COMPARITIVE ANALYSIS OF AVIAN DIVERSITY IN FOREST CLOSURES IN SUBTROPICAL CHIR PINE FOREST ECOSYSTEM SHINKIARI DISTRICT MANSEHRA KHYBER PAKHTUNKHWA, PAKISTAN

Ahmad Zamir*, Asad Ullah* Syed Ghias Ali

*Centre of Plant Biodiversity, University of Peshawar, Khyber Pakhtunkhwa, Pakistan

Abstract- This research focused on analysing the types, diversity, and abundance of bird species within the BTAP closures compartment Baz-02, encompassing Kowari Genwal and Masar, located in the nearby controlled area with similar land use. The study employed a point count method, leading to the observation of a total of 49 bird species were recorded in both research sites. The Black Bulbul exhibited the greatest relative prevalence at 0.0079 within the BTAP closure, while the Barn Swallow Bird held the highest relative prevalence at 0.138 within the controlled areas. The total bird population recorded across the entire research area was 553, with 260 of them observed in the controlled areas. Notably, the BTAP closure exhibited higher species diversity (H=3.25) compared to the controlled areas (H=2.73). The BTAP Closures contained 31 different bird species, while the controlled areas had 18 species. Among these species, the Steppe Eagle, classified as endangered according to the IUCN Red List, was found in both research sites. Additionally, the Mountain Hawk Eagle, listed as nearly threatened, was present, and the rest of the species were categorized as least concerned. The Accipitridae family had the highest representation among families in BTAP closures, comprising 16.1% of the species, followed by the Columbidae family at 12%. In controlled areas, the Accipitridae family was also the most dominant among the nine families, accounting for 27.78% of the species, with the Pycnonotidae family coming next at 16.67%. As per the Simpson Diversity Index, the controlled areas display a species richness of 92%, whereas the closures exhibit a slightly higher species richness of 95%. Additionally, the Sorenson diversity index is recorded at 0.20 for both research sites. The standard deviation for the closed areas is 0.02289, while for the controlled areas, it is 0.157. After T-test analysis, the resulting P-value is greater than 0.9999. According to the findings of this study, the BTAP Closures have seen an enhancement in vegetation cover, better control over grazing and forest fires, increased regulation of hunting and poaching, as well as the collection of grass and fuelwood. These efforts have led to improved ecological conditions and habitat quality. Additionally, the involvement of forest-based communities in social fencing and the implementation of Naghban's recommendations, as endorsed by the forest department, have played a significant role in fostering an upward trend in avian biodiversity within the BTAP Closures.

Index terms-Closures, social fencing, endangered, Ecological conditions, avian biodiversity

INTRODUCTION

Forests provides habitat for birds, supporting around 75% of all bird species, whereas only 45% of all bird species have adapted to human-modified ecosystems (Brooks et al., 2008). Human activities such as farming, urban sprawl, charcoal production, pole cutting, and firewood collection have significantly contributed to the destruction of birds' natural habitats, impacting their diversity and variability (Storch et al., 2003). There are number of threats to bird populations, including habitat destruction, habitat loss, fragmentation, and several anthropogenic stresses. Birds are a prevalent fauna in all habitat types, and since they are adaptable, their diversity and abundance can reflect biological changes in other species (Furness et al., 1993). Birds have a variety of functions in ecosystems, including predators, pollinators, scavengers, seed dispersers, seed predators, and ecosystem engineers (Sekercioglu, 2006).

The study of avifaunal diversity is an important ecological tool that serves as an important indicator to evaluate different habitats both qualitatively and quantitatively. Unfortunately, global bird diversity is decreasing inexorably, owing primarily to anthropogenic disturbances and climate change (Singha Roy et al., 2012). Birds face a number of hazards, including deforestation, poaching, habitat loss, and climate change. Birds are excellent bioindicators and helpful models for researching a wide range of environmental issues, and the significance of local landscapes for avian conservation can only be grasped by understanding the structure of the bird community in the region (Narasimmarajan et al., 2013).

The present study was designed to evaluate and compare the status of avian biodiversity inside and outside BTAP Closures. certain acts were abandoned inside the BTAP Closure such as pooching and hunting, fire ignition, fuelwood collection, grazing, grass collection, collection of medicinal plant, quarrying of stone, all trespass of nomadic graziers have been choked through local available

material and social fencing. Selection of Naghbans from the forest based community through consultation and recommendation of village development committee after broad based consultation not only ensured the protection also created the sense of ownership.

Materials and method and sites description:

The study area is situated between 34°28°N latitude and 73°17°E longitude with an altitudinal gradient from 600-2260 m asl and elevation of 1100-1750 m in Shinkiari, Mansehra, Khyber Pakhtunkhwa. The Shikiari Chir Pine forest ecosystem is situated in the east of Mansehra and Abbottabad of Khyber Pakhtunkhwa-Pakistan. (Fig. 1&2)

Bird survey was conducted during June and July 2022. Point count method was used as described by Carlton (2023). Transect lines were established with 25 vintage points inside and outside the closures 250 meters apart covering each research site. On each vintage point data were recorded in 100-meter radius in concentric circle (Table 1, 2 & 3).

Table-1: Transect line along with Vantage Points in Baz khan Closure and Controlled Area

S.No.	Name	Category	Vantage Point	Latitude	Longitude	Transect line	Length
1	Baz Khan	Closure	a	34.53185	73.21413	a-b	250
2			b	34.53185	73.21688	b-c	250
3			c	34.53182	73.21964	c-d	250
4			d	34.53181	73.22237	d-e	250
5			e	34.53177	73.22512	f-g	250
6			f	34.52918	73.21919	g-h	250
7			g	34.52916	73.22194	h-i	250
8			h	34.52914	73.22469	j-k	250
9			i	34.52912	73.22747	k-l	250
10			j	34.52625	73.22259		
11			k	34.52627	73.22521		
12			l	34.52625	73.22797		
13		Control	a	34.53754	73.21884	a-b	250
14			b	34.53751	73.22159	b-c	250
15			c	34.53752	73.22432	c-d	250
16			d	34.53749	73.22708	d-e	250
17			e	34.53471	73.21901	f-g	250
18			f	34.53468	73.22177	g-h	250
19			g	34.53467	73.22454	h-i	250
20			h	34.53464	73.22729	j-k	250
21			i	34.53462	73.23004		
22			j	34.53218	73.22622		
23			k	34.53215	73.22898		

Table-2: Transect line along with Vantage Points in Kawari Genewal Closure and Controlled Area

