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Comparison of Interrelationship with Site Occupancy, Population Structure and Foraging Ecology of Lesser Whistling Duck (*Dendrocygna javanica*) Among 10 Wetland Habitats of Paya Indah Wetlands, Peninsular Malaysia

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Abstract: Protecting ecosystems in the vicinity of rapidly urbanizing areas requires continuous monitoring and assessment. Currently, the extent of occurrence <20,000 km2 combined of Lesser Whistling Duck (LWD) is declining or fluctuating in range size, habitat extent/quality and population size. It is mostly found in either small number or small fragmented locations due to limited source of food variety. Hence, the study aimed to evaluate the interrelationship among site occupancy, population structure and foraging ecology of LWD (*Dendrocygna javanica*) among 10 wetland habitats in a Paya Indah Wetland (PIW), Peninsular Malaysia. Population analysis indicated that PIW harbored LWD density of 4.66 ± 1.12 birds/ha and relative abundance of 1,234 bird individuals. The highest naïve occupancy (NO=0.80), occupancy (Ψ=0.80 ± 0.18) and detection probability (P=0.98 ± 0.01) was detected for Belibis habitat and the lowest occupancy (Ψ=0.31 ± 0.04) in Kemoning habitat. LWD foraged on vegetation predominantly aquatic plants and as well as small vertebrates. The Akaike Information Criteria indicated that, the LWD had significant relationships with occupancy models (R2=0.93) and positive/strong correlationship with food varieties (R2=0.95). The findings indicated that Belibis wetland habitat harbored the highest LWD in terms of relative abundance and density than the other 10 wetland habitats. This study concludes that the interrelationship of site occupancy, density, and foraging ecology of LWD varied among different habitats.
Keywords: *Lesser Whistling Duck, Interrelationship, Foraging, Site occupancy and Population.*
Abbreviations: *LWD-Lesser Whistling Duck and PIW- Paya Indah Wetland.*

1. Introduction

Lesser Whistling Duck (LWD) - *Dendrocygna javanica*, is one of the most important game species in the ecosystem of wetlands [1] hunted for bushmeat and sport. It has a wide distribution throughout the Southeast Asia and Indian Subcontinent across the diverse aquatic habitats e.g., freshwater wetlands, paddy fields, lakes, reservoirs, aquaculture ponds, coastal areas and islands [2-4]. LWD is widely distributed across the India, Nepal, Sir Lanka, Malaysia, Singapore, Indonesia, Myanmar, Thailand and Vietnam. They also utilized the Andaman, Microbar and Maldives islands. Approximately, 718 bird species occur in Malaysia out of which 63 species are globally threatened, 11 critically endangered, 15 endangered, 37 vulnerable, 109 near threatened and nine endemic species [5] BirdLife International 2020b). Currently, LWD is not approaching the thresholds for vulnerable under the range size criterion and it is currently classified as "least concern" (Birdlife International 2020a). In recent years, several discontinued tin-mining areas in Peninsular Malaysia have been declared as a wetland reserve to protect the water bird species. This degraded land is prevalent in the landscape of Peninsular Malaysia, with approximate land coverage of 113,000 ha, mostly in Selangor and Perak states [6]. The landscape resulted from the existence of former mining activities mainly tin mining [7]. The tin–mining industry had contributed to the livelihood development of communities and foreign exchange for the country in the past decades [8-10]. The land had acted as a natural water catchment area to flood control [7].

Thus, the high accumulation of heavy metals over time had rendered most discontinued tin mines productive for agriculture and wildlife. At present, Malaysian wetlands are facing an overwhelming pressure from rapid development and urbanization [11]. Anthropogenic activities have altered the wetland habitats in a variety of ways that consequently cause greater threats, such as trapping/hunting, habitat destruction through sedimentation and conversion into aquaculture and paddy fields, water pollution and eutrophication that ultimately cause a declined in the population of wetland dependent birds [12, 13].

Such affected species are Masked Finfoot-*Hellipais personatus* (EN), Lesser Adjutant-*Leptoptilos javanicus* (VU), Milky Stork – *Mycteria cinerea* (EN), Asian Woolyneck-*Ciconiae piscopus* (VU), Storm's Stork-*C. stormi* (EN), White-shouldered Ibis-*Pseudibis davisoni* (CR), Chinese Egret-*Egretta eulophotes* (VU), Christmas Frigate bird- *Fregata andrewsi* (CR), Far Eastern Curlew-*Numenius madagascariensis* (EN), Spoon-billed Sandpiper-*Calidris tenuirostris* (CR), Spotted Greenshank-*Tringa guttifer* (EN), Chinese Crested Tern -*Thalasseus bernsteini* (CR) and White-winged Duck-*Asarcornis scutulata*, EN [14-18], BirdLife International 2020b).

In respect to this, the future challenges for wetland conservation and management are to estimate the wetland resources and monitoring the trends in waterbird populations, particularly wetland dependent birds that are in a decline state [19]. The information about the site occupancy, population structure, choice of food type selection and foraging behavior of LWD in the wetland habitats of Malaysia has not been sufficiently examined [5].

