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Emerging threat of urbanization to ponds and avian fauna in Punjab, India

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Abstract
The present study was conducted to investigate the impact of change in land use pattern around urban ponds due to anthropogenic activities in relation to avian diversity, community composition and population number by selecting one man-made brick pond (Pond A, location I), two natural ponds (Pond B and Pond C, location II) at Kot Ise Khan, district Moga, Punjab. From the pooled data, 25 bird species (six migratory, nineteen resident) belonging to eight orders and seventeen families were recorded from December 2018 to May 2019. Community characteristics of pond A, B and C like species richness (17, 9, 11) and species diversity (2.83, 2.20, 2.40) were highest in the month of February, December and January respectively. Such instances of urbanization engulfing water bodies in urban areas are common throughout the Punjab; there must be well framed policy and its honest implementation to address the emerging issues for preservation and protection of avian diversity and overall biodiversity.

Keywords: Urbanization, ponds, conservation, water level, aquatic birds

Introduction
Urban land cover is anticipated to triple globally from 2000 to 2030 [15]. In India, level of urbanization increased from 27.81% in 2001 census to 31.16% in 2011 census [2]. Urbanization can lead to simplification of avian assemblages [12]. India predominantly had vast variety of water resources like ponds, tanks, lakes, bawdis, talab, etc. Continuous and rapid urbanization also have negative impacts on these water bodies [16]. According to the 4th MI census, carried out during 2006-2007, there were 5,23,816 water bodies- declining by 32,785 from 5,56,601 water bodies identified during the 3rd MI census of 2000-2001. Ponds help in various ecological services like carbon sequestration, pollution abatement, flood control and ground water recharge [16]. Ponds provide habitat to large number of resident and migratory birds due to high nutritional value [4]. Waterbirds can act as biological indicators in aquatic environment because these waterbirds belong to the top level of food chain and depend on lower tropic levels for their nesting, resting and feeding activities [9]. Water level fluctuations influence the physical structure of habitats, the availability and accessibility of food and the presence of safe roosting and breeding sites for water birds [13]. Out of 1263 bird species reported from India [14], about 25% species are known to be dependent on wetlands [8]. Anthropogenic pressure due to agricultural land drainage, pollution and rapid urbanization has led to loss of many ponds. Due to various anthropogenic activities, a decrease in number of bird species from 29 to 23 was recorded in ponds of eight villages over a period of six years in Punjab state [5]. This study investigates the species diversity of birds inhabiting in and around the urban ponds of Kot Ise Khan, district Moga, Punjab. It would further help in providing information on avian diversity in and around these natural and man-made ponds and also the threat of impact of anthropogenic activities mainly on water bodies in the urban habitat.

Material and Methods
Study Area
The avian diversity was investigated by selecting a permanent man-made brick pond (Pond A, location I) near a religious complex, one permanent natural pond (Pond B, location II) and one temporary natural pond (Pond C, location II) near grain market at Kot Ise Khan (latitude 30°56'28"N and longitude 75°8'10"E), district Moga, Punjab were studied. Location I was comprised of a religious complex, a single housing structure and a man-made brick pond (Pond A). Location II was comprised of grain market, some residential buildings and two natural ponds (Pond B and C). Pond C was at 350 metre distance from pond B. Dimensions of

pond A, B and C were (60x50x11), (45x20x5) and (25x10x1) feet respectively. All three ponds were fed by direct rainfall and surface flow. Pond A and B remained filled throughout year; pond C dried in summer season. Both pond A and C were found polluted with domestic waste and garbage while pond B was being used as sewage dumping site also. Pond B and C were filled up in the month of May by grain market authorities. Both locations were having Peepal (*Ficus religiosa*), Banyan (*Ficus benghalenesis*), Ber *(Ziziphus mauritiana*), Dhek (*Melia azedarach*), Safeda (*Eucalyptus globulus*) and Kikar (*Acacia nilotica*) trees. At location I, Mulberry (*Morus alba*), Jamun (*Syzygium cumini*), and Jand (*Prosopis cineraria*) trees were also present. Surrounding area of pond A was mainly covered by Congress grass (*Parthenium hysterophorus*), Indian lovegrass (*Eragrostis pilosa*), Rubber bush (*Calotropis procera*), Hemp (*Cannabis sativa*) and Mexican prickly poppy (*Argemone mexicana*). Congress grass (*Parthenium hysterophorus*) was the only wild vegetation around pond B and C.

