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Floral and Avifaunal Diversity of Thol Lake Wildlife (Bird) Sanctuary of Gujarat State, India

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Additional information is available at the end of the chapter

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1. Introduction

Wetlands are the ecotonal or transitional zones between terrestrial and aquatic ecosystems where the water table is usually at or near the surface of the land, which is covered by the shallow water (Mitsch & Gosselink, 1986). Due to these characteristics, wetlands provide opportunities for adaptations to different plant and animal species with high diversity of life-forms. Thus wetlands are among the most biologically diverse and productive ecosystems on earth. Wetlands can further be classified by one or more of the following attributes: (a) at least periodically, the land supports hydrophytes, (b) the substrate is predominantly undrained hydric soil, and (c) the substrate is saturated with water or covered by shallow water at some time during the growing season each year.

As per the convention on Wetlands of International importance (RAMSAR) (1971) – Article 1.1: wetlands are “Areas of marsh, fen, and peat land or water whether natural or artificial, permanent or temporary with water, that is static or flowing, fresh, brackish or salt including areas of marine water the depth of which does not exceed 6 meters.” Also according to Article 2.1: “[Wetlands] may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six meters at low tide lying within the wetlands”.

The values of the World’s wetlands are increasingly receiving due attention as they contribute to a healthy environment in many ways. They help to retain water during dry periods, thus keeping the water-table high and relatively stable. During periods of flooding, they act to reduce flood levels and to trap suspended solids and nutrients directly flowing into the lakes. The removal of such wetland ecosystems because of urbanization or other factors typically causes lake water quality to worsen. In addition, wetlands are important feeding, breeding, and drinking area for wildlife and provide a stopping place and refuge for waterfowl. As with any natural habitat, wetlands are important in supporting species

diversity and have a complex and important food web. The recent millennium assessment of ecosystems puts freshwater biodiversity as the most threatened of all types of biodiversity.

The interaction of man with wetlands during the last few decades has been of concern largely due to the rapid population growth, accompanied by intensified industrial, commercial and residential development. Thereby leading to pollution of wetlands by domestic, industrial sewage, and agricultural run-offs as fertilizers, insecticides and feedlot wastes. The fact that wetland values are overlooked has resulted in threat to the source of these benefits. Apart from the above the absence of reliable and updated information and data on extent of wetlands, their conservation values and socioeconomic importance has greatly hampered development of policy, legislation and administrative interventions by the state.

Fortunately in the recent years, the wetlands have received a good deal of attention. It really started with the conference held in Ramsar in Iran in 1971 where the first listing of wetlands of international importance was made and the contracting parties agreed to take necessary steps to safeguard these wetlands for posterity. India, as one of the original signatories, has made impressive efforts in initiating work for conservation and management of wetlands.

2. Indian scenario

India by its unique geographical position and with its annual rainfall of over 130 cm, and its varied terrain, and climate ranging from the cold arid of Ladakh to the warm arid of Rajasthan, with a cost line of over 7500 km, with its major river systems and lofty mountain ranges has, no wonder, a wealth of wetlands.

In addition to the various types of natural wetlands, a large number of man-made wetlands also contribute to the faunal and floral diversity. These man-made wetlands, which have resulted from the needs of irrigation, water supply, electricity, fisheries and flood control, are substantial in numbers. The various reservoirs, shallow ponds and numerous tanks support wetland biodiversity and add to the countries wetland wealth.

It is estimated that freshwater wetlands alone support 20 per cent of the known range of biodiversity in India (Deepa & Ramachandra, 1999). Wetlands in India occupy 58.2 million hectares, including area under wet paddy cultivation (Directory of Indian Wetlands).

Of about 35 Protected Areas (PAs) of India, which have been specifically notified for bird conservation, seven are in Gujarat (Grimmett et al. 1998). The State also falls within the Indus flyway a route that extends along the Indus valley from Pakistan to northwest India. This flyway is highly used by birds migrating from their breeding grounds in the Palearctic realm (Grimmett et al. 1998). The World Conservation Union (IUCN), International Wetland and Waterfowl Research Bureau (IWRB) and Birdlife International have rated this passage as the fourth major bird migration flyway in the world (Grimmett et al. 1998).

Gujarat is the State where the wetlands cover 27.1 lakhs hectares, a sizable area out of the total geographical area of the State. Of the total wetland area, inland wetlands cover 7.7%

and coastal wetland covers 92.3%. In coastal wetlands maximum area is under tidal flats/mud flats and the main contribution is from Great and Little Rann of Kachchh i.e. 1,930,581 ha. Analysis of the natural and man-made categories of wetlands indicate that, of the coastal wetlands, only 1.83% (mainly salt pans) is man-made, while in case of inland wetlands man-made wetlands account for 76.39% area.

Thol is one such man-made inland wetland situated in Mehsana district which is one of the top food grain producing districts in Gujarat (Anno. 1975). This marks the presence of well developed irrigation system consisting of wells and irrigation tanks. Thol water body is irrigation tank originally constructed in 1912 by the Gayekwadi State Rulers, built to prevent erosion and flooding and to store rainwater for irrigation purpose (Vaghela, 1993). Initially the area was declared as "Game Reserve" vide Government notification dated 29th May 1986 by Forest and Environment Department. Later on, due to its popularity amongst the bird fraternity, the area was notified as Bird Sanctuary through the notification GVN-53-88-WLP-1386-162-V.2 dated 18th November, 1988 under Section 18 of Wildlife (Protection) Act, 1972 (Anno. 2001).

Thol lake Wildlife Sanctuary which is now known as Thol Bird Sanctuary (TBS), as a part of conservation and management of Thol wetlands the biodiversity was studied to implement the Action Plan of Thol lake wildlife (Bird) sanctuary. This information will be comprehensive for preparing the management plan of the Sanctuary.

3. Study area

Thol Bird Sanctuary is situated in Mehsana district of Gujarat state, India between 23° 15' to 23° 30' N latitudes and 72° 30' to 72° 45' E longitude. It is a shallow water reservoir situated 25 km northwest of Ahmedabad and most popular birding place near Ahmedabad from Nal Sarovar Bird Sanctuary which is about 50 km away. Geographically, Thol Wildlife Sanctuary falls in the Kadi taluka of Mehsana district, North Gujarat region. Kadi taluka is head quarter of the district which is just 22 km away from the Sanctuary (Figure 1).

3.1. Salient features

Thol water body occupies a total area of 699 ha (6.99 sq.km.) and its periphery is 5.62 km long. Thol wetland catchment area is spread within six villages i.e. Thol, Jethlaj, Adhana, Vayana, Chandanpura, Jhaloda, which spreads 55.95 sq.km. It has well-developed canal based irrigation system. There are four head regulators at the water body to control the flow of water. The canals and their distributaries / sub-distributaries are about 19.97 km long.

The catchment area of the water body which covers 320 sq.km is located to its north and north-east so the spread is from Kadi taluka of Mehsana district and Kalol taluka of Gandhinagar district. These areas have seven small or big industrial areas they are, Karoli, Saij, Wamaj, Kalol, Chhatral, Indrad and Rajpur (Information from INDEXTb, Industrial Extension Bureau, Gandhinagar). Water finds its way through a number of canals draining into the feeder canal located on the north to northeastern sides of the water body. Water is

received through Eastern canal, Saij-Hajipur canal, Irana-Indrad-Wamaj canal, Hajipur-Piyaj canal, Eastern feeder at Saghan drain, and Jaspur canal at Thol water body.

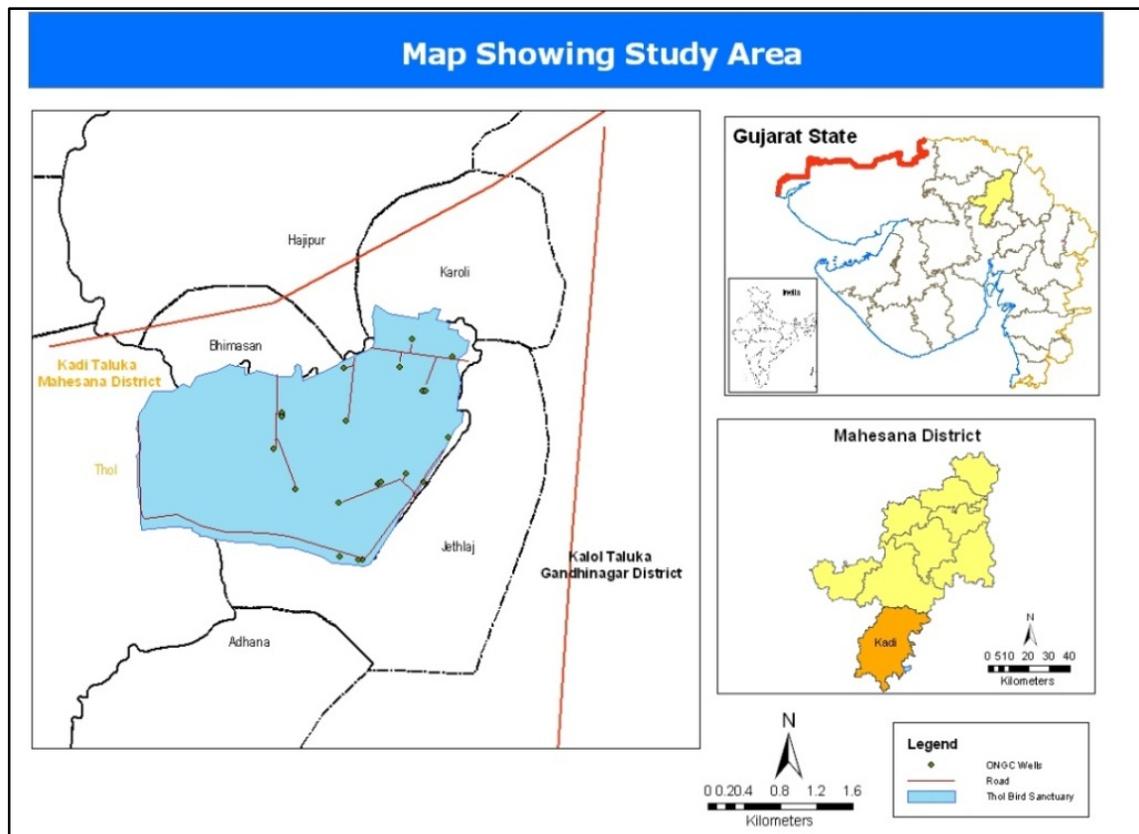


Figure 1.

