RUHUNA JOURNAL OF SCIENCE
Vol. 3, September 2008, pp 34-43
http://www.ruh.ac.lk/rjs/
ISSN 1800-279X

Factors affecting the avi-faunal distribution in the three lagoons (Malala, Embillakala and Bundala Lewaya) of Bundala National Park (A Ramsar Wetland) in Sri Lanka

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Abstract. Bundala National Park, covering an area of 6216 ha, is located about 250 Km Southeast of Colombo, in the Hambantota District. The shallow brackish water lagoons located within the park - Koholankala (390 ha), Malala (650 ha), Embilikala (430 ha) and Bundala (520 ha) form a complex wetland system that harbors a rich bird life, including several species of migratory waterfowl. This led to the declaration of Bundala as Sri Lanka's first Ramsar wetland - a wetland of international importance especially for migratory waterfowl, in 1990. Distribution and the composition of the aquatic bird species inhabiting these lagoons with respect to the habitat characters are poorly understood. Present study was conducted (December, 2000-December, 2001) in Malala, Embillakala and Bundala Lewaya lagoons with the objective of investigating the relationship between some lagoon parameters (salinity, perimeter, area) and water bird abundance and diversity. Data were collected weekly basis. Bird abundance and the composition significantly differ among lagoons. This study revealed the most abundant bird groups in each lagoon. Highest aquatic bird diversity was recorded in Embillakala. This high diversity in Embillakala lagoon can be partly attributed to its moderate salinity, water depth and abundance of aquatic macrophytes. Lowest aquatic bird diversity was recorded in Bundala Lewaya. This study also revealed that salinity, aquatic macrophytes and lagoon area were key determinants of aquatic bird abundance. Although these lagoons are in the same landscape, they vary each other physically and chemically so that different bird communities might be supported.

Keywords: Bundala National Park, Lagoons, Waterbirds

1 Introduction

Wetlands support and maintain a diverse community of birds (Duncan et al 1999). Man has been aware of the link between birds and wetlands for thousands of years. Coastal lagoons are important bird habitats since they occupy a diverse array of

microhabitats. These habitats are useful for birds for breeding, nesting, and rearing of young (Acuna et al, 1994). Many lagoonal wetlands are stopovers for migratory birds. Declining number of wetland associated birds is partly attributed to the loss of wetlands (Duncan et al 1999; Mads et al 2002). Consumption of the energy at the higher levels of food chain makes birds useful biological indicators (Furners et al 1993). Wetland bird communities are important biological indicators. Comprehension of the aquatic bird diversity and abundance might be helpful in designing conservation strategies.

There are many factors affecting the relationship between wetlands characteristics and birds. These include the availability of habitats and healthy water, food, shelter and predators. Although the size of a wetland is often a crucial determinant of water bird richness and abundance (Akihisa & Satoshi 2001), trophic status and or shallowness are also major factors influencing water bird richness and abundance (Suter, 1994). Studies have shown the direct and indirect responses of water bird populations in response to changes in water quality (Owino, 2001). Similarly, biotic interactions between primary producers, aquatic invertebrates, fish and birds are gradually becoming better understood and appreciated with reference to the impact of trophic interactions on avian reproductive success (Cynthia and William 2000). Different waterfowl species adapt to different wetland types, inhabit different geographic areas, and nest at different times. In fact, the relationship between the aquatic birds and their habitats are complex. Bundala National Park (BNP) is located in deep south of Sri Lanka (Figure 1). BNP was recognized as the first Ramsar Wetland in Sri Lanka and best known for the diverse and abundant water birds (Bambaradeniya, 2001). Five brackish water lagoons viz. Maha Lewaya, Koholankala Lewaya, Malala Lewaya, Embillakala Kalapuwa and Bundala Lewaya located in the BNP, occupy a total area of 2,250ha (Benthem et al, 1993). This study was concentrated only on Malala (650ha), Embillakala (430ha) and Bundala Lewaya (520ha) because usually these three lagoons support diverse community of water birds. The five lagoons of the Bundala wetland in Sri Lanka are known to be a seasonal home to large populations of migratory birds, visiting Sri Lanka from as far away as Siberia (De Silva & Jakobsson, S., 1996). They find adequate supplies of food in Bundala lagoons. The brackish water lagoons (mixed seawater and freshwater) serve as nurseries for shrimp, fish,

