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ASCERTAIN THE PRODUCTIVITY OF HETEROGENOUS WETLAND AND ADJACENT HABITATS THROUGH AVIAN FORAGING GUILDS

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ABSTRACT

Birds are the most conspicuous component of wetland habitats, i.e., they are highly motile and sensitive to multitude habitat variables. Various avian species were surveyed using a distance sampling point count method and were assigned into different foraging guilds based on food selection, foraging techniques and habitat preferences. The results of foraging guilds indicated that the marsh swamp habitat was most productive, i.e., heavily utilized by avian species (i.e. 143.00 ± 23.86 birds ha^{-1}) and the dryland with scattered trees was less productive, i.e., less preferred by them (i.e. 65.03 ± 9.79 birds ha^{-1}). Overall, guild Frugivore/Insectivore birds were the most dominant (149.89 ± 20.25 birds ha^{-1}) and Carnivore (0.40 ± 0.19 birds ha^{-1}) were less abundant in five habitats. Likewise, resident birds were the most dominant in each habitat and vagrant birds were rarely observed. For migrant bird, guild Insectivore was the most dominant in five habitats such as marsh swamp; 1.24 ± 0.08 birds ha^{-1}, lotus swamp; 1.28 ± 0.32 birds ha^{-1}, open water body; 0.74 ± 0.12 birds ha^{-1}, dryland with scattered trees; 2.05 ± 0.20 birds ha^{-1} and scrubland; 1.44 ± 0.15 birds ha^{-1}. The findings of foraging guilds indicated that birds are specialize in food selection, i.e., foraged on a wide array of animals through employing various foraging techniques to catch their prey and select the available wetland and adjacent habitats in different ways depending on availability of food resources, foraging behaviour and niche. Hence, birds are bio-indicators of wetland and adjacent habitats and can be ascertained the productivity (health) of the particular habitat.

Keywords: Foraging guild, Marsh Swamp, Bird, Migrant, Residents, Scrubland.

INTRODUCTION

Food is major crucial factor for avian species to take energy and to perform multiple activities for survival and reproduction (Guillemain and Fritz, 2002). For bird species, foraging site selection and feeding technique are important factors to exploit the food resources (Jing *et al*. 2007, Gatto *et al*. 2008). Food resources in wetland habitats distributed sparsely and densely depending on habitat structure and composition. The monitoring foraging guild is an effective method to ascertain the health of particular habitat and lead to improve the habitat in the future. Birds are perhaps the most conspicuous and highly motile, and sensitive to multitude habitat variables (Thorngate *et al*., 2006, Jing *et al*., 2007) and are bio-indicators of wetland ecosystems (Gokula and Vijayan, 2000; Hobson and Bayne, 2000; Loyn, 2002; Gray *et al*., 2007). They forage on a variety of animals such as insects, centipedes, crustaceans, molluscs, amphibians, fish, reptiles, small birds, rodents and plant materials. While, birds employ various foraging techniques to hunt their prey is called feeding guild. Whereas, feeding guild is a group of bird species which may exploit the same foraging sites, same food resources, and foraging techniques in a similar way, even though they differs taxonomically (Simberloff and Dayan, 1991; Somasundaram and Vijayan, 2008).

Foraging guilds provide information on bird community structure and productivity of a particular habitat (Blondel, 2003; Lopez de Casenve *et al*., 2008). Feeding guilds among avian species may vary, which may effectively avoid the interspecific competition of food resources and fully utilized the food resources of a particular habitat. Bird richness and diversity is attributed to various factors such as diversity of vegetation, availability and richness of food resources, and water depth, etc. Vegetation diversity and richness create ideal foraging and nesting sites for a variety of bird assemblages, reduced the risk of predation and influence on bird distribution (Gunnarsson, 1996; Ydenberg *et al*., 2002; Adamik *et al*., 2003, Jing *et al*., 2007; Casas *et al.,* 2016). In addition, the occurrence of shallow water, richness of food resources, adjacent landscape and microclimate are major drivers to attract a wide array of avian species to utilize a dwelling habitat.

Globally, habitat loss and degradation have affected the populations of many bird species (Stroud *et*

al., 2004; Goudie, 2006; Gray *et al*., 2007; Rendon *et al*., 2008) which extensively depend on wetland and adjacent habitat for food, shelter, roosting and breeding purposes. Information on foraging guilds and bird assemblage utilizing wetland and adjacent habitat is extremely important to understand the food resources and the importance of particular habitat for avian species. A detailed information on foraging guilds and food resources in different wetland and adjacent habitat is still lacking. Only few studies have been carried out on food resources and foraging guilds of bird species utilize wetland and adjacent habitats. The primary aim of this study was to determine foraging guilds of avian assemblages inhabited in five different wetland and adjacent habitats such as marsh swamp, lotus swamp, open water body, open area with scattered trees and shurblands to understand the bird assemblages and productivity of each habitat.

MATERIALS AND METHODS

Study Area: The research study was carried out into five remnant habitats (i) marsh swamp (140 hectares), (ii) lotus swamp (116 hectares), (iii) open water body (238 hectares), (iv) open area with scattered trees (55 hectares), and (v) shrublands (51 hectares) located within 101°10′ to 101°50′ longitude and 2°50′ and 3°00′ latitude (Figure 1). Each area may vary in vegetation composition and represented specific environmental features that meet the biological needs of wetland bird as well as open country bird species.