In addition to the feeder canal, the water body receives run-off water directly from the catchment area. Before the feeder canal reaches the manmade wetland, there is a diversion, which is known as waste weir and is employed to control the volume of water in the water body. If the level of water reaches beyond 9 ft., the water is diverted to waste weir. Waste weir drains into a canal, which runs along the eastern boundary of the Thol pond/tank to reach Nalsarovar Bird Sanctuary located southwest of Thol Bird Sanctuary. Thol and Nalsarovar Bird Sanctuary are thus connected with each other.

There are no villages and settlements inside the sanctuary. Majority of the population is engaged in farming either as landholders or labourers. Also there are oil wells belonging to the public sector company Oil and Natural Gas Commission (ONGC) within the sanctuary area. There are total 21 number of wells among which 13 are functional. Polymer injection wells are 3 in number and Chase water wells are 5 in number. The total oil production from Thol area wells is 102 tpd.

3.2. Geology

Geologically, it is a part of the alluvial plain of recent age. The soil is clayey to sandy clay. There are no hard rock outcrops in and around the sanctuary.

3.3. Climate

Thol area experiences three distinct seasons namely winter (November to February), summer (April to May) and monsoon (June to September). Months of October and March mark the transition period from monsoon to winter and winter to summer respectively. The pond receives rainfall from July to September through the southwest monsoon. Old records for Mehsana district in general (Anno., 1975), as well as rainfall data of previous years at TS indicate that the rainfall is highly erratic and ranging from 189 to 786 mm.

4. Methodology

4.1. Land use / Cover studies

The methodology employed for preparation of Land use and land cover map included:

- Data collection
- Interpretation of satellite data
- Ground truth study
- Final map preparation

4.1.1. Data collection

- Downloading of Satellite imagery using the licensed software, Google Earth Pro having high resolution (<1.0m) data.
- Topographical maps as base map.
- Quick reconnaissance survey of the study area to get a feel of the entire ground area which can aid in the preliminary interpretation of the data.

4.1.2. Interpretation of satellite data

The downloaded satellite imagery was imported to Arc GIS 9.3 software and georeferencing of the imagery was done by registering it to the SOI maps through identification of common points between the map and the image. Considering the basic elements of interpretation such as tone, size, shape, texture, pattern, location, association, shadow, aspect and resolution, along with ground truth and ancillary information collected during the preliminary reconnaissance survey the interpretation was accomplished.

4.1.3. Ground truth study

A detailed ground truth was carried out to check the discrepancy of the interpreted data. It comprises of data collection of ground features along with the respective geographical position in terms of latitudes and longitudes.

4.1.4. Final map preparation

The interpreted file was then projected with Universal Transverse Mercator, which is universally followed projection system. The proportional presence of different land uses and

land cover in terms of statistical percentages was derived for the study area. Appropriate legends were used to represent the various categories of land use and land cover, and were then written on the prepared land use and land cover maps. Based on interpreted map floral and faunal sampling site was selected so that the entire area will be covered.

4.2. Vegetation cover

The phyto-sociological studies were carried out using quadrant method with in terrestrial vegetation covered region. Quadrate plots were laid in triplicate at each selected locations. Density, frequency, abundance and dominance and their relative values were calculated along with IVI values (Ambasht, 1990). The basal area was calculated by formula using diameter at breast height (Ravindranath & Premnath, 1997). Secondary analyses like different indices were calculated using this primary data (Odum, 1983).

The lower side of embankment had species diversity within this area the phytosociological studies were done. The grass cover region along the sanctuary boundary and on the beyts was surveyed and the herbs growing in this region was enlisted. The enlisting of the aquatic floral species like floating, emergent and submerged species had also been done.

4.3. Avifaunal studies

Avifaunal diversity studies sampling location was decided based on the water level and distribution as seen from interpreted satellite data. Observations were done by conducting field visits at regular intervals. Field works were conducted during winter season by visiting the place thrice in a season mainly from 0600 hr to 1200 hrs in the morning. The observations were recorded using field binocular (Pentax 10x50) and identified on basis of standard field guides like Grimmett *et al.* 1998, Salim Ali, 2002. This was done for both waterfowls and surrounding terrestrial birds. The bird diversity was classified according to its Order & Family, and their migratory statuses were noted.

4.4. Correlation between bird diversity & macrophytes

The relationship of the availability of bird diversity and macrophytes growing in the area was studied using statistical correlation method. The number of bird diversity distributed between the six sampling location and the available macrophytes diversity was documented.

5. Results

5.1. Land use / Cover studies

Visual interpretation of satellite data categorized area into five classes, they are shallow and deep water covered area, among terrestrial area it had been classified as vegetation cover, scrub land and agriculture land (Figure 2). The major portion of the sanctuary geographical area is covered by scrub land i.e. 36 per cent followed by 27 per cent of agricultural land. The category wise percentage area is as given in Table 1.



Figure 2.

Sr. No.	Class	Area (%)
1	Shallow water	15.08
2	Deep water	6.36
3	Vegetation Cover	15.69
4	Scrub	36.06
5	Agriculture	26.81

Table 1. Land use/cover Area Statistics of TBS

Each category is specific on its own as described below.

- Shallow water: It could be delineated based on the light tone on the satellite data. Shallow water region was having less than 1 foot, as correlated on the ground. This was on the western side of the sanctuary boundary.
- Deep water: It had dark coloured tone and smooth texture on the satellite data by which it was delineated as deep water. This was water filled region having more than 2 feet, as correlated on the ground. Its was on the western region or the corner of the sanctuary area.
- Vegetation Cover: This was only 15 per cent of the area. This category will be described in details in following section.
- Scrub: Most of the sanctuary area was covered by scrub, it is described as area coverage with less than 10 % of the canopy density (FSI, 2011) i.e. with scattered tree species and undergrowth dominated area.

- e. Agriculture: This was delineated based on the square patterns as seen on the data. The major crop grown in the region was Wheat, Juwar, and Bajra with water source as canal, bore or rainfed.

5.2. Vegetation cover

According to the vegetation map prepared using the satellite image of the Thol bird sanctuary area. There are three main patches of terrestrial vegetation first towards the Bhimasan village, on the north-east region along the water inlet to the Thol water body and lower side of the embankment. The vegetation towards the Bhimasan village was of monoculture type i.e. the plantation of *Acacia nilotica*, done by forest department. On the north east region along the water flow there was dominance of *Ipomoea fistula* and *Acacia nilotica* (Baval) vegetation. Lower side of the embankment had comparatively more species diversity where the phyto-sociological studies were done. Apart from this there were some patches of terrestrial vegetation which was again dominated by the planted species *Acacia nilotica* (Baval).

Phytosociological studies in the mixed vegetation type on the southern side of the sanctuary area showed presence of few species only. The highest abundance was of the *Acacia nilotica* (Baval) plantlet and its tree species had the highest IVI which showed that there was good regeneration of this species (Table 2). The understorey vegetation in this region was very less.

Sr. No.	Species	Abundance	IVI
1	<i>Acacia nilotica</i>	9.5	187.50
2	<i>Acacia planifrons</i>	2	22.80
3	<i>Zizyphus mauritiana</i>	2	19.67
4	<i>Azadirachta indica</i>	2	21.02

Table 2. Plant Species Status in Mixed Vegetation

The index calculated from the field data showed the dominance index to be greater than 0.5 indicating that one or two species contribute very highly in the community. Also from the high evenness index it could be judged that there is even distribution of the species (Table 3).

Index	Value
Simpson Dominance Index	0.67
Shannon-Wiener Diversity Index	1.03
Evenness Index	1.12
Species Richness Index	0.83

Table 3. Vegetation indices estimated from Mixed Vegetation

Along with this the enlisting of the species diversity within the sanctuary boundary was done, which showed the presence of 88 plant species (Annexure 1, see Appendix). It includes herbs, shrubs, grasses and hydrophytes species. There were in all 12 floating, emergent and submerged hydrophytes species.

5.3. Avifaunal diversity

Bird diversity recorded from Thol during present study were 144 in number out of it 76 are waterfowl rest are terrestrial birds (Annexure 2, see Appendix). The enlisted birds within the sanctuary area had 9 no. of rare and endangered species according to the Red Data Book (Table 4).

