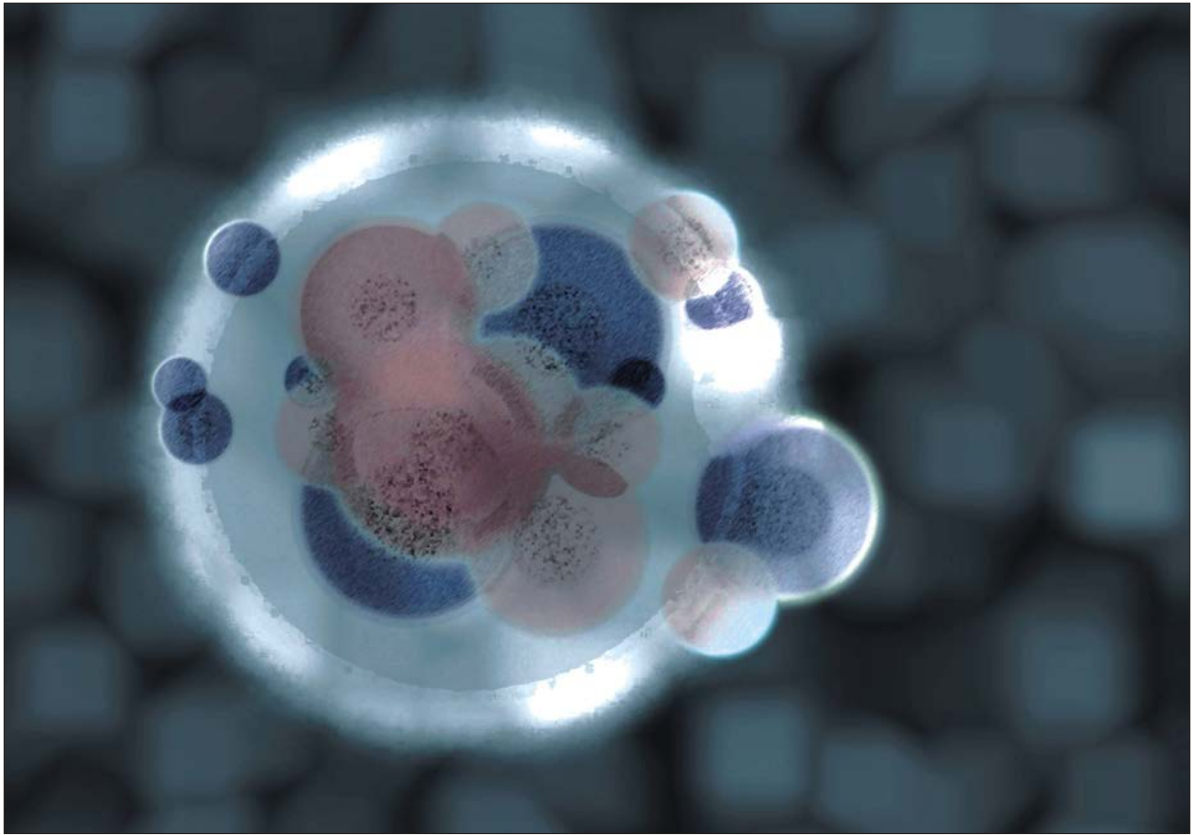




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## Density and Diversity of Water Birds and Terrestrial Birds at Paya Indah Wetland Reserve, Selangor Peninsular Malaysia

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**Abstract:** The main objectives of this study was to determine and compare the density and diversity of water birds and terrestrial birds using distance sampling point count method at Paya Indah Wetland Reserve, Selangor Peninsular Malaysia. A total of 13872 bird individuals from 100 bird species were recorded in the wetland reserve. Out of the total, 25 (22.26% of all detections) and 75 (77.74% of all detections) bird species belong to water birds and terrestrial birds respectively. The results showed that total bird density of the wetland reserve is  $83.92 \pm 4.53$  birds  $\text{ha}^{-1}$  and ranged from 75.40-93.41 birds  $\text{ha}^{-1}$  (95% confidence interval). The terrestrial birds have higher density ( $70.26 \pm 4.48$  birds  $\text{ha}^{-1}$ ) as compared to water birds ( $13.09 \pm 1.78$  birds  $\text{ha}^{-1}$ ). The highest water bird density was recorded for Purple Swampphen ( $5.05 \pm 0.89$  birds  $\text{ha}^{-1}$ ) and the lowest was Ballion's Crake ( $0.31 \pm 0.13$  birds  $\text{ha}^{-1}$ ). The highest terrestrial bird density was recorded for Yellow-vented Bulbul ( $12.97 \pm 1.05$  birds  $\text{ha}^{-1}$ ) and the lowest was Ashy Minivet ( $0.31 \pm 0.18$  birds  $\text{ha}^{-1}$ ). The highest species diversity i.e. Shannon's index ( $N_1 = 20.83$ ), species richness i.e. Margalef's index ( $R_1 = 7.97$ ) and species evenness, i.e., McIntosh's index ( $E = 0.73$ ) was recorded in terrestrial birds. This study indicated that Paya Indah Wetland Reserve is a highly important habitat and provides diverse food, shelter, nesting and roosting sites for water birds as well as terrestrial birds.

**Key words:** Wetland birds, vegetation structures, distance sampling, food resources, habitat diversity

### INTRODUCTION

Wetlands are widely recognized as highly important ecosystem with diverse attributes including a distinctive avifauna (Burger, 1985). Freshwater wetlands hold more than 40% bird species of the entire world and 12% of all animal species (Kirsten and Brander, 2004). The gradual losses of wetland habitats and degradation have caused declining of many bird species (Taylor and Pollard, 2008). Many of them are under heavy pressure and at risk due to degradation of breeding sites, water level destabilization, sedimentation, contaminant and nutrient inputs and invasion of exotic plants and animals (Scott and Poole, 1989).