S.No.	Name	Category	Vantage Point	Latitude	Longitude	Track Part	Length
1	Kawari Genewal	Closure	a	34.27388	73.12071	a-b	250
2			b	34.27154	73.12059	b-c	250
3			c	34.2692	73.12054	d-e	250
4			d	34.27048	73.12103	e-f	250
5			e	34.27036	73.12389	g-h	250
6			f	34.27025	73.12671	h-i	250
7			g	34.26816	73.12078		
8			h	34.26805	73.1236		
9			i	34.26792	73.12641		
10		Control	a	34.27881	73.11742	a-b	250
11			b	34.27645	73.11727	b-c	250
12			d	34.27178	73.11709	c-d	250
13			c	34.27413	73.1172	e-f	250
14			f	34.27623	73.12285	b-e	250
15			e	34.27634	73.12009		

Table-3: Transect line along with Vantage Points in Masar -9 (i) Closure and Controlled Area

S.No.	Name	Category	Vantage Point	Latitude	Longitude	Track Part	Length
1	Masar-9 (i)	Closure	a	34.43553	73.29536	a-b	250
2			b	34.43333	73.2944	b-c	250
3			c	34.43112	73.29348	c-d	250
4			d	34.42891	73.29249		
5		Control	a	34.43468	73.29922	a-b	250
6			b	34.43248	73.29827	b-c	250
7			c	34.43027	73.29734	c-d	250
8			d	34.42806	73.29635		

The avian diversity was calculated using Simpson and Shannon-Weiner diversity index, Sorenson diversity index and t-test was used to compare bird species diversity between the BTAP closures and controlled research sites. The level of significance was set at $p < 0.05$. and similarity index was used to measure the similarities. Paleontological statistical package (PAST version 2.17, Hammer et al. 2001) was used for the analyses of data .

Fig-1: Study area maps showing the research area Shinkiari Forest Range

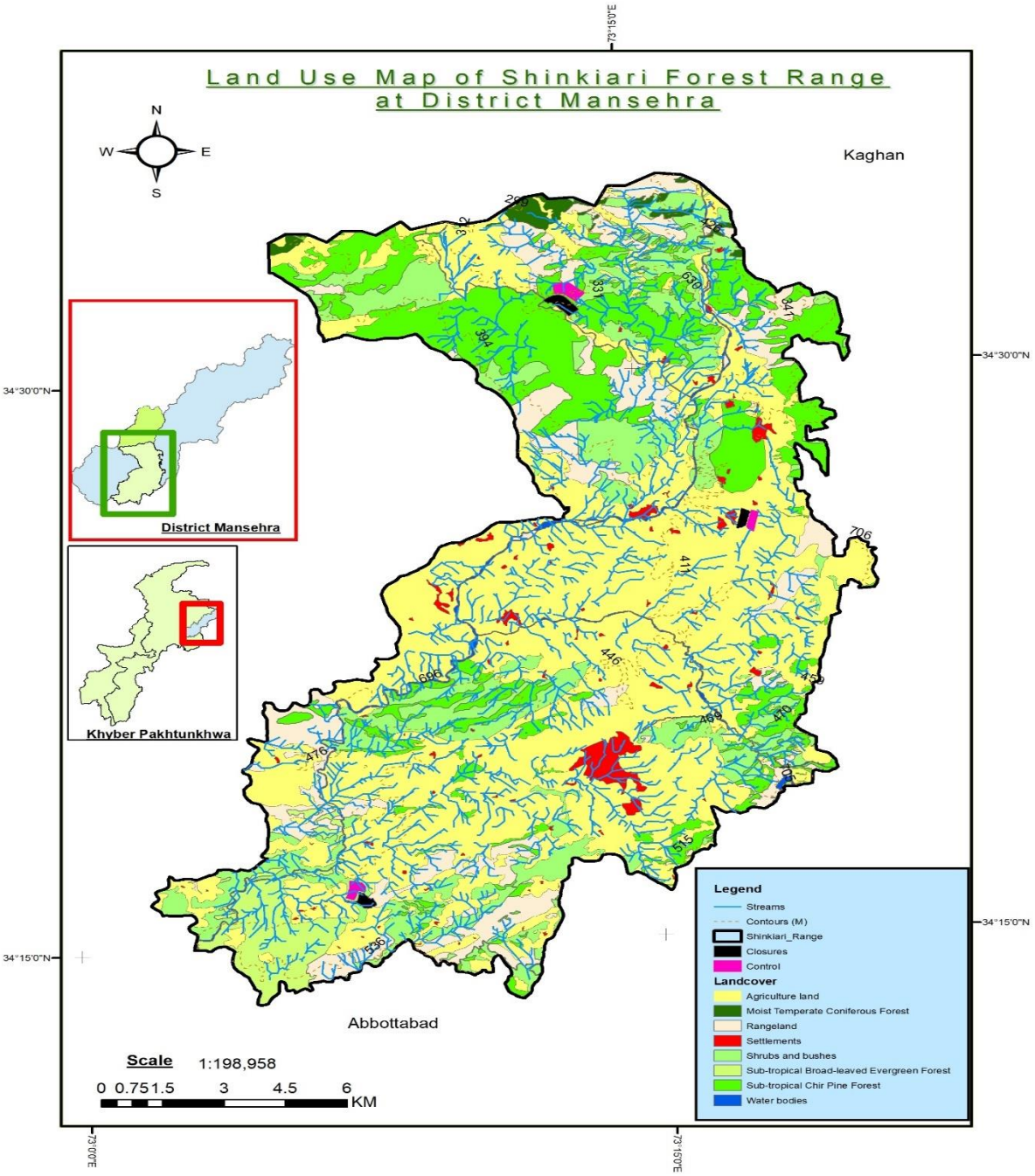
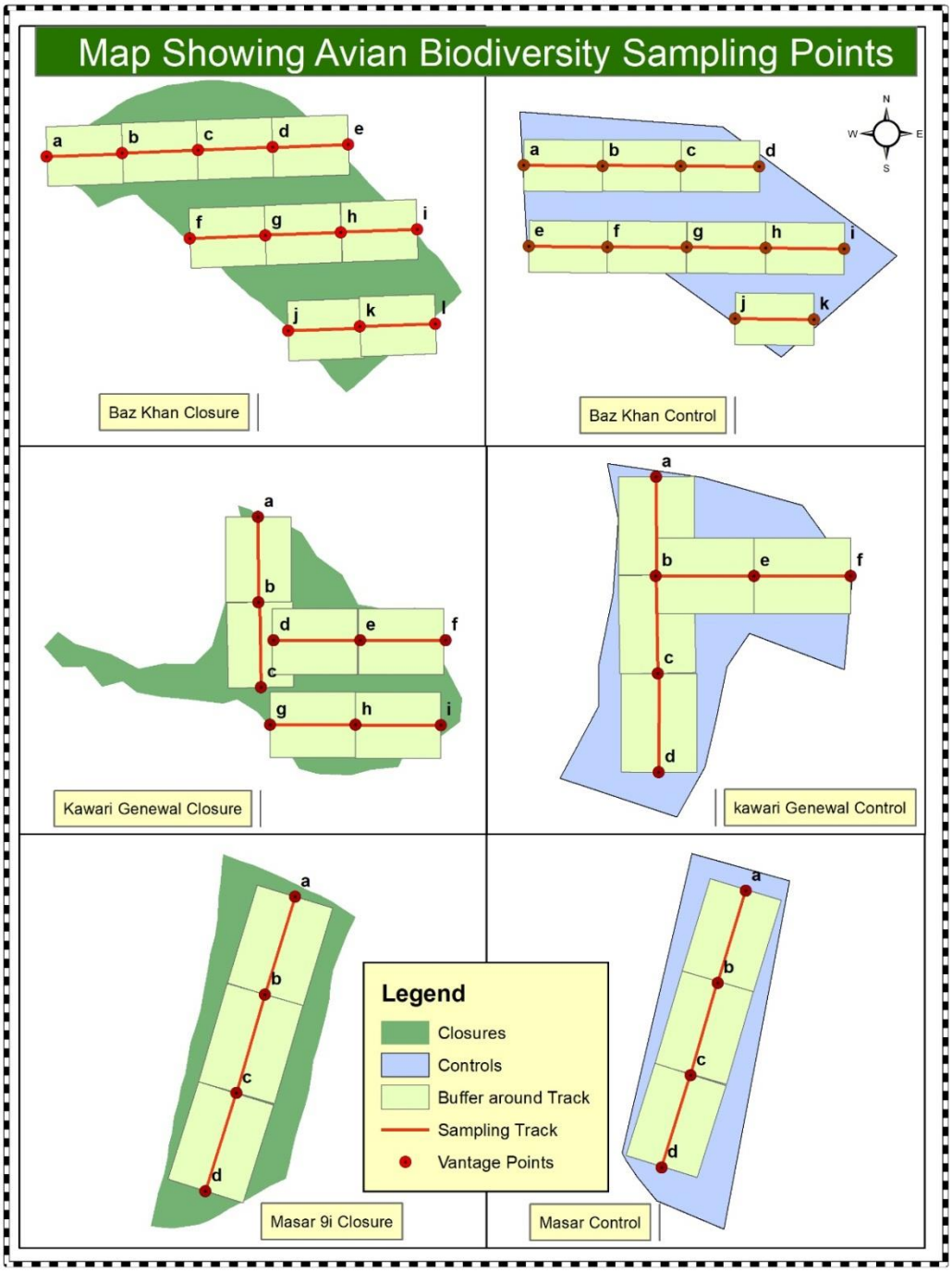