Within waterfowl there are members from 21 families and the family Anatidae had the most members i.e. 15, followed by Ardeidae having 11 members rest of the family have less than 10 members. This indicates that the ducks and geese are the dominating species, followed by herons, egrets and bitterns. Anatidae family members are mostly resident migratory or migratory species, only Comb duck is resident species. Resident migratory species are five i.e. Mallard, spot billed duck, bar headed goose, white eyed pochard and ruddy shelduck.

Terrestrial birds also had members from 21 numbers of families, and the Accipitridae family had highest number i.e. 10 members, followed by Corvidae having 9 members. These shows the dominating diversity within terrestrial area surrounding the water body are shikara, kite, eagle, vulture, buzzard, osprey and besra.

The statistics of residential status of species indicates that within aquatic birds diversity the highest number of species are resident-migratory i.e. 40 % while there are 33 % of resident species and 27 % of the migratory species. While within terrestrial birds species highest is of resident species having as high as 76 %, next is resident-migratory species of 21 % and just 3 % of migratory species.

Sr.No.	Scientific name	Common name	Migratory Status	Threatened Birds
1	<i>Anhinga melanogaster</i>	Oriental Darter	RM	NT
2	<i>Mycteria leucocephala</i>	Painted Stork	R	NT
3	<i>Phoenicopterus minor</i>	Lesser Flamingo	RM	NT
4	<i>Aythya nyroca</i>	White-eyed Pochard	RM	NT
5	<i>Threskiornis melanocephalus</i>	Oriental White Ibis	R	NT
6	<i>Grus antigone</i>	Sarus Crane	R	V
7	<i>Aquila heliaca</i>	Imperial Eagle	RM	V
8	<i>Aquila clanga</i>	Greater Spotted Eagle	RM	V
9	<i>Pelecanus philippensis</i>	Spotbilled Pelican	RM	V

NT - Near Threatened, V - Vulnerable, R - Resident, M - Migratory, RM- Resident-Migratory.

Table 4. List of Threatened Birds in Thol Bird Sanctuary

The habitat requirement of the waterfowl inhabiting in Thol were studied. The details are as given in the Annexure 3. The foremost requirement is that of the open water both deep and shallow waters, in terms of percentage 47 % of birds which includes all the members of the dominating family Anatidae this habitat was used. Birds inhabiting in the muddy habitats are 22 % this includes some heron & egret, plovers, godwit, greenshank and sandpiper. Thereafter 16 % of the birds require emergent vegetation habitat, followed by 7 % shoreland, 6% agriculture and fallow land and 3 % of wooded area. Among the agriculture & fallow land habitat the dominating species is Sarus crane which comes under the vulnerable status. Among this there are overlapping of the use of habitat as per the birds resting, roosting and foraging habits.

5.4. Correlation between bird diversity & macrophytes

It has been observed that there was lot of variation in the floral and faunal diversity within selected six locations (Table 5). The sampling locations were selected based on the difference in the availability of water and the congregation of birds found in the region and the accessibility of the region. The sampling location P6 had presence of more floral diversity and location P1 had more of bird diversity.

Sample No.	Location	Longitude	Latitude	Remarks	Macrophyte Diversity	Bird Diversity
P1	Towards Bhimasan village	72°23'44.6"E	23°08'34.7"N	Shallow water nearly half foot	4	27
P2	Check Post side	72°23'35.0"E	23°08'25.8"N	Deep water around 2 feet	2	17
P3	Middle region	72°23'55.2"E	23°08'26.0"N	Shallow water	2	15
P4	Camp site	72°24'09.0"E	23°08'09.7"N	Muddy Area, no disturbance	2	16
P5	Towards Jetlaj village	72°24'50.3"E	23°07'52.6"N	Emergent Vegetation in pockets	4	11
P6	Towards ONGC well No. 30	72°24'41.0"E	23°08'13.6"N	Small ponds of water, gets flooded during monsoons, less biotic disturbance	6	23

Table 5. Floral and Faunal Diversity

6. Discussion

6.1. Land use / Cover studies

Land use and land cover classification is an essential prerequisite for any management operation as it is a direct indicator of the ecology of the area. This is particularly important

to identify what kind of habitats in relation to the water level is formed and to find out habitat preferences of various species of waterfowl. Habitat is the natural home of any living form, may be an animal or a plant. Mc Farland (1980) suggested that birds respond to a summation of many factors and habitat selection thus, has some variability within a species. According to him a. characteristics of the terrain, b. nesting, feeding and drinking sites, c. food availability, d. other animals, are important factors influencing habitat selection. Therefore, identification of various habitat types are important factors influencing habitat selection.

The statistics reveals that there is more availability of shallow water habitat which in due course of time will be muddy region once water gets dried out. This study is very dynamic, thereby changes the types of birds visiting the wetlands. Also the availability water depends on the rainfall and the irrigation system. So this study needs to be conducted along with the bird census on regular basis.

6.2. Vegetation analyses

Macrophytes occurring in the area clearly indicate habitats and condition prevailing in the area of its occurrence. The habitat in the study area is mostly muddy and also it is saline, as indicated by sediment analysis (GEC, 2009).

Submerged rooted aquatic vegetation in Thol water body was of *Vallisneria spiralis* found near the Bhimasan village site and *Hydrilla verticillata* on the south eastern side near the ONGC well no. 30. The *Najas graminea* was found to be grown in abundant with *Hydrilla verticillata* and the *Potamogeton sp.* in the waters of Narmada Canal reaching TBS. Also on the sedges of the Narmada canal water there was growth of emergent hydrophyte *Typha sp.*, and floating *Paspalum sp.* This indicates the presence of nutrients content in the Narmada canal water. While in sanctuary area waters such abundant growth of submerged hydrophytes was not seen. The bed of Thol water body was covered with the grass *Cynodon dactylon* (Darba) and the free-floating hydrophyte *Ipomea aquatic* (Nala ni Vel) on the south-western corner of the sanctuary. *Cynodon dactylon* (Darba) shows salt tolerance capacity and at the same time these are nutritious and palatable species. Rooted floating weeds *Nelumbo lutea* (Kamal) was seen to cover the small portion of the water body. On the check post side of the pond the growth of grass on the sedge was seen that of *Eragrostis sp.* Thus the reeds and sedges provide resting, rooting or nesting habitat for many species apart from providing an excellent cover, too many birds which take shelter in such habitats. In the middle portion of the sanctuary area from northern side, which is less disturbed site had the presence of free floating *Lemna* (Kaye) sp. on the edge the Amarantheceae member herb *Alternanthera sessilis*.

On the small bets, there appear mostly abundant *Ipomea fistulosa* and in others bets *Acacia nilotica* (Desi baval) tree. On the other side of the waterbody i.e. on south eastern side near the ONGC well no. 30, there along with *Acacia nilotica*, *Parkinsonia accuminata* was found. These trees are extensively used by egrets, black ibis, crows, doves etc. for roosting. They are also used for nesting by crows, doves etc.

It was observed that on the south eastern side near the ONGC well no. 30 there appears reed meadow sedge, a seral stage where due to siltation, sedges, grasses grow abundantly. These include *Cyperus* sp. which play an important role of air circulation in the lake, as they are hollow and possess aerenchymous tissues. They help in gaseous exchanges of carbon dioxide and oxygen, which are thus made available to the submerged species. Also there was growth of *Polygonum* sp. on the sedges in this area. Emergent *Scirpus* sp. was also found in this region on the sedges, it has advantage to inhibit soil erosion and provide habitat for other wildlife. The plant rhizomes have medicinal value. So in this area we find diversity of macrophytes indicating the quality of water in Thol wetlands.

Major part of the Thol wetland sanctuary area is covered with scrub area. In this area there was sparse distribution of *Acacia nilotica* tree and the mesquite *Prosopis juliflora* (Gando baval) most of which are of shrubby appearance, seldom attaining a height of more than 5 meters. The ground is covered with grass *Cynodon dactylon* (Darba) and few herb species. The *Xanthium strumarium* (Gadariyu) an abnoxious weed appears at places along the shore and on some bays, which is indicative of excessive grazing in the area. This can be confirmed by the field survey in the area. The scrub area had more growth of herbs like the *Grangea maderaspatan* (zinki mundi), *Coldenia procumbens* (basario okharad), and *Glinus lotoides* (mitho okharad).

Among the tree species growing on the boundary of the Sanctuary were *Azadirachta indica* (Limdo), *Cordia myxa* (Gunda) and *Ailanthus excelsa* (Maharukh), etc. Apart from this on the southern boundary of the sanctuary area the natural vegetation grows where phytosociological parameters were studied. Micro level vegetational studies carried out aided to bring out sharp differences in the vegetation of these areas.

Each of the species within the community has a large measure of its structural and functional individualism and has more or less different ecological amplitude and modality (Singh and Joshi, 1979). This requires the understanding of the phytosociological status of each species within a community. Importance Value Index is a measure of plant status which brings out the overall role of a plant in a community (Ambasth, 1990). The study of phyto-sociology along with floristic composition proves useful in comparison of species from season to season and year to year (Singh, 1976). The study of vegetation its spatial distribution and analyses, and on field study indicates that the anthropogenic pressure had resulted in decrease in the undergrowth of the area. This would increase the possibility of the environmental stress i.e. soil erosion. This area shows the dominance of *Acacia nilotica* (Desi baval) with highest IVI of 187.5 and the dominance index. With the changing environmental conditions, the vegetation may reflect changes in structure, density and composition as observed by Gaur, (1982). The high evenness index shows the even distribution of vegetation in the community. It could be found out from survey that there is decrease in the undergrowth since it gets subjected to more anthropogenic pressure.

