Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

Journal of Entomology and Zoology Studies

ISSN 2320-7078
JEZS 2014; 2 (5): 01-06

Received: 01-08-2014
Accepted: 16-08-2014

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Role of an Ex-situ conservation site in sustaining the biodiversity of urban bird population

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ABSTRACT
Significant loss of natural habitats in urban areas has increased the emphasis upon the capacity of zoos and parks in contributing towards the conservation of biodiversity of native fauna. This study identifies the role of *ex-situ* conservation sites in providing the essential requirements and habitat for the native birds of the area, in addition to their primary role in protecting and supporting the exhibited animals. A total of 37 species of birds belonging to 26 families under 13 orders were identified in the area. Among the diverse orders represented in the study site, Passeriformes topped the position with 10 families, followed by Coraciiformes with three families. Correlation studies between canopy cover and bird population showed high positive correlation, whereas in the case of visitor density and bird population it showed a negative correlation. Percentage occurrence showed Passeriformes to be the most dominant order. The study area showed a Shannon Weiner index of 3.03 and a corresponding effective number of species of 20.69. This was found to be higher than the corresponding value of a nearby verdant site in the same city.

Keywords: Avian diversity, Urban, Conservation site, Visitor density.

1. Introduction
Human activity directly contributes to climate change, over consumption of the earth's limited resources and biodiversity loss [1, 2, 3, 4]. The International Union for the Conservation of Nature based on evaluation of nearly 56,000 different species suggests that 33% of animal life on earth is presently threatened [5]. In relation to biodiversity loss, much emphasis has been placed upon the potential of reputable zoological parks and aquaria [6]. Beyond serving as places for entertainment and leisure, zoos are increasingly seeking to build their capacity to educate the public and contribute to a conservation ethic [7, 8].
Urban areas are constantly being subjected to a lot of stringent activities, which imparts direct pressure on the native population residing in these areas. Loss of foraging grounds, nesting areas and intrusion into their alcove would definitely have a negative effect on bird species population. An *ex-situ* conservation site like an animal zoo situated within an urban boundary can act as a buffering zone not only for the protected and exhibited species, but also for the native species, especially the avian fauna seen in the locality. The diverse habitat provided in these conservation areas are inadvertently being utilized by a good number of native fauna also.
Although the urban birds have a fairly long history, urban ecosystems have been largely ignored throughout many decades of ecological research [9, 10]. Since the early 1990s, a different view emerged, accepting urban settings as ecosystems that are structured and function like other natural ecosystems [11, 12, 13, 14]. Until the early 2000s, an experimental and mechanistic approach had rarely been taken in urban bird research [15]. Currently, ecologists are trying to understand in a better way the drivers of urban bird population dynamics and community structure, the role of habitat and vegetation profile and also predator-prey interactions, and the interspecific competition for food and other resources.

2. Materials and Methods
The study area included the Thrissur Zoo and its premises. The State Museum & Zoo, Thrissur located in a 13.5-acre area in the heart of Thrissur city, Kerala, India was opened in 1885. It is one of the oldest zoos in the country, and houses a variety of mammals, reptiles, and birds. The Zoo compound also includes a natural history museum and an art museum that showcases the

socio-cultural heritage of the region. Just in front of the museum is a small memorial for the soldiers who went from Thrissur to fight World War I. The Zoo is open to the public six days a week.

Geographically Thrissur is located in the coordinates of $10^0$32'N and $76^0$15'E. The maximum and minimum average temperature recorded in the city are 36 ^{0}C and 22.5 ^{0}C respectively. The winter season records a maximum average of 32 ^{0}C and a minimum average of 20 ^{0}C. Heavy rainfall is received during the two distinct rainy seasons South-West monsoon (June to September) and North-East monsoon (October to November). Maximum precipitation is in the months of June-July with an average annual rainfall record of 3200 mm. January and February are the driest months, with March, April and May months experiencing occasional rains.

The present study was conducted during 2008-09. Bird survey in the study area was mainly based on line transect method [16] by systematically surveying fixed routes and estimating the bird population by direct counting. Point transect method [17] was also employed. The time of observation was between 0600 hrs to 0900 hrs and 1500 hrs to 1800 hrs. Birds were identified and classified according to Ali and Ripley [18, 19]. The common and scientific names are after Manakadan and Pittie [20] and taxonomy according to Inskipp *et al*. [21] and Ripley [22]. The study area was divided into seven sectors and canopy cover was measured with score 0 when there was no foliage overhead, 1 when adjacent crowns barely meet, 2 when they overlap and 3 when sky is not visible. A ten points score was taken in each sector and expressed as percentage canopy cover. The visitor density categories were created to facilitate data collection, as it is not usually possible to calculate absolute numbers during periods of high foot fall. The following score category was used in the study for recording visitor density: zero for no visitors, one for 1-10 visitors, two for 11-20 visitors, three for 21-50 visitors and four for 51 or more visitors. The area of study divided into seven distinct sectors as mentioned earlier was used for the assessment of visitor density.

