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Abstract

Bajwat Wetland and Wildlife Sanctuary (BWWS) is an internationally important wetland that is located near Sialkot district, Punjab, Pakistan. The present study was conducted for 11 months from October 2020 to August 2021. One to two surveys were conducted per week at dawn and dusk. Data was collected both by direct and indirect observation methods. A total of 23 species of mammals, 22 of herpetofauna, 37 of fish and 107 bird species were recorded during the study period. Out of 107 bird species, 49.53%, 33.64%, 16.53%, 3.73% were resident, winter, summer, and year-round visitors respectively. One bird species *Dendrocitta vagabunda* (Rufous treepie), also known as Indian treepie is also recorded in the study area that was not reported in earlier studies. Different indexes were also calculated for the avifauna which showed the area was rich in biodiversity. Although Bajwat Wildlife Sanctuary was found very rich in animal fauna however, many threats such as destruction, fragmentation of habitat illegal hunting, human interference in animal breeding sites, lack of awareness, and pollution of water were recorded. These threats might be due to the careless attitude of the wildlife department. It is suggested that the study site should be conserved for noticed threats on priority basis by implementation and regulation of already formed wetland and wildlife sanctuaries rules.

Keywords: Fauna, breeding sites, habitat loss, Bajwat Wildlife Sanctuary

Introduction

Biodiversity is very important for both man-made and natural ecosystems (Gamfeldt et al., 2008). There are almost 102 protected areas found throughout the world which covers almost an area of 18.8 million km² or more. This value is almost equal to the 12% of total surface area of earth and more than the total area of China, Asia and Southeast Asia (Chape et al., 2003). Biodiversity plays a vital role for natural values of the ecosystem and provides a variety of benefits that contributes towards human welfare and living standards (Nunes and van den Bergh, 2001). Most recent literature reported on integrative role of biodiversity and ecosystem (Mitchell, 2007). The role of community in biodiversity as supporting surroundings capabilities is important, which in turn assist to maintain the supporting of vital ecosystem resources to human's need (Haines-Young and Potschin, 2008; Teeb, 2010a). However, biodiversity is facing serious threats from man-made disasters such as habitat destruction and habitat loss, and there should be proper management to protect biodiversity (Wei and Mundkur, 2003). Some animal and plant species are threatened, some are endangered due to over use and exploitation and loss of natural habitats (Baig and Al-Subaiee, 2009).

An increase in human population growth results in excessive loss of biodiversity. Moreover, deforestation, overgrazing, soil erosion, salinization, waterlogging and other factors pose a serious threat to the country's protected biodiversity. The continued loss of forest and related flora and fauna will have serious adverse effects for other natural and agricultural ecosystems in the country. Various protected areas were created to protect biodiversity. Although, several laws have been made to protect the various species of biodiversity but are not practiced properly. Without local participation, all practices and laws are hard to implement and leads to biodiversity loss. The Environmental Protection Regulations of 1983 was a milestone in Pakistani law and the formal recognition of the overall approach to environmental issues (Momtaz and Kabir, 2013). An actual implementation of these rules gives the control over pollution and maintenance of a comprehensive national environmental policy. However, it was reported that there are flaws in implementation of the current law and these does not compete with international standards. Although, protected reserves are one of the most important natural places which are working for the conservation of diversity of all life either at local, regional or global strategies (Gaston et al., 2008). The nature reserves also provide a restoration mechanism by creating leisure space for people, promoting eco-tourism, creating employment opportunities, enhancing resilience to natural disasters, and promoting food and water security by restoring ecosystems (Gaston et al., 2008).

Bajwat is an internationally important wetland and wildlife sanctuary. The area is situated in Punjab Province near Sialkot district, Pakistan. This area is the most unique part of district because of wide diversity of plants and animals (Bhinder et al., 2015). They provide the products necessary for the existence and survival of countless plant and animal species and protect natural ecosystems by

supporting large numbers of fishes, mammalian fauna, various avifauna, herpetofauna and other invertebrate species. In addition, wetlands are important economically as they are also mandatory reserves of plant genetic material (Chardonnet et al., 2002). Although, there is sparse data which is reported on avifauna from Bajwat Wildlife Sanctuary. However, no data is reported about status of mammalian and reptile species from this wetland and Sanctuary. So, the present study was designed to estimate the vertebrate diversity and their abundance in Bajwat Wetland and Wildlife Sanctuary and to highlight the importance and threats of Bajwat Wetland and Wildlife Sanctuary (BWWS) in conservation of biodiversity.

Material and methods

Location of study sites

The study was conducted at Bajwat Wetland and Wildlife Sanctuary (BWWS). The area is Situated in Punjab Province near Sialkot district, at 32°62 N and 74°60 E of Pakistan. This area is the most important part of district due to a large diversity of plants and animals. 18 study sites were selected to observe total vertebrate biodiversity such as mammals, birds, reptiles and fish and avian fauna. The GPS (GARMIN, GPS map 76CS x) was used for the vantage points coordinates and shown in Fig. 1.

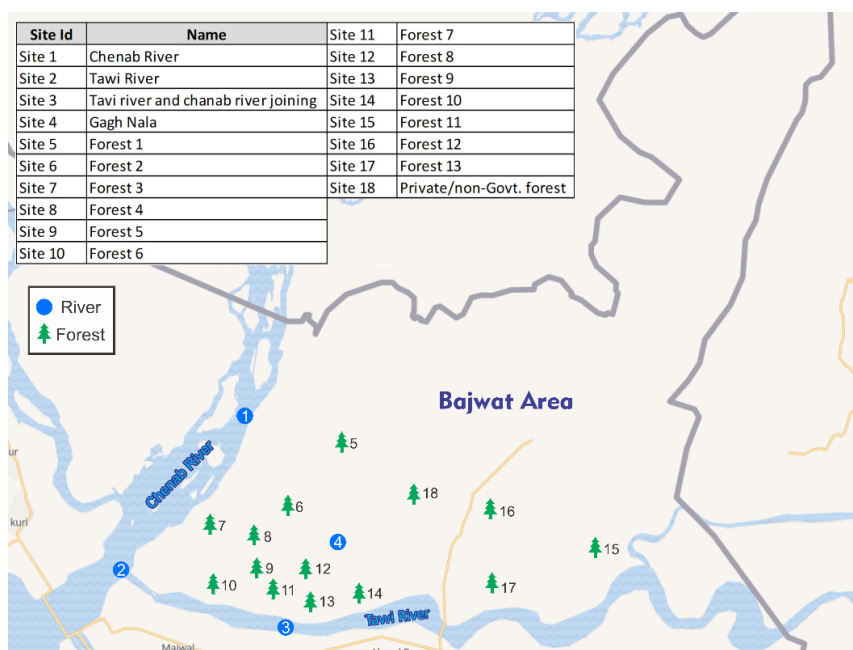


Figure 1. Map of different study sites of Bajwat Wetland and Sanctuary

Number of Sampling Survey

Extensive surveys 1-2 per week were made to observe and collect data during the period of 11 months from October 2020 to August 2021. Different direct and indirect observations were made to collect and identify different species of birds, mammals, herpetofauna, and fish. Direct Observation

methods for data collection included Direct count method, Track count method, Boat surveys, Point Surveys and Indirect observations were made via meetings and discussions with local inhabitants, farmers, hunters, fishermen, wildlife department staff and other people interested in wildlife. The data was recorded at dawn and dusk time during winter, spring and summer seasons.

