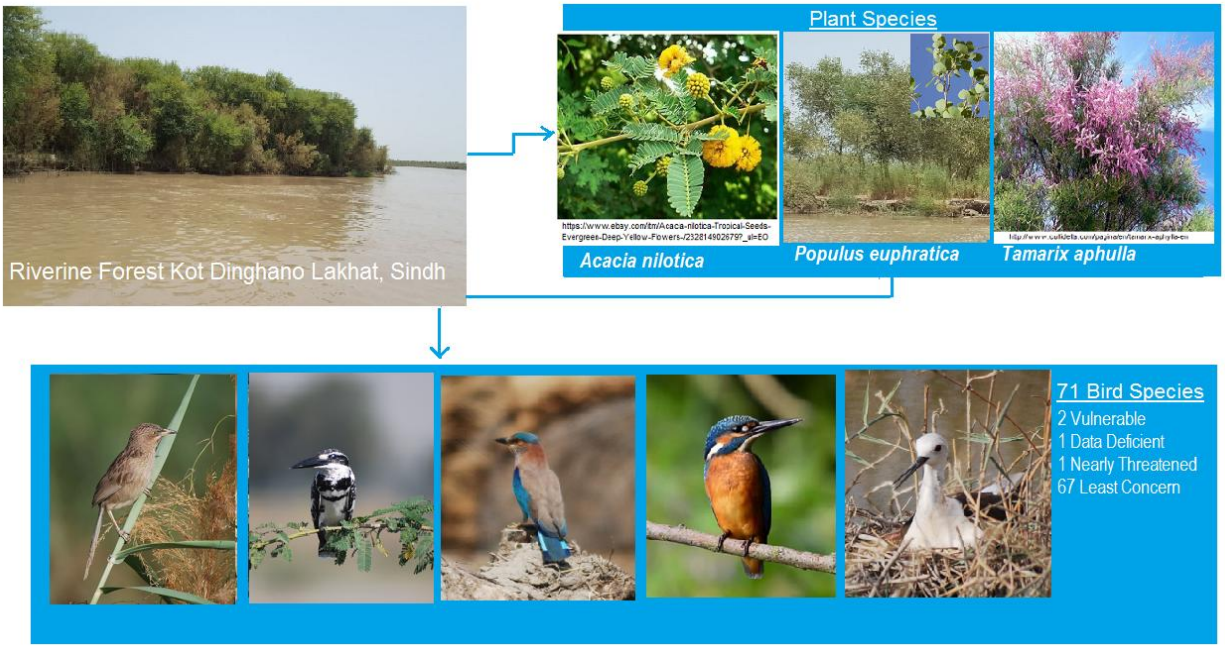
REPORT ON

CONSERVATION STATUS AND POPULATION STRUCTURE OF BIRDS IN RIVERINE FOREST HABITAT FOR FUTURE MANAGEMENT

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Summary

Riverine forest is unique and highly significant ecosystem, globally important for diverse and threatened avian species. Apart from cradle of life, i.e., it provides critical habitat for a wide array of avian species and serve as gene pool that harbors the variety of flora and fauna species. Unfortunately, this fragile riverine ecosystem facing a diversity of threats due to human interventions. Ascertaining the conservation status and population structure of birds inhabiting riverine forest habitat is utmost important for better future conservation and management actions. Distance sampling point count method was applied to perform multiple surveys during 15 consecutive months from January 2018 to March 2019. A total of 250–point count stations were fixed systematically at 300m intervals. Notably, 9929 bird individuals were detected representing 11 orders, 57 species and 34 families. Out of the 57 bird species, two species were vulnerable, one data deficient, one nearly threatened and rest 53 species least concern. The results revealed that Eurasian Collard Dove – *Streptopelia decaocto* (14.641 ± 2.532 / ha), White–eared Bulbul – *Pycnonotus leucotis* (13.398 ± 4.342/ ha) and Common Babbler – *Turdoides caudata* (10.244 ± 2.345/ ha) were three the most dominant bird species with the highest population. However, the population of three species, i.e., Lesser Whitethroat – *Sylvia curruca,* Grey Heron – *Ardea cinerea* and Pallas Fish Eagle – *Haliaeetus leucoryphus* were not analyzed due to small sample size. CAP analysis indicated that Riverine forest harbored the diverse avian species that evenly distributed across the forest. Ten foraging guilds were detected, i.e., Insectivore (27.60%) was the most abundant guild and Carnivore/Insectivore (0.14%) was the rarest guild. Overall, results revealed that Riverine forest is a highly productive and attractive habitat for the survival of a wide array of avian species.



INTRODUCTION

Conservation status and population structure indicate the habitat productivity, extent and severity of human footprints on avian species and its habitat. This could be due that, bird species play a significant role in the management of riverine forest ecosystem health, (i.e., they indicate habitat quality, restoration success, conservation plans) and protection. The Bird's population structure reflects long term temporal changes in forest vegetation cover, management activities and threats caused by anthropogenic activities due to which some species become threatened, endangered and vulnerable.

Riverine forest is unique and highly significant ecosystem, globally important for diverse and threatened avian species. Apart from cradle of life, i.e., it provides critical habitat for a wide array of avian species and serve as gene pool that harbors the variety of flora and fauna species. Riverine forest are the forefront of conservation and protection due to high dependence of local communities for livelihood and are hotspots for agriculture cultivation.

Over exploitation of the riverine forest of Pakistan, especially Sindh had declined the forest cover at the alarm rate due to deforestation for agriculture expansion and human settlement purposes. Furthermore, the flora and fauna of the riverine forest are poorly examined and its importance often undervalued and appreciated. In Pakistan, huge riverine forested areas have been lost and degraded due to human interventions that ultimately declined the population of bird species. The habitat loss and degradation due to human footprints in land use pattern, uncontrolled used of pesticides, illegal hunting and trapping, the population of various wildlife species has declined at an alarming rate. For example; Sociable Lapwing – *Vanellus gregarious,* Jerdon's Babbler – *Moupinia altirostris,* Marbled Duck – *Marmaronetta angustriostris,* Sarus Crane – *Grus antigone,* Ferruginous Duck – *Aythya nyroca,* Lesser White–fronted Goose –

Anser erythropus and White–headed Duck – *Oxyura leucocephala* that has become threatened and endangered due to human interventions.

Unfortunately, no study has been conducted to examine the conservation status and population structure of bird in Riverine forest habitats. The conservation status and population structure of birds inhabiting in riverine forest for the better future management and to reduce the threats was ascertained.