Freshwater wetlands provide suitable breeding and foraging sites for more than one quarter of the regional avifauna and most of them are nongame species (Naugle *et al.*, 2000). Various globally threatened and non-threatened bird species depend on wetland to fulfil the daily requirements such as food, water and shelter (Ishikawa *et al.*, 2003). Wetland birds are diverse and often show different behavioural tactics to explore the wetland areas and reflect the ecological conditions of a particular area. Nevertheless, the information on the

population parameters and ecology of wetland birds is scarce (De Leon and Smith, 1999).

Malaysia is blessed with a total of 3.5 to 4.0 million ha of natural wetland areas which is equal to 10% of the total land area (Aik, 2002). Malaysian wetlands are divided into ten major types namely mangroves, mudflats, nipa swamps, freshwater swamp forest, peat swamp forest, lakes, river systems (nearly 100 river systems), fresh marshes and wet rice paddy fields (Malaysian Wetland Working Group, 1986). These wetland areas serve as important habitats and refuges for wide array of migratory and threatened bird species (Asmawi, 2007; Min, 2007).

To date no population study has been done to compare between waterbirds and terrestrial birds in freshwater wetland of Malaysia. Very little is known about the bird assemblages and population trends in freshwater wetland habitats. The main objective of this study was to determine and compare the density and diversity of waterbirds and terrestrial birds at Paya Indah Wetland Reserve, Selangor Peninsular Malaysia.

In this study the term water birds refers to bird species that entirely depend on wetlands for variety of activities such as foraging, nesting, loafing and moulting (Rajpar and Zakaria, 2009). Whereas the term terrestrial

birds refers to bird species that do not totally depends on the wetland habitats but may use the wetland areas in search of food, shelter and loaf. The species diversity is the number of different bird species in a particular area while species density is a number of birds per unit area.

## MATERIALS AND METHODS

**Study site:** Paya (swamp) Indah (beautiful) wetland reserve encompasses of 3050 ha out of which 450 ha are under the administration of the Department of Wildlife and National Parks, Peninsular Malaysia. The study area is located adjacent to Malaysia's administrative centre Putrajaya within the quadrant of  $101^{\circ} 10'$  to  $101^{\circ} 50'$  longitude and  $2^{\circ} 50'$  and  $3^{\circ} 00'$  latitude (Fig. 1).

**Bird surveys:** Bird surveys were carried out at Paya Indah Wetland Reserve, Peninsular Malaysia using distance sampling point count method to determine species composition, diversity and density within November 2007 to January 2009. Sixty one point-count stations 300 m interval distance apart from each other were established within the study area. The main reason of using 300 m interval apart between point count stations was to avoid double counting of the same birds at more than one station. The birds were surveyed fifteen consecutive times at monthly interval for each station to obtain reliable estimates and to reduce bias. The replication of point count stations increased precision and provide reliable results (Petit *et al.*, 1995; Smith *et al.*, 1993).

The survey was done early in the morning from 0730 and 1100 h. The detections of birds within each point

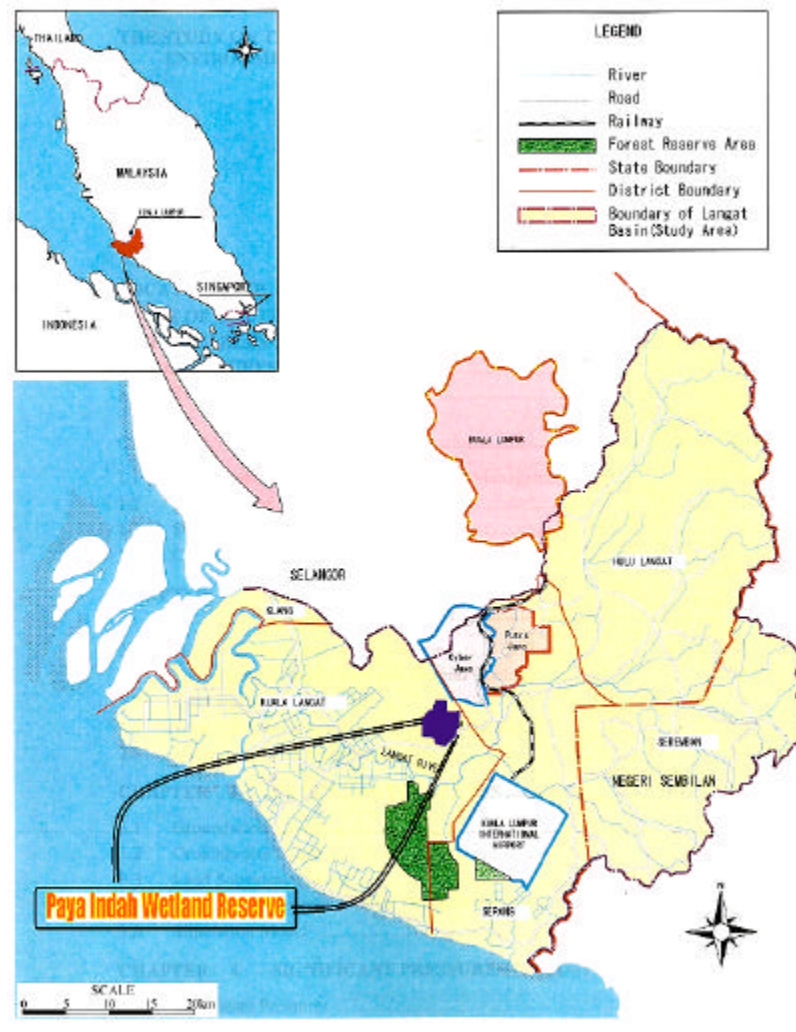


Fig. 1: Location map of paya indah wetland reserve, selangor peninsular Malaysia

count station were done for ten-minutes. Ten-minute count enables to record sufficient number of individuals with minimal efforts and disturbance (Lee and Marsden, 2008; Jimenez, 2000; Lynch, 1995; Gutzwiller, 1991). During each survey all bird species and individuals seen or heard and the distance from the point station to the birds were estimated. The flushed birds with known original position were included in the analysis while flying birds were omitted due to unknown original position. The methodology was followed as described by Nadeau *et al.* (2008), Aborn (2007), Buckland *et al.* (2004) and Bibby *et al.* (2000).

