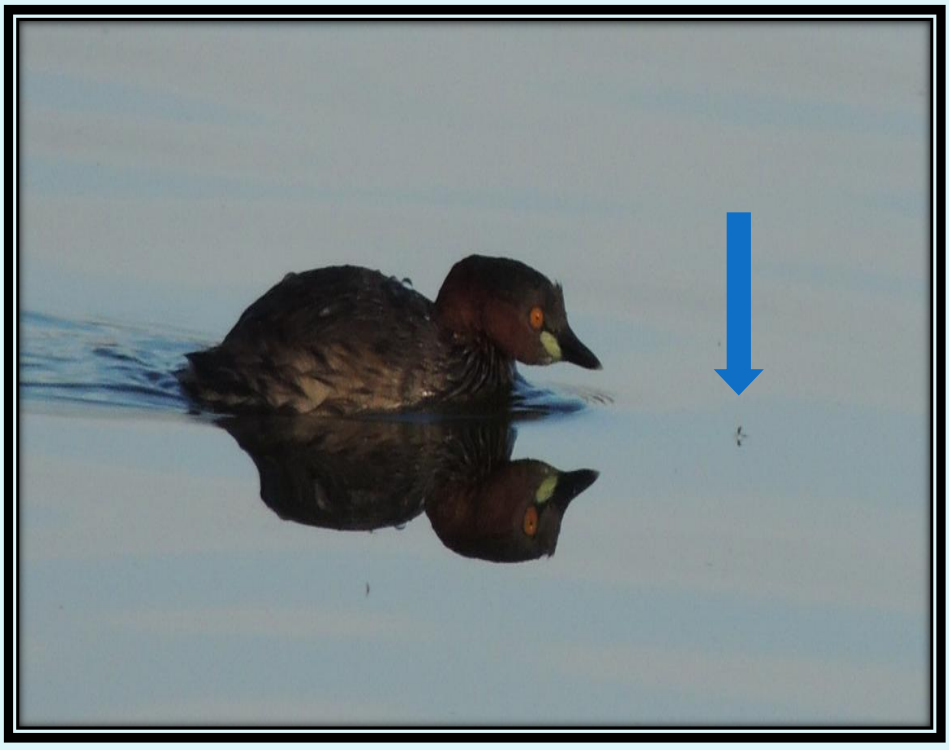
SUMMARY



- Some area of Mehsana and Banaskantha Districts are selected for the study. It is situated in North of the, Gujarat state, India. It lies between located at $23^0$02' to $24^0$09' N latitude and $71^0$26' to $72^0$51' E longitude.
- The study area is divided into ten sites according to their ecological condition. The tropic of cancer passes through Mehsana and Banaskantha Districts it has extreme climate.
- Ten sites are divided into two groups urban and rural.
- It is very hot in summer and very cold in winter.
- The climate of study area is almost dry and in the monsoon, it is semi-dry to humid type.
- It is periodic and seasonal.
- The average rainfall was 786.87mm. The highest rainfall 389mm was in August 2013 and lowest rainfall 0.20mm was January 2013 during study period.
- The highest maximum temperature recorded at study area was 40.34^0C in June-2014 and lowest minimum temperature was 7.83^0C in January-2013.
- Wind velocity was 23.62km/hrs in June-2014 and 2.3km/hrs in November-2012.
- Photoperiodism was 13:31hrs during June and 10:46hrs January respectively.
- Lowest Bright Sunshine Hours recorded in Monsoon (Aug-2012) i.e. 1.20 Hours while highest in summer (May 2014) i.e. 10.41 Hours and average Bright Sunshine 1.98 to 10.39.
- The urban and rural areas full with several water bodies, vegetation and fauna where birds of selected wetland birds roost, rest, feed and breed successfully.
- Temperature has affected on seasonal population. at any time temperature decreases, at that time population increase.
- Total 45 species was investigated at ten sites for 24 months.
- All 45 species are belonging to 8 orders and 16 families.
- During investigation 45 species of the selected wetland birds are recorded, out of which 31Resident, 01Residential migratory, 01 Migratory, 01 Breeding migratory, 01 Local migrant and 10 Winter visitor.