6.3. Avifaunal diversity

Bird communities are often referred as an ideal indicator to monitor the ecological condition of any wetlands as they impact on all the trophic levels of an aquatic ecosystem. On the

other hand aquatic ecosystems have significant impact on migratory birds. Birds carry out, diverse ranges of ecological functions among vertebrates. As consumers, they help regulate populations of smaller animals they prey upon, disperse plant seeds, and pollinate flowering plants. As prey items, birds and bird eggs are consumed by a variety of larger predators.

Birds also benefit humans by providing important ecosystem services such as regulating services by scavenging carcasses and waste, by controlling population of invertebrates and vertebrate pests, by pollinating and dispersing the seeds of plants; and supporting services by cycling nutrients (Croll *et.al.*, 2005) and by contributing to soil formation (Post, 1998).

There are two birds which has been identified as flagship species for Thol wetlands, being fresh water ecosystem, they are Sarus Crane (*Grus antigone*) and Osprey (*Pandion haliaetus*) since they represent the present ecosystem which is in need of conservation. They are distinctive in order to engender support and acknowledgement from the public.

- Sarus Crane (*Grus antigone*)

Sarus Crane is a large crane that is a resident breeding bird with *disjunct* populations that are found in parts of the Indian Subcontinent, Southeast Asia and Australia. Having height up to 1.8m, it is tallest of the flying birds; they are conspicuous and iconic species of open marshlands. As a species, the Sarus crane is classified as vulnerable this means that the global population has declined by about a third since 1980, and is expected to continue to do so until the late 2010. Estimates of the global population suggest that the population in 2000 was at best about 10% and at the worst just 2.5% of the numbers that existed in 1850 (BirdLife International, 2001). Unlike many cranes which make long migrations, the Sarus Crane does not; they may however make short-distance dispersal movements in response to rain or dry weather conditions. They tend to be more gregarious in the non-breeding season.

- Osprey (*Pandion haliaetus*)

Ospreys are sometimes known as the sea hawk, it is a large raptor, reaching 60 centimeters (24 in) in length with a 1.8 meter (6 ft) wingspan, is a resident-migratory species. They are widespread during winters in Indian Union, Bangladesh; Pakistan; Sri Lanka; Myanmar. Ospreys are diurnal, fish eating hawk, they flies up and down over the water scanning the surface for any fish coming up within striking depth.

Thol waterbody and surrounding area is most suitable habitat for Sarus, it can be appreciated from records that large number of Sarus congregations were seen. It has presence of over 50 birds feeding in the farmlands neighboring Thol, as late as 1998; the Sarus has remained the integral part of the avifauna of this territory (Singh & Tatu, 2000).

This shows that type of habitat is very important for wetland dependent species. Different species have different set of adaptations due to which they require certain types of habitats only. In case there is habitat loss in breeding areas it may directly result in loss of birds. Also the habitat is species specific and birds differ according to the habitat availability. Thus, the foremost requirement is identification of habitats in relation to various species of waterfowl.

TBS have variety of habitat which attracts many birds to the area. It was observed that dominating family Anatidae is having members like ducks and geese using open water habitat both deep and shallow. Thus the high usage of open water habitat explains why number of birds decrease with changes in the water spread and its level. Vijayan (1991) also reported preference of open water habitat over other categories by waterfowl at Keoladeo National Park. Anatidae group could truly be regarded as an indicator of the quality of habitat. As they depend on TBS for foraging, resting as well as roosting. Almost 60 per cent of Anatid members present are migratory and some species like the Whistling duck and Spot billed duck are potential breeders at TBS (GEER, 2002). Wetland could also be acting as a staging and dispersal area for the migrant ducks, which first arrive there and later spread to other smaller water bodies.

The migratory birds which come to TBS are coming mostly from northern and central Asia, Siberia and Europe or locally from Himalayas so their path is mostly north, north-east or north-west direction of TBS.

A total of 144 birds' species including 76 waterfowl and 68 terrestrial birds had been recorded at TBS during the study. The species diversity of waterfowl is similar to as recorded by Patel and Dharaiya, 2008 as 77 species. Species diversity was compared with other wetlands falling in semi-arid region like Wild Ass Sanctuary (Little Rann of Kachchh) and Nal Sarovar Bird Sanctuary. At Wild Ass Sanctuary (a seasonal fresh cum saline water protected wetland) Singh *et al.* (1999) had recorded 100 species of waterfowl (including wagtails and oriental pratincole) belonging to 18 families (as per old nomenclature). At Nal Sarovar Bird Sanctuary, Singh (1998) recorded about 113 waterfowl species. While Patel and Dharaiya in 2008 recorded 50 species of waterfowl. If we consider the area coverage Wild Ass Sanctuary is spread within 4953 sq. km., Nal Sarovar Bird Sanctuary spread within 120.82 sq. km. and TBS within 6.99 sq. km., if area is considered species diversity of TBS can be regarded remarkable.

The earlier study reveals that Nal Sarovar Bird Sanctuary which is just 50 km away, have high vegetation and faunal diversity compared to TBS (Patel, et al. 2006) due to different physical and hydrological configuration of largest natural fresh water reservoir. TBS and Nal Sarovar Bird Sanctuary are the valuable wetlands for migratory bird species. Moreover it can be also said that the Thol lake is more favored by the wetland obligatory birds. Since the study reveals that comparatively Nal Sarovar sanctuary had high disturbance score which indicates less healthy wetland for bird integrity than that of the TBS (Patel and Dharaiya, 2008). It was observed that towards the southwest direction of TBS is Nal Sarovar Bird Sanctuary, which is known to be one of the richest food crop (mainly paddy) growing areas, so there is continuous movement of birds between TBS and agricultural areas. This makes the birds visiting nearby village tanks and water bodies, which needs to be surveyed.

Thol has privilege of sustaining nine near threatened and vulnerable species. As reported by Chase et.al. (2000), presence of individual species may serve as indicator of the overall species composition of birds, but it may say less about the species richness, so the focus should be given to a diverse suite of the range of species representative for conservation

purpose. The efforts should go in the line to conserve the threatened and lower risk species so that the population should not come down and they become extinct in near future. As per the red data guidelines they should be conserved when their populations are still healthy, before they become genetically impoverished and their populations gets fragmented. Out of nine vulnerable and near threatened species six are resident migratory species, and rests are resident species. Two species like eastern imperial eagle and greater spotted eagle are terrestrial birds and they are birds of prey.

6.4. Correlation between bird diversity & macrophytes

The enlisting of the bird diversity and availability of macrophytes in the region was subjected to statistical correlation which shows that there is positive correlation with 86 per cent of variance is related.

6.5. Avifaunal population trend in thol bird sanctuary

Avifaunal density trend was studied from the year 2000 to 2008. The year 2000 data was from the GEER foundation report 2002 while 2004 data was of Forest department; this was the first census of Thol bird sanctuary. Remaining two census data were taken of the year 2006 and 2008 conducted by Forest department. The trend changes in the population density of the birds found in the Thol bird sanctuary is as given in the table 6.

Sr. No.	Group of Species	2000 [#]	2004 [*]	2006 [*]	2008 [*]
1	Grebes	0	2	40	3
2	Pelicans	120	4	321	750
3	Cormorants & Darters	0	830	942	482
4	Hérons & Egrets	1	479	485	210
5	Storks	4	83	236	95
6	Ibises & Spoonbills	19	768	183	5099
7	Flamingos	2	0	273	205
8	Geese & Ducks	419	1753	5599	7671
9	Cranes	525	380	664	1651
10	Reas, Crakes, Gallinules & Coots	0	21	943	552
11	Jacanas	0	0	0	0
12	Shorebirds & Waders	188	13839	8140	8120
13	Gulls, Terns & Skimmers	1	199	143	234
14	Kingfishers	0	10	15	25
15	Wagtails & Pipits	2	0	0	53
16	Eagles & Harriers	0	4	7	15
17	Total	1281	18372	17991	25165

GEER, (2002), * Forest Department Census

Table 6. Comparative Account of Birds Population (2000 to 2008)

It has been observed that over the years, there is increase in the population of the Pelicans, with sudden decrease in the year 2004. This growth can be attributed to the availability of the food; Pelicans mainly depend on the fish for food. It can be concluded that the forest department initiative of releasing fresh water fishes to the wetland was fruitful. Thus it could attract the migratory species to Thol wetlands.

The group Ibises & Spoonbill also shows the increase from just 19 numbers in year 2000 to 5,099 in the year 2008. The increase in population change of nil in year 2000 to 4,876 in year 2008 of Glossy ibis i.e. shore birds. The Glossy Ibis requires the muddy habitat and they depend mainly on benthos for food. Thus over the years there is improvement of the food and availability of muddy habitat had increased Glossy ibis population. While, there is decrease in population of Eurasian spoonbill from 661 in 2004 to 187 in 2008. So it could be inferred that as there is habitat changes in the wetland ecosystem bird population changes. Reason could be that there is shift from water availability to muddy habitat availability.

Geese and Ducks group which had maximum diversity in Thol wetlands also shows the increasing trend from 2000 to 2008. This could be due to the increase in population of the migratory species Common teal to 4,769 in 2008. They are dependent on benthos as well as vegetation matter for food and require shallow water habitat.