**Data analysis:** The density of bird species was determined using Distance Software (Version 4.1) by Buckland *et al.* (2004). The bird density of those species whose numbers of detections were below five were not analyzed due to low number of sample size. The methodology was followed as described by Marsden (1999). The diversity indices such as species diversity, richness and evenness were determined using Community Analysis Package Software (CAP, Version 4.0) by Henderson and Seaby (2007).

## RESULTS

**Species composition:** Distance sampling point count method detected a total 13872 bird individuals that belong to 100 species and 38 families at Paya Indah Wetland Reserve, Selangor Peninsular Malaysia. Out of the total

number of species, 25 bird species were belongs to water birds (3088 detections; 22.26%) and 75 bird species were belongs to terrestrial birds (10784 detections; 77.74%) (Appendix 1 and 2).

**Overall bird density:** The density analysis shows that the bird density of Paya Indah Wetland Reserve, Peninsular Malaysia is  $83.92 \pm 4.53$  birds  $\text{ha}^{-1}$  that ranged from 75.40-93.41 birds  $\text{ha}^{-1}$  (95% confidence interval). The results also show that the terrestrial birds have higher density ( $70.26 \pm 4.48$  birds  $\text{ha}^{-1}$ ) as compared to water birds ( $13.09 \pm 1.78$  birds  $\text{ha}^{-1}$ ) (Table 1).

**Water bird density:** The five highest waterbird species density was recorded for Purple Swampphen ( $5.05 \pm 0.89$  birds  $\text{ha}^{-1}$ ) followed by Lesser Whistling Duck ( $4.66 \pm 1.12$  birds  $\text{ha}^{-1}$ ), White-breasted Waterhen ( $3.02 \pm 0.35$  birds  $\text{ha}^{-1}$ ), Yellow Bittern ( $2.84 \pm 0.62$  birds  $\text{ha}^{-1}$ ) and Cotton Pygmy Goose ( $2.63 \pm 0.11$  birds  $\text{ha}^{-1}$ ). The five lowest waterbird density was recorded for Little Grebe ( $0.35 \pm 0.12$  birds  $\text{ha}^{-1}$ ), Black-crowned Nightheron ( $0.33 \pm 0.12$  birds  $\text{ha}^{-1}$ ), Ballion's Crake ( $0.31 \pm 0.13$  birds  $\text{ha}^{-1}$ ), Pheasant-tailed Jacana ( $0.26 \pm 0.12$  birds  $\text{ha}^{-1}$ ) and Grey Heron ( $0.13 \pm 0.05$  birds  $\text{ha}^{-1}$ ). In addition, the densities of four water birds namely Common Kingfisher; *A. atthis*, Great Egret; *C. albus*, Little Egret; *E. garzetta* and Slaty-breasted Crake; *G. striatus* were not analyzed due to very low detections (< 5 observations) (Table 2).

Table 1: The density of water birds and terrestrial birds of paya indah wetland reserve, peninsular Malaysia

| Status of bird species | Density estimate (birds $\text{ha}^{-1}$ ) | Density estimate at 95% confidence interval (birds $\text{ha}^{-1}$ ) |
|------------------------|--------------------------------------------|-----------------------------------------------------------------------|
| Over all density       | $83.92 \pm 4.53$                           | 75.40-93.41                                                           |
| Water birds            | $13.09 \pm 1.78$                           | 10.01-17.12                                                           |
| Terrestrial birds      | $70.26 \pm 4.48$                           | 61.94-79.69                                                           |

Table 2: Ranking of water bird density at paya indah wetland reserve, peninsular Malaysia