Fig-2: Study area maps showing sampling sites of Avian diversity.



RESULTS AND DISCUSSION

A total of 49 species were recorded in both sites. The BTAP closures had higher species diversity (H` = 3.25) than controlled area (Table 4 and 5). Highest relative abundance in BTAP closure was of Black Bulbul which was 0.079566 (Table 4). Whereas in controlled areas the highest relative abundance was of Barn Swallow Bird which was 0.13846154 (Table 5). Species richness in Closures and Controlled areas were 31 and 18 species respectively (Fig 3 and 4). Total number of Individuals in closures were 553 and 260 in controlled areas. In both the study sites one specie (Steppe Eagle) is listed in endangered category, one species (Mountain Hawk Eagle)

lies in near threatened and the rest of them lies in least concerned according to IUCN red list categories (Table 4 and 5). According to Simpson diversity index BTAP Closures have 95% specie richness and controlled areas have 92% respectively (Table 8 and 9). While Sorenson diversity index shows similarity, index is 0.20 in both sites (Table 14). The standard deviations between Closure and Controlled areas are 0.02289 and 0.157 respectively. While the P value analysed from T test is >0.9999 (Table 17). This study reveals that BTAP Closures have experienced notable improvements in vegetation cover, enhanced management of grazing and forest fires control, increased oversight of hunting and poaching, and more efficient collection of grass and fuelwood. These initiatives have contributed to better ecological conditions and habitat quality. Furthermore, the active participation of forest-based communities in social fencing and the implementation of Naghban's recommendations, supported by the forest department, have significantly contributed to the positive trajectory of avian biodiversity within the BTAP Closures.

Birds recorded inside BTAP closures

In the BTAP closure the Black Bulbul and Indian Flycatcher exhibit the highest relative abundance, recorded at 0.079566, followed by the Himalayan Bulbul and Coal Tit with the second-highest relative abundance at 0.06509946, and the Asian Koel ranking third with a relative abundance of 0.05786618 (Table 4). These findings suggest that Black Bulbul, Indian Flycatcher, Himalayan Bulbul, and Coal Tit are more abundant compared to species such as Rock Pigeon, Spotted Dove, and Indian Cuckoo, which are among the least abundant in the area. Specifically, the Indian Cuckoo is the least abundant in the BTAP closure, with a relative abundance of 0.00723327 in the BTAP closure (Fig. 3 & 4).

Among the families, members of the Monarchidae and passerine family are relatively more abundant in the BTAP closures. However, members of the Columbidae family are comparatively least abundant in the study site (Fig 5). Out of 31 species, 05 species belong to family Accipitridae, however of the family Columbidae 4 and Cuculidae 3 species were recorded (Table-4).

Table-4: showing list of bird recorded inside BTAP closures at the research area

S.No.	Common Name	Scientific Name	Family	IUCN Status	Number of Individual recorded	Relative Abundance
1	Common Hill Partridge	Arborophila torqueola	Phasianidae	Least Concern	10	0.01808318
2	Kalij Pheasant	Lophura leucomelanos'	Phasianidae	Least Concern	11	0.0198915
3	Rock Pigeon	Columba livia	Columbidae	Least Concern	08	0.01446655
4	Spotted Dove	S. chinensis	Columbidae	Least Concern	06	0.01084991
5	Indian Cuckoo	Cuculus micropterus	Cuculidae	Least Concern	04	0.00723327
6	Black Eagle	Ictinaetus malaiensis	Accipitridae	Least Concern	09	0.01627486
7	Steppe Eagle*	Aquila nipalensis	Accipitridae	Endangered	20	0.03616637
8	Shikra*	Accipiter badius	Accipitridae	Least Concern	16	0.02893309
9	Black Bulbul	Hypsipetes leucocephalus	passerine	Least Concern	44	0.079566
10	Himalayan Bulbul	Pycnonotus leucogenis	Pycnonotidae	Least Concern	36	0.06509946
11	Red-vented Bulbul*	P.cafer	Pycnonotidae	Least Concern	09	0.01627486
12	Hume's Leaf Warbler	Abrornis humei	Phylloscopidae	Least Concern	11	0.0198915

