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Food Variety of Lesser Whistling Duck in Malaysian Lakes

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ABSTRACT

Food distribution and diversity is a significant factor that determines the habitat and site selection of avian species. Its effects on the health, reproduction, survival rate, diversity indices, population structure and home range of avian species. In wetland ecosystem, bird home range and population structure is influenced by richness and diversity of food resources and availability of suitable foraging sites. The aim of the study was to ascertain the food variety of Lesser Whistling Duck – *Dendrocygna javanica* in Paya Indah Wetland Reserve (PIWR). A scan method was employed from strategic places or blinds using a spotting scope and binocular to determine the food selection and density by Distance sampling point count method. Food items were categorised into the aquatic plants (AP), aquatic invertebrates (AIV), aquatic vertebrates (AV), terrestrial plants (TP), terrestrial vertebrates (TV) and terrestrial invertebrates (TIV). Distance analysis indicated that PIWR harboured 3.88 ± 0.00 birds per ha (n = 188 individuals). In addition, the results revealed that higher bird relative abundance of Lesser Whistling Duck concentrated in the shallow of Belibis lake that was rich in submerged and emergent vegetation (*Eleocharis dulcis*, *Philydrum lanuginosum, Utricularia vulgaris*, and *Potamogeton perfoliatus*). Kruskal–Wallis *H* test showed that food items were significantly different. Lesser Whistling Duck showed strong correlationship with AIV (r^2 = 1.00*, P* < 0.05) and negative relationship with water TP (r^2 = –0.061*, P*< 0.05). The regression model highlighted that Lesser Whistling

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Duck significantly preferred aquatic invertebrates, $r^2 = -0.686\pm0.68$; $P<0.001$ and aquatic vertebrates, –0.459±0.26) than other food items. The results revealed that shallow marshy-based lakes rich in aquatic vertebrates and invertebrates harboured higher population of Lesser Whistling Ducks to utilize it and performed multiple activities than other habitats.

Keyword: Density, duck, food, lakes, relative abundance, wetland habitat

INTRODUCTION

Lesser Whistling Duck (*Dendrocygna javanica*) is a waterbird with square head, pale buff face with a restricted yellow eye-rings, round, and more extensive wings, dim dark bill, leg, and feet (Zakaria & Rajpar, 2015). The colour of the body is commonly brownish, especially around the chest, while the other parts of the body may be light cinnamon with unnoticeable whitish flank quills. Lesser Whistling Duck are mostly found foraging around freshwater wetlands, for example, lakes, repositories, and swamps filled with aquatic vegetation, i.e., *Eleocharis dulcis, Stenochlaena palustris, Scleria purpurascens* and *Philydrum lanuginosum*. In addition, they feed on different pieces of aquatic plants (e.g., seed, shoots, tuber, and leaves). They also forage on different sources of aquatic vertebrates (fishes and creatures of land and water) and invertebrates, which constitute a significant portion of their diet. Their population is large in dense vegetation or grasslands, as dense vegetation keeps them safe from predators and provide a safe environment for nesting (Tellkamp, 2004; Zakaria & Rajpar, 2014). Although the current conservation status of this species is “least- concern”, this species is currently declining in number, and if studies are not carried out to understand daily foraging requirement, they may become threatened (BirdLife International, 2016).

Family Anatidae (geese, ducks, and swans) comprises 49 genera and 148 species. Out of 148 species, 48 species have become threatened and endangered species due to human footprints, i.e. 27 vulnerable, 12 endangered, 9 critically endangered and 7 extinct (Andy, 1996; Howard, 2003; Martins et al., 2019). Currently, the members of anatidae are facing severe threats due to human interference, i.e. habitat loss due to urbanization and agriculture expansion (73.0%), illegal hunting (48.0%), and introduction of exotic species (31.0%) (Thiel et al., 2007; Asmawi, 2007; Johnsgard, 2010). Habitat loss and degradation may cause shift in home range, i.e. movements to unsuitable and less productive areas that ultimately affect reproduction success, increase chances of hunting and trapping (Shuford & Gardali, 2008; Gillespie, 2007). It has been stated that lesser whistling ducks spend most of their time to refuel the energy to maintain vigorous health and perform multiple activities for their survival and existence (Strasser & health, 2013; Rehnus et al., 2014).