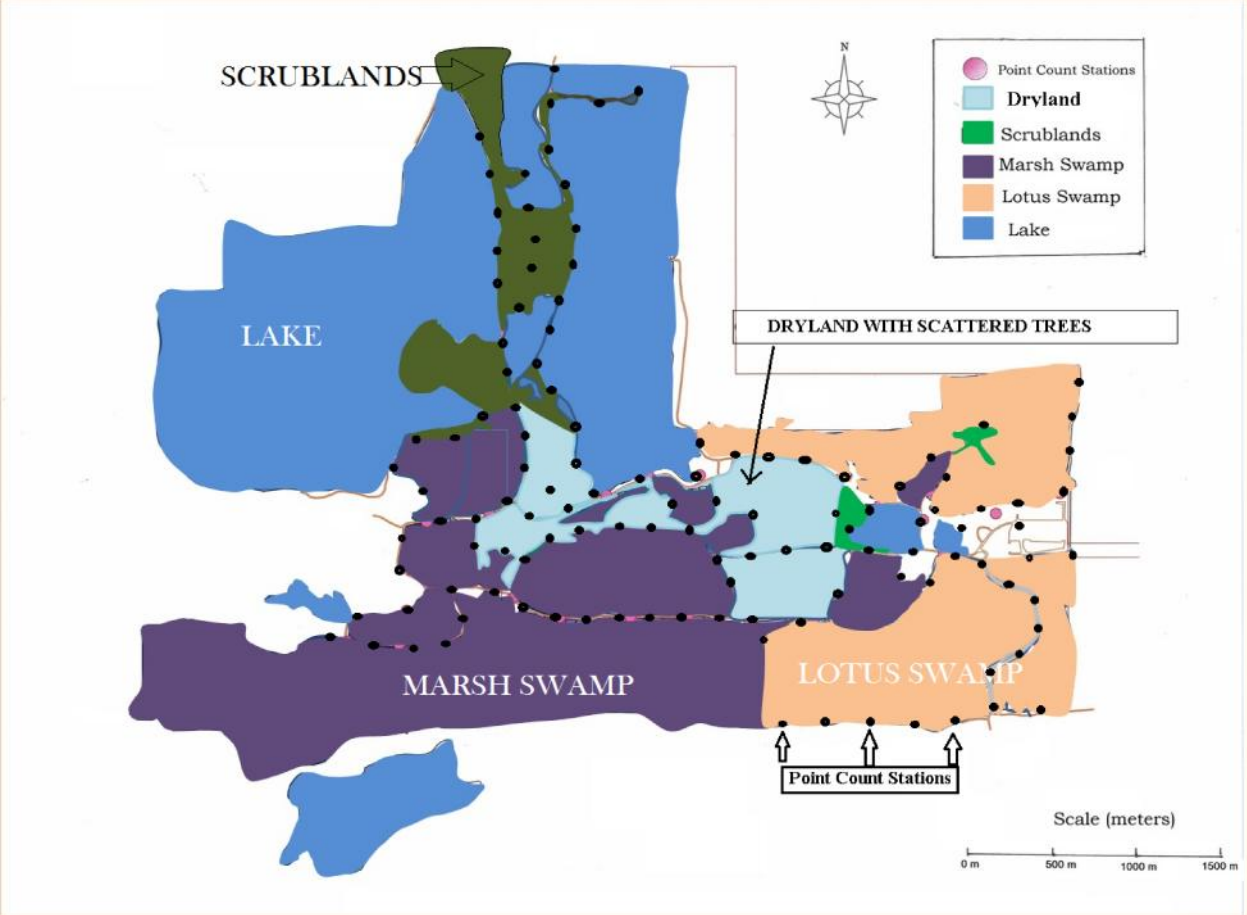

Fig 1. Detailed map of study areas

Marsh Swamp: Marsh swamp was larger lakes with shallower water dominated by lush growths of aquatic herbaceous vegetation such as sedges, reeds, rushes and grasses (Fig. 2). The plants grow with their stems partly in and partly out of the water. Marsh swamp is predominantly covered with aquatic plants, i.e., *Eleocharis dulcis, Lepironia articulata, Stenochlaena palustris, Philydrum lanuginosum,* and *Scleria purpurascens*. The water body edges were covered with different tree species such as *Acacia auriculiformis*, *A. mangium, Macaranga tanarius, Peltophorum pterocarpum, Cinnamonum iners, Melicope glabra*, and *Melastoma malabathricum* along the edges.

Fig 2. Aesthetic view of marsh swamp

Lotus Swamp: Lotus Swamp was a shallower water pond dominated *Nelumbo nucifera, N. nouchali, N. pubescens, E. dulcis, Elodea* sp., *Phragmites karka* reeds and *Typha angustifolia* while dry area were covered with *A. auriculiformis*, *A. mangium* and some parts with *M. malabathricum* (Fig. 3)

Fig 3. Aesthetic view of lotus swamp

Lake: Lake habitat was a group of larger and deep water bodies dominated by submerged and emergent vegetation such as *Nymphaea odorata, Potamogeton* spp., *E. dulcis, Myriophyllum spicatum, Salvinia molesta, Scirpus sylvaticus, S. californicus, S. Mucronatus, S. Maritimus, E. dulcis, S. purpurascens, Sagittaria latifolia* and *Hydrilla* sp. (Fig. 4).

