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Population Density of Avian Species in a Man-Made Wetland of Peninsular Malaysia

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Abstract. This study determined the density and diversity of water and terrestrial dependent avian species in man-made Putrajaya wetlands, Peninsular Malaysia using the distant point count techniques. A total sum of 36,544 bird's individuals (25 water bird and 75 terrestrial bird species) was identified from November 2016 to July 2018. The overall bird's density is 1.17 ± 0.04 birds' ha⁻¹ at 95.00% confidence limit. The terrestrial bird species (TBS) had a higher density (1.35 ± 0.04 birds' ha⁻¹), while the water bird species (WBS) had a lower density (0.98 ± 0.16 birds' ha⁻¹). For WBS, *Nycticorax nycticorax* and *Casmero diusalbus* recorded the highest (5.31 ± 3.27 birds' ha⁻¹) and least (0.13 ± 0.15 birds' ha⁻¹) densities respectively. Also, *Columba livia* and *Arachnothera flavigaster* recorded the highest (7.15 ± 1.77 birds' ha⁻¹) and least (0.07 ± 0.02 birds' ha⁻¹) densities respectively in TBS. The TBS had higher Shannon–Wiener species diversity index ($N1 = 5.67$), Margalef's species richness index ($R1 = 15.06$) and Pielou's J species evenness index ($E = 1.29$) in contrast to the WBS ($N1 = 3.71$; $R1 = 4.58$ and $E = 1.18$). The study revealed the potentials of the man-made Putrajaya wetlands to harbour diverse avian species. This implied the needs to conserve this enclave in order to increase the population, perpetuity and sustainability of the avian species.

1. Introduction

Wetlands are periphery environments amongst earthly and oceanic biological systems [1]. They are exceedingly essential territory for various fauna including warm-blooded creatures, birds, reptiles, terrestrial and water animals, and sea-going spineless creatures [1]. Their significance relies upon numerous elements - wetland estimate, network to encompassing regions, and variety of vegetation, water quality, sustenance assets and geography. Wetlands are evaluated to possess almost 6.4% of the world's surface, 30% of which is comprised of lowlands, 26% fens, 20% marshes, around 15% surge fields, and so forth [2]. The measure of crisp water on earth is little contrasted with seawater, of which 69.6% is secured away in the mainland ice, 30.1% in underground aquifers, and 0.26% in streams and lakes. Lakes specifically possess under 0.007% of the world's new water. Wetlands are among the most intensely affected natural surroundings of every environmental framework [3,4]. Half of the wetland regions of the world have been obliterated in the past century [1,4]. The remaining half is under serious dangers and is declining locally and territorially due to redirection and damping of



stream streams, change of bogs, swamps, lakes and floodplains into farming fields and aquaculture lakes, eutrophication, defilement of water from agrarian fields and ventures [5].

Malaysia is honoured with 5.19 million ha wetland assets which cover 15.65% of an aggregate land zone of the nation. This aggregate territory is separated into mangroves (0.63 m. ha), mudflats (0.05 m. ha), freshwater swamps (0.54 m. ha), peat swamps (1.54 m. ha), swamps (0.74 m. ha), nipa overwhelm (1.65 m. ha) and melaleuca overwhelm (0.03 m. ha) [3]. Numerous species rely upon these wetland territories to fulfil their necessities and perform different exercises. They select wetland natural surroundings in light of vegetation structure and arrangement, nourishment assets and microclimatic conditions that give ideal assets to their survival. Birds are bioindicators of wetland biological system, show an assortment of methods to use the wetland zone and demonstrate environmental conditions and wetland efficiency [1,3,7].

Therefore, determining the accurate population size of different bird species that inhabit the wetland habitats is highly important to understand the bird community structures and population status of existing species. It is also essential to evaluate the factors that cause population fluctuations of different bird species in their habitats. This understanding will allow comparison of different habitats in consequent studies to determine the most preferable habitat for wetland birds towards their conservation and management actions. There is little or no information on the avian density among different habitats such as marshes, swamps, open water bodies and adjacent areas in Peninsular Malaysia. Thus, this study aimed to determine the population density and diversity of terrestrial and water avian species in a man-made wetland of Peninsular Malaysia.

