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Avian diversity around the riparian zone of Vishwamitri river, Vadodara, Gujarat

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Abstract
Riparian zone is the area adjoining the river and includes the river bank. This zone has high relevance and plays an important role in the river ecosystem. The present study was undertaken to understand the distribution of the avian diversity along the riparian zone and related the same with the landscape. The study was undertaken in river Vishwamitri flowing through the Vadodara city covering a distance of 90 Km before draining into the Arabian Sea. The paper reveals that there are about 69 species distributed all along the lengths of the river and the distribution is governed by the land use pattern like agriculture or urban area. Alteration of the riparian zone by human interventions would disturb the natural habitat and result in decline of diversity.

Keywords: riparian zone, avifauna, abundance

Introduction
Riparian zones are long and thin, and consequently have an extensive interface with adjacent ecosystems. Its defined as an ecological complex, is all land directly adjacent to a watercourse includes flood plains and wetlands (Parsons, 1991; Walker, 1993). The role of riparian areas as corridors has become increasingly important as surrounding ecosystems are modified for urban and agricultural purposes. The riparian land act as buffering zone and protects aquatic environments against erosive or polluting land uses. Home ranges of many animals include areas of both the riparian zone and adjacent habitats, and so habitat modification to either area will affect these species. Many riparian zones are now characterized by the loss of linear and upslope connectivity. The importance of riparian vegetation for wildlife habitat has been shown in a number of studies (Crome *et al.*, 1994; Fisher and Goldney, 1997; Recher and Lim, 1990) [4]. Vegetation with a complex structure like herb, shrub and tree layers which often occurs in the riparian zone is important nesting and foraging habitat for many bird species. Some water-birds such as herons, rails and bitterns and warblers use thick reed beds and other vegetation fringing watercourses. The riparian zone provides food for all trophic levels of the food web, starting with microbes to top consumers. The extensive ecotone is intrinsically linked to the surrounding catchment through material flows like water, soil, nutrients, chemicals and animal movement (Naiman and Décamps, 1997).
Threats to the terrestrial or aquatic birds of the riparian zone stem are largely from habitat fragmentation and removal or modification of riparian zone itself or arising adjacent ecosystems. Other threats include urbanization, changes in water quality or flows, increased predation from introduced predators, and human disturbance.
Vishwamirti river is a small river with a span of 90 km before merging with the Dhaddhar river and finally into the Arabian Sea. The river is known to harness Schedule IV species like fresh water marsh crocodiles, fresh water turtle and about 77 bird species (Dhuru, 2002) [8]. Majority of the bird species seen are resident, however, a few species of migratory birds such as the wagtails, Rosy pastor, sandpipers, snipes etc have also been sighted (Dhuru, 2002) [8]. The river passes through Vadodara city and about 14 km of the stretch falls within the urban area.

Study Area
The total length of the river is about approximately 90 Km. It flows for 58Km through Vadodara district and 13 km through Vadodara city, dividing the city into Northern and Southern Part (Gujarat Engineering Research Institute (GERI, 2014). Considering the short length of the river ten sampling stations were selected in such a manner that six stations were in the clean zone of the river, three in the septic zone and one in the recovery zone. As far as possible equal distance (average 9 Km distance occur between each two points) was maintained between all the stations.

Methodology
Satellite Imagery Data (Google Earth) was use in order to demarcate and total of 10 sites recognized and survey conducted in the month of January and February. Survey was carried out early in the morning from 8: 00 to 10: 30 h using line transect or point transects (point count) method. Birds was observed using binoculars (10*50). The species was identified using recognized field guides (Grimmett *et al*. 2006).
Data was collated and various indices calculated like relative abundance, Species richness, Shannon-Weiner's diversity index, Species evenness index and Jaccard's similarity index.

