

Diurnal avifaunal diversity and density along the Bolgoda Canal of the Bellanwila- Attidiya Marsh, Western Sri Lanka

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Abstract

Diurnal Avifaunal species richness, diversity and density was studied along the Bolgoda Canal in Bellanwila- Attidiya Marsh from June 2005 to February 2006 using the fixed distance line transect method. Six line transects (length 500m each) totaling 3.00 km, which provided the maximum visibility of the Bolgoda canal was marked along the canal bank using a GPS. All birds seen within one hundred meters on either side of each transect were recorded for each month from June 2005 to February 2006. A total number of 107 individuals belong to 53 bird species, thirteen orders and thirty one families were recorded during the study period. The globally endangered Spot Billed Pelican (*Pelecanus philippensis*) and four migratory species Common Sandpiper (*Actitis hypoleucos*), Eurasian Thick- Knee (*Burhinus Odicnemus*), Gull - Billed Tern (*Gelochelidon nilotica*), and Asian Paradise Flycatcher (*Terpsiphone paradisi*) were among them. Diversity and density indices were significantly different among months (ANOVA, $F=4.24$, $p<0.01$ and $F=8.828$, $p<0.001$) respectively. Relative abundance indicated that House Crow (*Corvus splendens*) was the most abundant species while Crested Serpent Eagle was the least abundant bird followed by Pheasant Tailed Jacana and Lesser Whistling Teal. Present study revealed that although the study site is in close proximity to densely populated residential areas; it still provides a vital habitat to large number of bird species and therefore warrants protection.

Key words: Avifauna, Diversity, Density, Bellanwila – Attidiya marsh

Introduction

World wide urban areas are expanding both in size and number and urbanization already ranks second among the causes for endangering wildlife (Czech and Krausman 1997). Urbanization has resulted in habitat loss and fragmentation

(FAO, 1993, Whitmore, 1997) and subsequently species loss (Turner and Corlett, 1996). Hence it has become necessary to measure the species diversity, species richness and the species abundance in areas of concern to understand the effects of urbanization on wildlife. Measurement of species diversity is crucial for assessing the natural richness, biological value and the uniqueness of a particular area (Gopal 1992) and indices of species diversity have been used widely in studies of environmental factors influencing avian community dynamics (Verner 1999). Just over a decade ago, Bellanwila-Attidiya marsh represented a prime wetland habitat that harbored a rich bird fauna, with over 153 species of birds (Nanayakkara, 1997, IUCN 1990). However, today alien invasive fauna and flora has found their way to the marsh, chemical effluents have been released by the adjoining factories, the marsh has been used as a garbage dump, increasingly encroached by the ever increasing human population and once crystal clear water has become muddy, brackish and silt filled (Maduranga, 2005). These factors have drastically reduced the value of this crucial bird habitat. Hence, it is of vital importance to study the present avifaunal composition to understand the effects of habitat change on them. The present study concentrated in recording the bird composition, the diversity and density variance of the diurnal avifaunal species with the aim of understanding the present day avifaunal composition of the marsh.

Materials and Methods

Study area

The study was conducted along the Bolgoda canal of the Bellanwila- Attidiya Marsh which is situated in the western province of Sri Lanka (Nanayakkara 1988). This area is situated within the low country wet zone and has a tropical monsoon climate. The marsh comprises of shallow water ponds and seasonally flooded grasslands with scattered pockets of shrubs and small trees. This creates a unique wetland that supports a wide array of both terrestrial and water bird species. The flora comprises mainly of *Annona sp.*, *Pandanus sp.*, Mango (*Mangifera indica*), Guava (*Psidium guajava*), Tamarind (*Tamarindus sp.*), Nuga (*Terminalia cattapa*), Ahela (*Cassia fistula*). Surface water of the Bolgoda canal is covered by invasive *Salvinia molesta* with scattered areas of native floating leaved plants (water lily- *Nymphaea spp* and lotus – *Nelumbu nucifera*).