Fig 4. Aesthetic view of lake habitat

Dryland with Scattered Trees: Dryland areas were dominated by scattered flowering and fruiting trees (i.e. *C. iners, M. glabra, Ficus rubiginosa, F. benjamina, Syzygium grande, S. polyanthum, Caryota mitis, Delonix regia*, and *Fragraea fragrans*) (Fig. 5). The ground were densely covered with different grass species such as *Imperata cylindrica, Cynodon dactylon,* and *Distichlis spicata*.

Fig 5. Aesthetic view of dryland habitat

Scrubland: Scrubland was dominated with an aggregation of woody plants or shrubs such as *Melastoma malabathricum, Dillenia suffruticosa* and young tree saplings of *A. auriculiformis* and *A. mangium* having less than ten feet height and 10cm dbh (Fig. 6). The ground vegetation dominated with grasses, i.e. Cogon Grass (*I. cylindrica*), Climbing Fern (*S. palustris*), Fern Tree (*Gleichenia linearis*) and Giant Weed (*S. molesta*).

Fig 6. Aesthetic view of scrubland

Bird Surveys: Birds were surveyed using a distance sampling point count technique (Buckland *et al*., 2004) for 15 consecutive months from July, 2013 to September, 2014. Distance sampling is widely used to study animal populations, including avian and mammal communities (Buckland *et al*., 2004) in a variety of habitats such as lakes (Aborn, 2007), forests (Lee and Marsden, 2008) and wetlands (Nadeau *et al*., 2008). The replication of point count stations increased the precision and provided reliable results (Smith *et al*., 1993; Petit *et al*., 1995). A total of 188 point count stations at 300 m intervals were established within five habitats (Marsh Swamp; 43 stations, Lotus Swamp; 38 stations, Lake; 40 stations, Dryland; 35 stations, and Scrubland; 32 stations). The main reason of using 300m intervals was to avoid double counting of the same birds at more than one station. The surveys were conducted between 0730 and 1100 hours. This period of time is appropriate, as most birds are active early in the morning. The detections of birds within each point station were done for 10 minutes. Ten-minute count enabled the researcher to record sufficient numbers of individuals with minimal efforts and disturbances (Jimenez 2000; Lee and Marsden 2008; Zakaria *et al*. 2009). During each survey, all bird species and individuals seen or heard were recorded. The flushed birds were also recorded and their known original positions were included in the analysis. However, flying birds were not recorded due to unknown original position. The sampling methodology was based on Bibby *et al*. (2000), Hosteler and Main (2001), Buckland *et al.* (2004), Aborn (2007), Nadeau *et al*. (2008), and Aynalem and Bekele (2008).

Bird Density Analysis: The feeding guild densities of bird species were determined by Distance Software (Version 6.1) (Buckland *et al*., 2004). Bird species with fewer than five detections were not analysed due to their low sample size, as recommended and described by Marsden (1999) and Buckland (2001).

Feeding Guilds: The feeding guilds of all the sampled bird species were categorized based on major food, foraging behaviour and habitat selection as reported by Ehrlich *et al*. (1988) and Degraaf *et al*. (1985). It was difficult to analyze feeding guild of each bird species separately, so we categorized birds in nine major feeding guilds which were exploit the same foraging sites, same food resources and foraging techniques in a similar way. Thorngate *et al.* (2006) reported that bird species can be grouped into functional guilds that may reflect the exploitation of same food resources and foraging technique in a similar way in a particular habitat.

RESULTS

The results of this study indicated that marsh swamp habitat was heavily utilized by avian species (i.e. (143.00 ± 23.86 birds ha^{-1}) and dryland with scattered trees was less preferred (i.e. (65.03 ± 9.79 birds ha^{-1}). Overall, in five habitats, the highest population was recorded for guild Frugivore/Insectivore (149.89 ± 20.25 birds ha^{-1}) and lowest population was determined for Carnivore (0.40 ± 0.19 birds ha^{-1}) (Table 1).

Feeding Guilds Density in Five Habitats: Three guilds i.e., Frugivore/Insectivore (57.18 ± 6.90 birds ha^{-1}), Insectivore (26.98 ± 4.94 birds ha^{-1}) and Omnivore (18.42 ± 2.64 birds ha^{-1}) were found most dominant in marsh swamp habitat. On the contrary, the Carnivore (0.11 ± 0.06 birds ha^{-1}) were the rarest guild in the marsh swamp habitat (Table 1 and 2).

Likewise, in lotus swamp habitat, three feeding guilds such as Frugivore/Insectivore (22.30 ± 3.25 birds ha^{-1}), Insectivore (14.09 ± 3.16 birds ha^{-1}) and Omnivore (12.99 ± 1.34 birds ha^{-1}) were the most dominant guilds. However, the density of two guilds, i.e. the Carnivore and the Carnivore/Insectivore was not calculated due to the low number of detections (Table 1 & 2).

