

## **ASSESSMENT OF BIRDS' FAUNA, OCCURRENCE STATUS, DIVERSITY INDICES AND ECOLOGICAL THREATS AT MANGLA DAM, AJK FROM 2011 TO 2014**

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### **ABSTRACT**

The field surveys of Mangla Dam AJK were conducted to measure its avian diversity between May 2011 and April 2014. The study was undertaken to determine the birds' fauna occurrence status, diversity indices and ecological threats to their conservation. Point count method was used for data collection. Findings of the research revealed that maximum account of 57892 birds of 188 species belonging to 57 families and representing 17 orders were observed during May 2011 to April 2012. A steady decline in birds' population was noticed while diversity of the order Passeriformes was highest on dam. The Maximum values of diversity indices were also recorded in study year 2011-2012 i.e. Shannon-Weiner Diversity Index ( $H'$ ) was 3.41; Census Index (CI) was 218/Km<sup>2</sup>, Simpson's Diversity Index (D) was 0.95 and evenness of birds was 0.65. According to ranking of birds occurrence status for the Mangla Dam 15 species were very abundant, 11 were abundant, very common were 41, common were 42, fairly common were 64, uncommon were 5 and 2 were rare. The season wise distribution of bird's species shown that 71 percent were year around resident, summer breeders were 13 percent, winter migrants were 64 percent and 29 percent were passage migrants. The most dominant species of study area were Common Pochard *Aythya ferina* (n=5011), Common Coots *Fulica atra* (n=4782), Little Cormorant *Phalacrocorax niger* (n=4764), Garganey *Anas querquedula* (n=3863) Mallard *Anas platyrhynchos* (n=3841), Northern Shoveler *Anas clypeata* (n=3743) Tufted Duck *Aythya fuligula* (n=3393) Northern Pintail *Anas acuta* (n=3261) and Gadwall *Anas strepera* (n=2971). The major threats observed including illegal hunting, trapping, unsustainable fisheries practices, deforestation in dam catchment area and water pollution.

**Key Words:** Avian Fauna, Diversity Indices, Ecological Threats, Mangla Dam.

### **INTRODUCTION**

The biodiversity is an indicator of healthy ecosystem, but avian diversity in this regard is very important due to its visibility and attraction to natural habitat. Pakistan is representing wide variety of bird's fauna because it is occupying an ideal location among famous biological realms and its considerable diverse habitats. Annually birds from European and Asian regions migrate towards wetlands of Pakistan to cope with harsh winter at their home land. These birds follow seven fly ways of all over the world and one of very important and frequently used Indus fly way is present in Pakistan (Ali, 2006).

The 9<sup>th</sup> largest dam in the world, Mangla, was built in 1967. Mangla Dam falls into fresh water wetland category and represents lacustrine (permanent fresh water lake) sub-group of wetland (Ali, 2006). Other wetlands of this kind are Bund Khushdil Khan, Haleji Lake, and Hub & Tarbella Dams are properly managed for protection and conservation of water birds. Unfortunately the internationally important Mangla lake of AJK state is most neglected wetland of Pakistan, although it is wintering ground for migratory birds. There are lots of Information gap about important wetland sites like

Mangla Lake, Rawal Lake and Zangi Nawar Lake. The presence of Black Stork *Ciconia nigra* has been reported several times due to limited studies of Water bird migration patterns and distribution in Pakistan these reports have not been justified. There had been infrequent efforts to observe and count birds, to develop a conservation policy, but the non-availability of consistent or reliable data is a major problem. Wetlands International's Asian Water Bird Census studied 94 wetlands in Pakistan from 1997 to 2001 but this effort is still very deficient (Li and Mundkar, 2004)

The Mangla wetland is an important staying and wintering ground for thousands of migratory birds. During August they start landing in, birds population is at peak in December/January and in April they fly back to their home town regularly. Ali *et al.*, 2011 noticed many threats to wildlife like exploitation of ecosystem by collecting fire-wood, livestock grazing, encroachment and cutting resulted in the habitat degradation, killing of wildlife by fighting and hunting dogs of local community in vicinities of Mangla Dam. They also illegally hunted foxes, jackals and wolfs just for fun (Ali *et al.* 2011).