The main threats to Lesser Whistling Duck are illegal hunting, trapping, habitat loss, habitat degradation and human intervention (Rajpar et al., 2017). There is a high incidence of sedimentation, as well as alien and invasive species invasion on the wetland, creating less space or suitable habitat for waterbirds. The duck may be affected by excessive use of agro-chemicals in the farmlands. According to Rajpar and Zakaria, (2014), reduced quality of foraging habitat in terms of food resources, protection from prey while foraging is another major factor affecting the population of Lesser Whistling Duck in most Malaysian wetland (i.e. the ducks may not have adequate source of food for their daily requirement). Hence, understand diet composition is of great importance, as it will help ecologist to know the exact foraging types and manipulate their wetlands to enhance suitable diet for this species. In addition, there is potential for Paya Indah Wetland Reserve (PIWR) Reserve as staging ground for other ducks and other waterbird species that are migratory or native threatened. The conservation and protection of waterbirds especially game birds are crucial challenge for wildlife managers because they need immense work, mass awareness and efforts to protect these species. Hence, the aim of this study was to ascertain the food variety consumed by Lesser Whistling Duck in (PIWR).

METHODOLOGY

Study Site

This study was carried out at 14 lakes at the Paya Indah Wetland Reserve that covers an area of 3,050 ha. Out of the 3,050 ha, 450 ha area is under the administration of Wildlife Department while the rest is private owned and state land. The study area is located within 101°10′ to 101°50′ longitude and 2°50′ and 3°00′ latitude (Figure 1). The wetland is characterized by different types of habitats (Table 1). All plants were identified using “Flora of Peninsular Malaysia, Series II: Seed Plants, Volume 7” (Kiew et al., 2018). These lakes vary in size, vegetation structure, and composition, water depth, water quality, inflow, and outflow of water (Table 2). The dominant vegetation comprises *Eleocharis dulcis, Stenochlaena palustris, Philydrum lanuginosum, Nelumbo nucifera, Nymphaea pubescens* and *Scleria purpurascens*), lowered vegetation such as *Potamogeton perfoliatus, Myriophyllum spicatum, Utricularia vulgaris* and *Salvinia molesta.* The wetland edges encompassing of *Scirpus olneyi, Stenochlaena palustris, Phragmites karaka* and *Typha angustifolia*. PIWR serve as the green lung or super corridor for a wide array of avian species due to its strategic location, (i.e. 12 km to the west of Putrajaya, 30 km to the south of Kuala Lumpur, 15 km to the north of the International Airport in Kuala Lumpur, 4 km to Dengkil), Kuala Langat Peat Swamp Forest Reserve (in the east), Ayer Hitam Isolated Tropical Lowland Forest Reserve (Selangor), and Sungai Lalang Forest Reserve (in the west) (Rajpar & Zakaria, 2012; Martins et al., 2017).

Table 1

Different habitat types of Paya Indah Wetland Reserve

Habitat Type	Plants found in the Habitat
Marshy Swamp	*Lepironia articulata, Eleocharis dulcis,Stenochlaena palustris, Scirpus spp., Philydrum lanuginosum, Hydrilla* spp.*, Carex* spp.*, Sagittaria latifolia, Panicum repends, Nymphaea pubescens, Scleria purpurascens, Phragmites karka, Nymphaea rubra, Nelumbo nucifera, Gleichenia linearis, Lycopodium cernuum and scattered trees such as Acacia auriculiformis, A. mangium, Macaranga tanarius, Peltophorum pterocarpum, Cinnamonum iners, Melicope glabra and Melastoma malabathricum*.
Lotus swamp	*Nelumbo nucifera, Nelumbo nouchali, Nelumbo pubescens, Eleocharis dulcis, Elodea* spp.*, Lepironia articulata*, *Phragmites karka* reeds and *Typha angustifolia*.
Open water body	*Nymphaea odorata, Potamogeton* spp.*, Eleocharis dulcis, Myriophyllum spicatum, Salvinia molesta, Utricularia aurea, Scirpus holoschoenus, Scirpus sylvaticus, Scirpus californicus, Scirpus mucronatus* and *Scirpus maritimus*. The edges are predominated by *Eleocharis dulcis, Lepironia articulata*, *Philydrum lanuginosum, Scleria purpurascens, Scirpus* spp.*, Carex* spp.*, Sagittaria latifolia* and *Hydrilla* spp.
Dry land with scattered Vegetation	*Mimusops elengi, Fragraea fragrans, Cassia fistula, Tectona* spp.*, Albizia julibrissin*, *Syzygium* spp., *Delonix regia, Samanea saman, Acacia auriculiformis, Acacia mangium, Melicope glabra, Melastoma malabathricum* and *Ficus* spp., *Imperata cylindrica, Cynodon dactylon, Wedelia trilobata, Nephrolepis acutifolia, Artocarpus altilis, Asystasia gangetica, Peltophorum pterocarpum, Plumeria obtuse* and *Passiflora caerulea.*
Shrub Patches	*Acacia auriculiformis, Acacia mangium, Fragraea fragrans, Delonix regia, Alstonia scholaris, Samanea saman, Macaranga lanrius, Ficus rubiginosa, Ficus benjamina, Ficus fistulosa, Lagerstroemia speciosa*, *Melastoma malabathricum, Wedelia trilobta, Nephrolepis acutifolia* and *Asystasia gangetica*.