Whereas the group Shorebirds & Waders shows the decreasing trend from highest of 13,839 in 2004 to 8,120 in 2008. This is largely because of decrease in migratory species Ruff from 13,345 (2004) to 5455 (2008), which is being compensated by the increase in population of Black tailed Godwit from 4 (2000) to 2,156 (2008). Ruffs are sporting birds they take larger quantities of weed seeds (Ali, 2002). Due to regulated supply of water for irrigation and developmental activities there is decrease in the agricultural fields and the availability of food for the species so there is negative change in the Ruff population. This year, Ruff species are not even noted, since as per the regulations due to construction work going on, the water supply was restricted causing the negligible population availability. This information was obtained from the forest officials of Thol wetlands.

Thus from the above discussion it can be concluded that due to adopted management practices there was overall increase in bird population of 1,281 (2000) to 25,165 (2008). But, definitely there was an overall change in the habitat causing the birds population to change accordingly. If we correlate the population of birds with the rainfall of the region it also had the increasing trend from 232 mm in 2000 to 786 mm in 2008 (Table 7). Rainfall in the year 2006 was slightly more as compared with 2008, but there was decrease in total bird population. This is probably due to favorable conditions prevailing in other wetlands also of the State during that period.

Looking at the avifaunal diversity it can be concluded that the Thol is the valuable wetlands for migratory bird species and it is more favored by the wetland obligatory birds because at Thol there is less human disturbance.

Sr. No.	Year	Rainfall (mm)
1	2008 - 2009	473
2	2007 - 2008	786
3	2006 - 2007	659
4	2005 - 2006	855
5	2004 - 2005	582
6	2003 - 2004	662
7	2002 - 2003	203
8	2001 - 2002	500
9	2000 - 2001	189
10	1999 - 2000	232

Table 7. Decadal Change In Rainfall Data of Thol.

7. Conclusion

TBS is important wetland of the western region as variety of migratory birds visit this wetland during winters. The study had identified the potential of TBS as an internationally important wetland due to species richness and home for nine near threatened and vulnerable species including endangered Sarus Crane, having pre-breeding congregations and nesting grounds.

It has been observed that though TBS is facing less human disturbance in comparison to Nal Sarovar Bird Sanctuary, there are certain threats if not controlled may increase. The foremost being the location of ONGC oil well within the sanctuary boundary and catchment area. It should be monitored regularly to check for oil spills or leaks as oil spills could be a threat for birds. Also the major portion of the sanctuary area is covered by agricultural region which is given to local people for cultivation at a meager rate. This activity causes disturbance to the birds. The withdrawal of water for irrigation which is through supply canals in command area and lift irrigation causes pressure to the wetland ecosystem.

Another major pressure on the Thol Bird Sanctuary is due to livestock population. Livestock of five peripheral villages as well as those belonging to the pastoral people from Kachchh and Saurashtra visit this area for grazing in scrub lands and for drinking water. The grazing pressure was confirmed by the field visit and the type of species growing in the region. The livestock includes goats, sheep, cows, buffaloes and camel which causes disturbance to birds. The forest department should manage TBS taking into consideration the mentioned threats.

Thus the present study has shown the importance of carrying out such a study on regular basis so as to monitor the changes of dynamic ecosystem due to concomitant changes in water regime at TBS. The study had a limited scope owing to its short span and was conceived only to document bird diversity. It is being suggested to carry out movement and dispersal pattern of migratory waterfowl. This can be extended to the neighboring villages' tank and water bodies which would enhance our knowledge about these winged visitors.

Author details

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Appendix

Sr. No.	Scientific Name	Vernacular Name
	Family: Mimosaceae	
1	<i>Acacia auriculiformis</i>	Pardeshi baval
2	<i>Acacia tomentosa</i>	Aniyar
3	<i>Acacia nilotica</i> ssp. <i>indica</i>	Baval
4	<i>Acacia farnesiana</i>	Talbaval
5	<i>Acacia planifrons</i>	
6	<i>Albizzia lebeck</i>	Siras
7	<i>Prosopis cineraria</i>	Khijado
8	<i>Prosopis glandulosa</i>	Gandobaval
9	<i>Prosopis juliflora</i>	Gandobaval
10	<i>Pithecellobium dulce</i>	Goras ambli
	Family: Malvaceae	
11	<i>Abutilon indica</i>	Kanski
	Family: Simaroubaceae	
12	<i>Ailanthus excelsa</i>	Maharukh
	Family: Amaranthaceae	
13	<i>Alternanthera sessilis</i>	
	Family: Meliaceae	
14	<i>Azadirachta indica</i>	Limdo
15	<i>Melia azadirach</i>	Bakan limdo
	Family: Ceasalpiniaceae	
16	<i>Bauhinia racemosa</i>	Asotri
17	<i>Cassia auriculata</i>	Aval
18	<i>Cassia fistula</i>	Garmalo
19	<i>Cassia italica</i>	Mindhi Aval
20	<i>Cassia occidentalis</i>	Kasundri
21	<i>Cassia siamea</i>	Kassod
22	<i>Cassia javanica renigera</i>	Pink cassia
23	<i>Cassia tora</i>	Kuvandio
24	<i>Delonix regia</i>	Gulmohar
25	<i>Tamarindus indica</i>	Ambli
	Family: Balanitaceae	
26	<i>Balanites aegyptiaca</i>	Ingorio
	Family: Papilionaceae	
27	<i>Butea monosperma</i>	Khakhro

Sr. No.	Scientific Name	Vernacular Name
28	<i>Crotalaria burhia</i>	Kharshan
29	<i>Derris indica</i>	Karanj
30	<i>Indigofera oblongifolia</i>	Zil, Ziladi
	Family: Poaceae	
31	<i>Cynodon dactylon</i>	Darba
32	<i>Cenchrus ciliaris</i>	Shukli
33	<i>Dicanthium annulatum</i>	Jinjavo
34	<i>Eragrostis sp.</i>	-
35	<i>Dactyolactelum aegypticum</i>	
	Family: Cyperaceae	
36	<i>Scirpus sp.</i>	
37	<i>Cyperus sp.</i>	-
	Family: Capparaceae	
38	<i>Capparis decidua</i>	Kerdo
39	<i>Capparis sepiara</i>	Kanther
	Family: Asclepiadaceae	
40	<i>Calotropis procera</i>	Nano akado
41	<i>Calotropis gigantea</i>	Akdo
	Family: Verbenaceae	
42	<i>Clerodendron multiflorum</i>	Arani
	Family: Boraginaceae	
43	<i>Coldenia procumbens</i>	Basario Okharad
44	<i>Heliotropium indicum</i>	Hathisundho
45	<i>Cordia myxa</i>	Gunda
	Family: Menispermaceae	
46	<i>Cocculus hirsutus</i>	Patalagarudi
	Family: Solanaceae	
47	<i>Datura metal</i>	Dholo Dhanturo
48	<i>Solanum xanthocarpum</i>	-
	Family: Euphorbiaceae	
49	<i>Euphorbia hirta</i>	Dudheli
50	<i>Euphorbia nivulia</i>	Thor
51	<i>Euphorbia obiculata</i>	-
52	<i>Phyllanthus reticulata</i>	Kamboi
53	<i>Ricinus communis</i>	Castor
	Family: Moraceae	
54	<i>Ficus benghalensis</i>	Vad
55	<i>Ficus religiosa</i>	Peepal
	Family: Asteraceae	
56	<i>Grangea maderaspatana</i>	Zinki Mundi
57	<i>Launaea procumbens</i>	Moti Bhonpatri
58	<i>Xanthium strumarium</i>	Gadariyu

Sr. No.	Scientific Name	Vernacular Name
	Family: Molluginaceae	
59	<i>Glinus lotoides</i>	Mitho Okharad
	Family: Ulmaceae	
60	<i>Holoptelea integrifolia</i>	Kanjo
	Family: Sterculiaceae	
61	<i>Helicteris isora</i>	Maradiya
	Family: Hydrocharitaceae	
62	<i>Hydrilla verticilliata</i>	-
63	<i>Vallisneria natans</i>	-
	Family: Convolvulaceae	
64	<i>Ipomoea fistulosa</i>	Naffatiyu
65	<i>Ipomoea aquatica</i>	Nada ni Vel
	Family: Lemnaceae	
66	<i>Lemna sp.</i>	Kaye
	Family: Sapotaceae	
67	<i>Madhuca indica</i>	Mahudo
	Family: Anacardiaceae	
68	<i>Mangifera indica</i>	Keri
	Family: Celastraceae	
69	<i>Maytenus emarginata</i>	Vicklo
	Family: Moringaceae	
70	<i>Moringa oliefera</i>	Saragavo
	Family: Najadaceae	
71	<i>Najas graminea</i>	-
	Family: Nelumbonaceae	
72	<i>Nelumbo lutea</i>	Kamal
	Family: Rubiaceae	
73	<i>Oldenlandia sp.</i>	-
	Family: Fabaceae	
74	<i>Parkinsonia floridum</i>	
	Family: Potamogetonaceae	
75	<i>Potamogeton sp.</i>	
	Family: Annonaceae	
76	<i>Polyalthia longifolia</i>	Asopalav
	Family: Polygonaceae	
77	<i>Polygonum plebeium</i>	-
78	<i>Polygonum glabrum</i>	-
	Family: Salvadoraceae	
79	<i>Salvadora persica</i>	Piludi
80	<i>Salvadora olioedis</i>	Pilu

