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Study of birds of Yashwant lake with respect to densities, species richness and Shannon Wiener indices and its correlation with lake dynamics.

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ABSTRACT

Toranmal Plateau is a quantum part of Satpura Mountains forming the cultural transition with its trijunctional location between Maharashtra, Madhya Pradesh and Gujarat States of India. Densities, species richness and Shannan Wiener indices of resident, resident migratory and migratory species of birds were studied over a two years period at higher altitude Yashwant Lake at Toranmal plateau. Maximum bird species were found to utilize the water body in the winter, while minimum in monsoon. Though the water body is utilized by the resident birds throughout the year the bird populations were maximum during winter due to the presence of migratory birds. The overall low densities and species richness of birds at Yashwant Lake may be due to its location at higher altitude.

Key words: Yashwant Lake, Birds, Densities, species richness and abiotic factors.

INTRODUCTION

More than 9,600 species of birds occur all over the world, out of these about 2100 species and their subspecies occur in Indian subcontinent [1] and more than 1200 species are recorded in various habitats of Indian subcontinent [2]. Several avifaunal species have silently vanished before science had even seen them well while over 1200 species across the world (12 percent of the world bird population) are currently under the threat of extinction [3].

Several species of birds inhabit wetlands, one of the most diverse and unique ecosystem in the world supporting huge biotic communities, these communities include diverse plants and animals that are adapted to shallow and often dynamic water regimes and form second most productive ecosystem next to the tropical forests. Birds form an important component of this biota that depend on vegetation structure [4]. They are one of the most visible indicators of the total productivity of such biotic systems. Many studies on bird-habitat relationships have been conducted for varied purposes and in many ways. There are several good reviews, conceptual papers and analytical treatises that deal with vertebrates in general [5] and habitat selection by birds [6, 7, 8] and bird community structure with strong emphasis on bird -habitat relationship [7, 9]. These studies indicate the importance of birds as simple, visible, easy to monitor indicators of health of an ecosystem.

In a wetland, multiple of sub-habitats or microhabitats are available in a small area which attracts different species of water fowls. Being ecologically important with high nutritional value and productivity, wetlands support good diversity of birds [10, 11]. In a wetland, water and vegetation are the two major factors influencing the abundance of the ducks and other water fowls [12] and thus wide varieties of birds use wetland habitat either throughout their life or during certain part of their life [13]. The microhabitats available in a wetland can supply a variety of different food sources to water fowl which include microscopic plankton to higher plants and animals. Many wetlands are

identified as Internationally Important Wetlands (Ramsar sites) for water fowl conservation. Management of all the wetlands is critical for conservation of nature and natural resources.

While studying avifauna of a wetland in addition to species richness, the parameters such as relative density and diversity of bird population are frequently used as indicators of habitat quality [14, 15, 16]. International Convention on Biodiversity through National Biodiversity Board and State Biodiversity Board puts emphasis on documenting all the biodiversity upto village level. The present study is an attempt to document one part of it, the avifaunal diversity of Yashwant Lake with its correlation to various biotic and abiotic parameters.

MATERIALS AND METHODS

STUDY AREA

Yashwant Lake is located on Toranmal Plateau, one of the important plateaus in mid Western Satpura. This plateau forms a table land on the summit, covering about 41 Sq.Km. area at 1155 meter (AMSL) altitude extending between 21^o 54´ to 21^o 61´ North latitude and 74^o 26´ to 74^o 34´ East longitude. Toranmal plateau is a quantum part of Satpura Mountains forming the cultural transition with its trijunctional location between Maharashtra, Madhya Pradesh and Gujarat states of India.

Yashwant Lake has a perimeter of 2.75 Km. and spreads in 39 hectares. It was constructed during British period by damming the dip gorge on Northern side of the gravel embankment of 400m by arresting the main flow of the stream. The littoral zone of Yashwant Lake is covered with various macrophytes. The west and northwest sides are surrounded by forested land. The Toranmal village is present on its eastern bank with its linear pattern settlement of tribal people across the road. The main drainage inflow of water enters the Lake from southern bank and minor drainages from Northwest. The outflow (spillway) of the Lake is located on Northern side near a temple.

Geologically, the area covers Deccan trap basalt rock formation and lies under monsoon semiarid deciduous forest cover. Annual rainfall exceeds above 1696.2 mm which again reduces the summer hotness. It is evident that the Toranmal plateau is never too hot and it is pleasantly comfortable all through out the year.

To study the avifauna of Yashwant Lake, bimonthly observations were conducted (monthly average is taken for calculation) from December 2006 to November 2008. During each visit the census of birds was carried out during morning hours, half an hour after sunrise, which is known to be the best time for the observation of birds. Simultaneously, the water spread and the hydrological conditions were also noted down. To count the waterfowl, the total count method was used. This method provides an overall estimate of the population in the pond and is proved to be the most appropriate method for the estimation of density and diversity of water birds [17, 18, 11].

Binoculars having the magnification of 8-16 × 40 (Olympus) was used to observe the birds and they were identified on the basis of field guide by [19].

