus</i>
	White-browed crane	<i>Porzana cinerea</i>
	Water cock	<i>Gallicrex cinerea</i>
	Ballion's crane	<i>Porzana pusilla</i>
	Slaty-breasted crane	<i>Gallirallus striatus</i>
	Pied fantail	<i>Rhipidura javanica</i>
Rhipiduridae	Pied fantail	<i>Rhipidura javanica</i>
Scolopacidae	Pintail snipe	<i>Gallinago stenura</i>
	Common sandpiper	<i>Tringa hypoleucos</i>

Appendix 2: Continued

Family name	Species name	Scientific name
Sturnidae	Common myna	<i>Acridotheres tristis</i>
	Jungle myna	<i>Acridotheres fuscus</i>
	Philippine glossy starling	<i>Aplonis panayensis</i>
	White-vented myna	<i>Acridotheres grandis</i>
Sylviidae	Hill myna	<i>Gracula religiosa</i>
	Oriental reed warbler	<i>Acrocephalus orientalis</i>
	Common tailorbird	<i>Orthotomus sutorius</i>
	Rufous-tailed tailorbird	<i>Orthotomus sericeus</i>
	Ashy tailorbird	<i>Orthotomus ruficeps</i>
	Rusty-rumped warbler	<i>Locustella certhiola</i>
	Inomate warbler	<i>Phylloscopus inornatus</i>
Turdidae	Arctic warbler	<i>Phylloscopus inornatus</i>
	Oriental magpie robin	<i>Copsychus saularis</i>
Turnicidae	Barred button quail	<i>Turnix susecator</i>

Appendix 3: Number of observations of bird species according to habitat in Paya Indah wetland reserve

Species common name	Marsh swamps	Lotus swamps	Open water bodies	Terrestrial area with scattered trees	Patchy of shrublands
Arctic warbler	0	0	0	0	3
Ashy drongo	1	0	0	0	0
Ashy minivet	0	0	3	17	5
Ashy tailorbird	14	4	0	6	1
Asian brown flycatcher	2	2	0	3	7
Ballion's crane	3	11	0	0	0
Barred button quail	7	1	0	6	6
Baya weaver	173	7	52	97	49
Black baza	1	0	1	2	0
Black-crowned nightheron	13	0	0	0	0
Black-headed munia	122	0	3	44	45
Plain sunbird	4	0	0	14	0
Black-naped oriole	59	11	14	43	51
Black-shouldered kite	4	0	0	12	1
Black-throated sunbird	3	0	0	1	2
Blue-breasted quail	1	0	2	1	2
Blue-tailed bee-eater	68	37	142	81	21
Blue-throated bee-eater	10	9	0	15	3
Brahminy kite	0	0	0	1	0
Brown shrike	64	16	12	40	28
Brown-throated sunbird	8	3	0	11	6
Chesnut-winged cuckoo	0	0	0	1	0
Ciunamon bittern	28	0	6	2	2
Common flameback	27	10	3	16	12
Common iora	28	3	5	15	12
Common kingfisher	2	1	0	1	0
Common koel	0	0	0	1	0
Common moorhen	61	28	6	0	2
Common myna	166	17	51	177	43
Common sandpiper	0	2	0	3	0
Common tailorbird	6	2	3	7	11
Copper-throated sunbird	0	1	0	1	1
Cotton pygmy goose	11	1	81	0	0
Dollar bird	4	0	0	29	7
Eurasian tree sparrow	94	8	1	9	0
Great egret	4	0	0	0	0
Greater coucal	4	0	2	5	4
Greater Flameback	0	0	0	2	1
Green iora	89	17	7	27	24
Grey heron	7	4	1	0	0
Hill myna	2	0	0	4	0
House crow	1	0	3	17	0
Jungle myna	154	15	117	204	81

Appendix 3: Continued

Species common name	Marsh swamps	Lotus swamps	Open water bodies	Terrestrial area with scattered trees	Patchy of shrublands
Large-billed crow	8	0	12	2	7
Large-tailed nightjar	2	0	1	2	7
Lesser coucal	48	0	12	26	20
Lesser whistling duck	37	0	199	8	0
Little Bronze cuckoo	5	2	2	7	4
Little egret	4	0	0	0	0
Little grebe	2	2	7	0	0
Little green pigeon	8	1	0	0	2
Little heron	20	3	0	0	0
Little spiderhunter	1	1	0	2	1
Long-tailed shrike	2	1	0	0	0
Inornate warbler	1	0	0	0	0
Mangrove whistler	4	0	1	1	2
Olive-backed sunbird	13	1	2	3	4
Olive-winged bulbul	6	0	0	4	3
Orange-breasted green pigeon	17	15	0	2	21
Oriental magpie robin	84	19	13	68	19
Oriental reed warbler	24	1	1	0	9
Pacific swallow	208	39	85	4	17
Peaceful dove	462	101	84	240	165
Pheasant-tailed jacana	1	6	0	0	0
Philippine glossy starling	116	0	24	40	14
Pied fantail	65	23	8	27	44
Pied triller	19	0	7	17	12
Pink-necked green pigeon	614	150	90	501	368
Pintail snipe	10	0	2	19	1
Rufescent prinia	0	0	0	1	0
Plaintive cuckoo	12	13	0	1	1
Purple heron	164	52	22	22	9
Purple-throated sunbird	0	0	0	1	0
Purple swamphen	798	78	25	33	20
Red junglefowl	21	8	7	27	19
Red-wattled lapwing	93	8	41	76	43
Richard's pipit	114	1	26	93	23
Rufous-tailed tailorbird	6	0	0	0	0
Rufous woodpecker	0	2	0	0	4
Inornate warbler	1	1	0	0	1
Savauna nightjar	3	0	1	5	3
Scaly-breasted munia	125	36	49	111	89
Schrenck's bittern	6	0	1	0	0
Slaty-legged crane	0	0	0	0	1
Speckled piculet	1	0	0	0	0
Spotted dove	386	56	67	273	97
Thick-billed green pigeon	0	1	0	0	0
Water cock	4	1	3	2	2
Western marsh harrier	0	0	0	1	0
White-bellied sea eagle	0	0	0	0	1
White-breasted waterhen	200	38	25	75	38
White-browed crane	24	5	0	0	2
White-headed munia	8	0	0	5	0
White-throated kingfisher	128	51	42	75	34
White-vented myna	44	7	6	38	13
Yellow bittern	162	42	11	14	17
Yellow-bellied prinia	65	21	20	32	37
Yellow-breasted bunting	0	0	0	1	0
Yellow-vented bulbul	690	101	129	437	326
Zitting cisticola	5	0	5	1	2
Total = 13872	6086	1097	1545	3212	1932

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