FLUCTUATIONS IN AVIAN DISTRIBUTION AND DIVERSITY IN ANAVILUNDAWA SANCTUARY

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ABSTRACT

Many of the seasonal water bodies in Sri Lanka harbour substantial numbers of aquatic birds. Local aggregation of water fowl during communal roosting and colonial breeding results in substantial inputs of nutrients into aquatic systems and can alter fresh water aquatic systems. The present study calculated the density and species richness of true aquatic bird and aquatic associated bird species in Anavilundawa Sanctuary (Ramsar Site) from July 2007 to July 2008 using the point count method. In Anavilundawa reservoir, the number of true aquatic bird species was higher (40.49 ± 1.251 birds ha^{-1}) than the number of aquatic associated bird species (3.40 ± 0.437 birds ha^{-1}). Amongst true aquatic birds recorded in the study area, *Anastomus oscitans* (Asian openbill) was the most abundant species (137.43 ± 7.246 birds ha^{-1}). Further, Asian openbill inhabited only the Anavilundawa reservoir for nesting and breeding. Density and species richness of birds were the highest during rainy season when migratory species also arrived at the site. During the rainy season; the highest bird density was recorded in tree-covered habitats (11.72 ± 1.683 birds ha^{-1}) followed by shallow open water habitats (2.05 ± 0.724 birds ha^{-1}) and grass covered habitats (1.84 ± 0.579 birds ha^{-1}). The lowest bird density was recorded in deep open water habitats (0.40 ± 0.263 birds ha^{-1}). During the dry season when the migratory species left the area a few resident species have engaged in nesting activities. During the dry season too, the highest bird density was recorded in tree covered habitats (1.57 ± 0.497 birds ha^{-1}) followed by grass covered habitats (0.99 ± 0.317 birds ha^{-1}) and shallow open water habitats (0.63 ± 0.374 birds ha^{-1}). Red-wattled Lapwing was the most abundant aquatic associated species recorded (2.05 ± 1.137 birds ha^{-1}). The result also showed that true aquatic birds have the highest species diversity *i.e.*, Shannon's index (N1 = 2.233), species richness *i.e.*, Margalf's index (R1 = 2.015), Menhinick's index (R2 = 0.782) and species evenness (E = 0.899) which were much higher compared to aquatic associated birds. It is concluded that Anawilundawa Sanctuary has retained its potential as an important ecosystem for avifauna despite human mediated disturbances.

KEY WORDS: Avian distribution, Diversity, Anavilundawa Sanctuary, Habitats

INTRODUCTION

Wetlands are widely recognized as highly important ecosystems with diverse attributes including distinctive avifauna. A range of globally threatened and non-threatened bird species directly or indirectly depend on wetland to fulfill their daily requirements such as food, water and shelter (Ishikawa *et al.*, 2003). Wetlands support congregation of large number of resident and migratory bird species as it has high nutritional value as well as productivity (Whittaker & Likens, 1973; Gibbs, 1993; Paracuellos, 2006).The gradual losses of these habitats through landscape alterations have led to degradation of wetlands and as a result, aquatic birds are declining (Shochat *et al.*, 2006). When wetland dynamics change, birds can be affected by multiple causes including destruction of breeding sites, destabilization of water level, eutrophication, heavy metal contamination due to weedicides and pesticides, nutrient inputs and invasion of exotic plants and animals (Scott & Poole, 1989).

In Sri Lanka, there are 103 perennial rivers, 242 major and medium-sized and 12,000 non-perennial reservoirs (Wijenayake *et al.*, 2005; Amarasinghe & Nguyen, 2009). Recent estimates suggest that nearly 10,000 non-perennial reservoirs are functional (Amarasinghe & Weerakoon, 2009). Linked to these reservoirs are many kilometres of canal systems, causeways and thousands of hectares of irrigated land mainly paddy fields (Gunasena, 2001; Kotagama & Bambaradeniya, 2006).

The current study investigated the diversity and abundance of avifauna in Anavilundawa Ramsar Sanctuary as the cascade system is affected by several factors including gradual siltation of the reservoirs in the system, spread of invasive species (Gunarathne *et. al.*,2009), bird assemblages releasing fecal matter, expanding land use in the vicinity due to shrimp farming and agriculture resulting in discharge of effluent waters from these production systems.