Methods

Study population

Six line transects (length 500m each) totaling 3.00 km, which provided the maximum visibility of the Bolgoda canal was marked along the canal bank using a GPS (Sutherland 1997). All birds seen within and beyond one hundred

meters on either side of each transect were recorded every month from June 2005 to February 2006 by traveling along these transects and observing them through a 15~60 x 25 spotting scope and 25 x 45 binocular (Verner 1999). The day was divided into three time periods as 0700 – 1000 (morning), 1200 – 1500 (noon) and 1600 – 1800 (evening). Data was collected three times per month in each time period. Field guides to the Bird of Sri Lanka were used to identify the birds (Harrison 2005, Kotagama & Wijeyasinghe, 2003). Monthly rainfall was obtained from the meteorological department of Sri Lanka. Temperature was recorded at each visit in all the time periods.

Data analysis

Bird communities at different times of the day were compared (Verner 1999). Population diversity was calculated using Shannon – Weiner Index $\{H'\}$ where $H' = -\sum P_i \ln P_i$, P_i = the proportion of individuals of the total sample belonging to the i^{th} Species. Population density was calculated using the equation, $\text{Density} = \frac{n_1 + n_2}{2rl} \log_e \frac{(n_1 + n_2)}{n_2}$, n_1 = Number of birds counted within r (100m), n_2 = Number of birds counted beyond r , r = Distance from the transect line to the boundary between two zones, l = Length of the transect line.

Statistical analysis

ANOVA was used to determine whether there was a significant variation between the diversity and density of the three time periods and among months. Fisher's post hoc test (PLDS) was used to determine where the difference originated.

Results

Fifty-three bird species belonging to thirteen orders and thirty one families were identified during the study period. These included the globally endangered Spot Billed Pelican (*Pelecanus philippensis*) and migratory species, Common Sandpiper (*Actitis hypoleucos*), Eurasian Thick – Knee (*Burhinus oedipnemos*), Gull Billed Tern (*Gelochelidon nilotica*) and Asian Paradise – Flycatcher (*Terpsiphone paradise*) (Table 1). Of the migrating species, Common Sandpiper was first recorded in December 2005 and was observed up to February 2006. Eurasian Thick – knee was observed for four months from November 2005 to February 2006. Gull Billed Tern which was fairly common occurred from August 2005 to February 2006 and the Asian Paradise Flycatcher was observed from June to September 2005 and from November 2005 to January 2006. Twenty four species were observed throughout the study period while three species Lesser Whistling Duck, Serpent Eagle and Pheasant Tailed Jacana were observed only in one month (Table 2).

Table 1. Diurnal bird species composition along the Bolgoda canal at Bellanwila - Attidiya Sanctuary during the period of June 2005 to February 2006