The present study has been planned to determine the existing state of avian diversity at Mangla dam, changes in their population size overtime, threats probably responsible for these changes on yearly basis

because sporadic research and birds count data is present in this regard. The multi-year data from this research will be helpful for policy making and designing conservation strategies of these guests on Mangla dam.

## MATERIALS AND METHODS

**Study Site:** The Mangla Dam 33.12 °N, 73.39 °E is located in the Mirpur District of Azad Kashmir with maximum elevation of 630 metres. The area covered by dam is of 26,500 ha and was constructed in 1967 on river Jhelum (Fig-1).

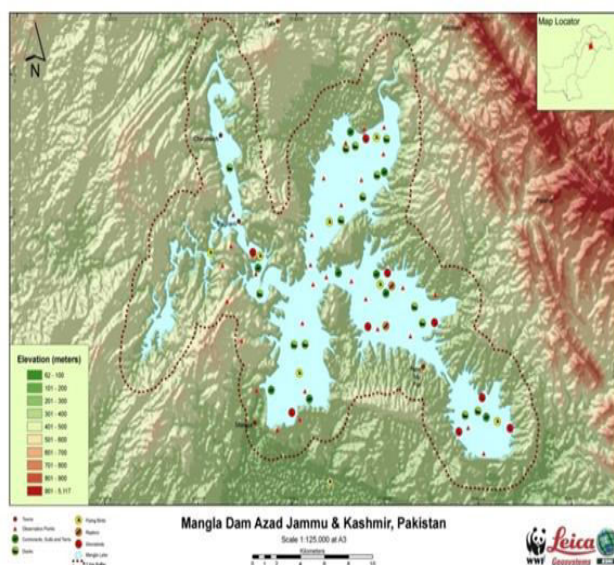


Figure-1. Mangla Dam (Source: Ali *et al.* 2011)

**Methods:** Field surveys were conducted by point count method between May 2011 and April 2014 with 30 days interval. Surveys were carried out at 06:30 h in the morning and at 04:00 h in the late afternoon site to assess, measure and identification of bird species with the help of spotting scope and binocular (Haldin and Ulfvens, 1987). Surveys were conducted on foot and by boat where necessary. Identification of birds was carried out by using field guides and information of experienced field professionals.

**Indirect Observation:** Indirect observations were collected from local community, fishermen hunters and concerned personal through informal meetings. This proved very useful tool to assess the hunting pressure on wildlife.

**Diversity Indices:** Species diversity indices are very important for biodiversity management and policy making. Different diversity indices on collected data were used in present research work like Shannon-Weiner

Index (Shannon and Weaver, 1948) species evenness and richness is important component of diversity (Hill, 1973) for expression evenly distribution of the individuals among other species and Simpson Index (Simpson, 1949). The local occurrence status of birds was determined according to Bull (1974).

## RESULTS AND DISCUSSION

Mangla water reservoir was surveyed between 2011 and 2014, it was observed that this man made wetland was rich in avian diversity especially for the migratory birds. Highest birds diversity 57892 birds of 188 species was recorded in 2011-2012, then 54311 birds of 186 species in 2012-2013 and 5268 birds of 187 species in 2013-2014. Overall a steady decrease in birds' population was noticed during study period. According to Ali and Akhter (2006) the size of lakes and number of birds are decreasing on some wetland of Punjab. Whereas total 31,920 birds of 141 species were observed by Ali *et al.*, 2011 while Khalique *et al.*, 2012 recorded 4774 birds of 31 species. These birds included near threatened birds like *Anhinga melanogaster*, *Aythya nyroca*, *Circus macrourus*, *Sterna acuticauda*, *Prinia burnesii* and Vulnerable species like *Haliaeetus leucoryphus*, *Ficedula subrubra* and *Saxicola macrorhyncha* according to IUCN red Data List.