- Out of total 45 species, 17 are swimming, 26 wading and 02 are diving species.
- The population of Cattle Egret as a Resident species was highest due to availability of food (insects) in cropland, better nesting sites and shelter. January and February are pick period for Cattle Egret.
- In the months of January (3813.25) and February (5535.67) maximum number of selected wetland birds are observed.
- The population ranges in between 0.83 to 2119.50. Cattle Egret is dominant species (9.03%) in this area while Sarus Crane, Darter are comparatively less dominant ((< 0.1%).
- The Black-winged stilt (7.46%), Northern Shoveler (7.68%) and Little Cormorant (7.89%) are one of the commonest birds of India. Sarus Crane is resident species and found very less number in this area. This species leave manly up on seed and insect, which is quite difficult for the bird to get throughout the year in this area. The climatic factors also took part in population.
- Among the ten selected sites, highest density was found in site-VI (468.87 birds / hector) because in this site birds can easily get food and breeds here.
- The lowest density was recorded in site-III (118.20 birds / hector). This site is unique site where check dam is build on the river, due to it water is collected in monsoon and remain up to April.
- The rest sites having moderate density (range in between 130.78 to 316.84 birds / hector) in this area.
- The density of studied birds range is in between 0.01 to 17.81 birds / hectors in this area.
- The highest density (17.81 birds / hector) is of Cattle Egret because it is highly adaptive and sustainable species of the area. While lowest is of Sarus Crane (0.01 birds / hector) because it is a migratory species and it only observed in the month of February in the area.
- Similar observation of lowest density observed in Darter (0.32 birds / hector).

- The total density of selected wetland birds in all selected site is 205.31 birds / hector during study period and it is quite good density of selected wetland birds. Results also indicate that this area favors the wetland birds
- The minimum and maximum abundance of the birds are 0.10 and 18.16 respectively in Sarus Crane and Little Cormorant.
- The frequency is a presence of birds in particular site in the area, the frequency of Saras Crane (10%), Great White Pelican, Indian Shag (20%), Pied Avocet, Lesser Flamingo (40%), Northern Pintail (50%), Ruddy Shel-Duck (60%), Purple Swamphen (70%), Pheasant-tailed Jacana, Common Teal, Indian Spot Billed Duck, Little Cormorant, Great Cormorant, Darter (80%) and Black Crowned Night Heron, Painted Stork, Comb Duck, Northern Shoveler (90%). All other birds have (100%) frequency.
- The number of Pied Avocet, Lesser Flamingo is lower than Great White Pelican, Indian Shag but in site wise frequency it is higher than Great White Pelican, Indian Shag. Great White Pelican accumulating in site-III and IV, Indian Shag are accumulating in site-IX and X. In other site, it is not found.
- The range of Species Richness remains 75.55 % to 100%.
- During January, March and December, it is 97.77% and in the month of February, it is 100%. From April it starts to decline and remain up to September, after September it increases.
- During October and November Species Richness is 95.55%. During July and August Species Richness is 75.55%, which is lowest.
- January and February months the maximum numbers of birds are observed due to winter visitor. Summer season is not favorable to selected wetland birds population.
- Statistically it shows that the relation between rainfall and average population is less negatively correlated (r=-0.45). It shows that rain fall is not much more affect on birds' population.
- The correlation between selected wetland birds and temperature is less negatively correlated (r=-0.70).
- The correlation between selected wetland birds and humidity is less negatively correlated (r=-0.35)