Methodology

Study Area: This study was carried out in the Kot Dinghano Riverine forest located along the right bank of Indus River Lakhat within 101°10′ to 101°50′ longitude and 2°50′ and 3°00′ latitude (Figure 1) in district Shaheed Banazirabad, Sindh Pakistan. This Riverine forest encompasses of about 4000 acres and has distinctive features, i.e., heterogeneity landscape that's comprised of forest, wetlands and agricultural fields, that represents specific environmental features to harbor the game and non-game birds. The vegetation comprised of Gum Arabic Tree – *Acacia nilotica*, Euphrate Poplar – *Populus euphratica*, Athel Tamarix – *Tamarix aphylla*, Salt Ceder or Ghaz – *T. dioica*, Phulai – *Acacia modesta*, Ghaf – *Prosopis cinerea*, Indian Jujubi – *Ziziphus jujuba* and Black–honey Shrub – *Phyllanthus reticulatus*. The Riverine forest blessed with a wide array of vegetation structure, food resources and breeding grounds that has potential to attract the avian species.

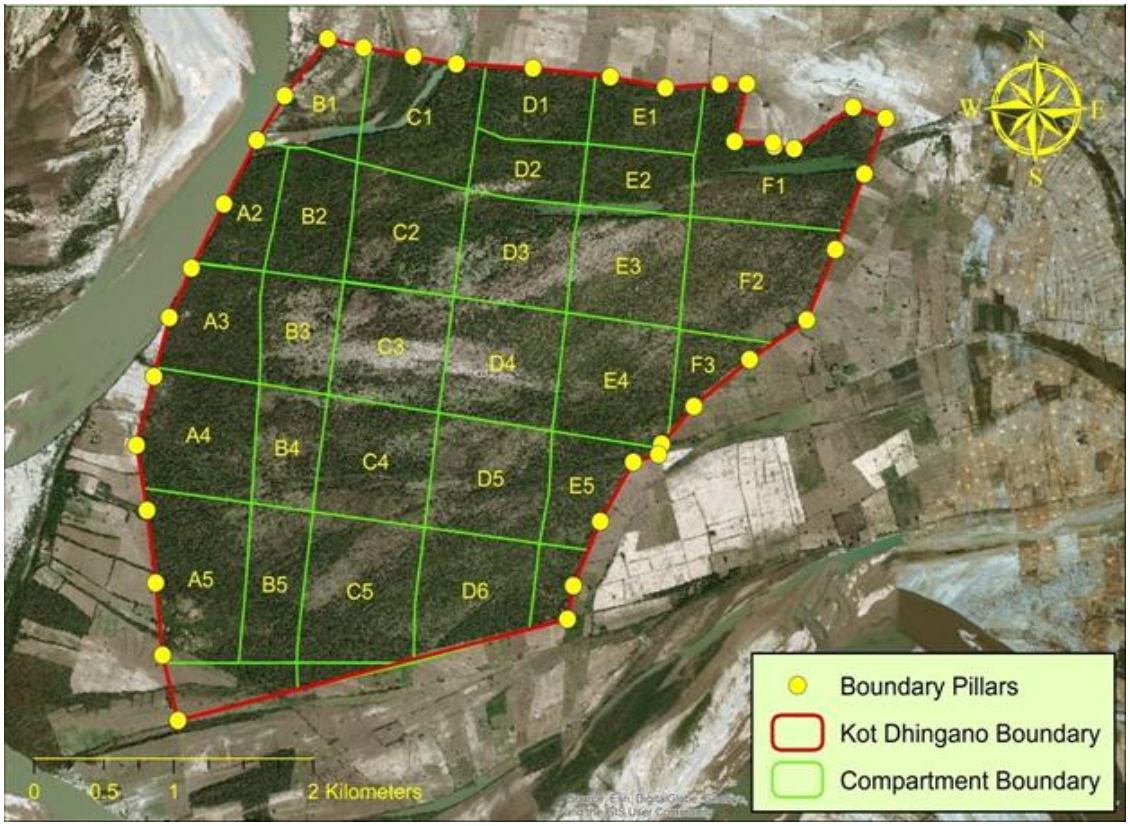


Figure 1: Location map of the study area



Figure 2: Aesthetic view of the riverine forest habitat

Survey of Bird Species:

Bird surveys were performed employing the Distance sampling point count method during 15 consecutive months from January 2018 to March 2019. Distance sampling point count method is one of the most common quantitative and robust method to examine population structure and habitat characteristics across the different habitats. This method involves the visual and auditory detection of birds with fixed or variable radius plots and it provides important information on the bird population structure and habitat characteristics (Verner and Ritter, 1985; Mills et al., 2000). However, the detections of birds in the Riverine forest habitat might vary depending on vegetation foliage density, canopy cover, visibility, and perception of sounds and observer's skill.

A total 250-point count stations were fixed at 300m intervals randomly to avoid double counting the same bird individuals at more than one station. The birds were surveyed at each point count station for 15 minutes. The distance from the bird to the observer was recorded using visual estimation within 100 m long distance bands. The surveys were carried out early in the morning 07.00–11.00 hrs. This time is appropriate and the most birds are active. However, flying birds was not recorded because their original positions were unknown..

Vegetation Survey

Vegetation cover is the one of the most important attribute to determine the vegetation structure and composition. This could be that, it indicates how much area covered by vegetation (e.g., trees, shrubs, weed and grasses) and indicate the habitat structure, habitat suitability and productivity to harbor the avian species. The vegetation structure was determined using the quadrat method. In this study, various sizes of quadrate were used, e.g., for trees 20x20m, for shrubs 5x5m and for grasses and weed 1x1m to examine the floral species composition, and vegetation cover percentage.

DATA ANALYSIS

IUCN Status: The conservation status of recorded bird species was identified with the comparison of IUCN Red List (2018).

Relative Abundance: Relative abundance (%) of documented bird individuals of each species was divided by the total observed bird individuals of all species.

Bird Density**:** It is a number of birds per unit area in a Riverine habitat. The density of each keystone bird species was determined using the Distance Software (Version, 6.0). The key to distance sampling is to use the distribution of the observed distances to estimate the "detection function," *g* (*y*), the probability of detecting a bird at distance *y*. This function can then be used to estimate the average probability of detecting a bird given that it is within *w* of the point, denoted *Pa*. Given an estimate of *Pa*, bird density can be estimated as;

$$\hat{D} = \frac{1}{a} \sum_{i=1}^{n} \frac{1}{\hat{P}_a(\mathbf{z}_i)}$$

Where, a is the size of the covered region, *n is* the number of birds seen, and *P*ˆ *a* (**z***i*) is the estimated probability of detecting the *i*th bird given that it is within *w* of the point and has the covariate values **z***i*.

Diversity Indices**:** Diversity indices have been used in many studies across diverse sub-fields of ecology such as; forest, plant community ecology, macro-benthic community ecology and wetland habitats. CAP Software used to determine the diversity indices of bird species of Kot Dinghano Riverine forest.

Foraging Guild Structure**:** Foraging guild structure is a group of bird species that exploit similar food items and techniques to obtain the food. The foraging behavior of all detected bird species was categorized into 10 different foraging guilds based on major food consumption, similar techniques employed while foraging and habitat preference.