Table 2

Habitat structure of 14 lakes in Paya Indah wetland Malaysia

Names of lakes	Vegetation type	Water Level (ft)		Size (ha)	WQI	WLF	NDVI
		Minimum	Maximum				
Belibis	Marsh swamp vegetation	0.65	3.38	5.09	88.53	7.81	0.51
Seroja	Open water vegetation	5.03	18.95	138.93	82.0	8.91	0.24
Telipok	Open water vegetation	3.84	20.74	85.09	83.6	7.14	0.33
Drift Wood	Lotus swamp vegetation	2.39	9.85	10.84	73.06	7.41	0.32
Tunira	Lotus swamp vegetation	1.47	5.46	7.50	80.22	7.55	0.54
Senduduk	Open water vegetation	0.73	3.10	7.52	50.26	6.56	0.53
Sendayan	Open water vegetation	2.98	10.89	28.17	82.24	6.5	0.21
Grebe	Lotus swamp vegetation	5.94	18.97	2.40	52.19	7.37	0.31
Resam	Lotus swamp vegetation	3.17	13.84	4.31	84.55	7.06	0.24
Teratai	Open water vegetation	1.54	20.60	149.04	82	5.86	0.33
Kemoning	Lotus swamp vegetation	2.92	8.23	1.91	85.49	6.65	0.27
Rusiga	Lotus swamp vegetation	3.38	16.79	37.45	72.3	7.07	0.36
Typha1	Lotus swamp vegetation	3.21	10.92	5.07	81.48	5.99	0.23
Typha2	Lotus swamp vegetation	1.19	5.90	6.81	72.3	7.07	0.36

Source: Martins et al.(2017) and Martins et al.(2019)

