

Diversity, Abundance and Distribution of Avifauna in District Jhang, Pakistan

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Abstract

The current study was conducted from March 2021 to February 2022 in Thal desert and Trimmu barrage of District Jhang located in Punjab province of Pakistan to find out the diversity, abundance and distribution of birds. Point count method was used for Trimmu barrage and line transect method was used for the collection of data in Thal desert area. We recorded 31696 individuals belonging to 67 species of birds from two distinct types of habitat (Thal desert and Trimmu barrage) of District Jhang. Among all these species, 39 species were resident, 18 species were winter visitors, 9 species were summer breeder and single species (Terek sandpiper) was passage migrant. Highly significant differences ($X^2 = 14979.7$, $df = 11$, $P < 0.01$) were observed in the abundance of birds between both habitats on monthly basis. From Thal desert area, 12905 individuals of 45 species were identified while 18791 individual from 58 bird species were observed from Trimmu barrage. Among 67 bird species, 36 species were common at both types of habitats. The most dominant species of Trimmu barrage were Common pochard, Little grebe, Common coot, Cattle egret, Gadwall, Little egret, Red wattled lapwing and Common teal. The most common species of Thal desert were Indian roller, Common quail, Cattle egret, Common myna and Indian kite. The most notable feature of the present study is the identification of *Xenus cinereus* (Terek sandpiper) and *Ammomanes phoenicura* (Rufous tail lark) in district Jhang as both species have no previous record in the study area.

1. Introduction

Deserts are low average annual rainfall area usually contains 100 millimeters (less than 4 inches) of rain per year or less. Desert ecosystems are expected to be one of the most susceptible ecosystems to world climate change. Increasing temperature, declining rainfall, and high level of atmospheric CO₂ are expected to highly affect the structure and function of desert ecosystems. Desert inhabiting birds also intensively disturb from climatic change (Bombi et al., 2021).

Birds are valuable component of world biodiversity and play a key role in maintaining healthy ecosystem. The birds assume human with their behavior, beautiful colors and songs (Silva et al., 2015). Insectivorous birds eliminate vectors of various disease and scavenger birds such as *Corvus albus* (Pied crow) as well as vultures serve as a decomposer (Gatesire et al., 2014). Birds are significant contributors in seed dispersion and pollination along with disease control (Pathan et al., 2014).

Agroecosystems have a central role to promote the diversity and abundance of birds. Small rodents which cause incalculable damage to crop are controlled by birds (Tanalgo et al., 2015). Desert birds have behavioral adaptations such as nomadism to survive in unfavorable condition. This behavior allows these birds to move from low resource sites to more productive resource site. Some birds use the burrows of rodents during mid-hot day to get rid from very high temperature. Majority desert birds frequently feed on ants, very rarely seen by other temperate region birds. Most of the birds show seasonal feeding behavior according to availability of food (Araneda et al., 2018). Since Pakistan is the 5th largest populous country of the world. That is why, the overpopulation impose some serious threat to avian diversity due to deforestation, agriculture practices, urbanization, industrialization, change in desert ecosystem and habitat loss (Ali et al., 2016).

Deserts are the results of mega climatic changes. Deserts contain scarcity of surface water which directly affects species richness (Pascoe et al., 2021). The total number of birds species across the globe is 9042 while 2700 avian species have been reported from Asia (Altaf et al., 2012). Pakistan harbor very diverse avian fauna due to its geographical structure and is home for more than 750 species of birds (Mehmood et al., 2018). Wetland and riverine system are some best sites for wintering and migratory birds (Mola et al., 2021). Thal desert area and trimmu barrage support huge number of resident as well as migratory birds such as houbara bustard, cuckoos and quails. Some of these birds travelled from central asia during winter to avoid from freezing temperature (khan et al., 2020). Regional study for determination of avian diversity is pivotal for conservation of species (Mansouri et al., 2021).

The study area Trimmu barrage is an important wetland site for migratory and endemic species of birds. The barrage area is a complex of aquatic and terrestrial ecosystem and provide an ideal habitat for a vast variety of migratory and endemic avian fauna (Mahboob and Nisa, 2009). Wetlands are in between form of aquatic and terrestrial ecosystem. Pakistan has one of the largest canal systems in the world representing 225 wetland sites. Pakistan contains 43% endemic bird species, 30% species are long distance migrant while 27% species are winter visitors (Nisa et al., 2021).

District Jhang is the 18th largest district of Pakistan and is the central part of the Punjab province. The total area of district Jhang is 6162 square kilometer. The maximum length of thal desert is 190 miles (306 kilometer) and its average breadth is 40 miles. Thal desert is spread across the districts of Jhang, Layyan, Bhakkar, Khushab and Mianwali. The most prominent feature of this desert is sand dunes (Mahboob et al., 2013). Thal desert area of district jhang is approximately 120 km. Athara hazari is the most dominant tehsil of district Jhang contributing 80 percent (100 km) desert area.

On one side the district contains an open desert ecosystem while on the other hand it contains flowing water in the form of river Chenab and river Jhelum. Peripheral region of these river contain very fertile land for the cultivation of wheat, rice, corn and sugar cane. The union of both these river contain huge reserve of water in the form of Trimmu barrage. Both the river merge at Athara hazari and then originate from trimmu barrage as a single Chenab river. Despite the fact that the study area (Jhang) is one of the dominant avian region of Pakistan due to two very distinct type

of habitat. Three major threats have been observed in the study area. Natural desert ecosystem is being converted by irrigation system, hunting on large scale have been adopted as a profession, even though the thal area have been declared as a game reserve by the government of Punjab (Pakistan) and disturbance by visitors specially at Trimmu barrage.

That is why the present study is conducted in Thal desert area and Trimmu barrage of district Jhang to find out the current status of avian diversity and abundance in one of the richest biodiversity region of Pakistan. The current survey is the second and recent research in Thal desert area of district Jhang as the first study was conducted in 2009. The combine research of both habitats (Thal desert and Trimmu barrage) simultaneously is first ever attempted.

2. Materials And Methods

2.1 Study area

The study area district (Jhang) is located between 31.1929° N and 72.2364° E. Jhang is surrounded by the neighbored districts of Chiniot and Sargodha on the north, Khanewal on the south, Faisalabad on the east and Layyah, Bhakkar, Khushab on the west. The total area of district Jhang is 6162 square kilometer and is administratively divide into four tehsils. The largest one is tehsil Jhang which represent 42% of the area, Athara hazari 25%, Shorkot 19% and Ahmad pur sial 14%.