***Vegetation Importance Value Index*:** Importance value index, indicates the importance of trees, shrubs, weed and grasses of a particular riverine forest habitat. It considers the relative value of density, frequency, and biomass of each species that indicate the ecological importance of vegetation structure in a dwelling habitat. Importance value index, demonstrates the potential of productivity of a particular habitat and revealed the most dominant species and the rarest one in the riverine forest. The value of vegetation structure; IVI was determined through employing the following formula;

$$IVI = RF + RD + RC$$

Where as; RF = Relative frequency, RD = Relative Density and RC = /Relative Cover

***Relative Density (RD)*:** Density is a number individual of a particular plant species per unit area (ha or Km^2). The Relative Density (RD) is a percentage of each plant species that contribute to the total number of plants in the area. RD = No. of Individuals of each plant species X 100/total number of plant individuals of all detected plant species.

***Relative Frequency (RF)*:** Frequency may define as a percentage of the quadrate in which a plant species occurs. Relative Frequency (RF) is a percentage frequency of the total frequency. RF = No of quadrate in which plant species occur X 100/Total No. of quadrate taken.

KEY FINDINGS

Bird Species Composition and Relative Abundance: Point count method detected 9929 bird individuals belong to 11 orders, 57 species and 34 families. Out of 57 species, two species were vulnerable, one species data deficient, one nearly threatened while rest 53 species were least concern. The results revealed that Eurasian Collard Dove – *Streptopelia decaocto* (15.56%), White–eared Bulbul – *Pycnonotus leucotis* (11.94%), and Grey Francolin – *Francolinus pondicerianus* (10.17%) were the three most dominant bird species having the highest relative abundance in the Kot Dinghano Riverine forest. In contrast, Lesser Whitethroat – *Sylvia curruca* (0.07%), Grey Heron – *Ardea cinerea* (0.06%), and Pallas Fish Eagle – *Haliaeetus leucoryphus* (0.05%) were the rarest bird species inhabited in the study area (Table 1).

Table 1: Relative abundance of avian species detected in Kot Dinghano Riverine forest, Lakhat

S. No	Scientific Name	Common Name	No of Detections	%	IUCN Status
Order Accipitriformes					
Family Accipitridae					
1	*Aquila rapax*	Tawny Eagle	28	0.28	LC
2	*Accipiter nisus*	Eurasian Sparrow Hawk	17	0.17	LC
3	*Accipiter virgatus*	Besra	15	0.15	LC
4	*Haliaeetus leucoryphus*	Pallas Fish Eagle	5	0.05	VU
Order Anseriformes					

Family Anatidae					
5	*Anas strepera*	Gadwall	167	1.68	LC
Order Bucerotiformes					
Family Upupidae					
6	*Upupa epops*	Common Hoopoe	13	0.13	LC
Order Charadriiformes					
Family Charadriidae					
7	*Vanellus indicus*	Red-wattled Lapwing	216	2.18	LC
Family Scolopacidae					
8	*Tringa totanus*	Common Redshank	340	3.42	LC
9	*Tringa. Hypoleucos*	Common Sandpiper	102	1.03	LC
10	*Tringa glareola*	Wood Sandpiper	12	0.12	LC
11	*Tringa stagnatilis*	Marsh Sandpiper	58	0.59	LC
Family Recurvirostridae					
12	*Himantopus himantopus*	Black-winged Stilt	180	1.18	LC
Family Laridae					
13	*Sterna aurantia*	River Tern	143	1.44	LC
14	*Sterna acuticauda*	Black-bellied Tern	26	0.26	NT
Order Columbiformes					
Family Columbidae					
15	*Streptopelia decaocto*	Eurasian Collard Dove	1545	15.56	LC
16	*Spiopelia senegalensis*	Laughing Dove	26	0.26	LC
Order Coraciiformes					
Family Alcidinidae					
17	*Ceryle rudis*	Pied Kingfisher	132	1.33	LC
18	*Halcyon smyrnensis*	White-throated Kingfisher	72	0.73	LC
19	*Alcedo atthis*	Common Kingfisher	45	0.45	LC
Family Coraciidae					
20	*Coracias benghalensis*	Indian Roller	23	0.23	LC
Family Meropidae					
21	*Merops orientalis*	Green Bee-eater	34	0.34	LC
Family Phasianidae					
22	*Francolinus pondicerianus*	Grey Francolin	1010	10.17	LC
Order Gruiformes					
Family Rallidae					
23	*Gallinula chloropus*	Common Moorhen	25	0.25	LC
Family Alaudidae					
24	*Ammomanes phoenicura*	Rufous-tailed Lark	17	0.17	LC
25	*Galerida cristata*	Crested Lark	16	0.16	LC
Family Campephagidae					

26	*Pericrocotus cinnamomeus*	Small Minivet	12	0.12	LC
Family Cisticolidae					
27	*Prinia inornata*	Plain Prinia	12	0.12	LC
Family Corvidae					
28	*Dendrocitta vagabunda*	Rufous Treepie	194	1.95	LC
29	*Corvus splendens*	House Crow	126	1.27	LC
Family Cuculidae					
30	*Centropus sinensis*	Greater Coucal	14	0.14	LC
Family Dicruridae					
31	*Dicrurus macrocercus*	Black Drongo	32	0.32	LC
Family Hirundinidae					
32	*Riparia paludicola*	Brown-throated Sand Martin	384	3.86	LC
Family Leiothrichidae					
33	*Turdoides striata*	Jungle Babbler	648	6.53	LC
34	*Turdoides caudata*	Common Babbler	322	3.24	LC
Family Motacillidae					
35	*Motacilla alba*	White Wagtail	125	1.26	LC
Family Muscicapidae					
36	*Phoenicurus ochruros*	Black Redstart	215	2.17	LC
37	*Saxicoloides fulicatus*	Indian Robin	214	2.16	LC
38	*Saxicola caprata*	Pied Bush Chat	175	1.76	LC
39	*Muscicapa sibirica*	Dark-sided Flycatcher	117	1.18	LC
Family Nectarniidae					
40	*Cinnyris asiaticus*	Purple Sunbird	21	0.21	LC
Family Passeridae					
41	*Passer domesticus*	House Sparrow	55	0.55	LC
Family Pellorneidae					
42	*Chaetornis striata*	Bristled Grassbird	326	3.28	VU
Family Phylloscopidae					
43	*Phylloscopus neglectus*	Plain Leaf Warbler	432	4.35	LC
44	*Phyllosocopus inornatus*	Yellow-browed Warbler	45	0.45	LC
Family Pycnonotidae					
45	*Pycnonotus cafer*	Red-vented Bulbul	121	1.22	LC
46	*Pycnonotus leucotis*	White-eared Bulbul	1186	11.94	LC
Family Rhipiduridae					
47	*Rhipidura aureola*	White-browed Fantail	217	2.19	LC
Family Sylviidae					
48	*Sylvia curruca*	Lesser Whitethroat	7	0.07	LC
Order Pelecaniformes					