Result and Discussion
Although entire riparian zone of Vishwamitri river was dominated by residential and terrestrial birds, but it also provide habitat to winter visitor and aquatic birds. Based on major feeding habit, riparian zone was highly visited by insectivorous birds followed by Carnivorous, Granivorous, Omnivorous, Frugivorous and Nectarivorous.
Relative abundance (%) of all the birds species was calculated where in the abundance of top five species in each study area was considered.

At study area 1 and 10, jungle babbler (*Turdoides striata*), an insectivore bird showed high relative abundance as compared to other birds species. Both the areas are away from the urban influence and studies indicate that the richness of insectivores bird species declines with increase in built up area and close to human habitation (Lim and Sodhi, 2004) [23]. Study area 2 shoed the dominance of Asian Palm Swift (*Cypsiurus balasiensis*) attributed to presence of palm trees which provides apt habitat for the species (Koladia, 2014). Rock Dove (*Columba livia*) showed high relative abundance at study area 3 supported by the thick vegetation that provide food and nesting material (Welty and Baptista, 1988) [41].

At study area 4, Bank Myna (*Acridotheres ginginianus*) had the highest relative abundance. It has a close association with man-made habitats and regularly enters cities and agricultural lands (Elliot, 2009). Large billed crow (*Corvus macrorhynchos*) shared similar relative abundance at study area 5 compared to other areas. Dense woody vegetation as well as food waste dumped by villager near the riparian zone makes the site prominently visited by this omnivorous bird. Thus, Omnivorous species has adapted to the semi urban environment and its particular food resources such as garbage (Clergeau *et. al.* 1998) [6]. At study area 6, Common Myna (*Acridotheres tristis*) had the highest relative abundance. A bold and aggressive bird has a close association with human habitation. It naturally occurs in open country, such as cultivated areas, floodplains and grasslands, but is now most abundant in towns and cities found around parks, gardens and refuse dumps (Sargatal, 2009).

Study area 7 had Rose-ringed parakeets (*Psittacula krameri*) as highest relatively occurring bird. Sparse vegetation in the bank and high human disturbance supported this species.

Incidentally at study area 8, Black headed ibis (*Threskiornis melanocephalus*) showed high relative density. This area has presence large woody trees like ficus species, acacia species, etc. that provide roosting and breeding grounds to the dominative species (Munjpara, 2012) [28]. At study area 9, cattle egret (*Bubulcus ibis*) showed the highest relative density. Dense bushy vegetation of *Prosopis juliflora* and presence of high insect density in the area provided the apt habitat for this species (Munjpara, 2012) [28].

On the distribution of the water birds a difference was observed among all the study area. Study area 1 and 5 showed the highest relative abundance of Red-wattled lapwing (*Vanellus indicus*). This indicates presence of worms, molluscs, amphibians and other invertebrates on which the bird feeds (Elliott, 1996). At the Study area 3, Grey wagtail (*Motacilla cinerea*) and Red-wattled lapwing share same relative abundance. Again this indicates the presence of insect's availability (Birdguide, 2011).

At the Study area 4 relative abundance of Glossy ibis (*Plegadis falcinellus*) was high, attributed to presence of irrigated agricultural fields that provides food like adults and larvae of various insects, molluscs, crustaceans (Sargatal, 1992). In case of Study area 7, relative abundance of Black-winged stilt (*Himantopus himantopus*) was high. It's bio-indicator species feeding on mosquito larvae that thrive in the water with high organic content (Khachar, 1994). At Study area 8, abundance of Black-headed ibis was found to be high as this species sometimes nest close to human dwellings if relatively undisturbed (Kahl, 1992).

Further, at study area 9, highest relative abundance was scored by Common Sandpiper (*Actitis hypoleucos*). In its winter range, this species occurs in a wide variety of habitats, from coastal shores to inland wetlands, riverbanks and even sewage works (Yalden,1986). At Study area 10, relative abundance of Indian Pond-heron (*Ardeola grayii*) was high. This species was found to be more tolerant towards water pollution and human disturbances because omnivorous species do exploit anthropogenic food resources effectively (Jokimaki and Suhonen, 1998).