METERIALS AND METHODS

Anavilundawa Ramsar Sanctuary is located between the coast and Negombo – Puttalam railway line, in the Puttalam District of the North Western province of Sri Lanka (07°42'N 079° 49'E) (Rodrigo *et al.*, 2008). The sanctuary covers an extent of 1400 ha (Rodrigo *et al.*, 2008).

The wetland system consists of seven small cascading seasonal reservoirs namely, Pinkattiya, Wellawela (or Wedagewela), Maradansole, Irrakkawala/Ihala wewa, Anavilundawa, Suruwila and Maiyawa (Plates 1 and Plate 2), roughly aligned north to south and Maiyawa being the sink of the system (IUCN, 2005). Of the seven reservoirs in the cascade system, two are nonfunctional mainly due to siltation and invasive infestation resulting in loss of water holding capacity. Consequently there are five functional reservoirs at present in the cascade system. The reservoir system covers an area of about 188 ha and none of them exceed a maximum depth of 4 m at the deepest point (Rodrigo *et al.*, 2008).

Bird survey was carried out at Anavilundawa reservoir using the point count method to determine species composition, diversity and density between July 2007 and June 2008. Three permamanet point count spots located 300 m apart from each other were established within the study area. The main reason of using 300 m interval between two point count spots was to avoid double counting of the same birds at more than one point (Fig. 1).

