Tropical Life Sciences Research, 21(2), 7–26, 2010

Bird Species Composition and Feeding Guilds Based on Point Count and Mist Netting Methods at The Paya Indah Wetland Reserve, Peninsular Malaysia

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Abstrak: Kajian perbandingan berdasarkan kaedah *point count* (PC) dan penjaringan kabut [*mist netting* (MN)] telah dijalankan untuk menentukan komposisi spesies burung, kepadatan diversiti spesies dan kumpulan pemakanan di Rezab Paya Indah Wetland (PIWR), Semenanjung Malaysia. Sejumlah 13872 pemerhatian burung daripada 100 spesies dan 38 famili telah direkodkan menggunakan kaedah *point count* sepanjang 15 bulan berturutan dan sejumlah 1478 individu burung daripada 65 spesies dan 33 famili telah ditangkap menggunakan kaedah penjaringan kabut selama 1260 jam jaringan. Keputusan menunjukkan bahawa *Treron vernans* (1723 pemerhatian; 12.42%) adalah yang paling tinggi kepadatannya menggunakan kaedah *point count* manakala *Pycnonotus goiavier* (378 individu; 25.64%) adalah yang paling tinggi kepadatannya menggunakan kaedah penjaringan kabut. Ardeidae (9 spesies; 23.68%) merupakan famili yang paling dominan dalam kaedah *point count* manakala Rallidae (6 spesies; 18.18%) adalah famili yang paling dominan dalam kaedah penjaringan kabut. Kaedah *point count* menghasilkan diversiti (Shannon's N_1 = 31.22) dan kekayaan spesies (Margalef's R_1 = 10.42) yang lebih tinggi manakala kaedah penjaringan kabut menghasilkan keserataan spesies (McIntosh's E = 0.86) yang lebih tinggi. Frugivor/insektivor yang merangkumi merbah, dendang, punai dan perling merupakan kumpulan pemakanan yang paling dominan dalam kedua-dua kaedah (*point count* = 27.81% dan penjaringan kabut = 32.88%). Sebagai perbandingan, karnivor yang merangkumi helang (cth. lang) adalah kumpulan pemakanan yang paling kecil menggunakan kedua-dua kaedah (cth. *point count* = 0.17% dan penjaringan kabut = 0.20%) di kawasan kajian. Kajian ini menunjukkan kaedah *point count* adalah lebih efisien dan menghasilkan keputusan yang lebih baik berbanding kaedah penjaringan kabut.

Kata kunci: Pensampelan Jarak Jauh, Penjaringan Kabut, Kepadatan spesies, Diversiti, Kumpulan Pemakanan

Abstract: A comparison study was conducted to determine the bird species composition, relative abundance, species diversity and feeding guilds based on point count (PC) and mist netting (MN) at the Paya Indah Wetland Reserve (PIWR), Peninsular Malaysia. A total of 13872 bird observations belonging to 100 species and 38 families were recorded using the PC method over 15 consecutive months, and a total of 1478 bird individuals belonging to 65 species and 33 families were captured using the MN method over 1260 netting hours. The results showed that *Treron vernans* (1723 observations; 12.42%) was the most abundant bird species using the PC method, whereas *Pycnonotus goiavier* (378 individuals; 25.64%) was the most abundant bird species using the MN method. The Ardeidae (9 species; 23.68%) was the most dominant family using the PC method, but the

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Rallidae (6 species; 18.18%) was the most dominant family using the MN method. The PC method produced higher species diversity (Shannon's N1 = 31.22) and richness (Margalef's R1 = 10.42) than MN, whereas the MN method produced higher species evenness (McIntosh's E = 0.86) than the PC method. Frugivore/insectivore comprised of bulbuls, orioles, pigeons and starlings was the most dominant feeding guild in both methods (PC = 27.81% and MN = 32.88%). In contrast, carnivore was the rarest feeding guild in both methods (i.e. PC = 0.17% and MN = 0.20%). These findings indicate that the PC method is more efficient and produces better results than the MN method.

Keywords: Distance Sampling, Mist Netting, Species Abundance, Diversity, Feeding Guild

INTRODUCTION

Wetlands are areas where water plays an important role in the development of aquatic plants and animal life. The global wetland size ranges between 5.3 to 12.8 million km^2 (Zedler & Kercher 2005). These wetlands provide important ecosystem functions such as supplying a wildlife habitat, water filtration and flood control (Houlahan *et al.* 2006). Wetlands are frequently used by a diverse number of bird species for foraging, nesting and roosting due to their heterogeneity of microhabitats and available rich food resources (Mitsch & Gosselink 2007; Zakaria *et al.* 2009).

Birds are an extremely diverse, conspicuous and significant component of freshwater wetland ecosystems, and they may fly to different areas in order to feed, mate and nest (Furness & Greenwood 1993; Kushlan 1993). The presence or absence of birds may indicate the ecological conditions of wetland habitats and form an important link between the food web and nutrient cycle. Moreover, birds may respond quickly to any change in habitat and climatic condition (Fuller *et al.* 1995; Gregory & Baillie 1998; Siriwardena *et al.* 1998; Krebs *et al.* 1999).