To find out if there exist any correlation between bird density with quality of water, density of plankton (Zoo and phyto) as well as molluscan density in soil, water and soil samples were collected from three stations YLA, YLB and YLC. For abiotic parameters water samples were analyzed for Acidity, Alkalinity, Chloride (Cl^-), Carbon dioxide (CO_2), Dissolved Oxygen (DO), Nitrates (NO_2^{-2}), Nitrite (NO_3^{-3}), pH, Phosphate (PO_4^{-3}), Total solids (TS), Total Dissolved solids (TDS) and Total suspended solids (TSS), and Total Hardness (TH) as per [20] Atmosphereic temperature (AT) and water temperature (WT) in ^oC with the help of mercury thermometer while Transparency (Trans) with Sechhi disc and water Cover (WC) visually. For biotic parameters Total density of Molluscs (TDM/cubic meter), total density of phytoplankton (TDP, per liter) and Total density of Zooplankton (TDZ per liter) were calculated Details in [21].

Analysis

The Density, species richness, diversity indices *i.e.* Shannon Wiener Index (H') and Equitability (E) [22, 18] of water birds were calculated for each visit. To make the analysis simpler the species observed were categorized into Resident, Resident migratory and Migratory species. The density is calculated as per Km^2 [17] and total number of species observed per visit is considered as species richness. To estimate diversity, Shannon Wiener Diversity Index is calculated as $H' = - \sum pi \ln pi$ (for maximum number of birds) where pi is total sample belonging to the i^{th} proportion of species, calculated as proportion of the total number of individuals of all the species and (ln) is the natural log. Evenness /equitability is calculated as $E = H'/H_{max}$ where H_{max} is information content of sample (individual birds) = index of species diversity.

For the statistical analysis the data for three months was pooled into four seasons as Summer: March, April, May; Monsoon: June, July, August; Post-monsoon: September, October, November and Winter: December, January, and February. Further, the Mean and Standard Error of Mean (SEM) were calculated for each season and analyzed further using One-way ANOVA as described by [23] with no post test for various parameters using Graph Pad Prism Version 3.00 for windows (Graph Pad Software, San Diego California USA). To find out if there exists any correlation between various abiotic parameters the data collected in each month [21] was applied to Pearson Correlation against the bird density using SPSS. P values at $P > 0.05$ is nonsingnificant, while $P < 0.05$ significant (*), $P < 0.01$ highly significant and $P > 0.001$ very highly significant.

RESULTS

During present study, 58 species of birds were observed in and around Yashwant Lake from December 2006 to November 2008 (Annexture). Among these 41 species were waterbirds while 17 were terrestrial. Among waterbirds 13 species were resident, 14 resident migratory and 14 migratory (Annexure).The variations in the bird density and the species richness are noted according to the seasonal changes.

DENSITY OF BIRDS Maximum density of total birds (Table: 1) was observed in winter (530.8 ± 17.6 /Sq.Km.) and minimum in monsoon (172.3 ± 11 / Sq.Km) with highly significant seasonal variations ($F_{3, 20}$ 33.92, $P < 0.001$) of the total birds, the density of resident birds in winter 272.4 ± 6 /Sq.Km and monsoon -120.3 ± 7.9 /Sq.Km. ($F_{3, 20}$ 30.2, $P < 0.0001$.), resident migratory birds 177.1 ± 5.2 /Sq.Km during winter and 48.9 ± 3 /Sq.Km. during monsoon ($F_{3,20}$ 25.02, $P < 0.0001$.), and migratory birds winter 81.6 ± 8.9 /Sq.Km and monsoon 3.4 ± 0.9 /Sq.Km. ($F_{3,20}$ 32.66, $P < 0.0001$) were maximum and minimum respectively.

SPECIES RICHNESS

The total bird species richness (No. of species present Table: 2) was maximum in winter (56.67 ± 0.4) and minimum in monsoon (16.17 ± 0.8). When seasonal variations were considered, highly significant differences were noted ($F_{3, 20}$ 28.97, $P < 0.0001$). The Species richness of resident birds was also maximum in winter 26.3 ± 0.33 and minimum in monsoon (11 ± 0.5 $F_{3,20}$ 19.65, $P < 0.0001$), of resident migratory birds also in winter (12.64 ± 0.2) and monsoon (4.16 ± 0.3) respectively ($F_{3, 20}$ 18.91, $P < 0.0001$) and migratory birds also in winter (14.67 ± 0.33) when the migratory bird population arrives (Table: 2) and monsoon 1.0 ± 0.25 when only early arrivals may be observed ($F_{3,20}$ 45.82, $P < 0.0001$).

SHANNON WIENER DIVERSITY INDEX (H´)

Shannon Wiener index (H´) (Table: 3) for total birds at Yashwant Lake was on higher side with maximum during winter (3.5 ± 0.02) and minimum in monsoon (2.4 ± 0.02) ($F_{3, 20}$ 31.69, $P < 0.0001$). However, though the variations were highly significant for the resident birds ($F_{3, 20}$ 32.09, $P < 0.0001$) H' in winter was 2.75 ± 0.01 and in monsoon 2.026 ± 0.02 , for Resident Migratory Birds with parallel trend to total birds, it was maximum in winter (2.19 ± 0.017) and minimum in monsoon (1.2 ± 0.55 $F_{3,20}$ 17.78, $P < 0.0001$) and for Migratory Birds H´ was maximum (2.65 ± 0.026) in winter and minimum (0.093 ± 0.093) in monsoon. ($F_{3,20}$ 42.18, $P < 0.0001$).

