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Habitat Preferences of Birds in Relation to Exotic Trees in Canal Bank Forests Gujranwala, Pakistan

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ABSTRACT

The anthropogenic activities are causing the habitat destruction of birds globally by replacing native forests with artificial forests containing exotic species. The canal bank forest is one of such artificial forests present in Gujranwala, Pakistan. This study is designed to investigate role of canal bank forest as habitat for the native species of birds, their adaptability to exotic trees, and to understand role of mixed tree population in establishing the population of birds. Field data of the forest (*N*=1533 trees, 15 species) and avifauna (*N*= 3445 birds, 37 species) were collected in September-October 2019 along the canal bank forest. MINITAB, CLAM software was used to analyze data. The non-native species made 80% of trees and poplar *Populus deltoides* was present in a ratio of 8%. The Cuculidae was the most diverse avian family while Sturnidae and Corvidae were the most abundant families. From recorded 37 bird species, 29 were using the forest as habitat and 5 were air borne. Thirty-three species were resident, one summer migrant and 3 winter migrants. The multinomial analyses and principal component analysis (PCA) results showed that out of 29 species using forest as habitat; 13 were "generalists", 6 species were "rare to classify", 9 species were "poplar specialist" and only one species was "*Eucalyptus opportunist*." Common myna and house crow were the most abundant species. Black kite, house crow, and common myna were found to be making nests on trees only. A clear pattern of habitat selection is present in the study area where poplar is a winner species in richness of birds, but dominant eucalyptus *Eucalyptus camaldulensis* could retain only half the number of species than poplar. It is recommended that if native trees are required to be replaced by exotic trees *Eucalyptus* should not be the first choice, but preference should be given to poplar for retaining the native diversity of avifauna. This however may necessitate an Economic analysis while selecting tree species for planting.

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ZN conceived the study and collected the field data. ZN and KS designed the study and performed the statistical analysis. KS corrected and finalized the manuscript.

Key words
Canal bank forest, Eucalyptus, Poplar.

INTRODUCTION

Native forests provide habitat to generations of birds and suits best for their ecological success. Unfortunately, the anthropogenic activities which are causing the habitat destruction of wild avifauna globally are also accelerating the process of replacement of native forests with artificially planted forests containing exotic and introduced species. The 7% of the forest in the world today constitutes the forested plantation with 55% of them in the temperate region (FAO, 2016). Forest plantations contribute significantly to the economy of a country (FAO, 2001; ITTO, 2016), provide many ecosystem services (like carbon sequestration), and help recover the degraded land (Parrotta and Knowles, 1999;Carle *et al*., 2002; Bull *et al*., 2006; Silva *et al*., 2018). However, these plantations may be accelerating the biodiversity loss of a region (Moreno-Mateos *et al*., 2017) due to the removal of native trees for raising monocultural crops. Many studies show that forest plantations support disturbance tolerant and generalist species of avifauna only as compared to natural forests (Barlow *et al*., 2007; Felton *et al*., 2016). Pakistan like many other regions of the world is also facing the phenomenon of the destruction of natural forests being replaced by artificial plantations. Planted forests are found in many districts of Pakistan. Canal bank (linear) forest along the Upper Chenab canal banks in Gujranwala district covers an area of about 8 km and 3 to 4 meters wide. The forest is composed of a mixed plantation of exotic and introduced tree species along with a few native trees. This study is designed to investigate the role of Canal bank forests as habitat for the native species of birds and to understand the role of mixed tree plantation in establishing the population of different species of birds and the adaptability of birds to exotic tree species.

MATERIALS AND METHODS

Study area

The study area is located in Gujranwala city in Northeast Punjab which is the seventh most populous

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metropolitan area in Pakistan (~5 million people: PBS, 2018). The city has a hot semi-arid climate with a summer variation of 36–42°C (June to September) and in winter (November to February) temperature can drop to an average of 7°C (Köppen, 1936; Sarfaraz *et al*., 2014). The average annual rainfall is 581 mm (Anjum *et al*., 2016). The Upper Chenab canal is an irrigation canal originating from the Marala Headworks at River Chenab and runs through the eastern side of Gujranwala city. The Canal Bank forest is 8 km in length starting from Nandipur hydroelectric power plant in the north and runs along the right bank of Upper Chenab canal for eight km including Gujranwala urban area. A 2.16 km strip of canal bank plantation in the urban area of Gujranwala city was sampled. The plantation is about 3 to 4 meter wide and trees are planted in several rows (3 to 4 rows). This part of the forest is surrounded by urbanized structures such as housing, buildings, bridges, roads etc., with a dense human population.

