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Full Length Research Paper

Effect of depth and open waters on site selection by wintering waterfowl in freshwater wetlands

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Most attempts to understand site selection by wintering waterfowl in the tropics have centered on food abundance. However, when wintering waterfowl are confronted with a choice of shifting mosaics along the Central Asian Indian migratory flyway, the wetland characteristics favoring selection of some wetlands over the others have been less understood. To obtain an insight into the influence of wetland characteristics like depth, water-spread, open-waters and macrophyte cover on waterbird site selection, a year long study was conducted on 2 lakes situated 3.5 km apart but harboring a differential waterbird population. Curtorim Lake (CuL) (10 ha) and Maina Lake (ML) (7 ha) had a maximum depth of 5.5 m. Their dominant vegetation included *Utricularia aurea*, *Nymphoides indicum* and *Nymphaea nouchali*. The weed *Salvinia molesta*, present at ML consistently reduced the open-waters to below 45%. At CuL, open waters ranged from 42 - 100%. CuL and ML housed 26 and 22 species of waterbirds respectively of which 18 were common to both lakes. These included pintail ducks, cotton teals, lesser whistling teals, garganeys, pheasant-tailed jacanas and bronze-winged jacanas. The innate wetland attributes showed pronounced variations between the lakes. This played an important role in structuring the waterbird community namely ducks and waterfowl. At both lakes, density of ducks and waterfowl increased significantly with depth and water-spread. At Curtorim Lake, waterbird density decreased significantly when open-waters exceeded 65% but increased as open-waters decreased to 40%. Both parameters remained stable thereafter. At ML, although a negative relation was observed between the waterbirds and open waters it was not statistically significant owing to the consistently high vegetation/weed cover throughout the year. When open -waters fell below 30%, anatids deserted the lake. This indicates that a) 40 - 60% open-water is essential for making lakes waterbird friendly b) innate wetland characters like depth and vegetation cover greatly influence site selection by waterbirds.

Key words: Open waters, water spread, *Salvinia molesta*, ducks, teals, wading birds, macrophytes.

INTRODUCTION

Wetlands are fragile ecosystems that have been credited as the lifelines of nature's equilibrium and climatic stability. Their position as vital links between aquatic and terrestrial biomes has made them one of the world's most bio-productive systems, offering extensive high quality habitat for a varied array of species (Azous and Horner, 2001). Waterfowl constitute an integral part of wetland ecosystems and occupy several trophic levels in wetland nutrient cycles (Lakshmi et al., 2001). Being top level consumers, waterfowl play a crucial role in the mass and energy fluxes of the wetland which in turn influences nutrient recycling and productivity of the ecosystem (Tiner, 1999). However, it was only after the Ramsar Convention in 1971 that the fundamental contribution of wetlands as waterfowl habitats was recognized. Although initially most research had focused on larger wetlands, smaller waterbodies particularly in the near vicinity of large wetlands are fast gaining increased importance as 'satellite waterbodies' that may provide alternative habitat for numerous species of waterfowl.

Inland waterfowl sites are typically characterized by birds dispersed throughout shifting mosaics of small spatially and temporally dynamic wetlands within a region (Skagen and Knopf, 1994). These wetlands because of their ephemeral nature are highly variable and differ in their physical attributes, vegetation and invertebrate communities. Consequently, waterfowl that use these dynamic wetlands may exhibit different habitat selection

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patterns than those that use more stable permanent wetlands (Davis and Smith, 1998). In India, most attempts to study site selection by waterfowl have been centered on studying the food availability based site selection by waterfowl (Malhotra et al., 1996; Shanbhag et al., 2001). But it is still unclear as to which other wetland characteristics besides food influence their selection by migratory waterbirds. This study was conducted to gather an insight into the effect of wetland characteristics like depth, water-spread, open waters and weed infestation on site selection by waterbirds.

Study area

Goa is a small state on the west coast of the country with a coastline of 104 km. It has 2 revenue districts-north Goa and South Goa. The Maina Lake (ML) and the Curtorim Lake (CuL) are both located in the Curtorim village ($15^0$17'21''N to $15^0$17'38''N and $74^0$1'8"E to $74^0$1'8"E) of South Goa. Both lakes are age old semipermanent impoundments of freshwater with a maximum depth of 5.5 m. The impounded water of both the lakes is used for irrigation of paddy crop in winter. Both lakes are man made semipermanent waterbodies that are drained in monsoons and impounded from late monsoon to summer. During impoundment commercially important carps are cultured in the lakes, the harvest of which takes place in late summer along with the pre-monsoon drainage.