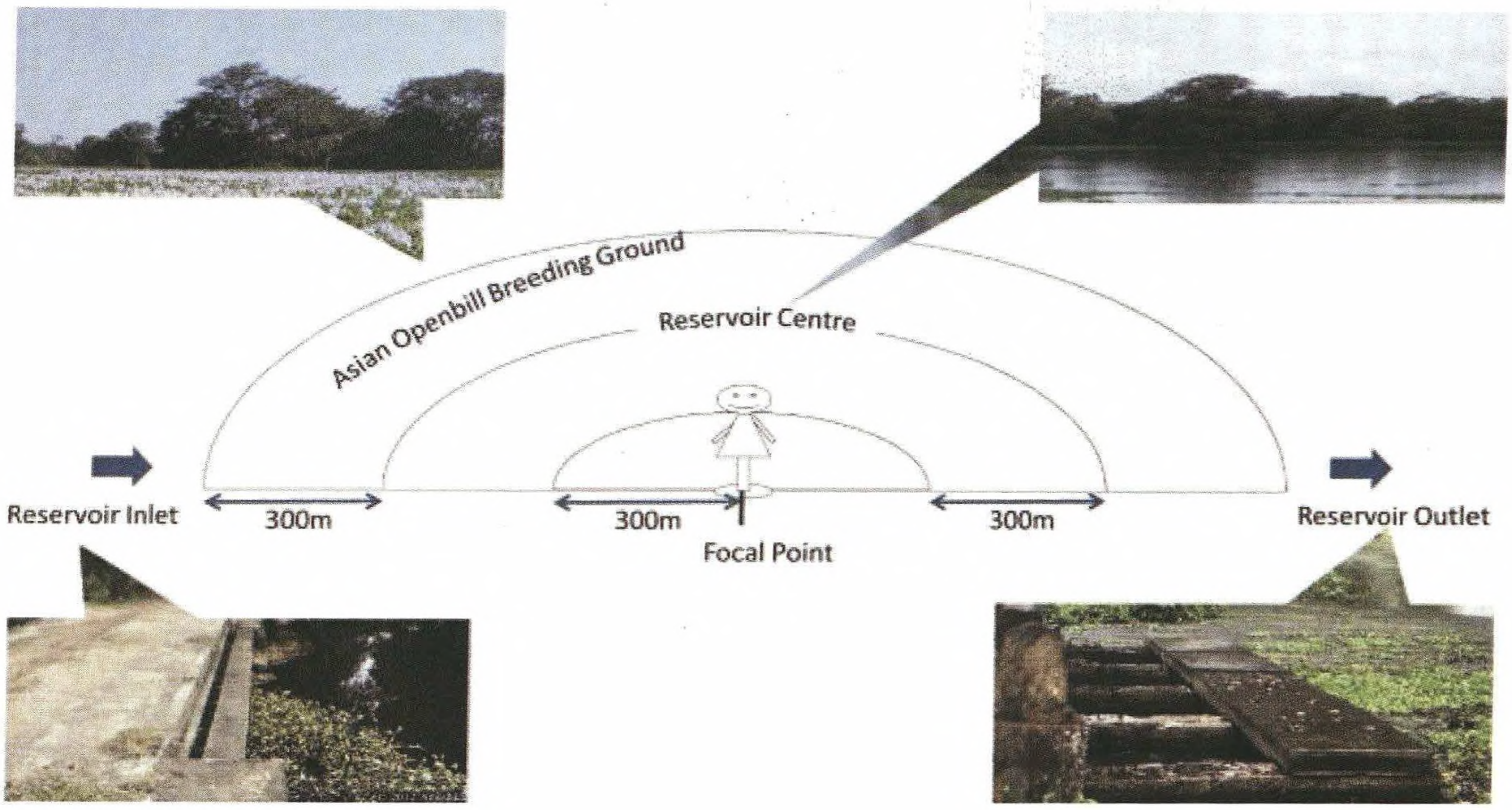

Figure 1. Schematic representation of sampling

The survey was conducted early in the morning from 0630 h to 1130 h and evening form 1530 h to 1830 h once in two weeks. The detection of birds within each point count spots are done for fifteen minutes. Fifteen minutes count enabled recording sufficient number of individuals with minimal efforts and disturbance. During each survey, all bird species and individuals seen were recorded. In addition, habitat types were also recorded for each individual.

The data were converted into density per hectare. Bird density of those species whose numbers of detections were below five were not analyzed due to low number of sample size. The diversity indices such as species diversity, richness and evenness were determined using Estimates S software (Colwell, 2009). The relationships between the species richness and habitat use by each species were analyzed using generalized linear models (GLMs). Student's t-test and ANOVA were used to compare diversity between seasons and between habitats.

RESULTS

Density and diversity of true aquatic bird and aquatic associated bird at Anavilundawa reservoir

Species composition

During the period from July 2007 to July 2008, a total of 23116 birds were counted in Anavilundawa reservoir. They belong to 46 families. Among them, 23 were true aquatic bird species with more than 5 sightings (Table 1). That comprised of 22771 (98.50%) detections from the area. A total of 14 true aquatic bird species with less than 5 sightings (0.15%) were also detected in the study.

Overall bird density

The density analysis shows that the bird density of Anavilundawa reservoir is 44.31 ± 1.372 birds ha^{-1}. The results also showed that the true aquatic birds have a higher density (40.49 ± 1.251birds ha^{-1}) compared to aquatic associated birds (3.40 ± 0.437 birds ha^{-1}) (Table 2).

Table 2: The density of true aquatic bird and aquatic associated bird of Anavilundawa reservoir.

Status of bird species	Density estimate (birds ha^{-1})
Over all bird density	44.31 ± 1.372
True aquatic birds	40.49 ± 1.251
Aquatic associated birds	3.40 ± 0.437

The five highest true aquatic bird species densities were recorded for *Anastomus oscitans* (Asian Openbilll (137.43 ± 7.246 birds ha^{-1}) followed by *Threskomis melanocephalus* (Black-headed Ibis) (50.22 ± 5.338 birds ha^{-1}), *Phalacrocorax niger*

(Little Cormorant) (27.70 ± 3.072 birds ha^{-1}), *Hydrophasianus chirurgus* (Pheasant-tailed Jacana) (21.99 ± 1.774 birds ha^{-1}) and *Phalacrocorax fuscicollis* (Indian Cormorant) (18.25 ± 2.473 birds ha^{-1}) (Table 1) (Fig.2). The highest aquatic associated bird density was recorded for *Vanellus indicus* (Red-wattled Lapwing) (2.05 ± 1.137 birds ha^{-1}). The lowest aquatic associated bird density was recorded for *Spilornis cheela* (Crested Serpent Eagle) (0.20 ± 0.178 birds ha^{-1}) (Fig. 2).

Table 1. The ranking of true aquatic bird density at Anavilundawa reservoir.