2.2 Features of Trimmu barrage

Trimmu barrage is located in tehsil Jhang in the district and is at the distance of 21 km from Jhang city on Bhakkar road. It indicates the features of both aquatic and terrestrial habitats. *Acacia nilotica*, *Albizia lebbeck*, *Ficus religiosa*, *Eucalyptus camaldulensis* and *Dalbergia sisoo* are the most dominant flora of marginal bunds. Ground plants include *Chenopodium album*, *Malva parviflora*, *Medicago polymorpha*, *Alhagi maurorum*, and *Melilotus indica*. Aquatic plant comprise of *Hydrilla verticillata*, *Vallisneria spiralis*, *Nymphaea lotus* and *Saccharun bengalense* etc. The head pond area of Trimmu barrage is 3,680,43 acres. Three major canals such as Rangpur canal, Sadhnai link canal and Haveli project canal emerge from the pond area. The barrage was constructed for irrigation, to control flood and to ensure water supply for head Sadhnai.

2.3 Features of Thal desert area

Thal desert is spread across the districts of Jhang, Layyan, Bhakkar, Khushab and Mianwali. Thal desert have been declared game reserve since 1974 by the government of Punjab. Athara hazari is the the major thal desert area which contribute 80% (100/ 120 km) of thal desert in district Jhang. The current study on Thal desert is conducted in Athara hazari tehsil. About 15% area of Thal desert (Jhang) remain under cultivation along the year as it is being irrigated by tube wells and canal. The major crops grown here are wheat, cotton, rice, corn and sugar cane. About 85% area is non-irrigated. The only non-irrigated cultivated crop is chick pea (*Cicer arietinum*) which is grown in winter and fully depend on rain. It is one major source of food and shelter for migratory and local birds. The non-cultivated flora include *Prosopis cineraria*, *Tamarix aphylla*, *Prosopis juliflora*, *Salvadora oleoides*, *Acacia jacquemontii*, *Capparis aphylla* and *Calligonum polygonoides*.

2.4 Field Survey

Survey was conducted along the year from March 2021 to February 2022 to find out the diversity and abundance of migratory and local birds. Survey was done on monthly bases from sun rise to sun set (full day) to explore every possible opportunity. Thus the study hours was no only limited to dawn and dusk. During each month out of two sampling sites (Trimmu barrage and Thal desert), each site was visited consecutively on separate day. Two visits were done during each month while 24 times the area was visited during the whole study. Point count method was used for determining the bird diversity and abundance of Trimmu barrage. Several random point counts were specified (Khan et al, 2020). The head pond area was visited by using wooden boat while the marginal bunds were visited by foot to observe the avian fauna. Both direct and indirect methods were used for the collection of data. Direct method includes field area observation by observers while indirectly the information were gained from local people and hunters. Birds were enumerated by using binocular, spotted scope while camera was used to photograph the birds for later identification. For identification of avian fauna, various practical guides (Roberts, 1992; Mirza and Wasig, 2012) were consulted.

By following Mola et al. (2021) Line transect method was used for observing the birds of wetland area of Thal desert. Since Thal desert contains uniform type of habitat due to very little vegetation, birds are easily visible. Two transect lines were arranged. The length of each transect line was 20 km. Keeping in mind the topography of the study area, the transect lines were isolated from each other at a distance of 200 to 250 meter.

2.5 Analysis of Data:

For statistical analysis, ManiTab software was used. Shannon Weiner index was calculated to find out the diversity of birds in the sample area. The Shannon-Wiener diversity index (H) point out that both species richness (the number of species in a given area) and their abundances. Its values normally ranges between 1.5 to 3.5. Following formula was used for Shannon wiener index.

$H = -\sum [(p_i) * \log(p_i)]$, where H = Shannon wiener index, p_i = Proportion of individuals of i-th species in a whole community and log is the natural logarithm.

Relative abundance = $n_i/N \times 100$ where n_i = number of individuals of a single species and N = total number of individuals of all the species

One way ANOVA and t test were used to compare the month wise diversity and abundance of birds at both sampling sites.

3. Results

3.1 Avian fauna of district Jhang

The current study was conducted in two different types of habitats (Trimmu barrage and Thal desert) of district Jhang. The field survey was done on monthly bases all around the year to find out the diversity, abundance and seasonal assessment of wild birds. During the study, 67 bird species were identified from the two different sampling sites (Trimmu barrage and Thal desert) of district Jhang. The most dominant order was Passeriformes representing 24 species of birds belonging to 13 families followed by Accipitriformes, Pelecaniformes, Coraciiform, Anseriformes and Charadriiformes each having 5 species of birds. Columbiformes, Gruiformes, Cuculiformes contain 3 species each while Bucerotiformes possess 2 species. Podicipediformes Strigiform, Otidiformes, Falconiformes, Galliformes, Piciformes and Phoenicopteriformes are represented by single species each. The most common families were Accipitridae, Ardeidae and Anatidae representing 5 species at each. Fifty eight species were observed at Trimmu barrage while 45 species were observed from the Thal desert area of district Jhang. Out of 67 bird species, 36 species were common at both types of habitat. A total of 31696 individual birds were observed at both sampling sites. **Fig. 1** represents the difference in the abundance of birds at both sites.

Fig. 1 here

Highly significant differences ($X^2 = 14979.7$, $df = 11$, $P < 0.01$) were observed in the diversity and abundance of birds overall between Trimmu barrage and Thal desert area on monthly basis (**Table 1**). The most prominent feature of the present study is the identification of *Xenus cinereus* (Terak sandpiper) and *Ammomanes phoenicura* (Rofous tail lark) in district Jhang as both species have no previous record in the study area.

Table 1 here

3.2 Distribution status of avian fauna in Jhang district

As for as distribution of avian fauna is concern, 39 species were resident, 18 species were winter visitors, 9 species were summer breeder and single species (Terek sandpiper) was passage migrant.