Survey methods

Bird survey was carried out from December 2018 to May 2019. Every pond was visited once a week in the morning i.e. from 6 a.m. to 8 a.m. and evening i.e. from 4 p.m. to 6 p.m. During each visit, birds were surveyed and counted from a single position following point count method [17] along the shoreline by using binoculars (7X50). Birds were identified on the basis of keys described by Ali [1]. Feeding habits of birds were noted with reference to Kler [6]. The checklist of species was prepared following the nomenclature of Manakadan and Pittie [10]. Data was analyzed as per Shannon-Wieners Index [7].

Statistical Analysis

Friedman test was used to compare variation in number of individuals at pond A, B and C. Kruskal- wallis H test was applied to find significant variation between bird orders and families observed at pond A, B and C. Student's t-test was carried out to find any significant difference between bird species abundance in summer and winter season at pond A, B and C.

Results and discussion

Total of 25 bird species were recorded at pond A, B and C; out of these, there were migratory (6), resident (19), water dependent (9) and terrestrial (16) birds (Table.1). Waterbirds comprises a large group of species including Anseriformes, Charadriiformes, Ciconiiformes, Gaviformes, Gruiformes, Procellariformes, Pelecaniformes [18]. Birds belonging to order Anseriformes, Charadriiformes, Coraciiformes, Cuculiformes, Gruiformes, Passeriformes, Pelecaniformes and Psittaciformes were observed at all selected ponds (Table.6). Bird observations had shown that avifauna belonged to families namely Alcedinidae, Anatidae, Ardeidae, Charadriidae, Columbidae, Corvidae, Cuculidae, Dicruridae, Motacillidae, Nectariniidae, Psittacidae, Pycnonotidae, Rallidae, Recurvirostridae, Scolopacidae, Sturnidae and Turdinae (Table.6). Cuculiformes were only present at pond A whereas Anseriformes and Columbiformes were only present at pond B and pond C respectively. Bank Myna, Black-winged Stilt, Common Myna, House Crow and Red-wattled Lapwing were the common bird species observed at pond A, B and C. There is less similarity in species richness between pond A and C as compared to observed value in pond A and B (Table.2). The similarity index between pond B and C were slightly higher than pond A and C. Among water dependent birds, Indian Pond Heron was found only at pond A whereas Spot-billed Duck was found exclusively at pond B. Common Snipe, Wood Sandpiper, Little Ringed Plover and Spotted Redshank were restricted only to pond C. Pond A supported more bird species and population abundance than pond B and C as it had higher tree diversity as well as wild vegetation around the pond which provided shelter and roosting sites to terrestrial birds also. On the basis of Friedman test, there was significant difference between numbers of individuals in the month of February, April and May at pond A, B and C (p<0.05) and there was significant difference between numbers of individuals in the month of March (p<0.01). Detailed analysis showed that there was no significant difference among bird orders observed at pond A, B and C (Kruskal- wallis H test, $\chi 2$= 3.523, p=0.172). There was significant variation among bird families observed at pond A, B and C ((Kruskal- wallis H test, $\chi 2$=5.97, p=0.049). Student's t-test analysis showed non significant difference between bird species abundance in summer and winter season at pond A, B and C.