Munjmahuda had highest species richness. This zone supported both terrestrial and aquatic birds. Dense scrub vegetation and nutrient rich water helped to sustain avian-fauna. Urban exploiters like Rock doves were plenty in number. Asoj and Dena had least numbers of species richness, irrespective of dense vegetation. High human disturbance have affected the species richness at this site.

In the case of species diversity, area 2 and 9 showed comparatively high diversity. Though being distantly apart, both the areas had almost similar vegetation characteristics, high tree density, low human disturbance.

Highest species evenness was found at area 6, because the population of individual bird species was similar and ranged from 1 to 5. Area 5 showed the low evenness score, because of high population (> 20) of few species.

Similarity index is high between study area 9 and 4 related presence of dense vegetation, food availability and nesting ground for birds. The old heritage type of buildings provide the suitable habitat for nesting to House Swifts and therefore their density is high (Rathod, 2009). The amount of shrub cover is also principal microhabitat characteristic that increases bird's tolerance to people in urban areas (Fernandez-J *et al*., 2001). Study area in close proximity like 7 and 8, 4 and 5 had same similarity index. The continuity of vegetation and other habitat in small distances is one of the reasons for the same similarity index. Degradation of riparian lands due to growth of slums, mining of river banks, overgrazing, dumping of domestic and health hazardous waste, removal or fragmentation of native vegetation, etc. will affect the riparian sensitive species (Geier & Best 1980, Pearce *et al*. 1994).

The study has immense potential to show case the varied diversity present along the river course and gains importance when the city is planning for river front. Clearing of native woody riparian vegetation will result in the replacement of a diverse wildlife community composed of species that are typically found in riparian forest or woodland by a different, often less diverse (Wardell-Johnson & Roberts 1991).