The data from the census and field observations were used to calculate bird species richness and species composition. The number of species recorded was taken as species richness, which is a measure of diversity. Species richness index like Margalef Index (R1) was calculated. Species diversity was assessed using Shannon-Weiner Index (H). Effective number of species was calculated as exp (H). Percentage occurrence of different orders was calculated from the data. The dominant species of the area were identified. The correlation between the canopy cover and number of birds was studied. Similarly the correlation between visitor density and number of birds was also worked out.

3. Results

The study area is located totally within the urban limits, right in the centre of a city and entertains large crowd of visitors. As depicted in Table1, a total of 37 species of birds were identified in the area. They belonged to 26 different families coming under 13 different orders. Among the diverse orders represented in the area, Passeriformes was represented by 10 different families (38.5%), followed by Coraciiformes with three different families (11.5%). Pelecaniformes and Ciconiiformes were represented by 2 families each. All the other orders had only one family representation in the area. While considering the species representation, Passeriformes topped the list with 14 different species (37.8%), followed by Ciconiiformes with 4 different species (10.8%). This was followed by Pelecaniformes, Cuculiformes and Coraciiformes with 8.1% each. Psittaciformes and Falconiformes formed 5.4% each and other orders were represented by 2.7% each (Figure1).

The relative occurrence of birds was calculated and statistics corroborated the dominance of Passeriformes in the area. It was also noted that *Corvus splendens* and *Acridotheres tristis* belonging to the order Passeriformes were the highest represented species of the area.

Table 1: Details of birds recorded from the study area

Order/Family	Bird Species	Number	Percentage occurrence
Podicipediformes		7	0.089
Podicipedidae	*Tachybaptus ruficollis* (Pallas, 1764)	7	0.089
Pelecaniformes		112	1.431
Phalacrocoracidae	*Phalacrocorax carbo* (Linnaeus, 1758) *Phalacrocorax niger* (Vieillot, 1817)	39 27	0.498 0.345
Anhingidae	*Anhinga melanogaster* (Pennant, 1769)	46	0.587
Ciconiiformes		397	5.072
Ardeidae	*Ardeola grayii* (Sykes, 1832) *Bubulcus ibis* (Linnaeus, 1758) *Egretta garzetta* (Latham, 1790)	40 343 12	0.511 4.382 0.153
Threskiomithidae	*Threskiornis melanocephalus* (Linnaeus, 1766)	2	0.025
Gruiformes		243	3.105
Rallidae	*Amaurornis phoenicurus* (Pennant, 1769)	243	3.105
Falconiformes		73	0.932
Accipitridae	*Haliastur indus* (Boddaert, 1783) *Accipiter badius* (Gmelin, 1788)	32 41	0.408 0.523
Columbiformes		303	3.871
Columbidae	*Columba livia* (Gmelin, 1789)	303	3.871
Cuculiformes		154	1.967
Cuculidae	*Eudynamys scolopaceus* (Linnaeus, 1758)	67	0.856

	Centropus sinensis (Stephens, 1815*)*	53	0.677
	Cuculus micropterus (Gould, 1837)	34	0.434
Coraciiformes		130	1.661
Alcedinidae	*Alcedo atthis* (Linnaeus, 1758)	99	1.265
Halcyonidae	*Halcyon capensis* (Linnaeus, 1766)	27	0.345
Bucerotidae	*Ocyceros birostris* (Scopoli, 1786*)*	4	0.051
Passeriformes		5510	70.406
Oriolida	*Oriolus xanthornus* (Linnaeus, 1758)	11	0.140
Sturnidae	*Acridotheres tristis* (Linnaeus, 1766)	715	9.136
	Acridotheres fuscus (Wagler, 1827)	214	2.734
Corvidae	*Dendrocitta vagabunda* (Latham, 1790)	363	4.638
	Corvus splendens (Vieillot, 1817*)*	789	10.081
Pycnonotidae	*Pycnonotus jocosus* (Linnaeus, 1758*)*	211	2.696
Muscicapidae	*Copsychus saularis* (Linnaeus, 1758*)*	558	7.130
Nectariniidae	*Cinnyris asiaticus* (Latham, 1790)	246	3.143
	Leptocoma zeylonica (Linnaeus, 1766)	146	1.865
Estrildidae	*Lonchura punctulata* (Linnaeus, 1758*)*	584	7.462
	Lonchura malacca (Linnaeus, 1766)	395	5.047
Dicruridae	*Dicrurus macrocercus* (Vieillot, 1817)	587	7.50
Leiothrichidae	*Turdoides striata* (Dumont, 1823)	673	8.599
Ploceidae	*Ploceus philippinus* (Linnaeus, 1766)	18	0.230
Psittaciformes		699	8.931
Psittacidae	*Psittacula krameri* (Scopoli, 1769*)*	472	6.031
	Psittacula cyanocephala (Linnaeus, 1766)	227	2.90
Strigiformes		52	0.664
Tytonidae	*Tyto alba* (Scopoli, 1769*)*	52	0.664
Piciformes		143	1.827
Picidae	*Dinopium benghalense* (Linnaeus, 1758)	143	1.827
Galliformes		3	0.038
Phasianidae	*Pavo cristatus* (Linnaeus, 1758)	3	0.038