The distance sampling point count (PC) and mist netting (MN) methods are the two most commonly used standard techniques to sample population parameters of different bird species in different habitats. A combination of the two techniques might be the most effective methodological approach for monitoring bird assemblages (Wallace *et al*. 1996; Gram & Faaborg 1997; Rappole *et al*. 1998; Poulin *et al*. 2000; Blake & Loiselle 2001; Wang & Finch 2002).

The distance sampling PC method has been widely used to monitor the density, diversity and relative abundance of bird species in different habitats (Blake 1992; Thompson *et al*. 1999; Verner & Purcell 1999; Mills *et al.* 2000). This method involves the visual and auditory detection of birds within fixed or variable radius plots and provides information on species abundance (Codesido & Bilenca 2000; Mills *et al*. 2000). However, the detections of birds may vary depending on foliage density, canopy cover, visibility and perception of sounds and the observer's skill (Schieck 1997; Whitman *et al*. 1997; Blake & Loiselle 2001).

The MN method has been widely used in avian studies and is a more effective method for detecting small, highly cryptic and shy bird species that have secretive behaviours and/or that vocalise infrequently (Ralph *et al*. 1993; Rappole *et al*. 1998; Blake & Loiselle 2000, 2001; Wang & Finch 2002; Barlow *et al.* 2006). However, MN is time consuming and requires large efforts to install (Humphrey *et al*. 1968; Meyers & Pardieck 1993). In addition, this method provides data on species distribution rather than abundance (Remsen & Good 1996).

Despite being rich in avifauna, freshwater wetlands are poorly documented, even in regards to basic avian parameters such as species composition, relative abundance, diversity indices, density and feeding guilds (Kantrud & Stewart 1984). The objective of this study was to examine the effectiveness of the distance sampling PC and MN techniques in obtaining information on bird species composition, relative abundance, species diversity and feeding guilds in the Paya Indah Wetland Reserve (PIWR).

MATERIALS AND METHODS

Study Site

The Paya (swamp) Indah (beautiful) Wildlife Sanctuary encompasses 3050 ha, of which 450 ha are under the administration of the Department of Wildlife and National Parks, Peninsular Malaysia. The study area was located adjacent to Malaysia's administrative capital Putrajaya, within the quadrant of 101° 10′ to 101° 50′ longitude and 2° 50′ and 3° 00′ latitude (Fig. 1).

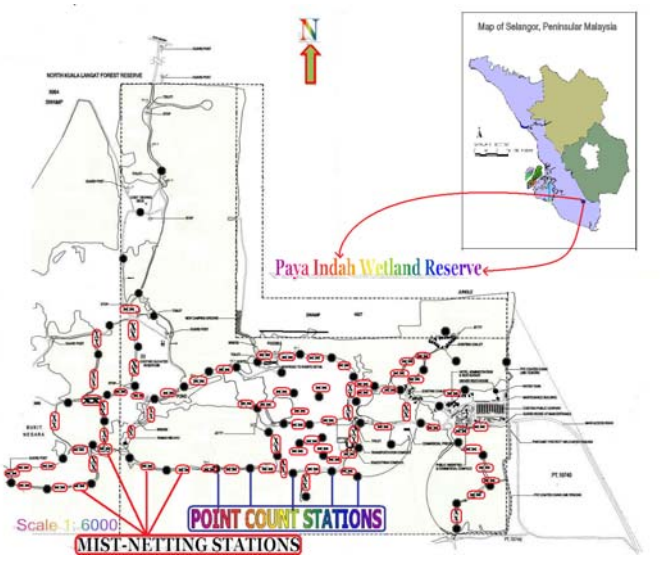

Figure 1: Location map of point count and mist netting stations at PIWR, Peninsular Malaysia.

Point Count (PC)

The bird surveys were carried out using the distance sampling PC method from November 2007 to January 2009 at the PIWR. We established 61 PC stations that were at least 300 m apart throughout the study area. Each PC station was surveyed for 15 consecutive months to obtain reliable estimates. The surveys were done for 10 minutes at each PC station. The 10-minute count was used to record a sufficient number of individuals with minimal effort and disturbance. During each PC visit, we recorded species and number of individuals detected by sight or sound. Flushed birds were recorded with original position and were included in the record, whereas flying birds were not recorded due to unknown original positions. The survey was conducted between 0730 h and 1100 h. The detail of the methodology was previously described by Buckland *et al.* (2004) and Nadeau *et al.* (2008).