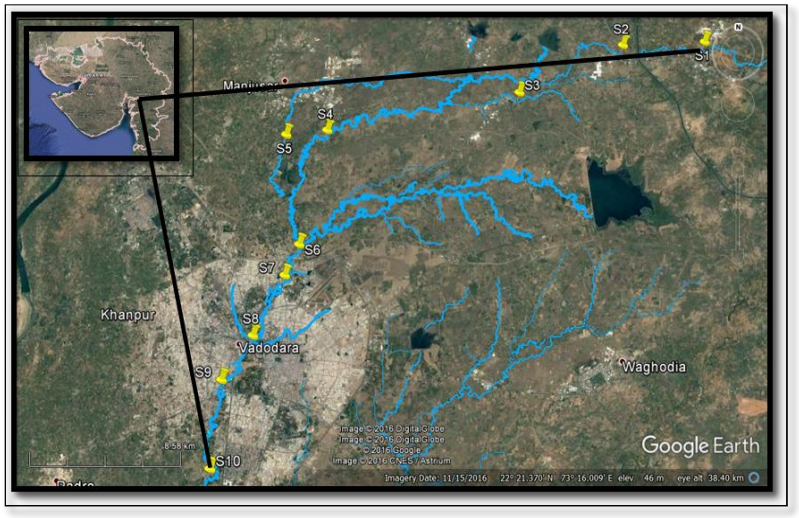

Fig 1: Google earth image of study areas

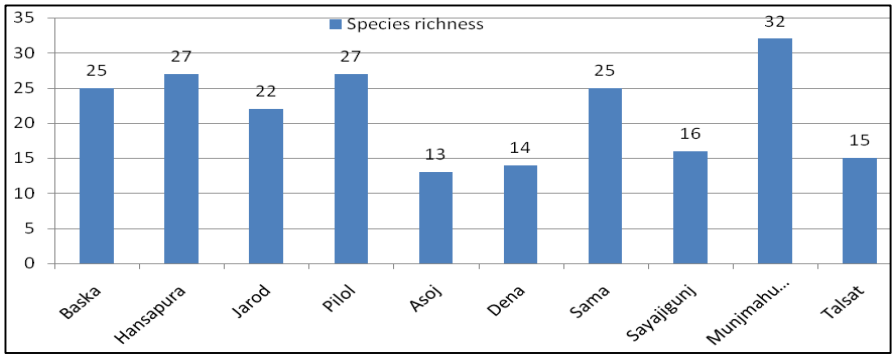

Fig 2: Study areas wise representation of species richness

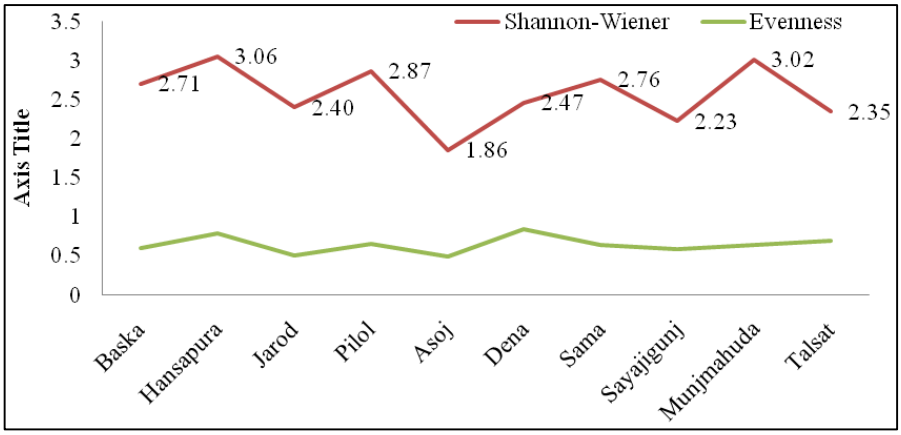

Fig 3: Study areas wise representation of species diversity and evenness

Table 1: Site code, name, locations, description and total transect areas.

Site code	Name of site	GPS location	Description	total walk (m)
1	Baska	22° 28.086'N 73° 27.138'E	Undisturbed habitat and support aquatic and terrestrial vegetations	500
2	Hansapura	22° 28.253'N 73° 24.181'E	Thorny vegetation and palm trees, and agro land	800
3	Jarod	22°26.406'N 73°20.378'E	fallow land, woody trees	500
4	Pilol	22°24.862'N 73°13.514'E	domestic activity and it supported sparse vegetation	500
5	Asoj	22° 24.611'N 73° 11.990'E	Good Vegetation	300
6	Dena	22°22.375'N 73°12.484'E	cremation site	500
7	Sama	22°20.277'N 73°12.248'E	Human pressures in form of solid waste	800
8	Sayagigunj	22°18.489'N 73°11.302'E	woody vegetation and castor plantation	200
9	Munjmahuda	22° 17.129'N 73°10.276'E	slum area	500
10	Talsat	22°14.501'N 73°10.073'E	slum area, alcohol distillation, Shrubby vegetation	300