EVENNESS (EQUITABILITY)

Shanon Wiener diversity index (Table: 4) for total birds is also reflected with higher evenness and highly significant seasonal variations ($F_{3,20}$ 31.69, $P < 0.0001$). The evenness for total birds was maximum during winter (0.87 ± 0.005) and minimum in monsoon (0.6 ± 0.006), for resident birds 0.83 ± 0.003 in winter and 0.61 ± 0.007 in monsoon ($F_{3, 20}$ 32.09, $P < 0.0001$), and for Resident migratory birds 0.809 ± 0.006 in winter while 0.443 ± 0.020 in monsoon ($F_{3,20}$ 17.78, $P < 0.0001$).Though the density of migratory birds was low at Yashwant Lake they were evenly distributed in winter with 0.955 ± 0.009 and less evenly distributed in monsoon with 0.03 ± 0.03 ($F_{3,20}$ 42.18, $P < 0.0001$).

When correlation of bird density was calculated with various abiotic (physicochemical) and biotic parameters of water, a negative correlation was established with almost all parameters except DO, Transparency, water cover and total hardness. Among the negatively correlated parameters NO_3 and TDM were correlated at varied levels at three stations, other parameters were correlated negatively at 0.01 levels. Among the positively correlated parameters transparency was correlated at 0.01 level at all three stations while DO at 0.01 level at YLA and YLB, at 0.05 level at YLC and Water Cover at 0.05 level whereas correlation of TH was nonsignificant.

DISCUSSION

Density and Species richness

One central objective of ecology is to study the factors affecting the distribution of biodiversity [24, 25]. The present study has been undertaken mainly from two perspectives *i.e.* global and local. From a global or biogeographical point of view, one of the most widely supported theory of distribution of biodiversity establishes that the main factor affecting diversity is the energy available to the system [26, 27]. However, from a local perspective, most studies point to the relationship between the number of species present in a habitat and its internal structure. The ecological studies of communities mostly show interest in this aspect of diversity that has resulted in significant production of scientific research [25, 28]. However, such studies at higher altitude in mid Satpura range are lacking.

To study any ecosystem the birds serve as important bio-indicators as they have the ability to fly away and avoid any obnoxious condition. Hence, they are considered as important health indicators of the ecological conditions and productivity of an ecosystem [29, 30]. Among the most important parameters of the bird study, the species richness [14, 15, 31], the density [32, 14] and the diversity [22], are known to differ between locations and seasons [33, 34, 35].

The density of migratory birds, though low at higher altitude Yashwant Lake, as compared to inland wetlands of semiarid plains [36], was maximum during winter. Small populations of migratory ducks utilize this small higher altitude Lake as their wintering ground. The ducks with different feeding habits, *i.e.* the dabbling duck *e.g.* Gadwall, *Anas strepera*, the diving ducks-various species of Pochards and the Marsh ducks [37], inhabit different microhabitats of the Yashwant Lake especially during winter. This proves that the site is potent enough to sustain the load of small population of migratory ducks feeding at different depths. This is expected to reduce the competition for food resources which is known to be the limiting factor for distribution of ducks [38, 39].

The density of birds in winter is affected not only by the increase in migratory bird species but by simultaneous increase in Resident and Resident migratory species too. The density as well as species richness of resident migratory birds was also maximum in winter. Resident migratory species include marsh birds like Coots and Moorhens, Large Egrets, Grey Heron, Purple Heron, Painted Stork, Black headed Ibis and waders, and also divers like Indian Shag, *etc*. These birds utilize Yashwant Lake equally during winters with other resident and migratory species as they are observed with their higher densities and species richness during winter. On the basis of this one can say that Yashwant Lake at higher altitude in Satpura range has sufficient productivity to sustain small population of migratory, resident migratory and resident birds. This indicates that when the pressure of migratory birds increases in plains some resident birds move to higher altitudes to reduce the competition for food resources.

According to [40], the water birds are related to vegetation community and vegetation may directly or indirectly affect the bird species abundance. This has also been discussed by [36] for reservoirs and village ponds in semiarid zone of Gujarat. During summer when the algae start drying and the dead algae float over the water, a suitable habitat is created for several microorganisms, hence making a good feeding habitat for resident Birds. Birds like Dabchick, little Cormorant, Herons and Egrets are favoured by this habitat. The exposure of vegetation due to decline in water level during summer creates suitable hiding places too. During this season the density of resident birds is maximum compared to migratory and resident migratory birds. This is probably the time when water bodies at the base of Satpura range dries off and hence the resident birds move to the habitats where water is available. In addition to routine energy demands, these resident birds need high food intake to enable them to build up nutrient reserves for the forthcoming breeding activities. The resident species that congregate at Yashwant Lake probably for such build up of nutrients for forthcoming breeding period are Dabchick, Little Cormorant, Indian Pond Heron, Little Egret and Purple Heron.

Yashwant Lake being in semiarid zone of North Maharashtra receives rains during South West monsoon. Two monsoons of study period were heavy and thereby the water of Yashwant Lake was flowing over the spillway. This has clearly indicated its impact on the density of the water birds being extremely low in this season. Wading birds like Herons, Egrets, Lapwings and Plovers prefer shallow water with marshes, where food can be easily procured [40]. During monsoon birds like Egrets and Herons were present at the margin of Yashwant Lake where muddy bottom and macrophytes are present. The drier side of Lake has forest on one side and traditional agricultural land on the other side which are also preferred by the said waders. However, as plovers are migratory they were not present during monsoon and probably Lapwings moved to lower altitude for breeding hence, not present around the lake. During Post-monsoon when the water level is high the lake is utilized mainly by the resident bird populations. This is the period when many early migrant and resident migratory species start arriving at Lake. Dabchicks, Egrets and Herons are present in abundance with their young. Moreover, by the month of October and November the

migratory population of Coots start arriving at the wetland increasing their dominance that results in increase in overall density of birds.