In the lake, the highest guild density was observed for Insectivore (18.64 ± 3.64 birds ha^{-1}), Omnivore (18.64 ± 2.68 birds ha^{-1}) and Granivore (17.38 ± 2.39 birds ha^{-1}). On the other hand, the lowest density was recorded for Carnivore/Insectivore (0.45 ± 0.13 birds ha^{-1}). However, the density of the Carnivore was not determined due to the less number of observations (Table 1 & 2).

Like a lotus swamp habitat, Frugivore/Insectivore (23.06 ± 3.43 birds ha^{-1}) and Insectivore (16.05 ± 2.05 birds ha^{-1}) was the most dominant guilds, whereas the Carnivore and Omnivore (each 0.29 ± 0.13 birds ha^{-1}) were the rarest guilds in a dryland with scattered trees (Table 1 & 2).

In scrubland habitat, the highest guild densities were recorded for Frugivore/Insectivore (34.52 ± 5.14 birds ha^{-1}) and Granivore (19.86 ± 3.12 birds ha^{-1}) whereas, the lowest density was noted in Carnivore/Insectivore (1.12 ± 0.30 birds ha^{-1}). However, the density of guild Carnivore was not analysed due to the less number of observations (Table 1 and 2).

Table 1. Feeding guild density (birds ha^{-1}) in five habitats

Feeding Guilds	Density (birds ha^{-1})					
	Marsh Swamp	Lotus Swamp	Lake	Dryland with Scattered Trees	Scrubland	Total
Frugivore/ Insectivore	57.18 ± 6.90 (n = 1511)	22.30 ± 3.25 (n = 279)	12.83 ± 1.53 (n = 257)	23.06 ± 3.43 (n = 987)	34.52 ± 5.14 (n = 785)	149.89 ± 20.25 (n = 3819)
Insectivore	26.98 ± 4.94 (n = 934)	14.09 ± 3.16 (n = 224)	18.64 ± 3.64 (n = 345)	16.05 ± 2.05 (n = 495)	11.98 ± 1.02 (n = 320)	87.74 ± 14.81 (n = 2318)
Omnivore	18.42 ± 2.64 (n = 1548)	12.99 ± 1.34 (n = 209)	18.64 ± 2.68 (n = 535)	0.29 ± 0.13 (n = 576)	6.58 ± 1.77 (n = 233)	56.92 ± 8.56 (n = 3101)
Granivore/ Insectivore	13.86 ± 2.71 (n = 744)	8.34 ± 2.49 (n = 117)	11.54 ± 2.75 (n = 139)	11.47 ± 1.60 (n = 314)	16.99 ± 2.13 (n = 215)	62.02 ± 11.68 (n = 1529)
Granivore	12.26 ± 2.82 (n = 744)	6.75 ± 1.72 (n = 89)	17.38 ± 2.39 (n = 119)	10.22 ± 1.19 (n = 434)	19.86 ± 3.12 (n = 231)	66.47 ± 11.24 (n = 1617)
Carnivore /Piscivore /Insectivore	12.99 ± 3.40 (n = 649)	9.57 ± 1.33 (n = 167)	5.38 ± 0.34 (n = 131)	1.92 ± 0.77 (n = 194)	1.89 ± 0.37 (n = 101)	31.75 ± 6.21 (n = 1242)
Carnivore/ Insectivore	0.71 ± 0.20 (n = 48)	(n = 0)	0.45 ± 0.13 (n = 12)	0.76 ± 0.25 (n = 26)	1.12 ± 0.30 (n = 20)	3.04 ± 0.88 (n = 106)
Nectarivore/ Insectivore	0.49 ± 0.19 (n = 29)	0.47 ± 0.13 (n = 6)	(n = 2)	0.97 ± 0.24 (n = 31)	2.37 ± 0.22 (n = 14)	4.30 ± 0.78 (n = 82)
Carnivore	0.11 ± 0.06 (n = 5)	(n = 0)	(n = 1)	0.29 ± 0.13 (n = 15)	(n = 3)	0.40 ± 0.19 (n = 24)
Total	143.00 ± 23.86 (n = 6212)	74.51 ± 13.42 (n = 1091)	84.86 ± 13.46 (n = 1541)	65.03 ± 9.79 (n = 3072)	95.31 ± 14.07 (n = 1922)	462.71 ± 74.60 (n = 13838)

Table 2. Feeding guild density (birds ha^{-1}) @ 95% confidence interval in five habitats.