13	Long-legged Buzzard	Buteo rufinus	Accipitridae	Least Concern	11	0.0198915
14	Yellow Fronted wood pecker	Melanerpes flavifrons	Picidae	Least Concern	06	0.01084991
15	White-throated king fisher	Halcyon smyrnensis	Alcedinidae	Least Concern	16	0.02893309
16	Common king fisher	Alcedo atthis	Alcedinidae	Least Concern	12	0.02169982
17	Cattle egret	Bubulcus ibis	Ardeidae	Least Concern	13	0.02350814
18	Green Bee eater	Merops orientalis	Meropidae	Least Concern	24	0.04339964
19	Asian house martin	Delichon dasypus	Hirundinidae	Least Concern	26	0.04701627
20	Laughing thrustT.	T.erythrocephlaum	Leiothrichidae	Least Concern	16	0.02893309
21	Common Myna	Acridotheres tristis	Sturnidae	Least Concern	19	0.03435805
22	Jungle Myna	A.fuscus	Sturnidae	Least Concern	32	0.05786618
23	Indian Paradise-flycatcher	Terpsiphone paradisi	Monarchidae	Least Concern	44	0.079566
24	Coal Tit	Periparus ater	Paridae	Least Concern	36	0.06509946
25	Spotted Forktail	Enicurus maculatus	Muscicapidae	Least Concern	12	0.02169982
26	Chestnut-bellied Rock Thrush	M.refiventris	Muscicapidae	Least Concern	24	0.04339964
27	Oriental Turtle Dove	Stregtopelia orientalis	Columbidae	Least Concern	11	0.0198915
28	Eurasian Collared Dove	S. decaocto	Columbidae	Least Concern	16	0.02893309
29	Asian Koel	Eudynamys scolopaceus	Cuculidae	Least Concern	32	0.05786618
30	Common Cuckoo	C.canorus	Cuculidae	Least Concern	11	0.0198915
31	Mountain Hawk Eagle	Nisaetus nipalensis	Accipitridae	Near Threatened	08	0.01446655

Table-5: Birds recorded in the controlled areas at the research area

S.No.	Common Name	Scientific Name	Family	Status	Number of Individual recorded	Relative Abundance
1	Oriental Turtle Dove	Stregtopelia orientalis	Columbidae	Least Concern	16	0.06153846
2	Eurasian Collared Dove	S.decaocto	Columbidae	Least Concern	18	0.06923077
3	Asian Koel	Eudynamys scolopaceus	Cuculidae	Least Concern	7	0.02692308
4	Common Cuckoo	C.canorus	Cuculidae	Least Concern	8	0.03076923
5	Mountain Hawk Eagle	Nisaetus nipalensis	Accipitridae	Near Threatened	12	0.04615385
6	Black Kite	Milvus migrans	Accipitridae	Least Concern	4	0.01538462
7	Mountain Scops Owl	Otus spilocephalus	Strigidae	Least Concern	16	0.06153846
8	Brown Wood Owl	Strix leptogrammica	Strigidae	Least Concern	12	0.04615385
9	Barn Swallow	Hirundo rustica	Hirundinidae	Least Concern	36	0.13846154
10	Mountain bulbul	Ixos mcclellandii	Pycnonotidae	Least Concern	24	0.09230769
11	Jungle Babbler	Turdoides straita	Leiothrichidae	Least Concern	16	0.06153846
12	Rose Ringed Parakeet	Psittacula krameri	Psittaculidae	Least Concern	13	0.05
13	Tickell's Thrush	T.unicolor	Turdidae	Least Concern	32	0.12307692
14	Black Eagle	Ictinaetus malaiensis	Accipitridae	Least Concern	8	0.03076923
15	Steppe Eagle	Aquila nipalensis	Accipitridae	Endangered	6	0.02307692
16	Shikra	Accipiter badius	Accipitridae	Least Concern	9	0.03461538
17	Black Bulbul	Hypsipetes leucocephalus	Pycnonotidae	Least Concern	11	0.04230769
18	Himalayan Bulbul	Pycnonotus leucogenis	Pycnonotidae	Least Concern	12	0.04615385