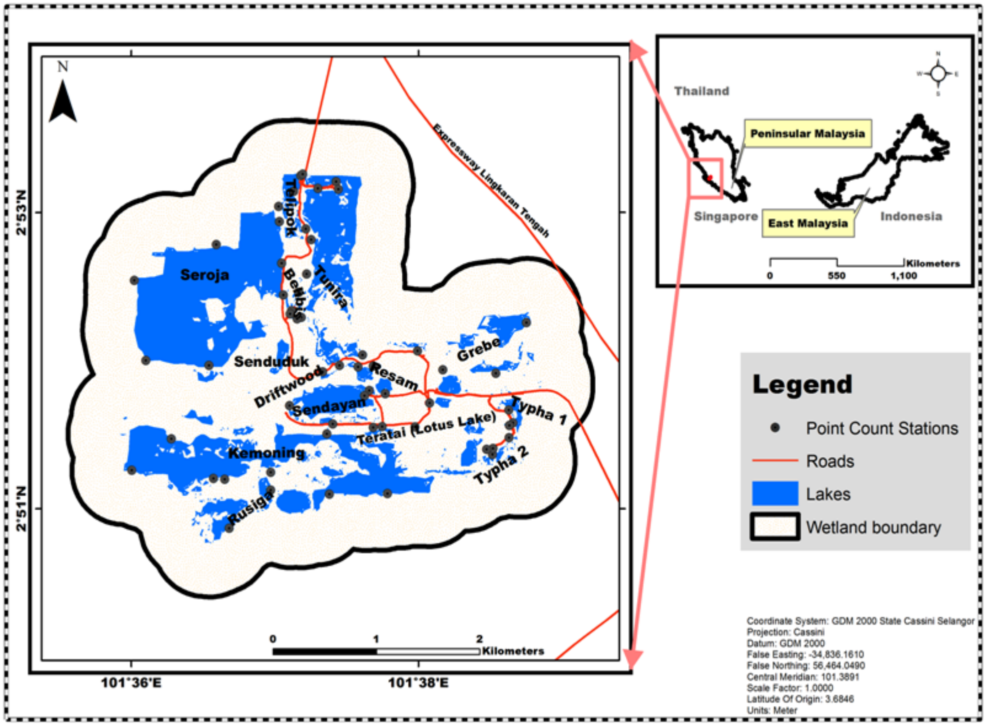

Figure 1. Map of 14 lakes in Paya Indah wetland

Foraging Ecology and Diet Composition of Lesser Whistling Duck

There are several sampling techniques to examine the foraging ecology of Anatidae. For foraging ecology of Lesser Whistling Duck, the scan through method was employed from strategic places (point count stations) using the spotting scope and binocular. All food types observed by Lesser Whistling Duck during the study were classified into the following diet composition classes, namely aquatic plants (AP), aquatic invertebrates (AIV), aquatic vertebrates (AV), terrestrial plants (TP), terrestrial vertebrates (TV), and terrestrial invertebrates (TIV). Each lake was observed daily from April to September 2019. Data collected were population of Lesser Whistling Duck in each lake and types of food seen eaten.

The distance sampling point count technique was employed. About 57 count stations in PIWR were systematically placed based on their visibility using binoculars and at least 100 m interval apart, to avoid the double count of the same avian species at more than one station. Bird count surveys in each count station with the maximum variable radius of 100m. The lakes were observed daily for 10 minutes each between 6 and 11am and between 5 and 7pm. Observation was carried out from a blind location (i.e., from a hideout to avoid disturbance). Thus, we avoided recording the foraging behaviour of Lesser Whistling

Duck individuals that occured outside of scan intervals. The methodology followed was as described by Boyce, (2010) and Rajpar and Zakaria, (2014).

Data Analysis

The distance software Version 7.2 was used to determine the population densities and detection functions (Equations 1, 2 & 3) (Thomas et al., 2010; Sebastián-González et al., 2018). According to Buckland et al. (2008), the distribution of the observed distances was used to estimate the "detection function," g(y) - the probability of detecting a bird at distance y. This function can be used to estimate the average probability of detecting a bird (denoted Pa), given that it is within mean radial distance to the point.

$$D = \frac{1}{a}\sum_{i=1}^{n}\frac{1}{p_a(z_i)} \tag{1}$$

Where, a = size of the covered region, n = number of birds seen, $P_{a(zi)}$ = the estimated probability of detecting the bird.

$$ER = \frac{\mathrm{n}}{\mathrm{K}} \tag{2}$$

Where, ER = Encounter rate (per point), n = total number of observed individuals in each point station, K = Point count effort (number of samples)

$$EDR = w(\sqrt{p}) \tag{3}$$

Where, EDR = Effective detection radius in meters, p = Detection probability, w = Radius of point transect in meters. However, six lakes were not analysed because there was no presence of Lesser Whistling Duck in the vicinity.

A Kruskal–Wallis *H* test was applied to examine if there was a significant difference between the diet composition classes of Lesser Whistling Duck among the lakes. After data transformation, Predictive Regression Model (PRM) was used to examine the correlation of Lesser Whistling Duck population with various food type classes, namely AIV, AV, AP, TIV, TV and TP in order to understand the food requirements of Lesser Whistling Duck. In addition, Pearson's Correlation Coefficient was also employed to examine the correlations between Lesser Whistling Duck density with the different food class types (Equation 4).