	Common name	Scientific name	Family	Density (birds ha^{-1})
01.	Asian Openbill	*Anastomus oscitans*	Ciconiidae	137.43 ± 7.246
02.	Black-headed Ibis	*Threskomis melanocephalus*	Threskiornithidae	50.22 ± 5.338
03.	Little Cormorant	*Phalacrocorax niger*	Phalacrocoracidae	27.70 ± 3.072
04.	Pheasant-tailed Jacana	*Hydrophasianus chirurgus*	Jacanidae	21.99 ± 1.774
05.	Indian Cormorant	*Phalacrocorax fuscicollis*	Phalacrocoracidae	18.25 ± 2.473
06.	Lesser Whistling-duck	*Dendrocygna javanica*	Anatidae	13.25 ± 1.281
07.	Little Egret	*Egretta garzetta*	Ardeidae	12.66 ± 1.074
08.	Cattle Egret	*Bubulcus ibis*	Ardeidae	9.91 ± 0.662
09.	Oriental Darter	*Anhinga melanogaster*	Anhingidae	6.73 ± 1.959
10.	Purple Swamphen	*Porphyrio porphyria*	Rallidae	6.72 ± 0.795
11.	Great Egret	*Ardea modesta*	Ardeidae	3.87 ± 0.317
12.	Indian Pond Heron	*Ardeola grayii*	Ardeidae	3.82 ± 0.364

13.	Intermediate Egret	*Egretta intermedia*	Ardeidae	3.67 ± 0.351
14.	Little Grebe	*Tachybaptus ruficollis*	Podicipedidae	3.30 ± 0.411
15.	Whiskered Tern	*Chlidonias hybridus*	Sternidae	2.72 ± 0.826
16.	Black-winged Stilt	*Himantopus himantopus*	Recurvirostridae	2.73 ± 0.739
17.	Cotton Pygmy-goose	*Nettapus coromandelianus*	Anatidae	2.51± 0.380
18.	Grey Heron	*Ardea cinerea*	Ardeidae	1.67 ± 0.536
19.	Purple Heron	*Ardea purpurea*	Ardeidae	1.61 ± 0.241
20.	Great Cormorant	*Phalacrocorax carbo*	Phalacrocoracidae	1.33 ± 0.266
21.	Pied Kingfisher	*Ceryle rudis*	Cerylidae	0.35 ± 0.138
22.	White-bellied Fish Eagle	*Haliaeetus leucogaster*	Accipitridae	0.23 ± 0.247
23.	Common Kingfisher	*Alcedo atthis*	Alcedinidae	0.23 ± 0.121