Hence, detailed information is crucially important for future conservation and protection of this game species in order to enhance the population across the wetland habitats. Even though LWD is still considered as least concern under the IUCN Red List, if left unchecked, the species will become vulnerable and threatened in the near future. Therefore, the study aimed to evaluate the interrelationship among site occupancy, population structure and foraging ecology of Lesser Whistling Duck (*D. javanica*) among 10 wetland habitats at the Paya Indah Wetland (PIW), Peninsular Malaysia.

2. Materials and Methods

2.1. Study Site

This study was carried out at the Paya Indah wetland (PIW), Peninsular Malaysia. Geographically PIW is located within the quadrant of 101°10′ to 101°50′ longitude and 2°50′ and 3°00′ latitude adjacent in Malaysia's administrative center of Putrajaya **(Figure 1)**. Presently PIW has been declared as a wetland reserve by state government to preserve and protect the fragile wetland flora and fauna in order to provide less disturbed habitats for an array of waterbird species [20]. The other reason is to preserve and increase

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the aesthetic beauty of the wetland. This area encompassing of 3,050 ha out of which 450 ha are under the management of the Department of Wildlife and National Parks, Peninsular Malaysia while the rest are state lands.

The 450 ha area has been divided into 10 interconnected wetland habitats, namely Belibis, Senduduk, Sendayan, Grebe, Resam, Teratai, Kemoning, Rusiga, Typha1 and Typha2 based on vegetation structure and composition **(Table 1)**. This wetland reserve is a part of Kuala Langat North Permanent peat swamp forest [21]. The PIW serves as a wildlife corridor due to its strategic location, i.e., 30 km south of Kuala Lumpur, 12 km west of Putrajaya and 15 km north of Kuala Lumpur International Airport. PIW harbored more than 100 bird species that comprised of 64 resident birds, 18 migrants, 16 residents-migrants and 2 vagrant species [22].

Avian Survey: The standardized Distance sampling point count technique was employed for the study to determine the site occupancy, population structure and foraging ecology of LWD among 10 wetland habitats [23, 24]. The survey was performed only on sunny days between 07.00 to 11.00 by a single observer between April to September 2018 for six consecutive months. The surveys were done on a daily basis, except Saturdays and Sundays and during rainy and cloudy days. During rainy and cloudy days' bird s were less active and often resting and difficult to observe.

In addition, the foraging behavior, habitat preference and food preference were ascertained through scanning method using Binocular 10 x 50 resolution, a DSLR camera with a high performance 400mm lens and spotting scope.

Table 1.
Descriptions of the types of wetland habitat at PIW.

Wetland ID	Names of lakes	Vegetation type
W1	Belibis	Marsh swamp vegetation
W2	Senduduk	Open water vegetation
W3	Sendayan	Open water vegetation
W4	Grebe	Lotus swamp vegetation
W5	Resam	Lotus swamp vegetation
W6	Teratai	Open water vegetation
W7	Kemoning	Lotus swamp vegetation
W8	Rusiga	Lotus swamp vegetation
W9	Typha1	Lotus swamp vegetation
W10	Typha2	Lotus swamp vegetation

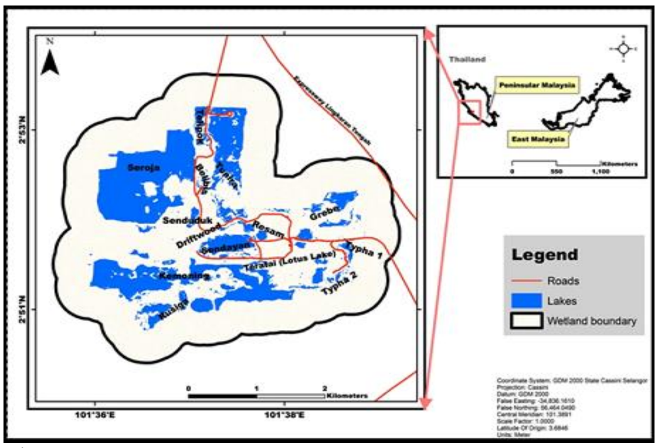

Figure 1.
The 10 wetland habitats within the PIW, Peninsular Malaysia.

Food Sampling: Besides scanning method, the food samples were collected using multiple techniques. Terrestrial invertebrates (TI) were sampled through the sweep-netting and terrestrial vertebrates (TV) by direct observation, aquatic invertebrate (AI) through cast net and vegetation structure, e.g., aquatic plants (AP) and terrestrial plants (TP) was determined through quadrat method. The interval between the start of successive scans was constantly recorded during the study period to obtain the most reliable results. Thus, recording the behavior of LWD outside the scan intervals was avoided because LWD is a shy species with secretive behavior [25-28].