Mist Netting (MN)

Ten mist nets (14 m x 4 m with 3 pockets) were used to catch birds, particularly those with cryptic or secretive behaviour. Netting was conducted for a total of 105 days, or 1260 netting hours. The nets were fixed and stretched between 2 bamboo poles randomly throughout the area in different locations, such as open terrestrial areas, along the paths and 1–3 feet inside the water. The nets were opened at 0700 h and closed at 1900 h. The nets were placed for 3 days at the same location before they were moved to other locations and were monitored at 2-hour intervals. Three days of netting was sufficient to capture most of the birds. After 3 days, birds may become familiar with the mist nets (Robbins *et al*. 1992). Each captured bird was banded with a numbered aluminium ring on the right tarsus before they were released. Recaptured birds were not included in the current analysis.

Data Analysis

The efficiencies of the PC and MN methods were evaluated based on the relative abundance (%) of bird species using the expression: n/N x 100, where n is the number of recorded bird species and N is the total observations recorded (Zakaria *et al.* 2009). In addition, species diversity, richness and evenness were determined using the Community Analysis Package (CAP) Version 4.0 by Henderson and Seaby (2007), and feeding guilds of bird species was based on the observed feeding behaviour (Zakaria *et al.* 2009). An analysis of variance (ANOVA) and Tukey's HSD test was used to assess the consistency of detecting relative abundance, families and feeding guilds between the two methods. A linear regression analysis with standardised PC detection as the dependent variable and standardised netting capture as the independent variable was performed for species detected by both techniques.

RESULTS

We recorded a total of 15349 birds belonging to 110 bird species and 40 families using the distance sampling PC and MN methods from November 2007 to January 2009 at the PIWR.

Bird Species

The PC method recorded a total of 13872 bird observations that belonged to 100 species and 38 families. *Treron vernans* (1723 observations; 12.42%), *Pycnonotus goiavier* (1683 observations; 12.13%), *Geopelia striata* (1052 observations; 7.58%), *Porphyrio porphyrio* (954 observations; 6.88%) and *Streptopelia chinensis* (879 observations; 6.37%) were the five most abundant bird species recorded by this method. In addition, 14 species (0.01% each; e.g., *Phylloscopus inornatus, Gallirallus striatus, Dicrurus leucophaeus, Haliastur Indus,* etc.) were only observed once (see Appendix).

The MN method captured a total of 1478 birds belonging to 64 species and 33 families. *Pycnonotus goiavier* (379 captures; 25.64%), *Geopelia striata* (152 captures; 10.28%) and *Ploceus philippinus* (141 captures; 9.54%) were the 3 most abundant bird species, whereas 18 other species (0.07%) (e.g., *Gallinula chloropus, Eurystomus orientalis, Porzana cinerea, Orthotomus ruficep,* etc.) were rarely recorded by this method (see Appendix).

The relative abundance of bird species based on the PC and MN methods was compared using ANOVA and Tukey's HSD test. Values obtained using the PC and MN methods were found to be significantly different [$F(1, 218) = 16.80$, $p < 0.05$] (Table 1).

Table 1: Comparison of bird observations recorded by the PC and MN methods at the PIWR, Peninsular Malaysia.

Methods	Mean value	Standard error (SE ±)
PC	126.12^{a}	2.42
MN	13.418^{b}	1.02

Notes: The mean values with different letters are significant at $p = 0.05$, Tukey's HSD test critical value = 53.88.

Bird Families

The PC method recorded a total of 38 bird families during the study period. Four families, namely Columbidae (3721 observations; 26.82%), Pycnonotidae (1696 observations; 12.23%), Rallidae (1485 observations; 10.71%) and Sturnidae (1333 observations; 9.61%), were the most dominant families and had the highest number of observations recorded by the PC method, whereas Dicruridae and Emberizidae were the rarest families with only one observation each (0.01%). The MN method captured a total of 33 bird families. Pycnonotidae (385 individuals; 26.05%), Columbidae (283 individuals; 19.15%) and Ploceidae (141 individuals; 9.54%) were the three most dominant families and had the highest number of individuals captured using the MN method. Phasianidae,

Table 2: Ranking of bird families based on the PC and MN methods at the PIWR, Peninsular Malaysia.

Family name	PC method			MN method		
	No. of species	No. of observations	%	No. of species	No. of individuals	%
Columbidae	6	3721	26.82	3	283	19.15
Pycnonotidae	2	1696	12.23	2	385	26.05
Rallidae	7	1485	10.71	6	28	1.89
Sturnidae	5	1333	9.61	4	18	1.22
Estrildidae	3	637	4.59	2	40	2.71
Ardeidae	9	616	4.44	5	84	5.68
Meropidae	2	386	2.78	2	35	2.37
Ploceidae	1	378	2.72	1	141	9.54
Hirundinidae	1	353	2.54	1	5	0.34
Anatidae	2	337	2.43	1	2	0.14
Alcidinidae	2	334	2.41	3	68	4.60
Charadriidae	1	261	1.88	2	13	0.88
Motacillidae	1	257	1.83	1	31	2.10
Aegithinidae	2	227	1.64	2	24	1.62
Turdidae	1	203	1.46	1	49	3.32
Cisticolidae	3	189	1.36	2	12	0.81
Oriolidae	1	178	1.28	1	3	0.20
Cuculidae	6	170	1.23	3	19	1.29
Rhipiduridae	1	167	1.20	1	39	2.64
Laniidae	2	163	1.18	1	31	2.10
Passeridae*	1	112	0.81	0	0	0
Sylviidae	7	102	0.74	5	37	2.50
Phasianidae	2	88	0.63	1	1	0.07
Nectariniidae	7	84	0.61	2	10	0.68
Campephagidae	2	80	0.58	1	17	1.15
Picidae	4	78	0.57	1	13	0.88