Data analysis

Different types of analysis were used such as species richness, Shannon-Wiener Diversity Index was used (Shannon, 1948) in an ecosystem when there are too many individuals found and there is need to identify all these individuals.

It is calculated as follows:

$$H = - \sum_{i=1}^k p_i \log p_i$$

Simpson Index (D) was used to find the estimation of the probability of different individuals which belongs to different species of selected site. This Index is widely used and it provides the presence of different individuals, present at specific area from a large community, associated with different species (Simpson 1949). Simpson Index was calculated by using following formula

$$D = \sum n(n-1) / N(N-1)$$

Here, n is the total number of individuals (Birds/Animals) of a specific specie

N is the total number of individuals (birds/animals) of all species at specific area

Evenness was monitored which is used to calculate the relative abundance of different species which contributes towards the richness of the sample of specific site. The formula of evenness is given below: Shannon Weiner Diversity Index / ln (log natural) of Total Population

Census index used for bird density and calculated by number of birds detected at a specific station (including those outside the effective area) divided by study area.

Relative Abundance was calculated by using the formula:

Relative Abundance: Number of birds observed in a species/ total number of birds

Results

During 11 month study period, 23 species of mammals were noticed that belongs to 8 different orders and 15 families. Details of all the orders, families and species was provided in table 1. It was noticed during the study that Order Carnivore was with the highest number of mammals. Out of the 23 species of mammals that observed in the study area, 3 species were endangered and one specie was vulnerable according to IUCN red list status. Endangered species were *Manis crassicaudata*, *Myotis*

lucifugus and *Axis porcinus* while, *Tachyglossus aculeatus* was recorded as vulnerable specie. Other 19 species were least concerned according to IUCN red list status (Table 1).

Table 1. Mammalian Diversity at Bajwat Wetland and Wildlife Sanctuary (BWWS)

Sr. NO.	Orders	Familie	Scientific Name	Common Names	IUCN Status
1	Monotremata	Tachyglossidae	<i>Tachyglossus aculeatus</i>	Spiny Anteater	VU
2	Pholidota	Manidae	<i>Manis crassicaudata</i>	Indian Pangolin	EN
3	Primates	Cercopithecidae	<i>Macaca mulatta</i>	Rhesus Monkey	LC
4	Chiroptera	Pteropodidae	<i>Pteropus giganteus</i>	Indian flying fox	LC
5	Chiroptera	Vespertilionidae	<i>Myotis lucifugus</i>	Little brown bat	EN
6	Carnivora	Felidae	<i>Felis chaus</i>	Jungle cat	LC
7	Carnivora	Felidae	<i>Felis catus</i>	Domestic cat	LC
8	Carnivora	Canidae	<i>Canis aureus</i>	Golden jackal	LC
9	Carnivora	Canidae	<i>Vulpes vulpes</i>	Red Fox	LC
10	Carnivora	Canidae	<i>Canis lupus</i>	Common wolf	LC
11	Carnivora	Herpestidae	<i>Herpestes edwardsii</i>	Indian grey mongoose	LC
12	Carnivora	Herpestidae	<i>Herpestes auropunctatus</i>	Indian small mongoose	LC
13	Lagomorpha	Leporidae	<i>Lepus capensis</i>	Cape hare	LC
14	Rodentia	Muridae	<i>Rattus argentiventer</i>	Field rat	LC
15	Rodentia	Muridae	<i>Rattus rattus</i>	House rat	LC
16	Rodentia	Muridae	<i>Rattus fuscipes</i>	Bush rat	LC
17	Rodentia	Muridae	<i>Mus booduga</i>	Little field mouse	LC
18	Rodentia	Sciuridae	<i>Funambulus palmarum</i>	Common Palm Squirrel	LC
19	Rodentia	Hystriidae	<i>Hystrix indica</i>	Indian crested porcupine	LC
20	Artiodactyla	Suidae	<i>Sus Scrofa</i>	Wild boar/ wild pig	LC
21	Artiodactyla	Bovidae	<i>Boselaphus tragocamelus</i>	Nilgai	LC
22	Artiodactyla	Cervidae	<i>Axis porcinus</i>	Indian Hog deer	EN
23	Artiodactyla	Cervidae	<i>Odocoileus virginianus</i>	White tailed deer	LC

During the study period, 22 species of herpetofauna were recorded that belongs to 3 different Orders and 11 families. Details of all the orders, families and species has shown in table 2. Highest number of species was reported from order Squamata and it has 16 species that belongs to 9 families. Four species such as *Bufo stomaticus*, *Hoplobatrachus tigerinus*, *Bufo bufo* and *Duttaphrynus melanostictus* species were from the order Anura and the family Bufonidae (Table 2). *Hoplobatrachus tigerinus* commonly known as Indian bull frog was seen in study area and shown in Fig. 2.

Out of these 22 species of herpetofauna, at the study area, according to IUCN red list status, one species *Hardella thurjii* (crowned river turtle) was recorded as endangered (EN). While two species were Vulnerable (VU) such as *Lissemys punctata* (Indian flapshell turtle) and *Python Molurus* (Indian python). Other 19 species were least concerned (Table 2).