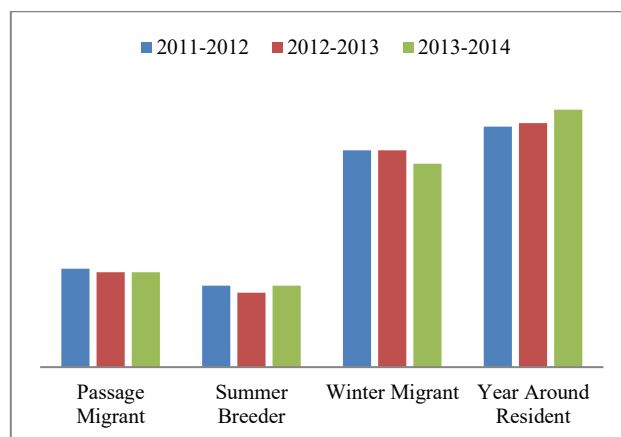
Different diversity indices of the avian species were also calculated to get an insight into the stability of ecosystem. The Shannon Weiner Index  $H'$  was 3.41 in 201-2012, 3.38 in 2012-2013 and 3.31 in 2013-2014. Simpson Index  $D$  0.94 was remaining same throughout the research. The decline in Census Index  $C.I$  was noticed in every year i.e. 218.5/Km<sup>2</sup>, 204.9/ Km<sup>2</sup> and 198.8/ Km<sup>2</sup>. Species evenness  $E$  was also decreasing from 201-2014 i.e. 0.65, 0.64 and 0.63 (Table-1). Ali *et al.* 2011 observed total 31,920 birds of 141 species at Mangla Dam in 2006. Census Index  $C.I$  was 120.4/Km<sup>2</sup>, Species Evenness  $E$  was 0.59. Simpson Index  $D$  0.92 was same like present research work and Shannon Weiner Index  $H'$  was 2.94 in 2006. These results indicate that there is an increase in avian diversity from 2006 to 2011 but there is steady decline in species account from 2011-2014. The decline in bird's population may be due to successive change in ecosystem such as water quality, variation of water level and increasing human disturbance over the time (Bibi and Ali 2013). This increase in bird's population noticed in 2011 as compared to 2006 may due to reason that previous study was conducted for short duration. On comparison between Khalique *et al.*, 2012 and present study it was noticed that Species Evenness  $E$  was also decreasing from 0.89 to 0.65 in 2011 (Table-1).

**Table 1. Comparison of Diversity Indices of Avian Fauna at Mangla dam, AJK**

| Diversity Indices       | 2011-2012             | 2012-2013              | 2013-2014              | Ali <i>et al.</i> , 2011 | Khalique <i>et al.</i> , 2012 |
|-------------------------|-----------------------|------------------------|------------------------|--------------------------|-------------------------------|
| No. of Individual N     | 57892                 | 54311                  | 52682                  | 31920                    | 4774                          |
| Species richness r      | 188                   | 186                    | 187                    | 141                      | 31                            |
| Census Index C.I        | 218.5/Km <sup>2</sup> | 204.9/ Km <sup>2</sup> | 198.8/ Km <sup>2</sup> | 120.4/Km <sup>2</sup>    | 6.00/Km <sup>2</sup>          |
| Species evenness E      | 0.65                  | 0.64                   | 0.63                   | 0.59                     | 0.89                          |
| Simpson Index D         | 0.94                  | 0.94                   | 0.94                   | 0.92                     | -                             |
| Shannon Weiner Index H' | 3.41                  | 3.38                   | 3.31                   | 2.94                     | 3.06                          |

The threat to avian diversity is illegal hunting; many migratory birds like ducks, geese, and coot are hunted at large scale but the bar-headed geese is killed ruthlessly. The waterfowls population of dam is facing random incidences of illegal hunting specifically in winter when a large no. of migratory birds are available same was observed by Khalique *et al.*, (2012). Many law enforcement departments are failed to accomplish protection of these guest birds in Pakistan. The population of migratory birds is decreasing every year. Same was observed by Ali in 2006 for the migratory birds of Uchalli Wetland Complex. The collective hunting index calculated from 1992 to 2004 was 0.085 at these lakes.