3. Data Analysis

The difference for both foraging guilds and food types and habitat use was examined through One–way blocked by time Analysis of Variance (ANOVA) using SPSS software [29, 30]. A single species–single season, occupancy modeling was used to estimate the site occupancy and detection probability of LWD in the various wetland habitats of PIW using PRESENCE 12.21 [31-34]. The Distance software (Version 7.2) was used to determine the population density [35-37]. The interrelationships among site occupancy estimates, detection probabilities and food varieties fed by LWD were determined using the third order polynomial regression-modeling algorithm [26, 38, 39].

4. Results

Site Occupancy of Lesser Whistling Duck among 10 Wetland Habitats: The highest naïve occupancy (NO=0.80 ± 0.18) and detection probability (P=0.98 ± 0.01) of LWD was obtained in Belibis wetland habitat. On the contrarily, lowest naïve occupancy (NO=0.31 ± 0.04) was obtained in Kemoning wetland and the lowest detection probability (P=0.17 ± 0.03) in Sendayan wetland. The occupancy model indicated the highest Akaike Information Criterion (AIC=184.80) for Teratai and the lowest one Akaike Information Criterion (AIC=37.26) for Belibis wetland **(Table 2)**. [NO=naive occupancy; Ψ=occupancy estimate; SE=standard error; CI=95% confidence interval (specified by Program PRESENCE output), P=detection probability, and Akaike Information Criterion=AIC]. The result showed that Belibis wetland harbored the highest number of bird individuals (n=883 and density (6.67 ± 0.02 birds/ha. However, wetland Sendayan was least preferred habitat as only a few individuals (n=23) of LWD were detected. Likewise, low density (1.02 ± 0.88 birds / ha) of LWD was detected in Belibis, Rusiga and Typha2 wetland habitats.

Table 2.
Density, site occupancy and detection probability of LWD among 10 wetland habitats at the PIW.

Wetland habitats	Belibis	Senduduk	Sendayan	Grebe	Resam	Teratai	Kemoning	Rusiga	Typha1	Typha2
Observed bird individuals	883	44	23	58	54	70	40	24	42	46
Density Bird/Ha	6.67 ± 0.02	1.62 ± 0.14	1.32 ± 0.04	1.44 ± 0.81	1.43 ± 0.51	1.31 ± 0.22	1.55 ± 0.77	0.98 ± 0.10	1.12 ± 0.90	1.02 ± 0.88
NO	0.8	0.57	0.44	0.36	0.43	0.33	0.31	0.4	0.44	0.4
Ψ ± SE	0.80 ± 0.18	0.57 ± 0.19	0.45 ± 0.17	0.36 ± 0.15	0.43 ± 0.19	0.33 ± 0.14	0.31 ± 0.04	0.40 ± 0.16	0.44 ± 0.17	0.40 ± 0.15
CI	0.31 – 0.97	0.23 – 0.86	0.18 – 0.75	0.14 – 0.66	0.14 – 0.77	0.13 – 0.62	0.22 – 0.38	0.18 – 0.75	0.23 – 0.38	0.16 – 0.70
P ± SE	0.98 ± 0.01	0.35 ± 0.04	0.17 ± 0.03	0.38 ± 0.04	0.28 ± 0.05	0.39 ± 0.04	0.30 ± 0.04	0.19 ± 0.04	0.29 ± 0.04	0.31 ± 0.04
CI	0.93 – 0.99	0.27 – 0.43	0.11 – 0.25	0.30 – 0.47	0.20 – 0.38	0.31 – 0.48	0.22 – 0.38	0.13 – 0.27	0.23 – 0.38	0.24 – 0.40
AIC	37.26	173.63	129.15	182.99	123.77	184.8	171.2	139.3	165.77	171.88

Table 3.
Food variety foraged by LWD.

Food types	Scientific /Common name	Mean	Upper	Lower	Tukey 95% CI
Terrestrial invertebrate	*Anisoptera/ Dragonfly*	1.93	0.68	3.83	a
Terrestrial vertebrate	Rodents	2.81	1.23	5.02	Ab
Terrestrial plant	Crown grass (*Paspalum*)	4.22	2.22	6.87	Abc
Aquatic invertebrate	Aquatic worms (Earthworms, snails, larvae of damselfly and midges)	6.08	3.61	9.19	Bcd
Aquatic vertebrate	Nile Tilapia- *Oreochromis niloticus*	6.91	4.26	10.2	Cd
Aquatic plant	Spike Sedge- *Eleocharis acicularis*, Fragrant Water Lily-Nymphaea *odorata*, Floating Pondweed -*Potamo gentonnatanus*	9.9	6.67	13.8	D

Food Resources Consumed By Lwd during Study Period: Food resource analysis indicated that LWD foraged on six different food type classes, namely, terrestrial vertebrates and invertebrates, aquatic vertebrates and invertebrates, and aquatic and terrestrial plants. One-way ANOVA and Tukey's test showed that food resources of 10 wetland habitats were significantly different **(Table 3)**. It was ascertaining that food selection by LWD might vary from April to September 2018. They consumed aquatic plants and vertebrates more than the terrestrial plants and vertebrates (Frequency of ± 50) in May and low foraging of aquatic plants and vertebrate's frequency was detected in July (Frequency of ± 5) **(Figure 3)**.