and a variety of other marine life. The delicate ecological balance of at least two of these lagoons has been severely affected by the drainage of water flow from the Kirindi Oya Irrigation and Settlement Project located upstream to the park (De Silva & Jakobsson, S., 1996). After the implementation of the project, the salinity of the lagoons has dropped due to inflow of upstream irrigation water (De Silva & Jakobsson, S., 1996). They also noted that this change in salinity levels has reduced the abundance of visiting water birds, as their food supply has diminished specially the reduced prawn fishery. They have also argued the risk of the conversion of Malala and Embillakala into freshwater lakes. De Silva and Jacobson (De Silva & Jakobsson, S., 1996) have recorded over eighty water bird species around these lagoons.

In contrast to fish, the structure and functioning of aquatic bird communities are often poorly documented and understood (Cynthia and William, 2000) and those of Bundala Lagoon systems are no exception.

The relationship between water bird species composition and the habitat characters of Malala, Embillakala and Bundala lewaya are poorly documented. Therefore the objective of this study was to investigate aquatic birds inhabiting the lagoon systems with a special reference to several environmental parameters.

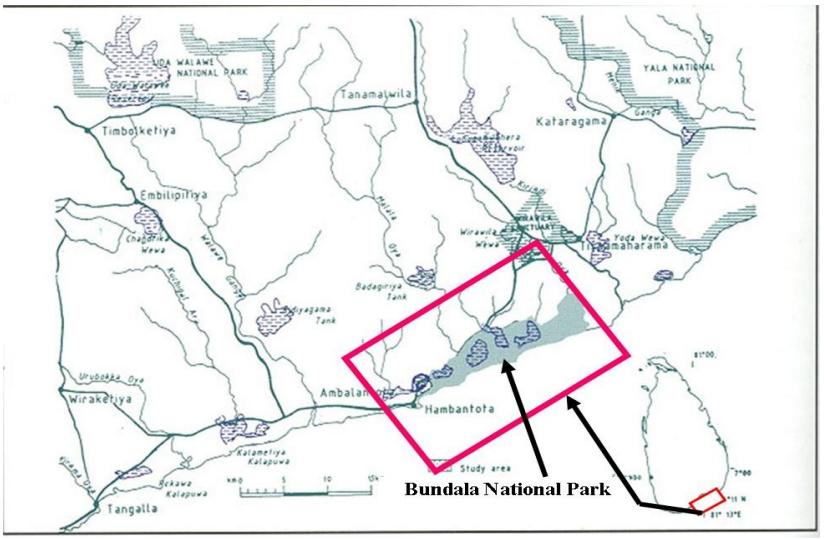

Figure 1: Bundala National Park and its major lagoons.

2. Methods

Embillakala, Malala, Bundala Lewaya were selected for this study since they are considered as very important habitat for birds (Bambaradeniya, 2001). Studies were carried out from December 2000 to December 2001. Bird counting was carried out in regular intervals throughout the period. Usually bird counts were taken 2-3 times per week during 07.00-11.00 hours each day as described elsewhere (Shutler et al, 2000; Taku, 2001). Four monitoring sites were selected in each lagoon. Bird counts were taken separately in each locality (figure 2) on the same day at the same time period. On the spot identifications were made using Binoculars with 10x50 field 5.70 100MAt 1000M, with the aid of standard picture guides (Harrison, 1999). Mean bird counts were computed for each month. Water salinity was measured by titration method and computed by Knudsen equation. Primary productivity was measured by *in situ* by Oxygen method (Owen, 1974).

Mean water depth was estimated by measuring the depth of lagoon at thirty sites. For this purpose a graduated pole was used. Scaled maps of each lagoon were drawn for the each month during the study period and the lagoon perimeter was estimated by cartometer method and area was estimated by rough calculation method (Owen, 1974).