(continued on next page)

Table 2: *(continued)*

Family name	PC method			MN method		
	No. of species	No. of observations	%	No. of species	No. of individuals	%
Corvidae**	2	50	0.36	0	0	0
Coraciidae	1	40	0.29	1	1	0.07
Scolopacidae	2	37	0.27	1	6	0.41
Accipitridae	5	24	0.17	2	3	0.20
Caprimulgidae	2	24	0.17	2	62	4.19
Turnicidae	1	20	0.14	1	10	0.68
Muscicapidae	1	14	0.10	1	1	0.07
Podicipedidae*	1	11	0.08	0	0	0
Pachycephalidae*	1	8	0.06	0	0	0
Jacanidae	1	7	0.05	0	0	0
Dicruridae**	1	1	0.01	0	0	0
Emberizidae**	1	1	0.01	0	0	0
Apodidae*	0	0	0	1	3	0.20
Strigidae*	0	0	0	2	4	0.27
Total	**100**	**13872**		**65**	**1478**	

Notes: *families missed by the PC method, **families missed by the MN method.

Table 3: Comparison of bird families based on the PC and MN methods at The PIWR, Peninsular Malaysia.

Method	Mean value	Standard error (SE ±)
PC	346.80 [a]	5.75
MN	36.95 [b]	1.96

Notes: The mean values with different letters are significant at $p = 0.05$, Tukey's HSD test critical value = 213.67.

Coraciidae and Muscicapidae were the rarest families with only one capture each (0.07%) (Table 2).

The number of bird families based on the PC and MN methods were compared using ANOVA and Tukey's HSD. The results showed that bird families based on PC and MN methods were significantly different [$F(1, 78) = 8.33$, $p < 0.05$] (Table 3).

Diversity Indices

The diversity of birds at the PIWR was determined using the CAP (Version 4.0) by Henderson and Seaby (2007) based on relative abundance recorded by the PC and MN methods. The species diversity and richness was higher in the PC method (Shannon's Index N1 = 31.22 and Margalef's Index R1 = 10.42), whereas the species evenness was higher when using MN (McIntosh's Index E = 0.86) (Table 4).

Table 4: Comparison of diversity indices of bird results obtained using the PC and MN methods at the PIWR, Peninsular Malaysia.

Indices	PC method	MN method
Diversity indices		
Shannon's index (N_1)	31.22	26.48
Simpson's index (N_2)	19.11	16.68
Richness indices		
Margalef's index (R_1)	10.42	9.14
Menhinik's index (R_2)	0.89	1.96
Evenness indices		
McIntosh's index (E)	0.77	0.86
Pielou J index (E)	0.73	0.69

Feeding Guilds

The foraging behaviours of bird species based on the PC and MN methods were grouped into nine trophic structures to determine the feeding behaviours of different bird species and the food resources of the study area. The PC method showed that frugivore/insectivore (27.81%), omnivore (22.64%) and insectivore (16.90%) were the three most abundant feeding guilds. Carnivore (0.17%), which was comprised of raptors, was the rarest feeding guild in the study area. The MN method showed that frugivore/insectivore (32.88%), insectivore (25.10%) and granivore/insectivore (20.57%) were the three most abundant feeding guilds. Carnivore (0.20%) was again found to be the rarest feeding guild in the study area using MN (Table 5).

The feeding guilds based on the PC and MN methods were compared using ANOVA and Tukey's HSD test. The result showed that feeding guilds identified using the PC and MN methods were significantly different [$F(1, 16) = 8.86$, $p < 0.05$] (Table 6).

Table 5: Comparison of feeding guilds based on the PC and MN methods at the PIWR, Peninsular Malaysia.

Feeding guilds	Point count method			Mist netting method		
	No. of species	No. of observations	%	No. of species	No. of individuals	%
Frugivore/insectivore	8	3858	27.81	5	486	32.88
Omnivore	19	3141	22.64	12	53	3.59
Insectivore	36	2345	16.90	25	371	25.10
Granivore/insectivore	6	1581	11.40	4	304	20.57
Granivore	3	1503	10.83	3	75	5.07
Carnivore/piscivore/ insectivore	15	1230	8.87	9	164	11.10
Carnivore/insectivore	1	106	0.76	3	12	0.81
Nectarivore/insectivore	8	85	0.61	2	10	0.68
Carnivore	4	23	0.17	2	3	0.20
Total	**100**	**13872**		**65**	**1478**	

Table 6: Comparison of feeding guilds based on the PC and MN methods at the PIWR, Peninsular Malaysia.