$$r = \frac{\sum_{i=1}^{n}\left(X_i - \overline{X}\right)\left(Y_i - \overline{Y}\right)}{\sqrt{\sum_{i=1}^{n}\left(X_i - \overline{X}\right)^2}\sqrt{\sum_{i=1}^{n}\left(Y_i - \overline{Y}\right)^2}} \tag{4}$$

Where; *Xi*=standard score, *X*=sample mean, and *SX*=standard deviation

RESULTS

Bird Density

A total 188 bird individuals of Lesser Whistling Duck (density 3.88±0.00 birds per ha) were detected during the sampling period in PIWR (Table 3). Table 4 shows the monthly-observed density of Lesser Whistling Duck in each lake. The result reveals that Belibis harboured the highest density of Lesser Whistling Duck as compared to the other lakes. However, Lesser Whistling Duck avoided utilizing the six lakes and were not analysed.

Table 3

Density estimate of Lesser Whistling Duck in PIWR

Total Observation of Lesser Whistling Duck	188 bird individuals
Density	3.88 ± 0.00
Encounter rate (per meter)	0.01 ± 0.00
Detection probability	0.29 ± 0.00
Effective detection radius	2.18 ± 0.00

Table 4

The density of Lesser Whistling Duck in PIWR

Name of Lake	Monthly density of Lesser Whistling Duck individuals/months					
	April	May	June	July	August	September
Belibis	3.26±0.12	3.13±0.05	2.84±0.62	3.44±0.23	2.98±0.56	3.53±0.15
Tunira	0.93 ± 0.20	0.33±0.01	0.71±0.23	0.11±0.12	0.25±0.63	0.65±0.34
Senduduk	0.89 ±0.11	0.21±0.36	0.25±0.37	0.45±0.55	0.69±0.65	0.59±0.57
Grebe	0.42± 0.09	0.23±0.48	0.55±0.66	0.63±0.56	0.96±0.68	0.88±0.87
Resam	0.55± 0.09	0.66±0.44	0.98±0.46	0.88±0.55	0.22±0.23	0.87±0.65
Teratai	0.32± 0.31	0.52±0.25	0.23±0.33	0.43±0.11	0.26±0.04	0.22±0.05
Rusiga	0.25± 0.13	0.66±0.32	0.14±0.66	0.21±0.05	0.22±0.01	0.41±0.23
Typha1	0.88± 0.31	0.22±0.11	0.85±0.26	0.24±0.65	0.23±0.55	0.21±0.54

Foraging Ecology of Lesser Whistling Duck

Visual estimation and scan method revealed that Lesser Whistling Duck was a gregarious omnivorous species, mostly preferred to forage in open water column through dabbling, dipping, skimming, and even some time half diving in water column. It was observed that Lesser Whistling Duck preferred areas with submerged and emerged aquatic plants, i.e., *Eleocharis dulcis, Philydrum lanuginosum, Utricularia vulgaris*, *Potamogeton perfoliatus* etc. Furthermore, it was observed that Lesser Whistling Duck were also concentrated in shallow waters along the edges of the lakes where aquatic invertebrates (molluscs and worms) and aquatic vertebrates (tadpoles and small fishes) were present (Figure 2).