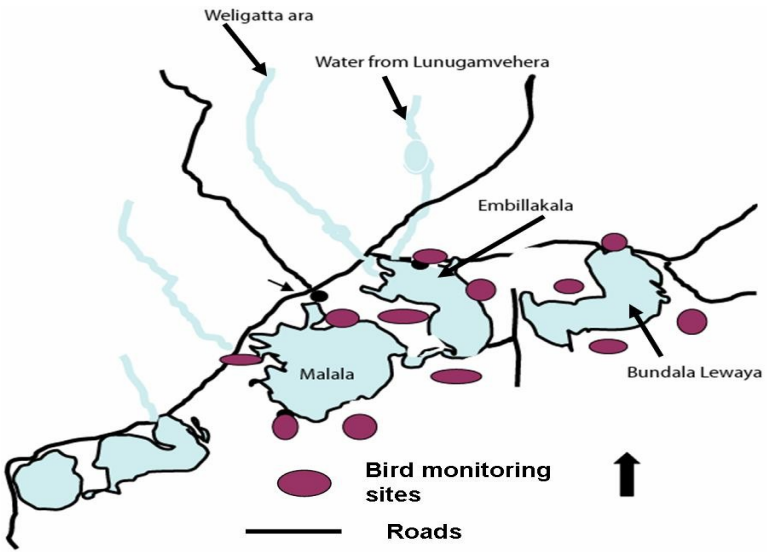

Figure 2: Chosen sites (filled circles) for bird counting in the three lagoons of the Bundala National Park.

Number of birds counted for particular species for each sampling occasion was pooled and divided by the number of sampling occasions to obtain the monthly mean count (December 2000 to December 2001). Shannon's diversity index **(**Freitas & Petrere, 2001)**)** and evenness were calculated for each lagoon. Pearson correlation coefficient was calculated between monthly mean bird density and either the lagoon area, lagoon perimeter, water depth or salinity. Overall abundance of bird species among lagoons was statistically compared. Bird abundance at each identified localities (where abundant aquatic bird community was observed) was also statistically compared. Statistical analysis was performed using SPSS 98 Statistics Software.

3. Results

Dominant groups of birds recorded in the three lagoons are given in the table 1. Based on the Shannon's diversity index, overall data indicated that the bird diversity was highest in Embillakala lagoon during the period of study. Malala lagoon accommodated a moderate diversity of birds while Bundala Lewaya accommodated the least diverse bird community during the study period (Table 2). The statistical comparisons of bird species densities of each lagoon revealed that Pelicans, Egrets, Herons, Painted Storks preferred Embillakala lagoon while Cormorants, Sand pipers and Plovers preferred Bundala Lewaya lagoon. In contrast, the Malala lagoon accommodated above bird groups in moderate densities (Table 1).

Table 1: Dominant groups of birds recorded in the three lagoons

Malala	Embillakala	Bundala Lewaya
Pelicans Egrets Herons Cormorants Painted Storks Terns	Pelicans, Egrets Herons Painted storks Terns in moderate numbers	Cormorants Sand pipers Plovers Terns

This study has identified the sites of each lagoon where aquatic birds abundantly inhabit (Figure 3). Interestingly, aquatic weeds were abundant at the sites where aquatic

birds were recorded abundantly. During the study period, however, mean Gross Primary Productivity of Malala lagoon and Embillakala lagoon were 1.48 ± 0.3 mg/h/l and 1.2 ± 0.2 mg/h/l respectively while it was 0.08 ± 0.02 mg/h/l in Bundala lagoon. Low primary productivity of Bundala Lewaya might not have supported a rich bird community.