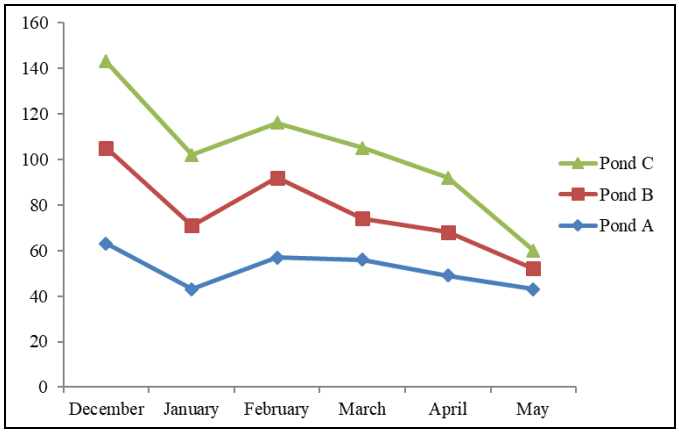

Fig 1: Number of individuals at pond A, B and C from December 2018 to May 2019

Table 1: Terrestrial and water dependent bird species recorded at studied ponds from December 2018 to May 2019

S. No		Common Name	Pond A	Pond B	Pond C
1	Terrestrial bird species	Asian Koel	✓	-	-
2		Asian Pied Starling	✓	-	-
3		Black Drongo	✓	-	-
4		Blue Rock Pigeon	-	-	✓
5		Bluethroat	✓	-	-
6		Cattle Egret	✓	✓	-
7		Common Moorhen	✓	-	-
8		Common Myna	✓	✓	✓
9		Greater Coucal	✓	-	-
10		House Crow	✓	✓	✓

11		Purple Sunbird	✓	-	-
12		Red-vented Bulbul	✓	-	-
13		Red-wattled Lapwing	✓	✓	✓
14		Rose-ringed Parakeet	✓	-	-
15		White Wagtail	✓	-	✓
16	Water dependent bird species	Bank Myna	✓	✓	✓
17		Black-winged Stilt	✓	✓	✓
18		Common Snipe	-	-	✓
19		White-breasted Kingfisher	✓	✓	-
20		White-breasted Waterhen	✓	✓	-
21		Indian Pond Heron	✓	-	-
22		Little Ringed Plover	-	-	✓
23		Wood Sandpiper	-	-	✓
24		Spot-billed Duck	-	✓	-
25		Spotted Redshank	-	-	✓

(✓) Observed (-) Not observed

Table 2: Sorenson's similarity index of bird species at studied ponds

	Pond A	**Pond B**	**Pond C**
Pond A	*	0.571	0.4
Pond B	0.571	*	0.5
Pond C	0.4	0.5	*

At pond A, a total of 19 bird species (six water dependent and thirteen terrestrial birds) were observed (Table.1). White-breasted Waterhen (16.39%) followed by Cattle Egret (13.86%) and Common Myna (10.16%) were the most abundant bird species present at pond A (Table.3). Values of species richness at pond A ranged from 12 to 17 while species diversity ranged from 2.48 to 2.83. Highest species richness (17) and species diversity (2.83) was observed in the month of February whereas highest species evenness (0.93) was observed in the month of January. Charadriiformes, Coraciiformes, Cuculiformes, Gruiiformes, Passeriformes, Pelecaniformes and Psittaciformes were the bird orders observed at the said pond. Passeriformes was the most dominant bird order amongst all other orders. Number of individuals was highest in the month of December followed by February and March whereas number of individuals was lowest in month of May and January (Fig.1). White-breasted Waterhen was most abundant at pond A as it preferred wild and bushy vegetation for breeding purposes. Indian Pond Heron was recorded only at pond A as the presence of Peepal (*Ficus religiosa*), Banyan (*Ficus benghalenesis*), Mulberry (*Morus alba*) and Dhek (*Melia azedarach*) provided it nest sites.

According to Kaur *et al.* [8], Indian Pond Heron mostly preferred Peepal (*Ficus religiosa*), Banyan (*Ficus benghalenesis*) and Dhek (*Melia azedarach*) for nesting. Observations have shown that birds visited animal dump near the pond for small invertebrates and small vertebrates.