- The month wise average population and seasonal index of the selected wetland birds. Among the selected wetland birds calculated the average population (birds/month). Average population of selected birds in the study area during study period is 521.41 (Total population = 23463.25).
- The highest population is of Cattle Egret ($\bar{X}$ = 477.75) was recorded in month of February then after population start to decline up to September. After that from October, it starts to increases up to February, this population trend is observed though out study period.
- The range of Seasonal Index is in between 124.06 to 1055.29. The highest index remains in February, where as lowest in May. It is similar to past record; February is the pick period for wetland and lowest population in July to August.
- Highest density is recorded at site-VI (468.87 birds / hector) (Table 2.2) Table 2.3 shows the comparison of site wise average population of selected wetland birds.
- More than 150 birds are recorded in site-II, IV and V to X were as less than 150 birds are at Site-I and III.
- Highest birds are recorded in site-II (2877) and III (3427) where water table remains high. Observation shows Site-provides good food source and ideal habitat.
- Observed during my study period and selected 10 (Ten) sites, that three types of birds with respect to their habitat selection are very common. They are wadding, swimming and diving birds.
- To study the habitat selection, habitats are divided into four major group's namely feeding, breeding, roosting and resting.
- For further study they are classified in to other categories Open Water feeding (OWF), Shallow water with sparse vegetation (SW + SV), Grass patch (GP), Edge of the dykes and mounds (EDM), Puddles (PU), Dumping station (DS) or (DP), Manure heap (MH, Carcass (CA), Reed bed (RB) or Reed and sedges-bed RS or R+S, Electric wire (EW), Farm field (FF), Sewage (S), Open land (OL), Newly flooded area (NFA), Vegetated with floating plants and Open water and emerge vegetation (VFP), Forest area

(FO), Canal (CL), On the trees, On the Shrub, Trees and bough over hanging water and Wall.

- Selected wetland birds are found in open water during feeding. Among all recorded species Great Cormorant found (46.46%) which is highest and Northern Shoveler were found (23.45%) which are lowest in this habitat.
- Shallow water with sparse vegetation (SW + SV) Major group of studied birds, they have selected this habitat first with 53.25% frequency of Purple Swamphen, which is highest, and Common Moorhen were found (11.52%) which are lowest in this habitat. Due to good food source, selected wetland birds these kind of microhabitat.
- Northern Pintail (42.94%) highly found in grassy patch while Asian Open Bill Stork was found (4.45%) which are lowest in this habitat.
- Mostly Great Cormorant prefers (45.85%) this habitat. Only (5.45%) frequency of Indian Shag found here. Among all study sites very less time found edge of the dyke and mound where birds can easily get food.
- During monsoon, some areas of the study sites remains full with the water and create puddles. Some phytoplankton's and insects, water bugs and zooplanktons attract to the selected wetland birds. Common Moorhen, Great Cormorant, Indian Shag, BlackIbis, Purple Swamphen and Pheasant-tailed Jacana still species, which is not found here throughout the study period.
- Black Headed Ibis (3.50%), Cattle Egret (2.07%) is two species, which is found at Dumping Station.
- Manure heap is a place where animal excreta, usually with straw, used to fertilize land dumped at the skirt area of village. Among by all recorded species Black Headed Ibis (4.32%) which is highest and Cattle Egret were found (1.54%) which is lowest in this habitat.
- It prove good habitat of some wading birds like Cattle Egret, Black Headed Ibis and Black Ibis Carcass is a place where dead body of animal is dumped at the outskirt of rural and urban area. The main carcass is located at the vadnagar and chimnabai sarovar in the study area. Only three birds viz. Cattle Egret (1.75%), Black Headed Ibis (3.57%), Black Ibis (1.98%) select this habitat in rare cases.