Sr. No.	Scientific Name	Vernacular Name
	Family: Verbenaceae	
81	<i>Tectona grandis</i>	Sag
	Family: Zygophyllaceae	
82	<i>Tribulus terrestris</i>	Bethu Gokhru
	Family: Typhaceae	
83	<i>Typha angustata</i>	
	Family: Rhamnaceae	
84	<i>Zizyphus mauritiana</i>	Bordi
85	<i>Zizyphus nummularia</i>	Chani Bor

Annexure 1. List of Vegetation (Aquatic & Terrestrial) Recorded in Thol Bird Sanctuary

Sr. No.	Scientific name	Common name	Migratory Status	Food Habits
AQUATIC BIRDS				
	Order: Anseriformes			
	Family: Anatidae			
1	<i>Anas acuta</i>	Northern Pintail	M	Aquatic plants, grains, insects, tadpoles etc.
2	<i>Anas clypeata</i>	Northern Shoveler	M	Water insects, snails, planktons, fish spawn.
3	<i>Anas crecca</i>	Common Teal	M	Chiefly vegetable matter, insects, crustaceans etc
4	<i>Anas penelope</i>	Eurasian Wigeon	M	Largely vegetarian
5	<i>Anas platyrhynchos</i>	Mallard	RM	Largely vegetarian
6	<i>Anas poecilorhyncha</i>	Spot billed Duck	RM	Chiefly vegetable matter
7	<i>Anas querquedula</i>	Garganey	M	Largely vegetarian
8	<i>Anas strepera</i>	Gadwall	M	Largely vegetarian
9	<i>Anser anser</i>	Greylag Goose	M	Vegetarian, winter crops, grass, aquatic weeds
10	<i>Anser indicus</i>	Bar-headed Goose	RM	Chiefly green shoots of winter crops - wheat/gram
11	<i>Aythya ferina</i>	Common Pochard	M	Vegetable matter, insects, molluscs, small fish etc
12	<i>Aythya nyroca</i>	White-eyed Pochard	RM	Vegetable matter, insects, molluscs, small fish etc
13	<i>Sarkidiornis melanotos</i>	Comb Duck	R	Grain, shoots vegetable matter
14	<i>Tadorna ferruginea</i>	Ruddy Shelduck	RM	Vegetable matter, insects, molluscs, small fish etc
15	<i>Tadorna tadorna</i>	Common Shelduck	M	Omnivorous, molluscs, algae, seeds etc.

Sr. No.	Scientific name	Common name	Migratory Status	Food Habits
	Family: Dendrocygnidae			
16	<i>Dendrocygna javanica</i>	Lesser Whistling Duck	R	Largely vegetarian - shoots and grain.
	Family: Anhingidae			
17	<i>Anhinga melanogaster</i>	Oriental Darter	RM	Fish
	Family: Ardeidae			
18	<i>Ardea cinerea</i>	Grey Heron	RM	
19	<i>Ardea purpurea</i>	Purple Heron	RM	Fish, Frogs, snakes etc.
20	<i>Ardeola grayii</i>	Indian Pond Heron	R	Frogs, fish, crabs and insects
21	<i>Bubulcus ibis</i>	Cattle Egret	R	Chiefly grasshoppers, blue bottle flies, lizards, fish etc
22	<i>Casmerodius albus</i>	Great Egret	RM	Fish, Frogs, etc.
23	<i>Egretta garzetta</i>	Little Egret	R	Insects, fish, frogs etc.
24	<i>Egretta gularis</i>	Western Reef Egret	RM	Mainly crustaceans, molluscs and fish
25	<i>Ixobrychus minutus</i>	Little Bittern	RM	Fish, molluscs etc.
26	<i>Ixobrychus sinensis</i>	Yellow Bittern	RM	Fish, frogs, molluscs etc.
27	<i>Mesophoyx intermedia</i>	Intermediate Egret	RM	Fish, frogs etc.
28	<i>Nycticorax nycticorax</i>	Black crowned Night Heron	R	Crabs, fish, frogs, aquatic insects, etc.
	Family: Charadriidae			
29	<i>Charadrius alexandrinus</i>	Kentish Plover	RM	Insects and crustacea
30	<i>Charadrius dubius</i>	Little Ringed Plover	RM	Insects, sand-hoppers, tiny crabs, etc.
31	<i>Vanellus indicus</i>	Red wattled Lapwing	R	Insects, grubs, molluscs, etc.
32	<i>Vanellus leucurus</i>	White tailed Lapwing	M	Aquatic insects and other vertebrates
33	<i>Vanellus malabaricus</i>	Yellow wattled Lapwing	R	Insects, grubs, molluscs, etc.
34	<i>Calidris minuta</i>	Little Stint	M	Tiny insects, crustaceans and molluscs.
	Family: Recurvirostridae			
35	<i>Himantopus himantopus</i>	Black winged Stilt	RM	Worms, molluscs, aquatic insects, etc.
36	<i>Recurvirostra avosetta</i>	Pied Avocet	RM	Worms, aquatic insects and small crustacea, etc.

Sr. No.	Scientific name	Common name	Migratory Status	Food Habits
	Family: Ciconiidae			
37	<i>Anastomus oscitans</i>	Asian Openbill	R	Frogs, crabs, large insects and other small living things.
38	<i>Ciconia episcopus</i>	Woolly necked Stork	R	Fish. Frogs. Reptiles, crabs, molluscs, large insects, etc.
39	<i>Mycteria leucocephala</i>	Painted Stork	R	Fish, frogs and snakes.
	Family: Jacanidae			
40	<i>Metopidius indicus</i>	Bronze Winged Jacana	R	Seeds, roots, etc., aquatic plants, insects and molluscs
41	<i>Hydrophasianus chirurgus</i>	Pheasant-tailed Jacana	R	Seeds, roots, etc., aquatic plants, insects and molluscs
	Family: Laridae			
42	<i>Chlidonias hybridus</i>	Whiskered Tern	RM	Tiny fishes, tadpoles, crabs, grasshoppers and insects.
43	<i>Sterna albifrons</i>	Little Tern	R	Small fish, crustaceans, insects.
44	<i>Sterna aurantia</i>	River Tern	R	Fish, crustaceans, tadpoles and water insects.
	Family: Pelecanidae			
45	<i>Pelecanus philippensis</i>	Spotbilled Pelican	RM	Fish
46	<i>Pelecanus crispus Bruch</i>	Great White Pelican	M	Fish, crustaceans
	Family: Phalacrocoracidae			
47	<i>Phalacrocorax carbo</i>	Great Cormorant	RM	Almost exclusively fish
48	<i>Phalacrocorax fuscicollis</i>	Indian Cormorant	RM	Almost exclusively fish
49	<i>Phalacrocorax niger</i>	Little Cormorant	RM	Exclusively fish
	Family: Phoenicopteridae			
50	<i>Phoenicopterus ruber</i>	Greater Flamingo	RM	Crustaceans, worms, insect larvae, seeds of marsh plants.
51	<i>Phoenicopterus minor</i>	Lesser Flamingo	RM	Phytoplankton (algae, diatoms, etc.)
	Family: Podicipedidae			
52	<i>Tachybaptus ruficollis</i>	Little Grebe	RM	Aquatic insects and larvae, tadpoles, etc.
	Family: Scolopacidae			
53	<i>Limosa limosa</i>	Black tailed Godwit	M	Worms, molluscs, crabs, insects.
54	<i>Limosa lapponica</i>	Bar-tailed Godwit	M	Marine invertebrates, insects.

Sr. No.	Scientific name	Common name	Migratory Status	Food Habits
55	<i>Tringa glareola</i>	Wood Sandpiper	M	Insects, larvae, worms and molluscs.
56	<i>Tringa hypoleucos</i>	Common Sandpiper	RM	Insects, worms, molluscs.
57	<i>Tringa nebularia</i>	Common Greenshank	M	Insects and other invertebrates, tadpoles, frogs.
58	<i>Tringa ochropus</i>	Green Sandpiper	M	
59	<i>Tringa stagnatilis</i>	Marsh Sandpiper	M	Insects, invertebrates and small frogs.
	Family: Threskiornithidae			
60	<i>Platalea leucorodia</i>	Eurasian Spoonbill	RM	Tadpoles, frogs, molluscs, insects and vegetable matter
61	<i>Plegadis falcinellus</i>	Glossy Ibis	RM	Molluscs, crustaceans, insects, etc.
62	<i>Pseudibis papillosa</i>	Red-naped/Black Ibis	R	Insects, grain and small reptiles.
63	<i>Threskiornis melanocephalus</i>	Oriental White Ibis	R	Tadpoles, frogs, molluscs, insects and vegetable matter
	Order: Coraciiformes			
	Family: Alcedinidae			
64	<i>Alcedo atthis</i>	Small Blue Kingfisher	R	Small fish, tadpoles and aquatic insects.
	Family: Cerylidae			
65	<i>Ceryle rudis</i>	Pied Kingfisher	R	Fish, tadpoles, frogs and aquatic insects.
	Family: Dacelonidae			
66	<i>Halcyon smyrnensis</i>	White-breasted Kingfisher	R	Fish, tadpoles, lizard, grasshoppers and other insects
	Order: Gruiformes			
	Family: Gruidae			
67	<i>Grus antigone</i>	Sarus Crane	R	Grain, shoots and other vegetable matter, insects, reptiles.
68	<i>Grus grus</i>	Common Crane	M	Largely vegetarian, tubers, grain, insects and small reptiles
69	<i>Grus virgo</i>	Demoiselle Crane	M	
	Family: Rallidae			
70	<i>Amaurornis akool</i>	Brown Crake	R	
71	<i>Amaurornis phoenicurus</i>	White-breasted Waterhen	R	Insects, worms, molluscs, grain, etc.
72	<i>Fulica atra</i>	Common Coot	RM	Grass and Paddy shoots, aquatic weeds, insects, etc.