In the present study the seasonal distribution of birds were also recorded and according to result shown in fig-2 winter migrants and year around visitors are maximum in number same were the findings of Ali *et al.*, (2011) and Khalique *et al.*, (2012). Passage migrants were at second number in distribution and summer breeders were at third number. But birds of 347 species were recorded by Roberts (1991, 1992) out of them non passerines were 176 and passerines were 171. Grimmit *et al.*, (2008) reported 336 species of birds among them 153 year around visitors, 115 were winter migrant, 39 passage migrant and 15 were summer breeder.

**Figure 2. Seasonal Distribution of Avian Fauna (2011-2014)**

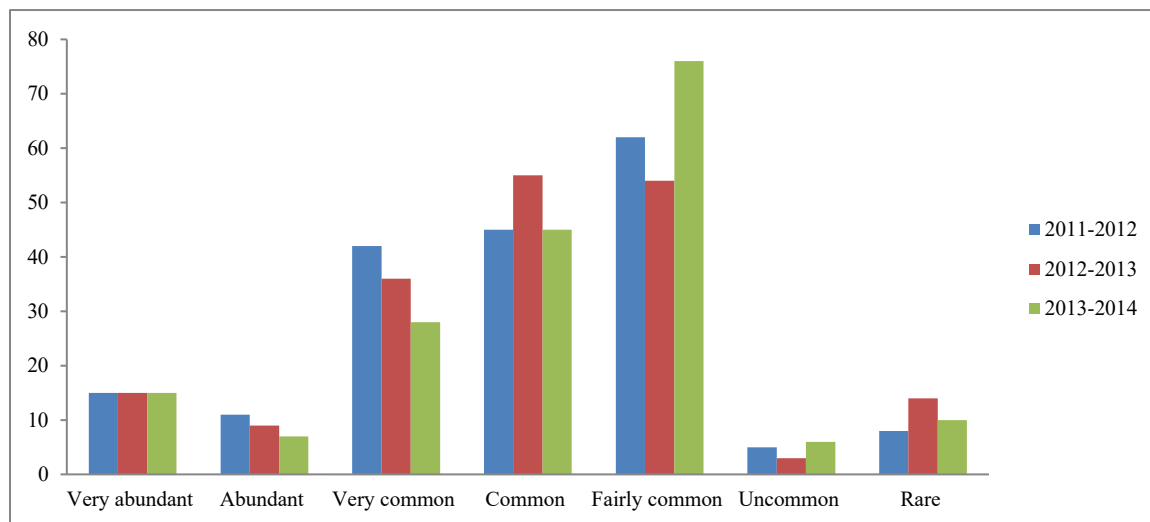
The difference is again due to difference of time period it may take a decade to observe the maximum diversity of birds. The Awan *et al.*, 2004 noted total of 59 species of similar seasonal distribution out of which 24 were resident, 14 were winter migrant, and 11 were summer breeder during the survey of Muzaffarabad, Azad Kashmir, Pakistan.