Name of Guilds	Density (birds ha^{-1})				
	Marsh Swamp	Lotus Swamp	Lake	Dryland with Scattered Trees	Scrubland
Frugivore/Insectivore	41.63 – 78.54	16.71 – 29.75	8.05 – 20.43	15.77 – 33.72	25.52 – 46.98
Insectivore	10.82 – 67.27	8.91 – 22.28	8.75 – 39.72	13.05 – 19.74	8.41 – 17.06
Omnivore	13.86 – 24.48	7.70 – 21.90	8.39 – 39.54	0.11 – 0.76	3.88 – 11.15
Granivore/Insectivore	9.41 – 20.41	3.92 – 17.74	6.58 – 20.23	8.00 – 16.46	11.38 – 25.35
Granivore	7.70 – 19.56	1.70 – 26.87	10.12 – 29.85	6.84 – 15.28	11.53 – 34.23
Carnivore /Piscivore/Insectivore	7.21 – 12.71	7.70 -21.90	3.03 – 9.53	0.90 – 4.13	1.27 – 2.83
Carnivore/Insectivore	0.40 – 1.26	--	0.12 – 1.73	0.39 – 1.50	0.65 – 1.94
Nectarivore/Insectivore	0.22 – 1.09	0.11 – 2.02	0.08 – 1.23	0.40 – 2.34	0.99 – 5.64
Carnivore	0.02 – 0.50	--	--	0.11 – 0.76	--

Feeding Guilds Density Based on Status in Five Habitats: The results highlighted that resident birds were the most dominant in each habitat and vagrant birds were the rarest in the study area (Table 3).

Furthermore, three feeding guilds, i.e., Insectivore, Omnivore, and Carnivore/Piscivore-/Insectivore of migrant birds were recorded in five habitats. The results showed that Insectivore was the most dominant guild of migrant birds in five habitats such as marsh swamp (1.24 ± 0.08 birds ha^{-1}), lotus swamp (1.28 ± 0.32 birds ha^{-1}), lake (0.74 ± 0.12 birds ha^{-1}), dryland with scattered trees (2.05 ± 0.20 birds ha^{-1}) and scrubland (1.44 ± 0.15 birds ha^{-1}). However, six feeding guilds of migrant birds were absent in marsh swamp, lotus swamp, seven guilds were absent in lake, dryland with scattered trees and scrubland habitats. In addition, guild Carnivore/Piscivore/Insectivore in marsh swamp, guild Omnivore in lake and scrubland habitats was not analysed due to low sample size (Table 3 and 4).

In Marsh swamp habitat guild Carnivore/Piscivore/Insectivore (2.22 ± 0.28 birds ha^{-1}), in lotus swamp habitat guild Frugivore/Insectivore (2.56 ± 0.35 birds ha^{-1}), in lake guild Granivore (4.53 ± 03.5 birds ha^{-1}), in dryland with scattered trees guild Granivore/Insectivore (4.52 ± 0.71 birds ha^{-1}) and in scrubland guild habitat Granivore/Insectivore (8.75 ± 0.79 birds ha^{-1}) were the most dominant feeding guilds of resident birds. In contrast, guild Carnivore (Marsh Swamp), Carnivore/Insectivore and Carnivore (Lotus Swamp), Nectarivore/Insectivore and Carnivore (lake), and Carnivore (Scrubland) was not analysed due to less number of detections (Table 5 and 6).

Four feeding guilds of Resident–Migrant birds were recorded in five habitats. However, feeding guild may vary from habitat to habitats. For example; Omnivore was major feeding in marsh swamp and lake, Insectivore in lotus swamp and dryland with scattered trees, and Frugivore/Insectivore in scrubland habitat. Five feeding guilds were absent in five habitats (Table 7 and 8).

The guild density of vagrant birds was not analysed due to less number of detections.

Table 3. Feeding guild density (birds ha^{-1}) of migrant birds in five habitats.

Feeding Guilds	Habitats					
	Marsh Swamp	Lotus Swamp	Lake	Dryland with Scattered Trees	Scrubland	Total
Frugivore/ Insectivore	0	0	0	0	0	0
Omnivore	0.18 ± 0.05 (n = 13)	0.67 ± 0.21 (n = 11)	(n = 1)	1.26 ± 0.34 (n = 19)	(n = 2)	2.11 ± 0.60 (n = 46)
Insectivore	1.24 ± 0.08 (n = 208)	1.28 ± 0.32 (n = 23)	0.74 ± 0.12 (n =42)	2.05 ± 0.20 (n = 138)	1.44 ± 0.15 (n = 76)	6.75 ± 0.87 (n = 487)
Granivore/ Insectivore	0	0	0	0	0	0
Granivore	0	0	0	0	0	0
Carnivore/ Piscivore/ Insectivore	(n = 1)	0.35 ± 0.19 (n = 6)	0	0	0	0.35 ± 0.19 (n = 7)
Carnivore/ Insectivore	0	0	0	0	0	0
Nectarivore/ Insectivore	0	0	0	0	0	0
Carnivore	0	0	0	0	0	0
Total	1.42 ± 0.13 (n = 222)	2.30 ± 0.72 (n = 40)	0.74 ± 0.12 (n = 43)	3.31 ± 0.54 (n = 157)	1.44 ± 0.15 (n = 78)	9.21 ± 1.66 (n = 540)

Table 4. Feeding guild density (birds ha^{-1}) of migrant birds in five habitats @ 95% confidence interval.