2. Methodology

2.1. Geographical description

The study was undertaken at the man-made Putrajaya wetlands. It is geographically situated within 2° 57' 43" latitude and 101° 41' 47" longitude. It is located at 26 km south to Kuala Lumpur (Figure 1) and covers a land cover mass of 200 ha (77.70 ha planted zone, 76.80 ha vast water bodies, 9.60 ha islands, 23.70 ha immersion region and 9.40 ha tracks) [8]. The wetland comprises of five arms (upper west, upper north, upper east, bring down east, upper bisa) and central swamp. It is highly diverse in plant species which provide a distinctive microhabitat to the avian species.

2.2. Bird surveys

The distance sampling point count technique was employed to survey the avian species of man-made Putrajaya wetlands from November 2016 to July 2018. This technique is a less demanding and more proficient approach to determine the population status of avian species [1,3,9]. It involves the visual and sound-related identification of winged animals with settled or variable radius plots, and this gives critical data on species abundance, diversity and density among various natural surroundings [10,11,12]. It enhances deductibility, which permits the estimation of density and abundance of wild creatures, including birds [13]. Information was collected for 19 consecutive months. 82 count stations were systematically placed at 300 m interval apart, to avoid the double count of the same avian species at more than one station. Each point count station was surveyed for 10min. The survey was taken from 0730–1100 h. The method was followed as delineated by [1,9,13,14].

2.3. Data analysis

The distance software Version 7.2 was used to determine the avian density and diversity [9,15]. 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 P_a . Given an estimate of P_a , bird density can be estimated as (Where a = size of the covered region, n = number of birds seen, and $P^* a(z_i)$ = the estimated probability) of detecting the bird given that it is within w = mean perpendicular distance of sighted birds at point and has the covariate values z_i .