Field data collection

Field data were collected in September and October in 2019 when temperature was mild ranging from 30°C to 35°C. Data were collected from 7:00 to 9:00 am in the morning for 21 days. A total of 1531 trees were identified up to species level and diameter and height was measured using measuring tape and the application software (mobile phone), respectively. For bird data twenty-one transects (size of each transect ~100 m) were walked during the fieldwork. The point count method was used for bird counting (Blondel *et al*., 1970; Gabrey, 1997). Birds were counted for 10 min with a break of ten minutes and in every 2-h observations, a total of 6 observations were taken daily and the average of these 6 observations was taken to count the total number of birds. In the case of high dense canopies, a binocular (Olympus 10x50 DPS) was used to identify the bird species. A camera was also used to take photographs which facilitated the identification of species. Species identification was carried out using the field manual (Ali and Ripley, 1978; Grimmett *et al*., 1999). The number of nests present at every tree was counted to find out the habitat selection of birds.

Statistical analysis

Field data were analyzed by using statistical tools such as SPSS, MINITAB, and CLAM. The ecological parameters of the ecosystem like the avian diversity index and tree diversity index were calculated by employing Shannon and Weaver diversity index (Shannon and Weaver, 1963). Species richness (SR) (Margalef, 1951) and species evenness (E) were calculated (Pielou, 1966) for avifauna of the area. Bird species were divided into guilds (species having similar feeding habits) and food type (carnivores, insectivores, granivores, omnivores, frugivores). The habitat specificity was determined by the method developed by Chazdon *et al*. (2011). Software CLAM (Chao and Lin, 2011) was employed to classify birds into categories of habitat specialists and generalists. This software compares only two groups hence we treated all four tree species *i.e.* eucalyptus, mesquit (*Prosopis juliflora)*, ficus (*Ficus bengalensis and F. religiosa*), and semal (*Bombax ceiba*) as one group and poplar trees as the second group. A multinomial model based on the abundance of species in two environments was used that divides species into one of the following groups: (1) generalists; (2) habitat "x" specialist; (3) habitat "y" specialist; and last (4) rare to classify (Chazdon *et al*., 2011). The rare species which are often a problem to classify are easily classified by this method simply in the division rare to classify as such there is no need to exclude them from data if it does not fit in any category of generalists or specialists. A specialization threshold K of value 0.667 (best for assessing the overall pattern) was standardized, with a p-value of 0.005 (Chazdon *et al*., 2011). A principal component analysis (PCA) was performed to understand the clusters and group behavior of avian species. The formula (Pi) Pi = Ni / N is used for the determination of the relative abundance of each species in the population.

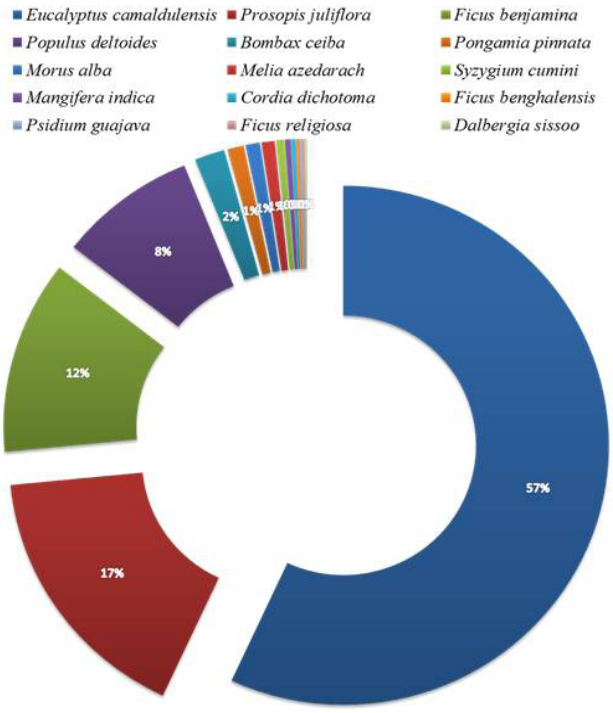

Fig. 1. Diagram showing various tree species present in the canal bank forest.