Feeding Guilds	Habitats				
	Marsh Swamp	Lotus Swamp	Lake	Dryland with Scattered Trees	Scrubland
		Migrants			
Frugivore/Insectivore	–	–	–	–	–
Omnivore	0.09 – 0.36	0.34 – 1.32	–	0.72 – 2.22	–
Insectivore	1.08 – 1.42	0.76 – 2.16	0.54 – 1.01	1.68 – 2.50	1.16 – 1.78
Granivore/Insectivore	–	–	–	–	–
Granivore	–	–	–	–	–
Carnivore /Piscivore/Insectivore	–	0.09 – 1.35	–	–	–
Carnivore/Insectivore	–	–	–	–	–
Nectarivore/Insectivore	–	–	–	–	–
Carnivore	–	–	–	–	–

Table 5. Feeding guild density (birds ha^{-1}) of resident birds in five habitats.

Feeding Guilds	Habitats					
	Marsh Swamp	Lotus Swamp	Lake	Dryland with Scattered Trees	Scrubland	Total
Frugivore/ Insectivore	2.56 ± 0.35 (n = 268)	1.41 ± 0.03 (n = 1451)	2.82 ± 0.57 (n = 243)	10.38 ± 1.69 (n = 944)	5.20 ± 0.52 (n = 734)	22.37 ± 3.16 (n = 3640)
Insectivore	1.94 ± 0.16 (n = 155)	0.99 ± 0.04 (n = 644)	1.29 ± 0.14 (n = 161)	1.23 ± 0.07 (n = 232)	0.94 ± 0.05 (n = 213)	6.39 ± 0.46 (n = 1405)
Omnivore	1.77 ± 0.05 (n = 1331)	0.82 ± 0.18 (n = 159)	2.04 ± 0.18 (n = 506)	2.62 ± 0.39 (n = 479)	0.72 ± 0.08 (n = 191)	7.97 ± 0.88 (n = 2666)
Granivore/ Insectivore	2.22 ± 0.28 (n = 744)	1.04 ± 0.09 (n = 117)	1.82 ± 0.19 (n = 139)	4.52 ± 0.71 (n = 314)	8.75 ± 0.79 (n = 215)	18.35 ± 2.06 (n = 1529)
Granivore	1.72 ±0.28 (n = 744)	1.84 ± 0.86 (n = 89)	4.53 ± 0.35 (n = 119)	3.72 ± 0.62 (n = 434)	4.50 ± 0.41 (n = 231)	16.31 ± 2.52 (n = 1617)
Carnivore/ Piscivore/Insectivore	2.67 ± 0.28 (n = 221)	1.94 ± 0.25 (n = 59)	0.54 ± 0.05 (n = 83)	2.12 ± 0.74 (n = 80)	0.62 ± 0.06 (n = 73)	7.89 ± 1.38 (n = 516)
Carnivore/ Insectivore	0.71 ± 0.11 (n = 48)	0	0.45 ± 0. 22 (n = 12)	0.82 ± 0.21 (n = 26)	1.00 ± 0.20 (n = 20)	2.98 ± 0.74 (n = 106)
Nectarivore/ Insectivore	0.36 ± 0.10 (n = 29)	0.35 ± 0.21 (n = 6)	(n = 2)	0.56 ± 0.16 (n = 31)	1.50 ±0.58 (n =14)	2.77 ± 1.05 (n = 82)
Carnivore	(n = 4)	0	0	0.27 ± 0.08 (n = 13)	(n =2)	0.27 ± 0.08 (n = 19)
Total	13.95 ± 1.61 (n = 3544)	8.39 ± 1.66 (n = 2525)	13.49 ± 1.70 (n = 1265)	26.24 ± 4.67 (n = 2553)	23.23 ± 2.69 (n = 1693)	85.30 ± 11.47 (n = 11580)

Table 6. Feeding guild density (birds ha^{-1}) of resident birds in five habitats @ 95% confidence interval.

Feeding Guilds	Habitats				
	Marsh Swamp	Lotus Swamp	Lake	Dryland with Scattered Trees	Scrubland
Frugivore/Insectivore	1.96 – 3.36	1.34 – 1.49	1.89 – 4.20	7.55 – 14.28	4.28 – 6.33
Insectivore	1.64 – 2.28	0.91 – 1.08	1.04 – 1.61	1.09 – 1.39	0.83 – 1.06
Omnivore	1.67 – 1.89	0.54 – 1.28	1.72 – 2.42	1.95 – 3.51	0.58 – 0.91
Granivore/Insectivore	1.74 – 2.83	0.86 – 1.26	1.52 – 2.19	3.32 – 6.17	7.32 – 10.46
Granivore	1.25 – 2.37	0.76 – 4.45	3.90 – 5.28	2.67 – 5.17	3.76 – 5.38
Carnivore/Piscivore/Insectivore	2.17 – 3.28	1.50 – 2.51	0.44 – 0.67	1.07 – 4.19	0.43 – 0.97
Carnivore/Insectivore	0.53 – 0.96	–	0.16 – 1.26	0.49 – 1.38	0.66 – 1.50
Nectarivore/Insectivore	0.20 – 0.66	0.08 – 1.49	–	0.32 – 1.00	0.66 – 3.42
Carnivore	–	–	–	0.13 – 0.52	–

Table 7. Feeding guild density (birds ha^{-1}) of resident–migrants in five habitats.