Methods	Mean value	Standard error (SE ±)
PC	1541.3 [a]	11.72
MN	164.22 [b]	4.68

Notes: The mean values with different letters are significant at $p = 0.05$, Tukey's HSD test critical value = 981.45.

DISCUSSION

It is highly important to monitor the species composition, relative abundance, diversity and habitats of wetland-dependent birds to examine population trends and thus identify and highlight the main causes of species decline due to growing pressure from anthropogenic activities. The PIWR is a natural wetland and dynamic habitat for different bird species due to heterogeneous vegetation, abundant food resources, and the presence of suitable loafing, roosting and breeding sites (Rajpar & Zakaria 2009).

The efficiency of methods applied to estimate bird populations has received considerable attention (Smith *et al*. 1993; Petit *et al.* 1995; Whitman *et al*. 1997; Rappole *et al*. 1998). We used the distance sampling PC method to record the species composition, relative abundance, species richness and feeding guilds in different habitats because it is an easy and efficient method to obtain information on population trends, affects of disturbance, habitat selection and to compare bird diversity among different sites. This type of research method was previously performed by Ralph *et al.* (1995), Dobkin and Rich (1998), Bibby

et al. (2000), Thompson *et al.* (2002), Kaminski *et al.* (2006), Aborn (2007) and Zakaria *et al.* (2009). Terborgh *et al.* (1990) reported that no sampling technique is free of bias or is effective for all groups of birds, and a combination of techniques is most useful in many cases. We therefore used the MN method as a supplement to PC rather than as a sole source of data, as reported by Faaborg *et al.* (1984). MN may aid in identifying different bird species and sampling cryptic and secretive species of small size (Ralph *et al.* 1995; Mason 1996; Blake & Loiselle 2000; Wang & Finch 2002). The advantages of using the MN method are the reduction of bias, the detection of bird species that were missed by the PC method, close examination of the birds (Ralph *et al*. 1995) and the simplification of species identification compared to other methods (Ralph *et al*. 1996).

We recorded a total of 110 species using the distance sampling PC and MN methods. The PC method detected 100 species (90.90%), whereas the MN captured 64 (58.18%) of the 110 species encountered during the study. Thus, the PC method failed to detect 10 species (9.09%), and the MN method failed to capture 44 (40.0%) of all the species encountered in this study. Moreover, 56 species (50.91%) were common bird species recorded by both methods (see Appendix). The estimates of relative abundance, bird families (Table 3) and feeding guilds (Table 6) indicated significantly different results for both methods. Overall, the detection rate of species composition, relative abundance, families, diversity indices and feeding guilds was higher using the PC method compared to the MN method.

Species that the PC method failed to detect were small and had cryptic behaviour, e.g., the Inornate Warbler. In addition, migratory species such as the Golden Pacific Plover, Japanese Sparrow Hawk and Black-caped Kingfisher, migratory and resident species such as the Violet Cuckoo, nocturnal species such as the Oriental Scops Owl and Collared Scops Owl, sallying foragers on the wing such as the edible-nest Swiftlet and species with a small population size such as the Besra and Stork-billed Kingfisher were also missed using the PC method.

MN recorded with greater frequency bird species with secretive behaviours and those that were ground foraging and non-singing species, such as the Yellow Bittern, Lesser Coucal, Cinnamon Bittern, Pintail Snipe, Plaintive Cuckoo, Barred Button Quail, Slaty-breasted Rail, Inornate Warbler, Large-tailed Nightjar, Schrenck's Bittern and Savanna Nightjar. Similar results have also been reported by Rappole *et al.* (1998, 1993), Wallace *et al.* (1996), Whitman *et al.* (1997), and Blake and Loiselle (2001).

Some species that MN failed to capture were abundant using the PC method (e.g., Purple Swamphen, Red Junglefowl, Large-billed Crow, House Crow and Greater Coucal). Moreover, arboreal and canopy foragers (e.g., Orange-breasted Green Pigeons, Little Green Pigeon, Thick-billed Green Pigeon, Hill Myna, Ashy Minivet, Ashy Drongo, Common Asian Koel, Plain Sunbird, Mangrove Whistler, Rufous Woodpecker, Little Spiderhunter, Plain Sunbird, Copper-throated Sunbird, Purple-throated Sunbird, Red-throated Sunbird, Black-throated Sunbird, Rufous Tailorbirds and Eurasian Tree Sparrow) were also missed by MN. In addition, migratory species (e.g., Rusty-rumped Warbler, Rufescent Prinia, Yellow-breasted Bunting, Common Sandpiper, Long-tailed