4.1. Interrelationships among Occupancy Estimates, Detection Probabilities and Food Varieties

The interrelationship between the detection probabilities and the AIC for occupancy models revealed a negative and strong significant relationship with occupancy ($R2=0.93$). However, the results of the interrelationships among occupancy estimates, detection probabilities and food varieties foraged by LWD were significantly related with occupancy, detection ($R2=0.72$) and food varieties versus detection probabilities ($R2=0.95$; **Figure 6**).

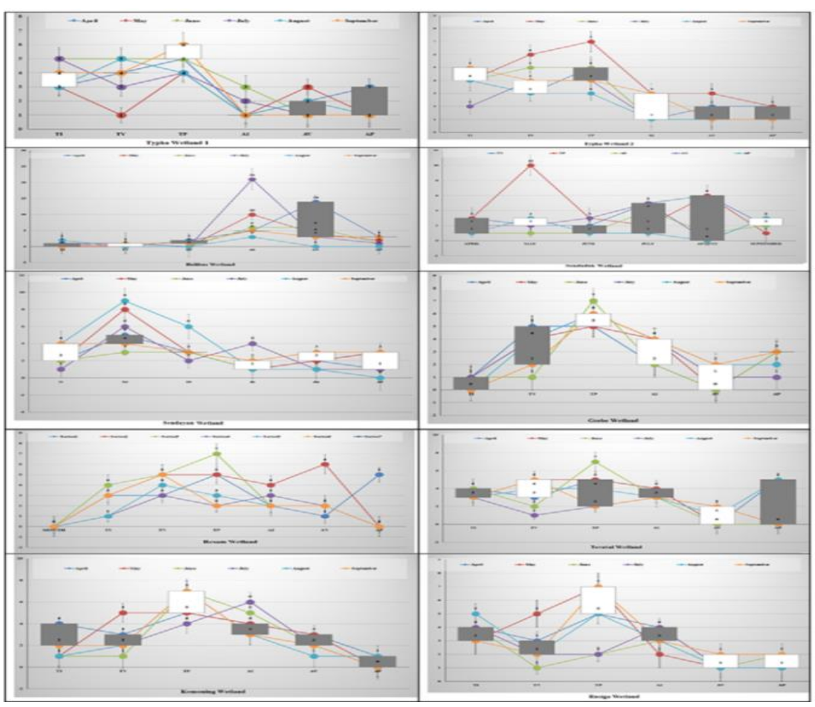

Figure 3.
Food variety consumed by LWD for each month from April– September 2018. [TI=terrestrial Invertebrate, TV= Terrestrial Vertebrates, TP= terrestrial Plant, AI= Aquatic invertebrate, AV= Aquatic vertebrate, AP=Aquatic plants].

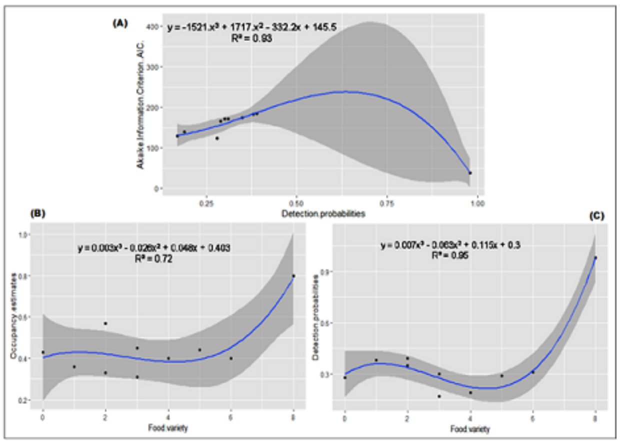

Figure 6.
The interrelationship among site occupancy estimates, detection probabilities and food varieties fed upon by LWD (A) Detection probabilities versus Akaike Information Criterion (B) Food varieties versus occupancy estimate (C) Food varieties versus detection probabilities.

5. Discussions

Wetlands provide critical habitat for diverse wildlife species, particularly waterbirds. Lesser Whistling Duck is a gregarious and sedentary waterbird often occurs in flocks and widely distributed across heterogeneous lowland freshwater wetlands bestowed with abundant submerged and emergent vegetation cover. The finding indicated that Belibis wetland habitat harbored more of LWD, in terms of relative abundance and density, than the other 9 wetland habitats. This may be due to the wetland habitat characteristics and availability of food resources which play a crucial role in habitat selection of these species [40].