**Table 2. Dominant Species of Birds recorded at Mangla Dam (2011-2014)**

| Birds Species                               | Relative Abundance |           |           |           |           |           |                                  |           |           |
|---------------------------------------------|--------------------|-----------|-----------|-----------|-----------|-----------|----------------------------------|-----------|-----------|
|                                             | Total (N)          |           |           | (R.A)     |           |           | Density (Birds/Km <sup>2</sup> ) |           |           |
|                                             | 2011-2012          | 2012-2013 | 2013-2014 | 2011-2012 | 2012-2013 | 2013-2014 | 2011-2012                        | 2012-2013 | 2013-2014 |
| Common Pochard <i>Aythya ferina</i>         | 5011               | 5660      | 4801      | 8.6       | 10.4      | 9.1       | 18.9                             | 21.3      | 18.1      |
| Common Coot <i>Fulica atra</i>              | 4782               | 3826      | 4582      | 8.2       | 7.04      | 8.6       | 18.4                             | 14.4      | 17.2      |
| Little Cormorant <i>Phalacrocorax niger</i> | 4764               | 3670      | 4470      | 8.2       | 6.7       | 8.4       | 17.9                             | 13.8      | 16.8      |
| Garganey <i>Anas querquedula</i>            | 3863               | 3587      | 0         | 6.6       | 6.6       | 0         | 14.5                             | 13.5      | 0         |
| Mallard <i>Anas platyrhynchos</i>           | 3841               | 3667      | 3321      | 6.6       | 6.7       | 6.3       | 14.4                             | 13.8      | 12.5      |
| Northern Shoveler <i>Anas clypeata</i>      | 3743               | 3310      | 3353      | 6.4       | 6.1       | 6.3       | 14.1                             | 12.4      | 12.6      |
| Tufted Duck <i>Aythya fuligula</i>          | 3393               | 0         | 23.1      | 5.8       | 0         | 4.5       | 12.8                             | 0         | 8.5       |
| Northern Pintail <i>Anas acuta</i>          | 3261               | 3115      | 4261      | 5.6       | 5.7       | 8.1       | 12.3                             | 11.7      | 16.1      |
| Great Cormorant <i>Phalacrocorax carbo</i>  | 0                  | 3231      | 3191      | 0         | 5.9       | 6.1       | 0                                | 12.1      | 12        |
| Gadwall <i>Anas strepera</i>                | 2971               | 3170      | 3072      | 5.1       | 5.5       | 5.5       | 11.2                             | 11.9      | 11.5      |
| Eurasian Wigeon <i>Anas penelope</i>        | 2575               | 3270      | 3263      | 4.4       | 6         | 6.1       | 9.7                              | 12.3      | 12.3      |

The Table-2 is representing the ten most dominant species with their relative abundance and density on Mangla dam during 2011-2014. In three years of research period the most dominant species is Common Pochard *Aythya ferina* 5011, 5660 and 4801 respectively. Common Coot *Fulica atra* is second dominant and Little Cormorant *Phalacrocorax niger* was third dominant species of Mangla water reservoir. These result coincide with findings of Ali *et al.*, 2011 the maximum count of that study has shown species dominance as Common Pochard (4,330), Coot (4,228), Pintail (2,727), Tufted

Duck (2,150), Shoveler (1, 802,) Mallard (1,906), Gadwall (1,672), Black-headed Gull (1,182), Little Cormorant (3,706), Great Cormorant (1,801) and Bar headed Geese (1,073). Contrary to this Khalique *et al.* 2012 has documented Common Gull *Larus canus* the most dominant birds of the area this might be due to difference in surveys duration and timings. Garganey *Anas querquedula* is absent from the dominant species count of 2013-2014, Tufted Duck and is not ranked as most dominant in 2012-2013 and Great Cormorant is absent from 2011-2012 ranking.



**Figure 3. Local Occurrence Status of Avian Diversity at Mangla Dam, AJK 2011-2014**

Local Occurrence Status of birds fauna is given in fig-3 explaining the very abundant species in three years are remain the same which are 15 in number including Little Cormorant, Indian Cormorant, Great Cormorant, Bar Headed Goose, Gadwall, Eurasian Wigeon, Mallard, Garganey, Northern Pintail, Northern Shoveler, Common Pochard, Tufted Duck, Common Coot, Brown Headed Gull and Black Headed Gull. Abundant species were almost same in three successive years; very common species are decreasing i.e. 42, 36 and 28 respectively. All abundant bird's species were winter migrant. The main reason for that could be the dam fish, fecal matter of these birds act as fertilizer which become

part of fish food chain and help fish growth. The number of rare species is increasing like 8, 14 and 10 in three successive years this include Black Stork, Pallas's Fish Eagle, White Eyed Buzzard Common Buzzard, Tawny Eagle, Greater Painted Snipe, Dusky Eagle Owl and Water Pipit. On the other hand the number of very common species is decreasing i.e. 42, 36 and 28. The possible reason for this could be degradation of habitat and increasing human impact on dam. Furthermore, average seasonal rainfall and availability of several of food resources around the year have strong impact on abundance of birds (Gaston *et al.* 2000).