Sr. No.	Scientific name	Common name	Migratory Status	Food Habits
73	<i>Gallicrex cinerea</i>	Watercock	R	Largely vegetarian - seeds and green shoots of rice etc.
74	<i>Gallinula chloropus</i>	Common Moorhen	RM	Insects, worms, molluscs, grain, etc.
75	<i>Porphyrio porphyrio</i>	Purple Swamphen/Moorhen	R	Shoots and vegetable matter, insects and molluscs.
	Family: Accipitridae (Or. Ciconiiformes)			
76	<i>Circus aeruginosus</i>	Western Marsh Harrier	M	Frogs, fish small birds, mammals and carrion.
TERRESTRIAL BIRDS				
	Order: Apodiformes			
	Family: Apodidae			
77	<i>Apus nipalensis</i>	House Swift	RM	Chiefly dipterous insects.
78	<i>Cypsiurus balasiensis</i>	Asian Palm-Swift	R	Tiny winged insects.
	Order: Ciconiiformes			
	Family: Accipitridae			
79	<i>Accipiter badius</i>	Shikra	R	Lizards, mice, squirrels, birds etc.
80	<i>Accipiter virgatus</i>	Besra	R	Largely small birds, mice, bats, lizards and insects.
81	<i>Aquila heliaca</i>	Imperial Eagle	RM	Rodents, ground dwelling birds, reptiles, etc.
82	<i>Aquila clanga</i>	Greater Spotted Eagle	RM	Frogs, waterfowl, small birds, etc.
83	<i>Elanus caeruleus</i>	Black-shouldered Kite	R	Locusts, crickets, mice, lizards, etc.
84	<i>Milvus migrans</i>	Black Kite	R	Offal and garbage, earthworms, mice, lizards etc.
85	<i>Neophron percnopterus</i>	Egyptian Vulture	RM	Animal carcasses and freshwater turtles.
86	<i>Pandion haliaetus</i>	Osprey	RM	Fish
87	<i>Pernis ptilorhynchus</i>	Oriental Honey-buzzard	RM	Honeybee larvae, small birds, reptiles, frogs etc.
88	<i>Spilornis cheela</i>	Crested Serpent-Eagle	R	Frogs, lizards, rats, snakes, etc.
	Order: Columbiformes			
	Family: Columbidae			
89	<i>Columba livia</i>	Rock Pigeon	R	Cereals, pulses, groundnuts, etc.
90	<i>Streptopelia chinensis</i>	Spotted Dove	R	
91	<i>Streptopelia decaocto</i>	Eurasian	R	

Sr. No.	Scientific name	Common name	Migratory Status	Food Habits
		Collared-Dove		
92	<i>Streptopelia orientalis</i>	Oriental Turtle-Dove	RM	Paddy, cereals, bamboo and grass seeds.
93	<i>Streptopelia tranquebarica</i>	Red Collared-Dove	R	
94	<i>Treron phoenicoptera</i>	Yellow-footed Green-Pigeon	R	Fruits and berries.
	Order: Coraciiformes			
	Family: Coraciidae			
95	<i>Coracias benghalensis</i>	Indian Roller	R	Insects,
96	<i>Merops orientalis</i>	Little Green Bee-eater	R	Insects, chiefly diptera and hymenoptera
97	<i>Centropus sinensis</i>	Greater Coucal	R	caterpillars, large insects, snails, lizards young mice etc.
	Family: Cuculidae			
98	<i>Cuculus micropterus</i>	Indian Cuckoo	RM	Mainly caterpillars, insects, etc.
99	<i>Eudynamis scolopacea</i>	Asian Koel	R	Largely fruits and berries, caterpillars and insects.
	Family: Phasianidae			
100	<i>Coturnix coturnix</i>	Common Quail	RM	Grain and grass seeds, termites, etc.
101	<i>Francolinus pictus</i>	Painted Francolin	R	Grain, grass seeds, green shoots, white ants and insects.
102	<i>Francolinus pondicerianus</i>	Grey Francolin	R	Grain, seeds, termites, beetle larvae, etc.
103	<i>Pavo cristatus</i>	Indian Peafowl	R	Grain, Vegetable shoots, insects, lizards, snakes, etc.
	Order: Passeriformes			
	Family: Aegithalidae			
104	<i>Aegithalos leucogenys</i>	White-cheeked Tit	R	
	Family: Alaudidae			
105	<i>Eremopterix grisea</i>	Ashy-crowned Sparrow-Lark	R	Seeds and insects.
106	<i>Eremopterix nigriceps</i>	Black-crowned Sparrow-Lark	R	
	Family: Cisticolidae			
107	<i>Prinia inornata</i>	Plain Prinia	R	Insects, caterpillars, ants, small beetles, etc.
108	<i>Prinia socialis</i>	Ashy Prinia	R	Insects.
	Family: Corvidae			
109	<i>Aegithina tiphia</i>	Common Iora	R	Insects, their eggs and larvae.

Sr. No.	Scientific name	Common name	Migratory Status	Food Habits
110	<i>Corvus splendens</i>	House Crow	R	Offal, dead sewer rat, kitchen scraps and refuse, termites etc
111	<i>Dendrocitta vagabunda</i>	Rufous Treepie	R	Fruits, insects, lizards, frogs, centipedes etc.
112	<i>Dicrurus leucophaeus</i>	Ashy Drongo	RM	Mainly insects, occasionally reptiles, and small birds.
113	<i>Dicrurus macrocercus</i>	Black Drongo	R	Insects, flower nectar, occasionally small birds.
114	<i>Garrulus glandarius</i>	Eurasian Jay	R	
115	<i>Pericrocotus cinnamomeus</i>	Small Minivet	R	Insects and their larvae.
116	<i>Rhipidura albicollis</i>	White-throated Fantail	R	
117	<i>Rhipidura aureola</i>	White-browed Fantail	R	Insects, chiefly diptera and hemiptera.
	Family: Hirundinidae			
118	<i>Delichon urbica</i>	Northern House-Martin	RM	Midges and other insects.
119	<i>Hirundo smithii</i>	Wire-tailed Swallow	R	Midges
	Family: Laniidae			
120	<i>Lanius vittatus</i>	Bay-backed Shrike	R	Locusts, lizards, large insects, etc.
	Family: Muscipidae			
121	<i>Copsychus saularis</i>	Oriental Magpie-Robin	R	Insects, flower nectar of Salmalia and Erythrina.
122	<i>Saxicoloides fulicata</i>	Indian Robin	R	Insects and their eggs, spiders, etc.
	Family: Nectariniidae			
123	<i>Nectarinia asiatica</i>	Purple Sunbird	R	Insects and spiders, very largely flower nectar.
	Family: Passeridae			
124	<i>Anthus campestris</i>	Tawny Pipit	RM	
125	<i>Anthus rufulus</i>	Paddyfield Pipit	R	Weev and other small insects
126	<i>Lonchura striata</i>	White-rumped Munia	R	Grass seeds, etc.
127	<i>Motacilla cinerea</i>	Grey Wagtail	M	Tiny insects.
128	<i>Motacilla flava</i>	Yellow Wagtail	RM	Insects, spiders and invertebrates, etc.
129	<i>Passer domesticus</i>	House Sparrow	R	Grains, insects, fruit buds, flower nectar, etc.
	Family: Pycnonotidae			
130	<i>Pycnonotus cafer</i>	Red-vented	R	Insects, fruits and berries, peas

Sr. No.	Scientific name	Common name	Migratory Status	Food Habits
		Bulbul		and vegetables etc.
131	<i>Pycnonotus leucotis</i>	White-eared Bulbul	R	Kitchen scraps, berries of peelu and wild caper.
	Family: Sturnidae			
132	<i>Acridotheres ginginianus</i>	Bank Myna	R	Grasshoppers and other insects.
133	<i>Acridotheres tristis</i>	Common Myna	R	Fruits, insects, kitchen scraps, etc.
134	<i>Sturnus pagodarum</i>	Brahminy Starling	R	Chiefly berries, wild figs and insects.
135	<i>Sturnus roseus</i>	Rosy Starling	M	Locusts, berries, nectar of Salmalia, etc.
	Family: Sylviidae			
136	<i>Acrocephalus arundinaceus</i>	Great Reed Warbler		
137	<i>Orthotomus sutorius</i>	Common Tailorbird	R	Tiny insects, their eggs and grubs, flower nectar.
138	<i>Turdoides caudatus</i>	Common Babbler	R	Insects, berries, grain and flower nectar.
139	<i>Turdoides earlei</i>	Striated Babbler	R	Insects, snails and some vegetable matter.
140	<i>Turdoides malcolmi</i>	Large Grey Babbler	R	Insects, berries, grain and flower nectar.
141	<i>Turdoides striatus</i>	Jungle Babbler	R	Spiders, cockaroaches, insects and their larvae grain, etc.
	Order: Psittaciformes			
	Family: Psittacidae			
142	<i>Psittacula krameri</i>	Rose ringed parakeet	R	Ripening fruits, standing crops of maize and jowar.
	Order: Strigiformes			
	Family: Strigidae			
143	<i>Athene brama</i>	Spotted Owlet	R	Chiefly beetle and other insects, mice, lizards, etc.
	Order: Upupiformes			
	Family: Upupidae			
144	<i>Upupa epops</i>	Eurasian Hoopoe	RM	Insects, grubs and pupae.