- Reed bed (RB) or Reeds and Sedges (R+S) among by all recorded species White Throated Kingfisher (21.79%) which is highest and Pied Kingfisher were found (18.31%) which are lowest in this habitat.
- Electric wires pass at the coastal part of pond, lakes and sewage canals. These wires provide a good habitat to selected diving birds. Among by all recorded species White Throated Kingfisher (50.82%) which is highest and Pied Kingfisher were found (8.01%) which are lowest in this habitat.
- Farm field (FF) among selected wetland birds Red wattled Lapwing (23.85%) which is highest and Black Headed Ibis were found (2.38%) which are lowest in this habitat.
- Sewage (S) Cattle Egret (4.44%), Asian Open Bill Stork (7.79%) and Black-headed Ibis (10.05%), Black Ibis (16.67%), Red wattled Lapwing (0.60%) are found here. During summer they were extremely recorded here where all wetland suffer from dry.
- Open land refers to non-built up land with no or with insignificant, vegetation. Surrounded by all recorded species Black ibis (6.98%) which is highest and Cattle Egret were found (2.07%) which are lowest in this habitat (e.g. Cattle Egret).
- Newly flooded area (NFA) Surrounded by all recorded species Painted Stork (18.65%) which is highest and Cattle Egret were found (6.25%) which are lowest in this habitat. (Plate Fig. 3.3.A.v).
- Some selected wetland birds like freshwater wetland well vegetated with floating plants like *Nelumbo nucifera, Vallisneria spiralis, Eichhornia crassipes, Hydrill verticillata, Lentana camerana and Ricinus communis, Pennisetum typhoides, Prosopis chilensis* etc. Surrounded by all recorded species Little Grebe (3.42%) which is highest and Pheasant-tailed Jacana were found (21.66%) which are lowest in this habitat.
- A forest is an area with a high density of tree. Surrounded by by all recorded species Black ibis (5.97%) which is highest and Cattle Egret were found (2.56%) which are lowest in this habitat (e.g. Cattle Egret) (Table 3.3(A), Fig.3.6 and Plate Fig. 3.10.A.xii). Thorny shrub species like *Acacia spe., Zizipus jujube* etc.

- Canal in the middle of selected wetland birds Red wattled Lapwing (4.65%) which is highest and Cattle Egret were found (0.90%) which are lowest in this habitat.
- Trees are the chief attraction of the study area where birds can easily built their nests, roost and rest. Little Cormorant (81%), Great Cormorant (51.57%), Indian Shag (100%), Cattle Egret (50.51%), Painted Stork (70.09%), Asian Open Bill Stork (70.23%), Black Headed Ibis (67.16%), Black Ibis (54.55%), Pheasant-tailed Jacana (55.15%), Red wattled Lapwing (59.18%) and some time Lesser Whistling Duck (45.28%). Trees are the first prefer for nesting, roosting and resting habitat.
- Shrubs are the second attraction of the study area where birds can easily built their nests, roost and rest. Little Cormorant (43.48%), Indian Shag (37.50%), Cattle Egret (58.06%), Black Headed Ibis (32.84%), Black Ibis (16.22%), Pheasant-tailed Jacana (45.85%), Red wattled Lapwing (41.82%), White Throated Kingfisher (4.94%), Pied Kingfisher (8.33%) used shrub for the nesting, roosting and resting habitat.
- In some stage of resting Little Cormorant (29.41%), Little Cormorant (48.25%), Cattle Egret (10.77%), Black-headed Ibis (35.45%), Black Ibis (55.41%), Red wattled Lapwing (5.80%), White Throated Kingfisher (5.00%), Pied Kingfisher (5.51%) found on wall this may use for bird to go for one more alternate habitat available around it. Mostly they are found within living area.
- Trees and bough hanging over water this serves as the chief attraction for many selected wetland birds, because such habitat is more suitable for aquatic birds to search the prey as well as to take rest after food catch. Among all recorded species, White Throated Kingfisher (100%) which is highest and Common Moorhen were found (8.27%) which are lowest in this habitat.
- In the study area, 21 roost sites are identified and divided into sub areas like; temporary and permanent. Out of total roosting site, 12 occupy by little Cormorant. Out of 05 occupy by Great Cormorant and out of 04 occupy by Indian Cormorant in urban area.