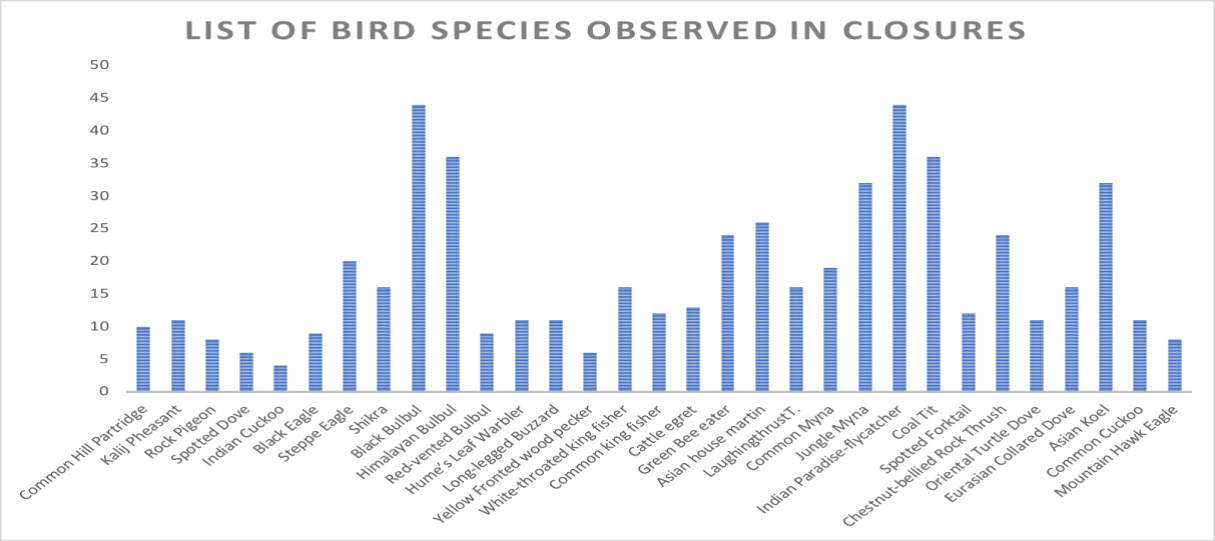


Fig.-3: Showing observed bird species in closures areas

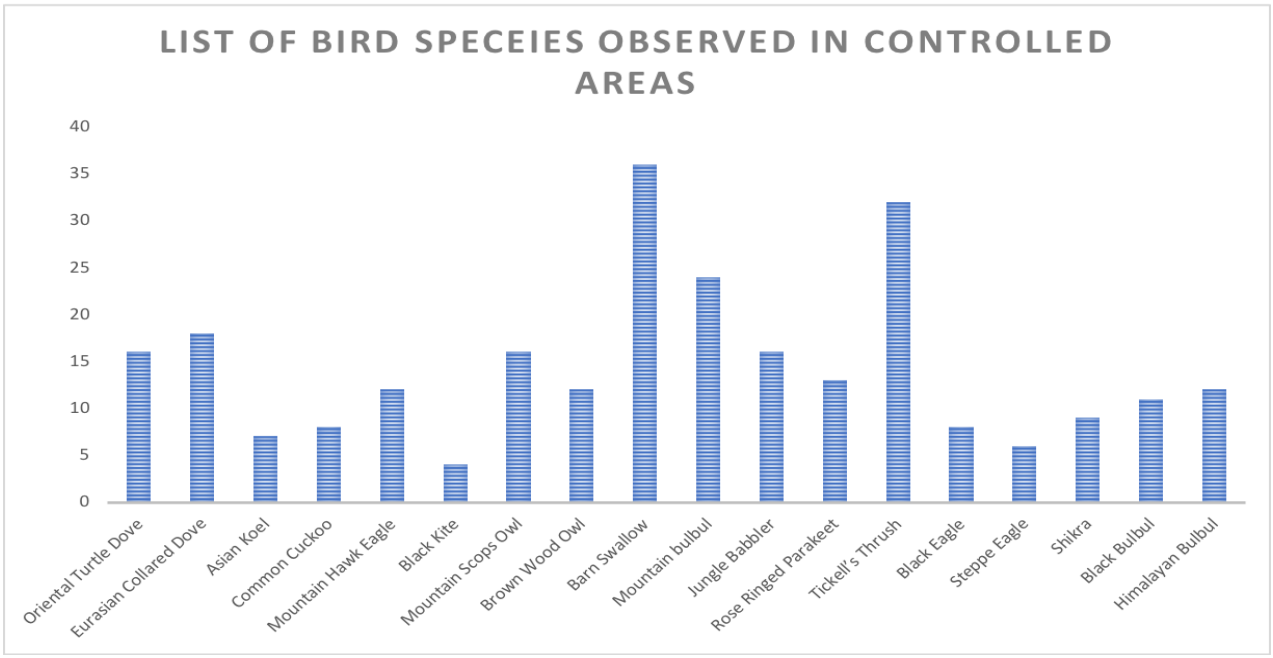


Fig.-4: Showing observed bird species in closures and controlled areas

Table-6: Showing family distribution inside BTAP closures

Family Distribution					
S.no		Frequency	Percent	Valid Percent	Cumulative Percent
1	Accipitridae	5	16.1	16.1	16.1
2	Alcedinidae	2	6.5	6.5	22.6
3	Ardeidae	1	3.2	3.2	25.8
4	Columbidae	4	12.9	12.9	38.7

5	Cuculidae	3	9.7	9.7	48.4
6	Hirundinidae	1	3.2	3.2	51.6
7	Leiothrichidae	1	3.2	3.2	54.8
8	Meropidae	1	3.2	3.2	58.1
9	Monarchidae	1	3.2	3.2	61.3
10	Muscicapidae	2	6.5	6.5	67.7
11	Paridae	1	3.2	3.2	71.0
12	passerine	1	3.2	3.2	74.2
13	Phasianidae	2	6.5	6.5	80.6
14	Phylloscopidae	1	3.2	3.2	83.9
15	Picidae	1	3.2	3.2	87.1
16	Pycnonotidae	2	6.5	6.5	93.5
17	Sturnidae	2	6.5	6.5	100.0
	Total	31	100.0	100.0	

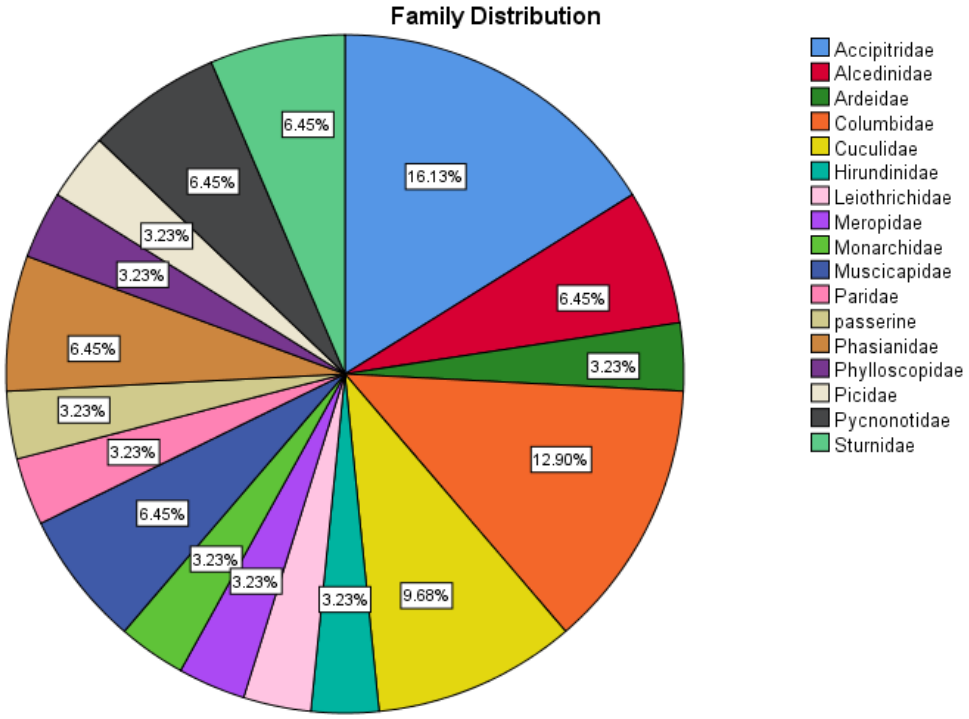


Fig. 5: Showing Birds family distribution inside BTAP closures

Table-7: Showing birds family Distribution in controlled areas

Family Distribution					
S. No.		Frequency	Percent	Valid Percent	Cumulative Percent
1	Accipitridae	5	27.8	27.8	27.8
2	Columbidae	2	11.1	11.1	38.9
3	Cuculidae	2	11.1	11.1	50.0
4	Hirundinidae	1	5.6	5.6	55.6
5	Leiothrichidae	1	5.6	5.6	61.1
6	Psittaculidae	1	5.6	5.6	66.7
7	Pycnonotidae	3	16.7	16.7	83.3
8	Strigidae	2	11.1	11.1	94.4
9	Turdidae	1	5.6	5.6	100.0
	Total	18	100.0	100.0	