Feeding Guilds	Habitats					
	Marsh Swamp	Lotus Swamp	Lake	Dryland with Scattered Trees	Scrubland	Total
Frugivore/Insectivore	2.25 ± 0.49 (n = 59)	1.82 ± 0.75 (n = 11)	0.29 ± 0.12 (n = 14)	0.97 ± 0.15 (n = 43)	0.73 ± 0.12 (n = 51)	6.06 ± 1.63 (n = 178)
Omnivore	4.18 ± 0.47 (n = 204)	2.14 ± 0.23 (n = 39)	1.74 ± 0.66 (n = 28)	1.78 ± 0.20 (n = 78)	0.44± 0.08 (n = 40)	10.28 ± 1.64 (n = 389)
Insectivore	0.84 ± 0.34 (n = 82)	2.37 ± 0.33 (n = 46)	0.50 ± 0.15 (n = 142)	2.22 ± 0.21 (n = 125)	0.64 ± 0.16 (n = 31)	6.57 ± 1.19 (n = 426)
Granivore/Insectivore	0	0	0	0	0	0
Granivore	0	0	0	0	0	0
Carnivore/ Piscivore/ Insectivore	1.19 ± 0.13 (n = 428)	1.59 ± 0.36 (n = 102)	0.80 ± 0.13 (n = 48)	1.00 ± 0.09 (n = 114)	0.65 ± 0.13 (n = 28)	5.23 ± 0.84 (n = 720)
Carnivore/Insectivore	0	0	0	0	0	0

Nectarivore/ Insectivore	0	0	0	0	0	0
Carnivore	0	0	0	0	0	0
Total	8.46 ± 1.43 (n = 773)	7.92 ± 1.67 (n = 198)	3.33 ± 1.06 (n = 232)	5.97 ± 0.65 (n = 360)	2.46 ± 0.49 (n = 150)	28.14 ± 5.30 (n = 1713)

Table 8. Feeding guild density (birds ha^{-1}) of Resident–Migrants in five habitats @ 95% confidence interval.

Feeding Guilds	Habitats				
	Marsh Swamp	Lotus Swamp	Lake	Dryland with Scattered Trees	Scrubland
Frugivore/Insectivore	1.47 – 3.43	0.74 – 4.46	0.13 – 0.69	0.69 – 1.34	0.53 – 1.00
Omnivore	3.34 – 5.23	1.59 – 2.90	0.82– 3.70	1.43 – 2.21	0.31 – 0.64
Insectivore	0.39 – 1.83	1.78 – 3.14	0.08 – 2.97	1.84 – 2.68	0.39 – 1.05
Granivore/Insectivore	–	–	–	–	–
Granivore	–	–	–	–	–
Carnivore/Piscivore/Insectivore	0.96 – 1.48	1.02 – 2.47	0.57 – 1.12	0.83 – 1.21	0.49 – 0.77
Carnivore/Insectivore	–	–	–	–	–
Nectarivore/Insectivore	–	–	–	–	–
Carnivore	–	–	–	–	–

DISCUSSION

Monitoring available food resources and foraging guilds of wetland dependent birds is an important step to examine the productivity of a particular habitat. The presence of food resources is a key factor that affects the habitat suitability and influences the reproductive success of wetland birds. The recording of the nine feeding guilds indicated that these habitats are rich in food resources and offer suitable foraging sites which have attracted a higher number of avian assemblages to utilize these wetland and adjacent habitats. Bird species foraged on diverse food resources such as fishes, amphibians, reptiles, invertebrates (insects, worms, centipedes, millipedes, gastropods, and crustaceans), vegetable matter, etc. However, the feeding guild population of avian species may vary from habitat to habitat and depending on suitable foraging sites, productivity (food resources), and shelter from harsh weather and predators. This might be due to difference in morphology, i.e., bill shape and size, foraging behaviour and habitat preference.

Bird species may forage on a variety of prey and select habitat based on prey richness, diversity and distribution (Ashley *et al*., 2000; Davis and Smith, 2001; Jing *et al*., 2007). They detect their prey through visual and tactile sensory mechanism (Ntimao-Baidu *et al*., 1998) and employ a variety of techniques such as probing, gleaning, nipping, stabbing, hawking, sallying, and grubbing to catch their prey (Danchin *et al.,* 2008). The morphological differences among the avian species may reduce the inter-specific competition and increase the species persistence. In addition, vegetation structure and composition, availability of shallow water and diversity of prey items also influence on foraging behaviour of avian species. Jing *et al*. (2007) reported that birds can change their feeding technique depending on richness, size, and distribution of prey items and also a substrate structure. In addition, surrounded landscape such as peat swamp forest, oil palm plantation, private lakes and agricultural fields also influence the distribution of avian species. Habitat structure and adjacent landscape influence the distribution and diversity of avian species (Pearman, 2002; Hubbard and Dugan, 2003; King *et al*., 2010). In addition, the status of avian species also influences on avian population, such as arrival and departure of migrant bird species.