Seasonal fluctuations in water levels of natural habitats are known to cause cyclic variations in abundance of birds [41, 40]. These fluctuations also change the availability of food resources for the water birds. Waders form major group of birds and seasonal variations are noted in their population at Yashwant Lake. During winter, the productivity of water body is stabilized and the food is easily accessible. This attracts the migratory species of wading birds that also increases species richness. However, during summer, though the water level is low, food is aggregated in small area where it becomes easy to obtain. This again creates a favourable foraging habitat for the birds. While during monsoon and post-monsoon although the water level is high some large waders (Egrets and Storks) start visiting the Lake and water logged fields around it with their nestlings.

In a comparative study of bird population of urban and rural water bodies it is reported that village ponds with human disturbance mainly support the resident species of birds [42, 43]. Yashwant Lake is a tourist place where crows and mynas are the common terrestrial birds. These species are known to exploit tourist places very well. These species are considered as commensal to human being as they feed on left over food thrown by men especially at picnic spots. As soon as the rains are over and probably picnickers start visiting the spot, increase in number of crows and maynas was observed. Their density was low during monsoon. [44] calls them urban adaptors of western part of India.

Population of House sparrows *Paser domestiocus* is declining in many areas [45] and ornithologists are concerned about the same. As far as Yashwant Lake and surrounding area is concerned an almost constant population of House sparrows was noted over the study period. Their density was low in summer probably because they are busy in nesting activities during this period. In Northern hemisphere majority of birds breed during warmer summer days [46].

Diversity Indices: Shannon Wiener (H´) and Evenness (Equitability) (E)

The H´ at Yashwant Lake is comparatively on higher side mainly because of resident species of birds. Heterogeneity is known to be higher in a community when there are more species that are equally abundant [22]. A large number of species increases the species diversity as measured by Shannon Wiener Index H´ and a more even or equitable distribution among species increases the Evenness index (E). This comparatively small Lake is inhabited mainly by resident species of birds all throughout the year and equally well by resident migratory and migratory species of birds especially during migratory season – winter resulting in the higher H´ and E. The diversity during post-monsoon is moderate as this is the season when resident migratory species inhabit the lake with their young and early migrants start arriving. Birds are more evenly distributed in winter and less evenly distributed in monsoon while utilize Yashwant Lake in moderate numbers in summer and post-monsoon.

Correlation with abiotic and biotic factors

Birds living in extreme cold are literally frozen out and must move to more favourable areas. Climatic factors such as temperature are especially important in the timing of water bird migration as it affects the arrival of the birds at breeding or wintering grounds. However, at the higher Altitude Lake studied in Satpura ranges of North Maharashtra Birds are not correlated with a single common abiotic factor (Table 5). The maximum density of total birds observed in the winter was when the average atmospheric temperature and water temperature were 17.25 ± 0.55 °C and 18.42 ± 0.2 °C (Table 3.1) respectively which are favorable for migratory birds [21]. Wetland birds living in moderate temperature regimes where water supply provides resources all throughout the year would not be forced to migrate and hence normally maintain year round territories. However, the population of resident birds at Yashwant Lake was maximum in winter. Negative Pearson correlation established between the temperature and total density of birds is due to migratory population in winter.

Compared to wetlands located in plains of Central Gujarat on the northern side of Satpura range, [36, 44] which support very high densities of migratory and resident birds, Yashwant Lake located above 1000 m above msl has very low density of birds. However, here also bird density is negatively correlated with Atmospheric and Water Temperature.

The total bird density at Yashwant Lake positively correlated with water cover at 0.05 level, may be attributed to maximum water cover during post-monsoon (92.5 ± 1 %) when the migratory and resident migratory birds start arriving. Shoreline configuration is one of the conspicuous features that influence bird use of wetlands. Shore line may have edges and meaningful parameters of edges are difficult to relate to birds and other mobile vertebrates [47]. Most workers use correlations with the shoreline index, a ratio of shoreline length to water area. According to [14] dabbling Ducks and Coots show a significant relationship to shoreline index, whereas Great Crested Grebes do not.

Similar relationships have been observed by [48] and have also been demonstrated experimentally [49]. The total bird densities in post-monsoon and winter were modest to maximum respectively when the water cover is respectively maximum to fair (Table 3.1). However, large area of shallow water indicates high shore development where food for the birds may be both dense [50] and easily available. Further, it also indicates that disturbances caused by man are less. This may be applied for the habitats around Yashwant Lake where human activities are low. Though the water cover influences the distribution of birds in the wetland most birds of deeper, open water with Shoreline Lake are divers that feed on mobile fish and large invertebrates. These are cormorants, certain grebes and fish eating raptor like Ospreys [51]. These species inhabit Yashwant Lake (Annexture). In a Lacustrine wetland or man made reservoir, drastic water level fluctuations does not occur as it occurs in a more shallow, seasonal basin. This gives greater opportunity for the establishment of annual or perennial hydrophytes. In the present study the average seasonal fluctuation of water cover is 66.67 ± 1.5 % to 92.5 ± 1.1 % hence, it is a stable habitat with good macrophytes that mainly support resident species.