| ORDER | FAMILY | COMMON NAME | SCIENTIFIC NAME |
|-------------------|----------------------|----------------------------------|---|
| Pelecaniformes | Pelecanidae | Spot Billed Pelican* | <i>Pelecanus philippensis</i> * |
| | Phalacrocoracidae | Great Cormorant | <i>Phalacrocorax carbo</i> |
| Little Cormorant | | <i>Phalacrocorax niger</i> | |
| Indian Cormorant | | <i>Phalacrocorax fuscicollis</i> | |
| Ciconiiformes | Ahingidae | Oriental Darter | <i>Anhinga melanogaster</i> |
| | Ardeidae | Purple Heron | <i>Ardea purpurea</i> |
| | | Grey Heron | <i>Ardea cinerea</i> |
| | | Intermediate Egret | <i>Mesophoyx intermedia</i> |
| | | Great Egret | <i>Casmerodius albus</i> |
| | | Little Egret | <i>Egretta garzetti</i> |
| | | Indian Pond Heron | <i>Ardeola grayii</i> |
| | | Black Crown Night Heron | <i>Nycticorax nycticorax</i> |
| | Yellow Bittern | <i>Ixobrychus sinensis</i> | |
| | Ciconiidae | Painted Stork | <i>Mycteria leucocephala</i> |
| | | Black Headed Ibis | <i>Threkiornis melanocephalus</i> |
| Threskiornithidae | Lesser Whisting Duck | <i>Dendrocygna bicolor</i> | |
| Anseriformes | Anatidae | Crested Serpent Eagle | <i>Spilornis cheela</i> |
| Falconiformes | Accipitridae | Brahminy Kite | <i>Haliastur indus</i> |
| | | White Breasted Water hen | <i>Amaurornis phoenicurus</i> |
| Gruiformes | Rallidae | Purple Coot | <i>Porphyrio porphyrio</i> |
| Charadriiformes | Jacaniidae | Pheasant Tailed Jacana | <i>Hydrophasianus chirurgus</i> |
| | Charadriidae | Red Wattled Lapwing | <i>Vanellus indicus</i> |
| | Burhinidae | Eurasian Thick Knee** | <i>Burhinus Oedicnemus**</i> |
| | Laridae | Gull Billed Tern** | <i>Gelochelidon nilotica**</i> |
| | Scolopacidae | Common Sandpiper** | <i>Actitis hypoleucos**</i> |
| Columbiformes | Columbidae | Spotted Dove | <i>Streptopelia chinensis cylonensis</i> |
| Psittaciformes | Psittacidae | Alexandriane Parakeet | <i>Psittacula eupatria</i> |
| | | Rose Ringed Parakeet | <i>Psittacula krameri</i> |
| Cuculiformes | Cuculidae | Asian Koel | <i>Eudynamis scolopacea</i> |
| | | Greater Coucal | <i>Centropus sinensis</i> |
| Apodiformes | Apodidae | Little Swift | <i>Apus affinis</i> |
| Coraciiformes | Alcedinidae | White Throated Kingfisher | <i>Halcyon smynensis</i> |
| | | Stork Billed Kingfisher | <i>Halcyon capensis</i> |
| | | Common Kingfisher | <i>Alcedo atthis</i> |
| | | Pied Kingfisher | <i>Ceryle rudis</i> |
| | | Blue-tailed Bee Eater | <i>Merops philippinus</i> |
| | | Little green Bee Eater | <i>Merops orientalis</i> |
| Piciformes | Meropidae | Brown Headed Barbet | <i>Megalaima zeylanica</i> |
| | Capitonidae | Greater Flame Back | <i>Chrysocolaptes lucidus stricklandi</i> |

| | | | |
|---------------|---------------------|-----------------------------|---|
| Passeriformes | Pycnonotidae | Red Vented Bulbul | <i>Pycnonotus cafer cafer</i> |
| | | Black Bulbul | <i>Hypsipetes leucocephalus humi</i> |
| | Turdidae | Oriental Magpie Robin | <i>Copsychus saularis</i> |
| | Timaliidae | Yellow Billed Babbler | <i>Turdoides affinis tapropanus</i> |
| | Sylviidae | Common Tailorbird | <i>Orthotomus sutorius sutorius</i> |
| | | Nectariniidae | Purple Rumped Sunbird |
| | Long Billed Sunbird | | <i>Nectarinia lotenia lotenia</i> |
| | Purple Sunbird | | <i>Nectarinia asiatica</i> |
| | Ploceidae | House Sparrow | <i>Passer domesticus</i> |
| | Sturnidae | Common Myna | <i>Acridotheres tristis melanosturnus</i> |
| | Monarchidae | Asian Paradise Flycatcher** | <i>Terpsiphone paradisi**</i> |
| | Oriolidae | Black Hooded Oriole | <i>Oriolus xanthornus ceylonensis</i> |
| Corvidae | House Crow | <i>Corvus splendens</i> | |
| | Black drongo | <i>Dicrurus macrocercus</i> | |

* Globally endangered

** Migratory

Table 2. Number of individuals of each avifaunal species recorded along the Bolgoda canal of the Bellanwila - Attidiya Sanctuary during the period of June 2005 to February 2006.