Shrike, Chestnut-winged Cuckoo and Common Sandpiper), sallying raptors (e.g., Black-shoulder Kite, Black Baza, Western Marsh Harrier, White-bellied Fish Eagle and Brahminy Kite), resident species with low population size (e.g., Greater Flameback, Speckled Piculet and White-headed Munia), resident and migratory species (e.g., Little Egret, Great Egret and Common Kingfisher), nocturnal foragers (Black-crowned Nightheron), open water body surface foragers (Cotton Pygmy Goose), floating vegetation foragers (Pheasant-tailed Jacana) and divers (Little Grebes) were also missed by MN. The PC method failed to record two families (Apodidae and Strigidae), whereas the MN method failed to record six families (Corvidae, Dicruridae, Emberizidae, Jacanidae, Pachycephalidae and Podicipedidae) in the study area. The results of this study showed that MN was a less efficient method compared to the PC method in terms of species composition, relative abundance, diversity and feeding guilds.

Consistent with past studies, we detected more species using the PC method than with the MN method. For example, Aborn (2007) recorded 91 species by PC and 41 species by MN from all Neotropical migrant species at the Lula Lake Land Trust. Derlindati and Caziani (2005) detected 78 species (85.71%) by PC and captured 48 species (52.75%) using the MN method in the Chaco forest. Blake and Loiselle (2000) recorded 226 species (86.59%) with PC and captured 168 of all 261 species (64.37%) with MN in Costa Rica. Whitman *et al.* (1997) reported that the PC method detected 60% and MN captured 25% of all forest species in northern Belize. The results of this study suggest that the PC and MN methods are relatively consistent and effective, especially when applied together to sample bird species composition, relative abundance, species diversity and feeding guilds in wetland ecosystems. Finally, it is recommended that the MN method should be used together with PC to obtain more accurate estimates of different parameters of bird species.

CONCLUSION

We conclude that PC provides better results and is a more efficient method compared to MN. When applied together, however, results are even more reliable than for either single method. Thus, we recommended that the PC and MN methods should be applied together to survey birds that are present in open areas such as wetlands.

ACKNOWLEDGEMENT

The authors would like to thank the Department of Wildlife and National Parks, Peninsular Malaysia for allowing us to conduct this research at the PIWR. This research was partially funded by Fundamental Grant Research Scheme (01-10-07-291FR) and the Forestry Sector Research Division Project, Pakistan Forest Institute, Peshawar, Pakistan.

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Appendix: List of bird species with relative abundance based on the PC and MN methods at the PIWR, Peninsular Malaysia.

Family name	Common name	Scientific name	PC method		MN method	
			No. of observations	%	No. of individuals	%
Columbidae	Pink-necked Green Pigeon	*Treron vernans*	1723	12.42	96	6.5
Pycnonotidae	Yellow-vented Bulbul	*Pycnonotus goiavier*	1683	12.13	379	25.64
Columbidae	Peaceful Dove	*Geopelia striata*	1052	7.58	152	10.28
Rallidae	Purple Swamphen**	*Porphyrio porphyrio*	954	6.88	0	0
Columbidae	Spotted Dove	*Streptopelia chinensis*	879	6.34	35	2.37
Sturnidae	Jungle Myna	*Acridotheres fuscus*	571	4.12	4	0.27
Sturnidae	Common Myna	*Acridotheres tristis*	454	3.27	2	0.14
Estrildidae	Scaly-breasted Munia	*Lonchura punctulata*	410	2.96	19	1.29
Ploceidae	Baya Weaver	*Ploceus philippinus*	378	2.72	141	9.54
Rallidae	White-breasted Waterhen	*Amaurornis phoenicurus*	376	2.71	23	1.56
Hirundinidae	Pacific Swallow	*Hirundo tahitica*	353	2.54	5	0.34
Meropidae	Blue-tailed Bee-eater	*Merops philippinus*	349	2.52	20	1.35
Alcidinidae	White-throated Kingfisher	*Halcyon smyrnensis*	330	2.38	66	4.67
Ardeidae	Purple Heron	*Ardea purpurea*	269	1.94	2	0.14
Charadriidae	Red-wattled Lapwing	*Vanellus indicus*	261	1.88	12	0.81
Motacillidae	Richard's Pipit	*Anthus richardi*	257	1.85	31	2.1
Ardeidae	Yellow Bittern	*Ixobrychus sinensis*	246	1.77	49	3.32
Anatidae	Lesser Whistling Duck	*Dendrocygna javanica*	244	1.76	2	0.14
Estrildidae	Black-headed Munia	*Lonchura malacca*	214	1.54	21	1.42
Turdidae	Oriental Magpie Robin	*Copsychus saularis*	203	1.46	49	3.32
Sturnidae	Philippine Glossy Starling	*Aplonis panayensis*	194	1.4	2	0.14
Oriolidae	Black-napped Oriole	*Oriolus chinensis*	178	1.28	3	0.2
Cisticolidae	Yellow-bellied Prinia	*Prinia flaviventris*	175	1.26	11	0.74
Rhipiduridae	Pied Fantail	*Rhipidura javanica*	167	1.2	39	2.64