For many species, there are habitat related issues such as water depth, vulnerability of the prey and water clarity. At the Yashwant Lake total density of birds is positively correlated with the transparency of water at 0.01 level. The most aquatic plants of wetlands are those that are rooted and often submerged at some stage, therefore associated either with shallow waters or with the littoral zone of lake or pond where light penetration is greatest. Dense mats can inhibit its use by diving birds *e.g.* Cormorants, while others can walk on it (*e.g.* Jacanas) and search for food. Higher transparency also favours the photosynthetic activities which influence the trophic structure in the wetland. TS, TSS and TDS are negatively correlated with the total density of birds (Table 6.5). The TSS is maximum in monsoon due to the inflow of rain water from neighbouring agricultural fields and this is the season when the density of birds was also minimum. In addition, absence of migratory birds as well as the resident birds due to their involvement in breeding activities cannot be overlooked.

Dissolved oxygen concentration that indicates status of water quality and productivity is positively correlated with the total density of birds at Yashwant Lake. The maximum density of birds recorded in winter may be correlated with macrophytes that are exposed due to reducing water cover as well as exposed substrate providing countless invertebrates of varying sizes which occurred as food resources. Emerging vegetation such as *Cattail spp* provides emergence sites for insects like damselflies, dragonflies and flying adults of other species that form food for various species of birds [47]. Butterfly and dragonfly diversity and density in the surrounding area have been recorded by [52]. Further, minimum oxygen level recorded in the summer reflects the lower water depth and higher temperature of water where in the fish or invertebrate species come to surface and are easy to catch, thus declining water depth and low oxygen level make invertebrates and fish vulnerable to predation by Egrets, Herons and Cormorants [53]. These can be noted for Yashwant Lake in the summer months with moderate density of birds like Egrets, Herons and Cormorants. Herons and other fish eating birds undoubtedly take enormous numbers of fish, but much of such feeding seems to be most efficient when water levels decline and oxygen is reduced so that fish come to the surface to get air/oxygen. An estimated take of 76% of the fish of a declining pond has been reported with a 93% loss during total drying [53].

In the present study the total density of birds is also negatively correlated with pH and alkalinity. However, pH and alkalinity are positively correlated with phytoplankton and zooplankton densities [21] as the alkaline pH favours their growth. Though in present study, the density of plankton was high in summer the total bird density and species richness were moderate, a direct evidence of absence of the migratory population and presence of resident and resident migratory birds. Further, the nutrients such as nitrates, nitrites and phosphates are negatively correlated with the density of total birds**.** These nutrients are recorded maximum in monsoon. This may be attributed to rainfall which carries organic matter; animal waste and agro waste [54] from surrounding area to the Lake. The nutrients are then utilized in the further succession of biota in post monsoon and winter which favours the higher density of total birds. Further, the water birds are also expected to be influenced by the quality of water. The role they have in the turnover of nutrients has been discussed by many authors [55, 56]. Availability of food is of great importance but is often difficult to relate to bird populations. The birds are known to depend on the molluscs to meet their calcium demand [57]. Many species of waterfowls feed on mollusc [58, 37]. During winter molluscan density was lowest at Yashwant Lake [21]. This is the period when the ambient temperature in the area falls below 10 ºC forcing molluscs to hibernate/ move to deeper soil. Studies have shown a pattern of presence – absence relationships between prey and predator, for example, Snail Kites occur only where there are Apple snails [59]. The birds like Ibises and storks known to feed on molluscs [60, 2] though found in small numbers are few of the species probably benefited because of their long beak in collecting molluscs from deeper soil of the Yashwant Lake.

The study indicates that the Yashwant Lake though a smaller lake has a balanced ecosystem with stabilized abiotic and biotic components that support higher trophic species like birds in sizable numbers.

Study of Birds of Yashwant Lake with respect to Densities, Species richness and Shannon Wiener indices and its correlation with Lake dynamics.

Table: 1 Density of different groups of birds (individuals/Sq.Km.) over four seasons at Yashwant Lake (TB-total birds, RB-Resident birds, RMB-Resident migratory birds, MB-Migratory birds) during December 2006 to November 2008 at Yashwant Lake.

Density	Winter	Summer	Monsoon	Post monsoon	F Value ($F_{3\,20}$)
TB-	530.8 ± 17.6	295.3 ± 34.4	172.3 ± 11	374.3 ± 32.3	33.92
RB-	272.4 ± 6	189.7 ± 14.2	120.3 ± 7.9	221.6 ± 15.3	30.2
RMB-	177.1 ± 5.2	94.2 ± 16.7	48.9 ± 3	104.7 ± 11.5	25.02
MB-	81.6 ± 8.9	11.9 ± 4.2	3.4 ± 0.9	48.5 ± 7.8	32.66

Table: 2 Species richness (No. of species) of different groups of birds over four seasons at Yashwant Lake during December 2006 to November 2008

Species Richness	Winter	Summer	Monsoon	Post monsoon	F Value ($F_{3\,20}$)
TB-	56.67 ± 0.4	29.33 ± 5.1	16.17 ± 0.8	46.17 ± 4.17	28.97
RB-	26.33 ± 0.3	18 ± 2.2	11 ± 0.5	21.33 ± 1.7	19.65
RMB-	12.64 ± 0.2	7.66 ± 1.7	4.16 ± 0.3	10.33 ± 1.1	18.91
MB-	14.67 ± 0.33	3.66 ± 1.49	1.0 ± 0.25	12.5 ± 1.45	45.82

Table: 3 Shannon-Weiner diversity Index (H´) of different groups of birds over four seasons at Yashwant Lake during December 2006 to November 2008