Table 3: Relative abundance (%) of bird species recorded at Pond A from December 2018 to May 2019

S. No	**Common name**	**December**	**January**	**February**	**March**	**April**	**May**	**Relative abundance**
1	Asian Koel	0.00	0.00	1.75	3.57	4.08	4.65	2.34
2	Asian Pied Starling	4.76	0.00	3.51	1.79	0.00	2.33	2.06
3	Bank Myna	9.52	9.30	0.00	8.93	12.24	9.30	8.22
4	Black Drongo	0.00	0.00	1.75	3.57	8.16	0.00	2.25
5	Black-winged Stilt	6.35	9.30	5.26	3.57	0.00	0.00	4.08
6	Bluethroat	0.00	2.33	1.75	0.00	0.00	0.00	0.68
7	Cattle Egret	7.94	9.30	10.53	5.36	8.16	41.86	13.86
8	Common Moorhen	14.29	11.63	7.02	12.5	8.16	0.00	8.93
9	Common Myna	12.70	11.63	12.28	7.14	10.20	6.98	10.16
10	Greater Coucal	1.59	0.00	3.51	3.57	0.00	0.00	1.44
11	House Crow	4.76	6.98	8.77	3.57	2.04	4.65	5.13
12	Indian Pond Heron	1.59	0.00	3.51	1.79	0.00	0.00	1.15
13	Purple Sunbird	0.00	0.00	0.00	1.79	4.08	2.33	1.37
14	Red-vented Bulbul	7.94	6.98	10.53	7.14	10.20	11.63	9.07
15	Red-wattled Lapwing	3.17	0.00	1.75	5.36	8.16	2.33	3.46
16	Rose-ringed Parakeet	6.35	6.98	7.02	8.93	4.08	6.98	6.72
17	White Wagtail	0.00	2.33	1.75	0.00	2.04	0.00	1.02
18	White-breasted Kingfisher	1.59	2.33	1.75	0.00	2.04	2.33	1.67
19	White-breasted Waterhen	17.46	20.93	17.54	21.43	16.33	4.65	16.39
	Species Richness	14	12	17	16	14	12	
	Species Diversity	2.64	2.48	2.83	2.77	2.64	2.48	
	Species Evenness	0.92	0.93	0.90	0.80	0.70	0.64	

Out of nine bird species observed at pond B, five were water dependent and four were terrestrial bird species (Table.1). Bird orders observed were Anseriformes, Charadriiformes, Coraciiformes, Gruiiformes, Passeriformes and Pelecaniformes. Passeriformes was the most dominant bird order amongst all other orders. Most abundant bird species were Black-winged Stilt (52.28%) followed by Common Myna (16.13%) and Bank Myna (15.96%) (Table.4). Number of individuals was highest in the month of December followed by February and January whereas number of

individuals of was lowest in month of May (Fig.1). Highest species richness (9) and species diversity (2.20) was observed in the month of December whereas highest species evenness (0.93) was observed in the month of April. Spot-billed duck was found only at pond B as it preferred deep water to swim and used floating vegetation as cover.

Table 4: Relative abundance (%) of bird species recorded at Pond B from December 2018 to May 2019

S. No	Common name	December	January	February	March	April	May	Relative abundance
1	Bank Myna	7.14	7.14	0.00	11.11	21.05	33.33	15.96
2	Black-winged Stilt	59.52	67.86	57.14	61.11	15.79	0.00	52.28
3	Cattle Egret	4.76	0.00	2.86	5.56	15.79	11.11	8.02
4	Common Myna	9.52	10.71	17.14	0.00	21.05	22.22	16.13
5	House Crow	2.38	0.00	5.71	16.67	5.26	11.11	8.23
6	Red-wattled Lapwing	2.38	7.14	2.86	0.00	5.26	22.22	7.97
7	Spot-billed Duck	2.38	0.00	5.71	0.00	0.00	0.00	1.62
8	White-breasted Kingfisher	2.38	3.57	0.00	5.56	5.26	0.00	3.35
9	White-breasted Waterhen	9.52	3.57	8.57	0.00	10.53	0.00	6.44
	Species Richness	9	6	7	5	8	5	
	Species Diversity	2.20	1.79	1.95	1.61	2.08	1.61	
	Species Evenness	0.66	0.62	0.48	0.57	0.93	0.67	