**Table 3. List of Order and Families of Birds Observed at Mangla Dam AJK.**

| Sr # | Orders                                                                                                       | Number of Observed Families |
|------|--------------------------------------------------------------------------------------------------------------|-----------------------------|
| 1.   | Passeriformes                                                                                                | 23                          |
| 2.   | Charadriiformes                                                                                              | 7                           |
| 3.   | Coraciiformes                                                                                                | 5                           |
| 4.   | Ciconiiformes, Falconiformes and Gruiformes                                                                  | 3                           |
| 5.   | Pelecaniformes, Columbiformes and Piciformes                                                                 | 2                           |
| 6.   | Podicipediformes, Anseriformes, Galliformes, Psittaciformes, Cuculiformes, Strigiformes and Caprimulgiformes | 1                           |

For present study classification of birds was adopted from Birdlife International (2008). During the present study avian fauna of 17 order and 57 families were observed given in table-3. The 23 families of order Passeriformes was recorded which may be of better climatic conditions and vegetation cover. Food plays vital role for the diversity of various birds' orders. Various

birds show different level of preference for a particular kind of food. In summer population of birds decreased due to shortage of food as shown in fig-2. Second diverse order is represented by 7 families i.e. Jacanidae, Rostratulidae, Glareolidae, Charadriidae, Laridae, Scolopacidae, and Sternidae.

**Table 4. Comparison of Order Charadiiformes Diversity between 2009-2010 and 2011-2014**

| Family & Species                                          | 2009-2010<br>(Khalique <i>et al.</i> , 2012) | 2011-2014    | Family & Species                                 | 2009-2010    | 2011-2014    |
|-----------------------------------------------------------|----------------------------------------------|--------------|--------------------------------------------------|--------------|--------------|
| <b>Jacanidae</b>                                          |                                              |              | <b>Charadriidae</b>                              |              |              |
| Pheasant-tailed Jacana<br><i>Hydrophasianus chirurgus</i> | Not Reported                                 | Reported     | Northern Lapwing<br><i>Vanellus vanellus</i>     | Not reported | Reported     |
| <b>Rostratulidae</b>                                      |                                              |              | Red-wattled Lapwing<br><i>Vanellus indicus</i>   | Reported     | Reported     |
| Greater Painted snipe<br><i>Rostratula benghalensis</i>   | Not Reported                                 |              | White-tailed Lapwing<br><i>Vanellus leucurus</i> | Not reported | Reported     |
| Black-winged Stilt<br><i>Himantopus himantopus</i>        | Reported                                     | Reported     | Little Ringed Plover<br><i>Charadrius dubius</i> | Reported     | Reported     |
| Pied Avocet<br><i>Recurvirostra avosetta</i>              | Not Reported                                 | Reported     | Kentish Plover<br><i>Charadrius alexandrinus</i> | Reported     | Reported     |
| <b>Glareolidae</b>                                        |                                              |              | Grey Plover<br><i>Pluvialis squatarola</i>       | Not reported | Reported     |
| Indian Courser<br><i>Cursorius coromandelicus</i>         | Not Reported                                 | Reported     | <b>Laridae</b>                                   |              |              |
| <b>Scolopacidae</b>                                       |                                              |              | Brown Headed Gull<br><i>Larus brunnicephalus</i> | Reported     | Reported     |
| Jack Snipe<br><i>Limnodromus cryptesminimus</i>           | Not Reported                                 | Reported     | Black Headed Gull<br><i>Larus ridibundus</i>     | Reported     | Reported     |
| Common Snipe<br><i>Gallinago gallinago</i>                | Not Reported                                 | Reported     | Slender Billed Gull<br><i>Larus genei</i>        | Reported     | Not reported |
| Spotted Redshank<br><i>Tringa erythropus</i>              | Not Reported                                 | Reported     | Pallas's Gull<br><i>Larus ichthyaetus</i>        | Reported     | Not reported |
| Common Redshank<br><i>Tringa totanus</i>                  | Not Reported                                 | Reported     | <b>Sternidae</b>                                 |              |              |
| Marsh Sandpiper<br><i>Tringa stagnatilis</i>              | Reported                                     | Reported     | Gull-billed Tern<br><i>Sterna nilotica</i>       | Reported     | Reported     |
| Common Greenshank<br><i>Tringa nebularia</i>              | Not Reported                                 | Reported     | River Tern<br><i>Sterna aurantia</i>             | Reported     | Reported     |
| Green Sandpiper<br><i>Tringa ochropus</i>                 | Reported                                     | Reported     | Common Tern<br><i>Sterna hirundo</i>             | Reported     | Reported     |
| Wood Sandpiper<br><i>Tringa glareola</i>                  | Not Reported                                 | Reported     | Black-bellied Tern<br><i>Sterna acuticauda</i>   | Reported     | Reported     |
| Common Sandpiper<br><i>Actitis hypoleucos</i>             | Reported                                     | Reported     | Whiskered Tern<br><i>Chlidonias hybridus</i>     | Not reported | Reported     |
| Little Stint<br><i>Calidris minuta</i>                    | Not Reported                                 | Reported     | Little Tern<br><i>Sterna albifrons</i>           | Reported     | Not reported |
| Temminck's Stint<br><i>Calidris temminckii</i>            | Not Reported                                 | Reported     |                                                  |              |              |
| Ruff<br><i>Philomachus pugnax</i>                         | Reported                                     | Not Reported |                                                  |              |              |