CuL is spread over an area of 10 ha and is surrounded by well built mud and stone embankments. The northern embankment serves as the main road leading into the Curtorim village. Extensive stretches of paddy fields lie adjacent to the northern and southern embankments. Scattered farmhouses dot the western side while an overflow channel flows parallel to the lake on the eastern side. Paddy is cultivated inside the well drained lake in May. The lake is impounded after the harvest of the paddy in September. The lake has 3 inlets along the eastern side and two outlets - a major sluice gate at the northwestern corner and an overflow gate to the north eastern side.

ML has an area of 7 ha and is situated 3.5 Km northwest of CuL. It is enclosed by well built mud and stone embankments towards the east and north. Adjacent to these embankments are paddy cultivations. The lake bed shows a gradual ox-bow gradient on the southern and western side. Residential areas lie close to the lake towards the south and west. The lake receives water from surface runoff and monsoon precipitation. It has only two outlets – a major sluice gate on the north eastern side and a guarded outlet along the eastern embankment.

The dominant vegetation of both the lakes included *Utricularia aurea*, *Spirogyra lineata, Oscillatoria formosa, Nymphoides indicum* and *Nymphaea nouchali*. CuL also had *Oryza rufipogon*, *Scirpus* sp. and while ML had *Nymphaea rubra* and *Limnophila heterophylla*. The weed *Salvinia molesta* was present only at ML.

Climate

The climate of Goa is greatly influenced by the southwest monsoon. The state receives 320 cm rainfall annually, the bulk of which occurs during the monsoon season extending from June to September. The post monsoon months of October and November are characterized by increased temperatures and thunderstorms. The temperatures drop sharply in winter (December to February) reaching a minimum of 17°C. Summer spans from March to May and is the hottest season in the year with temperatures rising to 36°C.

MATERIALS AND METHODS

The two lakes were studied at monthly intervals for a period of 13 months from May. 2006 to May 2007. An initial checklist of the vegetation and birds was prepared following random trips to the lake before commencing the systematic study. The depth of the lakes was calculated using coloured markings made along the embankments and along stakes randomly erected in the middle of the lakes. The percentage of open waters and the total water coverage was calculated by dividing each lake into 10 linear sectors using stationary landmarks. The percentage of weed coverage was also calculated in the same manner at ML. Bird census was carried out on two consecutive days at the two lakes using 8 x 50 binoculars. Point count method from 6 marked points along the periphery of the lake was used for the purpose. Identification was done using appropriate field guides (Ali, 1996; Sonobe and Usui, 1993; Grimett et al., 1998).

All data was $\log_{10}$ transformed to meet the requirements of parametric tests. The correlations between the parameters were statistically analysed by calculating the Pearson multivariate corelation coefficient 'r' and the significant correlations were tested for regression. Seasonal variations in the physical parameters and densities birds were subjected to non-parametric Kruskal-Wallis One-Way ANOVA. All statistical analyses were performed in SPSS (version 7.5.1 for windows) with the alpha probability level set at 0.05.

OBSERVATION

Physical characteristics

The seasonal variations in the physical characteristics and densities of waterfowl of the 2 lakes are provided in Table 1. The monthly profiles of the physical parameters and the densities of ducks and waterbirds at CuL and ML are shown in Figures 1 and 2 respectively.

The CuL was almost dry from May to July with a minimum depth of 0.5 m. During this period only the central part 1 ha was waterladen and the rest of the lake area was used for paddy cultivation. The lake was impounded by the end of September (24th) following the paddy harvest resulting in a sudden increase in the depth of the water column to 4 m in 6 - 7 days. Following the impoundment the water spread over the lake area also increased from 0.5% in May to 70% in October. The lake was completely flooded from November to March. In late March (22nd), the water of

Table 1. Seasonal variations in the physical parameters and the densities of waterbirds (encounter rate) of the two lakes during the study period.