Diversity Calculation

Simpson Diversity Index

Simpson index $D = 1 - \frac{\sum n (n-1)}{N (N-1)}$

Where:

n = number of individuals of each species

N = total number of individuals of all species

Table-8: Simpson diversity index for closures

S.NO	Common Name	Scientific Name	Number of Individual	Relative Abundance	n-1	n(n-1)
1	Common Hill Partridge	Arborophila torqueola	10	0.01808318	9	90
2	Kalij Pheasant	Lophura leucomelanos'	11	0.0198915	10	110
3	Rock Pigeon	Columba livia	8	0.01446655	7	56
4	Spotted Dove	S. chinensis	6	0.01084991	5	30
5	Indian Cuckoo	Cuculus micropterus	4	0.00723327	3	12
6	Black Eagle	Ictinaetus malaiensis	9	0.01627486	8	72
7	Steppe Eagle	Aquila nipalensis	20	0.03616637	19	380
8	Shikra	Accipiter badius	16	0.02893309	15	240

9	Black Bulbul	Hypsipetes leucocephalus	44	0.079566	43	1892
10	Himalayan Bulbul	Pycnonotus leucogenis	36	0.06509946	35	1260
11	Red-vented Bulbul	P.cafer	9	0.01627486	8	72
12	Hume's Leaf Warbler	Abrornis humei	11	0.0198915	10	110
13	Long-legged Buzzard	Buteo rufinus	11	0.0198915	10	110
14	Yellow Fronted wood pecker	Melanerpes flavifrons	6	0.01084991	5	30
15	White-throated king fisher	Halcyon smyrnensis	16	0.02893309	15	240
16	Common king fisher	Alcedo atthis	12	0.02169982	11	132
17	Cattle egret	Bubulcus ibis	13	0.02350814	12	156
18	Green Bee eater	Merops orientalis	24	0.04339964	23	552
19	Asian house martin	Delichon dasypus	26	0.04701627	25	650
20	LaughingthrustT.	T.erythrocephlaum	16	0.02893309	15	240
21	Common Myna	Acridotheres tristis	19	0.03435805	18	342
22	Jungle Myna	A.fuscus	32	0.05786618	31	992
23	Indian Paradise-flycatcher	Terpsiphone paradisi	44	0.079566	43	1892
24	Coal Tit	Periparus ater	36	0.06509946	35	1260
25	Spotted Forktail	Enicurus maculatus	12	0.02169982	11	132
26	Chestnut-bellied Rock Thrush	M.refiventris	24	0.04339964	23	552
27	Oriental Turtle Dove	Stregtopelia orientalis	11	0.0198915	10	110
28	Eurasian Collared Dove	S.decaocto	16	0.02893309	15	240
29	Asian Koel	Eudynamys scolopaceus	32	0.05786618	31	992
30	Common Cuckoo	C.canorus	11	0.0198915	10	110
31	Mountain Hawk Eagle	Nisaetus nipalensis	8	0.01446655	7	56
Total			**553**			**13112**

N = 553,
N-1 = 553-1 = 552
N(N-1) = 553(552)
= 305256

Simpon Diversity Index for Closure

$$D = 1 - \frac{\sum n(n-1)}{N(N-1)}$$

$$= 1 - \frac{13112}{305256}$$

=0.95 (95% different species)

Table-9: Simpson diversity index for controlled areas

S. No.	Common Name	Scientific Name	Number of Individual	Relative Abundance	n-1	n(n-1)
1.	Oriental Turtle Dove	Stregtopelia orientalis	16	0.06153846	15	240
2.	Eurasian Collared Dove	S.decaocto	18	0.06923077	17	306
3.	Asian Koel	Eudynamys scolopaceus	7	0.02692308	6	42
4.	Common Cuckoo	C.canorus	8	0.03076923	7	56
5.	Mountain Hawk Eagle	Nisaetus nipalensis	12	0.04615385	11	132
6.	Black Kite	Milvus migrans	4	0.01538462	3	12
7.	Mountain Scops Owl	Otus spilocephalus	16	0.06153846	15	240
8.	Brown Wood Owl	Strix leptogrammica	12	0.04615385	11	132
9.	Barn Swallow	Hirundo rustica	36	0.13846154	35	1260
10.	Mountain bulbul	Ixos mcclellandii	24	0.09230769	23	552
11.	Jungle Babbler	Turdoides straita	16	0.06153846	15	240
12.	Rose Ringed Parakeet	Psittacula krameri	13	0.05	12	156
13.	Tickell's Thrush	T.unicolor	32	0.12307692	31	992
14.	Black Eagle	Ictinaetus malaiensis	8	0.03076923	7	56
15.	Steppe Eagle*	Aquila nipalensis	6	0.02307692	5	30
16.	Shikra*	Accipiter badius	9	0.03461538	8	72
17.	Black Bulbul	Hypsipetes leucocephalus	11	0.04230769	10	110
18.	Himalayan Bulbul	Pycnonotus leucogenis	12	0.04615385	11	132

Total	**260**			**4760**

N = 260,
N-1 = 260-1 = 259
N(N-1) = 260(259)
= 67340

Simpon Diversity Index for Controlled Area

$$D = 1 - \frac{\sum n(n-1)}{N(N-1)}$$

$$= 1 - \frac{4760}{67340}$$

=0.92 (92% different species)

Table-10: Simpson diversity index rank table

Rank	Index value	Diversity
4	S > 0.65	High diversity
3	S=0.55 - 0.65	Medium Diversity
2	S= 0.45 - 0.55	Low Diversity
1	S< 0.45	Near specialization

Shannon diversity index:

$$H = -\sum_{i=1}^{s} pi\log(pi)$$

where:
H = Shannon Index
Pi = Proportion of each i^{th} species
S = Number of species in a community
i = Constant
Log = Natural Logarithm

Table-11: Simpson diversity index for closures

S. No.	Common Name	Family	Number of Individual	pi (proportion)	Log (pi)	-pi*log (pi)
1	Common Hill Partridge	Arborophila torqueola	10	0.01808318	4.01277291	0.07256371
2	Kalij Pheasant	Lophura leucomelanos'	11	0.0198915	3.91746273	0.07792421
3	Rock Pigeon	Columba livia	8	0.01446655	4.23591646	0.06127908
4	Spotted Dove	S. chinensis	6	0.01084991	4.52359853	0.04908064
5	Indian Cuckoo	Cuculus micropterus	4	0.00723327	4.92906364	0.03565326
6	Black Eagle	Ictinaetus malaiensis	9	0.01627486	4.11813342	0.06702206