Family Ardeidae					
49	*Ardeola grayii*	Indian Pond Heron	219	2.21	LC
50	*Egretta garzetta*	Little Egret	183	1.84	LC
51	*Egretta albus*	Great Egret	89	0.90	LC
52	*Butriodes striata*	Little Heron	29	0.29	LC
53	*Ardea cinerea*	Grey Heron	6	0.06	LC
Order Piciformes					
Family Picidae					
54	*Dinopium javanense*	Common Flameback	34	0.34	LC
Order Podicipediformes					
Family Podicipedidae					
55	*Tachybaptus ruficollis*	Little Grebe	23	0.23	LC
Order Suliformes					
Family Phalacrocoracidae					
56	*Microcarbo niger*	Little Cormorant	44	0.44	LC
57	*Phalacrocorax carbo*	Great Cormorant	35	0.35	DD
		Total	**9929**		

LC = Least Concern, VU = Vulnerable, DD = Data Deficient, NT = Nearly Threatened,

Bird Density: The results of Distance Software Analysis (DSA) indicated that four bird species, namely; Eurasian Collard Dove – *Streptopelia decaocto* (14.641 ± 2.532 / ha), White-eared Bulbul – *Pycnonotus leucotis* (13. 398 ± 4.342 / ha), Common Babbler – *Turdoides caudate* (10.244 ± 2.345 / ha), and Grey Francolin – *Francolinus pondicerianus* (9.453 ± 4.321 / ha) had highest bird density/ha. In contrast, the lowest bird density/ha was recorded for House Sparrow – *Passer domesticus* (0.231 ± 0.127 / ha) followed by Small Minivet – *Pericrocotus cinnamomeus* (0.213 ± 0.121 / ha) and Eurasian Sparrow Hawk – *Accipiter nisus* (0.172 ± 0.122 / ha). Furthermore, the density of 3 species, i.e., Lesser Whitethroat – *Sylvia curruca,* Grey Heron – *Ardea cinerea* and Pallas Fish Eagle – *Haliaeetus leucoryphus* were not analyzed due to small sample size, i.e., less than ten individuals detected (Table 2).

Table 2: List of bird Density (birds / ha) in Kot Dinghano Riverine forest

Family	Scientific Name	Common Name	Density (birds / ha)/ Density at 95% CFI (birds / ha)	Detection Probability (%)
Columbidae	*Streptopelia decaocto*	Eurasian Collard Dove	14.641 ± 2.532/6.893– 17.438 (n = 1545)	98.60%
Pycnonotidae	*Pycnonotus leucotis*	White-eared Bulbul	13.398 ± 4.342/10.598 – 14.681 (n = 1186)	95.00%
Leiothrichidae	*Turdoides caudata*	Common Babbler	10.244 ± 2.345/8.538 – 10.983 (n = 322)	89.30%
Phasianidae	*Francolinus pondicerianus*	Grey Francolin	9.453 ± 4.321/6.58 – 11.385 (n = 1010)	99.40%
Phylloscopidae	*Phylloscopus neglectus*	Plain Leaf Warbler	6.947 ± 2.092/4.348 – 7.632 (n = 432)	99.90%
Hirundininae	*Riparia paludicola*	Brown-throated Sand Martin	6.238 ± 4.464/3.761 – 6.332 (n = 384)	93.70%
Leiothrichidae	*Turdoides striata*	Jungle Babbler	4.755 ± 1.980/2.985 – 6.324 (n = 648)	83.90%
Muscicapidae	*Saxicola caprata*	Pied Bush Chat	4.213 ± 0.893/2.653– 5.921 (n = 175)	99.20%
Meropidae	*Merops orientalis*	Green Bee-eater	3.763 ± 1.232/1.562 – 4.345 (n = 34)	100.00%
Pycnnotidae	*Pycnonotus cafer*	Red-vented Bulbul	3.598 ± 1.672/1.324 – 3.326 (n = 121)	100.00%
Rhipiduridae	*Rhipidura aureola*	White-browed Fantail	3.463 ± 0.436/2.393 – 4.369 (n = 217)	98.30%
Corvidae	*Dendrocitta vagabunda*	Rufous Treepie	2.763 ± 0.564/1.648 – 3.984 (n = 134)	98.90%
Muscicapidae	*Phoenicurus ochruros*	Black Redstart	2.566 ± 0.456/1.678 – 3.427 (n = 215)	99.70%
Muscicapidae	*Saxicoloides fulicatus*	Indian Robin	2.129 ± 0.980/1.238 – 4.879 (n = 214)	100.00%
Anatidae	*Anas strepera*	Gadwall	2.129 ± 0.881/1.376 – 2.862 (n = 167)	77.60%
Scolopacidae	*Tringa totanus*	Common Redshank	1.983 ± 0.789/1.341 – 2.893 (n = 340)	98.70%
Pellorneidae	*Chaetornis striata*	Bristled Grassbird (VU)	1.899 ± 0.657/1.230 – 3.651 (n = 326)	99.70%
Dicruridae	*Dicrurus macrocercus*	Black Drongo	1.873 ± 0.983/1.275 – 2.384 (n = 32)	98.00%
Corvidae	*Corvus splendens*	House Crow	1.645 ± 0.78I/1.324 – 3.872 (n = 126)	93.20%
Phalacrocoracidae	*Microcarbo niger*	Little Cormorant	1.214 ± 0.678/0.789 – 1.543 (n = 44)	97.20%
Picidae	*Dinopium javanense*	Common Flameback	1.213 ± 0.311/0.873 – 2.098 (n = 34)	99.40%
Phylloscopidae	*Phyllosocopus inornatus*	Yellow-browed Warbler	1.021 ± 0.348/0.841 – 1.345 (n = 45)	98.20%
Ardeidae	*Egretta garzetta*	Little Egret	0.978 ± 0.423/0.345 – 1.321 (n = 123)	98.90%
Phalacrocoracidae	*Phalacrocorax carbo*	Great Cormorant (DD)	0.954 ± 0.342/0.745 – 1.832 (n = 35)	99.20%
Motacillidae	*Motacilla alba*	White Wagtail	0.879 ± 0.323/0.439 – 2.873 (n = 125)	99.90%
Muscicapidae	*Muscicapa sibrica*	Dark-sided Flycatcher	0.870 ± 0.343/0.438 – 2.073 (n = 117)	99.20%
Rallidae	*Gallinula chloropus*	Common Moorhen	0.732 ± 0.542/0.547 – 0.982 (n = 25)	98.00%
Scolopacidae	*Tringa stagnatilis*	Marsh Sandpiper	0.732 ± 0.230/0.342 – 0.984 (n = 58)	97.50%