| Common name               | Scientific name           | Density (birds $\text{ha}^{-1}$ ) | Density at 95% confidence interval (birds $\text{ha}^{-1}$ ) |
|---------------------------|---------------------------|-----------------------------------|--------------------------------------------------------------|
| Purple swampphen          | <i>P. porphyrio</i>       | $5.05 \pm 0.89$                   | 3.54-7.21                                                    |
| Lesser whistling duck     | <i>D. javania</i>         | $4.66 \pm 1.12$                   | 1.42-11.62                                                   |
| White-breasted waterhen   | <i>A. phoeniurus</i>      | $3.02 \pm 0.35$                   | 2.35-3.88                                                    |
| Yellow bittern            | <i>I. sineusis</i>        | $2.84 \pm 0.62$                   | 1.85-4.36                                                    |
| Cotton pygmy goose        | <i>N. coromandelianus</i> | $2.63 \pm 0.11$                   | 1.12-6.18                                                    |
| Little heron              | <i>B. striatus</i>        | $2.45 \pm 0.76$                   | 0.5-11.96                                                    |
| Red-wattled lapwing       | <i>V. indicus</i>         | $2.19 \pm 0.43$                   | 1.48-3.24                                                    |
| White-throated kingfisher | <i>H. smyensis</i>        | $1.92 \pm 0.22$                   | 1.51-2.43                                                    |
| Common moorhen            | <i>G. chloropus</i>       | $1.70 \pm 0.36$                   | 1.10-2.62                                                    |
| White-browed crake        | <i>P. cinererea</i>       | $1.28 \pm 0.50$                   | 0.57-2.89                                                    |
| Purple heron              | <i>A. pupurea</i>         | $1.05 \pm 0.15$                   | 0.78-1.40                                                    |
| Schrenck's bittern        | <i>I. eurhythmus</i>      | $0.93 \pm 0.35$                   | 0.27-3.22                                                    |
| Pintail snipe             | <i>G. stenura</i>         | $0.73 \pm 0.19$                   | 0.43-1.25                                                    |
| Water cock                | <i>G. cinerea</i>         | $0.53 \pm 0.19$                   | 0.25-1.13                                                    |
| Cinnamon bittern          | <i>I. cinnamomeus</i>     | $0.51 \pm 0.19$                   | 0.35-0.74                                                    |
| Common sandpiper          | <i>T. hypoleucos</i>      | $0.42 \pm 0.17$                   | 0.09-1.94                                                    |
| Little grebe              | <i>T. ruficollis</i>      | $0.35 \pm 0.12$                   | 0.10-1.24                                                    |
| Black-crowned nightheron  | <i>N. nycticorax</i>      | $0.33 \pm 0.12$                   | 0.02-5.46                                                    |
| Ballion's crake           | <i>P. pusilla</i>         | $0.31 \pm 0.13$                   | 0.13-0.78                                                    |
| Pheasant-tailed jacana    | <i>H. chirurgus</i>       | $0.26 \pm 0.12$                   | 0.10-0.71                                                    |
| Grey heron                | <i>A. cinerea</i>         | $0.13 \pm 0.05$                   | 0.05-0.32                                                    |

Table 3: Ranking of terrestrial bird density at paya indah wetland reserve, selangor peninsular Malaysia

| Common name                     | Scientific name         | Density<br>(birds ha <sup>-1</sup> ) | Density at 95%<br>confidence<br>interval<br>(birds ha <sup>-1</sup> ) |
|---------------------------------|-------------------------|--------------------------------------|-----------------------------------------------------------------------|
| Yellow-vented bulbul            | <i>P. goiavier</i>      | 12.97±1.05                           | 11.97-15.07                                                           |
| Pink-necked green pigeon        | <i>T. vernans</i>       | 11.40±1.15                           | 9.09-13.66                                                            |
| Peaceful dove                   | <i>G. striata</i>       | 9.85±0.96                            | 8.12-11.95                                                            |
| Eurasian tree sparrow           | <i>P. montanus</i>      | 7.85±2.17                            | 2.75-22.41                                                            |
| Rufous-tailed tailorbird        | <i>O. sericeus</i>      | 7.54±1.43                            | 1.89-29.91                                                            |
| Scaly-breasted munia            | <i>L. punctulata</i>    | 7.20±1.25                            | 3.61-14.36                                                            |
| Baya weaver                     | <i>P. philippinus</i>   | 6.85±0.40                            | 4.60-10.19                                                            |
| White-headed munia              | <i>L. maja</i>          | 6.13±1.23                            | 2.48-15.19                                                            |
| Spotted dove                    | <i>S. chinensis</i>     | 5.16±0.63                            | 4.04-6.58                                                             |
| Black-headed munia              | <i>L. maacca</i>        | 4.77±1.06                            | 2.08-10.90                                                            |
| Common myna                     | <i>A. tristis</i>       | 3.56±0.86                            | 2.22-5.71                                                             |
| Orange-breasted<br>green pigeon | <i>T. bicincta</i>      | 3.54±1.23                            | 1.78-7.07                                                             |
| Jungle myna                     | <i>A. fuscus</i>        | 3.28±0.42                            | 2.50-4.30                                                             |
| Pacific swallow                 | <i>H. tachitica</i>     | 3.07±0.17                            | 1.41-6.40                                                             |
| Pied fantail                    | <i>R. javanica</i>      | 2.94±0.54                            | 2.04-4.24                                                             |
| Philippine glossy starling      | <i>A. panayensis</i>    | 2.64±0.35                            | 1.43-4.89                                                             |
| Blue-breasted quail             | <i>C. chinensis</i>     | 2.63±0.58                            | 0.61-11.39                                                            |
| Richard's pipit                 | <i>A. richardi</i>      | 2.38±0.56                            | 1.48-3.80                                                             |
| Mangrove whistler               | <i>P. grisola</i>       | 2.36±0.87                            | 0.48-11.70                                                            |
| Blue-tailed bee-eater           | <i>M. philippinus</i>   | 2.36±0.82                            | 1.21-4.63                                                             |
| Oriental reed warbler           | <i>A. orientalis</i>    | 2.10±0.50                            | 1.30-3.37                                                             |
| Common lora                     | <i>A. tiphia</i>        | 2.00±0.45                            | 1.19-3.06                                                             |
| White-vented myna               | <i>A. grandis</i>       | 1.93±0.55                            | 1.08-3.44                                                             |
| Yellow-bellied prinia           | <i>P. flaviventris</i>  | 1.86±0.27                            | 1.39-2.49                                                             |
| Green iora                      | <i>A. viridissima</i>   | 1.86±0.24                            | 1.43-2.43                                                             |
| Oriental magpie robin           | <i>C. saularis</i>      | 1.83±0.32                            | 1.29-2.62                                                             |
| Ashy tailorbird                 | <i>O. ruficeps</i>      | 1.81±0.62                            | 0.92-3.57                                                             |
| Dollar bird                     | <i>E. orientalis</i>    | 1.59±0.73                            | 0.59-4.30                                                             |
| Large-tailed nightjar           | <i>C. macrurus</i>      | 1.55±0.66                            | 0.65-3.71                                                             |
| Little green pigeon             | <i>T. olax</i>          | 1.55±0.27                            | 0.59-4.03                                                             |
| Black-napped oriole             | <i>O. chinensis</i>     | 1.45±0.54                            | 1.12-1.88                                                             |
| Brown-throated sunbird          | <i>A. malaccensis</i>   | 1.36±0.65                            | 0.54-3.42                                                             |
| Brown shrike                    | <i>L. cristatus</i>     | 1.34±0.15                            | 1.07-1.68                                                             |
| Little bronze cuckoo            | <i>C. minutillus</i>    | 1.30±0.46                            | 0.63-2.67                                                             |
| Pied triller                    | <i>L. nigra</i>         | 1.26±0.31                            | 0.77-2.04                                                             |
| Blue-throated bee-eater         | <i>M. viridis</i>       | 1.22±0.39                            | 0.65-2.32                                                             |
| Common flameback                | <i>D. javanese</i>      | 1.20±0.26                            | 0.77-1.85                                                             |
| Olive-winged bulbul             | <i>P. plumosus</i>      | 1.07±0.42                            | 0.27-1.46                                                             |
| House crow                      | <i>C. splendens</i>     | 0.98±0.37                            | 0.19-5.06                                                             |
| Zitting cisticola               | <i>C. juncidis</i>      | 0.96±0.13                            | 0.49-1.89                                                             |
| Hill myna                       | <i>G. religiosa</i>     | 0.94±0.56                            | 0.23-3.83                                                             |
| Barred button quail             | <i>T. suscitator</i>    | 0.92±0.35                            | 0.43-1.94                                                             |
| Savauna nightjar                | <i>C. affinis</i>       | 0.86±0.25                            | 0.30-2.52                                                             |
| Lesser coucal                   | <i>C. bengalensis</i>   | 0.82±0.13                            | 0.59-1.15                                                             |
| Plaintive cuckoo                | <i>C. merulinus</i>     | 0.79±0.26                            | 0.40-1.55                                                             |
| Common tailorbird               | <i>O. sutorius</i>      | 0.71±0.13                            | 0.48-1.04                                                             |
| Large-billed crow               | <i>C. macrorhynchus</i> | 0.65±0.27                            | 0.28-1.52                                                             |
| Red junglefowl                  | <i>G. gallus</i>        | 0.64±0.13                            | 0.42-0.96                                                             |
| Olive-backed sunbird            | <i>N. jugularis</i>     | 0.63±0.26                            | 0.28-4.07                                                             |
| Plain sunbird                   | <i>A. simplex</i>       | 0.58±0.14                            | 0.15-2.36                                                             |
| Black-shouldered kite           | <i>E. caeruleus</i>     | 0.54±0.31                            | 0.18-1.61                                                             |
| Asian brown flycatcher          | <i>M. dauica</i>        | 0.43±0.18                            | 0.19-0.99                                                             |
| Black-throated sunbird          | <i>A. saturate</i>      | 0.41±0.19                            | 0.14-1.19                                                             |
| Rufous woodpecker               | <i>C. brachyurus</i>    | 0.40±0.14                            | 0.10-1.52                                                             |
| Greater coucal                  | <i>C. sineusis</i>      | 0.39±0.15                            | 0.18-0.85                                                             |
| Little spiderhunter             | <i>A. longirostra</i>   | 0.34±0.12                            | 0.05-2.54                                                             |
| Ashy minivet                    | <i>P. divaricatus</i>   | 0.31±0.18                            | 0.09-1.09                                                             |