A total of eleven bird species were found at pond C; six were water dependent and five were terrestrial bird species (Table.1). Charadriiformes followed by Columbiiformes and Passeriformes were dominant bird observed. At pond C, Black-winged Stilt (30.54%) followed by Common Myna (19.25%) and Blue Rock Pigeon (16.06%) were most abundant (Table.5). Highest species richness (11) and species diversity (2.40) was observed in the month of December and January whereas highest species evenness (0.93) was observed in the month of February. Number of individuals was highest in the month of December followed by January and March whereas number of individuals was lowest in month of May (Fig.1). Pond C harboured more water dependent migratory bird species as it was shallow and provided substrate for feeding to wader bird species like Common Snipe, Wood Sandpiper and Spotted Redshank. Deep water has been reported to reduce the availability and accessibility of invertebrates to feeding waders [11]. Little Ringed Plover was only observed at pond C. Small sized bird species preferred shallow ponds to feed because of their limited leg and bill length [3].

Table 5: Relative abundance (%) of bird species recorded at Pond C from December 2018 to May 2019

S. No	Common name	December	January	February	March	April	May	Relative abundance
1	Bank Myna	5.26	9.68	0.00	12.90	4.17	12.50	7.42
2	Black-winged Stilt	28.95	32.26	62.50	38.71	20.83	0.00	30.54
3	Blue Rock Pigeon	10.53	16.13	12.50	9.68	29.17	37.50	19.25
4	Common Myna	13.16	12.90	8.33	16.13	33.33	12.50	16.06
5	Common Snipe	2.63	3.23	4.17	3.23	0.00	0.00	2.21
6	House Crow	15.79	3.23	8.33	3.23	4.17	12.50	7.87
7	Little Ringed Plover	5.26	6.45	0.00	6.45	0.00	0.00	3.03
8	Red-wattled Lapwing	7.89	3.23	0.00	0.00	4.17	25.00	6.71
9	Spotted Redshank	2.63	6.45	4.17	3.23	0.00	0.00	2.75
10	White Wagtail	2.63	3.23	0.00	3.23	0.00	0.00	1.51
11	Wood Sandpiper	5.26	3.23	0.00	3.23	4.17	0.00	2.65
	Species Richness	11	11	6	10	7	5	
	Species Diversity	2.40	2.40	1.79	2.30	1.95	1.61	
	Species Evenness	0.88	0.86	0.69	0.82	0.81	0.93	

Table 6: List of bird species recorded at studied ponds along with their scientific names, families, order, migratory status, feeding habit and flock size

S. No	Common name	Scientific names	Families	Order	Migratory status	Feeding habit	Flock size
1	Asian Koel	*Eudynamys scolopacea*	Cuculidae	Cuculiformes	R	F,I	S,P
2	Asian Pied Starling	*Sturnus contra*	Sturnidae	Passeriformes	R	I,F	S,P
3	Bank Myna	*Acridotheres ginginianus*	Sturnidae	Passeriformes	R	I,F	S,P,G
4	Black Drongo	*Dicrurus macrocercus*	Dicruridae	Passeriformes	R	I	S,P
5	Black-winged Stilt	*Himantopus himantopus*	Recurvirostridae	Charadriiformes	M	I	P,G
6	Blue Rock Pigeon	*Columba livia*	Columbidae	Columbiformes	R	G	S,P,G
7	Bluethroat	*Luscinia svecica*	Turdinae	Passeriformes	M	I	S
8	Cattle Egret	*Bubulcus ibis*	Ardeidae	Pelecaniformes	R	I,SI	S,P,G
9	Common Moorhen	*Gallinula chloropus*	Rallidae	Gruiformes	R	I,SI,G,P	P,G
10	Common Myna	*Acridotheres tristis*	Sturnidae	Passeriformes	R	I,F	S,P,G
11	Common Snipe	*Gallinago gallinago*	Scolopacidae	Charadriiformes	M	SI,P	S,P
12	Greater Coucal	*Centropus sinensis*	Cuculidae	Cuculiformes	R	I,SI,V	S,P
13	House Crow	*Corvus splendens*	Corvidae	Passeriformes	R	I,G,SV	S,P