LWD used the Belibis wetland extensively compared to the other wetland at PIW for foraging, loafing, perching and breeding. This might be due to the presence of diverse aquatic plants such as Water Chestnut (*Eleocharis dulcis*), Spike Watermifoil (*Myriophyllum spicatum*), Kariba Weed (*Salvinia molesta*), Softstem rush (*Juncus effuses*), Golden Baldderwort (*Utricul ariaaurea*), Bog Bulrush (*Schoenoplectus mucronatus*), Wooly Frogs Mouth (*Philydrum lanuginosum*), Nutrush (*Scleria purpurascens*), Leafy Pond Weed (*Potamogeton foliosus*) and Soft stemmed Bulrush (*Scirpus validus*) [5] and other food resources such as fish fingerlings, amphibians, mollusks and worms [17, 41] stated that LWD is omnivorous alimentary in foraging, eat among dense mats of aquatic vegetation, dominantly prey on small mollusks especially snails, insects, worms, fish fingerlings and small animals often resting inside dense aquatic vegetation. The data of food sampling shows that LWD foraged on vegetation (aquatic plants), fish fingerlings, amphibians, mollusks and worms that often attached to submerged vegetation through dabbling in shallow water, but sometime may dive into water [42-44].

Moreover, the heterogeneity of aquatic vegetation provides camouflage from weather and predators. This was one of the advantages Belibis wetland habitat had over the other wetland habitats. The Belibis wetland characteristics, particularly shallowness, vegetation diversity and cover play crucial role to attract the population of LWD. In addition, the surrounding landscapes such as oil–palm plantations, agriculture fields, fishing ponds and peat swamp forest in PIW may have affected the distribution and density of the ducks through offering refuge areas [45, 46]. This may imply that human interference could alter habitat characteristics and temporal change in the distribution of waterfowl habitats [47].

The results also indicated that dispersal of emergent and submerged vegetation and other food resources in Belibis wetland may potentially affect the distribution, population density, foraging behavior and population structure of LWD. The diversity of this wetland (especially Belibis) plants, food abundance and density tend to vary greatly from habitat to habitat and even within the same habitat from edge to center and water depth. The findings of this study suggested that the LWD is dietary in foraging and they show great flexibility in food selection and site occupancy. It has been illustrated that the wetland vegetation and food distribu tion and diversity often varied in relation to water depth [48, 49]. In another large wetland, LWD may be found around edges dominated by Water Chestnut, *Spike Water Milfoils*, *Kariba Weed*, *Softstem Rush*, *Golden Baldderwort*, *Bog Bulrush*, *Wooly Frogs Mouth*, *Nutrush*, *Leafy Pond Weed* and Soft-stemmed Bulrush with deep water and open center adhered to food resources [50-52]. Previously, it has been found that nutrimental quality of submerged leaves [53] seed (high fat and crude protein contents, e.g. *Nympheaceae* [54-56] and seed ease significantly foraging decisions [57]. Variety of food resources provide a stable diet rich in nutrients that are essential for his growth, feather strength, breeding success.
The study indicated that Belibis wetland habitat was the most preferred habitat due to the abundant food resources. However, clear species-specific habitat occupancy and preferences of LWD highlighted that the rest of wetland habitats also play a role as intrinsic habitats. These other wetland habitats attract other waterfowl species such as, *Cotton Pygmy Goose*, *Purple Swamphen*, *Common Moorhens* and *Crake* species and enhance the waterbird diversity in this PIW [58].

Notably, the highest relative abundance of LWD was detected in the morning hours than evening hours. The morning time was appropriate for ducks to forage on a variety of food resources. Such findings were also recorded by Martins, et al. [21]. When the temperature rises, the ducks hide in vegetation surrounded by trees for perching and loafing. However, these ducks are a shy species often disturbed by human presence, illegal fishing, noise pollution and conservation works, i.e., weed cutting along the wetland edges, piling work along the walking paths and tourists [59]. These activities, disturbed the activities performed by LWD; shift in movement, use of alternate wetland habitat might be not suitable for them, less success of breeding and dispersal of the duck ling that may be caught by predators, e.g., water monitor lizard, Western Marsh Harriers, Brahminy kites, Grey and Purple Herons. These animals are common predators of this wetland reserve.

6. Conclusions

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. LWD flocked more in Belibis wetland habitat because of its shallow depth and presence of diverse food sources such as aquatic and terrestrial plants and vertebrates. LWD is omnivorous in nature and the have a variety of diet. This different food sources provide good nutrition for the health of LWD growth, feather strength, muscle development, and breeding success. Aquatic plants provide shelter, protection, nutrition and breeding grounds for a LWD. This study provides conservationist and wetland managers with a detailed understanding of the preferred habitat, and the type of food sources eaten by LWD.

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References

[1] M. Zakaria, M. Rajpar, and S. Sajap, "Species diversity and feeding guilds of birds in Paya Indah Wetland Reserve, Peninsular Malaysia," *International Journal of Zoological Research*, vol. 5, pp. 86-100, 2009. https://doi.org/10.3923/ijzr.2009.86.100

[2] L. Heinz, "Waterfowl of the carambolim lake," *Newsletter for Birdwatchers*, vol. 40, pp. 59-60, 2000.

[3] R. Anderson and M. Baldock, "New records of birds from the Maldives, with notes on other species," *Forktail*, vol. 17, pp. 67-73, 2001.

[4] S. Mazumdar, P. Ghosh, and G. K. Saha, "Diversity and behaviour of waterfowl in Santragachi Jheel, West Bengal, India, during winter season," *Indian Birds*, vol. 1, no. 3, pp. 68-69, 2005.