7	Steppe Eagle	Aquila nipalensis	20	0.03616637	3.31962573	0.1200588
8	Shikra	Accipiter badius	16	0.02893309	3.54276928	0.10250327
9	Black Bulbul	Hypsipetes leucocephalus	44	0.079566	2.53116837	0.20139495
10	Himalayan Bulbul	Pycnonotus leucogenis	36	0.06509946	2.73183906	0.17784124
11	Red-vented Bulbul	P.cafer	9	0.01627486	4.11813342	0.06702206
12	Hume's Leaf Warbler	Abrornis humei	11	0.0198915	3.91746273	0.07792421
13	Long-legged Buzzard	Buteo rufinus	11	0.0198915	3.91746273	0.07792421
14	Yellow Fronted wood pecker	Melanerpes flavifrons	6	0.01084991	4.52359853	0.04908064
15	White-throated king fisher	Halcyon smyrnensis	16	0.02893309	3.54276928	0.10250327
16	Common king fisher	Alcedo atthis	12	0.02169982	3.83045135	0.0831201
17	Cattle egret	Bubulcus ibis	13	0.02350814	3.75040864	0.08816512
18	Green Bee eater	Merops orientalis	24	0.04339964	3.13730417	0.13615787
19	Asian house martin	Delichon dasypus	26	0.04701627	3.05726146	0.14374105
20	LaughingthrustT.	T.erythrocephlaum	16	0.02893309	3.54276928	0.10250327
21	Common Myna	Acridotheres tristis	19	0.03435805	3.37091902	0.11581819
22	Jungle Myna	A.fuscus	32	0.05786618	2.8496221	0.16489676
23	Indian Paradise-flycatcher	Terpsiphone paradisi	44	0.079566	2.53116837	0.20139495
24	Coal Tit	Periparus ater	36	0.06509946	2.73183906	0.17784124
25	Spotted Forktail	Enicurus maculatus	12	0.02169982	3.83045135	0.0831201
26	Chestnut-bellied Rock Thrush	M.refiventris	24	0.04339964	3.13730417	0.13615787
27	Oriental Turtle Dove	Stregtopelia orientalis	11	0.0198915	3.91746273	0.07792421
28	Eurasian Collared Dove	S. decaocto	16	0.02893309	3.54276928	0.10250327
29	Asian Koel	Eudynamys scolopaceus	32	0.05786618	2.8496221	0.16489676
30	Common Cuckoo	C. canorus	11	0.0198915	3.91746273	0.07792421
31	Mountain Hawk Eagle	Nisaetus nipalensis	8	0.01446655	4.23591646	0.06127908
Total			**553**			**3.25721967**

Table-12: Simpson diversity index for controlled areas

S. No.	Common Name	Family	Number of Individual	pi (proportion)	Log (pi)	-pi*log (pi)
1.	Oriental Turtle Dove	Stregtopelia orientalis	16	0.06153846	-2.78809291	0.17157495
2.	Eurasian Collared Dove	S.decaocto	18	0.06923077	-2.67030987	0.18486761
3.	Asian Koel	Eudynamys scolopaceus	7	0.02692308	-3.61477148	0.09732077
4.	Common Cuckoo	C.canorus	8	0.03076923	-3.48124009	0.10711508
5.	Mountain Hawk Eagle	Nisaetus nipalensis	12	0.04615385	-3.07577498	0.14195885
6.	Black Kite	Milvus migrans	4	0.01538462	-4.17438727	0.06422134
7.	Mountain Scops Owl	Otus spilocephalus	16	0.06153846	-2.78809291	0.17157495
8.	Brown Wood Owl	Strix leptogrammica	12	0.04615385	-3.07577498	0.14195885
9.	Barn Swallow	Hirundo rustica	36	0.13846154	-1.97716269	0.27376099
10.	Mountain bulbul	Ixos mcclellandii	24	0.09230769	-2.3826278	0.21993487
11.	Jungle Babbler	Turdoides straita	16	0.06153846	-2.78809291	0.17157495
12.	Rose Ringed Parakeet	Psittacula krameri	13	0.05	-2.99573227	0.14978661
13.	Tickell's Thrush	T.unicolor	32	0.12307692	-2.09494573	0.25783947
14.	Black Eagle	Ictinaetus malaiensis	8	0.03076923	-3.48124009	0.10711508
15.	Steppe Eagle*	Aquila nipalensis	6	0.02307692	-3.76892216	0.08697513
16.	Shikra*	Accipiter badius	9	0.03461538	-3.36345705	0.11642736
17.	Black Bulbul	Hypsipetes leucocephalus	11	0.04230769	-3.16278636	0.13381019
18.	Himalayan Bulbul	Pycnonotus leucogenis	12	0.04615385	-3.07577498	0.14195885
Total			**260**			**2.73977589**

Table-13: Shannon Diversity Index Rank Table

Index Value	Diversity
<1.5	Low diversity
<2.5 --->1.5	Medium Diversity
>2.5	High Diversity

Sorenson Similarity Index

$$Cs = \frac{2(c)}{a+b}$$

c=Number of Common Species in both sites
a= Number of Species at Site A
b= Number of Species at Site B

Where Cs is the Sorensen's index of similarity, a is the number of species in the Closures areas (CPT- Baz-02, Kowari Genwal, Masar), b is the number of species in the Controlled areas (Baz Khan, Kowari Genwal, Masar), and c is the number of species common to both areas.

Table-14: Sorenson diversity index for both sites

S. No.	Common Name	Common Name
1	Common Hill Partridge	Oriental Turtle Dove
2	Kalij Pheasant	Eurasian Collared Dove
3	Rock Pigeon	Asian Koel
4	Spotted Dove	Common Cuckoo
5	Indian Cuckoo	Mountain Hawk Eagle
6	Black Eagle	Black Kite
7	Steppe Eagle	Mountain Scops Owl
8	Shikra	Brown Wood Owl
9	Black Bulbul	Barn Swallow
10	Himalayan Bulbul	Mountain bulbul
11	Red-vented Bulbul	Jungle Babbler
12	Hume's Leaf Warbler	Rose Ringed Parakeet
13	Long-legged Buzzard	Tickell's Thrush
14	Yellow Fronted wood pecker	Black Eagle
15	White-throated king fisher	Steppe Eagle
16	Common king fisher	Shikra
17	Cattle egret	Black Bulbul

18	Green Bee eater	Himalayan Bulbul
19	Asian house martin	
20	Laughing thrust	
21	Common Myna	
22	Jungle Myna	
23	Indian Paradise-flycatcher	
24	Coal Tit	
25	Spotted Forktail	
26	Chestnut-bellied Rock Thrush	
27	Oriental Turtle Dove	
28	Eurasian Collared Dove	
29	Asian Koel	
30	Common Cuckoo	
31	Mountain Hawk Eagle	

$$Cs = \frac{10}{31+18}$$

Sorensen's index of similarity Cs=0.20 (table 14)

Table-15: Various parameters used in controlled and closures in the research area

Parameter	Controlled Area	Closures
Number of values	9	9
Minimum	0.02308	0.01447
Maximum	0.06923	0.07957
Range	0.04615	0.06510
Mean	0.04274	0.03436
Std. Deviation	0.01507	0.02289
Std. Error of Mean	0.005025	0.007630
Lower 95% CI of mean	0.03115	0.01676
Upper 95% CI of mean	0.05432	0.05195
Geometric mean	0.04046	0.02902
Geometric SD factor	1.422	1.811
Harmonic mean	0.03832	0.02529
Quadratic mean	0.04504	0.04057