Resident birds

The birds which are found all around the year in a particular area are called resident birds. The current study find out 39 resident species which are *Streptopelia decaocto* (Eurasian collared dove), *Columba livia* (Rock pigeon), *Gallinula chloropus* (Common moorhen), *Amauornis phoenicurus* (White breasted water hen), *Dinopium benghalense* (Black rump woodpecker), *Centropus sinensis* (Greater coucal), *Himantopus himantopus* (Black winged stilt), *Venellus indicus* (Red wattled lapwing), *Actitis hypoleucos* (Common sandpiper), *Upupa epops* (Eurasian hoopoe), *Sexicola caprata* (Pied bushchat), *Saxicoloides fulicatus* (Indian robin), *Lanius schach* (Long tail shrike), *Lanius excubitor* (Great grey shrike), *Corvus splendens* (Indian house crow), *Corvus corax* (Common raven), *Dendrocitta vagabunda* (Rofous treepie), *Dicrurus macrocercus* (Black drongo), *Acridotheres tristis* (Common myna), *Acridotheres ginginianus* (Bank myna), *Pycnonotus cafer* (Red vented bulbul), *Motacilla alba* (The white wagtail), *Galerida cristata* (Crested lark), *Ammomanes phoenicura* (Rofous tail lark), *Argya earlei* (Striated babbler), *Argya striatus* (Jungle babbler), *Argya caudate* (Common babbler), *Milvus migrans* (Pariah Kite), *Elanus caeruleus* (Black winged kite), *Bubulcus ibis* (Cattle egret), *Ergetta garzetta* (Little egret), *Ardea intermedia* (Intermediate egret), *Ardeola grayii* (Indian pond heron), *Ixobrychus sinensis* (Yellow bittern), *Coracias benghalensis* (Indian roller), *Halcyon smyrnensis* (White throated kingfisher), *Alcedo atthis* (Common kingfisher), *Ceryle rudis* (Pied kingfisher), *Athene noctua* (Little owl).

Winter Visitors

The study area hosted 18 species of visitor birds which migrated here after covering thousands of miles. These birds started to arrive in Pakistan during October and November from central Asian countries to avoid intense cold. The frequent winter visitors species of Jhang district are *Oenanthe deserti* (Desert wheatear), *Hirundo rustica* (Common swallow), *Motacilla flava* (Yellow wagtail), *Circus cyaneus* (Hen harrier), *Aquila nipalensis* (Steppe eagle), *Accipiter nisus* (Eurasian sparrow hawk), *Tachybaptus ruficollis* (Little grebe), *Aythya ferina* (Common pochard), *Anas crecca* (Common teal), *Anas platyrhynchos* (Mallard), *Anas strepera* (Gadwall), *Anas penelope* (Wigeon), *Fulica atra* (Common coot), *Chlamydotis undulate* (Houbara bustard), *Falco peregrines* (Peregrine falcon), *Coturnix coturnix* (Common quail), *Phoenicopus roseus* (Greater flamingo) and *charadrius dubius* (Little ring plover).

Summer Breeders

The 9 species of summer breeders in district Jhang were *Cinnyris asiaticus* (Purple sunbird), *Hirundo smithi* (The wire tailed swallow), *Oriolus kundoo* (Indian golden oriole), *Ploceus philippinus* (Baya weaver), *Merops orientalis* (Green bee eater), *Streptopelia tranquebarica* (Red collared dove), *Clamator jacobinus* (Jacobin cuckoo), *Tockus nasutus* (Grey hornbill) and *Eudynamys scolopacea* (Asian koel).

Passage Migrant

The single observed passage migrant species of the study area was *Xenus cinereus* (Terek sandpiper; **Table 2**).

Table 2 here

3.3 Bird diversity at Trimmu barrage

Trimmu barrage was very dominant site with respect to avian fauna as its shows the features of both terrestrial and aquatic habitats. During the 12 month field survey, 58 species of birds were identified and 18791 individual birds were observed from terrestrial and aquatic habitats of Trimmu barrage. Common pochard (2332 individuals) was the most abundant species followed by little grebe (2327 individuals), common coot (1776 individuals), cattle egret (1281 individuals), gadwall (1270 individuals), little egret (956 individuals), red wattled lapwing (488 individuals) and common teal (475 individuals). The least common bird species were grey hornbill (6 individuals) Hen harrier (12 individuals), Terek sandpiper (15 individuals) and Crested lark (16 individuals). Highest relative abundance was noted for Common pochard (12.4 %) followed by Little grebe (12.3 %), Common coot 9.5 %), Cattle egret (6.8 %), Gadwall (6.7 %), Little egret (5 %), Red wattled lapwing (2.6 %) and Common teal (2.5%; **Fig. 2A**).

Fig. 2A here

Maximum number (4106) of bird individuals were observed during January followed by December (3133), February (2767), November (2230), March (1678), October (910), April (790), July (677), June (659), May (647), August (611) and September (583). Highest Shannon Weiner diversity index (3.450) was recorded for January while lowest for September (2.901; **Table: 3**). Huge population of birds in winter month is due to the arrival of winter visitor birds. Highest diversity of avian fauna was also observed during December and January when 51 bird species were identified followed by February (48), November (47), March (45), April (43), July (40), June (38) and May (37).

Table 3 here

The least number of species were observed during September and October when only 35 species were identified. During this part of the year summer breeder move back and winter visitor yet to arrive. So bird diversity and abundance decreases. By comparing both study sites, during the months of April ($t=7.86$), May ($t=9.90$), June ($t=4.10$), July ($t=4.50$), August ($t=3.62$), December ($t=2.60$) and February ($t=6.81$) highly significant difference ($P<0.01$) was detected in the diversity of birds. Significant variations ($P<0.05$) were recorded during September ($t=1.98$) and November ($t=2.06$). Statistically non-significant differences ($P>0.05$) were noted during January ($t=0.00$), March ($t=1.28$) and October ($t=1.07$; **Table: 3**). According to distribution of birds, 36 species were resident, 6 species were summer breeder, 15 species were winter visitors and single species was passage migrant. **Table 4** briefly shows the diversity of birds at Trimmu barrage of district Jhang.

Table 4 here

3.4 Bird diversity at Thal desert

The study find out 45 bird species and 12905 individual birds from the Thal desert of district Jhang. The most abundant species with respect to number of individuals were Indian roller (1830), Common quail (1122), Cattle egret (939), Green bee eater (712), Little egret (642), Red vented bulbul (594), Common myna (482), Indian house crow (471) and Indian/Pariah kite (461). The least common species were Crested lark (12 individuals), Common kestrel (15 individuals), Steppe eagle (41 individuals), Red collared dove (48 individuals) and Desert wheatear (50 individuals). Highest relative abundance was recorded for Indian roller (14 %) followed by common quail (8 %), cattle egret (7 %), green bee eater (5.5 %) little egret (5 %), red vented bulbul (4 %), common myna (3.71 %), Indian house crow (3.6 %) and Indian/Pariah kite (3.5 %; **Fig. 2B**).

Fig. 2B here

According to distribution of avian fauna in Thal desert area, 33 species were resident, 6 species were winter visitors and six species were summer breeder. During the month of January, bird abundance was at peak level as 1447 individuals were observed followed by December (1231), March (1210), August (1195), May (1134), November (1075), June (1034), February (993), July (990), April (980), October (865) and September (750). **Table 5** concisely elaborates the diversity and abundance of birds at Thal desert of district Jhang.