Coraciidae	*Coracias bengalensis*	Indian Roller	0.682 ± 0.348/0.459 – 1.283 (n = 23)	98.50%
Ardeidae	*Butriodes striata*	Little Heron	0.678 ± 0.890/0.456 – 1.121 (n = 29)	97.9%
Podicipedidae	*Tachybaptus ruficollis*	Little Grebe	0.678 ± 0.438/0.453 – 0.862 (n = 23)	96.00%
Alaudidae	*Ammomanes phoenicura*	Rufous-tailed Lark	0.653 ± 0.398/0.432 – 0.982 (n = 17)	97.4%
Recurvirostridae	*Himantopus himantopus*	Black-winged Stilt	0.650 ± 0.289/0.237 – 0.983 (n = 180)	96.7%
Charadriidae	*Vanellus indicus*	Red-wattled Lapwing	0.649 ± 0.231/0.439 – 0.983 (n = 216)	94.90%
Alcidinidae	*Halcyon smyrnensis*	White-throated Kingfisher	0.637 ± 0.213/0.430 – 1.230 (n = 72)	99.40%
Upupidae	*Upupa epops*	Common Hoopoe	0.623 ± 0.489/0.457 – 0.983 (n = 13)	98.90%
Ardeidae	*Ardeola grayii*	Indian Pond Heron	0.623 ± 0.320/0.538– 0.738 (n = 219)	94.60%
Laridae	*Sterna aurantia*	River Tern	0.623 ± 0.308/0.325 – 1.653 (n = 143)	99.00%
Alcidinidae	*Alcedo atthis*	Common Kingfisher	0.565 ± 0.416/0.326 – 0.846 (n = 45)	98.50%
Nectariniidae	*Cinnyris asiaticus*	Purple Sunbird	0.562 ± 0.342/0.324 – 0.980 (n = 21)	98.00%
Scolopacidae	*Tringa glareola*	Wood Sandpiper	0.548 ± 0.348/0.420 – 0.894 (n = 12)	98.90%
Alcidinidae	*Ceryle rudis*	Pied Kingfisher	0.538 ± 0.243/0.387 – 0.753 (n = 132)	99.90%
Cuculidae	*Centropus sinensis*	Greater Coucal	0.532 ± 0.342/0.348 – 0.976 (n = 14)	98.90%
Accipitridae	*Aquila rapax*	Tawny Eagle	0.452 ± 0.148/0.432 – 0.879 (n = 28)	99.40%
Laridae	*Sterna acuticauda*	Black-bellied Tern (NT)	0.434 ± 0.252/0.289 – 0.842 (n = 26)	95.00%
Columbidae	*Spiopelia senegalensis*	Laughing Dove	0.421 ± 0.209/0.389 – 0.984 (n = 26)	97.50%
Scolopacidae	*Tringa. hypoleucos*	Common Sandpiper	0.342 ± 0.241/0.203 – 0.896 (n = 102)	98.20%
Cisticolidae	*Prinia inornata*	Plain Prinia	0.328 ± 0.234/0.298 – 0.563 (n = 12)	97.90%
Alaudidae	*Galerida cristata*	Crested Lark	0.324 ± 0.287/0.239 – 0.563 (n = 16)	98.90%
Ardeidae	*Egretta albus*	Great Egret	0.312 ± 0.143/0.231 – 0.781 (n = 36)	99.90%
Accipitridae	*Accipiter virgatus*	Besra	0.268 ± 0.126/0.213 – 0.424 (n = 15)	95.00%
Passeridae	*Passer domesticus*	House Sparrow	0.231 ± 0.127/0.162 – 0.329 (n = 55)	99.00%
Campephagidae	*Pericrocotus cinnamomeus*	Small Minivet	0.213 ± 0.121/0.198 – 0.563 (n = 12)	98.0%
Accipitridae	*Accipiter nisus*	Eurasian Sparrow Hawk	0.172 ± 0.122/0.128 – 0.450 (n = 17)	93.00%
Sylviidae	*Sylvia curruca*	Lesser Whitethroat	(n = 7)	–
Ardeidae	*Ardea cinerea*	Grey Heron	(n = 6)	–
Accipitridae	*Haliaeetus leucoryphus*	Pallas Fish Eagle (VU)	(n = 5)	–
		Total	**9929**	

Diversity Indices of Keystone Bird Species: In this study, species diversity is the number of different bird species that occurs in a Kot Dinghano Riverine habitat. The results of Community Analysis Package indicated that avian species are diverse (Shannon's N_1 = 16.56 –18.36), rich (Margalef's R_1= 5.977 – 6.088) and evenly (McIntosh E = 0.8721 – 0.8819) distributed in Kot Dinghano Riverine habitat. This indicated that riverine forest habitat characteristics, food resources, and less disturbance are major factors that had attracted a wide array of keystone bird species to utilize this fragile habitat (Table 3).

Table 3: Diversity indices of bird species in Kot Dinghano Riverine forest

Indices	**Index Values**
Diversity Index	
Shannon's Diversity index N_1	16.56 –18.36
Richness Index	
Margalef's Richness index R_1	5.977 – 6.088
Evenness Index	
McIntosh E	0.8721 – 0.8819

***Foraging Guilds*:** Ten avian foraging guilds detected in Kot Dinghano Riverine forest habitat. Notably, Insectivore (27.60%), Carnivore/Piscivore/Insectivore (18.95%) and Granivore (15.82%) were three the most abundant guilds that heavily utilize this riverine habitat. On the contrarily, Carnivore (0.65%), Nectarivore/Insectivore (0.21%) and Carnivore/Insectivore (0.14%) were the rarest guilds in the study area (Table 4).

Table 4: Foraging guild of avian species detected in Kot Dinghano Riverine forest habitat

Guild	**Total No of Individuals**	**Percentage (%)**
Insectivore	2740	27.60
Carnivore/Piscivore/Insectivore	1882	18.95
Granivore	1571	15.82
Frugivore/Insectivore	1307	13.16
Granivore/Insectivore	1191	12.00
Omnivore	867	8.73
Piscivore	271	2.73
Carnivore	65	0.65
Nectarivore/Insectivore	21	0.21

Carnivore/Insectivore	14	0.14
Total	**9929**	

Vegetation Structure and Importance Value Index

The vegetation structure indicated that Kot Dinghano Riverine forest is diverse and rich in plant species. IVI was used to determine the ecological importance of vegetation structure (trees, shrubs, weed and grasses) of Kot Dinghano Riverine forest as major driven factors that effects on habitat selection, food resource utilization, shelter and breeding grounds of a wide array of avian species. The vegetation structure demonstrated that riverine forest habitat comprised of trees, shrubs, weed and grasses.

Notably, the high importance value (23.91%) was determined for Gum Arabic Tree that shows that this tree species densely occupied the riverine forest and the lowest one (2.38%) for Jand, indicated the rare species that occupied only a small proportion of the study area. Likewise, IVI indicated that twiggy shrub (i.e., 35.88%) and black honey shrub (30.22%) were the most abundant shrubs that constitute of the around 65.0% of the total shrub covers. On the contrary, apple of Sodom (3.67%) and bindii (1.14%) were the rarest shrubs in the study area. Furthermore, IVI indicated that camel thorn bush was the dominant weed that contributed 10.98% and bitter apple (0.74%) was the rare weed that covered only small areas of the study area. Similarly, the highest index value was determined for big cordgrass that cover 33.16% of the ground cover and Kapok Bush was the less abundant that cover only (1.59%) of the ground vegetation. Overall, the IVI test findings revealed that riverine forest is encompasses of a wide array of trees, shrubs, weeds and grass. However, the ecological importance for avian species may vary from species to species (Table 5 and Figure 6 – 9).