**Terrestrial bird density:** The five highest terrestrial bird density was recorded for Yellow-vented Bulbul (12.97±1.05 birds ha<sup>-1</sup>) followed by Pink-necked Green Pigeon (11.4±1.15 birds ha<sup>-1</sup>), Peaceful Dove

Table 4: Comparison of bird species diversity of terrestrial birds and water birds at paya indah wetland reserve, selangor peninsular Malaysia

| Diversity indices                  | Water birds | Terrestrial birds |
|------------------------------------|-------------|-------------------|
| Shannon's index (N <sub>1</sub> )  | 9.56        | 20.83             |
| Simpson's index (N <sub>2</sub> )  | 6.62        | 12.69             |
| Richness indices                   |             |                   |
| Margalef's index (R <sub>1</sub> ) | 2.99        | 7.97              |
| Menhinik's index (R <sub>2</sub> ) | 0.45        | 0.72              |
| Evenness indices                   |             |                   |
| McIntosh's index (E)               | 0.62        | 0.73              |

(9.85±0.96 birds ha<sup>-1</sup>), Eurasian Tree Sparrow (7.85±2.17 birds ha<sup>-1</sup>) and Rufous-tailed Tailorbird (7.54±1.43 birds ha<sup>-1</sup>). The five lowest terrestrial bird density was recorded for Black-throated Sunbird (0.41±0.19 birds ha<sup>-1</sup>) followed by Rufous Woodpecker (0.40±0.14 birds ha<sup>-1</sup>), Greater Coucal (0.39±0.15 birds ha<sup>-1</sup>), Little Spiderhunter (0.34±0.12 birds ha<sup>-1</sup>) and Ashy Minivet (0.31±0.18 birds ha<sup>-1</sup>). In addition, eighteen bird species were not analyzed due to small sample size (<5 observations) (Table 3).

**Diversity:** Diversity is a major aspect of species structure in avian community. Principal Component Analysis Software (CAP Version 4.0) by Henderson and Seaby (2007) was used to determine and compare the diversity of water birds and terrestrial birds in the study area. The result shows that terrestrial birds have the highest species diversity i.e., Shannon's index (N<sub>1</sub> = 20.83), species richness i.e., Margalef's index (R<sub>1</sub> = 7.97) and species evenness i.e., McIntosh's index (E = 0.73) was recorded in terrestrial birds compared to water birds (Table 4).