	Monsoon	Post monsoon	Winter	Summer
Curtorim lake				
Depth (m)	0.75 ± 0.14	4.25 ± 0.25	5.5±0	3 ± 1.44
Waterspread (%)	1.75 ± 0.32	85 ± 15.04	100 ±0	40.25 ± 23.31
Open water (%)	85 ± 2.89	68.5 ± 1.5	52.33 ± 6.75	71 ± 16.74
Ducks	6 ± 4	36 ± 9	1027 ± 816	1594 ± 915
Waterfowl	92 ± 5	147 ± 74	299±6	334 ± 152
Wading birds	182±7	60± 13	70 ± 4	121 ± 28
Waders	10 ± 7	0	2 ± 1	25±8
Maina lake				
Depth (m)	1.75 ± 0.32	3.5±0	3.5±0	1.37 ± 0.51
Waterspread (%)	2.08 ± 0.39	85 ± 15.04	95 ± 5	17.75 ± 11.69
Open water (%)	43.75 ± 3.14	60± 10	33 ± 4	53.75 ± 20.75
Ducks	46 ± 18	2513± 1014	3098 ± 211	438 ± 367
Waterfowl	283 ± 24	452 ± 22	416 ± 23	185 ± 37
Wading birds	116 ± 24	23 ± 9	45±13	51±9
Waders	8 ± 5	0	2 ± 1	14±1

the lake was released in 4 phases at intervals of 12 - 15 days to facilitate the harvest of the cultured fish, resulting in a sudden decrease in the depth as well as the water spread. The vegetation cover comprising predominantly of the macrophytes mentioned in the study area was minimum in May thereby increasing the open waters to 100%. With the onset of monsoon in June, there was a proliferation of macrophytes thereby gradually decreasing the percentage of open waters to 70% by the end of monsoon and to a minimum of 42% in summer. The percentage of open waters was significantly higher than the Maina lake (One Way ANOVA df = 25, p = 0.04, F = 3.63).

At ML, the depth was least in summer following the complete release of water. The depth increased gradually through monsoon and was 2.5 m in August following impounding. The depth was highest (3.5 m) in post monsoon and winter. A 2 m deep trench dug out along the eastern and northern edge of the lake remained filled with water throughout the year. The average depth of the rest of the lake never exceeded 3.5 m except in the region of the trench where the depth was 5.5 m when the lake was full. The lake was drained in 3 phases- once each in March, April and May. Following impounding of the lake, the water spread increased from 0.5% in May to 100% in November. It started decreasing in February with the phased release of the water. The vegetation cover comprised largely of the weed *S. molesta* in addition to the macrophytes mentioned in the study area. The open waters were below 45% during most of the year because of the weed cover.

CuL housed 26 species of waterbirds that included 8 species of ducks, 10 species of waterfowl and 4 species each of waders and wading birds. ML harboured 22 species of waterbirds of which 7 were ducks, 9 were waterfowl and 3 each were waders and wading birds. Lesser whistling teal *Dendrocyna javanica*, cotton teals *Nettapus coromandelianus*, pintail ducks *Anas acuta*, blue winged teals *A. querquedula,* little grebes *Tachybaptus ruficollis,* coots *Fulica atra*, purple swamphen *Porphyrio porphyrio*, bronze-winged jacana *Metopidius indicus* and pheasant -tailed jacana *Hydrophasianus chirurgus* formed the bulk of the waterbird population of the 2 lakes. In both the lakes, the densities of both ducks as well as waterfowl were significantly higher in winter (CuL: ^{2} = 8.2, p = 0.04, df = 3; ML: ^{2} = 8.29, p = 0.04, df = 3). ML harboured small population of 40 - 50 ducks persisted in the lake even in monsoon but CuL was prominent for the total absence of ducks during monsoon. The teals started arriving at CuL in small flocks following its impoundment towards the end of post monsoon. The density of cotton teals in the lake increased significantly in winter (^{2} = 7.97, p = 0.05, df = 3) while that of blue winged teals was significantly higher in summer (^{2} = 8.49, p = 0.04, df = 3). On the other hand, waterfowl continued patronizing ML even in monsoon with jacanas and purple swamphens using it as a breeding site. The populations of purple moorhens (One Way ANOVA df = 25, p = 0.00, F = 56.78) and Indian moorhens (One Way ANOVA df = 25, p = 0.04, F = 4.23) were significantly higher at ML while those of openbill storks and white-necked storks were significantly higher at CuL (One Way ANOVA df = 25, p = 0.02, F = 6.07). On the whole, the density of waterbirds at CL was 318 birds/ha during peak migration while that at ML was 544 birds/ha. At both lakes, densities of ducks and waterfowl increased significantly with depth (df = 12, p = 0.00; Ducks:- y_{CuL} =2.05x + 1.14; r^2 = 0.69, F = 22.18; y_{ML}= 2.64x +1.3; r^2 = 0.79, F = 41.06; Waterfowl: y_{CuL}= 0.81x + 1.84; r^2 = 0.79, F = 41.34; y_{ML}= 0.38x+2.06; r^2 = 0.67, F = 22.09) and water-spread (p = 0.00; Ducks: y_{CuL}= 0.9x + 0.9; r^2 = 0.62, F = 16.08; y_{ML}= 1.17x + 1.09; r^2 = 0.92, F = 127.89; Waterfowl: y_{CuL}= 0.38x + 0.9; r^2 = 0.73, F = 30.87; y_{ML} = 0.15x + 2.05; r^2 = 0.73, F = 30.87). At CuL, waterbird density decreased significantly when open- waters exceeded 65% (p = 0.00; y_{Ducks} = 15.91 - 7.75x; r^2 = 0.92, F = 116.77; $y_{Waterfowl}$ = 7.39 - 2.9x; r^2 = 0.88, F = 80.42) but increased as open-waters decreased to 42%. Both parameters remained stable thereafter. At ML, open-waters had no significant impact on the waterbird community. However, when open-waters decreased below 30% of the water spread, anatids deserted the lake.