Table 5 here

Bird diversity was also at top level during January when (38 species) were observed followed by November and August (37 species), December, February, March and June (35 species), April, May and July (34 species). Bird diversity was at least level during September and October when only

32 species and 31 species were observed respectively. Highest Shannon Weiner diversity index (3.292) was noted for January while lowest for October (2.704; **Table 3**). As for as abundance of birds is concern between Thal desert desert and Trimmu barrage, significant difference ($P < 0.05$) was observed for the months of April ($t = 2.01$), May ($t = 1.99$), July ($t = 2.21$) and August ($t = 2.22$). During the months of January, February, March, June, September, October, November and December, no significant difference ($P > 0.05$) was recorded (**Table 6; Fig. 1**).

Table 6 here

4. Discussion

The current study was conducted on monthly bases in district Jhang to find out the diversity, abundance and distribution of avian fauna. During the year around study, 67 species of birds were identified and 31696 individual birds were observed from the two sampling areas (Trimmu barrage and Thal desert) of the district Jhang. From Trimmu barrage, 18791 individuals and 58 bird species were identified while 45 species and 12905 individuals were observed from the thal desert area. Among 67 species, 39 species were resident and are found throughout the year, 18 species were winter visitors, 9 species were summer breeder and single species was passage migrant. The most dominant order was Passeriform followed by Accipitriformes, Pelecaniformes, Coraciiform, Anseriformes, Charadriiformes Columbiformes, Gruiformes, Cuculiformes, Bucerotiformes Podicipediformes Strigiform, Otidiformes, Falconiformes, Galliformes, Piciformes and Phoenicopteriformes.

Mahboob and Nisa (2009) conducted a 9 month survey at the same site (Trimmu barrage) during 2004–2005 and recorded 89 species of birds having 9699 individuals. Resident species were 52, winter visitors 29, summer breeders 4 and ordinary migrant were also 4. Comparison of both studies reveals that bird diversity has been decreased while the number of individuals rose up. Our findings are similar to previous study with respect to distribution of birds as both studies share that December and January (winter season) was the most favorable time for the diversity and abundance of avian fauna. During the previous study Green bee eater was observed from December to August continuously while during current study it was found from February to August only. No individual was observed during the winter months of December and January.

Khan et al. (2020) did a field survey during 2018 at Trimmu barrage and reported 11556 individuals birds belonging to 26 species. Both the studies have 16 common species. Common coot (7240 individuals) was the most common species of 2018 survey followed by Common pochard (1102), Northern shover (630), Little grebe (495), Common teal (311), Black wing stilt (258) and Gadwall (193). Current survey also identified these species exception include Northern shover but contradict with the diversity and abundance of avian fauna. In the present study 58 species and 18791 individuals were observed from Trimmu barrage. The most dominant species were Common pochard (2332 individuals) followed by Little grebe (2327 individuals), Common coot (1776 individuals), Cattle egret (1281 individuals), Gadwall (1270 individuals), Little egret (956 individuals), Red wattled lapwing (488 individuals) and Common teal (475 individuals).

Bibi et al. (2016) conducted a study during 2008 at Taunsa barrage located in the Muzaffargarh District of Pakistan and recorded 171 species of birds. The most notable thing was the presence of various vulture species such as *Gyps bengalensis* and *Gyps africanus*. However no vulture species was observed in present study. Secondly, in taunsa barrage survey the population of Black drongo and Gadwal was in decreasing trend but in current study the population of both species was increasing. Akbar et al. (2009) find out the diversity and abundance of Chashma barrage (Mianwali, Pakistan) and recorded 533,965 individuals of 46 species. The most dominant species of the present study were also recorded from the study of Chashma barrage but their number of individuals was very high. Common pochard represented itself with 50408 individuals, Common teal 35279 individuals, Gadwall 26407 individuals, Common coot 181052 individuals and Mallard 50892 individuals.

Nisa et al. (2021) determined the bird diversity of Dhapchapak lake of Dera Ismail Khan (KPK, Pakistan) and observed 13933 individuals belonging to 39 species of birds. Great Egret and Gadwal were the most abundant species. The least common species were Asian koel, Eurasian hoopoe, Common kestrel, Greater coucal, Indian roller, Black drongo, Purple sunbird, Red collared dove and Indian golden oriole. We also recorded similar observation about Common kestrel, Red collared dove and Indian golden oriole as all the three the species were fairly common while rest of the species were common. During survey of birds at Ketu Bunder wildlife sanctuary (Thatta, Pakistan) 4280 individuals belonging to 49 bird species were identified (Ali et al., 2016). In another survey conducted at Natural Wetland Reserve of Peninsular Malaysia recorded 8728 bird individuals of 89 species. *Porphyrio porphyrio* (Purple swamphen) was the most abundant species.

A study conducted in Australian desert identified 28000 individuals belonging to 91 bird species. It was pointed out that climatic changes and rainfall affect diversity and abundance of avian fauna (Pascoe et al., 2021). A survey which was done in the desert of northern Saudi Arabia recorded 131 species of birds. Most (70%) were resident while 30% were migratory. Crested lark and Hoopoe lark were the most abundant residential species (Heezik and Seddon, 1999). A total of 130 species of birds were reported from the study of Sahara desert (Morocco). Passeriformes with 68 bird species of 16 families was the most dominant order followed by Accipitriformes (13 species) and Charadriiformes with 6 species. Fringillidae with 280520 individual birds was the most abundant family (Mansouri et al, 2021). Avian diversity of wetlands in Bahir dar, Ethiopia was determined during wet and dry seasons. The field survey identified 96 species of birds in which 40 species were observed in wet season, 13 species in dry season while 43 species were common at both seasons (Mola, 2021).

Mahboob et al. (2013) conducted a study from December 2008 to November 2009 at Thal desert of district Jhang to find out the diversity of birds. During the year around survey 2550219 individuals from 55 species of birds were reported. Among these bird species, 36 species were resident, 13 species were winter visitors, 6 species were summer breeders while single species was ordinary migrant. Passeriformes was the most dominant order with 26 species. Common myna and House sparrow were the most abundant species. According to present survey, the most common species of birds of Thal desert were Indian roller, Common quail, Cattle egret, Little egret, Red vented bulbul, Common myna, Indian house crow and Indian/Pariah kite. Both studies have similar findings as mid-winter season (December and January) was the most dominant time for the diversity of avian fauna. The most distinguish feature between both the studies is the abundance of avian fauna. Previously, a total of 2550219 individual birds were identified while in present study only 12905 individuals of 45 species were observed. By comparing with other studies, current recent study demonstrates that the diversity and abundance of avian fauna have been declined in district Jhang.