| COMMON NAME | June | July | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Total |
|--------------------------|------|------|-----|-----|-----|-----|-----|-----|-----|-------|
| Spot Billed Pelican* | 0 | 0 | 2 | 0 | 4 | 1 | 2 | 0 | 0 | 9 |
| Great Cormorant | 2 | 3 | 3 | 2 | 3 | 2 | 2 | 3 | 1 | 21 |
| Little Cormorant | 6 | 10 | 8 | 7 | 4 | 10 | 12 | 6 | 4 | 67 |
| Indian Cormorant | 3 | 4 | 6 | 5 | 3 | 4 | 8 | 7 | 5 | 45 |
| Oriental Darter | 2 | 3 | 2 | 4 | 4 | 2 | 6 | 3 | 2 | 28 |
| Purple Heron | 1 | 3 | 6 | 2 | 3 | 4 | 7 | 5 | 3 | 34 |
| Grey Heron | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 6 |
| Intermediate Egret | 3 | 2 | 3 | 0 | 1 | 2 | 3 | 3 | 2 | 19 |
| Great Egret | 2 | 1 | 3 | 2 | 0 | 1 | 2 | 0 | 1 | 12 |
| Little Egret | 2 | 1 | 2 | 2 | 3 | 2 | 2 | 1 | 2 | 17 |
| Indian Pond Heron | 5 | 3 | 4 | 4 | 5 | 5 | 7 | 4 | 4 | 41 |
| Black Crown Night Heron | 0 | 1 | 1 | 0 | 1 | 2 | 1 | 0 | 2 | 8 |
| Yellow Bittern | 0 | 1 | 2 | 0 | 0 | 0 | 2 | 1 | 1 | 7 |
| Painted Stork | 0 | 0 | 0 | 2 | 0 | 4 | 1 | 1 | 0 | 8 |
| Black Headed Ibis | 7 | 4 | 7 | 4 | 0 | 0 | 0 | 0 | 0 | 22 |
| Lesser Whisting Duck | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 4 |
| Crested Serpent Eagle | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Brahminy Kite | 0 | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 0 | 11 |
| White Breasted Water hen | 4 | 9 | 4 | 5 | 7 | 8 | 11 | 6 | 4 | 58 |

| | | | | | | | | | | |
|-----------------------------|----|----|----|----|----|----|----|----|----|-----|
| Purple Coot | 5 | 4 | 5 | 0 | 0 | 0 | 10 | 8 | 11 | 43 |
| Pheasant Tailed Jacana | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 4 |
| Red Wattled Lapwing | 2 | 2 | 2 | 2 | 4 | 2 | 2 | 2 | 2 | 20 |
| Eurasian Thick Knee** | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 4 |
| Gull Billed Tern** | 0 | 0 | 2 | 2 | 4 | 3 | 5 | 3 | 2 | 21 |
| Common Sandpiper** | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 3 | 2 | 7 |
| Black drongo | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 18 |
| Spotted Dove | 1 | 2 | 3 | 0 | 2 | 2 | 1 | 1 | 0 | 12 |
| Alexandriane Parakeet | 4 | 4 | 6 | 2 | 4 | 5 | 5 | 2 | 2 | 34 |
| Rose Ringed Parakeet | 9 | 8 | 11 | 9 | 6 | 8 | 15 | 12 | 8 | 86 |
| Asian Koel | 0 | 2 | 0 | 2 | 0 | 2 | 2 | 2 | 0 | 10 |
| Greater Coucal | 1 | 3 | 4 | 3 | 4 | 3 | 3 | 2 | 4 | 27 |
| Little Swift | 2 | 4 | 1 | 6 | 4 | 8 | 4 | 3 | 5 | 37 |
| White Throated Kingfisher | 4 | 2 | 5 | 6 | 6 | 4 | 8 | 4 | 6 | 45 |
| Stork Billed Kingfisher | 0 | 2 | 2 | 4 | 5 | 2 | 7 | 4 | 1 | 27 |
| Common Kingfisher | 0 | 1 | 0 | 1 | 0 | 1 | 2 | 2 | 1 | 8 |
| Pied Kingfisher | 0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 16 |
| Little green Bee eater | 0 | 0 | 0 | 0 | 4 | 6 | 2 | 2 | 2 | 16 |
| Blue tailed Bee eater | 0 | 0 | 3 | 7 | 8 | 5 | 6 | 4 | 2 | 35 |
| Brown Headed Barbet | 4 | 3 | 1 | 6 | 1 | 4 | 2 | 1 | 3 | 27 |
| Greater Flameback | 0 | 0 | 2 | 2 | 0 | 0 | 1 | 0 | 0 | 5 |
| Red Vented Bulbul | 6 | 4 | 7 | 5 | 7 | 5 | 3 | 4 | 3 | 44 |
| Black Bulbul | 2 | 3 | 2 | 2 | 0 | 3 | 0 | 0 | 0 | 12 |
| Oriental Magpie Robin | 0 | 0 | 0 | 2 | 0 | 2 | 4 | 2 | 2 | 12 |
| Yellow Billed Babbler | 4 | 6 | 7 | 4 | 4 | 5 | 4 | 2 | 3 | 39 |
| Common Tailorbird | 0 | 0 | 1 | 1 | 1 | 0 | 3 | 3 | 2 | 11 |
| Purple Rumped Sunbird | 1 | 1 | 2 | 4 | 1 | 3 | 4 | 2 | 3 | 21 |
| Long Billed Sunbird | 2 | 3 | 1 | 2 | 3 | 2 | 2 | 4 | 1 | 20 |
| Purple Sunbird | 4 | 3 | 1 | 5 | 5 | 4 | 2 | 5 | 2 | 31 |
| House Sparrow | 2 | 3 | 2 | 4 | 2 | 2 | 3 | 4 | 3 | 25 |
| Common Myna | 8 | 7 | 9 | 10 | 13 | 9 | 10 | 14 | 5 | 85 |
| Asian Paradise Flycatcher** | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 7 |
| Black Hooded Oriole | 0 | 1 | 0 | 1 | 2 | 1 | 2 | 2 | 3 | 12 |
| House Crow | 11 | 13 | 12 | 15 | 12 | 11 | 10 | 11 | 12 | 107 |