14	Indian Pond Heron	*Ardeola grayii*	Ardeidae	Pelecaniformes	R	I,SI,SV	S
15	Little Ringed Plover	*Charadrius dubius*	Charadriidae	Charadriiformes	R	I	P
16	Purple Sunbird	*Nectarinia asiatica*	Nectariniidae	Passeriformes	R	P	S,P
17	Red-vented Bulbul	*Pycnonotus cafer*	Pycnonotidae	Passeriformes	R	I,P,F	S,P
18	Red-wattled Lapwing	*Vanellus indicus*	Charadriidae	Charadriiformes	R	I,SI	S,P
19	Rose-ringed Parakeet	*Psittacula krameri*	Psittacidae	Psittaciformes	R	F,P,G	S,P,G
20	Spot-billed Duck	*Anas poecilorhyncha*	Anatidae	Anseriformes	R	SV,P	S,P
21	Spotted Redshank	*Tringa erythropus*	Scolopacidae	Charadriiformes	M	SI	S,P
22	White Wagtail	*Motacilla alba*	Motacillidae	Passeriformes	M	I,SI	S,P
23	White-breasted Kingfisher	*Halcyon smyrnensis*	Alcedinidae	Coraciiformes	R	I,Fish	S,P
24	White-breasted Waterhen	*Amaurornis phoenicurus*	Rallidae	Gruiformes	R	I,SI,G,P	S,P,G
25	Wood Sandpiper	*Tringa glareola*	Scolopacidae	Charadriiformes	M	I,SI	S,P

Migratory status: R (Resident) and M (Migratory)

Feeding habit: I (Insectivorous), G (Granivorous), F (Fruits/berries), P (Plants/aquatic vegetation/nectar), SI (Small invertebrates) and SV (Small vertebrates/mice/rat/small birds/eggs/reptiles) Flock size: S (Single), P (Pair) and G (Group)

It was surprising to find that pond B and C were filled with sand and soil by grain market authorities. Encroachment of these ponds led to loss of habitat for both terrestrial and water dependent species which reflected the lack of concern for biodiversity and value of water bodies by stakeholders. Kupekar *et al.* [9] stated that major threat affecting the avian community is unchecked habitat loss and degradation of aquatic surroundings due to anthropogenic activities as water bodies in and around the urban habitats are being drained and filled up with soil. As per reports of India Today, 21 major cities in India will run out of ground water completely by the end of 2020 which will affect the lives of 100 million people. Surveys conducted by second author had shown that water bodies are rapidly disappearing from urban as well as rural areas in Punjab because of land appreciation and other anthropogenic activities (Authors unpublished data). Urbanization, industrialization and chemical intensive agriculture are some factors contributing to the depletion of these water bodies [16]. Conserving and protecting temporary as well as permanent ponds might help in easing the crisis by recharging ground water and it might tackle biodiversity losses.

Conservation Strategies

Location	Anthropogenic threats	Mitigation measures
Pond A	Being in proximity to religious complex, people use plastic bags, matchsticks, incense sticks, milk packets, disposable utensils, earthen pots, etc. that are often carried to pond by winds.	Community participatory program need to be undertaken to rejuvenate the pond.
Pond B	Misuse of pond as sewage and domestic waste disposal site; was filled up in the month of May.	Rejuvenation of the pond to provide habitat to avifauna.
Pond C	Used as domestic waste disposal site was filled up in the month of May.	Rejuvenation of the pond to provide habitat to avifauna.

List of anthropogenic threats to pond A, B and C along with recommendations for mitigation measures

Conclusion

In spite of it being a localized study, impact of urbanization on urban water ponds is posing a severe threat to avian fauna and overall biodiversity which need to be countered by all stakeholders in the urban landscape of Indian subcontinent. The rejuvenation of the ponds should be given due attention and protection not only for recharging ground water but also for larger benefits of biodiversity especially avian diversity.

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