Khalique *et al.*, 2012 found Charadiiformes the diverse waterfowl order of Mangla dam AJK during 2009-2010 but they reported only 4 families like Charadriidae, Scolopacidae, and Sternidae. On comparison it is observed that variations and similarities

are present in both studies explained in Table-4. Recurvirostridae is not observed in present study while Jacanidae, Rostratulidae, Glareolidae, in not reported during 2009-2010. Jack Snipe, Common Snipe, and Spotted Redshank are reported in present work contrarily



Slender Billed Gull, Pallas's Gull and Little Tern were observed by Khalique *et al.*, 2012. These variations may be due to difference of study period, timings and identification ability of observer, other possible reason could be availability of food, water level, hunting pressure, disturbance by fishermen/boatmen.

**Stressors/Threats:** The numbers of threats were accessed at Mangla Dam AJK facing by bird populations. Among them use of pesticide by farmers have an immense effect on insectivorous birds, leakage of oil from diesel pumps for water extraction directly pollute the dam water. Aquatic fauna including fish birds also poisoned by agriculture runoff. Weathering of rock in catchments of River Jhelum and Pir Panjal Range led to emission of heavy metals in dam also dangerous for birds. Logging and wood cutting lead to habitat degradation. Disturbance to little egret, night heron population by invasion of introduced species such as house crow and common myna lead to homogenization of species diversity of dam. These invasive species are associated with different aspects of human modified environment (Lim *et al.*, 2003) In addition to this hunting and trapping was also significant reason for decline of wildlife in AJK according to Kiani *et al.*, 2013, total 202 case of illegal hunting are registered in Wildlife and Fisheries Department AJK between 2000-2011 among them 57% cases were of birds, main reasons were easily availability of 12-bore shotgun, lack of awareness, lack of entertainment opportunities, illegal hunting by wealthier people and poor implementation of wildlife protection law.

**Recommendations:** To conserve and protect the Mangla Dam avian diversity following recommendations are made:

- There should be a complete ban on hunting of migratory birds. Exploitation of vegetation should be controlled for protection of habitat.
- Deputation of well-equipped staff in reasonable number along with transport facility
- The natural habitat of the area should be conserved.
- Public should aware about the local environmental problems through publicity campaigns, brochures, boards.
- Sustainable fisheries practices should be adopted.