H'	Winter	Summer	Monsoon	Post monsoon	F Value ($F_{3\,20}$)
TB-	3.5 ± 0.02	2.8 ± 0.11	2.4 ± 0.02	3.2 ± 0.11	31.69
RB-	2.75 ± 0.01	2.39 ± 0.07	2.02 ± 0.02	2.39 ± 0.07	32.09
RMB-	2.19 ± 0.01	1.52 ± 0.15	1.20 ± 0.55	1.82 ± 0.01	17.78
MB-	2.65 ± 0.02	0.93 ± 0.34	0.09 ± 0.09	2.48 ± 0.13	42.18

Table: 4 Evenness of different groups of birds over four seasons at Yashwant Lake during December 2006 to November 2008

Evenness	Winter	Summer	Monsoon	Ptmonsoon	F Value ($F_{3\,20}$-)
TB-YSL	0.87 ± 0.005	0.70 ± 0.028	0.60 ± 0.006	0.79 ± 0.02	31.69
RB-YSL	0.83 ± 0.003	0.72 ± 0.021	0.61 ± 0.007	0.72 ± 0.022	32.09
RMB-YSL	0.80 ± 0.006	0.56 ± 0.057	0.44 ± 0.02	0.67 ± 0.042	17.78
MB-YSL	0.95 ± 0.009	0.33 ± 0.12	0.03 ± 0.033	0.89 ± 0.047	42.18

Table: 5 Pearson correlation between bird density and abiotic and biotic parameters at three stations selected YLA, YLB and YLC at Yashwant Lake during December 2006 to November 2008

Sr.No.	Parameter	YLA	YLB	YLC
1	Acidity	-.738**	-.733**	-667**
2	Alkalinity	-.639**	-.649**	-.639**
3	AT ^{o}C	-.820**	-.843**	-.783**
4	Chloride	-.637**	-.645**	-.532**
5	CO_2	-.833**	-.850**	-.799**
6	DO	.547**	.544**	.470*
7	NO_2	-.926**	-.858**	-.875**
8	NO_3	-.531**	-.354	-.426*
9	p^H	-.738**	-.752**	-.681**
10	PO_4	-.955**	-.953**	-.834**
11	TDM	-.444*	-.341	-.424*
12	TDP	-.701**	-.577**	-.552**
13	TDS	-.725**	-.640**	-.658**
14	TDZ	-.636**	-.623**	-.634**
15	TH	.247	.361	.334
16	Trans.	.854**	.849**	.876**
17	TS	-.925**	-.843**	-.886**
18	TSS	-.646**	-.713**	-.670**
19	WT ^{o}C	-.662**	-.698**	-.707**
20	WC	.504*	.504*	.441*