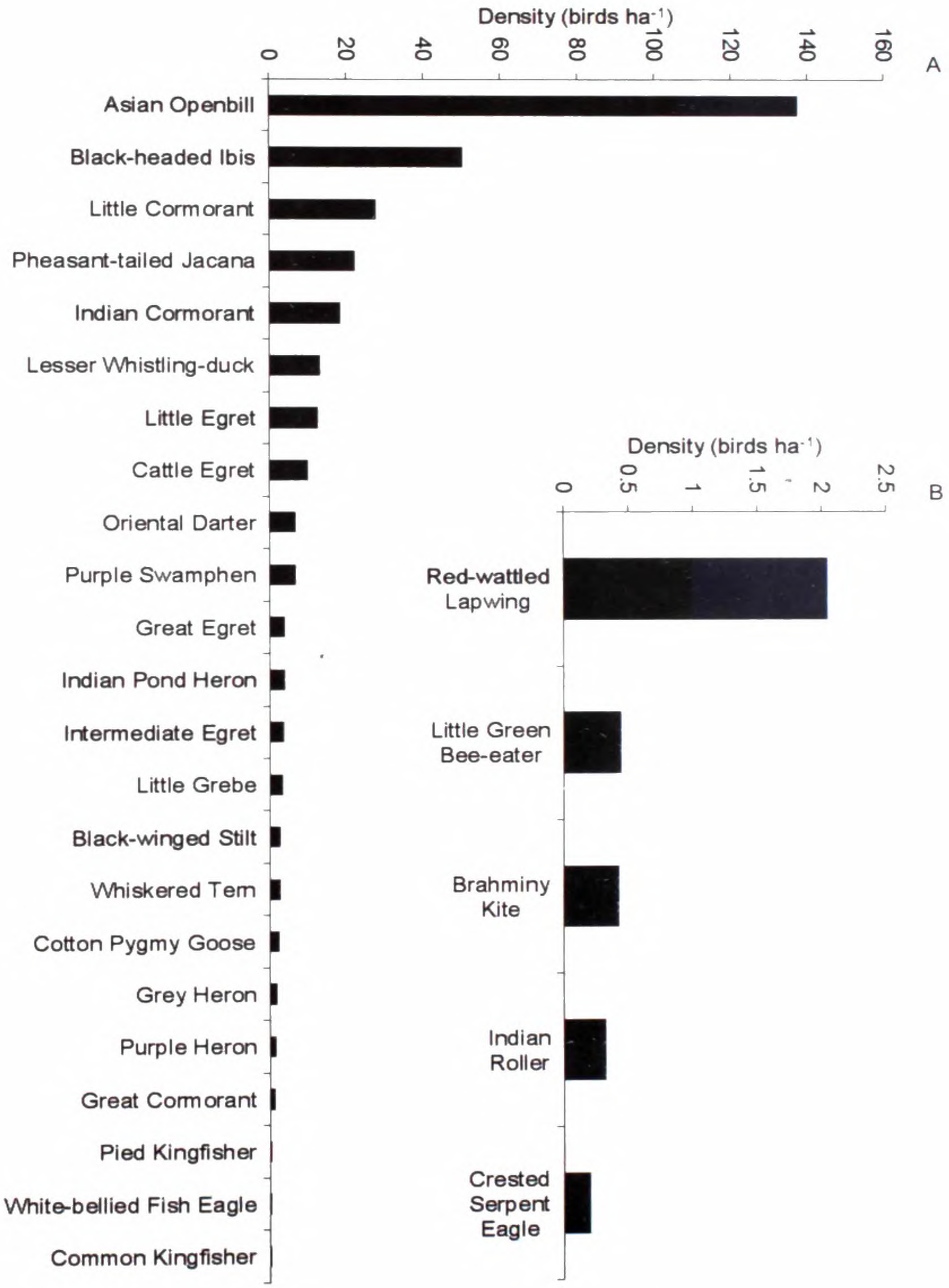

Figure 2. Ranking of bird density in Anavilundawa reservoir. (A) True aquatic birds (B) Aquatic associated birds.

Seasonal variation of total true aquatic bird density in different habitats

During the rainy season, the highest bird density was recorded in tree covered habitats (11.72 ± 1.683 birds ha^{-1}) followed by shallow open water habitats (2.05 ± 0.724 birds ha^{-1}) and grass covered habitats (1.84 ± 0.579 birds ha^{-1}). The lowest bird density was recorded in deep open water habitats (0.40 ± 0.263 birds ha^{-1}).

Similarly during the dry season also the highest bird density was recorded in tree covered habitats (1.57 ± 0.497 birds ha^{-1}) followed by grass covered habitats (0.99 ± 0.3174 birds ha^{-1}) and shallow open water habitats (0.63 ± 0.37 birds ha^{-1}).

Annual variation of true aquatic bird and aquatic associated bird individuals

The highest number of true aquatic bird individuals (4179) was recorded in February 2008 and lowest number of true aquatic bird individuals (436) was recorded in August 2007. The highest number of aquatic associated bird individuals (51) was recorded in June 2008 and lowest number of aquatic associated bird individuals (13) was recorded in November 2007 (Fig. 3).