Table 5: Vegetation structure and composition with importance value index

Family	**Scientific Name**	**Common Name**	**IVI (Importance Value Index)**
Trees			
Fabaceae	*Acacia nilotica*	Gum Arabic Tree	23.91
Fabaceae	*Prosopis cineraria*	Jand	17.64
Rhamnaceae	*Ziziphus mauritiana*	Indian Jujube	14.85
Tamricaceae	*Tamarix aphylla*	Athel Tree	14.98
Salicaceae	*Populus euphratica*	Bahan	14.39
Minmosaceae	*Acacia modesta*	Phulai	11.85
Salicaceae	*Salix tertrasperma*	Willow	2.38

Shrubs			
Tamricaceae	*Tamarix dioica*	Ghaz or Twiggy Shrub	35.88
Phyllanthaceae	*Phyllanthus reticulatus*	Black Honey Shrub	30.32
Poaceae	*Saccharum spontaneum*	Wild Sugar Cane	14.95
Capparaceae	*Capparis decidua*	Karira	13.04
Apocynaceae	*Calotropis procera*	Apple of Sodom	3.67
Zygophyllaceae	*Tribulus terrestris*	Bindii	1.14
Weed			
Rhamnaceae	*Alhaji maurorum*	Camelthorn Bush	11.98
Verbenaceae	*Phyla nodiflora*	Tangle Frogfruit	10.96
Solanaceae	*Solanum surattense*	Yellow Fruit Nightshade	9.83
Asteraceae	*Launaea procumbens*	Creeping Launaea	6.32
Boraginaceae	*Heliotropium sp*	Indian Helitrope	6.26
Asteraceae	*Sonchus asper*	Spiny Swothistle	6.25
Amaranthaceae	*Chenopodium album*	Pig Weed	3.69
Polygonaceae	*Polygonum plebeium*	Knot Weed	3.21
Phyllanthaceae	*Phyllanthus sp*	Black Catnip	2.68
Euphorbiaceae	*Euphorbia prostrata*	Prostrate Sandmat	1.69
Solanaceae	*Solanum nigrum*	Black Nightshade	1.50
Asteraceae	*Eclipta alba*	False Daisy	1.12
Cucurbitaceae	*Citrullus colocynthis*	Bitter Apple	0.74
Grasses			
Poaceae	*Desmostachya bipinnata*	Big Caordgrass	33.16
Poaceae	*Cynodon dactylon*	Scutch Grass	17.72
Amaranthaceae	*Amaranthus viridis*	Slender Amaranth	5.73
Cypraceae	*Cyperus sp*	Nut Grass	4.68
Amaranthaceae	*Aerva javanica*	Kapok Bush	1.59