Table 2. Herpetofauna at Bajwat Wetland and Wildlife Sanctuary (BWWS)

Sr. No.	Order	Family	Scientific Name	Common Names	IUCN Status
1	Anura	Bufonidae	<i>Bufo stomaticus</i>	Indus valley toad	LC
2	Anura	Bufonidae	<i>Hoplobatrachus tigerinus</i>	Indian bullfrog	LC
3	Anura	Bufonidae	<i>Bufo bufo</i>	Common toad	LC
4	Anura	Bufonidae	<i>Duttaphrynus melanostictus</i>	Asian common toad	LC
5	Testudines	Geoemydidae	<i>Lissemys punctata</i>	Indian flapshell turtle	VU
6	Testudines	Geoemydidae	<i>Hardella thurjii</i>	Crowned river turtle	EN
7	Squamata	Agamidae	<i>Saara hardwickii</i>	Indianspiny-tailed lizard	LC
8	Squamata	Agamidae	<i>Japalura kumaonensis</i>	Kumaon mountain lizard	LC
9	Squamata	Gekkonidae	<i>Hemidactylus frenatus</i>	Common house gecko	LC
10	Squamata	Gekkonidae	<i>Hemidactylus brookii</i>	Brooke's house gecko	LC
11	Squamata	Gekkonidae	<i>Hemidactylus flaviviridis</i>	Yellow belly gecko	LC
12	Squamata	Gekkonidae	<i>Cyrtopodion scabrum</i>	Rough bent-toed gecko	LC
13	Squamata	Scincidae	<i>Eutropis dissimilis</i>	Striped grass skink	LC
14	Squamata	Typhlopidae	<i>Namibiana gracilior</i>	Slender Worm Snake	LC
15	Squamata	Alapidae	<i>Bungarus sindanus</i>	Sindhi krait/ Krait	LC
16	Squamata	Colubridae	<i>Xenochrophis piscator</i>	Checkered Keelback	LC
17	Squamata	Colubridae	<i>Spalerosophis diadema</i>	Royal snake	LC
18	Squamata	Colubridae	<i>Psammophis schokari schokari</i>	Afro-asian Sand Snake	LC
19	Squamata	Elapidae	<i>Naja oxiana</i>	Indian cobra	LC
20	Squamata	Pythonidae	<i>Python Molurus</i>	Indian python	VU
21	Squamata	Viperidae	<i>Daboia russelii</i>	Russell's viper/ Domoii	LC
22	Squamata	Viperidae	<i>Echis carinatus</i>	Saw Scaled Viper	LC



Figure 2. Indian Bullfrog (*Hoplobatrachus tigerinus*) captured from Village

During the study period, 37 species of fish fauna were seen belongs to 5 different Orders and 14 families were recorded. Details of all the orders, families and species is given in table 3. Most of the fishes belonged to order Cypriniformes and family Cyprinidae. Their number was 14 and it was highest number of species recorded from same family. According to IUCN red list status one specie *Tor putitora* (Mahsheer) was belong to Cyprinidae family was endangered (Table 3).

Table 3. Fish Diversity at Rivers of Bajwat Wetland and Wildlife Sanctuary (BWWS)

Sr. No.	Order	Family	Scientific Name	Common Names	IUCN Status
1	Cypriniformes	Cyprinidae	<i>Labeo rohita</i>	Rohu	LC
2	Cypriniformes	Cyprinidae	<i>Cirrhinus mrigala</i>	Mori/ margal	LC
3	Cypriniformes	Cyprinidae	<i>Gibelion catla</i>	Thaila	LC
4	Cypriniformes	Cyprinidae	<i>Cirrhinus reba</i>	Reba carp	LC
5	Cypriniformes	Cyprinidae	<i>Hypophthalmichthys molitrix</i>	Silver carp	NT
6	Cypriniformes	Cyprinidae	<i>Ctenopharyngodon idella</i>	Grass carp	LC
7	Cypriniformes	Cyprinidae	<i>Osteobrama cotio</i>	Paalin	LC
8	Cypriniformes	Cyprinidae	<i>Esomus danrica</i>	Flying bard	LC
9	Cypriniformes	Cyprinidae	<i>Cyprinus carpio</i>	Gulfam	VU
10	Cypriniformes	Cyprinidae	<i>Tor putitora</i>	Mahsheer	EN
11	Cypriniformes	Cyprinidae	<i>Salmophasia punjabensis</i>	Punjabi Chal	Not evaluated
12	Cypriniformes	Cyprinidae	<i>Securicula gora</i>	Bari Chal	LC
13	Cypriniformes	Cyprinidae	<i>Puntius chola</i>	Chola Barb	LC
14	Cypriniformes	Cyprinidae	<i>Puntis Sphore</i>	Spotfin Swamp Barb	LC
15	Perciformes	Channidae	<i>Channa marulius</i>	Saul	LC
16	Perciformes	Channidae	<i>Channa Striata</i>	Sauli/ snakehead Murrel	LC
17	Perciformes	Channidae	<i>Channa gachua</i>	Dauli/ Dwarf Snakehead	LC
18	Perciformes	Channidae	<i>Channa punctata</i>	Dauli/ spotted snakehead	LC
19	Perciformes	Ambassidae	<i>Chanda nama</i>	Elongate glass perchlet/ Shesha machli	LC
20	Perciformes	Ambassidae	<i>Parambasis ranga</i>	Idian glassy fish	LC
21	Perciformes	Nandidae	<i>Nandus nandus</i>	Patta machli	LC
22	Perciformes	Gobiidae	<i>Glossogobius giuris</i>	Bareye Goby Gullu Machli	LC
23	Perciformes	Cichlidae	<i>Oreochromis niloticus</i>	Chirri Machli	LC
24	Perciformes	Cichlidae	<i>Oreochromis mossambicus</i>	Chirra Machli	VU
25	Perciformes	Osphronemidae	<i>Trichogaster fasciata</i>	Kanghi/ Gourami	LC
26	Perciformes	Osphronemidae	<i>Trichogaster lalius</i>	Choti Kanghi /Dwarf Gourami	LC
27	Siluriformes	Bagridae	<i>Mytus cavasius</i>	Kinghar	LC
28	Siluriformes	Bagridae	<i>Mytus Bleekeri</i>	Kinghar	LC
29	Siluriformes	Schilbeidae	<i>Clupisoma garua</i>	Bachva	LC
30	Siluriformes	Schilbeidae	<i>Eutropiichthys vacha</i>	Jhali Machli	LC
31	Siluriformes	Sisoridae	<i>Bagarius bagarius</i>	Fauji khaga	NT
32	Siluriformes	Sisoridae	<i>Gagaata cenia</i>	Indian gangana	LC
33	Siluriformes	Siluridae	<i>Wallago attu</i>	Malli	VU
34	Siluriformes	Heteropneustidae	<i>Heteropneustes fossilis</i>	Singee machli	LC
35	Osteoglossiformes	Notopteridae	<i>Notopterus notopterus</i>	Buut Pari	LC
36	Synbranchiformes	Mastacembelidae	<i>Macrognathus punctatus</i>	Garuj	LC
37	Synbranchiformes	Mastacembelidae	<i>Mastacembelus armatus</i>	Spiny eel/Baam	LC