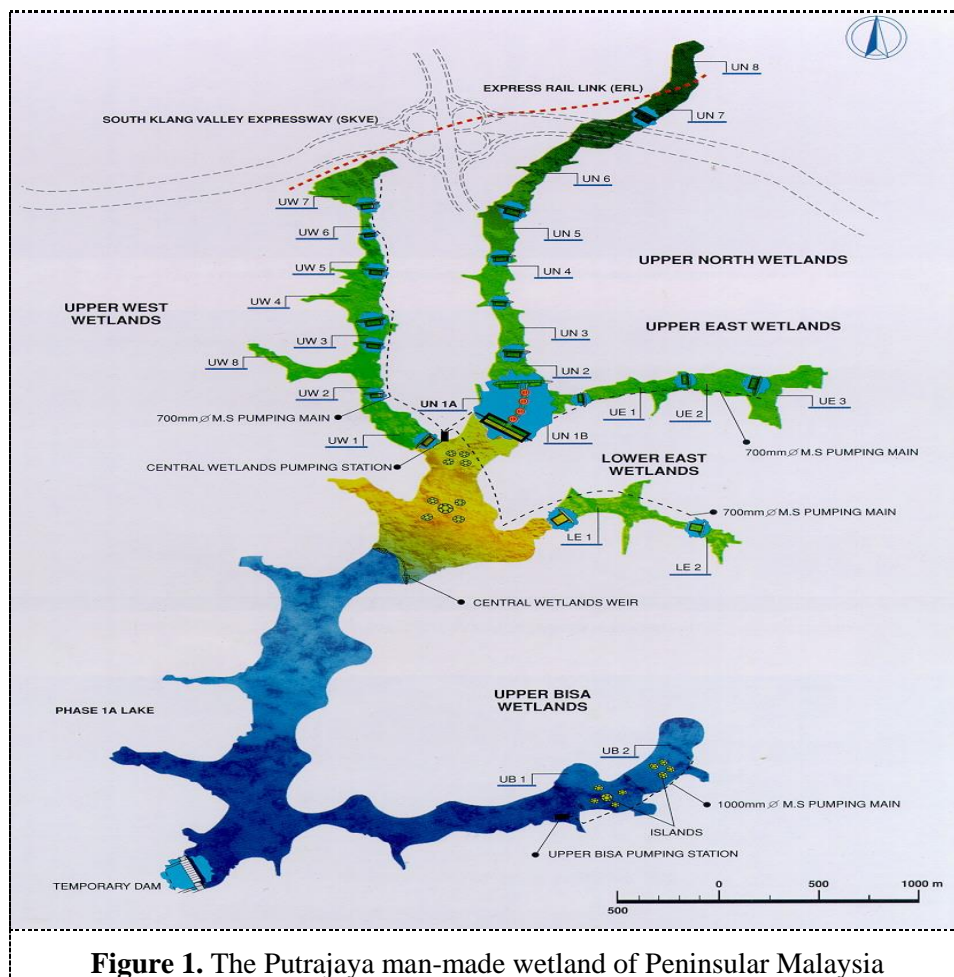


Figure 1. The Putrajaya man-made wetland of Peninsular Malaysia

3. Results and Discussion

Bird diversity indices and densities of the terrestrial and water birds in Putrajaya man-made wetland are presented in Table 1. The result showed that the terrestrial birds had higher observed individuals ($n = 25,242$), species diversity ($N1 = 5.67$), richness ($R1 = 15.06$), evenness ($E = 1.29$) and density (1.35 ± 0.04 bird's ha^{-1}) as compared to the water birds ($N1 = 3.71$; $R1 = 4.58$, $E = 1.18$ and density = 0.98 ± 0.16 bird's ha^{-1}). The overall observed individuals, species diversity, richness, evenness and density of the birds were 36,544 individuals, 6.17, 18.66, 1.33 and 1.17 ± 0.04 bird's ha^{-1} respectively. Table 2 showed the density estimates of the individual water bird in Putrajaya man-made wetlands. *Nycticorax nycticorax* had the highest density (5.31 ± 3.27 bird's ha^{-1}) for the water birds, then followed by *Ardea cinerea* (2.82 ± 1.69 bird's ha^{-1}), while *Casmero diusalbus* had the least density (1.91 ± 0.24 bird's ha^{-1}). However, three water birds (*Dendrocygna javanica*, *Dupetor flavicollis* and *Ixobrychus cinnamomeus*) had no density computation due to their low detection (< 5 detections). The density estimates of the individual terrestrial bird in Putrajaya man-made wetlands were presented in Table 3. *Columba livia* had the highest density (7.15 ± 1.77 bird's ha^{-1}), then followed by *Passer montanus* (6.81 ± 1.88 bird's ha^{-1}), while *Arachnothera flavigaster* had the least density (0.07 ± 0.02 bird's ha^{-1}). However, the population densities of 17 terrestrial bird species were not computed due to their low detection (< 5 detections).

Table 1. Bird diversity indices and densities of the terrestrial and water birds in Putrajaya man-made wetland

Indices	Terrestrial birds	Water birds	Overall
Observed bird individual	25,242	11,302	36,544
No. of Species	25	75	100
Shannon's diversity index (N1)	5.67	3.71	6.17
Margalef's richness index (R1)	15.06	4.58	18.66
Pielou's J evenness index (E)	1.29	1.18	1.33
She analysis	5.67	6.15	
Density (bird's ha ⁻¹)	1.35 ± 0.04	0.98 ± 0.16	1.17 ± 0.04

Table 2. Density estimates of the individual water bird in Putrajaya man-made wetlands