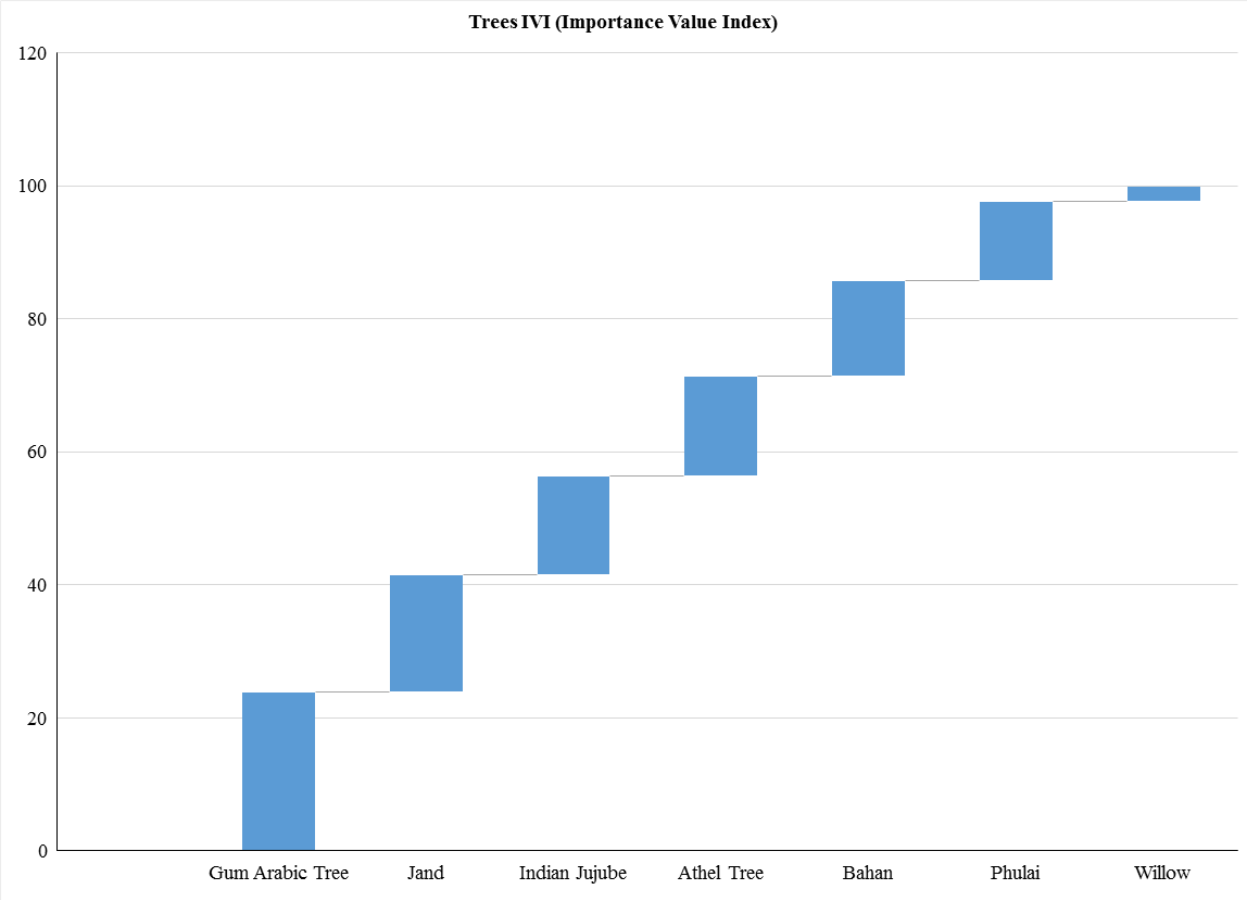


Figure 3: Importance Value Index of trees species of riverine forest habitat

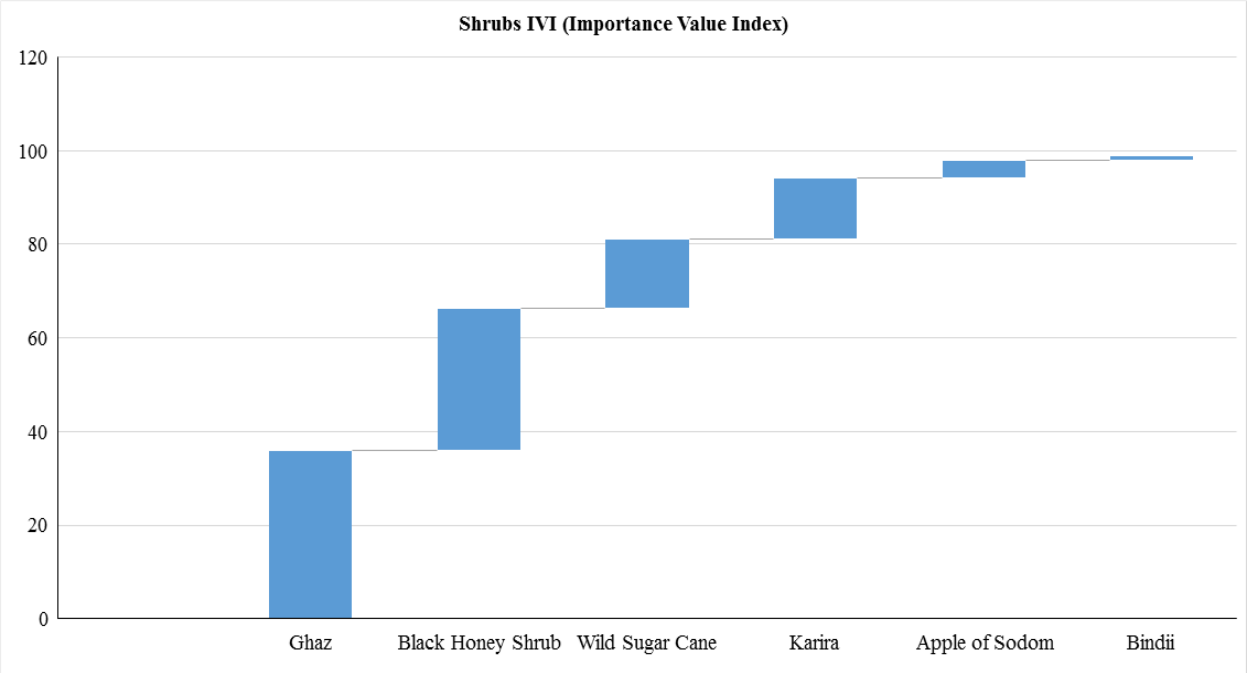


Figure 4: Importance Value Index of shrub species of riverine forest habitat

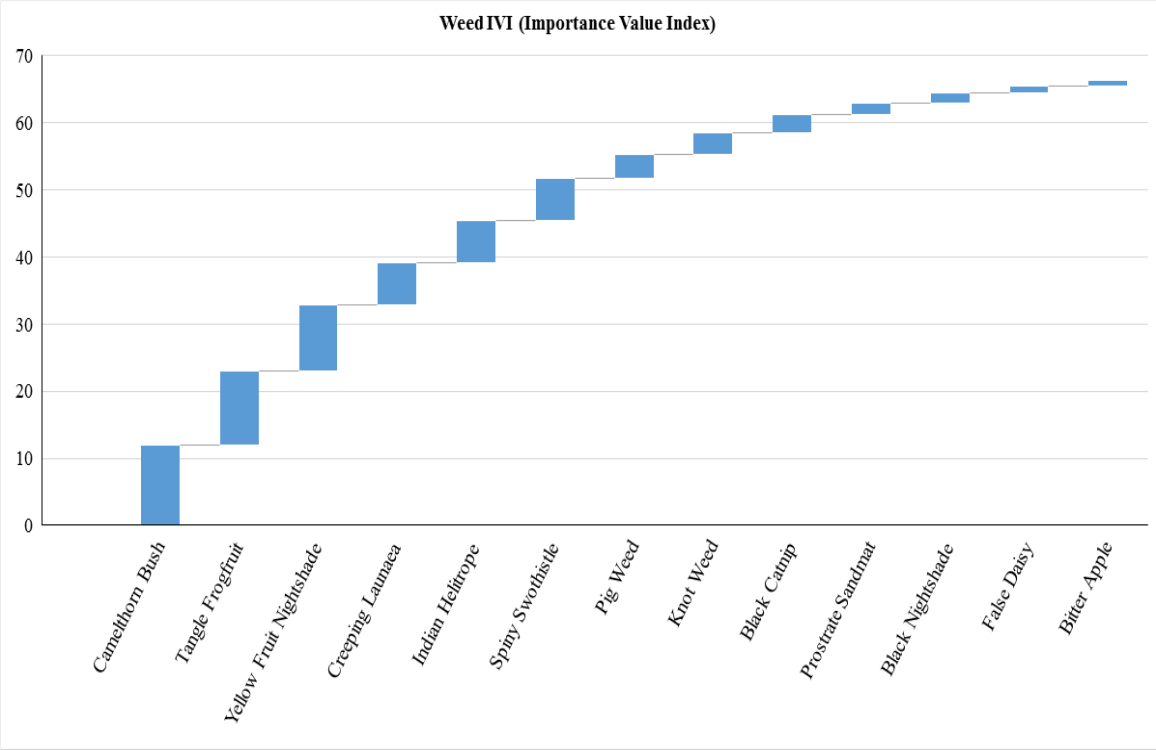


Figure 5: Importance Value Index of weed species of riverine forest habitat

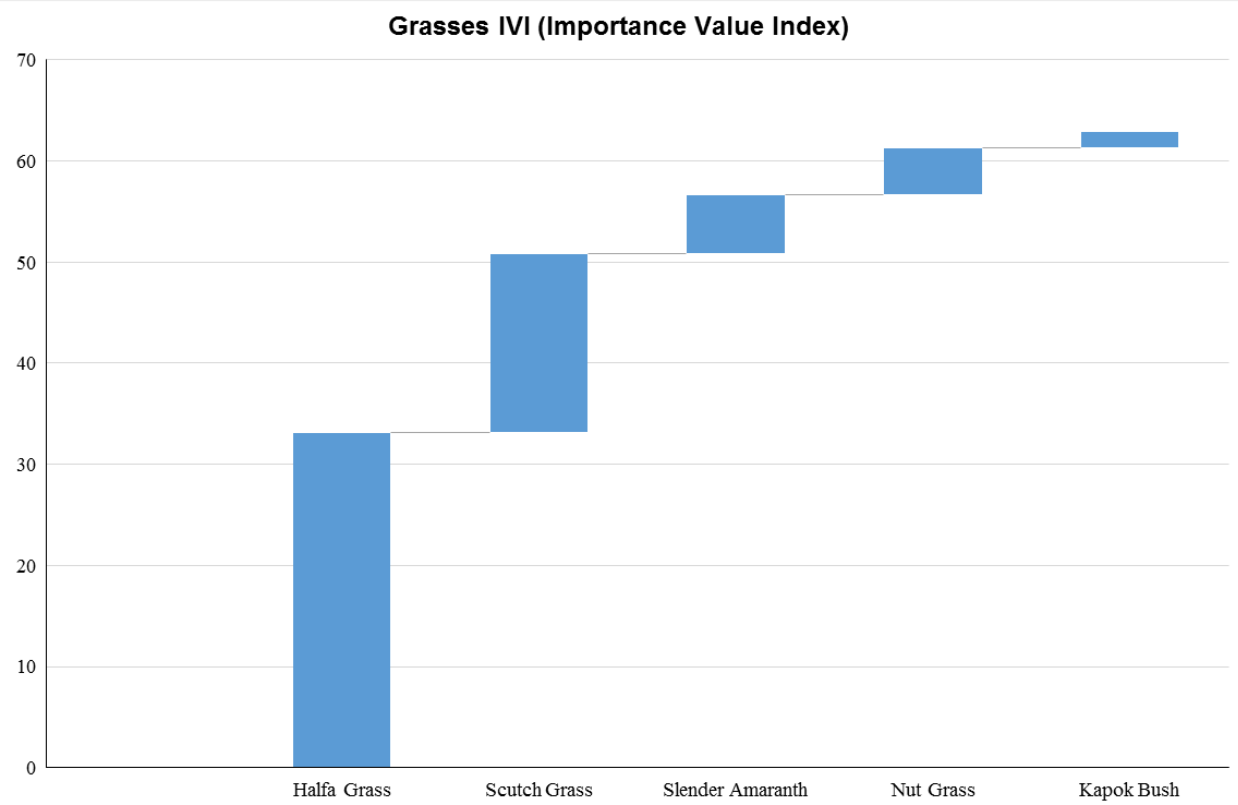


Figure: Importance Value 9Index of grass species of riverine forest habitat

DISCUSSIONS

Riverine forest are the forefront of conservation and protection due to high dependence of local communities for their livelihood. These forests are facing the highest deforestation rate due to the conversion into an agriculture field and human settlement. The uncontrolled deforestation and degradation has severely created immense pressure on the bird population structure. It has been reported that many forest-dependent species become threatened and endangered due to habitat loss and degradation.

Foraging behavior and habitat selection is important activities of the bird's life through which they find a suitable place to live, obtain energy, and perform multiple activities. Determining the habitat preference, foraging behavior and guild is key tools to ascertain the habitat requirements and food resources of a particular habitat that will help in conservation and protection activities in order to enhance the population and reproductive success rate. The occurrence of 57 bird species in the Kot Dinghano Riverine Forest highlighted that this habitat is an ideal place for avian species to inhabit and reproduce. This might be that this riverine forest is rich in food resources, such as; grains, invertebrates (insects, worms) and amphibians, reptiles, fishes and fresh foliage that satisfied their need.

Furthermore, the results of foraging guilds further demonstrated that bird species variability in foraging behavior. Some species were arboreal forager (caught their prey on wing through sallying in the air and tree canopy, e.g., fantails, flycatchers and martins) while others were ambushed forager (catch and kill their prey immediately; herons, egrets, and cormorant). Likewise, some bird species solitary forager (forage alone; besra, eagles, and hawks) and another have been cryptic forager (often hide in the bushes and shrubs to catch their prey; francolin, prinias, and warblers). Similarly, some species were diving forager (catch their prey while diving; grebes and cormorants), gregarious and social forager (often concentrated where prey items occurs in sufficient numbers; babblers, sparrows, bulbuls, and doves), social dabbling forager (often forager on the surface of water in flocks on aquatic plants; ducks). Furthermore, some species were mud prober (often probe in mud to catch insects and invertebrate hidden in mud or soft soil; sandpipers, shanks, and stilts) and nectar feeder (nip the flower nectar; sunbirds).

Furthermore, the results also demonstrated that bird species are habitat specialist and often closely associated vegetation. For example, *P. neglectus, P. ochruros* and *T. caudate* were habitat specialist, i.e., often utilized the forest interior. Likewise, *P. leucotis* and *P. cafer* preferred the forest edges dominated by shrubs (*T. tetanus* and *A. strepera*) and wetland areas. Similarly, *Streptopelia decaocto, F. pondicerianus* selected the adjacent agricultural fields in search of food, shelter, and reproduction. In addition, it was observed that partridges occupied the scrub vegetation and brush-lined water channels for shelter and grassy areas for breeding