Figure 3. Gulfam (*Cyprinus carpio*) from study Site

During the study period, 15034 birds from 107 different species were seen belonging to 15 different Orders and 39 families. Details of all the orders, families and species is given in table 4. Out of 107 recorded species, 49.53% species were resident, 33.64% were winter visitors to the area, 16.53% species were summer visitors and 3.73% species were year-round visitors. Highest number of species was found from order Passeriformes and it was 39 species belonging to 15 different families. Family Anatidae belongs to order Anseriformes has highest no of species, it was 14. One New specie was discovered for the first time, it was *Dendrocitta vagabunda* (Rufous treepie), also known as Indian treepie (Fig. 4). No member of these four species were seen, *Gyps bengalensis* (White-rumped vulture), *Gyps indicus* (Long billed vulture), *Hydrophasianus chirurgus* (Pheasant tailed jacana) and *Larus ridibundus* (black headed gull) which is an indication of bird's [species decline in the study area. According to IUCN red list data *Gyps bengalensis* (White-rumped vulture), and *Gyps indicus* (Long billed vulture) are critically endangered (CR) while *Hydrophasianus chirurgus* (Pheasant tailed jacana) and *Larus ridibundus* (black headed gull) were Least concerned but not a single member of these specie was seen during study period. Two species, *Aythya farina* (Common pochard) and *Sterna aurantia* (Indian river tern) are Vulnerable VU according to IUCN red list status. Two species, *Vanellus vanellus* (Northern lapwing) and *Numenius arquata* (Eurasian Curlew) are Near Threatened according to IUCN status.

Most common species were *Corvus splendens* (House Crow), *Passer domesticus* (House Sparrow), *Acridotheres ginginianus* (Bank Myna), *Acridotheres tristis* (Common Myna), *Turdoides caudatus* (Common Babbler), *Petronia xanthocollis* (Yellow Throated Sparrow), *Vanellus indicus* (Red Wattled Lapwing), *Egretta garzetta* (little Egret), *Milvus migrans* (Pariha kite), *Tringa nebularia*

(Green Shank), *Merops orientalis* (Little Green Bee Eater) were *Cinnyris asiaticus* (Black Dragno) at the study area. Different Indexes were also calculated for the study, such as Species Richness, Shannon Weiner Index, Simpson Index and Evenness, Relative abundance and Census Index. Value of Shannon Weiner Index was 3.733, Simpson Index was 0.04277, Evenness was 1.5319 and Species Richness was 107.

Table 4. Birds Diversity at Bajwat Wetland and Wildlife Sanctuary (BWWS)

Sr. NO.	Order	Family	Scientific Name	Common Names	Residential status	IUCN Status	n	R. A	C.I
1	Passeriformes	Motacillidae	<i>Motacilla cinerea</i>	Grey wagtail	Winter visitor	LC	31	0.0020	0.0015
2	Passeriformes	Motacillidae	<i>Motacilla flava</i>	Western Yellow wagtail	Winter visitor	LC	87	0.0074	0.0044
3	Passeriformes	Motacillidae	<i>Motacilla citreola</i>	Yellow headed wagtail	Winter visitor	LC	39	0.0025	0.0020
4	Passeriformes	Motacillidae	<i>Motacilla maderaspatensis</i>	White-browed wagtail	Resident	LC	97	0.0064	0.0049
5	Passeriformes	Motacillidae	<i>Motacilla alba</i>	White wagtail	Resident	LC	58	0.0038	0.0029
6	Passeriformes	Motacillidae	<i>Anthus rufulus</i>	Oriental pipit	Resident	LC	17	0.0011	0.0008
7	Passeriformes	Alaudidae	<i>Alauda gulgula</i>	Oriental Skylark	Resident	LC	82	0.0054	0.0042
8	Passeriformes	Alaudidae	<i>Aluada arvensis</i>	Eurasian skylark	Winter visitors	LC	39	0.0025	0.0020
9	Passeriformes	Alaudidae	<i>Calandrella brachydactyla</i>	Greater short toed lark	Winter visitor	LC	94	0.0062	0.0048
10	Passeriformes	Alaudidae	<i>Galerida cristata</i>	Crested lark	Resident	LC	25	0.0016	0.0012
11	Passeriformes	Hirundinidae	<i>Hirundo fluvicola</i>	Streak-throated Swallow	Resident	LC	41	0.0027	0.0021
12	Passeriformes	Hirundinidae	<i>Hirundo smithi</i>	Wire tailed swallow	Summer Visitor	LC	16	0.0010	0.0008
13	Passeriformes	Hirundinidae	<i>Riparia paludicola</i>	Sand martin	Resident	LC	19	0.0012	0.0009
14	Passeriformes	Hirundinidae	<i>Delichon urbicum</i>	Northern house martin	Summer visitor	LC	21	0.0013	0.0010
15	Passeriformes	Sturnidae	<i>Acridotheres tristis</i>	Common myna	Resident	LC	858	0.056	0.0441
16	Passeriformes	Sturnidae	<i>Sturnus contra</i>	Indian Pied myna	Summer Visitor	LC	51	0.0033	0.0026
17	Passeriformes	Sturnidae	<i>Acridotheres ginginianus</i>	Bank myna	Resident	LC	943	0.062	0.0484
18	Passeriformes	Sturnidae	<i>Sturnus Vulgaris</i>	Common starling	Winter visitors	LC	155	0.033	0.0079
19	Passeriformes	Sturnidae	<i>Sternus pagodarum</i>	Barhaminy starling	Summer visitors	LC	74	0.0048	0.0038
20	Passeriformes	Timalidae	<i>Turdoides striata</i>	Jungal babbler	Resident	LC	98	0.0064	0.0050
21	Passeriformes	Timalidae	<i>Turdoides caudatus</i>	Common Babbler	Resident	LC	483	0.0318	0.0248
22	Passeriformes	Timalidae	<i>Turdoides malcolmi</i>	Large grey babbler	Resident	LC	10	0.0006	0.0005
23	Passeriformes	Turdidae	<i>Copsychus saularis</i>	Magpie robin	Resident	LC	33	0.0021	0.0016
24	Passeriformes	Turdidae	<i>Saxicola caprata</i>	Pied bush chat	Resident	LC	96	0.006	0.0049
25	Passeriformes	Ploceidae	<i>Ploceus manyar</i>	Streaked weaver	Resident	LC	154	0.0010	0.0079
26	Passeriformes	Ploceidae	<i>Ploceus philippinus</i>	Baya weaver	Resident	LC	216	0.0142	0.0111