*** Correlation is significant at the 0.01 level (two -tailed)*

**Correlation is significant at 0.05 level (two –tailed)*

REFERENCES

[1] Welty, J. C. and Baptista, L. **1988**. *The life of Birds*. 4th Eds. Saunders College Publishing by Saunders, W. B., New York.
[2] Ali, S. and Ripley, S.D. **1983**. *Handbook of the Birds of India and Pakistan*, University Press Bombay, Bombay, India.
[3] Rahmani, A. R. **2003**. Bombay Natural History Society, Oxford University Press. Pp. 343.
[4] Lack, D. **1933**. Habitat selection in birds. *J. of Animal Ecology*, **2**: 239-62.
[5] Morrison, M. L., Marcot, B. G. and Mannan, R. W. **1992**. Wildlife-habitat relation-ships. University of Wisconsin Press, Madison, WI.
[6] Hilden, O. **1965**. *Annals Zoologici Fennici*, **2**: 53-75.
[7] James, F. C. **1971**. *Wilson Bulletin*, **82**: 215-236.
[8] Cody, M.L. (ed.) **1985**. *Environmental Management*, **9**: 493-536.
[9] Wiens, J. A. **1989**. *The ecology of bird communities*, Vol 1 and 2. Cambridge: Cambridge University Press.
[10] Gibbs, J. P. **1993**. *Wetlands*, **13**: 25-31.
[11] Paracuellos, M. **2006**. *Biodiversity and Conservation*, **15**: 4569-4582.
[12] Vijayan, V. S. **1991**. Bombay Natural History Society, Bombay.
[13] Weller, M. W. **1981**. Freshwater marshes and wildlife management. University of Minnesota Press. Minneapolis.
[14] Nilsson, S. G. and Nilsson, I. N. **1978**. *Oikos*, **31**: 214-221.
[15] Weller, M. W. **1978**. Management of freshwater marshes for wildlife.
[16] Nagarajan, R. and Thiyagesan, K. 1996. *IBIS*, **138**: 710-721.
[17] Rodgerrs, W.A. **1991**. *Techniques for Wildlife census in India: A field Manual*. Wildlife Institute of India, Deharadun, India.
[18] Javed, S. and Kaul, R. **2002**. *The Field Methods for Birds Surveys*. Bombay Natural History Society. Mumbai.
[19] Grimmett, R., Inskipp, C. and Inskipp, T. **2001**. Pocket Guide of the Birds of the Indian sub-continent. Oxford University Press. Mumbai.
[20] APHA, 1998. American Public Health Association. Washington, D.C.
[21] Ekhande, A. P. **2010**. Ph. D. Thesis submitted to The Maharaja Sayajirao University of Baroda, Vadodara, India.
[22] Krebs, C.J. **1985**. *Ecology*: *the experimental analysis of distribution and abundance*. Third edition, Harper and Row Publisher, New York.
[23] Fowler, J. and Cohen, L. **1995**. *Statistics for Ornithologist*. 2nd edition. British Trust for Ornithology, Guide No 22, Distributed by NHBS, UK.
[24] Lubchenco, J., Olson, A. M., Brubaker, L.B., Carpenter, S.R., Hol-land, M. M., Hubell, S. P., Levin, S. A., MacMahon, J. A., Matson, P. A., Melillo, J. M., Money, H. A., Peterson, C. H., Pulliam, H. R., Real, L. A., Regal, P. J. and Risser, P. G. **1991**. *Ecology*, **72**: 371-412.
[25] Huston, M. A. **1994**. Biological Diversity. Cambridge University Press, Cambridge, UK.
[26] Wright, D.A. **1983**. *Oikos*, **41**: 456-507.
[27] Kerr, J. T. and Packer, L. **1997**. *Nature*, **385**: 252-254.
[28] Miller, J. N., Brooks, R. P. and Croonquist, M. J. **1997**. *Landscape Ecology*, **12**: 137-153.
[29] Newton, I. **1995**. *J. Anim. Ecol.*, **64**: 675-699.
[30] Li, Z. W. D. and Mundkar, T. **2007**. Numbers and distribution of waterbirds and wetlands in the Asia-Pacific region. Published by Wetlands International, Kuala Lumpur, Malaysia.
[31] Jose A. Atauri and Jose V. de Lucio. **2001**. *Landscape Ecology*, **16**:147-159.
[32] Patterson, J. H. **1994**. *IBIS*, **137**: S215-S218.
[33] Austin, G.T. and Tomoff, C. S. **1978**. *Am. Nat.*, **112**: 695-699.
[34] Rotenbery, J., Fitzner, R. and Richard, W. **1979**. *Auk*, **96**: 499-505.
[35] Bethke, R. W. and Nudds, T. **1993**. *Oecologia*, **93**: 242-250.
[36] Deshkar, S. L. **2008**. Ph. D. Thesis submitted to The Maharaja Sayajirao University of Baroda, Vadodara, India.
[37] Grimmett, R., Inskipp, C. and Inskipp, T. **1998**. Birds of the Indian sub Continent. Christopher Helm, London.
[38] Tramer, E. J. **1969**. *Ecology*, **50**: 927-929.
[39] Green, A.J. **1998**. *Can. J. Zool*., **76**: 500-507.
[40] Bancroft, G., Gawlik, D. and Rutchey, K. **2002**. *Waterbirds*, **25**(3): 265-277.
[41] Powell, G. V. N. **1987**. *Auk*, **104**: 740-749.
[42] Traut, A. H. **2003**. A thesis presented to the Graduate School of the University of Florida in partial fulfillment of the requirements for the degree of Masters of Science.
[43] Rathod, J. and Padate, G. **2008**.'Taal 2007' the World Lake Conference. (eds.) Sengupta, M. and Dalwani R. Pp. 537-541.

[44] Rathod, J. Y. **2009**. Ph. D. Thesis submitted to the M. S. University of Baroda, Vadodera, India.
[45] Dilwar, M. **2006**. Published by BNHS, India.
[46] Lake, D. **1968**. *Ecological Adaptations for Breeding in Birds*. Edward Grey Institute of Field Ornithology, Oxford, Methuen and Co. Ltd. London.
[47] Weller, M. W. **1999**. Wetland Birds. Cambridge University Press, Cambridge.
[48] Kaminski, R. M. and Weller, M. W. **1992**. In: *Ecology and managenment of breeding waterfowl*. MN University of Minnesota Press. pp 568-89.
[49] Kaminski, R. M. and Prince, H. H. **1984**. *Journal of Wildlife Management*, **10**: 37-50.
[50] Holopainen, I. J. and Paasivirta, L. **1977**. *Ann. Zool. Fennici*, **14**: 124-134.
[51] Esler, D. **1992**. *Journal of Field Ornithology*, **63**: 241-392.
[52] Patil, J. V. **2011**. Ph. D. Thesis submitted to The Maharaja Sayajirao University of Baroda, Vadodara, India.
[53] Kushlan, J.A. **1976**. *Auk*, **93**: 464-76.
[54] Parashar, C., Dixit, S. and Shrivastava, R. **2006**. *Asian J. Exp. Sci*., **2**: 297-302.
[55] Gere, G. and Andrikovics, S. **1992**. *Hydrobiologia*, **243/244**: 445-448.
[56] Mukherjee, A. and Borad, C. K. **2001**. *Hydrobiologia*, **464**: 201-205.
[57] Nisbet, I. C. T. **1997**. *IBIS*, 139:400.
[58] Stanczykowska, A., Zyska, P., Dombrowski, A., Kot, H. and Zyska, E. 1990. *Hydrobiologia*, **191**: 233-240.
[59] Stiles, F. G. and Skutch, A. F. **1989**. Ithaca, N.Y. *A guide to the birds of Costa Rica*. Cornell University Press.
[60] Cramp, S. and Simmons, K. E. L. **1977**. Handbook of the birds of Europe, the middle East and North Africa. Volume I, London, Great Britan: Oxford University Press, London.