6. Conclusion

District Jhang provide ideal environment for birds due to variety of habitats. The district contains desert ecosystem, aquatic ecosystem and agriculture land for the cultivation of variety of crops which support avian fauna. Current study clearly indicates that the bird diversity over the years have been dramatically decrease when we compare it with previous research conducted in the area. The reports from hunters and local villagers also support the results of current study. The winter migratory birds are especially vulnerable due to extreme hunting pressure by Arab dignities as well as local hunters. Hunting, contamination of aquatic ecosystem and disturbance of natural habitat are some major threats in the study area. Strict and immediate action is required in this matter to prevent the decline in the diversity and abundance of avian fauna.

Declarations

Conflicts of interest

The authors declare no conflicts of interest in regards of this article publication.

Authors Contribution:

AZ and AR conceptualized, worked and completed the write up of the manuscript, FJ, TS and SS supervised the work and SA and MSM proof read the article to bring it in final form.

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Tables

Table: 1 Month-wise Analysis of Variance (ANOVA) between sampling sites

Source	Overall		Thal desert		Trimmu barrage	
	df	Mean squares	Df	Mean squares	df	Mean squares
Month	11	14979.7**	11	553.49 ^{NS}	11	22223.8**
Error	910	4003.5	405	1639.46	493	5850.8
Total	921		16		504	

Key : NS = Non-significant ($P > 0.05$); * = Significant ($P < 0.05$); ** = Highly significant ($P < 0.01$)

Table 2: Distribution of Avian fauna of District Jhang

	Order	Family	Scientific name		Common name	Status
1	Passeriformes	Nectariniidae	<i>Cinnyris asiaticus</i>	(Latham, 1790)	Purple sunbird	SB
2		Muscicapidae	<i>Sexicola caprata</i>	(Linnaeus, 1766)	Pied bushchat	R
3			<i>Oenanthe deserti</i>	(Temminck, 1829)	Desert wheatear	WV
4			<i>Saxicoloides fulicatus</i>	(Linnaeus, 1766)	Indian robin	R
5		Laniidae	<i>Lanius schach</i>	(Linnaeus, 1758)	Long tail shrike	R
6			<i>Lanius excubitor</i>	(Linnaeus, 1758)	Great grey shrike	R
7		Corvidae	<i>Corvus splendens</i>	(Linnaeus, 1758)	Indian house crow	R
8			<i>Corvus corax</i>	(Linnaeus, 1758)	Common raven	R
9			<i>Dendrocitta vagabunda</i>	(Latham, 1790)	Rufous treepie	R
10		Dicruridae	<i>Dicrurus macrocercus</i>	(Vieillot, 1817)	Black drongo	R
11		Sturnidae	<i>Acridotheres tristis</i>	(Linnaeus, 1766)	Common myna	R
12			<i>Acridotheres ginginianus</i>	(Latham, 1790)	Bank myna	R
13		Hirundinidae	<i>Hirundo rustica</i>	(Linnaeus, 1758)	Common swallow	WV
14			<i>Hirundo smithi</i>	(Leach, 1818)	The wire tailed swallow	SB
15		Pycnonotidae	<i>Pycnonotus cafer</i>	(Linnaeus, 1766)	Red vented bulbul	R
16		Motacillidae	<i>Motacilla alba</i>	(Linnaeus, 1758)	The white wagtail	R
17			<i>Motacilla flava</i>	(Linnaeus, 1758)	Yellow wagtail	WV
18		Oriolidae	<i>Oriolus kundoo</i>	(Sykes, 1832)	Indian golden oriole	SB
19		Alaudidae	<i>Galerida cristata</i>	(Linnaeus, 1758)	Crested lark	R
20			<i>Ammomanes phoenicura</i>	(Franklin, 1831)	Rufous tail lark	R
21		Leiothrichidae	<i>Argya earlei</i>	(Blyth, 1844)	Striated babbler	R
22			<i>Argya striatus</i>	(Dumont, 1823)	Jungle babbler	R
23			<i>Argya caudate</i>	(Dumont, 1823)	Common babbler	R
24		Ploceidae	<i>Ploceus philippinus</i>	(Linnaeus, 1766)	Baya weaver	SB
25	Accipitriformes	Accipitridae	<i>Circus cyaneus</i>	(Linnaeus, 1766)	Hen harrier	WV
26			<i>Milvus migrans</i>	(Boddaert, 1783)	Pariah Kite	R
27			<i>Aquila nipalensis</i>	(Hodgson, 1833)	Steppe eagle	WV
28			<i>Elanus caeruleus</i>	(Desfontaines, 1789)	Black winged kite	R
29			<i>Accipiter nisus</i>	(Linnaeus, 1758)	Eurasian sparrow hawk	WV
30		Ardeidae	<i>Bubulcus ibis</i>	(Linnaeus, 1758)	Cattle egret	R
31			<i>Ergetta garzetta</i>	(Linnaeus, 1766)	Little egret	R
32			<i>Ardea intermedia</i>	(Wagler, 1827)	Intermediate egret	R
33			<i>Ardeola grayii</i>	(Sykes, 1832)	Indian pond heron	R
34			<i>Ixobrychus sinensis</i>	(Gmelin, 1789)	Yellow bittern	R
35		Coraciidae	<i>Coracias benghalensis</i>	(Linnaeus, 1758)	Indian roller	R
36		Alcedinidae	<i>Halcyon smyrnensis</i>	(Linnaeus, 1758)	White throated kingfisher	R
37			<i>Alcedo atthis</i>	(Linnaeus, 1758)	Common kingfisher	R
38			<i>Ceryle rudis</i>	(Linnaeus, 1758)	Pied kingfisher	R
39		Meropidae	<i>Merops orientalis</i>	(Latham, 1801)	Green bee eater	SB