Table I.- Community parameters on five dominant tree species in canal bank forest.

Community parameters	Eucalyptus	Poplar	Mesquit	Ficus	Semul
Diversity (H')	2.06	2.27	1.91	1.304	1.35
Richness (SR)	18	29	11	4	5
Evenness (E)	0.734	0.667	0.616	0.946	0.82

Table II.- Bird families, species, residential status, and guild found in canal bank forest.

Family name	Species common name	Scientific name	Status	Guild
Accipitridae	Black kite	*Milvus migrans*	Resident	Carnivorous
Alaudidae	Eurasian skylark	*Alauda arvensis*	Resident	Omnivorous
Alcedinidae	White-throated kingfisher	*Halcyon smyrnensis*	Resident	Carnivorous
Apodidae	House swift	*Apus nipalensis*	Resident	Insectivorous
Ardeidae	Indian Pond heron	*Ardeola grayii*	Resident	Carnivorous
Charadriidae	Red-wattled lapwing	*Vanellus indicus*	Resident	Omnivorous
Columbidae	Rock dove	*Columba livia*	Resident	Granivorous
	Red collared dove	*Streptopelia tranquebarica*	Resident	Granivorous
	Eurasian collard dove	*Streptopelia decaocto*	Resident	Granivorous
Corvidae	Rufous tree pie	*Dendrocitta vagabunda*	Resident	Frugivorous
	House crow	*Corvus splendens*	Resident	Omnivorous
Cuculidae	Common cuckoo	*Cuculus canorus*	Summer migrant	Omnivorous
	Common hawk cuckoo	*Hierococcyx varius*	Resident	Omnivorous
	Asian koel	*Eudynamys scolopaceus*	Resident	Omnivorous
	Greater coucal	*Centropus sinensis*	Resident	Carnivorous
Dicruridae	Black drongo	*Dicrurus macrocercus*	Resident	Insectivorous
Hirundinidae	Wire-tailed swallow	*Hirundo smithii*	Resident	Insectivorous
	Barn swallow	*Hirundo rustica*	Resident	Insectivorous
	Grey- throated martin	*Riparia chinensis*	Resident	Insectivorous
	Common house martin	*Delichon urbicum*	Winter migrant	Insectivorous
Laniidae	Isabelline shrike	*Lanius isbellinus*	Winter migrant	Carnivorous
Leiothrichidae	Jungle babbler	*Argya striata*	Resident	Insectivorous
	Striated babbler	*Argya earlei*	Resident	Omnivorous
	Common babbler	*Argya caudate*	Resident	Omnivorous
Motacillidae	White wagtail	*Motacilla alba*	Winter migrant	Insectivorous
Muscicapidae	Brown rock chat	*Cercomela fusca.*	Resident	Insectivorous
Oriolidae	Golden oriole	*Oriolus oriolus*	Resident	Omnivorous
Passeridae	House sparrow	*Passer domesticus*	Resident	Granivorous
Phasianidae	Poultry	*Gallus gallus domesticus*	Resident	Omnivorous
Psittaculidae	Alexandrine parakeet	*Psittacula eupatria*	Resident	Granivorous
	Rose-ringed parakeet	*Psittacula krameri*	Resident	Granivorous
Pycnonotidae	Red-vented bulbul	*Pycnonotus cafer*	Resident	Frugivorous
Rallidae	White breasted water hen	*Amaurornis phoenicurus*	Resident	Omnivorous
Sturnidae	Bank myna	*Acridotheres ginginianus*	Resident	Omnivorous
Sturnidae	Common myna	*Acridotheres tristis*	Resident	Omnivorous
Tytonidae	Barn owl	*Tyto alba*	Resident	Carnivorous
Upupidae	Common hoopoe	*Upupa epops*	Resident	Insectivorous

RESULTS

Type of tree plantation

The mixed trees population of native and non-native trees was observed. A very few native trees were found to be dispersed distantly from each other with no specific pattern of distribution. A total of 15 species of trees are present in the study area. Non-native species like eucalyptus, mesquit ficus species, and semal made 72% of the tree population. Mesquit, an exotic however naturalized shrub was found to be 17% of the total population. The composition of several tree species (eucalyptus, ficus, semal and mesquit) were planted in line intermixed with each other on the southern end of the sampling area. Poplar (8% of the population) is mostly present on the northern side of the forest grown in a circular distribution pattern. The remaining 11 tree species made only 4% of the tree population collectively. The percentage composition of all tree species is shown in Figure 1.