DISCUSSION

The two wetlands under study, although small in size harboured a rich population of waterbirds both in terms of diversity as well as density. The diversity is comparable to that recorded in other larger wetlands in the country (Vijayan, 1986). The density of waterbirds was initially

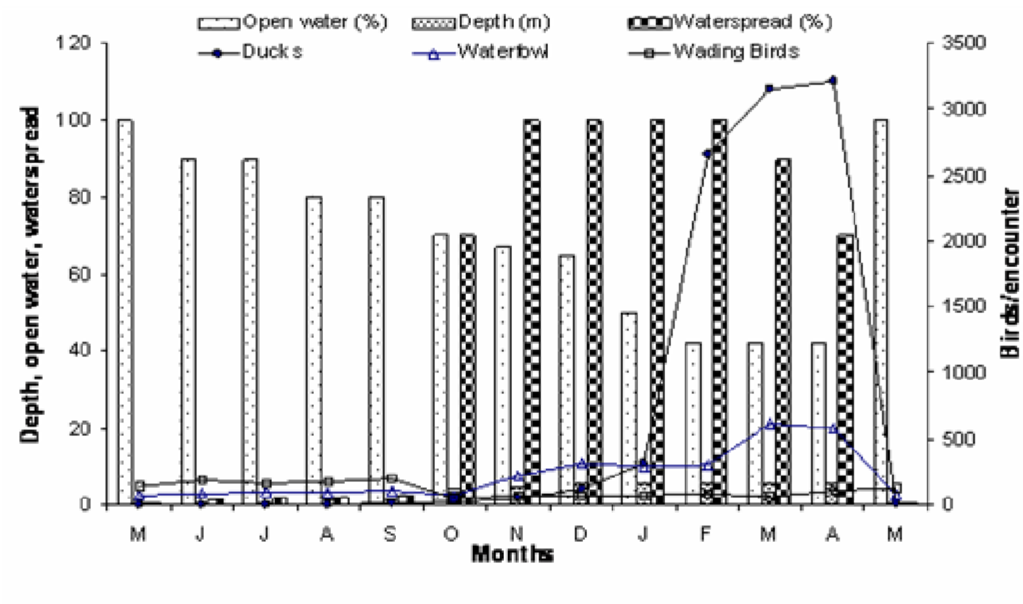

Figure 1. Variations in the physical charecteristics of Curtorim Lake and those in the densities of the 3 components of waterbirds from May 2006 to May 2007