	Order	Family	Scientific name		Common name	Status
40	Podicipediformes	Podicipedidae	<i>Tachybaptus ruficollis</i>	(Pallas, 1764)	Little grebe	WV
41	Strigiform	Strigidae	<i>Athene noctua</i>	(Scopoli, 1769)	Little owl	R
42	Columbiformes	Columbidae	<i>Streptopelia decaocto</i>	(Frisvaldszky, 1838)	Eurasian collared dove	R
43			<i>Streptopelia tranquebarica</i>	(Hermann, 1804)	Red collared dove	SB
44			<i>Columba livia</i>	(Gmelin, 1789)	Rock pigeon	R
45	Anseriformes	Anatidae	<i>Aythya ferina</i>	(Linnaeus, 1758)	Common pochard	WV
46			<i>Anas crecca</i>	(Linnaeus, 1758)	Common teal	WV
47			<i>Anas platyrhynchos</i>	(Linnaeus, 1758)	Mallard	WV
48			<i>Anas strepera</i>	(Linnaeus, 1758)	Gadwall	WV
49			<i>Anas Penelope</i>	(Linnaeus, 1758)	Wigeon	WV
50	Gruiformes	Rallidae	<i>Fulica atra</i>	(Linnaeus, 1758)	Common coot	WV
51			<i>Gallinula chloropus</i>	(Linnaeus, 1758)	Common moorhen	R
52			<i>Amauornis phoenicurus</i>	(Pennant, 1769)	White Breasted water hen	R
53	Otidiformes	Otididae	<i>Chlamydotis undulate</i>	(Jacquin, 1784)	Houbara bustard	WV
54	Falconiformes	Falconidae	<i>Falco peregrines</i>	(Tunstall, 1771)	Peregrine falcon	WV
55	Galliformes	Phasianidae	<i>Coturnix coturnix</i>	(Linnaeus, 1758)	Common quail	WV
56	Piciformes	Picidae	<i>Dinopium benghalense</i>	(Linnaeus, 1758)	Black rump woodpecker	R
57	Cuculiformes	Cuculidae	<i>Centropus sinensis</i>	(Stephens, 1815)	Greater coucal	R
58			<i>Clamator jacobinus</i>	(Linnaeus, 1758)	Jacobin cuckoo	SB
59			<i>Eudynamys scolopacea</i>	(Linnaeus, 1758)	Asian koel	SB
60	Phoenicopteriformes	Phoenicopteridae	<i>Phoenicopus roseus</i>	(Pallas, 1811)	Greater flamingo	WV
61	Charadriiformes	Recurvirostridae	<i>Himantopus himantopus</i>	(Linnaeus, 1758)	Black winged stilt	R
62		Charadriidae	<i>Venellus indicus</i>	(Boddaert, 1783)	Red wattled lapwing	R
63			<i>Charadrius dubius</i>	(Scopoli, 1786)	Little ring plover	WV
64		Scolopacidae	<i>Xenus cinereus</i>	(Guldenstadt, 1775)	Terek sandpiper	PM
65			<i>Actitis hypoleucos</i>	(Linnaeus, 1758)	Common sandpiper	R
66	Bucerotiformes	Upupidae	<i>Upupa epops</i>	(Linnaeus, 1758)	Eurasian hoopoe	R
67		Bucerotidae	<i>Tockus nasutus</i>	(Linnaeus, 1766)	Grey hornbill	SB

Key: R= Resident, SB = Summer breeder, WV= Winter visitor, PM= Passage migrant

Table: 3 Comparison in diversity between Thal desert and Trimmu barrage in different months by t test and Shannon diversity index.

Month	Thal desert			Trimmu barrage			t-value	p-value
	S	H'	Var H	S	H'	Var H		
Mar	35	3.170	0.00051	45	3.207	0.00071	1.28 ^{NS}	0.100
Apr	34	2.910	0.00068	43	3.012	0.00072	7.86 ^{**}	0.000
May	34	2.989	0.00102	37	2.990	0.00055	9.90 ^{**}	0.000
June	35	3.090	0.00083	38	2.993	0.00092	4.10 ^{**}	0.000
July	34	2.801	0.00074	40	2.991	0.00084	4.50 ^{**}	0.000
Aug	37	3.119	0.00067	35	2.941	0.00076	3.62 ^{**}	0.000
Sep	32	2.734	0.00096	35	2.901	0.00130	1.98 [*]	0.024
Oct	31	2.704	0.00160	35	3.013	0.00162	1.07 ^{NS}	0.142
Nov	37	3.092	0.00136	47	3.264	0.00070	2.06 [*]	0.020
Dec	35	3.179	0.00081	51	3.391	0.00049	2.60 ^{**}	0.005
Jan	38	3.292	0.00093	51	3.450	0.00037	0.00 ^{NS}	0.500
Feb	35	3.067	0.00065	48	3.314	0.00054	6.81 ^{**}	0.000
Total	45	3.342	0.00007	58	3.351	0.00007	0.77 ^{NS}	0.222

Key: S = Number of species (richness), H' = Shannon's diversity index

NS = Non-significant (P>0.05); * = Significant (P<0.05); ** = highly significant (P<0.01)

Table: 4 Diversity of birds at Trimmu barrage of District Jhang (March 2021- Feb 22 Survey on Month bases)

Sr no.	Scientific name	Common name	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Total
1	<i>Cinnyris asiaticus</i>	Purple sunbird	0	21	17	12	35	8	0	0	0	0	0	0	93
2	<i>Sexicola caprata</i>	Pied bushchat	27	16	25	32	17	35	4	17	10	21	15	14	233
3	<i>Lanius schach</i>	Long tail shrike	12	5	28	4	0	24	5	0	2	2	15	3	100
4	<i>Lanius excubitor</i>	Great grey shrike	20	7	10	3	6	4	12	0	5	2	6	4	79
5	<i>Corvus splenden</i>	Indian house crow	32	39	35	17	11	20	13	14	20	25	10	21	257
6	<i>Dendrocitta vagabunda</i>	Rofous treepie	13	24	21	6	2	5	18	0	4	5	30	3	131
7	<i>Dicrurus macrocercus</i>	Black drongo	28	13	7	6	5	7	9	13	7	16	5	8	124
8	<i>Acridothera stristis</i>	Common myna	42	21	30	33	43	9	16	26	20	18	27	12	297
9	<i>Acridotheres ginginianus</i>	Bank myna	18	10	9	6	7	0	11	13	0	4	5	3	86
10	<i>Hirundo rustica</i>	Common swallow	0	0	0	0	0	0	0	3	23	17	32	24	99
11	<i>Hirundo smithi</i>	The wire tailed swallow	10	4	21	11	18	0	0	0	0	0	0	0	64
12	<i>Pycnonotus cafer</i>	Red vented bulbul	28	15	23	31	20	16	10	19	26	34	21	25	268
13	<i>Motacilla alba</i>	The white wagtail	34	12	6	11	1	7	11	10	18	30	42	15	197
14	<i>Motacilla flava</i>	Yellow wagtail	0	0	0	0	0	0	0	0	10	25	20	13	68
15	<i>Oriolus kundoo</i>	Indian golden oriole	0	0	25	14	18	1	0	0	0	0	0	0	58
16	<i>Galerida cristata</i>	Crested lark	3	2	0	0	4	1	0	0	1	3	1	1	16
17	<i>Ammomanes phoenicura</i>	Rofous tail lark	5	8	7	11	10	4	18	11	3	15	18	12	122
18	<i>Argya earlei</i>	Striated babbler	30	12	8	18	0	12	9	14	22	17	45	14	201
19	<i>Argya striatus</i>	Jungle babbler	27	15	17	27	30	17	10	5	31	33	48	40	300
20	<i>Argya caudate</i>	Common babbler	14	20	8	14	3	28	16	10	6	19	27	24	189
21	<i>Saxicoloides fulicatus</i>	Indian robin	5	3	13	0	8	5	3	0	1	4	6	2	50
22	<i>Circus cyaneus</i>	Hen harrier	0	0	0	0	0	0	0	0	3	4	5	0	12
23	<i>Milvus migrans</i>	Pariah Kite	51	10	22	11	18	20	15	26	19	40	62	12	306
24	<i>Aquila nipalensis</i>	Steppe eagle	0	0	0	0	0	0	0	0	12	21	39	23	95
25	<i>Elanus caeruleus</i>	Black winged kite	15	2	0	7	5	0	1	3	4	33	38	26	134
26	<i>Accipiter nisus</i>	Eurasian sparrow hawk	0	0	0	0	0	0	0	0	14	29	24	19	86
27	<i>Bubulcus ibis</i>	Cattle egret	112	81	55	80	51	49	67	72	104	210	275	125	1281
28	<i>Ergetta garzetta</i>	Little egret	47	61	32	55	29	65	77	55	70	170	145	150	956