Family	Scientific name	Common name	Density (birds ha ⁻¹)
Ardeidae	<i>Nycticorax nycticorax</i>	Black-crowned Night-heron	5.31 ± 3.27
Ardeidae	<i>Ardea purpurea</i>	Purple Heron ©	2.82 ± 1.69
Ardeidae	<i>Ardea cinerea</i>	Grey Heron ©	1.91 ± 0.24
Ardeidae	<i>Bubulcus ibis</i>	Cattle Egret ©	1.18 ± 0.45
Ciconiidae	<i>Mycteria leucorhynchos</i>	Painted Stork ©	0.93 ± 0.20
Ardeidae	<i>Ixobrychus sinensis</i>	Yellow Bittern	0.89 ± 0.11
Charadriidae	<i>Vanellus indicus</i>	Red-wattled Lapwing	0.78 ± 0.11
Ardeidae	<i>Egretta garzetta</i>	Little Egret	0.76 ± 0.22
Ardeidae	<i>Mesophoyx intermedia</i>	Intermediate Egret	0.73 ± 0.27
Rallidae	<i>Amaurornis phoenicurus</i>	White-breasted Waterhen	0.42 ± 0.09
Ardeidae	<i>Butorides striata</i>	Little Heron	0.42 ± 0.05
Ardeidae	<i>Ardeola speciosa</i>	Javan Pond Heron	0.40 ± 0.16
Alcedinidae	<i>Alcedo atthis</i>	Common Kingfisher	0.20 ± 0.13
Rallidae	<i>Porphyrio porphyrio</i>	Purple Swamp-phen	0.35 ± 0.05
Alcedinidae	<i>Halcyon smyrnensis</i>	White-throated Kingfisher	0.35 ± 0.02
Rallidae	<i>Gallinule chloropus</i>	Common Moorhen	0.27 ± 0.16
Scolopacidae	<i>Tringa hypoleucos</i>	Common Sandpiper	0.22 ± 0.04
Scolopacidae	<i>Gallinago gmelini</i>	Pintail Snipe	0.15 ± 0.05
Ardeidae	<i>Egretta alba</i>	Chinese Egret	0.15 ± 0.04
Ardeidae	<i>Casmerodius albus</i>	Great Egret	0.13 ± 0.15
Anatidae	<i>Dendrocygna javanica</i>	Lesser Whistling Duck	(n = 4)
Ardeidae	<i>Dupetor flavicollis</i>	Black Bittern	(n = 2)
Ardeidae	<i>Ixobrychus cinnamomeus</i>	Cinnamon Bittern	(n = 2)

Table 3. Density estimates of the individual terrestrial bird in Putrajaya man-made wetlands

Family	Scientific name	Common name	Density (bird's ha ⁻¹)
Columbidae	<i>Columba livia</i>	Rock Pigeon ©	7.15 ± 1.77 (n = 443)
Passeridae	<i>Passer montanus</i>	Eurasian Tree Sparrow ©	6.81 ± 1.88 (n = 1083)
Corvidae	<i>Corvus splendens</i>	House Crow ©	6.75 ± 0.60 (n = 77)
Sturnidae	<i>Aplonis panayensis</i>	Philippine Glossy Starling ©	6.18 ± 0.97 (n = 2838)
Sturnidae	<i>Sturnus sturninus</i>	Purple-backed Starling	4.46 ± 3.44 (n = 31)
Estrildidae	<i>Lonchura punctulata</i>	Scaly-breasted Munia ©	2.74 ± 0.68 (n = 523)
Pycnonotidae	<i>Pycnonotus goiavier</i>	Yellow-vented Bulbul ©	2.36 ± 0.15 (n = 4170)
Sturnidae	<i>Acridotheres fuscus</i>	Jungle Myna ©	2.12 ± 0.22 (n = 1541)
Estrildidae	<i>Lonchura malacca</i>	Black-headed Munia	2.07 ± 0.66 (n = 18)
Sturnidae	<i>Sturnus contra</i>	Asian Pied Starling	2.01 ± 0.55 (n = 29)
Megalaimidae	<i>Megalaima haemacephala</i>	Copper-smith Barbet	1.63 ± 0.68 (n = 38)
Nectariniidae	<i>Anthreptes malacensis</i>	Brown-throated Sunbird	1.35 ± 0.11 (n = 337)
Sturnidae	<i>Acridotheres tristis</i>	Common Myna ©	0.71 ± 0.11 (n = 882)