* Globally endangered

** Migratory birds

Relative abundance indicated that House Crow was the most common bird followed by the Rose Ringed Parakeet, Common mynah, Little Cormorant, White Breasted Waterhen, Indian Cormorant. These birds accounted for 33.26% of the total population. Crested Serpent Eagle was the least common bird followed by Pheasant Tailed Jacana, Lesser Whistling Teal and Eurasian Thick Knee, Greater Flameback and Grey Heron. These six species accounted only for 1.86% of the total population. Water birds such as teals and cormorants and water dependent birds like herons, coots, kingfishers and jacanas accounted only for 35.47 % of the total population (Table 3).

Table 3. Relative abundance of the avifauna recorded along the Bolgoda canal recorded during the period of June 2005 to February 2006.

| Common Names | Relative Abundance | Rank |
|---------------------------|--------------------|------|
| House Crow | 7.94 | 1 |
| Rose Ringed Parakeet | 6.38 | 2 |
| Common Myna | 6.31 | 3 |
| Little Cormorant | 4.97 | 4 |
| White Breasted Water hen | 4.31 | 5 |
| Indian Cormorant | 3.34 | 6 |
| White Throated Kingfisher | 3.34 | 7 |
| Red Vented Bulbul | 3.27 | 8 |
| Purple Coot | 3.19 | 9 |
| Indian Pond Heron | 3.04 | 10 |
| Yellow Billed Babbler | 2.90 | 11 |
| Little Swift | 2.75 | 12 |
| Blue tailed Bee eater | 2.60 | 13 |
| Alexandriane Parakeet | 2.52 | 14 |
| Purple Heron | 2.52 | 15 |
| Purple Sunbird | 2.30 | 16 |
| Oriental Darter | 2.08 | 17 |
| Brown Headed Barbet | 2.00 | 18 |
| Greater Coucal | 2.00 | 19 |
| Stork Billed Kingfisher | 2.00 | 20 |
| House Sparrow | 1.86 | 21 |
| Black Headed Ibis | 1.63 | 22 |
| Great Cormorant | 1.56 | 23 |
| Gull Billed Tern** | 1.56 | 24 |
| Purple Rumped Sunbird | 1.56 | 25 |
| Long Billed Sunbird | 1.48 | 26 |
| Red Wattled Lapwing | 1.48 | 27 |
| Intermediate Egret | 1.41 | 28 |
| Black drongo | 1.34 | 29 |
| Little Egret | 1.26 | 30 |
| Little green Bee eater | 1.19 | 31 |
| Pied Kingfisher | 1.19 | 32 |
| Black Bulbul | 0.89 | 33 |
| Black Hooded Oriole | 0.89 | 34 |
| Great Egret | 0.89 | 35 |
| Oriental Magpie Robin | 0.89 | 36 |
| Spotted Dove | 0.89 | 37 |
| Brahminy Kite | 0.82 | 38 |
| Common Tailorbird | 0.82 | 39 |
| Asian Koel | 0.74 | 40 |
| Spot Billed Pelican* | 0.67 | 41 |
| Black Crown Night Heron | 0.59 | 42 |
| Common Kingfisher | 0.59 | 43 |