(continued on next page)

Appendix: *(continued)*

Family name	Common name	Scientific name	PC method		MN method	
			No. of observations	%	No. of individuals	%
Aegithinidae	Green Iora	*Aegithina viridissima*	164	1.18	19	1.29
Laniidae	Brown Shrike	*Lanius cristatus*	160	1.15	31	2.1
Passeridae	Eurasian Tree Sparrow**	*Passer montanus*	112	0.81	0	0
Sturnidae	White-vented Myna	*Acridotheres grandis*	108	0.78	10	0.68
Cuculidae	Lesser Coucal	*Centropus bengalensis*	106	0.76	8	0.54
Rallidae	Common Moorhen	*Gallinula chloropus*	97	0.7	1	0.07
Anatidae	Cotton Pygmy Goose**	*Nettapus coromandelianus*	93	0.67	0	0
Phasianidae	Red Jungle-fowl**	*Gallus gallus*	82	0.59	0	0
Picidae	Common Flameback	*Dinopium javanense*	68	0.49	13	0.88
Aegithinidae	Common Iora	*Aegithina tiphia*	63	0.45	5	0.34
Campephagidae	Pied Triller	*Lalage nigra*	55	0.4	17	1.15
Columbidae	Orange-breasted Green Pigeon**	*Treron bicincta*	55	0.4	0	0
Coraciidae	Dollar Bird	*Eurystomus orientalis*	40	0.29	1	0.07
Ardeidae	Cinnamon Bittern	*Ixobrychus cinnamomeus*	38	0.27	19	1.29
Meropidae	Blue-throated Bee-eater	*Merops viridis*	37	0.27	15	1.01
Sylviidae	Oriental Reed Warbler	*Acrocephalus orientalis*	35	0.25	27	1.83
Scolopacidae	Pintail Snipe	*Gallinago stenura*	32	0.23	6	0.41
Rallidae	White-browed Crake	*Porzana cinerea*	31	0.22	1	0.07
Sylviidae	Common Tailorbird	*Orthotomus sutorius*	29	0.21	6	0.41
Corvidae	Large-billed Crow**	*Corvus macrorhynchos*	29	0.21	0	0
Nectariniidae	Brown-throated Sunbird	*Anthreptes malacensis*	28	0.2	7	0.47
Cuculidae	Plaintive Cuckoo	*Cacomantis merulinus*	27	0.19	10	0.68
Sylviidae	Ashy Tailorbird	*Orthotomus ruficeps*	25	0.18	1	0.07
Campephagidae	Ashy Minivet**	*Pericrocotus divaricatus*	25	0.18	0	0
Ardeidae	Little Heron	*Butorides striatus*	23	0.17	3	0.2

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Appendix: *(continued)*

Family name	Common name	Scientific name	PC method		MN method	
			No. of observations	%	No. of individuals	%
Nectariniidae	Olive-backed Sunbird	*Nectarinia jugularis*	23	0.17	3	0.2
Corvidae	House Crow**	*Corvus splendens*	21	0.15	0	0
Turnicidae	Barred Button Quail	*Turnix suscitator*	20	0.14	10	0.68
Cuculidae	Little Bronze Cuckoo**	*Chrysococcyx minutillus*	20	0.14	0	0
Nectariniidae	Plain Sunbird**	*Anthreptes simplex*	18	0.13	0	0
Accipitridae	Black-shouldered Kite**	*Elanus caeruleus*	17	0.12	0	0
Cuculidae	Greater Coucal**	*Centropus sinensis*	15	0.11	0	0
Muscicapidae	Asian Brown Flycatcher	*Muscicapa dauurica*	14	0.1	1	0.07
Rallidae	Ballion's Crake	*Porzana pusilla*	14	0.1	1	0.07
Pycnonotidae	Olive-winged Bulbul	*Pycnonotus plumosus*	13	0.09	6	0.41
Cisticolidae	Zitting Cisticola	*Cisticola juncidis*	13	0.09	1	0.07
Ardeidae	Black-crowned Night Heron**	*Nycticorax nycticorax*	13	0.09	0	0
Estrildidae	White-headed Munia**	*Lonchura maja*	13	0.09	0	0
Caprimulgidae	Large-tailed Nightjar	*Caprimulgus macrurus*	12	0.08	48	3.25
Caprimulgidae	Savanna Nightjar	*Caprimulgus affinis*	12	0.08	14	0.95
Rallidae	Water Cock	*Gallicrex cinerea*	12	0.08	1	0.07
Ardeidae	Grey Heron**	*Ardea cinerea*	12	0.08	0	0
Podicipedidae	Little Grebe**	*Tachybaptus ruficollis*	11	0.07	0	0
Columbidae	Little Green Pigeon**	*Treron olax*	11	0.07	0	0
Pachycephalidae	Mangrove Whistler**	*Pachycephala grisola*	8	0.06	0	0
Ardeidae	Schrenck's Bittern	*Ixobrychus eurhythmus*	7	0.05	11	0.74
Jacanidae	Pheasant-tailed Jacana**	*Hydrophasianus chirurgus*	7	0.05	0	0
Phasianidae	Blue-breasted Quail	*Coturnix chinensis*	6	0.04	1	0.07