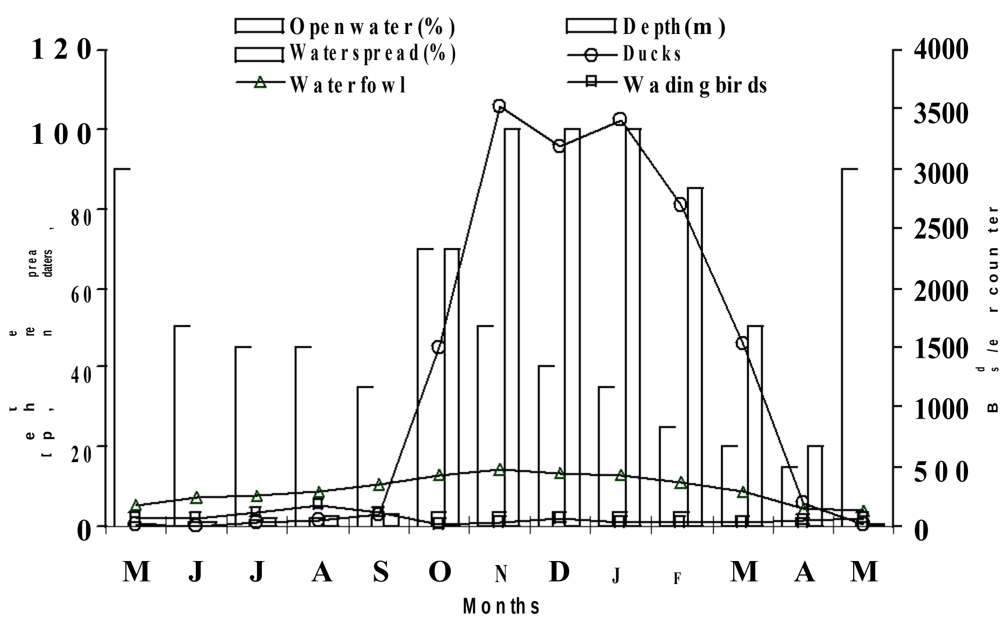

Figure 2. Variations in the physical charecteristics of the Maina Lake and those in the densities of the 3 components of waterbirds from May 2006 to May 2007

higher at the smaller ML owing to its higher vegetation cover and shallow nature. Both the lakes, like most other wetlands in the tropics, serve as wintering sites for a large number of local and distant migrants as can be ascertained by the significant increase in the waterbird populations during the nonbreeding season. A significant increase in the density of ducks at both lakes in winter was due to the presence of large flocks of migrant lesser whistling teals and blue winged teals besides pintails, cotton teals, green winged teals and naktas.

The dense vegetation of ML even in monsoon and post monsoon sustained small populations of lesser whistling teals and cotton teals not exceeding 50 birds. The better vegetation at the lake during the breeding season also encouraged its use by the breeding waterfowl like purple swamphens, pheasant tailed jacanas and bronze-winged jacanas as can be under-stood from the significantly higher densities of these waterfowl at the lake. However, the impounding of the lake in late monsoon resulted in a gradual increase in the depth and water spread thereby providing adequate open spaces and varied ecological niches for larger populations of ducks and waterfowl in winter. The increase in open spaces also facilitated the rapid proliferation of the *S. molesta* weed, in the process almost wiping out the native vegetation of the lake. This in turn resulted in an increased competition for open spaces between the waterbirds and the weed. As the availability of open spaces decreased the ducks persisted in the lake until almost 70% of the open spaces were covered by vegetation. As the open spaces decreased to below 30%, the ducks deserted the lake enblock due to increased competition for open spaces and depletion of food resources. The *S. molesta* weed has also posed an increased threat to wetland dependent birds in other parts of the world (Finlayson et al., 1997; Trivinho-Strixino et al., 2000; McFarland et al., 2003).

At CuL the weed was never recorded in the year. The complete drying of the lake in summer and the pre-cultivation curing of the lake bed through processes such as repeated ploughing may have been responsible for keeping the weed at bay. A similar management practice of drying up wetlands adopted in USA wildfowl game fields has also been reported to enhance wetland productivity (Baldassare and Bolen, 1994). The closure of the sluice in late monsoon caused a sudden increase in the depth and waterspread. Due to the sudden increase in the water level, the availability of open waters remained more than 65% for a longer period. The greater depth, increased open spaces and lack of vegetation was not conducive for its use by waterbirds as indicated by the regular sorties by the birds to the lake environs. However, as the vegetation cover consisting of a mixed mat of submergent, emergent and floating macrophytes increased steadily, open spaces decreased to 40% by late winter. This resulted in a sudden increase in the waterbird population with large flocks of ducks inhabiting the lake till the end of summer. An increase in the water level and depth has also been known to adversely affect wading birds (Maheswaran and Rahmani, 2001) and divers (Wanless et al., 1993).

This study indicates that the innate wetland attributes-depth, water spread, vegetation and open spaces greatly influence site selection by waterbirds. Of these the vegetation and provision of adequate open spaces (40 - 60%) play an important role in structuring the community of ducks and waterfowl of a freshwater wetland. The study also indicates that weed infes-tation is indeed a severe threat to waterbird diversity. But tradi-tional farming techniques when properly implemented can be successful employed to protect the smaller yet potentially important satellite wetlands. However, it may be noted that it is not the presence of the weed alone that is a threat to waterbird diversity but its rapid proliferation that should be checked before eradicating the weed completely. If sufficient open deep spaces are maintained within the wetland the wetland will continue to sustain a rich waterbird population.

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