- Out of total 21 roost sites, 07 (27.27%) are found temporary whereas 14 (72.73%) permanent. According to the above classification for Little Cormorant, 03 roosting sites. Someway 09 roosting sites found permanent in urban area respectively. Someway Great Cormorants, 03 roosting sites are found temporary and 02 roosting sites found permanent in urban area respectively. Someway Indian Cormorant, 01 roosting site is found temporary and 03 roosting sites found permanent in urban area respectively.
- Distance of the aquatic foraging from roosts is found to be important factor in the site selection. Immediate locations of the aquatic foraging temporary and permanent roosts within 2 km radius are considered.
- All the 07 temporary roosts, except 5(71.43%) are located nearby aquatic foraging and all the 14 permanent roosts, except 11(78.57) are located nearby aquatic foraging.
- For the safe roosting, tall trees play important role.
- It is observed that Cormorant at all the 21 (temporary + permanent) communal roosts located within the study area are occupied altogether 36 roosting trees. The maximum occupation noticed on *Azadirachta indica* (28.00%) which seems to the most favorable for roosting. The other trees occupied by Cormorant i.e. *Ficus religiosa* (22.00%), *Acacia nilotica* (22.00%), *Prosopis chilensis* (17.00%), *Ficus benghalensis* (11.00%)
- Out of total 21 roosting site, maximum 12 on *Azadirachta indica* and rest on the *Acacia nilotica*. *Acacia indica,* it is also observed that Cormorants mostly use for roosting.
- Arrival and departure timings at roosts do not remain constant throughout the year and is changed with the seasonal photoperiod. Peak arrival time of the Cormorant at roosts is determined to be just before an average sunset time.
- The pattern of arrival and departure is inconsistent with relation to geographical direction. That mean random direction of a flight in North, South, East and West in an equal flock size does not occur.
- The majority of the Cormorant at the Tanariri Tempal from the North and East during 2012 and departed mainly towards East.

- Little Cormorant, pre-roosting gathering is recorded at foraging site. It minimum occurrence for pre-roosting is in pond and lack.
- In the present study, Cormorants observed to roost in mixed as well as pure roosting sites.
- In the mixed roosting site, they roost with White ibis, Cattle egret, Darter, Indian pond heron, Intermediate egret, Asian open-bill stork; Black winged stilt etc (17) Species of birds were recorded roosting along with the Cormorants on the some selected roosting sites.
- Nine site, which are selected to study breeding chronology of available wetland species (in attendance at Vadnagar is located at 23.78°N 72.63°E and Kheralu is located at 23.88°N 72.62°E).
- Some nests were on the trees, some nest on ground and some nest on the open water. The nests classify according.1. Nests on the trees (Nesting trees). 2. Open Water Nests (Fresh aquatic open water). 3. Dry wetland and the Ground Nests (Open ground).
- During two years of observation, some selected wetland birds nesting recorded hear. Some Rural and urban birds nesting in this area, lots of wetland species are nesting here.
- Throughout study period breeding of selected ten species of the six Orders and Eight Family were recorded.
- During study period ten species recorded, among them Little Grebe, Indian Shag, Cattle Egret, Black Headed Ibis, Black Ibis, Common Moorhen, Purple Swamphen, Pheasant-tailed Jacana, Red-wattled Lapwing and Lesser Whistling Duck.
- Selected wetland birds breeding season among them 1.Podicipedidae 1.Little Grebe Mid. July- Ear. Sep and Mid. Nov-Ear. Dec, 2.Phalacrocoracid 2.Indian Shag Mid. July to Ear. Sep, 3.Ardeidae 3.Cattle Egret Mid. May to Ear. Sep, 4.Threskiornithidae 4.Black Headed Ibis Mid. May- Ear. Sep, 5.Rallidae 6. Common Moorhen July, Aug and Oct-Nov, 5.Rallidae 7.Purple Swamphen July-Aug and Feb-Mar, 8.Anatidae 10.Lesser Whistling Duck July-Sep and Oct-Nov in this area.