Table 2: Relative abundance of avifauna recorded at different study area

Sr. no.	Common name of the species of birds	Study areas									
		1	2	3	4	5	6	7	8	9	10
1	Jungle babbler	30.0	6.8	0	10.9	15.6	0	0	0	0	25.9
2	Rock dove	10.0	0	33.7	0	6.7	0	0	24.3	8.1	0
3	Asian green bee-eater	6.7	0	0	8.7	10.0	0	0	0	0	0
4	Barn swallow	5.0	0	0	0	0	0	0	0	0	0
5	Rose-ringed parakeet	5.0	0	5.4	0	0	14.8	13.0	0	0	10.3
6	Asian Palm swift	0	16.9	0	0	0	0	0	0	0	0
7	Indian Robin	0	6.8	0	0	0	7.4	0	0	0	0
8	Black ibis	0	5.1	0	0	0	0	0	0	0	0
9	Common stonechat	0	5.1	0	0	0	0	0	0	0	0
10	Western Yellow wagtail	0	0	17.4	0	0	0	0	0	0	0
11	Cattle Egret	0	0	6.5	0	28.9	0	0	0	17.6	0
13	Common Babbler	0	0	3.3	0	0	0	0	0		0
14	Bank myna	0	0	0	19.6	0	7.4	12.0		5.4	0
15	Clamorous reed-warbler	0	0	0	6.5	0	0	0	0	0	0
16	Glossy ibis	0	0	0	5.4	0	0	0	0	0	0
17	Large-billed crow	0	0	0	0	31.1	0	0	0	0	0
18	Black Drongo	0	0	0	0	0	11.1	0	0	0	10.3
19	Common Myna	0	0	0	0	0	18.5	0	0	0	0
20	Black winged stilt	0	0	0	0	0	0	12.0	6.8	6.8	0
21	Common sandpiper	0	0	0	0	0	0	10.0		6.8	0
22	Little swift	0	0	0	0	0	0	10.0		0	0
23	Black headed ibis	0	0	0	0	0	0	0	27.0	0	0
24	Indian pond-heron	0	0	0	0	0	0	0	8.1	0	0
25	Red-vented bulbul	0	0	0	0	0	0	0	6.8	0	12.1
26	House sparrow	0	0	0	0	0	0	0	0	0	8.6

Table 3: Relative abundance of aquatic birds recorded at different study area

Sr. no.	Common name of the species	Relative abundance (%)									
		1	2	3	4	5	6	7	8	9	10
1	Black headed ibis	0	11.1	0.0	0.0	0	0	0.0	48.8	0.0	0
2	Black-winged stilt	0	0.0	0.0	0.0	0	0	34.3	12.2	20.8	0
3	Citrine wagtail	0	0.0	0.0	0.0	0	0	2.9	0.0	0.0	0
4	Common moorhen	0	0.0	0.0	0.0	0	0	0.0	0.0	2.1	0
5	Common sandpiper	0	11.1	0.0	9.1	0	0	28.6	7.3	20.8	0
6	Glossy ibis	0	0.0	0.0	45.5	0	0	0.0	0.0	0.0	0
7	Great egret	0	11.1	0.0	0.0	0	0	0.0	2.4	0.0	0
8	Grey heron	0	0.0	0.0	0.0	0	0	0.0	0.0	0.0	0
9	Grey Wagtail	0	0.0	42.9	0.0	0	0	0.0	2.4	0.0	0
10	Indian pond-heron	0	0.0	0.0	0.0	0	0	2.9	14.6	14.6	100
11	Little cormorant	0	0.0	0.0	9.1	25	0	0.0	0.0	0.0	0
12	Little egret	0	0.0	0.0	0.0	0	0	2.9	2.4	0.0	0
13	Marsh sandpiper	0	0.0	0.0	0.0	0	0	5.7	2.4	0.0	0
14	Asian Openbill-stork	20	11.1	0.0	0.0	0	0	0.0	0.0	0.0	0
15	Pied kingfisher	0	0.0	0.0	0.0	0	0	0.0	0.0	2.1	0
16	Purple heron	20	0.0	0.0	0.0	25	0	0.0	0.0	0.0	0
17	Red-wattled lapwing	40	22.2	42.9	18.2	50	0	8.6	7.3	12.5	0
18	Small blue kingfisher	0	11.1	0.0	0.0	0	0	2.9	0.0	2.1	0
19	Whiskered tern	0	0.0	0.0	0.0	0	0	0.0	0.0	16.7	0
20	White-breasted water hen	20	22.2	0.0	0.0	0	0	0.0	0.0	2.1	0
21	White wagtail	0	0.0	0.0	18.2	0	0	2.9	0.0	2.1	0
22	Wood sandpiper	0	0.0	14.3	0.0	0	0	8.6	0.0	4.2	0