Diversity index of tree species

The Shannon-wiener diversity index (H') of the canal bank forest was calculated to be 1.35 indicating a low diversity in the Canal bank forest ecosystem. The species evenness (E) value was found to be 0.5 pointing to the presence of a few dominant species in the system. Table I shows the ecological parameters of trees in the study area planation.

Relative diversity and abundance of avian families

At the canal bank forest, 37 bird species belonging to 24 avian families were present (Table II). The avian species belonging to the families using trees as habitat were separated from the families found to be flying only in air. In the families using trees as habitat, the Cuculidae was the most diverse family consisting of four species followed by Leiothrichidae and Columbidae both consisting of 3, 3 species each. In terms of population, the Sturnidae was the most abundant family constituting 24% of all birds found in the area followed by Corvidae consisting of 21% of bird population. The Accipitridae and Passeridae were present in the ratio of 14.7% and 14.3%, respectively. Hirundinidae was the most diverse and abundant family containing 4 out of 5 flying (air borne) species and contributing 69% to all the flying birds (air borne) as shown in Table II.

Guild of birds

Of all sampled bird species 35% were omnivorous and 27% insectivorous. The percentage of both carnivorous and granivorous species was 16%, and frugivorous made 6% of the population. Of all bird species 33 were found to be resident to the area and 3 species were winter migrants and only one species was a summer migrant.

Canal bank plantation as bird species habitat

A total of 3445 (2810 using forest as habitat and 635 airborne) birds of 37 species were observed in canal bank forest. The 2810 birds of 29 species were found to be using the forest as a habitat. The common myna was the most abundant bird (~24.7% of the population) in the area. House crow population was registered as the second most abundant species (~ 20.5%) present in the area. The black kite was found to be present as 4.7% of the population and the house sparrow was 14.3% of the total population. Rufous tree pie and Isabelline shrike were found to be the least abundant species and only one bird of each species was observed during the field sampling.

Air borne species

The 635 birds of 5 air borne species were also found to be present. Common house martin was the most dominant species making 25.5% of the population. House swift was the second most dominant species making 24.8% of the population. Grey-throated martin, wire-tailed swallow, and barn swallow are the other species observed flying in the study area.

Tree species to habitat

The diversity index and species richness showed that the poplar was the winner among all tree species in terms of diversity and abundance of bird species (Table I). Only 8% of the forest trees were poplar and no other species matched it to diversity and abundance of birds. The eucalyptus was the second most important species followed by mesquit. Ficus and semul did not seem to play a significant role by sustaining only 4 and 5 species, respectively.

Habitat preference of avian species to trees

The habitat specificity based upon the multinomial model showed that the eucalyptus was the dominant tree (57%) in the forest but only 18 bird species were found to be using it as a habitat. Most of these species were opportunists and generalists in nature. House crow was the most abundant species on this tree species followed by the black kite. Common myna was the third most dominant species. Mesquit was found to the second most dominant species in the forest but sustained only 15 bird species. Ficus was the third most dominant tree in terms of population but only 4 species of birds were present on it. The most interesting trend was seen in poplar that it made only 8% of trees in the forest but sustained 30 bird species on it. Many generalist species were using it as a habitat, but the specialist of canal bank forest was found only at this tree species. Table III shows the habitat preference of

birds to five dominant tree species in the canal bank forest. Table III is also showing that from the 29 species, 13 are "generalist" and six are "rare to classify" and nine are "poplar specialist" and only one species is the "Eucalyptus opportunist."

Nesting preference

The nesting preference and behavior of various bird species on the tree species are given in Table IV. From the 29 species using trees as habitat only three were found to be making the nests. Black kite and House crow were the two species found to be having nests on the Eucalyptus tree. Common myna was the only species found to be having nests on the poplar trees. The nests were also found to be present on mesquit but bird species were unknown (Table IV).

The remaining 26 bird species were not found to be having nests on the trees and were found to be only roosting, flying, or foraging on trees.

Table III.- The habitat preference of avian species in relation to type of trees.