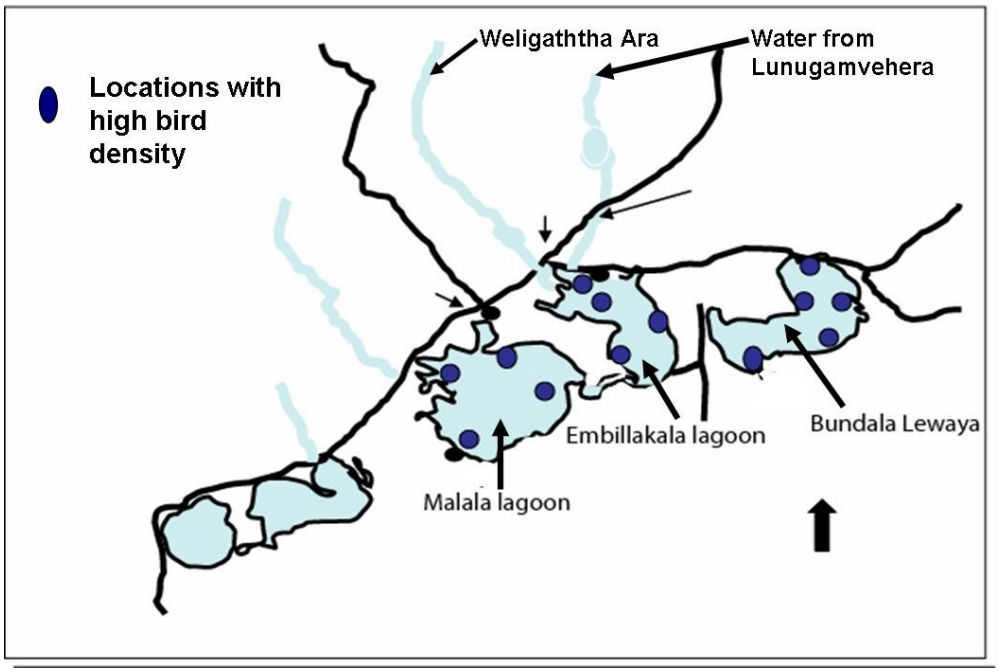

Figure 3: Localities in the Embillakala, Malala and Bundala Lewaya where aquatic birds inhabit abundantly.

Lagoon water levels were drastically reduced in mid February 2001 (table 3) and eventually dried out at the beginning of August 2001. Nevertheless, Embillakala lagoon was completely dried out in September 2001. In March 2001 all three lagoons accommodated a low density of birds. Nevertheless, all the three lagoons accommodated a high number of birds when water level was around 20 -40cm. Highest and lowest salinity levels recorded in Embillakala laggon, Malala lagoon and Bundala Lewaya during the study period were 0.4-28 ppt, 0.71-48.3 ppt and 13.6-42.6 ppt respectively. Embillakala lagoon accommodated more birds than other two lagoons at moderate depths (40-80 cm) with moderate salinity levels (1.8 ppt). This could be attributed to the enhancement of food material produced by aquatic weeds under moderate salinity levels (Leck and Brock, 2000). Statistical analysis showed that (table 4) there was no significant correlation of bird density and lagoon perimeter, water depth. This may be due to the fact that birds show a specific distribution pattern rather than a uniform distribution. Nevertheless, the bird density was significantly correlated with the salinity levels and lagoon area (table 4).

Table 3: Monthly bird density, Water depth, Lagoon area and Lagoonperimeter recorded in each of the three lagoons during study period

	Approximate Lagoon area (ha)			Lagoon Mean Depth (cm)			Approximate Lagoon perimeter (km)			Bird density (Total Count per Month per visit x10)		
	M	**E**	**BL**	**M**	**E**	**BL**	**M**	**E**	**BL**	**M**	**E**	**BL**
December, 2000	600	450	450	152± 2.3	107±2.1	36±2.6	6	3.6	4	343	132	366
January 2001	600	450	450	152±2.6	108±2.6	37±2.9	6	3.6	4	320	361	213
February	350	300	400	48±3.1	102±2.3	38±3.6	3.2	2.1	4.2	60	83	89
March	350	250	300	46±2.3	76±2.1	30±3.2	3.2	2	3.6	10	4	21
April	350	200	200	46±2.6	48±2.6	30±2.5	3	2	3	183	378	164
May	300	200	100	42±2.8	48±2.3	29±2.5	3	2	3	254	440	141
June	250	150	100	38±3.0	48±2.3	20±2.6	3	2	3	160	477	110
July	100	100	50	28±2.3	50±3.2		2.5	1.6	3	53	1057	
August*												
September*												
October*												
November	100	75	50	14±1.6	10±2.3	10±1.6	0.4	0.3	0.6	30	85	2
December	100	75	50	12±1.2	9±2.3	8±2.3	1	0.6	0.3	740	137	342

M-Malala lagoon**, E-**Embillakala lagoon**, BL-**Bundala Lewaya**, *-**Significant occurrences of birds were not detected since lagoons were almost dried out**.**

Table 4: Significant levels of Correlation Coefficients computed for Bird density vs Lagoon perimeter, Water depth and lagoon area.