Annexure 2. List of Aquatic & Terrestrial Birds in Thol Bird Sanctuary

Sr. No.	Scientific name	Common name	Migratory Status	Open Water - Deep	Open Water - Shallow	Emergent Aquatic Vegetation	Muddy	Shore Land	Surrounding Environment - Agri	Surrounding Environment - Fallow	Wooded Areas
	Order: Anseriformes										
	Family: Anatidae										
1.	<i>Anas acuta</i>	Northern Pintail	M	L	H	L					
2.	<i>Anas clypeata</i>	Northern Shoveler	M		H	M					
3.	<i>Anas crecca</i>	Common Teal	M		H	M					
4.	<i>Anas penelope</i>	Eurasian Wigeon	M	L	H	L					
5.	<i>Anas platyrhynchos</i>	Mallard	RM	L	H	L					
6.	<i>Anas poecilorhynchos</i>	Spot billed Duck	RM	L	H	L					
7.	<i>Anas querquedula</i>	Garganey	M	L	H	L					
8.	<i>Anas strepera</i>	Gadwall	M	L	H	L					
9.	<i>Anser anser</i>	Greylag Goose	M		H	L		M	H	H	
10.	<i>Anser indicus</i>	Bar-headed Goose	RM		M	L		M	H	H	
11.	<i>Aythya ferina</i>	Common Pochard	M	H	M	L					
12.	<i>Aythya nyroca</i>	White-eyed Pochard	RM	H	M	L					
13.	<i>Sarkidiornis melanotos</i>	Comb Duck	R	L	H	M					
14.	<i>Tadorna ferruginea</i>	Ruddy Shelduck	RM	L	M	L		L			
15.	<i>Tadorna tadorna</i>	Common Shelduck	M	L	L	L		L			
16.	Family: Dendrocygnidae	Lesser Whistling Duck/Teal	R	L	H	M		L	L	L	
17.	<i>Anhinga melanogaster</i>	Oriental Darter	RM	H	M						
18.	Family: Ardeidae										
18.	<i>Ardea cinerea</i>	Grey Heron	RM			L	H	M			
19.	<i>Ardea purpurea</i>	Purple Heron	RM			H		L			
20.	<i>Ardeola grayii</i>	Indian Pond Heron	R			L	H	M			
21.	<i>Bubulcus ibis</i>	Cattle Egret	R			L	H	H	H	H	
22.	<i>Casmerodius albus</i>	Great Egret	RM		H	M	M	L	L	L	M
23.	<i>Egretta garzetta</i>	Little Egret	RM		M	M	H	M	M	L	M
24.	<i>Egretta gularis</i>	Western Reef Egret	RM		H	M	H	M	M	L	M
25.	<i>Ixobrychus minutus</i>	Little Bittern	RM			H	L				
26.	<i>Ixobrychus sinensis</i>	Yellow Bittern	RM			H	H	L	L		
27.	<i>Mesophoxys intermedia</i>	Intermediate Egret	RM				H				
28.	<i>Nycticorax nycticorax</i>	Black crowned Night Hero	R			M	M	L	L	L	
29.	Family: Charadriidae										
29.	<i>Charadrius alexandrinus</i>	Kentish Plover	RM			L	H				
30.	<i>Charadrius dubius</i>	Little Ringed Plover	RM			H	H	M			
31.	<i>Vanellus indicus</i>	Red wattled Lapwing	R			L	L	H	M	M	
32.	<i>Vanellus leucurus</i>	White tailed Lapwing	M			L	L	H	M	M	
33.	<i>Vanellus malabaricus</i>	Yellow wattled Lapwing	R			L	L	H	M	M	
34.	<i>Calidris minuta</i>	Little Stint	M			L	H	L			
35.	Family: Recurvirostridae										
35.	<i>Himantopus himantopus</i>	Black winged Stilt	RM		M	M	H	M			
36.	<i>Recurvirostra avosetta</i>	Pied Avocet	RM		M	L	H				
37.	Family: Ciconiidae										
37.	<i>Anastomus oscitans</i>	Asian Openbill	R		H	L	L		M	M	M
38.	<i>Ciconia episcopus</i>	Woolly/White necked Stork	R		H	L	M		L	L	L
39.	<i>Mycteria leucoccephala</i>	Painted Stork	R		H	H	M				
40.	Family: Jacanidae										
40.	<i>Metopidius indicus</i>	Bronze winged Jacana	R		M	L	L	L			
41.	<i>Hydrophasianus chirurgus</i>	Pheasant-tailed Jacana	R		M	L	L	L			
42.	Family: Laridae										
42.	<i>Chlidonias hybridus</i>	Whiskered Tern	RM	H	H	L	L	M			
43.	<i>Sterna albibronis</i>	Little Tern	R	H	H	L	L	M			

Annexure 3. Habitat Requirement of Waterfowls in Thol Bird Sanctuary

44	<i>Sterna aurantia</i>	River Tern	R	H	H	-	L	M	-	-	-
	Family: Pelecanidae										
45	<i>Pelecanus crispus Bruch</i>	Great White Pelican	RM	H	-	-	-	-	-	-	-
46	<i>Pelecanus philippensis</i>	Spot-billed Pelican	M	H	-	-	-	-	-	-	-
	Family: Phalacrocoracidae										
47	<i>Phalacrocorax carbo</i>	Great Cormorant	RM	H	-	-	-	-	-	-	-
48	<i>Phalacrocorax fuscicollis</i>	Indian Cormorant	RM	H	M	L	-	-	-	-	-
49	<i>Phalacrocorax niger</i>	Little Cormorant	RM	H	M	-	-	-	-	-	-
	Family: Phoenicopteridae										
50	<i>Phoenicopterus ruber</i>	Greater Flamingo	RM	-	H	-	-	-	-	-	-
51	<i>Phoenicopterus minor</i>	Lesser Flamingo	RM	-	H	-	-	-	-	-	-
	Family: Podicipedidae										
52	<i>Tachybaptus ruficollis</i>	Little Grebe	RM	H	M	L	-	-	-	-	-
	Family: Scolopacidae										
53	<i>Limosa limosa</i>	Black tailed Godwit	M	-	M	L	H	L	-	-	-
54	<i>Limosa lapponica</i>	Bar-tailed Godwit	M	-	M	L	H	L	-	-	-
55	<i>Tringa glareola</i>	Wood Sandpiper	M	-	-	L	H	L	-	-	-
56	<i>Tringa hypoleucos</i>	Common Sandpiper	RM	-	-	L	H	L	-	-	-
57	<i>Tringa nebularia</i>	Common Greenshank	M	-	L	L	H	L	-	-	-
58	<i>Tringa ochropus</i>	Green Sandpiper	M	-	-	L	H	L	-	-	-
59	<i>Tringa stagnatilis</i>	Marsh Sandpiper	M	-	-	-	H	-	-	-	-
	Family: Threskiornithidae										
60	<i>Platalea leucorodia</i>	Eurasian Spoonbill	RM	-	H	L	M	L	-	-	M
61	<i>Plegadis falcinellus</i>	Glossy Ibis	RM	-	-	M	H	M	L	L	H
62	<i>Pseudibis papillosa</i>	Red-naped/Black Ibis	R	-	-	-	M	H	M	M	H
63	<i>Threskiornis melanocephalus</i>	Black-headed/White Ibis	R	-	L	L	H	L	L	L	H
	Order: Coraciiformes										
	Family: Alcedinidae										
64	<i>Alcedo atthis</i>	Common Kingfisher	R	-	L	M	H	L	M	-	L
	Family: Cerylidae										
65	<i>Ceryle rudis</i>	Pied Kingfisher	R	-	M	H	L	-	L	-	L
	Family: Dacelonidae										
66	<i>Halcyon smyrnensis</i>	White-throated Kingfisher	R	-	M	H	L	L	L	L	M
	Order: Gruiformes										
	Family: Gruidae										
67	<i>Grus antigone</i>	Sarus Crane	R	-	-	-	-	M	L	H	H
68	<i>Grus grus</i>	Common Crane	M	-	-	-	-	L	M	H	H
69	<i>Grus virgo</i>	Demoiselle Crane	M	-	-	-	-	L	M	H	H
	Family: Rallidae										
70	<i>Amauromis akool</i>	Brown Crake	R	-	-	-	H	L	L	-	-
71	<i>Amauromis phoenicurus</i>	White-breasted Waterhen	R	-	-	-	H	M	L	L	-
72	<i>Fulica atra</i>	Common Coot	RM	-	H	M	L	-	-	-	-
73	<i>Gallinula cinerea</i>	Watercock	R	-	-	-	H	M	-	M	L
74	<i>Gallinula chloropus</i>	Common Moorhen	RM	-	-	-	H	M	L	-	-
75	<i>Porphyrio porphyrio</i>	Purple Swamphen/Moorhen	R	-	-	-	H	M	L	-	-

R: Resident species, M: Migratory species, RM: Resident Migratory species
Habitat: L: Less used habitat, M: Moderately used habitat, H: Highly used habitat

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