29	<i>Ardea intermedia</i>	Intermediate egret	15	10	11	0	4	18	0	20	14	7	18	12	129
30	<i>Ardeola grayii</i>	Indian pond heron	35	18	0	40	32	0	48	26	33	41	48	21	342
31	<i>Ixobrychus sinensis</i>	Yellow bittern	21	11	0	30	16	24	8	3	33	40	49	10	245
32	<i>Coracias benghalensis</i>	Indian roller	31	8	16	19	39	22	5	13	16	25	20	12	226
33	<i>Halcyon smyrnensis</i>	White throated kingfisher	27	12	18	4	2	23	14	5	20	26	40	31	222
34	<i>Alcedo atthis</i>	Common kingfisher	4	7	0	3	9	2	5	3	0	1	2	3	39
35	<i>Ceryle rudis</i>	Pied kingfisher	2	5	6	10	7	11	20	4	0	5	1	0	71
36	<i>Merops orientalis</i>	Green bee eater	51	30	27	29	41	31	18	0	0	0	0	10	237

37	<i>Anas Penelope</i>	Wigeon	0	0	0	0	0	0	0	0	40	70	62	135	52	359
38	<i>Phoenicopiterus roseus</i>	Greater flamingo	0	0	0	0	0	0	0	0	0	60	55	81	34	230
39	<i>Amauornis phoenicurus</i>	White Breasted water hen	30	39	27	40	55	19	28	38	15	26	36	17	370	
40	<i>Venellus indicus</i>	Red wattled lapwing	41	23	37	19	48	42	51	22	30	45	59	71	488	
41	<i>Himantopus himantopus</i>	Black winged stilt	28	15	10	20	5	30	27	12	18	34	30	47	276	
42	<i>Xenus cinereus</i>	Terek sandpiper	0	0	0	0	0	0	0	0	15	0	0	0	15	
43	<i>Actitis hypoleucos</i>	Common sandpiper	16	7	5	0	5	12	4	1	10	6	24	17	107	
44	<i>Charadrius dubius</i>	Little ring plover	19	0	0	0	0	0	0	0	50	73	148	80	370	
45	<i>Upupa epops</i>	Eurasian hoopoe	24	16	34	8	10	14	7	15	14	23	9	0	174	
46	<i>Streptopelia decaocto</i>	Eurasian collared dove	17	10	19	15	5	11	8	18	9	12	10	16	150	
47	<i>Aythya ferina</i>	Common pochard	230	40	0	0	0	0	0	0	366	541	780	375	2332	
48	<i>Fulica atra</i>	Common coot	280	55	0	0	0	0	0	111	266	280	434	350	1776	
49	<i>Tachybaptus ruficollis</i>	Little grebe	120	18	0	0	0	0	0	250	392	488	586	473	2327	
50	<i>Anas strepera</i>	Gadwall	50	27	0	0	0	0	0	0	248	335	310	300	1270	
51	<i>Anas crecca</i>	Common teal	11	0	0	0	0	0	0	0	45	104	205	110	475	
52	<i>Anas platyrhynchos</i>	Mallard	20	0	0	0	0	0	0	0	60	75	66	80	301	
53	<i>Athene noctua</i>	Little owl	11	6	4	5	12	9	3	8	1	2	3	0	64	
54	<i>Falco peregrines</i>	Peregrine falcon	0	0	0	0	0	0	0	0	0	4	15	20	39	
55	<i>Columba livia</i>	Rock pigeon	12	14	5	2	7	0	3	7	0	6	4	8	68	
56	<i>Tockus nasutus</i>	Grey hornbill	0	0	2	1	3	0	0	0	0	0	0	0	6	
57	<i>Ploceus philippinus</i>	Baya weaver	0	0	2	3	8	6	0	0	0	0	0	0	19	
58	<i>Gallinula chloropus</i>	Common moorhen	10	18	5	2	28	0	9	3	10	20	32	25	162	
Total			1678	790	647	659	677	611	583	910	2230	3133	4106	2767	18791	

Table: 5 Diversity of Birds at Thal desert of District Jhang (March 2021– Feb 2022 Survey on Monthly bases)