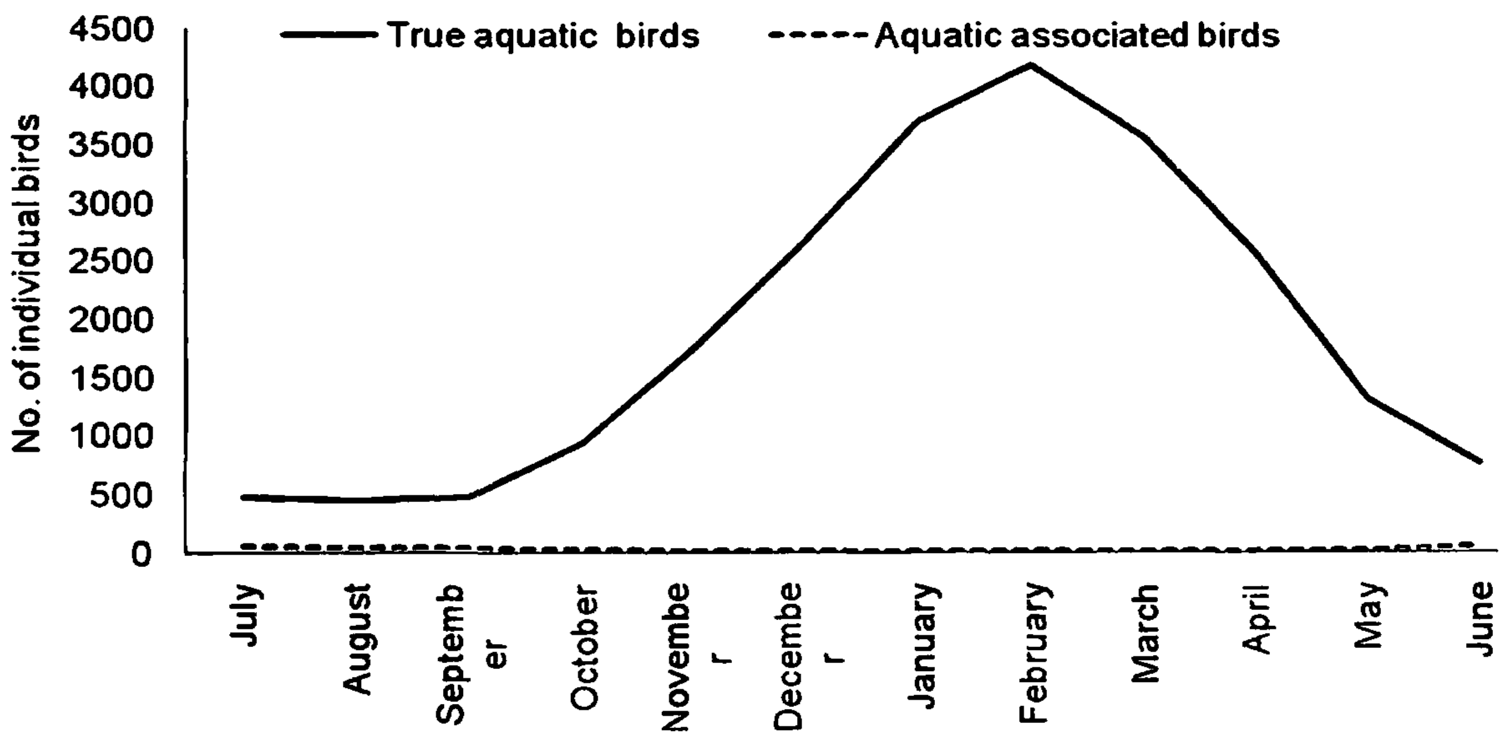

Figure 3. True aquatic bird and aquatic associated bird distribution during study period July 2007 to June 2008.

Diversity

The result showed that true aquatic birds have the highest species diversity *i.e.*, Shannon's Index (H_1 = 2.233), species richness *i.e.*, Margalef's Index (R_1 = 2.015), Menhinick's Index (R_2 = 0.7828) and Species Evenness i.e., Equitability (E = 0.8988) (Table 3).

Table 3. Comparison of bird species diversity of true aquatic bird and aquatic associated bird at Anavilundawa reservoir.

Diversity indices	True aquatic birds	Aquatic associated birds
Shannon's index (H_1)	2.233	2.196
Simpson's index (N_2)	0.8761	0.864
Richness indices		
Margalef's index (R_1)	2.015	1.096
Menhinick's index (R_2)	0.7828	0.07952
Evenness indices		
Equitability (E)	0.8988	0.8835

Species diversity in different habitats

The result showed that grass covered habitats have the highest species diversity *i.e.*, Shannon's index (H_1 = 2.222), followed by shallow open water habitats (Shannon's index H_1 = 2.062) and Water hyacinth covered habitats (Shannon's index H_1 = 2.043). The lowest species diversity was in deep open water habitats (Shannon's index H_1 = 1.553). The highest species richness was in grass covered habitats (Margalef's index R_1 = 2.263), followed by shallow open water habitats (Margalef's index R_1 =2.135) and Trees (Margalef's index R_1 =2.089). However, species evenness was highest in the deep open water habitats (Equitability E = 0.8668), followed by Water hyacinth covered habitats (Equitability E = 0.7966) and grass covered habitats (Equitability E = 0.7547) (Table 4).

Table 4: Total true aquatic bird diversity in different habitats.

	Deep open water habitats	Water hyacinth covered habitats	Grass covered habitats	Lily covered habitats	Shallow open water habitats	Trees
Shannon's index (H_1)	1.553	2.043	2.222	1.953	2.062	1.605
Simpson's index (N_2)	0.734	0.811	0.824	0.739	0.750	0.692
Richness indices						
Margalef's index (R_1)	0.788	1.722	2.263	1.935	2.135	2.089
Menhinick's index (R_2)	0.252	0.398	0.355	0.402	0.335	0.175
Evenness indices						
Equitability (E)	0.866	0.796	0.754	0.721	0.713	0.527

The results also showed that rainy season had the highest species diversity *i.e.*, Shannon's index ($H_{1\ wet}$ = 1.546 and $H_{1\ dry}$ = 1.132) species richness (Margalef's index R_{1wet} = 0.6187 and R_{1dry} = 0.5055) and species evenness (Equitability E_{wet} = 0.8629 and E_{dry} = 0.6319), than in dry season (Equitability E = 0.6319).