S. No.	Common name	Eucalyptus	Semul	Ficus	Mesquit	Poplar	Category
1	Alexandrine parakeet	0	0	0	0	16	Poplar specialists
2	Asian koel	0	0	0	0	8	Poplar specialists
3	Bank myna	28	0	0	0	12	Generalist
4	Barn owl	0	0	0	0	4	Rare to classify
5	Black drongo	25	1	1	10	28	Generalist
6	Black kite	216	13	0	0	133	Eucalyptus opportunist
7	Brown rock chat	0	0	0	0	3	Rare to classify
8	Common babbler	23	0	0	19	34	Generalist
9	Common cuckoo	0	0	0	0	4	Poplar specialists
10	Common hawk cuckoo	0	0	0	0	3	Poplar specialists
11	Common hoopoe	0	0	0	0	6	Poplar specialists
12	Common myna	137	6	2	23	389	Generalist
13	Eurasian collared dove	17	0	0	18	5	Generalist
14	Eurasian skylark	0	0	0	0	6	Poplar specialists
15	Golden oriole	0	0	0	0	8	Poplar specialists
16	Greater coucal	0	0	0	0	8	Poplar specialists
17	House crow	191	15	14	52	233	Generalist
18	House sparrow	6	0	0	140	39	Generalist
19	Indian pond heron	5	0	0	10	23	Generalist
20	Isabelline shrike	1	0	0	0	1	Rare to classify
21	Jungle babbler	14	0	0	4	28	Generalist
22	Red collared dove	36	2	0	8	14	Generalist
23	Red- vented bulbul	17	0	8	9	26	Generalist
24	Rose-ringed parakeet	0	0	0	0	13	Poplar specialists
25	Rufous tree pie	1	0	0	0	1	Rare to classify
26	Striated babbler	16	0	0	9	22	Generalist
27	White wagtail	1	0	0	0	1	Rare to classify
28	White-breasted water hen	1	0	0	0	2	Rare to classify
29	White-throated kingfisher	6	0	0	0	10	Generalist

Table IV.- Number of nests on trees with nesting species and nesting material.

S. No.	Type of tree	No. of nests	Nesting species	No. of nests of each species	Nesting material
1	Eucalyptus	173	House crow Black kite	45 128	Large nests of wood and branches of trees
2	Poplar	109	Common myna	109	Medium sized nests of branches, twigs and feathers
3	Mesquit	21	Unknown	Unknown	Unknown
4	Sheesham	2	Unknown	Unknown	Unknown
5	All other trees	0	0	0	-

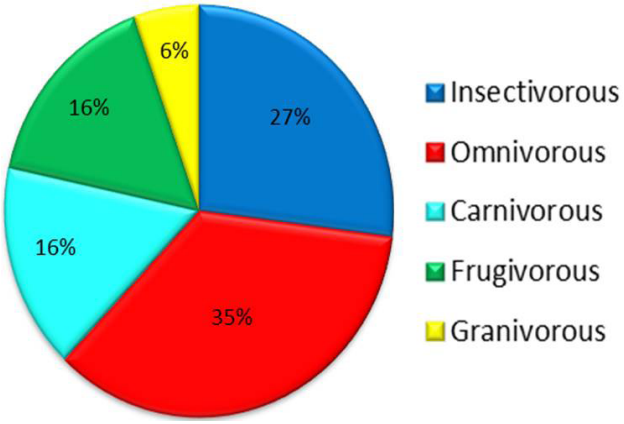

Fig. 2. Percentage foraging guilds of avian species.

DISCUSSION

The canal bank forest is not very rich in terms of abundance and diversity as the bird species showed very little connection and affiliation with the exotic and introduced trees. This is true for all the artificial forests and has been reported to sustain less diversity and number of birds as compared to the natural forests (Volpato *et al*., 2010; Castano-Villa *et al*., 2019).

About one-third of species in the study area were omnivorous probably due to the location of Canal forest surrounded by feeding opportunities near human settlements and urban structures (Fig. 2). Secondly, due to the presence of forest along the canal, some food sources in the aquatic environment such as insects, fish, and crustaceans were also easily accessible. Still, another reason is the development of feeding areas all along the canal where people throw various food items (*e.g.* pulses, wheat, rice,) for the religious purpose to birds that in turn support the dominance of omnivorous species in the area. The granivorous species may be encouraged by feeding areas along the canal and insectivorous species present due to the presence of insects (mosquitoes, larvae, and crustaceans) on the water surface of the canal and insects present in the forest and agriculture surroundings. The frugivorous species were least common in the area most likely due to the absence of fruit-producing native trees and supported by the presence of a few trees like guava *Psidium guajava*, jamun, dharek, *Melia azedarech etc*.