Sr no.	Scientific name	Common name	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Total
1	<i>Chlamydotis undulate</i>	Houbara bustard	0	0	0	0	0	0	0	0	95	65	78	0	238
2	<i>Corvus corax</i>	Common raven	31	14	0	10	0	22	8	13	9	35	28	0	170
3	<i>Coturnix coturnix</i>	Common quail	0	0	0	0	0	0	68	190	121	248	380	115	1122
4	<i>Gracupica contra</i>	Asian pied starling	34	17	23	11	0	28	6	14	0	22	10	5	170
5	<i>Aquila nipalensis</i>	Steppe eagle	0	0	0	0	0	0	0	0	19	13	7	2	41
6	<i>Columba livia</i>	Rock pigeon	54	68	40	0	3	61	12	25	10	30	44	50	397
7	<i>Falco tinnuculis</i>	Common kestrel	0	0	0	0	0	0	0	0	7	0	3	5	15
8	<i>Pycnonotus cafer</i>	Red vented bulbul	65	50	38	28	35	67	12	30	39	50	80	60	554
9	<i>Motacilla alba</i>	The white wagtail	33	18	20	15	9	14	10	5	12	15	8	11	170
10	<i>Oriolus kundoo</i>	Indian golden oriole	0	0	12	35	48	45	0	0	0	0	0	0	140
11	<i>Galerida cristata</i>	Crested lark	4	2	1	0	0	0	1	0	3	0	1	0	12
12	<i>Ammomanes phoenicura</i>	Rofous tail lark	14	10	17	3	20	8	3	9	14	11	5	4	118
13	<i>Argya earlei</i>	Striated babbler	6	11	4	0	5	3	5	0	4	8	3	8	57
14	<i>Argya striatus</i>	Jungle babbler	25	15	16	9	6	4	0	3	2	10	5	9	104
15	<i>Milvus migrans</i>	Pariah Kite	37	22	30	41	48	60	35	30	6	40	52	60	461
16	<i>Elanus caeruleus</i>	Black winged kite	5	12	0	3	10	22	7	0	6	15	0	7	87
17	<i>Accipiter nisus</i>	Eurasian sparrow hawk	0	0	0	0	0	0	0	0	16	28	37	0	81
18	<i>Bubulcus ibis</i>	Cattle egret	130	65	48	34	66	87	100	47	105	123	91	43	939
19	<i>Ergetta garzetta</i>	Little egret	40	31	25	100	58	125	80	20	67	30	37	29	642
20	<i>Ardeola grayii</i>	Indian pond heron	17	0	23	10	25	14	12	7	18	14	26	19	185
21	<i>Ixobrychus sinensis</i>	Yellow bittern	15	26	7	5	18	2	0	25	9	6	13	20	146
22	<i>Coracias benghalensis</i>	Indian roller	141	100	245	160	165	178	66	188	273	95	104	115	1830
23	<i>Halcyon smyrnensis</i>	White throated kingfisher	27	11	25	15	0	12	15	8	18	20	16	24	191
24	<i>Merops orientalis</i>	Green bee eater	100	140	170	122	78	65	37	0	0	0	0	0	712
25	<i>Amauornis phoenicurus</i>	White Breasted water hen	30	14	24	8	13	7	12	3	5	0	40	16	172

26	<i>Venellus indicus</i>	Red wattled lapwing	32	24	8	28	9	15	10	19	8	3	10	12	178
27	<i>Himantopus himantopus</i>	Black winged stilt	0	2	11	5	30	5	17	6	10	25	32	20	163
28	<i>Actitis hypoleucos</i>	Common sandpiper	10	7	5	0	11	8	0	5	3	14	12	17	92
29	<i>Streptopelia tranquebarica</i>	Red collared dove	5	17	0	9	14	3	0	0	0	0	0	0	48
30	<i>Streptopelia decaocto</i>	Eurasian collared dove	60	37	40	55	45	20	15	17	38	32	46	53	458
31	<i>Dinopium benghalense</i>	Black rump woodpecker	26	15	19	15	0	8	10	4	1	8	3	7	116
32	<i>Centropus sinensis</i>	Greater coucal	20	31	35	15	7	10	12	9	14	0	8	10	171
33	<i>Clamator jacobinus</i>	Jacobin cuckoo	0	0	14	42	32	22	25	0	0	0	0	0	135
34	<i>Eudynamys scolopacea</i>	Asian koel	0	0	20	31	40	44	0	0	0	0	0	0	135
35	<i>Oenanthe deserti</i>	Desert wheatear	1	0	0	0	0	0	0	0	13	7	9	20	50
36	<i>Athene noctua</i>	Little owl	16	23	30	16	10	12	13	29	17	25	33	14	238
37	<i>Cinnyris asiaticus</i>	Purple sunbird	0	6	19	30	43	55	0	0	0	0	0	0	153
38	<i>Sexicola caprata</i>	Pied bushchat	42	30	20	33	11	5	19	15	27	45	40	50	337
39	<i>Lanius schach</i>	Long tail shrike	14	3	0	8	11	5	0	25	2	8	15	20	111
40	<i>Upupa epops</i>	Eurasian hoopoe	56	35	47	24	30	27	17	20	15	45	40	28	384
41	<i>Corvus splendens</i>	Indian house crow	28	40	26	47	38	55	42	39	30	44	34	48	471
42	<i>Dendrocitta vagabunda</i>	Rufous treepie	8	0	4	11	14	0	8	5	0	13	10	11	84
43	<i>Dicrurus macrocercus</i>	Black drongo	14	17	22	11	8	30	22	10	6	21	34	28	223
44	<i>Acridotheres tristis</i>	Common myna	55	48	46	38	20	32	47	34	25	53	40	44	482
45	<i>Acridotheres ginginianus</i>	Bank myna	15	19	0	7	10	15	4	11	8	10	14	9	122
Total			1210	980	1134	1034	990	1196	750	865	1075	1231	1447	993	12905

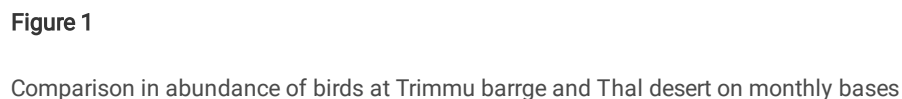
Table: 6 Comparison in abundance of birds between Thal desert and Trimmu barrage in different months by t Test

Month	Site	N	Mean	Std. deviation	t-test for equality of means	
					T	P-value
Mar	S1	35	34.57	32.89	-0.27 ^{NS}	0.7915
	S2	45	37.29	53.17		
Apr	S1	34	28.82	28.75	2.01*	0.0483
	S2	43	18.37	16.42		
May	S1	34	33.35	46.89	1.99*	0.0500
	S2	37	17.49	12.09		
June	S1	35	29.54	34.15	1.97 ^{NS}	0.0532
	S2	38	17.34	16.55		
July	S1	34	29.12	30.70	2.21*	0.0304
	S2	40	16.93	15.40		
Aug	S1	37	32.30	36.97	2.22*	0.0295
	S2	35	17.46	14.31		
Sep	S1	32	23.44	24.31	1.31 ^{NS}	0.1944
	S2	35	16.66	17.77		
Oct	S1	31	27.90	44.49	0.17 ^{NS}	0.8633
	S2	35	26.00	44.76		
Nov	S1	37	29.05	50.25	-1.13 ^{NS}	0.2605
	S2	47	47.45	88.03		
Dec	S1	35	35.17	44.94	-1.29 ^{NS}	0.1997
	S2	51	61.43	114.10		
Jan	S1	38	38.11	62.43	-1.64 ^{NS}	0.1055
	S2	51	80.51	150.26		
Feb	S1	35	28.37	27.62	-1.63 ^{NS}	0.1067
	S2	48	57.65	103.35		
Total	S1	45	286.78	335.52	-0.43 ^{NS}	0.6693
	S2	58	323.98	501.74		

Key: S1 = Thal desert, S2 = Trimmu barrage, N = Number of species

NS = Non-significant (P>0.05); * = Significant (P<0.05); ** = Highly significant (P<0.01)

Figures



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