| | | |
|-----------------------------|------|----|
| Painted Stork | 0.59 | 44 |
| Asian Paradise Flycatcher** | 0.52 | 45 |
| Common Sandpiper** | 0.52 | 46 |
| Yellow Bittern | 0.52 | 47 |
| Grey Heron | 0.45 | 48 |
| Greater Flameback | 0.37 | 49 |
| Eurasian Thick Knee** | 0.30 | 50 |
| Lesser Whisting Duck | 0.30 | 51 |
| Pheasant Tailed Jacana | 0.30 | 52 |
| Crested Serpent Eagle | 0.15 | 53 |

Highest species diversity of 3.77 ± 0.13 was recorded in September 2005 while the least diversity of 2.85 ± 0.16 was recorded in February 2006. Highest species richness of 37.00 ± 6.1 and the least species richness of 34.33 ± 3.5 were recorded in September 2005 and February 2006 respectively. Highest species density of 3.80 ± 0.53 was recorded in September 2005 while the least density of 1.27 ± 0.23 was recorded in June 2006. Dominance was high in June 2005 and February 2006 and was low in September 2005. Evenness was high in September while it was low in February (Table 4).

Table 4. Means and SE of bird community parameters along the Bolgoda canal of Bellanwila - Attidiya sanctuary, during June 2005 to February 2006.

| | | Bird diversity \pm SE | Bird density \pm SE | Evenness \pm SE | Dominance \pm SE | Bird species richness \pm SE |
|-----|----|----------------------------|--------------------------|----------------------|-----------------------|-----------------------------------|
| JUN | 05 | 3.11 ± 0.06 | 1.27 ± 0.23 | 0.54 ± 0.03 | 0.46 ± 0.03 | 35.33 ± 2.5 |
| JUL | 05 | 2.89 ± 0.14 | 3.17 ± 0.14 | 0.63 ± 0.05 | 0.37 ± 0.04 | 36.33 ± 1.2 |
| AUG | 05 | 3.00 ± 0.17 | 1.70 ± 0.24 | 0.45 ± 0.02 | 0.55 ± 0.05 | 35.33 ± 2.1 |
| SEP | 05 | 3.77 ± 0.13 | 3.80 ± 0.53 | 0.74 ± 0.04 | 0.27 ± 0.04 | 37.00 ± 6.1 |
| OCT | 05 | 3.25 ± 0.05 | 3.58 ± 0.21 | 0.59 ± 0.06 | 0.41 ± 0.03 | 39.66 ± 1.5 |
| NOV | 05 | 3.20 ± 0.17 | 3.04 ± 0.38 | 0.69 ± 0.03 | 0.31 ± 0.04 | 37.33 ± 2.5 |
| DEC | 05 | 3.70 ± 0.30 | 3.75 ± 0.29 | 0.75 ± 0.02 | 0.25 ± 0.02 | 40.00 ± 1.0 |
| JAN | 06 | 3.76 ± 0.28 | 3.25 ± 0.31 | 0.66 ± 0.04 | 0.34 ± 0.04 | 36.66 ± 4.5 |
| FEB | 06 | 2.85 ± 0.16 | 2.84 ± 0.16 | 0.55 ± 0.01 | 0.45 ± 0.02 | 34.33 ± 3.5 |

Morning had the lowest mean temperature of 27.33 ± 0.34 while noon had the highest mean temperature of 30.32 ± 0.6 . Mean evening temperature was 29.31 ± 0.57 which was low when compared to noon temperature. Mean temperature among the three time periods was significantly different (ANOVA, $F= 8.79$, $p < 0.005$). Post Hoc test revealed that mean temperature in the morning was significantly low when compared with noon and evening. Post Hoc test also revealed that there is a significant difference in the temperature among months. November had the highest rainfall while August had the least rainfall (Table 5).