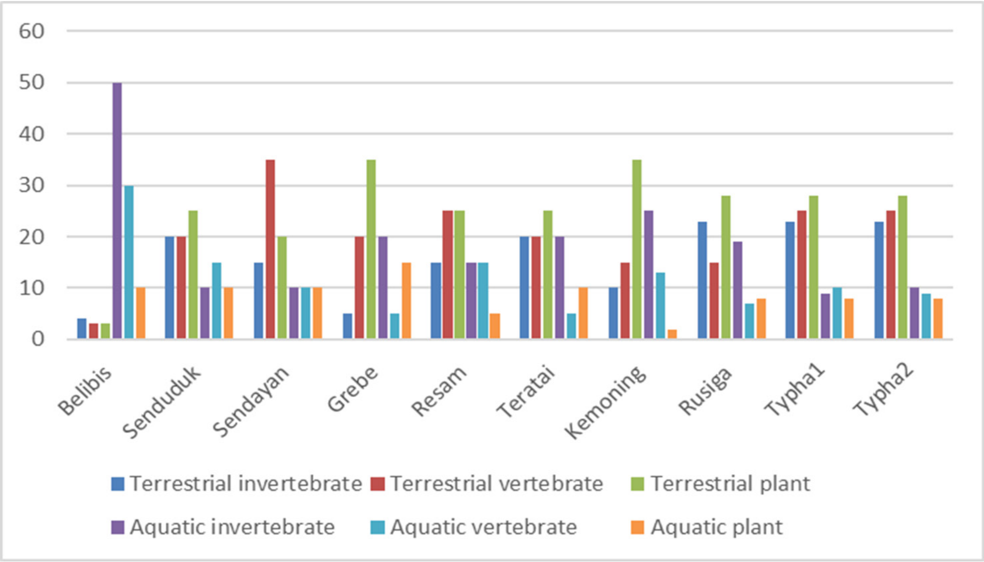

Figure 2. Food type foraged by Lesser Whistling Duck

Table 5
Kruskal–Wallis H test showing the temporal differences in diet composition of the ducks

Source of Variation	SS	df	MS	F	P-value	F crit
Between groups	2332.3	5	466.46	6.346395	0.00069	2.620654
Within groups	1764	24	73.5			
Total	4096.3	29				

Table 5 shows the Kruskal–Wallis *H* test result among the diet composition classes; the result revealed that there was a significant difference among the different diet composition classes. Pearson Correlation Coefficient was applied to determine the relationship density with the food types (Table 6). Lesser Whistling Duck showed strong relationship with aquatic invertebrates ($r2 = 1.00$, $P > 0.05$). Table 7 shows the predictive regression model correlation matrix. The result showed that there was a strong correlation of Lesser Whistling Duck with aquatic invertebrates and vertebrates.

Table 6

Pearson Correlation Coefficient test results indicating correlation of Lesser Whistling Duck with the diet composition classes

Name of food type	Association with Lesser Whistling Duck
Aquatic invertebrates (AIV)	Strong correlation with AIV ($r2$ = 1.00, $P > 0.05$)
Aquatic vertebrates (AV)	A positive relationship with water AV ($r2$ = 0.595, $P > 0.05$)
Aquatic plants (AP)	Moderate correlation with AP ($r2$ = 0.640, $P > 0.05$)
Terrestrial invertebrates (TIV)	A moderate negative relationship with TIV ($r2$= – 0.651, $P > 0.05$
Terrestrial vertebrates (TV)	A weak positive relationship with water TV ($r2$ = 0.343, $P > 0.05$)
Terrestrial plants (TP)	Weak negative relationship with water TP ($r2$ = – 0.061, $P > 0.05$)

Table 7

Results of predictive regression model correlation matrix results

Food Type	Terrestrial invertebrate	Terrestrial vertebrate	Terrestrial plants	Aquatic invertebrate	Aquatic vertebrate	Aquatic plants
Terrestrial invertebrate	1					
Terrestrial vertebrate	0.888058	1				
Terrestrial plant	0.895427	0.981274	1			
Aquatic invertebrate	0.025659**	0.193363	0.155506	1		
Aquatic vertebrate	0.040306**	-0.36174	-0.35284	0.780217	1	
Aquatic plant	0.577926	0.166542	0.174283	0.906403	0.642829	1

Table 8

Slope and standard errors of ecological factors in parsimonious model

Food Type variable	Slope	Standard Error
Terrestrial invertebrate	0.587	0.524
Terrestrial vertebrate	0.356	0.236

Table 8 *(Continued)*

Food Type variable	Slope	Standard Error
Terrestrial plant	0.236	0.014
Aquatic invertebrate	-0.686	0.68
Aquatic vertebrate	-0.459	0.26
Aquatic plant	0.164	0.52

In addition, predictive regression model analysis test was carried out to ascertain the diet composition class variables that was most important and play a major role in foraging of Lesser Whistling Duck within the wetlands (Table 7). The results highlighted that the ducks significantly preferred more of aquatic-based food (i.e. aquatic invertebrates -0.686±0.68; $P<0.001$) (Table 8).