Bird density of each month vs	Malala	Embillakala	Bundala Lewaya
Water depth	0.256/0.128	0.486/0.243	0.074/0.037
Area	0.04	0.03	0.02
Lagoon perimeter	0.286/0.143	0.261/0.131	0.253/0.127
Salinity	0.01	0.01	0.01

4. Discussion

Birds are ideal to be used as an Index of Biotic Integrity since their presence or absence tends to signal the health of several conditions that are keys to the proper functioning of an ecosystem. Furthermore, this relationship is often associated with levels of human disturbance (Cintia et al, 2001). In addition to providing an overall signal of ecosystem health, birds are also ideal because they are relatively easy to sample and their natural history is well described relative to other taxonomic groups in wetland ecosystems.

Habitat heterogeneity usually increases with area (Elmberg et al. 1994). The degree of community persistence is likely to depend on the physical and temporal stability of habitats and on the interactions between the species in the community (Tejo et al, 2001; Benston et al, 1997) based on, for example, foraging guilds, territory size, and winter range. A positive relationship between island area and species richness has been so widely documented that it comes close to being a universal ecological law. The relationship has played an important role in the development of ideas in population biology, community ecology and island biogeography. A previous study has shown that sandpipers were strictly sensitive to the size of the habitat for their breeding success (Peter and Malcolm, 1994).

Our results confirm the importance of habitat size in explaining the richness of aquatic birds within the wetland complex analyzed. Our findings are also consistent with results of other studies in a variety of environments (Sillén and Solbreck 1977; Brown and Dinsmore 1986; Opdam 1991; Andrén 1994a; Turner 1996).

Embillakala lagoon maintained the moderate water depth with more aquatic macrophytes and more associated grasslands when compared to Malala lagoon and Bundala Lewaya. Rich aquatic bird diversity in the Embillakala lagoon can be partly explained by high habitat heterogeneity.

Bird populations are influenced by a variety of factors at both small and large scales that range from the presence of suitable nesting habitat, predators, and food supplies to climate conditions and land-use patterns (Forcey et al, 2007). Present study revealed that there is no uniformity in the bird distribution pattern in each lagoon. Moreover, our data indicate that aquatic birds preferred specific localities in Malala, Embillakala and Bundala lagoons for foraging and resting (figure 2). This observation indicates the existence of specific ecological relationship between birds and the lagoon environment. These sites retain a moderate water depth and abundant aquatic weed community.

Lagoon area in Bundala water bodies might also influence species richness indirectly via its correlation with other factors that affect diversity directly. Among the most plausible of such potentially confounding variables is habitat diversity, which is often presumed to increase in direct relation to island area (Kohn & Walsh, 1994). If larger islands supported greater habitat diversity as a result of greater topographic and geological heterogeneity, this increased habitat diversity might promote increased species richness, particularly if the species involved tended to be habitat specialists. Habitat area influenced the habitat diversity in many instances **(**Douglas & Lake, 1994**)**.

Several studies indicated the relationship between habitat parameters and aquatic bird density (Davis, and Smith, 1998; Mark, 2006). Our study indicates that salinity was negatively correlated with bird density. This phenomenon can be partly attributed to the changes of abundance of food items such as fishes and invertebrate tax in the lagoons with varying salinity levels.

The Bundala lagoon systems change continuously. Habitat parameters and inhabiting aquatic fauna and flora also change. This might also influence the avi-fauna diversity and distribution. Continuous monitoring of aquatic bird populations with habitat parameters is highly recommended.

Acknowledgements

We would like to thank University Grants commission for funding and Department of Zoology, Faculty of Science for providing the infra structure facilities. We also thank for the Department of Wild Life Conservation of Sri Lanka for granting the necesssary permission to carry out this study.

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