Sturnidae	<i>Acridotheres javanicus</i>	White-vented Myna ©	1.26 ± 0.16 ($n = 434$)
Hirundinidae	<i>Hirundo tahitica</i>	Pacific Swallow ©	1.24 ± 0.26 ($n = 300$)
Estrildidae	<i>Lonchura maja</i>	White-headed Munia ©	1.23 ± 0.33 ($n = 357$)
Columbidae	<i>Treron vernans</i>	Pink-necked Green Pigeon ©	1.23 ± 0.11 ($n = 2849$)
Phasianidae	<i>Turnix suscitator</i>	Barred Button Quail	1.12 ± 0.05 ($n = 24$)
Ploceidae	<i>Ploceus philippinus</i>	Baya Weaver ©	1.01 ± 0.11 ($n = 596$)
Nectariniidae	<i>Nectarinia jugularis</i>	Olive-backed Sunbird	0.93 ± 0.16 ($n = 93$)
Columbidae	<i>Chalcophaps indica</i>	Emerald Dove	0.91 ± 0.29 ($n = 20$)
Dicaeidae	<i>Dicaeum cruentatum</i>	Scarlet-backed Flowerpecker	0.86 ± 0.24 ($n = 20$)
Rhipiduridae	<i>Rhipidura javanica</i>	Pied Fantail	0.82 ± 0.07 ($n = 532$)
Chloropseidae	<i>Aegithina tiphia</i>	Common Iora	0.73 ± 0.05 ($n = 596$)
Sylviidae	<i>Acrocephalus orientalis</i>	Oriental Reed Warbler	0.68 ± 0.18 ($n = 53$)
Nectariniidae	<i>Anthreptes simplex</i>	Plain Sunbird	0.62 ± 0.15 ($n = 64$)
Cisticolidae	<i>Prinia flaviventris</i>	Yellow-bellied Prinia	0.62 ± 0.07 ($n = 249$)
Pycnonotidae	<i>Pycnonotus plumosus</i>	Olive-winged Bulbul	0.60 ± 0.13 ($n = 40$)
Zosteropidae	<i>Zosterops palpebrosus</i>	Oriental White-eye	0.59 ± 0.46 ($n = 27$)
Sylviidae	<i>Orthotomus sutorius</i>	Common Tailorbird	0.57 ± 0.18 ($n = 130$)
Picidae	<i>Picumnus innominatus</i>	Speckled Piculet	0.55 ± 0.20 ($n = 11$)
Cuculidae	<i>Centropus sinensis</i>	Greater Coucal	0.55 ± 0.18 ($n = 11$)
Muscicapidae	<i>Muscicapadaurica</i>	Asian Brown Flycatcher	0.55 ± 0.13 ($n = 27$)
Columbidae	<i>Streptopeliachinensis</i>	Spotted Dove	0.55 ± 0.04 ($n = 1425$)
Turdidae	<i>Copsychussaularis</i>	Oriental Magpie Robin	0.51 ± 0.07 ($n = 924$)
Columbidae	<i>Geopeliastriata</i>	Peaceful Dove	0.51 ± 0.02 ($n = 1246$)
Cisticolidae	<i>Cisticolajuncidis</i>	Zitting Cisticola	0.49 ± 0.24 ($n = 29$)
Sylviidae	<i>Orthotomusruficeps</i>	Ashy Tailorbird	0.49 ± 0.05 ($n = 210$)
Motacillidae	<i>Anthusnovaeseelandiae</i>	Richard's Pipit	0.48 ± 0.09 ($n = 232$)
Cuculidae	<i>Eudynamysscolopacea</i>	Common Asian Koel	0.48 ± 0.07 ($n = 57$)