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Appendix: *(continued)*

Family name	Common name	Scientific name	PC method		MN method	
			No. of observations	%	No. of individuals	%
Nectariniidae	Black-throated Sunbird**	*Aethopyga saturata*	6	0.04	0	0
Sturnidae	Hill Myna**	*Gracula religoisa*	6	0.04	0	0
Picidae	Rufous woodpecker**	*Celeus brachyurus*	6	0.04	0	0
Sylviidae	Rufous-tailed Tailorbird**	*Orthotomus sericeus*	6	0.04	0	0
Scolopacidae	Common Sandpiper**	*Tringa hypoleucos*	5	0.036	0	0
Nectariniidae	Little Spiderhunter**	*Arachnothera longirostra*	5	0.036	0	0
Accipitridae	Black Baza**	*Aviceda leuphotes*	4	0.028	0	0
Alcidinidae	Common Kingfisher**	*Alcedo atthis*	4	0.028	0	0
Ardeidae	Great Egret**	*Casmerodius albus*	4	0.028	0	0
Ardeidae	Little Egret**	*Egretta garzetta*	4	0.028	0	0
Sylviidae	Arctic Warbler	*Phylloscopus borealis*	3	0.021	1	0.07
Nectariniidae	Copper-throated Sunbird**	*Nectarinia calcostetha*	3	0.021	0	0
Picidae	Greater Flameback**	*Chrysocolaptes lucidus*	3	0.021	0	0
Laniidae	Long-tailed Shrike**	*Lanius schach*	3	0.021	0	0
Sylviidae	Rusty-rumped Warbler**	*Locustella certhiola*	3	0.021	0	0
Rallidae	Slaty-breasted Rail	*Gallirallus striatus*	1	0.007	1	0.07
Dicruridae	Ashy Drongo**	*Dicrurus leucophaeus*	1	0.007	0	0
Accipitridae	Brahminy Kite**	*Haliastur indus*	1	0.007	0	0
Cuculidae	Chestnut-winged Cuckoo**	*Clamator coromandus*	1	0.007	0	0
Cuculidae	Common Asian Koel**	*Eudynamys scolopacea*	1	0.007	0	0
Nectariniidae	Purple-throated Sunbird**	*Nectarinia sperata*	1	0.007	0	0
Nectariniidae	Red-throated Sunbird**	*Anthreptes rhodolaemus*	1	0.007	0	0
Cisticolidae	Rufescent Prinia**	*Prinia rufescens*	1	0.007	0	0
Picidae	Speckled Piculet**	*Picumnus innominatus*	1	0.007	0	0

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Appendix: *(continued)*

Family name	Common name	Scientific name	PC method		MN method	
			No. of observations	%	No. of individuals	%
Columbidae	Thick-billed Green Pigeon**	*Treron curvirostra*	1	0.007	0	0
Accipitridae	Western Marsh Harrier**	*Circus aeruginosus*	1	0.007	0	0
Accipitridae	White-bellied Sea Eagle**	*Haliaeetus leucogaster*	1	0.007	0	0
Emberizidae	Yellow-breasted Bunting**	*Emberiza aureola*	1	0.007	0	0
Strigidae	Collared Scops Owl*	*Otus lettia*	0	0	3	0.2
Apodidae	Edible-nest Swiflet*	*Aerodramus fuciphagus*	0	0	3	0.2
Sylviidae	Inornate Warbler	*Phylloscopus inornatus*	0	0	2	0.14
Accipitridae	Japanese Sparrow Hawk*	*Accipiter gularis*	0	0	2	0.14
Alcidinidae	Black-caped Kingfisher*	*Halcyon pileata*	0	0	1	0.07
Accipitridae	Besra*	*Accipiter virgatus*	0	0	1	0.07
Alcidinidae	Stork-billed Kingfisher*	*Pelargopsis capensis*	0	0	1	0.07
Charadriidae	Pacific Golden Plover*	*Pluvialis fulva*	0	0	1	0.07
Strigidae	Oriental Scops Owl*	*Otus sunia*	0	0	1	0.07
Cuculidae	Violet Cuckoo*	*Chrysococcyx xanthorhynchus*	0	0	1	0.07
Total			**13872**		**1478**	

Notes: *Species missed by the PC method, ** species missed by the MN method.