[5] M. Rajpar and M. Zakaria, "Density and diversity of water birds and terrestrial birds at Paya Indah Wetland Reserve, Selangor Peninsular Malaysia," *Journal of Biosciences*, vol. 10, pp. 658- 666, 2010. https://doi.org/10.3923/jbs.2010.658.666

[6] L. Ang, W. Ho, and L. Tang, "A model of greened ex-tin mine as a lowland biodiversity depository in Malaysia," *Journal of Wildlife and Parks*, vol. 29, pp. 61-67, 2014.

[7] M. Hashim, N. Nayan, Y. Saleh, H. Mahat, and Z. Said, "Water quality assessment of former tin mining lakes for recreational purposes in Ipoh city, Perak, Malaysia," *Indonesian Journal Geo*, vol. 50, pp. 25-33, 2018. https://doi.org/10.22146/ijg.15665

[8] G. McMahon and S. Moreira, *The contribution of the mining sector to socio-economic and human development* Washington, DC: World Bank, USA, 2014.

[9] U. Iqbal, "The historical development of Japanese investment in Malaysia (1910-2003)," Thesis Universiti Kebangsaan Malaysia, 2015.

[10] N. H. Sulaiman, S. I. Khalit, Z. Sharip, M. S. Samsudin, and A. Azid, "Seasonal variations of water quality and heavy metals in two ex-mining lake using chemometric assessment approach," *Malaysian Journal of Fundamental and Applied Sciences*, vol. 14, no. 1, pp. 67-72, 2018.

[11] M. Z. Asmawi, "The effects of town planning system in wetland management Peninsular Malaysia," in *In Proceedings of the International Seminar on Wetlands and Sustainability, Sept*, 2007, pp. 4-6.

[12] K. Orji, N. Sapari, K. Yusof, R. Asadpour, and E. Olisa, "Comparative study of water quality of rivers used for raw water supply and ex-mining lakes in Perak, Malaysia," *IOP Conference Series: Earth and Environmental Science*, vol. 16, pp. 1-4, 2013. https://doi.org/10.1088/1755-1315/16/1/012072

[13] M. Widyastuti and E. Haryono, "Water quality characteristics of JongeTelaga doline pond as water resources for the people of Semanu district Gunungkidul regency," *Indonesian Journal Geography* vol. 48, pp. 157-167, 2016. https://doi.org/10.22146/ijg.17595

[14] A. Gillespie, "Protected areas and international environmental law," *Koninkilijke, Brill NV, Leiden, Netherland*, p. 318, 2007. https://doi.org/10.1163/ej.9789004161580.i-320

[15] S. Taylor and K. Pollard, "Evaluation of two methods to estimate and monitor bird populations," *PLoS One*, vol. 3, p. e3047, 2008. https://doi.org/10.1371/journal.pone.0003047

[16] B. Hansen, P. Menkhorst, P. Moloney, and R. Lyon, "Long-term declines in multiple waterbird species in a tidal embayment, South-east Australia," *Austral Ecology*, vol. 40, pp. 515-527, 2015. https://doi.org/10.1111/aec.12219

[17] B. Manjari and U. Withanage, "Variation of avifaunal diversity in relation to land-use modifications around a tropical estuary, the Negombo estuary in SriLanka," *Journal Asia-Pacific Biodiversity*, vol. 8, pp. 72-82, 2015. https://doi.org/10.1016/j.japb.2015.02.001

[18] W. Wang, J. Fraser, and J. Chen, "Wintering waterbirds in the middle and lower Yangtze river floodplain: Changes in abundance and distribution," *Bird Control International*, vol. 27, pp. 167-186, 2017. https://doi.org/10.1017/S0959270915000398

[19] S. Mohamed and P. Anjana, "Conservation status, species composition and distribution of avian community in Bhimbandh wildlife sanctuary, India," *Journal Asia-Pacific Biodiversity*, vol. 10, pp. 20-26, 2017. https://doi.org/10.1016/j.japb.2016.07.004

[20] G. Thiere, S. Milenkovski, P. Lindgren, G. Sahlén, and O. Berglund, "Wetland creation in agricultural landscapes: Biodiversity benefits on local and regional scales," *Biological Conservation*, vol. 142, pp. 964-973, 2009. https://doi.org/10.1016/j.biocon.2009.01.006

[21] C. Martins, M. Rajpar, S. Nurhidayu, and M. Zakaria, "Habitat selection of dendrocygnajavanica in heterogeneous lakes of Malaysia," *Journal Biodivers Manage Forestry*, vol. 6, 2017. https://doi.org/10.4172/2327-4417.1000183

[22] M. Rajpar, M. Zakaria, I. Ozdemir, M. Ozturk, and S. Gucel, "Avian assemblages at Paya Indah natural wetland reserve, Malaysia," *Expert Opinion on Environmental Biology Journal*, vol. 7, no. 1, p. 3, 2017. https://doi.org/10.4172/2325-9655.1000148

[23] J. Altmann, "Observational study of behavior: Sampling methods," *Behaviour*, vol. 49, pp. 227-266, 1974. https://doi.org/10.1163/156853974X00534

[24] F. Bibi and Z. Ali, "Measurement of diversity indices of avian communities at Taunsa Barrage Wildlife Sanctuary, Pakistan," *Journal of Animal and Plant Sciences*, vol. 23, pp. 469-474, 2013.