DISCUSSION

Lesser Whistling Duck are omnivorous in nature and the have a varied diet. The different diet composition sources provide good nutrition for the health of Lesser Whistling Duck and positively affect the species' growth, feather strength, muscle development, and breeding success. Understanding the different sources of food eaten by Lesser Whistling Duck will help conservationist to maintain the habitat that supports food resources. The diet composition classes were classified into six classes and this were based on feeding observations of this species. The wetland (PIWR) has 14 lakes, and Lesser Whistling Duck was found foraging in 8 of them. These lakes provide different sources of food, especially Lake Belibis. A large population of Lesser Whistling Duck was present in lake Belibis. This may be due to its richness in aquatic vertebrates and invertebrates (Figure 2), which agrees with Rajpar and Zakaria (2014), who stated that the presence of aquatic food resources was a major player for the distribution of water birds in various wetlands. Although some of the food classes and shelter vegetation might have been present in the avoided lakes, Lesser Whistling Duck still completely avoided six lakes which were characterized as having higher water level (deeper waters). Hence, this may have affected the population of Lesser Whistling Duck in these lakes. Hansson et al., (2010) stated that water quality parameter such as dissolved oxygen, water depth, salinity would affect the presence of macrophytes and aquatic invertebrates in wetlands, hence this might be the major reason why Lesser Whistling Duck avoided lakes that were not rich with this food source. It was also reported that water depth was an important variable affecting the habitat selection in water birds (Koli, 2014; Sulaiman et al., 2018) because it directly determined the accessibility of prey while foraging (McMahon & Moreira, 2014; Jayathilake & Chandrasekara, 2015). Wading birds prefer shallow water because foraging efficiency decreases with increasing water depth. This indicated that water birds obtain higher net energy intake in shallower water than deeper water, as reported by Ma et al., (2009) and Sulaiman et al., (2018). It was observed that water level fluctuation created different foraging habitats from time to time, depending on inflow of water from catchment areas and rainfall pattern. When water level is reduced, the food resources such as fishes and tadpoles are concentrated in low–lying sites attracting a higher number of wading birds due to visibility of prey resources and increased foraging success.

Our study showed that both aquatic vertebrates and aquatic invertebrates were significantly associated (Table 6 and 7). Some aquatic plants provide sheltering, protection, nutrition and reproduction habitat for Lesser Whistling Duck These plants produce oxygen, acts as bio filters of the water, whereby they reduce the effect of pollutants. However, there also have negative impacts. Aquatic plants grow in lakes and fresh water and have positive or negative implication to the water bodies and to the waterfowls (Hansson et al., 2010). These plants are rooted in shallow waters with the ascend part emerging above the water surface. Water lily, for example, is found in fresh water ecosystem and is submerged in water (Sun et al., 2014). The impact of some macrophytes has been highlighted by many authors (Widyastuti & Haryono, 2016; Zhang et al., 2014). However, water lily can be an alternative protein source for Lesser Whistling Duck (Welsh et al., 2013; Russell et al., 2014).

Habitat characteristics play a vital role in determining habitat utilization for waterfowl, which include the availability of adequate food and shelter, and water body characteristics (Rajpar et al., 2017). Furthermore, it is known that human interference could lead to momentary modification in characteristics and sectionally change temporal distribution of waterfowl (Sun et al., 2014). The results of this study show that Lesser Whistling Duck prefered to utilize the lake area dominated with aquatic vegetation, such as; lotus (*Nelumbo nucifera*), water chestnut (*Eleocharis dulcis*), wooly waterlily (*Philydrum lanuginosum*), marsh sedge (*Sphenarium purpurascens*), common duckweed (Salvinia minima), spike water milfoil (*Myriophyllum spicatum*), and smooth cordgrass (*Spartina alterniflora*), for foraging and loafing. This highlights that aquatic vegetation composition is the key factor that plays a vital role in the habitat selection of the Lesser Whistling Duck, i.e., aquatic vegetation spread assumed a significant role in the circulation of prey resources, which is the major diet of Lesser Whistling Duck in the wetland ecosystem (Zhang et al., 2014; Zhang et al., 2018).

CONCLUSION

Based on the results, it is concluded that diversity and richness of food sources are driven factors that affect on habitat selection and home range of Lesser Whistling Ducks in PIWR.

In addition, it was observed that Lesser Whistling Duck often-select marshes densely occupied with emergent and submerged aquatic vegetation and having shallow ~~in~~ water depth. It may be that, these marshy areas rich in in aquatic vertebrates and invertebrates that are staple diet of Lesser Whistling Ducks.

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