- Due to climatic condition of this area most of the selected wetland birds start their breeding season one or two month earlier than other parts of Gujarat and India.
- July and Aug month is pick period, where maximum nests of some selected wetland birds except Little Grebe, Indian Shag, Black Headed Ibis, Common Moorhen, Pheasant-tailed Jacana, and Lesser Whistling Duck.
- Generally, (Podicipedidae, Phalacrocoracid, Ardeidae, Threskiornithidae, Rallidae, Jacanidae, Charadriidae and Anatidae families) select Associated, Compact, Tree, Homogeneous, Mixed heronry because most of the birds prefer to build their nest within human habitation.
- Mostly Indian Shag, Cattle Egret and Black-headed Ibis species nest close to one another in colonies called mixed heronries. Black Ibis species is solitary during breeding and built their nest on individual tree.
- Selection of nesting site is considered to be the mainly important cause in reproductive success in a lot of bird species.
- Nesting activities of some selected wetland birds were studied to know the factors affecting the selection of nesting habitat and nesting tree, the fresh water like river, pond, lake, sarovar and on the ground like dry wetland nests, its importance for supervision of the species for the conservation purpose.
- As it can be, little over 58% of the nesting sites are found within or close to human habitation with only 42% of the site around the wetland.
- These families mostly preferred to build their nest on thorny trees. It is observed to build their nests on *Acacia nilotica* (37.14%), *Azadirachta indica* (27.14%), *Pithcelobium dulcae* (5.71%), *Eucalyptus globules* (12.14%), *Tamarinudus indica* (5.00%), *Annona* squamosa (5.00%) and *Ficus benghalensis* (7.86%).
- The range of height and GBH of the nesting trees are 6.37±0.50m to11.08 ± 0.53m and 0.28±0.01m to 0.32±0.05m respectively.
- The average tree height, nest height and GBH of the nesting trees were 9.04± 0.36m, 7.00±0.34m and 0.30±0.04.

- It has been observed that the family Ardeiae never preferred less than 5m height trees and family Threskiornithidae, never preferred less than 7m height trees and family Phalacrocoracid, never preferred less than 8m height trees.
- Cattle Egret preferred small canopy tree, which is 2.73m. Black Headed Ibis and Indian Shag are preferred middle canopy trees, which is 4.93m and 4.22m.Black Ibis preferred big canopy tree, which is 6.90m.
- Several nests were on the open water. All these nests were on different range and at edge of the fresh water like river, pond, and lake, sarovar some selected wetland birds like Common Moorhen, Little Grebe, Purple Swamphen, Lesser Whistling Duck and Pheasant-tailed Jacana.
- Red-wattled Lapwing prefers to build their nest on open grand. The nest of Red-wattled Lapwing found on dry wetland and farmland or Ground-nests were located by noting typical breeding behavior
- Cattle Egret nest supported by 2.20 crotches, which is lowest, while in Black Headed Ibis 3.34, which is highest among all. The distance from the trunk to the nest is between 2.15m to 3.49m in these families.
- Various times Lesser whistling duck nest site may be a tree hole lined with twigs and grass or built in the fork of large trees *Mangifera indica* (40%), *Solanum nigrum* L (20%), *Azadirachta indica* (20%), *Holoptelea integrifolia* (Roxb) (20%). Sometimes reusing and old nest of a kite or heron or even on the ground,
- Average tree hole height from the ground 3.8m.
- Sometimes nests are in open ground near the fresh aquatic water like river, sarovar, and pond, lack.
- During study period ten species of the six Orders and Eight Families were recorded, among them ten species successfully breed in this area, they usually collect the nesting materials from various trees and to weave ideals
- Some Selected wading birds usually collect the nesting materials from the ground, nearby tree as well as from nesting trees.
- Some Selected swimming birds are like Little Grebe, Lesser Whistling Duck, Pheasant-tailed Jacana, Common Moorhen, Purple Swamphen use aquatic plants Total 18 plant species were recorded from the nest materials.