Table 5. Mean \pm SD temperature, rainfall, recorded during the study period of June 2005 to February 2006.

| Month | Temperature/ °C | | | | Rainfall |
|-------|-----------------|------|---------|------------------------|----------|
| | Morning | Noon | Evening | Mean \pm SE | |
| June | 28.45 | 31.5 | 29.91 | 29.95 ± 0.88^{ac} | 220.2 |
| July | 27.5 | 32 | 30.5 | 30.00 ± 1.30^a | 165.8 |
| Aug. | 28.5 | 31.4 | 31.2 | 30.37 ± 0.90^a | 21.8 |
| Sep | 27.95 | 32.3 | 30.3 | 30.18 ± 1.26^a | 85.3 |
| Oct | 27.25 | 30.4 | 30.1 | 29.25 ± 1.00^{ac} | 504.0 |
| Nov. | 26.65 | 30.1 | 30.1 | 28.95 ± 1.15^{abc} | 760.4 |
| Dec | 25.23 | 27.5 | 26.1 | 26.28 ± 0.66^{bc} | 818.5 |
| Jan | 26.7 | 27.5 | 27.1 | 27.10 ± 0.20^c | 126.9 |
| Feb | 27.7 | 30.2 | 28.5 | 28.80 ± 0.70^{abc} | 156.9 |

Mean \pm SE 27.33 ± 0.34^x 30.32 ± 0.6^y 29.31 ± 0.57^z

ANOVA was used to determine the differences of temperature between different time periods and different months. Post Hoc test (Fisher's PLSD) was used to see where the differences originated. Means followed by the identical superscript letter was not significantly different ($p > 0.05$).

Morning had the highest mean diversity of 3.53 ± 0.16 while noon had the lowest mean diversity of 3.01 ± 0.13 . Mean diversity was significantly different among the three time periods (ANOVA, $F=3.928$, $p < 0.05$). Morning time period also had the highest mean density of 3.42 ± 0.33 while noon had the lowest mean density of 2.50 ± 0.29 . Mean density was significantly different among the three time periods (ANOVA, $F=2.311$, $p < 0.05$). The diversity (ANOVA, $F=4.24$, $p < 0.01$) and density (ANOVA, $F=8.828$, $p < 0.001$) were significantly different among months (Table 6).

Table 6. Monthly variation of Mean temperature \pm SE, Mean rainfall \pm SE, trees with fruits and trees with flowers during the study period

| | Mean Temperature \pm SE | Mean Rainfall | No. of trees with fruits | No. of trees with flowers |
|------|------------------------------|---------------|-----------------------------|------------------------------|
| June | 29.9 \pm 0.88 | 220.2 | 3 | 11 |
| July | 30.0 \pm 1.30 | 165.8 | 3 | 17 |
| Aug. | 30.4 \pm 0.90 | 21.8 | 8 | 12 |
| Sep | 30.2 \pm 1.26 | 85.3 | 15 | 20 |
| Oct | 29.3 \pm 1.00 | 504 | 23 | 10 |
| Nov. | 28.9 \pm 1.15 | 760.4 | 25 | 8 |
| Dec | 26.3 \pm 0.66 | 818.5 | 15 | 5 |
| Jan | 27.1 \pm 0.20 | 126.9 | 10 | 17 |
| Feb | 28.8 \pm 0.70 | 156.9 | 16 | 8 |

Discussion

Importance of the Bellanwila - Attidiya Marsh as a important bird habitat was recognized by the department of wild life which led it to be declared as a sanctuary. However, the vegetation structure has changed over the years with large tracts of invasive flora and the habitat has been degraded due to various anthropogenic activities including garbage dumping, affluent releasing and encroaching. With the change of the habitat the bird community too has changed. Therefore, it is important to understand the present composition of the avifauna at this once highly valued marsh habitat.

Present study recorded fifty-three bird species belonging to thirteen orders and thirty one families in the study area out of which 23 species were aquatic and 30 species were terrestrial. Gunewardane (1991) recorded 147 bird species in the same study area out of which 59 species were aquatic and 88 species were terrestrial. Central Environmental Authority recorded 152 bird species belonging to 48 families out of which 67 species were aquatic and 85 species were terrestrial (Wetland site report of the Bellanwila – Attidiya marsh, CEA (1993). Hence, the present study revealed that the importance of the marsh as a prime bird habitat has been reduced drastically.