Table 4: Jaccard's similarity index between the study areas

Study areas name and code	Jaccard coefficient (%)									
	1	2	3	4	5	6	7	8	9	10
1		34%	21%	27%	31%	15%	28%	15%	32%	33%
2			24%	36%	26%	14%	24%	33%	28%	24%
3				23%	21%	13%	21%	17%	23%	13%
4					38%	28%	30%	24%	43%	24%
5						23%	27%	29%	24%	33%

6							15%	8%	21%	26%
7								34%	38%	25%
8									21%	26%
9										23%

Table 5: Check-list of birds encountered during study

Sr. no	Common Name of Species	Scientific Name of species	1	2	3	4	5	6	7	8	9	10	A/T	M/R	H/I/C/G/O/F/N
1	Asian green bee-eater	*Merops orientalis*	✓	✓	✓	✓	✓		✓	✓	✓	✓	T	R	I
2	Asian Openbill-stork	*Anastomus oscitans*	✓	✓									A	R	C
3	Asian palm-swift	*Cypsiurus balasiensis*		✓				✓					T	R	I
4	Bank myna	*Acridotheres ginginianus*				✓		✓	✓	✓	✓	✓	T	R	O
5	Barn swallow	*Hirundo rustica*	✓	✓		✓					✓	✓	T	M	I
6	Baya weaver	*Ploceus philippinus*		✓		✓							T	R	G
7	Bay-backed shrike	*Lanius vittatus*			✓	✓							T	R	I
8	Black drongo	*Dicrurus macrocercus*		✓		✓	✓	✓		✓	✓	✓	T	R	I
9	Black headed ibis/oriental white ibis	*Threskiornis melanocephalus*		✓						✓			A	R	C
10	Black kite	*Milvus migrans*		✓		✓			✓	✓	✓		T	R	C
11	Black-winged kite/black-shouldered kite	*Elanus caeruleus*	✓						✓				T	R	C
12	Black-winged stilt	*Himantopus himantopus*							✓	✓	✓		A	R	I
13	Brahminy starling	*Sturnia pagodarum*				✓							T	R	I
14	Cattle egret	*Bubulcus ibis*	✓	✓	✓	✓	✓		✓	✓	✓	✓	T	R	C
15	Citrine wagtail	*Motacilla citreola*							✓				A	M	I
16	Clamorous reed-warbler	*Acrocephalus stentoreus*	✓	✓		✓							T	M	I
17	Common babbler	*Argya caudata*			✓								T	R	I
18	Common hawk-cuckoo	*Hierococcyx varius*				✓							T	R	C
19	Common hoopoe	*Upupa epops*			✓								T	M	I
20	Common kingfisher/small blue kingfisher	*Alcedo atthis*		✓					✓		✓		A	R	C
21	Common moorhen	*Gallinula chloropus*									✓		A	R	GC
22	Common myna	*Acridotheres tristis*	✓		✓			✓	✓		✓		T	R	O
23	Common sandpiper	*Actitis hypoleucos*		✓		✓			✓	✓	✓		A	M	I
24	Common stonechat	*Saxicola torquatus*		✓									T	M	I
25	Common tailorbird	*Orthotomus sutorius*	✓										T	R	NI
26	Dusky crag martin	*Ptyonoprogne concolor*						✓				✓	T	R	I
27	Glossy ibis	*Plegadis falcinellus*				✓							A	M	C
28	Great egret	*Ardea alba*		✓						✓			A	R	C
29	Greater coucal	*Centropus sinensis*	✓			✓					✓		T	R	C
30	Grey francolin	*Francolinus pondicerianus*			✓								T	R	G
31	Grey heron	*Ardea cinerea*	✓										A	R	C
32	Grey wagtail	*Motacilla cinerea*			✓					✓			A	M	I
33	House crow	*Corvus splendens*			✓	✓					✓		T	R	O
34	House sparrow	*Passer domesticus*									✓	✓	T	R	GI
35	Indian peafowl	*Pavo cristatus*	✓			✓		✓			✓		T	R	O
36	Indian pond-heron	*Ardeola grayii*							✓	✓	✓	✓	A	R	C
37	Indian robin	*Saxicoloides fulicatus*		✓	✓	✓		✓	✓		✓		T	R	I
38	Indian silverbill/white-throated munia	*Euodice malabarica*	✓	✓	✓							✓	T	R	GI
39	Jungle babbler	*Turdoides striata*	✓	✓		✓	✓		✓		✓	✓	T	R	O
40	Large grey babbler	*Argya malcolmi*			✓								T	R	O
41	Large-billed crow/jungle crow	*Corvus macrorhynchos*				✓	✓	✓			✓		T	R	O
42	Laughing dove	*Spilopelia senegalensis*			✓	✓	✓	✓			✓		T	R	G
43	Lesser whitethroat	*Sylvia curruca*		✓	✓								T	M	I
44	Little cormorant	*Microcarbo niger*				✓	✓						A	R	C
45	Little egret	*Egretta garzetta*							✓	✓			A	R	C
46	Little swift/house swift	*Apus affinis*	✓						✓			✓	T	R	I
47	Long-billed pipit	*Anthus similis*			✓								T	M	I
48	Marsh sandpiper	*Tringa stagnatilis*							✓	✓			A	M	C
49	Oriental honey buzzard	*Pernis ptilorhynchus*						✓					T	R	I
50	Paddyfield pipit	*Anthus rufulus*		✓	✓								T	R	I
51	Pied kingfisher	*Ceryle rudis*									✓		A	R	C
52	Purple heron	*Ardea purpurea*	✓				✓						A	R	C
53	Purple sunbird	*Cinnyris asiaticus*	✓			✓	✓	✓	✓			✓	T	R	N
54	Red naped ibis/black ibis	*Pseudibis papillosa*	✓	✓							✓		T	R	I
55	Red-vented bulbul	*Pycnonotus cafer*	✓	✓			✓		✓	✓	✓	✓	T	R	I
56	Red-wattled lapwing	*Vanellus indicus*	✓	✓	✓	✓	✓		✓	✓	✓		A	R	I
57	Rock dove	*Columba livia*	✓	✓	✓	✓	✓		✓	✓	✓		T	R	G
58	Rose-ringed parakeet	*Psittacula krameri*	✓	✓	✓	✓	✓	✓	✓		✓	✓	T	R	F