- The height of the nest from the ground surface range in between 5.38±0.17 to 7.88 ±0.76m and average is 7.00±0.34m in the selected wading birds.
- The diameter of nest rim and depth of nest range is between 19.50c.m to 38.60cm and 3.25 to 4.28cm respectively.
- The sticks were used for nest building varied from 128 to 234 and weight of a nest varied from 134.75 to 858.50gm.
- The remark shows that both the partners took part to collect the nest material.
- Birds of the selected wetland arrange the material, by using their breast, legs and bill to give the nest a proper shape.
- The nest building period of the selected wetlands birds varied from 3.70± 1.57days to 14.58±0.67 days (Table 5.9).
- Egg laying period is varied in selected wetland birds. The minimum 4 to 7 days in Little Grebe, and maximum 10 to 14 days in Black Headed Ibis for egg laying.
- Clutch size is a significant parameter, which determines the reproductive rate in the birds. Clutch size 2-3 clutch sizes were observed in Little Grebe, Lesser Whistling Duck, Pheasant-tailed Jacana, Common Moorhen, Red wattled Lapwing and Indian Shag, Cattle Egret, Black Headed Ibis, Black Ibis, Purple Swamphen have 3-4 clutch size so on an average clutch size varied from 2-4 in selected wetland birds.
- Little Grebe's eggs are pale yellowish marble to reddish buff, blotched and marked with reddish brown. Indian Shag's eggs are in pale bluish green colour. Cattle Egret's eggs are broad ovals, very pale sea green, almost white or skim milk blue. Black Headed Ibis's eggs are almost white or skim milk blue. Black Ibis's eggs of the Black Ibis are simple and white with faint bluish tinge by a few dark bloody reddish spots. Common Moorhen's eggs, pale yellowish marble to reddish buff, blotched and marked with reddish brown. Purple Swamphen's eggs are pale yellowish marble to reddish buff, blotched and marked with reddish brown. Pheasant-tailed Jacana's eggs are pale yellowish marble to reddish buff, blotched and marked with reddish brown. Red-wattled Lapwing's eggs are black-blotched buff, greenish marble

and eggs' shape is a bit like a pet-top. Lesser Whistling Duck's eggs are in pale bluish green colour.

- Incubation period is the Pheasant-tailedJacana11.33±1.97 Days which is minimum and the Black Headed Ibis 23.06±1.65days which is maximum in selected wetland birds.
- Egg mortality is the proportion of egg in a clutch that failed to yield the chicks. Predation, infection, egg fallen and nest destruction are caused the demise of many eggs.
- The egg mortality 10.45% (lowest) and 47.60% (highest) is observed in, Cattle Egret and Pheasant-tailed Jacana respectively.
- Hatching failure, predation and unknown causes. 1.49% hatching failure in Cattle Egret which is lowest, while 10.53% in Purple Swamphen which is highest.
- Predation is second reason for egg mortality. Some time unknown, causes also participate in the egg mortality.
- Hatching success is the proportion of egg in a clutch that produces young. The egg hatched during daytime, with a crack of the eggshell at the middle of the egg.
- In the highest hatching, success has show in Cattle Egret 88.06 % and lowest in Pheasant tail Jacana 47.06%.
- The range of nestling period is 35.50±4.77 to 51.50±1.17 respectively in, Lesser Whistling Duck and Black Ibis. Nesting period is defined as interval of time between the laying of the first egg to the nest leaving by the last fledges.
- The Red-wattled Lapwing completed their nesting cycle in 43.81±8.57 days which is lowest in the selected birds while Black Ibis completed it within 60.75±2.86 which is highest.
- All the ten species completed their breeding cycle with in 2.5 months.
- Starvation, the most commons cause of chick mortality in the selected wetland birds is probably true for selected Wetland birds. Predation and other unknown causes also participated in chick mortality.

- Chicks of Black Headed Ibis highly suffered by starvation 66.67%
- In the case of Red-wattled Lapwing predation, create major trouble for chick survival.