[25] D. Ward and M. Lariviere, "Terrestrial invertebrate surveys and rapid biodiversity assessment in New Zealand: Lessons from Australia," *New Zealand Journal of Ecology*, vol. 28, pp. 151-159, 2004.

[26] J. Henke, "Assessing the efficacy of different sampling methods and determining lenth-mass relationship for wetland invertebrates." Georgia: The University of Georgia, 2005, p. 34.

[27] E. Gage and D. Cooper, *Vegetation sampling for wetland delineation: A review and Synthesis of methods and sampling issues*. Washington DC: US Army Corps of Engineers, 2010.

[28] M. Yaseen, R. Saxena, and V. Koli, "Avian diversity of Sitamata Wildlife Sanctuary, Rajasthan, India," *Geobios*, vol. 38, pp. 257-264, 2011.

[29] C. McGraw-Hill, *Statistix 8.1 analytical software*. Tallahassee Florida: Maurice/Thomas text, 2008.

[30] J. Carvajal-Castro, A. Ospina-L, Y. Toro-Lopez, A. Pulido-G, and L. Cabrera-Casas, "Birds vs bricks: Patterns of species diversity in response to urbanization in a neotropical Andean city," *PLoSONE*, vol. 14, p. e0218775, 2019. https://doi.org/10.1371/journal.pone.0218775

[31] D. MacKenzie, J. Nichols, G. Lachman, S. Droege, and R. Andrew, "Estimating site occupancy rates when detection probabilities are less than one," *Ecology*, vol. 83, pp. 2248-2255, 2002. https://doi.org/10.1890/0012-9658(2002)083[2248:ESORWD]2.0.CO;2

[32] B. Williams, J. Nichols, and M. Conroy, *Analysis and management of animal populations*. London: Academic Press, 2002.

[33] J. Howell, C. Moore, M. Conroy, R. Hamrick, and R. Cooper, "Conservation of northern bobwhite on private lands in Georgia, USA under uncertainty about landscape-level habitat effects," *Landscape Ecol*, vol. 24, pp. 405-418, 2009. https://doi.org/10.1007/s10980-008-9320-x

[34] D. MacKenzie, J. Nichols, J. Royle, K. Pollock, and L. Bailey, *Occupancy estimation and modeling-inferring patterns and dynamics of species occurrence*, 2nd ed. Massachusetts, USA: Elsevier/Academic Press, 2018.

[35] L. Thomas, S. Buckland, E. Rexstad, J. Laake, and S. Strindberg, "Distance software: Design and analysus of distance sampling surveys for estimating population size," *Journal of Applied Ecology*, vol. 47, pp. 5-14, 2010. https://doi.org/10.1111/j.1365-2664.2009.01737.x

[36] T. Marques, S. Buckland, R. Bispo, and B. Howland, "Accounting for animal density gradients using independent information in distance sampling surveys," *Statistical Methods & Applications*, vol. 22, pp. 67-80, 2013. https://doi.org/10.1007/s10260-012-0223-2

[37] T. Gatesire, D. Nsabimana, A. Nyiramana, J. Seburanga, and M. Mirville, "Bird diversity and distribution in relation to urban landscape types in Northern Rwanda," *The Scientific World Journal*, vol. 2014, pp. 1-12, 2014. https://doi.org/10.1155/2014/157824

[38] A. Welsh, D. Lindenmayer, and C. Donnelly, "Correction: Fitting and interpreting occupancy models," *PLoS ONE*, vol. 8, pp. 1-2, 2013. https://doi.org/10.1371/annotation/83cc3ff1-9438-4b1d-abf4-07f378ed558f

[39] B. Sun, H. Liu, S. Zhou, and W. Li, "Evaluating the performance of polynomial regression method with different parameters during color characterizations," *Mathematical Problems in Engineering*, vol. 2014, pp. 1-7, 2014. https://doi.org/10.1155/2014/418651

[40] V. Koli, "Diversity and status of avifauna in Todgarh-Raoli Wildlife Sanctuary, Rajasthan, India," *Journal Asia-Pacific Biodiversity*, vol. 7, pp. 401-407, 2014. https://doi.org/10.1016/j.japb.2014.10.005

[41] A. Naithani and D. Bhatt, "Bird community structure in natural and urbanized habitats along an altitudinal gradient in Pauri district (Garhwal Himalaya) of Uttarakhand state, India," *Biologia*, vol. 67, pp. 800-808, 2012. https://doi.org/10.2478/s11756-012-0068-z

[42] A. Rahmani and M. Islam, "Ducks, geese and swans of India: Their status and Distribution indian bird conservation network: Bombay natural history society, royal society for protection of birds and bird life international," Oxford University Press, 2008, p. 374.