DISCUSSION

Many bird species are currently experiencing significant population declines and area-sensitive species show greatest decline and are strongly influenced by the scarcity of habitats (Fuller *et al.*, 2007). Currently, invasive alien species are considered one of the most important causes of biodiversity loss and one of the major drivers of global change (Sala *et al.*, 2000; SCBD, 2010) and in the current study it was documented that a major portion of Anawilundawa reserviour is covered with invasive water hyacinth (*Eichhornia crassipes*). Once established, some invasive alien species have the ability to bring about changes in the ecosystems and reduce biodiversity (Lovell & Stone, 2005). It is a known fact that invaders can alter ecological interactions that have arisen over evolutionary time-scales and thus, could modify evolutionary trajectories (Traveset & Richardson, 2006). It is established that diminution in the structural complexity of the invaded habitat, together with the replacement of the rich native biota, results in a dramatic reduction in the richness and diversity of the affected associated fauna (Galil, 2007). However, Pulliam and Dunning (1987) have stated that each species is best adapted to a few habitats where it can out-compete other species. After all, native faunal species adapted to the invasive floral species make new plant-animal interactions to conserve and sustain their existence. In the current study several species, mainly Purple Moorhen (*Porphyrio porphyrio*), were encountered in water hyacinth mats. Even though certain aquatic faunal species are capable of adapting to new environment, habitat specialists are still in trouble because of aquatic invasive flora invading their natural habitats. If this continues, the habitat specialists like Little Grebe and Cotton Teal may be adversely affected.

Anavilundawa bird sanctuary has gained its recognition as a Ramsar site because it harbours a high density of aquatic birds, especially migratory birds which enter in to the island from the Mannar pathway (Kotagama *et al.*, 2006). Freshwater habitats available have been naturally or artificially modified along the migratory path of this route. Still, Anavilundawa is an important Ramsar site in spite of modification to ecosystem after exotic plants have invaded the system. The present study does not promote invasives, but highlights the value of invasive for maintaining and supporting the bird diversity in Anaviludawa, especially the habitat generalists. Yet, the potential threats to habitat specialists cannot be ignored. One of the tools to measure wetland quality is the use of diversity indices. If the diversity is greater, the habitat would be more complex and thus, more stable. The species in these habitats are capable of responding to environmental changes (Magurran, 2003). Present study showed that the number of wetland bird species was higher than the number of wetland associated bird species in Anavilundawa reservoir. Obviously, this difference might be due to the reason that wetland birds take advantage of habitats distributed in the study area. Also, the limited availability of resources for wetland associated birds to fulfil their requirements may be the reason for their low populations.

Results of current study found that the density and species richness of birds were the highest during rainy season when migratory species also arrived and the lowest during dry season when the migratory species left the area and a few inhabitant species were engaged in the breeding and roosting activities. Comparing the two seasons, resource availability in rainy season is likely to be more stable than in dry season. Amongst wetland birds recorded in the study area, Asian Openbill was the most abundant species and its density contributed to high density of birds recorded in trees in this study. Asian Openbills inhabit only the Anavilundawa reservoir for nesting and breeding behaviour, but not in other adjacent reservoirs. This could be due to the presence of large number of veteran trees within the reservoir itself, a character not seen in other adjacent reservoirs. However, it was observed that most trees, where the nesting occurred, were without leaves during the breeding season. Hence stunting, retarded growth and death of trees could occur due to mass nesting of wetland birds; a phenomenon observed by Johnson & Beck (1988); Lapointe *et al.* (2000). The signs of the dying back of veteran trees within Anavilundawa reservoir may be an indication of the impacts of high nesting pressure on the trees. This seems to be true because during the latter part of the Asian Openbill breeding season, the Little Cormorants (*Phalacrocorax niger*) began their nesting and breeding behaviour and were followed by Black-headed Ibis (*Threskiornis melanocephalus*) and Oriental Darter (*Anhinga melanogaster*).

Tree covered habitats had greater species diversity and richness than open habitats, explaining that the trees provide excellent habitat structure to certain bird species. This is most likely a reflection of the well-established relationship between vegetation structure and bird species diversity.

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