Relative Abundance descriptive Statistics

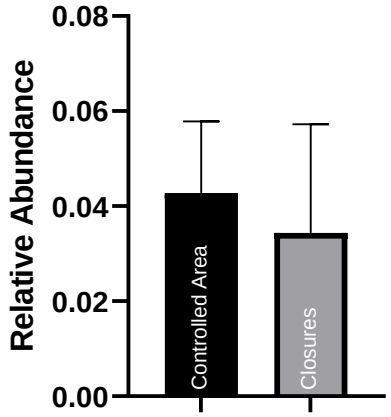


Fig. 6: Relative abundance descriptive Statistics

Bin Center	Controlled Area	Closures
0.01	0	1
0.02	1	3
0.03	3	2
0.04	1	1
0.05	2	0
0.06	1	0
0.07	1	1
0.08	0	1

Table-16: Showing the Bin centre in controlled and closures

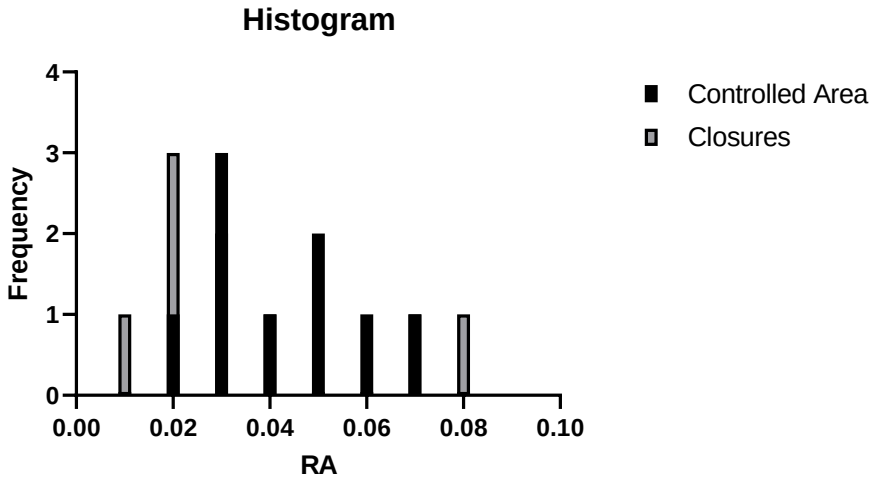


Fig. 7: Relative abundance descriptive Statistics

Table-17: T-Test performed for the various parameters

Table Analyzed	Histogram of Data 1: Frequency distribution
Column B	Closures
vs.	vs.
Column A	Controlled Area
Unpaired t test	
P value	>0.9999
P value summary	ns
Significantly different (P < 0.05)?	No
One- or two-tailed P value?	Two-tailed
t, df	t=0.000, df=14
How big is the difference?	
Mean of column A	1.125
Mean of column B	1.125
Difference between means (B - A) ± SEM	0.000 ± 0.4955
95% confidence interval	-1.063 to 1.063
R squared (eta squared)	0.000
F test to compare variances	
F, DFn, Dfd	1.000, 7, 7
P value	>0.9999
P value summary	ns
Significantly different (P < 0.05)?	No
Data analyzed	
Sample size, column A	8
Sample size, column B	8

In conclusion, the study underscores that BTAP Closures exhibit a higher diversity of bird species compared to the controlled area. This enhancement in avian biodiversity can be attributed to the positive impact of increased vegetation cover, improved control over grazing and forest fires, heightened regulation of hunting and poaching, and more efficient practices in the collection of grass and fuelwood. These collective efforts within the BTAP Closures have not only led to an enhancement in ecological conditions but have also contributed to an improvement in overall habitat quality.

Based on these findings, it is recommended that similar conservation measures and sustainable management practices be implemented in other regions to promote avian biodiversity. Strengthening community engagement, particularly through the active involvement of forest-based communities, can further enhance the success of such initiatives. Additionally, collaboration between local communities, government authorities, and environmental organizations is crucial for the continued success of conservation efforts. Ongoing monitoring and adaptive management strategies should be implemented to ensure the sustained improvement of ecological conditions and the preservation of diverse bird species within protected areas.

REFERENCES

Brooks, T. M., Collar, N. J., Green, R. E., Marsden, S. J. & Pain, D. J. (2008). The science of bird conservation. *Bird Conservation International*, 18(S1): S2-S12.

Carlton, C. Community Biodiversity Survey Manual-Birds Survey Methods [Online] 2023, Available at https://www.environment.nsw.gov.au/resources/howyoucanhelp/09birdsurveys baseline.pdf (accessed 7/14/2023).

Furness, R.W., Greenwood, J.J.D. & Jarvis, P.J. (1993). Can birds be used to monitor the environment?. In *Birds as monitors of environmental change* (pp. 1-41). Dordrecht: Springer Netherlands.

Narasimmarajan, K., Chetri, D., Ri, C. & Mathai, M. T. (2013). Bird Species of conservation concern along the Brahmaputra river in Assam, Northeast India. *Journal homepage*, 14 (2): 135-143.

Sekercioglu, C.H. 2006. Increasing awareness of avian ecological function. *Trends in Ecology & Evolution*, 21 (8): 464-471.

Singha Roy, U., Banerjee, P., & Mukhopadhyay, S. K. (2012). Study on avifaunal diversity from three different regions of North Bengal, India. *Asian Journal of Conservation Biology*, 1(2): 120–129.

Storch, D., Konvicka, M., Benes, J., Martinková, J. & Gaston, K.J. (2003). Distribution patterns in butterflies and birds of the Czech Republic: separating effects of habitat and geographical position. *Journal of Biogeography*, 30(8): 1195-1205.

Harper, D. A. T. (2001). PAST: paleontological statistics software package for education and data analysis. *Palae. Elec.*, 4: 4-12.

AUTHORS

First Author-Ahmad Zamir, PhD Scholar, Centre of Plant Biodiversity, University of Peshawar, Khyber Pakhtunkhwa, Pakistan
Second Author- Asad Ullah, Ph.D. Assistant Professor & Director Centre of Plant Biodiversity, University of Peshawar, Pakistan
Third Author- Dr. Syed Ghias Ali**,** Assistant Professor Centre of Plant Biodiversity, University of Peshawar, Pakistan
Correspondence Author – Asad Ullah, Ph.D. Assistant Professor & Director Centre of Plant Biodiversity, University of Peshawar, Pakistan, e-mail: asadcpb@uop.edu.pk, contact: 0092-91-9222267