27	Passeriformes	Ploceidae	<i>Ploceus benghalensis</i>	Black-breasted weaver	Resident	LC	186	0.0122	0.0095
28	Passeriformes	Passeridae	<i>Passer domesticus</i>	House sparrow	Resident	LC	1786	0.1178	0.0918
29	Passeriformes	Passeridae	<i>Petronia xanthocollis</i>	Yellow throated sparrow	Summer visitor	LC	902	0.0595	0.0463
30	Passeriformes	Pycnonotidae	<i>Pycnonotus cafer</i>	Red vented bulbul	Resident	LC	132	0.0087	0.0067
31	Passeriformes	Corvidae	<i>Corvus frugilegus</i>	Rook	Winter visitor	LC	104	0.0068	0.0053
32	Passeriformes	Corvidae	<i>Corvus macrorhynchos</i>	Jungle crow	Winter visitor	LC	117	0.0077	0.0060
33	Passeriformes	Corvidae	<i>Corvus splendens</i>	House crow	Resident	LC	1281	0.0845	0.0658
34	Passeriformes	Estrildidae	<i>Lonchura punctulata</i>	Scaly-breasted mania	All year visitor	LC	29	0.0019	0.0014
35	Passeriformes	Nectariniidae	<i>Cinnyris asiaticus</i>	Purple sunbird	Summer visitor	LC	14	0.0009	0.0007
36	Passeriformes	Dicruridae	<i>Cinnyris asiaticus</i>	Black drogno	Resident	LC	597	0.0394	0.0306
37	Passeriformes	Laniidae	<i>Lanius schach</i>	Long tailed shrike	Resident	LC	63	0.0041	0.0032
38	Passeriformes	Laniidae	<i>Lanius vittatus</i>	Bay backed shrike	Resident	LC	103	0.0067	0.0052
39	Passeriformes	Oriolidae	<i>Oriolus oriolus</i>	Eurasian Golden oriole	Summer visitor	LC	69	0.00455	0.0035
40	Psittaciformes	Psittaculidae	<i>Alexandrinus krameri</i>	Rose ringed parakeet	Resident	LC	315	0.02079	0.0161
41	Piciformes	Picidae	<i>Leiopicus mahrattensis</i>	Mahratta woodpecker	Resident	LC	23	0.00151	0.0011
42	Piciformes	Picidae	<i>Dinopium benghalense</i>	Black-rumped flameback	Resident	LC	71	0.00468	0.0036
43	Pelecaniformes	Phalacrocoridae	<i>Microcarbo niger</i>	Little cormorant	All year visitor	LC	99	0.00653	0.0050
44	Pelecaniformes	Phalacrocoridae	<i>Phalacrocorax carbo</i>	Great cormorant	Winter visitor	LC	22	0.00145	0.0011
45	Podicipediformes	Podicipedidae	<i>Tachybaptus ruficollis</i>	Little grebe	Resident	LC	29	0.00191	0.0014
46	Gruiformes	Rallidae	<i>Fulica atra</i>	Common coot	Winter visitor	LC	81	0.00534	0.0041
47	Gruiformes	Rallidae	<i>Gallinula chloropus</i>	Common moorhen	Resident	LC	91	0.00600	0.0046
48	Gruiformes	Rallidae	<i>Amauornis phoenicurus</i>	White breasted water hen	Resident	LC	63	0.00415	0.0032
49	Gruiformes	Rallidae	<i>Porphyrio porphyrio</i>	Purple swamp hen	Resident	LC	54	0.00356	0.0027
50	Galliformes	Phasianidae	<i>Francolinus francolinus</i>	Black partridge	Resident	LC	43	0.00283	0.0022
51	Galliformes	Phasianidae	<i>Francolinus pondicerianus</i>	Grey partridge	Resident	LC	19	0.00125	0.0009
52	Columbiformes	Columbidae	<i>Streptopelia chinensis</i>	Laughing dove	Winter visitor	LC	26	0.00171	0.0013
53	Columbiformes	Columbidae	<i>Streptopelia senegalensis</i>	Little brown dove	Resident	LC	19	0.00125	0.0009
54	Columbiformes	Columbidae	<i>Streptopelia decaocto</i>	Collared dove	Resident	LC	168	0.001	0.0086
55	Columbiformes	Columbidae	<i>Streptopelia tranquebarica</i>	Red turtle dove	Summer visitor	LC	46	0.00303	0.0023