## DISCUSSION

Freshwater wetlands are highly important habitat for wide array of waterbirds as well as terrestrial birds and their importance depends on size, diversity of vegetation, water quality, food resources and topography. Birds are most conspicuous and significant component of freshwater wetland ecosystems and their presence or absence may indicate the ecological conditions of the particular areas.

The growing pressure on wetland resources due to human activities, climatic and edaphic changes has caused great threats to wetland fauna especially water birds throughout the world (Greenwood *et al.*, 1995; Laurance, 1999). Determining the accurate population size and population fluctuation of different birds in wetland habitats is highly important to understand the bird community structures and population status of existing species in the dwelling area (Thompson, 2002; De Sante *et al.*, 2005; Kaminski *et al.*, 2006).

Paya Indah Wetland Reserve is a natural wetland and extremely variable in vegetation structures, vegetation composition and productivity (food resources, nesting sites and shelter). The recording of 25 water bird species and 75 terrestrial bird species using point count method shows that this wetland reserve is a highly important habitat and support diverse water birds and terrestrial birds in order to perform multiple activities such as foraging, breeding, loafing and roosting. The occurrence of higher number of species could be due to vegetation diversity such as trees, shrubs, emergent and submerged vegetation, reeds and sedges, ferns, grasses and herbs that provides multiple microhabitats. The different strata of vegetations also have attracted different bird species through offering optimal combinations of food, water and shelter resources that satisfy the daily requirements of bird species to maintain their populations.

The results of this study show that the highest water bird density was recorded in Purple Swampphen followed by Lesser Whistling Duck and White-breasted Waterhen. This may be due to diversity and richness of aquatic vegetation such as emergent vegetation (i.e. *Eleocharis dulcis*, *Nelumbo nucifera*, *Nelumbo pubescens* and *Philydrum lanuginosum*), grasses (i.e., *Scirpus olneyi*, *Panicum maximum* and *Imperata cylindrical*), sedges and rush (i.e., *Scleria purpurascens* and *Spartina alterniflora*), ferns (i.e., *Stenochlaena palustris*, *Cyclosorus interruptus* and *Lycopodium cernuum*), reeds (i.e., *Phragmites karaka* and *Typha angustifolia*), submerged (*Myriophyllum spicatum*, *Salvinia minima*, *Ceratophyllum demersum* and *Elodea* sp.) and herbaceous plants (i.e., *Cyperus* sp., *Juncus effuses* and *Panicum repens*) that created suitable habitats and offer abundant food resources, safe breeding sites and hiding cover from predators and weather. Heterogeneity of aquatic vegetation also provides a dwelling area for different invertebrate assemblages such as Oligochaeta, Turbellaria, Hirudinidea, Pelecypoda, Arachnida, Insecta and Crustacea (Kostecke *et al.*, 2005). These invertebrates are an important food sources for waterbirds (Anderson and Smith, 2000). The greater abundance of invertebrate are closely related to dense aquatic vegetation due to higher habitat structural complexity (Gray *et al.*, 1999; De Szalay and Resh, 2000).

Water birds are closely associated to wetland aquatic vegetation to complete their life cycles and often select the most available microhabitats in different ways depending on their behaviour or spatial location (Nudds *et al.*, 1994; Green, 1998; Hag *et al.*, 1998). Vegetation composition and structure (Isacch *et al.*, 2005), habitats characteristics and food resources (Murkin *et al.*, 1997; Farmer and Wiens, 1999;

Ashley *et al.*, 2000) and surrounding landscape are the key factors that influence the distribution, diversity, density and habitat selection of bird species (Pearson, 1993; Koopowitz *et al.*, 1994; Vos and Stumpel, 1995).

Factors that influence the habitat selection may vary from species to species. For example; species morphology, foraging behaviour (e.g., visual vs. tactile foragers) and prey availability (i.e., prey density and vulnerability to capture) may affect the distribution and reproduction success of water birds (Gawlik, 2002). Hattori and Mae (2001) stated that the highest species richness and density of water birds occurs in reed bed of aquatic vegetation where the water level is 20 to 65 cm in depth. Fairbairn and Dinsmore (2001) and Kushlan (2000) also reported that water bird density is associated with habitat variables such as vegetation cover, food, safe nursing and loafing sites. This study indicated that waterbird populations are directly influenced by the amount and quality of available foraging habitats and they select wetland areas with surface water that supply suitable prey organisms for foraging.

The highest terrestrial bird density was recorded in Yellow-vented Bulbul followed by Pink-necked Green Pigeon, Peaceful Dove, Eurasian Tree Sparrow, Scaly-breasted Munia and Baya Weaver. This could be due to the presence of different habitats such as marsh swamp, lotus swamp, open water body, dryland and patches of shrubs and availability of abundant food sources such as variety of fruits, insects, seeds, grains, safe roosting and breeding sites. These similar observations have been recorded by Zakaria *et al.* (2009) and Rajpar and Zakaria (2009). The distribution of scattered trees and patches of shrubs created different layers of vegetation that serve as potential foraging and nesting sites for them. Vertical layering and complexity of vegetation has increased the foraging surfaces for terrestrial insectivore and frugivore bird species. The adjacent areas such as oil palm plantation and forest reserve may also influence the distribution of bird species. Petit and Petit (1996) and Cody (1985) reported that bird density is positively correlated with habitat heterogeneity and preference.