**Conclusion:** It was concluded that there is a steady decrease in bird's diversity at Mangla Dam from 2011-2014. This decline in avian diversity is due to many factors like habitat degradation, hunting, lacking of trained staff and poor law enforcement. This is need of time to chalk out some policy for protection and conservation of water birds an integral part of ecosystem. To achieve this goal effort at national and international level should be made and this important fresh water reservoir must be treated according to international

wetland standards to conserve the unique fauna of the migratory birds.

## REFERENCES

- Ali, Z. (2006). Avian species analysis at three major wetlands complex Pakistan. *Biologia (Pakistan)* 2 (2): 203-213.
- Ali, Z and M. Akhter (2006). Decrease in size of lacks and number of birds in selected wetlands of Punjab. In: waterbirds around the world (eds. G.C Boere, C.A. Edinburg, J.K., pp.292-293.
- Ali, Z., Shelly, S. Y., Bibi, F. Joshua, G., Khan, A. M., Khan B. N and Akhtar, M (2011). Peculiarities of Mangla Reservoir: Biodiversity with Sustainable use Options. *Anim. Plant Sci.* 21(2 Suppl.): 372-380
- Awan, M.N., M. S. Awan, K. B. Ahmed, A. A. Khan and N. I. Dar, (2004). A Preliminary Study on Distribution of Avian Fauna of Muzaffarabad–Azad Jammu and Kashmir, Pakistan. *IJAB.* 06 (2): 300–302.
- Bibi, F. and Z. Ali (2013). Measurement of Diversity Indices of Avian Communities at Taunsa Barrage Wildlife Sanctuary, Pakistan. *The J. Anim. Plant Sci.*, 23(2):469-474.
- Bull, J. (1974). *Birds of New York State*. Published by Doubleday/Natural History Press. Edited by Emanuel Levine (1985). Cornell University Press. 622pp.
- Birdlife International (2008). *Partnership for Nature and People*.
- Gaston, K. J., T. M. Blackburn, J. D. Greenwood, R. D. Greroryx, M. Q. Rachel and J. H. Lawton (2000). Abundance-occupancy relationships. *J. of Applied Ecology*, 37: 39-59.
- Grimmett, R., T. Roberts, and I. Inskipp (2008). *Birds of Pakistan*. Christopher Helm, London Yale University Press, New Heaven. 256 pp.
- Haldin, M. and J. Ulfvens (1987). On the efficiency of censusing waterbirds by boat. *Ornis Fennica* 64: 74-75.
- Hill, M. O. (1973). Diversity and evenness: a unifying notation and its consequences. *Ecology* 54: 427-432.
- Khalique, N., M. Rais, T. Mehmood, M. Anwar, S. Ali, S. Bilal, and B. Kabeer (2012). Study on some waterfowls of Mangla Dam, Azad Jammu and Kashmir. *Фауна і населення Беркут* 21 Вип. 1-2: 44 – 49.
- Kiani, S, T., R.A. Minhas, M.S. Awan, U. Ali, S.S. Bibi, and N. Dar (2013). The Illegal Wildlife Hunting and Law Enforcement in AJK and Kashmir: A pioneer Study. *ABSTRACT published in abstracts book of 33<sup>rd</sup> Pakistan Congress of Zoology (International) April 2-4.*

- Li, Z. W. D. and T. Mundkur (2004). Numbers and distribution of waterbirds and wetlands in the Asia-Pacific region. Results of the Asian Waterbird Census: 1997-2001. Wetlands International, Kuala Lumpur, Malaysia.
- Lim, H. C., N.S. Sodhi, B.W. Brook, and M.C.K. Soh (2003). Undesirable aliens: factors determining the distribution of three invasive birds' species in Singapore. J. trop. Ecol. 6: 685-695.
- Roberts, T.J (1991). *The Birds of Pakistan*. Volume 1. Oxford University Press, Karachi, pp. 598.
- Roberts, T.J. (1992). *The Birds of Pakistan*. Volume 2. Oxford University Press, Karachi, pp. 617.
- Shannon, C.E (1948) A mathematical theory of communication. The Bell System Technical Journal, 27, 379-423 and 623-656.
- Simpson, E.H (1949) Measurement of diversity. Nature, 163, 688.