56	Columbiformes	Columbidae	<i>Columba livia</i>	Blue Rock Dove	Resident	LC	33	0.00227	0.0016
57	Coraciiformes	Alcedinidae	<i>Ceryle rudis</i>	Pied kingfisher	Resident	LC	61	0.00402	0.0031
58	Coraciiformes	Alcedinidae	<i>Halcyon smyrnensis</i>	White breasted kingfisher	Resident	LC	54	0.00356	0.0027
59	Coraciiformes	Alcedinidae	<i>Alcedo atthis</i>	Common kingfisher	Resident	LC	29	0.00191	0.0014
60	Coraciiformes	Meropidae	<i>Merops superciliosus</i>	Blue cheeked bee-eater	Summer visitor	LC	46	0.00303	0.0023
61	Coraciiformes	Meropidae	<i>Merops orientalis</i>	Little green bee-eater	Summer visitor	LC	327	0.0215	0.0168
62	Coraciiformes	Upupidae	<i>Upupa epops</i>	Common Hoopoe	Resident	LC	7	0.00046	0.0003
63	Coraciiformes	Coraciidae	<i>Coracias benghalensis</i>	Indian roller	Resident	LC	133	0.00877	0.0068
64	Charadriiformes	Charadriidae	<i>Vanellus vanellus</i>	Northern lapwing	Winter visitor	NT	25	0.00165	0.0012
65	Charadriiformes	Charadriidae	<i>Vanellus indicus</i>	Red wattled lapwing	Resident	LC	529	0.03491	0.0271
66	Charadriiformes	Scolopacidae	<i>Calidris minuta</i>	Little stint	Winter visitor	LC	19	0.00125	0.0009
67	Charadriiformes	Scolopacidae	<i>Gallinago gallinago</i>	Common snipe	Winter visitor	LC	21	0.00138	0.0010
68	Charadriiformes	Scolopacidae	<i>Actitis hypoleucos</i>	Common sand piper	Resident	LC	69	0.00455	0.0035
69	Charadriiformes	Scolopacidae	<i>Tringa totanus</i>	Common Red Shank	Winter visitor	LC	17	0.00112	0.0008
70	Charadriiformes	Scolopacidae	<i>Tringa nebularia</i>	Green shank	Winter visitor	LC	334	0.0222	0.0171
71	Charadriiformes	Scolopacidae	<i>Numenius arquata</i>	Eurasian Curlew	Winter visitor	NT	15	0.00099	0.0007
72	Charadriiformes	Recurvirostridae	<i>Himantopus himantopus</i>	Black winged stilt	Summer visitor	LC	13	0.00085	0.0006
73	Charadriiformes	Glareolidae	<i>Glareola lactea</i>	Little pratincole	Summer visitor	LC	79	0.00521	0.0040
74	Charadriiformes	Sternidae	<i>Sterna aurantia</i>	Indian river tern	Resident	VU	59	0.00389	0.0030
75	Accipitriformes	Accipitridae	<i>Elanus caeruleus</i>	Black winged kite	Resident	LC	13	0.00085	0.0006
76	Accipitriformes	Accipitridae	<i>Milvus migrans</i>	Black/Pariah kite	Resident	LC	391	0.02580	0.0201
77	Accipitriformes	Accipitridae	<i>Circus aeruginosus</i>	Western marsh harrier	Winter visitor	LC	29	0.00191	0.0014
78	Accipitriformes	Accipitridae	<i>Accipiter badius</i>	Shikra	Resident	LC	7	0.00046	0.0003
79	Ciconiiformes	Ardeidae	<i>Egretta garzetta</i>	Little egret	Resident	LC	351	0.02316	0.0180
80	Ciconiiformes	Ardeidae	<i>Ardea intermedia</i>	Intermediate egret	All year visitor	LC	14	0.00092	0.0007
81	Ciconiiformes	Ardeidae	<i>Ardea alba</i>	Great white egret	Winter visitor	LC	7	0.00046	0.0003
82	Ciconiiformes	Ardeidae	<i>Ardea cinerea</i>	Grey heron	Winter visitor	LC	13	0.00085	0.0006
83	Ciconiiformes	Ardeidae	<i>Ardeola grayii</i>	Indian pond heron	Resident	LC	132	0.00871	0.0067
84	Ciconiiformes	Ardeidae	<i>Babulcus ibis</i>	Cattle egret	Resident	LC	664	0.043	0.0341
85	Ciconiiformes	Ardeidae	<i>Nycticorax caledonicus</i>	Rufous Night heron	Summer visitor	LC	23	0.00151	0.0011
86	Ciconiiformes	Ciconiidae	<i>Ciconia nigra</i>	Black stork	Winter visitor	LC	82	0.00541	0.0042
87	Apodiformes	Apodidae	<i>Apus affinis</i>	Little swift	Resident	LC	27	0.00178	0.0013
88	Cuculiformes	Cuculidae	<i>Eudynamys</i>	Western Koel	Summer	LC	69	0.00455	0.0035

89	Cuculiformes	Cuculidae	<i>scolopaceus</i> <i>Clamator jacobinus</i>	Jacobin cuckoo	Visitor Summer Visitor	LC	16	0.00105	0.0008
90	Cuculiformes	Cuculidae	<i>Centropus sinensis</i>	Crow pheasant/greater coucal	Resident	LC	104	0.00686	0.0053
91	Cuculiformes	Cuculidae	<i>Cuculus micropterus</i>	Indian cuckoo	Summer Visitor	LC	21	0.00138	0.0010
92	Cuculiformes	Cuculidae	<i>Caculus varius</i>	Brain fever bird/ common hawk-cuckoo	Summer Visitor	LC	31	0.00204	0.0015
93	Anseriformes	Anatidae	<i>Maraca strepera</i>	Gadwal	Winter visitor	LC	119	0.0078	0.0061
94	Anseriformes	Anatidae	<i>Spatula querquedula</i>	Gargany	Winter visitor	LC	123	0.00811	0.0063
95	Anseriformes	Anatidae	<i>Anas crecca</i>	Common teal	Winter visitor	LC	129	0.00851	0.0066
96	Anseriformes	Anatidae	<i>Aythya ferina</i>	Common pochard	Winter visitor	VU	117	0.00772	0.0060
97	Anseriformes	Anatidae	<i>Spatula clypeata</i>	Shoveler	Winter visitor	LC	35	0.00231	0.0017
98	Anseriformes	Anatidae	<i>Anas poecilorhyncha</i>	Indian Spot-billed duck	Winter visitor	LC	19	0.00125	0.0009
99	Anseriformes	Anatidae	<i>Aythya fuligula</i>	Tufted duck	Winter visitor	LC	3	0.00019	0.0001
100	Anseriformes	Anatidae	<i>Tadorna ferruginea</i>	Ruddy shelduck	Winter visitor	LC	75	0.00495	0.0038
101	Anseriformes	Anatidae	<i>Tadorna tadorna</i>	Common shelduck	Winter visitor	LC	32	0.00211	0.0016
102	Anseriformes	Anatidae	<i>Aythya nyroca</i>	Ferruginous duck	Winter visitor	NT	2	0.00013	0.0001
103	Anseriformes	Anatidae	<i>Mareca penelope</i>	Eurasian wigeon	Winter visitor	LC	123	0.00811	0.0063
104	Anseriformes	Anatidae	<i>Anas acuta</i>	Northern pintail	Winter visitor	LC	117	0.00772	0.0060
105	Anseriformes	Anatidae	<i>Anser indicus</i>	Bar-headed goose	Winter visitor	LC	35	0.00231	0.0017
106	Anseriformes	Anatidae	<i>Anas platyrhynchos</i>	Mallard	Winter visitor	LC	138	0.00910	0.0070
107	Passeriformes	Corvidae	<i>Dendrocitta vagabunda</i>	Rufous treepie	Resident	LC	17	0.00112	0.0008



Figure 4. Rufous Treepie (*Dendrocitta vagabunda*) species discovered in study area at study site

Results of the study indicated the importance and richness of Biodiversity at Bajwat Wildlife Sanctuary, which was supporting 23 species of Mammalian fauna, 22 species of Herpetofauna, 37 species of Fish fauna and 107 species of avian fauna.

Discussion

During the study period, 23 species of Mammals were observed that belongs to 8 different Orders and 15 families. Details of all the orders, families and species is given in table 1. Order Carnivore has highest number of mammals, these were 7 species belonging to 3 families. Out of these 23 species of mammals that were reported from the study area, 3 species were endangered and one species was vulnerable according to IUCN red data status. The three endangered species were *Manis crassicaudata*, *Myotis lucifugus* and *Axis porcinus* from family Manidae, Vespertilionidae and Cervidae respectively. Other 19 species were least concerned according to IUCN red list status.