[43] L. Hansson, A. Nicolle, C. Bronmark, A. Hargeby, and A. Lindstrom, "Waterfowl, macrophytes and the clear water state of shallow lakes," *Hydrobiologyia*, vol. 646, pp. 101-109, 2010. https://doi.org/10.1007/s10750-010-0169-z

[44] B. Kreakie, Y. Fan, and T. Keitt, "Enhanced migratory waterfowl disribution modeling by inclusion of depth of water table data," *PlosOne*, vol. 7, p. e30142, 2012. https://doi.org/10.1371/journal.pone.0030142

[45] M. Piha, J. Tiainen, J. Holopainen, and V. Vepsäläinen, "Effects of land-use and landscape characteristics on avian diversity and abundance in a boreal agricultural landscape with organic and conventional farms," *Biopharmaceutical Company*, vol. 140, pp. 50-61, 2007. https://doi.org/10.1016/j.biocon.2007.07.021

[46] Y. Zhang, A. Fox, L. Cao, Q. Jia, and C. Lu, "Effects of ecological and anthropogenic factors on waterbird abundance at a Ramsar Site in the Yangtze river Floodplain," *Ambio*, vol. 48, pp. 293-303, 2018. https://doi.org/10.1007/s13280-018-1076-1

[47] J. Madsen, "Impacts of disturbance on migratory waterfow," *IBISI*, vol. 137, pp. S67-S74, 1995. https://doi.org/10.1111/j.1474-919X.1995.tb08459.x

[48] A. Bonias, J. Lepart, and P. Grillas, "Seed bank dynamics and co-existence of annual macrophytes in a temporary and variable habitat," *JSTOR*, vol. 74, pp. 81-92, 1995. https://doi.org/10.2307/3545677

[49] Y. Ntimamoa-Baidu, T. Piersma, P. Wiersma, M. Poot, and P. Battley, "Water depth selection, daily feeding routines and diets of waterbirds in coastal lagoons in Ghana," *IBIS*, vol. 140, pp. 89-103, 1998. https://doi.org/10.1111/j.1474-919X.1998.tb04545.x

[50] A. Green, "Habitat selection by marbled teal Marmaronettaangustirostris, ferrugineous duck Aythyanyroca and other ducks in the Goksu Delta, Turkey in late summer," *Revue d'Ecologie (La Terre et la Vie)*, vol. 53, pp. 225-243, 1998.

[51] T. Nudds, J. Elmberg, K. Sjoberg, H. Poysa, and P. Nummi, "Ecomorphology in breeding Holarctic dabbling ducks: The importance of lamellar density and body lenth varies with habitat type," *Okios*, vol. 91, pp. 583-588, 2000. https://doi.org/10.1034/j.1600-0706.2000.910321.x

[52] M. Takeuchi, "Winter bird communities in the heterogeneous farmlands of the Aso region in Japan," *Journal Asia Pacific Biodiversity*, vol. 12, pp. 152-159, 2019. https://doi.org/10.1016/j.japb.2019.01.013

[53] P. Clausen, B. Nolet, A. Fox, and M. Klaassen, "Long-distance endozoochorous dispersal of submerged macrophyte seed by migratory waterbirds in northern Europe: A criticl review of possibilities and limitations," *ActaOecologica*, vol. 23, pp. 191-203, 2002. https://doi.org/10.1016/S1146-609X(02)01150-5

[54] A. Smith, R. Van Ruremonde, and G. Van der Velde, "Seed dispersal of three nymphaeidmacrophytes," *Aquatic Bot*, vol. 35, pp. 167-180, 1989. https://doi.org/10.1016/0304-3770(89)90103-4

[55] S. Petrie, "Red-billed teal foods in semiarid South Africa: A north-temperate contrast," *JSTOR*, vol. 60, pp. 874-881, 1996. https://doi.org/10.2307/3802388

[56] S. Rachakonda, S. Umesh, M. Christos, C. Jin, and M. Uromi, "The effect of land-use on the diversity and mass-abundance relationships of understory avian insectivores in Sri Lanka and southern India," *Scientific Reports*, vol. 5, p. 11569, 2015. https://doi.org/10.1038/srep11569

[57] I. Charalamnidou and L. Santamaria, "Waterbirds as endozoochorous dispersers of aquatic organisms: A review of experimental evidence," *ActaOecologica*, vol. 23, pp. 165-176, 2002. https://doi.org/10.1016/S1146-609X(02)01148-7

[58] B. McMahon, T. Campus, and J. Whelan, "A comparison of winter bird communities in agricultural grassland and cereal habitats in Ireland: Implications for common agricultural policy reform," *Bird Study*, vol. 60, pp. 176-184, 2013. https://doi.org/10.1080/00063657.2012.758227

[59] A. Lord, J. Waas, J. Innes, and M. Whittingham, "Effects of human approaches to nests of morthern New Zealand dotterels," *Biological Conservation*, vol. 98, pp. 233-240, 2001. https://doi.org/10.1016/S0006-3207(00)00158-0