The scatter plot of diversity and abundance showed a contrasting trend that the families which are rich in abundance are poor in diversity and vice versa, for example, the Sturnidea and Corvidae were the most abundant of all families. The possible reason may be the generalist nature of the food (omnivorous diet) and habitat that they were flourishing in the area. Cuculidae and Leiothrichidae (cuckoos and babblers) recorded the highest diversity but the number was not more than a few individuals because of the high specificity of food and habitat suitability. These two groups of birds require thick canopies for hiding (Ali *et al*., 2007) which is less common in the exotic tree species (*e.g.* eucalyptus) hence are not present abundantly. Among the air-borne species, hirundinidae (swallows and martins) were the most abundant followed by Apodidae (swifts). All these are insectivorous species (Arena *et al*., 2011) and found to be preying insects from the air and water surface of the canal.

The Common myna is the most abundant species found in the area followed by the house crow (Fig. 3). Noreen and Sultan (2021) reported that these avian species are opportunist in nature and are most successful in exploiting the available food and habitat. This study also agrees with the findings and that these two species are flourishing in the area as compared to any other bird by using natural and anthropogenic resources of food and are best fit for living in the proximity of an urbanized environment.

House sparrow and black kite were the next dominant species found in the area (Fig. 3). The number of black kites in the forest area was surprisingly high. Noreen and Sultan (2021) reported a much less number in the area. The higher number could be due to the development of feeding areas along the canal side where people throw food items especially meat for some religious purposes which are attracting many raptors in the area. Kumar *et al*. (2019) also reported

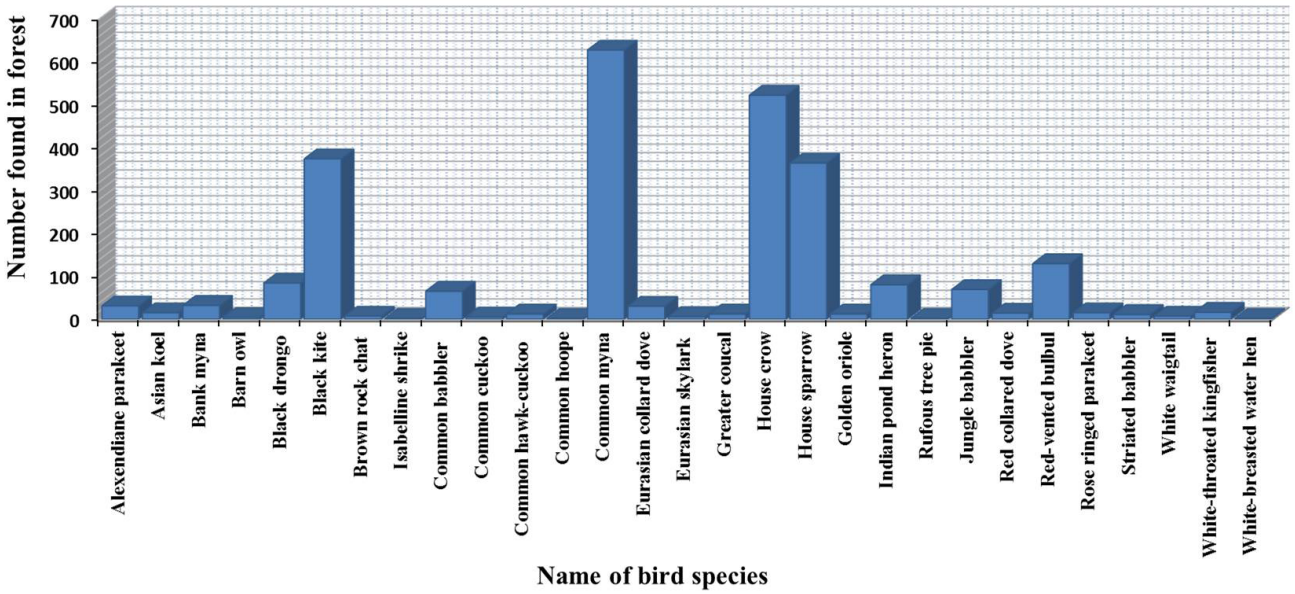

Fig. 3. Total Number of avian species found in the canal bank forest.

that the number of kites had increased in New Delhi in the last century than any other region of the world because of feeding on meat thrown by people for religious purposes. The accessibility of fish from canal water can also be the factor for an abundance of kite population. All the flying species (air borne), *i.e.* swallows, martins, and swifts, were present in nearly equal numbers (Fig. 4) probably due to the availability of insects in canal water and from the forest.