Phasianidae	<i>Gallus gallus</i>	Red Junglefowl	0.48 ± 0.04 ($n = 445$)
Chloropseidae	<i>Aegithinaviridissima</i>	Green Iora	0.44 ± 0.07 ($n = 59$)
Meropidae	<i>Meropsviridis</i>	Blue-throated Bee-eater	0.42 ± 0.11 ($n = 51$)
Oriolidae	<i>Orioluschinensis</i>	Black-naped Oriole	0.40 ± 0.02 ($n = 617$)
Laniidae	<i>Laniuscristatus</i>	Brown Shrike	0.38 ± 0.04 ($n = 126$)
Meropidae	<i>Meropsphilippinus</i>	Blue-tailed Bee-eater	0.38 ± 0.04 ($n = 326$)
Nectariniidae	<i>Arachnotheralongirostra</i>	Little Spiderhunter	0.35 ± 0.18 ($n = 13$)
Picidae	<i>Celeusbrachyurus</i>	Rufous Woodpecker	0.35 ± 0.07 ($n = 31$)
Campephagidae	<i>Lalage nigra</i>	Pied Triller	0.27 ± 0.16 ($n = 35$)
Cuculidae	<i>Cacomantismerulinus</i>	Plaintive Cuckoo	0.24 ± 0.16 ($n = 13$)
Corvidae	<i>Corvusmacrohynchos</i>	Large-billed Crow	0.24 ± 0.11 ($n = 18$)
Picidae	<i>Dinopiumjavanense</i>	Common Flameback	0.20 ± 0.07 ($n = 24$)
Nectariniidae	<i>Anthreptesrhodolaema</i>	Red-throated Sunbird	0.18 ± 0.07 ($n = 13$)
Cuculidae	<i>Centropusbengalensis</i>	Lesser Coucal	0.16 ± 0.05 ($n = 21$)
Picidae	<i>Picoidesmoluccensis</i>	Brown-caped Woodpecker	0.13 ± 0.04 ($n = 9$)
Cuculidae	<i>Cacomantissolleratii</i>	Banded Bay Cuckoo	0.13 ± 0.09 ($n = 7$)
Passeridae	<i>Passer domesticus</i>	House Sparrow	0.13 ± 0.09 ($n = 7$)
Pycnonotidae	<i>Pycnonotusjocosus</i>	Red-whiskered Bulbul	0.13 ± 0.09 ($n = 7$)
Timaliidae	<i>Macrnousgulais</i>	Striated Babbler	0.13 ± 0.09 ($n = 7$)
Dicruridae	<i>Dicrurusmacrocerus</i>	Black Drongo	0.07 ± 0.02 ($n = 5$)
Accipitridae	<i>Elanuscaeruleus</i>	Black-shouldered Kite	0.07 ± 0.02 ($n = 5$)
Nectariniidae	<i>Arachnotheraflavigaster</i>	Spectacled Spiderhunter	0.07 ± 0.02 ($n = 5$)
Accipitridae	<i>Avicedaleuphotes</i>	Black Baza	($n = 4$)
Cuculidae	<i>Cuculusmicropterus</i>	Indian Cuckoo	($n = 4$)
Accipitridae	<i>Accipiter gularis</i>	Japanese Sparrow Hawk	($n = 4$)
Estrildidae	<i>Lonchuraleucogastroides</i>	Javan Munia	($n = 4$)
Caprimulgidae	<i>Caprimulgusmacrurus</i>	Large-tailed Nightjar	($n = 4$)
Laniidae	<i>Laniusschach</i>	Long-tailed Shrike	($n = 4$)
Columbidae	<i>Treroncurvirostra</i>	Thick-billed Green Pigeon	($n = 4$)