purpose. This could be that, these vegetated areas regulate heat, provide shade, and protection cover for them from predators and harsh weather. It also has been illustrated that bird relative abundance and distribution influenced by vegetation species composition, food resources and environmental variables, i.e., temperature and relative humidity.

Notably, the ground vegetation dominated by grasses and weed provided food resources for partridges, doves, babblers, and larks. It was observed that the partridges were sensitive and shy species with secretive behavior. They easily disturbed and become vulnerable due to anthropogenic activities, i.e., habitat loss and degradation for deforestation, uncontrolled grazing and fuel wood collections. Doves and partridges foraged for seeds of herbaceous plants, acorns, legumes, waste grains. Likewise, bulbul preferred to consume the fruits (berries) and insects, in grasses as well as shrubs.

Overall, in the riverine forest ecosystem, 32 floral species were detected that encompasses of tree; eight species, shrubs; six species, weed; thirteen species, and grasses; five species. IVI value demonstrated the ecological importance of the Riverine forest, i.e., ecological benefits at various nested scales ranging from habitat to ecoregion and composition of dominant vegetation that indicate the potential to conserve biodiversity. In addition, riverine forest may provide the robust data to support the mechanisms for biodiversity conservation.

Direct observation revealed that Kot Dinghano riverine forest is under heavy pressure due to fuelwood collection and uncontrolled grazing by livestock that exerted immense pressure on habitat productivity and breeding success of partridges, warbler, grass birds, and larks. In addition, this riverine forest also under heavy pressure due to encroachment, i.e., agriculture expansion that may cause the habitat loss and degradation that negatively decline the population of various avian species. According to the perceptions of local communities, the populations of partridges in the Kot Dinghano Riverine forest has declined > 50.0% due to illegal hunting within adjacent agricultural habitats, heavy use of pesticides, uncontrolled grazing by livestock and human occurrence in breeding areas for the purpose of fuel wood, fodder and honey collection, and incidence fire during honey collection.

CONCLUSION

The finding of the inventory revealed that Kot Dinghano Riverine forest is highly productive and an attractive habitat to harbor a wide variety of bird species satisfy their needs. Unfortunately, this fragile ecosystem facing a diversity of threats due to human interventions and rapidly declining day by day. Based on the findings, it is strongly recommended that this valuable productive habitat should be protected on the priority basis to protect the population structure of birds utilizing riverine forest.

ACKNOWLEDGEMENT

The authors acknowledge the United Nation Development Program (Sustainable Forest Management Unit, Sindh Pakistan) and Universiti Putra Malaysia for financial support and Sindh Wildlife Department, Pakistan to conduct this valuable research work.