A clear pattern of habitat selection and partitioning of resources is occurring in the mixed plantation of canal bank forest. The northern part consisting of poplar plantation and the southern part consisting of the mixed plantation of eucalyptus, ficus, semul, and mesquit as a strip all along the canal. Poplar trees emerged to be the most suitable habitat with high abundance and diversity of birds. Eucalyptus, the dominant tree in the forest (57%), could retain only half of the species than the Poplar. This lower bird variety in introduced plantations (eucalyptus) can be related to the availability of a few food resources (fleshy fruits and especially insects) and the absence of places for nests in the stem (Barlow *et al*., 2007; Calvino-Cancela, 2013). A few native trees present in the area are playing a minor role in sustaining the diversity of birds. The reason may be their small number or their occurrence *i.e.* they were dispersed distantly from each other's here and there with no continuous distribution. Moreover, many of the native trees (*e.g.* dharek, toot/mulberry *Morus alba*, jamun) are young and may not provide fully developed canopies to birds. Similarly, two mature bohr *Ficus bengalensis* and a few shisham or tahli *Dalbergia sissoo* trees were isolated from the other native trees with no significant contribution in sustaining the diversity of birds.

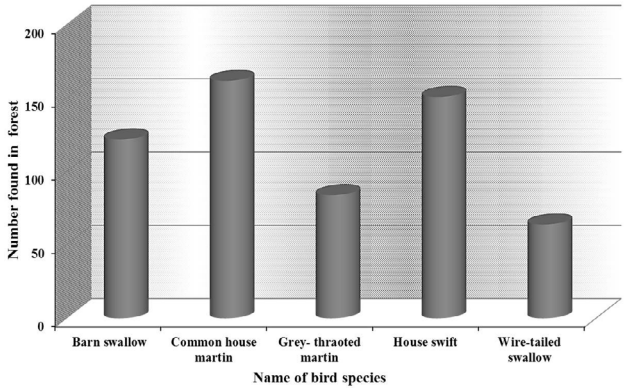

Fig. 4. Number of air borne species found in the canal bank forest.

A principal component analysis (PCA) plot showed visually the variables as clusters based on the statistical correlations. A group of 29 (birds using trees as habitat) variables was found to be strongly correlated to the most important inputs of diversity and abundance. The first cluster is concentrated near the poplar along with the variable of diversity. This cluster is showing the specialists of forest present only on poplar trees (also supported by Table III). The nine specialist species of the forest in connection with poplar include Asian koel, alexandrine

parakeet, Rose-ringed parakeet, golden oriole, common hawk-cuckoo, greater coucal, common cuckoo, common hoopoe, and Eurasian skylark. Several studies also showed that some rare avian species use Poplar plantations as habitat, for example, Dagley (1994) found that in Great Britain the Golden oriole was found to be present in poplar plantations only. The number of breeding birds in North America was higher in poplar plantations than in the row crop plantations (Hanowski *et al*., 1997). Thus, the poplar may be used as an alternative by these native tree specialists after the replacement of all native trees of the area. The shift of habitat from natural forests towards the poplar may be keeping these species from vanishing out of the area.

The second cluster can be seen with both eucalyptus mixed plantation and poplar. This cluster consists of 13 generalist species found all over the forest. The variable of abundance is tightly packed with this cluster probably because these species are generalist and more abundant in the area. Common myna, house crow, doves, black drongo, and red-vented bulbul are the most important generalist species of canal bank forest. Studies conducted in different ecological regions showed that the exotic plantations support an indigenous subset of native birds (*i.e.* generalist species and disturbance tolerant) than the species found in natural forests (Calvino-Cancela, 2013; Barlow *et al*., 2007; Felton *et al*., 2016). The different environmental filters controlled by exotic forest plantations cause such composition differences that result in favoring a few species over others (Castano-Villa *et al*., 2019). Moreover, the forest-dependent, endemic, and threatened species are usually absent from the exotic forest plantations and these are usually inhabited by species with broad distribution ranges and generalists in nature (Peh *et al*., 2006; Barlow *et al*., 2007). Findings reported in these studies support and agree with the presence of generalist species in the study area because these species can survive in every type of habitat and foraging resources.