59	Rosy starling	*Pastor roseus*						✓				T	M	F
60	Rufous treepie/indian treepie	*Dendrocitta vagabunda*						✓				T	R	F
61	Shikra	*Accipiter badius*		✓						✓		T	R	C
62	Western spotted dove	*Spilopelia suratensis*	✓							✓		T	R	G
63	Western yellow wagatil	*Motacilla flava*	✓		✓							T	M	I
64	Whiskered tern	*Chlidonias hybrida*								✓		A	M	C
65	White wagtail	*Motacilla alba*				✓		✓		✓		A	M	I
66	White-breasted kingfisher	*Halcyon smyrnensis*	✓		✓		✓				✓	T	R	C
67	White-breasted water hen	*Amaurornis phoenicurus*	✓	✓						✓		A	R	GC
68	Wire-tailed swallow	*Hirundo smithii*		✓		✓		✓				T	R	I
69	Wood sandpiper	*Tringa glareola*			✓			✓		✓		A	M	C

Note: T= Terrestrial, A= Aquatic, R= Residential, M= Migratory, I= Insectivore, C= Carnivore, G= Granivore, F= Frugivore, O= Omnivore, N= Nectarivore

Conclusion

The study conducted along the riparian zone of Vishwamitri river concludes that, the river and the riparian zone together support a good diversity of bird species. The varied vegetation characteristics along the river influenced the high bird diversity reported here. The results of the present study form a comprehensive baseline data to assess and correlate the faunal diversity with its associated habitat. Any form of manmade intervention to the riverine system will affect the bird diversity and associated other wildlife species. There is need to restore the riparian vegetation in the areas where the vegetation is cleared for pasture or agriculture.

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