All the species that mentioned in results were observed keenly and data was collected carefully as there was not a single research data noticed on mammalian fauna from this study area. However, some studies conducted on others sanctuaries and national parks indicates the presence of diverse species of mammals in Pakistan. Younas et al. (2017) explored the vertebrate fauna at district Karak, Khyber Pakhtunkhwa, Pakistan and 28 mammalian species were reported. In another study Younas et al. (2017) reported on vertebrate fauna in Khurum dam and Muhabbat Khel dam. At both dams Bovidae family of mammals was found in abundance. Khan et al. (2018) studied Vertebrate fauna at Lal Suhanra National Park (LSNP) Bahawalpur and 17 species of mammals were reported including

Asiatic wolf that was endangered in that study area. Ram and Banyal (2012) conducted a detailed taxonomic and ecological study at Kalatop-Khajjiar Wildlife sanctuary situated Chamba District and 16 mammalian species from 14 genera that belongs to 12 families and 6 orders were reconnoitered. During study at BWWS, 22 species of herpetofauna were observed belongs to 3 different Orders and 11 families. Details of all the orders, families and species is given in table 2. Highest no of species was reported from order Squamata as it contain 16 species belonging to 9 families. According to IUCN status out of 22 species of herpetofauna one specie *Hardella thurjii* (crowned river turtle) from family Geoemydidae and order Testudines was found endangered. While, two species *Lissemys punctata* (Indian flapshell turtle) from family Geoemydidae and *Python Molurus* (Indian python) from family Viperidae were Vulnerable (VU). Other 19 species's status were least concerned. All the species mentioned in results were observed keenly and data was collected by careful methods as no data was reported on herpetofauna from BWWS. However, Masroor (2011) did same type of study at the Margalla Hills National Park (MHNP) from 2003 to 2009 and 41 species of herpetofauna was reported from the park, including 32 species of reptiles and 9 species of amphibians. *Asymblepharus himalayanus*, *Laudakia agrorensis*, and *Ophisops jerdonii* were species of lizards, which identified and reported for the first time in this park. Baig et al. (2008) did a study of the herpetofauna of Cholistan Desert from 2001 to 2003. 44 species of amphibians and reptiles were collected and observed in different parts of Cholistan Desert. Younas et al. (2017) conducted the study during the year 2016 to 2017 to explore both the vertebrate fauna at district Karak, Khyber Pakhtunkhwa, Pakistan. 6 amphibian's species and 12 reptiles' species were found.

During the study period, 38 species of fish were seen that belongs to 5 different Orders and 14 families. Details of all the orders, families and species are given in table 3. The results were close to findings of Qazi et al. (2000) who reported 37 species of fish from 28 genera, 13 families and 7 orders from Bajwat. In the present study most of the fish belonged to order Cypriniformes and family Cyprinidae. Latif et al. (2016) also reported Cyprinidae as a most abundant family from Chenab River. Altaf et al. (2015) conducted a study at Chenab River and a diversity of 34 species have been recorded.

During the study period, 15034 birds from 107 different species were seen belonging to 15 different Orders and 39 families. Details of all the orders, families and species is given in table 4. Out of 107 recorded species, 49.53% species were resident, 33.64% were winter visitors to the area, 16.53% species were summer visitors and 3.73% species were year-round visitors. Highest number of species was found from order Passeriformes and it was 40 species belongs to 15 different families. Among non-Passerines, family with highest number of species (14) was Anatidae that belongs to order Anseriformes. One New specie was discovered during study, it was *Dendrocitta vagabunda* (Rufous

treepie), also known as Indian treepie. Khan et al. (2021) reported *Dendrocitta vagabunda* (Rufous treepie) at district Abbotabad, Pakistan. No member of these four species were seen, *Gyps bengalensis* (White-rumped vulture), *Gyps indicus* (Long billed vulture), *Hydrophasianus chirurgus* (Pheasant tailed jacana) and *Larus ridibundus* (black headed gull). Although these four species were reported by Bhinder et al. (2015) in his studies. According to IUCN red list data *Gyps bengalensis* (White-rumped vulture), and *Gyps indicus* (Long billed vulture) are Critically endangered (CR) while *Hydrophasianus chirurgus* (Pheasant tailed jacana) and *Larus ridibundus* (black headed gull) were Least concerned but not a single member of these both species were seen during study period. Two species, *Aythya farina* (Common pochard) and *Sterna aurantia* (Indian river tern) were present in the study area at site even though both species are vulnerable according to IUCN status. Two species, *Vanellus vanellus* (Northern lapwing) and *Numenius arquata* (Eurasian Curlew) were also recorded and their number was noticed as 25 and 15 respectively and these both were considered in Near Threatened status according to IUCN red list.

A study was reported by Bhinder et al. (2015) from Bajwat Wildlife Sanctuary and reported 110 species belong to 73 genera, 39 families and 15 orders. Like our findings Passerines were reported in highest number and 39 species of order Passeriformes belongs to 23 genera and most abundant species were from Motacillidae family. Bibi et al. (2016) reported the same study at Taunsa Barrage Wildlife Sanctuary to count the avifauna diversity from 2009 to 2011. 119 species were very common to fairly common. Seasonal occurrence for different bird species was also recorded; it was as summer breeders 7%, year-round residents 42%, passage migrants 13% and winter migrants 38%. Ali et al. (2011) did a comparative study for a year on bird's biodiversity at two wetlands, the Jiwani Coastal Wetland and Taunsa barrage wetland. 109 bird species related to 16 orders and 38 families were reported at Jiwani Coastal Wetland and 110 species belongs to 45 families was recorded at Taunsa Barrage. Ardeidae family was dominant at Taunsa Barrage while syllviidae family was found with highest number of species at the study site. Only one species was reported from family Oriolidae, while out of 110 species, 66 species were resident, 8 species were breeding resident, 34 species were winter visitor and only 2 species were summer visitor. At Jiwani Coastal Wetland out of 109 bird species, migratory species were 77 and 32 species were resident. It was noticed 39 species were common at both the study sites. Irfan (2010) reported the bird's species diversity at Safari Zoo Lahore located in district Lahore, Punjab, Pakistan from 2014 to 2015. 71 species, 40 families from 12 orders were recorded. 50 species were year-round residents, 8 were summer breeders, 12 were winter migrants, and one species was passage migrant. Dominant species were house sparrow, house crow, common myna, jungle babbler and black-crowned night heron that were same as noticed in our study at BWWS.

A number of literature studies highlighted same threats in their studies at different study areas as destruction and fragmentation of habitat along with illegal hunting, human over-population, interference in their breeding sites, natural habitat or their nesting places, lack of awareness, pollution of water, toxicity of water due to overuse of pesticides, herbicides and insecticides in surrounding areas were most common threats (Ali et al., 2011; Bhatti et al., 2019; Irfan, 2010; Latif et al., 2016).