Cuculidae	<i>Chrysococcyxanthorhynchus</i>	Violet Cuckoo	(n = 4)
Nectariniidae	<i>Arachnotherachrysogenys</i>	Yellow-eared Spiderhunter	(n = 4)
Sylviidae	<i>Phylloscopus borealis</i>	Arctic Warbler	(n = 2)
Strigidae	<i>Ketupaketupu</i>	Buffy-fish Owl	(n = 2)
Coraciidae	<i>Eurystomusorientalis</i>	Dollar Bird	(n = 2)
Psittacidae	<i>Psittaculalongicauda</i>	Long-tailed Parakeet	(n = 2)
Caprimulgidae	<i>Eurostopodustemminckii</i>	Malaysian Nightjar	(n = 2)
Accipitridae	<i>Spilornischeela</i>	Serpent Eagle	(n = 2)
Accipitridae	<i>Haliaeetusleucogaster</i>	White-bellied Fish Eagle	(n = 2)
Megalaimidae	<i>Megalaimahenricl</i>	Yellow-crowned Barbet	(n = 2)

Avian species are exceptionally versatile animals that frequently display unmistakable relationship with specific habitat [16, 17]. Observing the avian density among various natural surroundings give data about population variety in a specific habitat [18,19,20]. A total sum of avian species recorded in Putrajaya wetlands showed that it is an appropriate habitat suitable for various avian species. Moreover, information on avian study demonstrated that bird's density fluctuated in various environments relying upon vegetation structure and composition, accessibility of nourishment assets, event of reasonable scavenging, settling and chick raising locales and furthermore encompassed scene. Vegetation composition of this Man-influenced wetland contains trees, bushes, grasses, emergent and submerged vegetation, reeds, sedges, greeneries and herbs.

The heterogeneity of vegetation has made different layers, for example, shade layer, bush layer and ground vegetation layer, i.e. grasses and water vegetation (new and submerged vegetation) that pulled in a wide cluster of avian species. The shelter layer of the wetland hold is inadequately circulated along the edges of water bodies and someplace thick stands of trees and bushes in the dryland. Besides, the bushes possess the vegetation underneath five meters' tallness under trees and along the banks of lakes, while the ground layer comprises of herbaceous plants, for example, grasses, reed beds of sedges and developing vegetation. Assorted variety of vegetation structure and piece gives physical design trademark to wetland living spaces and pull in decent variety of bird's species [9,21,22,23,24], in light of the fact that vegetative structure and arrangement is an essential proximate factor that figures out where and how fowls utilize assets, influencing natural surroundings choice, affected the species abundance, distribution, diversity and density [25,26].

Above all, this investigation uncovered that Putrajaya wetland marsh swamps of this wetland encourage higher birds' density. This is likely because of lavishness and assorted variety of vegetation of rising vegetation (Water Chestnuts, Marsh Sedges, Water Lilies, Water-Milfoils, and Bulrushes), accessibility of plenteous nourishment sources (spineless creatures, vegetable, fishes, amphibians, reptiles, and mammals), shelter from harsh weather and predators, suitable nesting and chick rearing sites as reported by earlier studies [20,24,28]. Emergent vegetation apparently goes about as an extreme factor, as it gives nourishment, settling locales and cover for swamp hen, crakes, moorhens, songbirds. The grasses along the edges of swamps offer settling reason for ducks, water hens, and water cocks. This showed avian species select living spaces that give an ideal blend of assets to enable them to play out different exercises, for example, scavenging, reproducing, perching and settling.

It has been accounted for that Putrajaya wetland marsh swamps have the most astounding avian assorted variety than other wetland writes and are the most vital normal instrument for keeping up water quality to help avifaunal decent variety to satisfy their day by day necessities and multiplication [25,26]. The avian density and assorted variety is related with the accessibility of sustenance, natural surroundings condition and safe rearing locales [26] and furthermore abiotic factors, for example, soil, temperature and relative humidity [27]. These elements thus influence the wetland subordinate networks and additionally the biological community characteristic, for example, species abundance, diversity and density [28]. Moreover, climate and atmosphere conditions likewise assume a huge part in avian populace influencing their rearing and wintering grounds, accessibility of nourishment assets specifically and in a roundabout way [29,30]. Besides, the landing and flight of transitory feathered creature species additionally impact avian species wealth and sustenance assets [31,32].

4. Conclusion

This investigation showed that Putrajaya Wetland Reserve incorporates heterogeneous vegetation that offers diverse living spaces and sustenance assets for a wide exhibit of avian species. Besides, this investigation additionally uncovered that marsh swamp man-made surroundings pulled in higher bird's density when contrasted with different marshes, vast water body, dryland and bushes patches. This is because of extravagance of nourishment assets, for example, fishes, mammals and aquatic invertebrates, amphibian spineless creatures and decent variety of new vegetation, for example, *Eleocharis dulcis*, *Littoraria articulata*, *Stachys palustris*, and *Racomitrium lanuginosum*, that give perfect scavenging, settling and chick raising destinations, and furthermore cover from predators and brutal climate.

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