The results also revealed that habitat selection among avian species often may vary from species to species such as the higher avian population was recorded in marsh swamp. The marsh swamp habitat was rich and diverse in herbaceous aquatic vegetation, such as emergent vegetation (sedges, rushes and reeds), ferns, grasses and submerged had create suitable microhabitats such as ideal foraging and breeding sites, and hiding covers from predators and harsh weather conditions (Fairbrain and Dinsmore, 2001; Ojija, 2015). The occurrence of higher population might be due to the availability of abundant food sources, such as invertebrates (i.e., insects and gastropods), fish (i.e., carps and catfish), amphibians (i.e., frogs and salamanders), reptiles (i.e., lizards, dragons and snakes), mammals (i.e., mice and rats), safe roosting and breeding sites, occurrence of the shallow water level and diversity of emergent and submerged vegetation (Colwell and Taft, 2000; Rajpar and Zakaria, 2009). The emergent vegetation supported the complex trophic structure in marsh swamp i.e. provided ideal habitat for invertebrates (such as insects, isopods, decapods, crustaceans, molluscs), as well as fish and birds (Lodge *et al*., 1998).

The higher abundance and richness of macro-invertebrates and fish occur in the emergent vegetation (Grenouillet *et al*., 2002; Toft *et al*., 2003; Meerhoff *et al*., 2003) that had attracted the highest number of bird species such as swamphens, moorhens, crakes, waterhens, water cocks, warblers, bitterns, herons and prinias to utilize it. Hattori and Mae (2001) stated that the highest species richness and density of waterbirds occurs in the reed beds of aquatic vegetation. The other reason could be that marsh swamp habitat had shallow water depth. The shallow water and moist soil had been considered as important foraging sites for wetland birds (van Gils *et al*., 2003, Granaderio *et al*., 2007). This is due to easy access, occurrence of plenty of prey items and higher success of prey catching. The other reason could be that, the highest diversity of fish occurs in shallow water and higher biomass of macroinvertebrate in soft mud (Li *et al*., 2013) which is a major diet of avian species. Stafford *et al.* (2010) reported that waterbird foraged on benthic, surface-dwelling invertebrates and aquatic vertebrates that mostly occur in shallow waters.

In addition, a substantial avian population was determined in scrubland habitat. The scrubland occupied by the vegetation below five meters' height under trees and along the banks of lakes, while the ground layer consists of herbaceous plants, such as grasses, reed beds of sedges, and emergent vegetation. The occurrence of substantial population could be due to the diversity of fruiting and flowering trees, shrubs and grasses. For example; Little Leaves or Rusty Figs (*Ficus rubiginosa*), Weeping Figs (*F. benjamina*), Ficus Condensa Kings or Curraniis (*F. fistulosa*), Malay Apples (*Syzygium jambos*), Sea Apples (*S. grande*), Indonesian Bay Leaves (*S. polyanthum*), Bullate Eugenis (*S. microcalyx*), Jambo Candolles (*S. lineatum*), Fish-tailed Palms (*C. mitis*), Sweet Fragraeas (*F. fragrans*), Flame Trees (*D. regia*), Giant Crape–myrtles (*Lagerstroemia speciosa*), Papayas (*Carica papaya*), Glabras (*M. glabra*), Ceylon Cinnamons (*C. iners*), Rhododendrons (*M. malabathricum*) and Shrubby Dillenias (*Dillenia suffruticosa*). The vegetation diversity and richness directly affect the species diversity and richness of birds (Canterbury *et al*., 1999; Soderstrom and Part, 1999; Martin, 2001). The trees and shrubs provide a diversity of flowers and fruits that attracted a wide array of insects such as wasps, bees, butterflies, moths, termites and caterpillars. The berries and insects were the main food resources for Frugivore and Insectivore birds. Chettri *et al.* (2005) stated that insect species may prefer vegetation having dense foliage rich in fruits and flowers and moist condition. In addition, the shrubs and trees provided hiding cover and offer suitable nesting sites for avian species. In addition, nearby the surrounding areas, i.e. oil palm plantations and forest reserve might influence the bird's relative abundance, distribution, and diversity (Koopowitz *et al*., 1994; Vos and Stumpe, 1995).

On the contrary, the lower feeding guild population was recorded in dryland areas having scattered trees. The occurrence of lower population could be that, these areas are open with scattered trees and their productivity is lower, such as, few fruiting and flowering trees had been planted to increase the aesthetic beauty of the study area. The planted trees are still in younger age, only a few tree species bear fruits and flowers. The other reason could be that the ground grasses are maintained manually and didn't provide hiding cover for avian species. Third reason could be that, these areas lack water ponds and avoided by waterbirds to utilize. These areas are utilized only by open country birds such as doves, mynas, munias, etc. for foraging only.

Furthermore, the higher number and population of feeding guild were recorded for resident birds and the lowest one was recorded for vagrant species. This might be due to that resident bird occurs throughout the year in the study area and forage in these habitats whole of the year. In contrast, the lowest bird population was recorded in the vagrant birds. This could be explained by the rare presence of the vagrant birds, which only visit the study area at a certain period of time and they keep on changing their habitat selection.

Conclusions: The findings of foraging guilds indicated that bird are specialized in food selection, i.e., they foraged on a wide array of animals through employing various foraging techniques to catch their prey and select the available wetland and adjacent habitats in different ways depending on availability of food resources, foraging behaviour and niches. The distribution of avian assemblages influenced by the richness and diversity of food resources, availability of foraging sites, shallow water depth and vegetation composition. Hence, birds are bio-indicators of wetland and adjacent habitats and can be ascertained the productivity (health) of a particular habitat.

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