PCA also shows the anomalous character of the Black kite and House sparrow from all other species. The Black kite was the only species found to be eucalyptus specialist (*Eucalyptus opportunists*). The close affiliation of the Black kite with Eucalyptus has already been established (Kumar *et al*., 2014). The reason may be the height of the tree (171 feet) or some other unknown reasons.

Moreover, many studies prove that the mixed tree plantation along the same line, have a less negative impact than monospecific plantations. Considering that the bird community is highly specific to habitat structure (Lindenmayer *et al*., 2006), mixed tree plantations offer more environmental heterogeneity (Kerr, 1999). But our study does not show this trend. The impact of the mixed plantation was not observed here because of the dominance of eucalyptus trees. Mostly the avian community is generalist distributed rather evenly in the forest showing no increase in both diversity and abundance as noted in this mixed plantation except the role of the poplar tree as described in the above section.

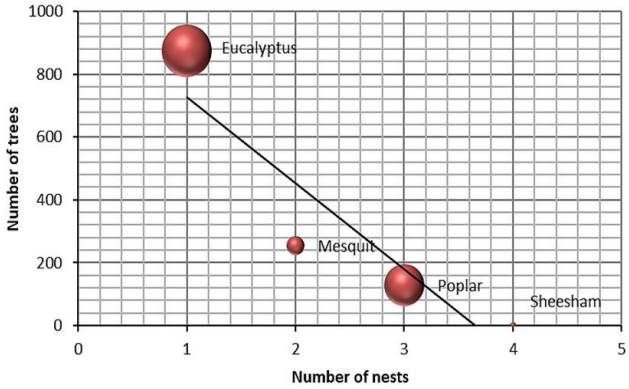

Fig. 5. The comparison of number of nests on different tree species.

Nests were present on a few trees of the forest only. A linear relationship was not found between the number of trees and the number of nests in the forest (Fig. 5). The highest number of nests was found on eucalyptus and then on the poplar. The number of mesquit shrubs was higher than the poplar tree but it was not preferred for nest making by birds probably due to the age factor as most of these shrubs were young. Common myna found to be making nests on poplar tree only and black kite and house crow on the eucalyptus tree. Kumar *et al*. (2014) also reported that black kite likes to make nests on the eucalyptus tree. For instance, in New Delhi, about 35% of nests are found on this tree species. House crow makes nests on tall trees and areas near human habilitation (Goodwin and Gillmor, 1976; Roberts, 1992). In this study, 100% of its nests were found on eucalyptus that is different from the findings of Kaur and Khera (2020) who reported that it could use 16 different tree species for nest building but 29% of its nests were present on eucalyptus and 13% on poplar. They also report that it makes nests on many native trees like jamun, peepal (*Ficus religiosa*), and sheesham. But this does not match our data because no nest was found on any of the native or exotic trees except eucalyptus. It was also observed that the vegetation structure in old artificial plantations was more similar to native forests (Murcia, 1997) but the age of canal bank forest is 25-30 years (assessed by age of trees) as such the capacity of eucalyptus for sustaining bird communities was increasing with time in the absence of native trees.

CONCLUSIONS

It is concluded that the canal bank forest is not much effective as a habitat for the native avifauna of the area as compared to other planted forests in the world and sustaining mostly generalist species. The mixed plantation is also not playing a significant role in attracting bird communities because of the dominance of eucalyptus in the forest. The native trees are also not being used as a habitat for retaining the bird population because of their existence in low numbers and being younger. Poplar is playing a significant role in sustaining the diversity of habitat specialist birds thus it is the most suitable artificial plantation. Tree species in an irrigated forest plantation are selected keeping in view their commercial importance and based on economic analysis. It is recommended that if native trees are required to be replaced by exotic trees Eucalyptus should not be the first choice, but preference should be given to poplar for retaining the native diversity of avifauna. This however may necessitate an Economic analysis while selecting tree species for planting.

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Statement of conflict of interest

The authors have declared no conflict of interests.

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