Birds of Yashwant Lake of Toranmal plateau in Satpuda ranges observed from December 2006 to November 2008

Sr. No.	Common Name	Scientific Name	Family	Status	Habitat
1	Dabchick(Little Grebe)	*Tachybaptus ruficollis*	Podicipedidae	R	Di
2	Little Cormorant	*Phalacrocorax niger*	Phalocrocracidae	R	Di
3	Indian Cormorant	*Phalacrocorax fuscicollis*	Phalocrocracidae	RM	Di
4	Grey Heron	*Ardea cinerea*	Ardeidae	RM	MB, W
5	Purple Heron	*Ardea purpurea*	Ardeidae	RM	MB, W
6	Indian pond Heron	*Ardeola grayii*	Ardeidae	R	MB, W
7	Cattle Egret	*Bubulcus ibis*	Ardeidae	RM	MB, W
8	Great Egret	*Casmerodius albus*	Ardeidae	RM	MB, W
9	Little Egret	*Egretta garzetta*	Ardeidae	R	MB, W
10	Painted stork	*Mycteria leucocephala*	Ciconiidae	RM	MB, W
11	Wooly Necked Stork	*Ciconia episcopus*	Ciconiidae	R	MB, W
12	Black Headed Ibis	*Threskiornis melanocephalus*	Threskiornithidae	RM	MB, W
13	Ruddy Shelduck	*Tadorna ferruginea*	Anatidae	M	D
14	Common Teal	*Anas crecca*	Anatidae	M	D
15	Gadwall	*Anas strepera*	Anatidae	M	D
16	Eurasian Wigeon	*Anas penelope*	Anatidae	M	D
17	Red crested Pochard	*Rhodonessa rufina*	Anatidae	M	D
18	Common Pochard	*Aythya ferina*	Anatidae	M	D
19	Tufted Duck	*Aythya fuligula*	Anatidae	M	D
20	Eurasian Marsh Harrier	*Circus aeruginosus*	Accipitridae	M	BP
21	Osprey	*Pandion haliaetus*	Accipitridae	RM	BP
22	Common Coot	*Fulica atra*	Rallidae	RM	MB, Di
23	Common Moorhen	*Gallinula chloropus*	Rallidae	RM	MB, Di
24	Pheasant tailed Jacana	*Hydrophasianus chirurgus*	Jacanidae	R	MB, Di
25	Red Wattled Lapwing	*Vanellus indicus*	Charadriidae	R	MB, W
26	Yellow Wattled Lapwing	*Vanellus malarbaricus*	Charadriidae	R	MB, W
27	Little Ringed Plover	*Charadrius dubius*	Charadriidae	RM	MB, W
28	Common Redshank	*Tringa totanus*	Scolopacidae	RM	MB, W
29	Marsh Sandpiper	*Tringa stagnatilis*	Scolopacidae	M	MB, W
30	Green Sandpiper	*Tringa ochropus)*	Scolopacidae	RM	MB, W
31	Wood Sandpiper	*Tringa glareola*	Scolopacidae	M	MB, W
32	Common Greenshank	*Tringa nebularia*	Scolopacidae	RM	MB, W
33	Pintail Snipe	*Gallinago stenura*	Scolopacidae	M	MB, W
34	Little Stint	*Calidris minuta*	Scolopacidae	M	MB, W
35	Temminck's stint	*Calidris temminckii*	Scolopacidae	M	MB, W
36	Black winged stilt	*Himantopus himantopus*	Charadriidae	R	MB, W
37	Whiskered tern	*Chlidonias hybridus*	Laridae	R	Di
38	White Throated Kingfisher	*Halcyon smyrnensis*	Alcedinidae	R	Di
39	Pied Kingfisher	*Ceryle rudis*	Alcedinidae	R	Di
40	Common Kingfisher	*Alcedo atthis*	Alcedinidae	R	Di
41	Green Bee-eater	*Merops orientalis*	Meropidae	M	T
42	Sand Martin	*Riparia riparia*	Hirundinidae	R	T
43	Red Vented Bulbul	*Pyconotus cafer*	Pycnonotidae	M	T
44	Red throated Flycatcher	*Ficedula parva*	Muscicapidae	RM	T
45	White-throated Faintail-Flycatcher	*Rhipidura albicollis* Vieillot 1818	Muscicapidae	R	T
46	Tickell's Blue Flycatcher	*Cyornis tickelliae*	Muscicapidae	R	T
47	Common Tailorbird	*Orthotomus sutorius*	Sylviidae	R	T
48	Puff-Throated Babbler	*Pellorneum ruficeps*	Sylviidae	R	T
49	Black Lored Tit	*Parus xanthogenys*	Paridae	R	T
50	White Browed Wagtail	*Motacilla maderaspatensis*	Passeridae	R	T
51	Purplerumped sunbird	*Nectarinia zeylonica*	Nectariniidae	R	T
52	Purple sunbird	*Nectarinia asiatica (Latham)*	Nectariniidae	R	T
53	House sparrow	*Passer domesticus*	Passeridae	R	T
54	Baya Weaver	*Ploceus phillipinus*	Passeridae	R	T
55	Indian Silverbill	*Lonchura malbarica*	Passeridae	R	T
56	House Crow	*Corvus splendens*	Corvidae	R	T
57	Large Billed Crow	*Corvus macrorhynchos*	Corvidae	R	T
58	Common Myna	*Acridotheres tristis*	Sturnidae	R	T

Divers (10), W-Waders (21), D-Ducks (07), BP-Birds of Prey (02), MB-Marsh species (40), T-Terrestrial species (18), M-Migratory species (15), R-Resident species (30), RM-Resident Migratory species(13)