The results of diversity analysis show that bird species diversity may vary from terrestrial birds to water birds. The higher bird diversity, richness and evenness were recorded in terrestrial birds as compared to water birds. This may be due to difference in habitat richness and diversity of vegetation such as trees, shrubs, emergent vegetation, grasses, sedges, rushes, ferns, reeds, submerged and herbaceous plants. The terrestrial birds seem to be capable of using all available habitats within the wetland area. Unlike the water birds which are

highly dependent on the water based or water related habitats such as marsh swamp, lotus swamp and open water body. In most instances, bird diversity is parallel to habitat diversity as suggested by Buffington *et al.* (1997) and Jobin *et al.* (2001) studies.

In addition, other factors such as weather (rainfall), social interactions and predators such as Water Monitor Lizard (*Varanus salvator*), Monitor Lizard (*Varanus begalensis*), Python (*Python reticulatus*), King Cobra (*Ophiophagus hannah*), Cobra (*Naja naja*) may also affect the distribution and habitat selection of water as well as terrestrial birds in the wetland reserve. These findings were consistent with other studies in similar types of habitat (Zakaria *et al.*, 2009).

## CONCLUSION

This study indicated that Paya Indah Wetland Reserve is highly important habitat for waterbirds as well as terrestrial birds. The wetland bird richness is closely associated with vegetation structure and composition, size of wetland, diversity and abundance of food resources and shallowness of water. Habitat structural diversity provides refuge from predators.

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## APPENDIX

Appendix 1: List of water bird species recorded using point count method at paya indah wetland reserve, peninsular Malaysia

| Family name   | Common name               | Scientific name                |
|---------------|---------------------------|--------------------------------|
| Rallidae      | Purple Swamphen           | <i>Porphyrio porphyrio</i>     |
| Rallidae      | White-breasted Waterhen   | <i>Amanornis phoenicurus</i>   |
| Alcedinidae   | White-throated Kingfisher | <i>Halcyon smyrneusis</i>      |
| Ardeidae      | Purple Heron              | <i>Ardea purpurea</i>          |
| Charadriidae  | Red-wattled Lapwing       | <i>Vanellus indicus</i>        |
| Ardeidae      | Yellow Bittern            | <i>Ixobrychus sineusis</i>     |
| Anatidae      | Lesser Whistling Duck     | <i>Dendrocygna javanica</i>    |
| Rallidae      | Common Moorhen            | <i>Gallinula chloropus</i>     |
| Anatidae      | Cotton pygmy goose        | <i>Nettion coromandelianus</i> |
| Ardeidae      | Cinnamon bittern          | <i>Ixobrychus cinnamomeus</i>  |
| Scolopacidae  | Pintail Snipe             | <i>Gallinago stenura</i>       |
| Rallidae      | White-browed crane        | <i>Porzana cinerea</i>         |
| Ardeidae      | Little heron              | <i>Bitorides striatus</i>      |
| Rallidae      | Ballion's Crane           | <i>Porzana pusilla</i>         |
| Ardeidae      | Black-crowned night heron | <i>Nycticorax nycticorax</i>   |
| Rallidae      | Water Cock                | <i>Gallinula cinerea</i>       |
| Ardeidae      | Grey Heron                | <i>Ardea cinerea</i>           |
| Podicipedidae | Little Grebe              | <i>Tachybaptus ruficollis</i>  |

Appendix 1: Continued

| Family name  | Common name            | Scientific name                 |
|--------------|------------------------|---------------------------------|
| Ardeidae     | Schrenck's bittern     | <i>Ixobrychus eurhythmus</i>    |
| Jacaniidae   | Pheasant-tailed Jacana | <i>Hydrophasianus chirurgus</i> |
| Scolopacidae | Common sandpiper       | <i>Tringa hypoleucos</i>        |
| Alcedinidae  | Common kingfisher      | <i>Alcedo atthis</i>            |
| Ardeidae     | Great egret            | <i>Chasmerodius albus</i>       |
| Ardeidae     | Little egret           | <i>Egretta garzetta</i>         |
| Rallidae     | Slaty-breasted crane   | <i>Gallirallus striatus</i>     |

Appendix 2: List of terrestrial bird species recorded using point count method at paya indah wetland reserve, peninsular Malaysia