Relative abundance revealed that this community comprises mostly of common birds such as House Crow, Rose Ringed Parakeet and Common Mynah. The dumping of domestic waste along the adjacent roads and inside the sanctuary may have caused to abundance of the House Crow (*Corvus*

splendens) and Common Mynah which are well known to scavenge on garbage dumps. The effluents discharged by the adjacent factories to the local drains flowed in to the channel and resulted in major fish kills which decimated the local populations of several fish species. This may have resulted in the low number of fish dependent bird species including Common Kingfisher (*Alcedo atthis*) Pied Kingfisher (*Ceryle rudis*) and Stork Billed Kingfisher (*Halcyon capensis*). Common Kingfishers consumes fish species with a length of 2cm-5cm and the Pied Kingfisher consumes fish species with a length of 2cm- 14 cm (Fergus 2001). These birds are known as food specialists. Cody (1985) observed that urbanization mostly effect food specialists than food generalists. Therefore the changing environmental factors may have led to the reduction in the number of kingfishers who are habitat specialists and the increase in the number of habitat generalist such as House Crow and Common Mynah.

Water dependent birds such as Lesser Whistling Duck, Spot Billed Pelican and Herons were scarce. Even the Pheasant Tailed Jacana for which the marsh was renowned was observed in extremely low numbers. Vegetation plays a vital role in bird species richness and density in an area. Plants provide shelter, food and nesting place for birds (McClure 1969). Importance of floating leaved vegetation such as *Nelumba nucifera* to Jacanas is well known (Mahaulpatha et al., 2007). Invasive water plants including *Salvinia molesta*, was observed covering large tracts of the canals which prevented native floating leaved plants from spreading in the canal. Jacanas have long toes and claws that are adapted to walk on floating aquatic plants (Janzen 1983). They are dependent on floating leaved plants for nest sites and foraging sites. Lack of these suitable plant species could be the reason for the low number of jacanas observed in and along the canal.

Birds are known to be active between 18°C – 25°C (Sutherland 1997) and during the first three hours after sunrise (Raman 2003). The findings of the present study argue well with the above findings as the highest species diversity and density were observed in the morning time period when the temperature was comparatively low. Highest value of temperature and lowest value of rainfall were recorded in August. This may have been due to the fact that it was the dry season in Colombo region. Lowest value of temperature and highest value of rainfall was recorded in December since it was the rainy season. These factors too may have had an effect on the bird species richness and density.

High species diversity and density observed in September to January could be due to the influx of migratory birds such as Common Sandpiper (*Actitis hypoleucos*), Eurasian Thick – knee (*Burhinus Oedicnemus*), Gull – billed Tern (*Gelochelidon nilotica*), Asian Paradise – Flycatcher (*Terpsiphone*

paradise) due to bird migrations. Sri Lanka is important for bird migrating south in the Northern winter season as there is no land for the next 8,000km until Antarctica is reached.

Reduction of the bird species recorded at the Bellanwila – Attidiya marsh could be due to several reasons. First the effluents released by the adjacent factories to the marsh rendered an oily look to the canal water, which diminished its value to the water birds. These effluents were known to be responsible for fish kills which further affected the fish dependent bird species. The canal water was covered to large extents by the invasive water hyacinth which affected the jacanas and coots which are known to depend on native floating leaved plants. The dumping of garbage along the adjacent roads has also caused serious pollution problems and increased the common birds such as House Crows and Mynahs which resulted in change of the bird composition. Most of the larger trees have been cut down for firewood resulting in reduced perching places for Kingfishers and Cormorants. Further, the ever present throw-net fishermen and villagers constantly collecting firewood disturbed the water dependent birds. Motor vehicles including noisy motor bikes which were frequently driven along the water edge of the canal further diminished the value of the marsh for the water dependent birds as these caused them to take flight. Therefore, the present study reveals that the importance of the Bellanwila – Attidiya Marsh as a prime water bird habitat has been reduced drastically. Hence the management should take serious action to stop, releasing of industrial effluents to the marsh, garbage dumping, firewood collection, throw net fishing, vehicle movement along the canal and should check on the spread of invasive flora including water hyacinth and terrestrial *Annona* to improve the habitat for marsh birds.

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