Conclusion

It was concluded Bajwat Wetland and Wildlife Sanctuary (BWWS) is rich in biodiversity of all type of life including mammals, fishes, amphibian, reptiles as well as birds. The highest biodiversity showed the importance of study area as a great natural and healthy supporting system for all type of life. While, decline in four species of birds *Gyps bengalensis* (White-rumped vulture), *Gyps indicus* (Long billed vulture), *Hydrophasianus chirurgus* (Pheasant tailed jacana) and *Larus ridibundus* (black headed gull) in the study area indicated the ignorance, lack of conservation status and poor management status of the study area. Study area is habitat of many Endangered (EN) as well as Vulnerable (VU) species so it was noticed that an urgent need of establishment of a proper wildlife department to conserve biodiversity and to avoid killing and illegal hunting is required. Moreover, human intervention should be blocked by local people to conserve the area in sustainable way.

References

- Ali, Z., Bibi, F., Shelly, S. Y., Qazi, A., and Khan, A. M. (2011). Comparative avian faunal diversity of Jiواني coastal wetlands and taunsa barrage wildlife sanctuary, Pakistan. *Journal of Animal and Plant Sciences*. 21(2): 381-387.
- Altaf, M., Javid, A., Khan, A. M., Hussain, A., Umair, M., and Ali, Z. (2015). The status of fish diversity of river Chenab, Pakistan. *The Journal of Animal and Plant Sciences*. 25(3): 564-569.
- Baig, K. J., Masroor, R., and Arshad, M. (2008). Biodiversity and ecology of the herpetofauna of Cholistan Desert, Pakistan. *Russian Journal of Herpetology*. 15(3): 193-205.
- Baig, M. B., & Al-Subaiee, F. S. (2009). Biodiversity in Pakistan: key issues. *Biodiversity*, 10(4), 20-29.
- Bhatti, Z., Khan, F. M., and Gondal, M. A. (2019). Vultures and Kites from Marala Wetlands. *Journal of Bioresource Management*. 6(4): 3.
- Bhinder, M. A., Iqbal, M., Shahbaz, M., Zahoor, M. Y., and Shehzad, W. (2015). Avian Biodiversity of Bajwat Wetland, District Sialkot. Pakistan. *Journal of Animal and Plant Sciences*. 25(3): 416-422.
- Bibi, F., Qaisrani, S. N., and Akhtar, M. (2016). Assessment of population trends of birds at Taunsa Barrage Wildlife Sanctuary, Pakistan. *Biologia*. 62: 201-210.
- Chape, S., Blyth, S., Fish, L., Fox, P., and Spalding, M. (2003). United Nations list of protected areas.
- Chardonnet, P., Clers, B. D., Fischer, J., Gerhold, R., Jori, F., and Lamarque, F. (2002). The value

- of wildlife. *Revue scientifique et technique-Office international des epizooties*. 21(1): 15-52.
- Gamfeldt, L., Hillebrand, H., and Jonsson, P. R. (2008). Multiple functions increase the importance of biodiversity for overall ecosystem functioning. *Ecology*. 89(5): 1223-1231.
- Gaston, K. J., Jackson, S. F., Cantu-Salazar, L., and Cruz-Pinon, G. (2008). The ecological performance of protected areas. *Annual review of ecology, evolution, and systematics*, 39, 93-113.
- Haines-Young, R., and Potschin, M. (2008). England's terrestrial ecosystem services and the rationale for an ecosystem approach. DEFRA Overview Report Project Code NR0107.
- Irfan (2010). Ecology and population of Birds of Changa Manga Forest, Pakistan. M.Phil. Thesis. University of Veterinary and Animal Sciences, Pakistan. 61 pp.
- Khan, B. N., Yasmeen, Z., Azhar, M., Abid, F., Mehmood, S., and Raza, H. (2018). Study of Vertebrate diversity at Lal Suhanra National Park, Pakistan. *The Journal of Animal and Plant Sciences*. 28(6): 1725-1734.
- Khan, R. A., Ullah, Z., Zaman, I. U., Khan, M. S., Mahmood, S., Akhtar, N., and Hussain, S. S. (2021). Population distribution and habitat analysis of Rufous treepie (*Dendrocitta vagabunda*) in Abbottabad, Pakistan. *Brazilian Journal of Biology*. 83.
- Latif, M., Siddiqui, S., Minhas, I. B., and Latif, S (2016). Diversity and Abundance of Fish Fauna at Head Marala, Chenab River, Punjab, Pakistan.
- Masroor, R. (2011). An annotated checklist of amphibians and reptiles of Margalla Hills National Park, Pakistan. *Pakistan Journal of Zoology*. 43(6).
- Mitchell, R. J., Morecroft, M. D., Acreman, M., Crick, H. Q. P., Frost, M., Harley, M., ... and Wilson, E. (2007). England Biodiversity Strategy-towards adaption to climate change. Final report to Defra for contract CRO327.
- Momtaz, S., and Kabir, Z. (2013). Evaluating environmental and social impact assessment in developing countries. Newnes.
- Nunes, P. A., and van den Bergh, J. C. (2001). Economic valuation of biodiversity: sense or nonsense?. *Ecological economics*, 39(2), 203-222.
- Qazi, M. B., Mirza, M. R., and Javed, M. N. (2000). Fishes of Bajwat area district Sialkot, Pakistan. *Pakistan Journal of Fisheries (Pakistan)*.
- Ram Singh, V., and Banyal, H. S. (2012). Diversity and Ecology of Mammals in Kalatop-khajjar Wildlife Sanctuary, District Chamba (Himachal Pradesh), India.
- Shannon, C. E. (1948). A mathematical theory of communication. *The Bell System Technical J.* 27: 379-423 and 623-656.
- Simpson, E. H. (1949). Measurement of diversity. *Nature*. 163-688.
- Teeb, R. O. (2010). Mainstreaming the Economics of Nature. TEEB Geneva, Switzerland.
- Wei, D. L. Z., and Mundkur, T. (2003). Status overview and recommendations for conservation of the White-headed Duck *Oxyura leucocephala* in Central Asia. *Wetlands International*.
- Younas, S., Gul, S., Rehman, H. U., Junaid, F., Achakzai, W. M., Saddozai, S., and Ahmad, Z. (2017). Zoological fauna of Khurum Dam and Muhabbat Khel Dam of district Karak, Khyber Pakhtunkhwa, Pakistan.
- Younas, S., Rehman, H. U., Gul, S., Gul, R., and Khattak, B. (2017). Animal diversity of district Karak, KP, Pakistan.