| Family name     | Common name                  | Scientific name                 |
|-----------------|------------------------------|---------------------------------|
| Columbidae      | Pink-necked green pigeon     | <i>Treron vernans</i>           |
| Pycnonotidae    | Yellow-vented Bulbul         | <i>Pycnonotus goiavier</i>      |
| Columbidae      | Peaceful Dove                | <i>Geopelia striata</i>         |
| Columbidae      | Spotted Dove                 | <i>Streptopelia chinensis</i>   |
| Sturnidae       | Jungle Myna                  | <i>Acridotheres fuscus</i>      |
| Sturnidae       | Common Myna                  | <i>Acridotheres tristis</i>     |
| Estrildidae     | Scaly-breasted Munia         | <i>Lonchura punctulata</i>      |
| Ploceidae       | Baya Weaver                  | <i>Ploceus philippinus</i>      |
| Hirundinidae    | Pacific Swallow              | <i>Hirundo tahitica</i>         |
| Meropidae       | Blue-tailed Bee-eater        | <i>Merops philippinus</i>       |
| Motacillidae    | Richard's Pipit              | <i>Anthus richardi</i>          |
| Estrildidae     | Black-headed Munia           | <i>Lonchura malacca</i>         |
| Turdidae        | Oriental Magpie Robin        | <i>Copsychus saularis</i>       |
| Sturnidae       | Philippine glossy starling   | <i>Aplonis panayensis</i>       |
| Oriolidae       | Black-napped Oriole          | <i>Oriolus chinensis</i>        |
| Cisticolidae    | Yellow-bellied Prinia        | <i>Prinia flaviventris</i>      |
| Rhipiduridae    | Pied Fantail                 | <i>Rhipidura javanica</i>       |
| Aegithinidae    | Green Iora                   | <i>Aegithina viridissima</i>    |
| Laniidae        | Brown Shrike                 | <i>Lanius cristatus</i>         |
| Passeridae      | Eurasian Tree Sparrow        | <i>Passer montanus</i>          |
| Sturnidae       | White-vented Myna            | <i>Acridotheres grandis</i>     |
| Cuculidae       | Lesser Coucal                | <i>Centropus bengalensis</i>    |
| Phasianidae     | Red Jungle-fowl              | <i>Gallus gallus</i>            |
| Picidae         | Common Flameback             | <i>Dinopium javanense</i>       |
| Aegithinidae    | Common Iora                  | <i>Aegithina tiphia</i>         |
| Campephagidae   | Pied Triller                 | <i>Lalage nigra</i>             |
| Columbidae      | Orange-breasted green pigeon | <i>Treron bicincta</i>          |
| Coraciidae      | Dollar Bird                  | <i>Eurystomus orientalis</i>    |
| Meropidae       | Blue-throated Bee-eater      | <i>Merops viridis</i>           |
| Sylviidae       | Oriental Reed Warbler        | <i>Acrocephalus orientalis</i>  |
| Sylviidae       | Common Tailorbird            | <i>Orthotomus sutorius</i>      |
| Corvidae        | Large-billed Crow            | <i>Corvus macrorhynchos</i>     |
| Nectariniidae   | Brown-throated Sunbird       | <i>Anthreptes malaceusis</i>    |
| Cuculidae       | Plaintive Cuckoo             | <i>Cacomantis merulinus</i>     |
| Sylviidae       | Ashy Tailorbird              | <i>Orthotomus ruficeps</i>      |
| Campephagidae   | Ashy Minivet                 | <i>Pericrocotus divaricatus</i> |
| Nectariniidae   | Olive-backed Sunbird         | <i>Nectarinia jugularis</i>     |
| Corvidae        | House Crow                   | <i>Corvus splendens</i>         |
| Turnicidae      | Barred Button Quail          | <i>Turnix suscitator</i>        |
| Cuculidae       | Little Bronze Cuckoo         | <i>Chrysococcyx minntillus</i>  |
| Nectariniidae   | Plain Sunbird                | <i>Anthreptes simplex</i>       |
| Accipitridae    | Black-shoulder Kite          | <i>Elanus caeruleus</i>         |
| Cuculidae       | Greater Coucal               | <i>Centropus sineusis</i>       |
| Muscicapidae    | Asian Brown Flycatcher       | <i>Muscicapa dauurica</i>       |
| Pycnonotidae    | Olive-winged Bulbul          | <i>Pycnonotus plumosus</i>      |
| Cisticolidae    | Zitting Cisticola            | <i>Cisticola juncidis</i>       |
| Estrildidae     | White-headed Munia           | <i>Lonchura maja</i>            |
| Caprimulgidae   | Large-tailed Nightjar        | <i>Caprimulgus macrurus</i>     |
| Caprimulgidae   | Savanna Nightjar             | <i>Caprimulgus affinis</i>      |
| Columbidae      | Little Green Pigeon          | <i>Treron olax</i>              |
| Pachycephalidae | Mangrove Whistler            | <i>Pachycephala grisola</i>     |
| Phasianidae     | Blue-breasted Quail          | <i>Coturnix chinensis</i>       |
| Nectariniidae   | Black-throated Sunbird       | <i>Aethopyga saturata</i>       |
| Sturnidae       | Hill Myna                    | <i>Gracula religiosa</i>        |
| Picidae         | Rufous woodpecker            | <i>Ceuleus brachyurus</i>       |
| Sylviidae       | Rufous-tailed Tailorbird     | <i>Orthotomus sericeus</i>      |

Appendix 2: Continued

| Family name   | Common name               | Scientific name                 |
|---------------|---------------------------|---------------------------------|
| Nectariniidae | Little Spiderhunter       | <i>Arachnothera longirostra</i> |
| Accipitridae  | Black Baza                | <i>Aviceda leuphotes</i>        |
| Sylviidae     | Arctic Warbler            | <i>Phylloscopus borealis</i>    |
| Nectariniidae | Copper-throated Sunbird   | <i>Nectarinia calcostetha</i>   |
| Picidae       | Greater Flameback         | <i>Chrysocolaptes lucidus</i>   |
| Laniidae      | Long-tailed Shrike        | <i>Lanius schach</i>            |
| Sylviidae     | Rusty-rumped Warbler      | <i>Locustella certhiola</i>     |
| Dicruridae    | Ashy Drongo               | <i>Dicrurus leucophaeus</i>     |
| Accipitridae  | Brahminy Kite             | <i>Haliastur indus</i>          |
| Cuculidae     | Chestnut-winged Cuckoo    | <i>Clamator coromandus</i>      |
| Cuculidae     | Common Asian Koel         | <i>Eudynamis scolopacea</i>     |
| Nectariniidae | Purple-throated Sunbird   | <i>Nectarinia sperata</i>       |
| Nectariniidae | Red-throated Sunbird      | <i>Anthreptes rhodolaema</i>    |
| Cisticolidae  | Rufescent Prinia          | <i>Prinia rufescens</i>         |
| Picidae       | Speckled Piculet          | <i>Picumnus innominatus</i>     |
| Columbidae    | Thick-billed green pigeon | <i>Treron curvirostris</i>      |
| Accipitridae  | Western Marsh Harrier     | <i>Circus aeruginosus</i>       |
| Accipitridae  | White-bellied Sea Eagle   | <i>Haliaeetus leucogaster</i>   |
| Emberizidae   | Yellow-breasted Bunting   | <i>Emberiza aureola</i>         |

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