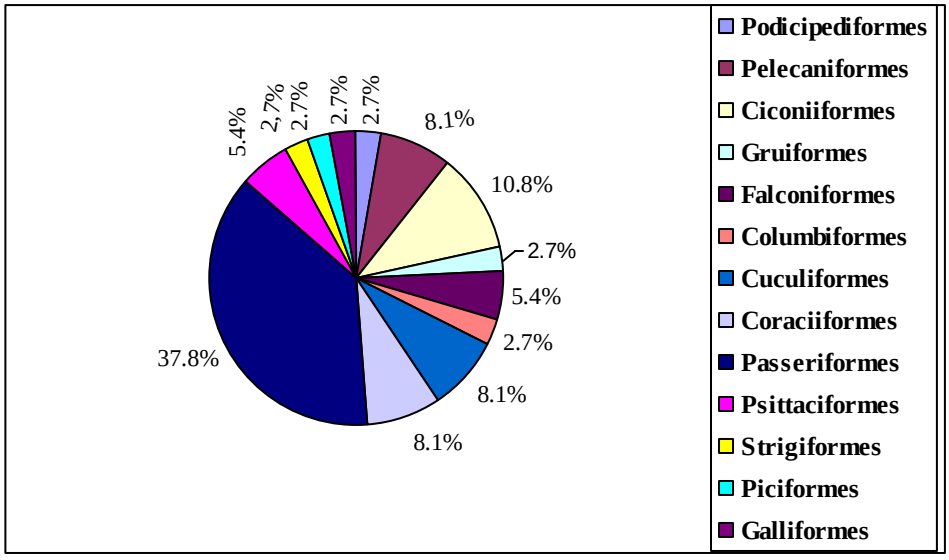

Fig 1: Percentage representation of bird species in the study area

Shannon-Weiner index of the study area was found to be 3.03. This index on conversion to the effective number of species becomes 20.69. Margalef index was found to be 4.016. Total canopy cover of the area was calculated and scaled to 57% (Table 2). There were areas with dense foliage and also areas completely devoid of foliage where exhibit cages and constructions stood.

Table 2: Species richness and diversity indices of study site

Parameter	Value
Shannon-Weiner Index	3.033
Margalef Richness Index	4.016
Total no. of species	37
Total no. of individuals	7826

Canopy cover indexing done in seven marked out sectors of the study area were correlated with the observed bird numbers. The correlation coefficient '*r*' strongly revealed a positive correlation between these two variables (Table 5). The abundantly seen bird species of the area like *Acridotheres tristis, Lonchura punctulata* and *Turdoides striata* showed high positive correlation. The only exception was *Bubulcus ibis* and *Columba livia. Corvus splendens* showed low positive correlation in comparison to other species. The correlation

study of birds with visitor density showed a negative correlation with most of the species. The only exceptions were *Bubulcus ibis*, *Columba livia* and *Corvus splendens.*

Table 3: Common bird species recorded from various sites within the study area

Bird	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site7	Total
Bubulcus ibis	39	45	57	71	27	32	72	343
Columba livia	112	38	-	132	-	21	-	303
Psittacula krameri	42	17	34	67	142	45	125	472
Acridotheres tristis	24	24	32	66	227	145	197	715
Dendrocitta vagabunda	47	40	49	47	62	50	68	363
Corvus splendens	133	94	89	78	47	135	213	789
Copsychus saularis	38	30	58	81	133	103	115	558
Lonchura punctulata	46	35	53	57	162	98	133	584
Dicrurus macrocercus	83	61	71	69	118	87	98	587
Turdoides striata	57	44	68	75	153	129	147	673
Total Birds	621	428	511	743	1071	845	1168	5387

Table 4: Canopy cover and visitor density recorded from various sites within the study area

Parameter	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7
Canopy cover (%)	53	48	50	51	66	64	67
Visitor density	4	4	3	3	1	3	2

Table 5: Correlation co-efficient of birds with canopy cover and visitor density

Bird	Canopy cover vs Birds	Visitor density vs Birds
Bubulcus ibis	−0.221	0.0603
Columba livia	-0.5165	0.5392
Psittacula krameri	0.7926	−0.9224
Acridotheres tristis	0.9527	−0.903
Dendrocitta vagabunda	0.8618	−0.8554
Corvus splendens	0.3843	0.0947
Copsychus saularis	0.8955	−0.9232
Lonchura punctulata	0.9347	−0.9371
Dicrurus macrocercus	0.8854	−0.848
Turdoides striata	0.9738	−0.8778

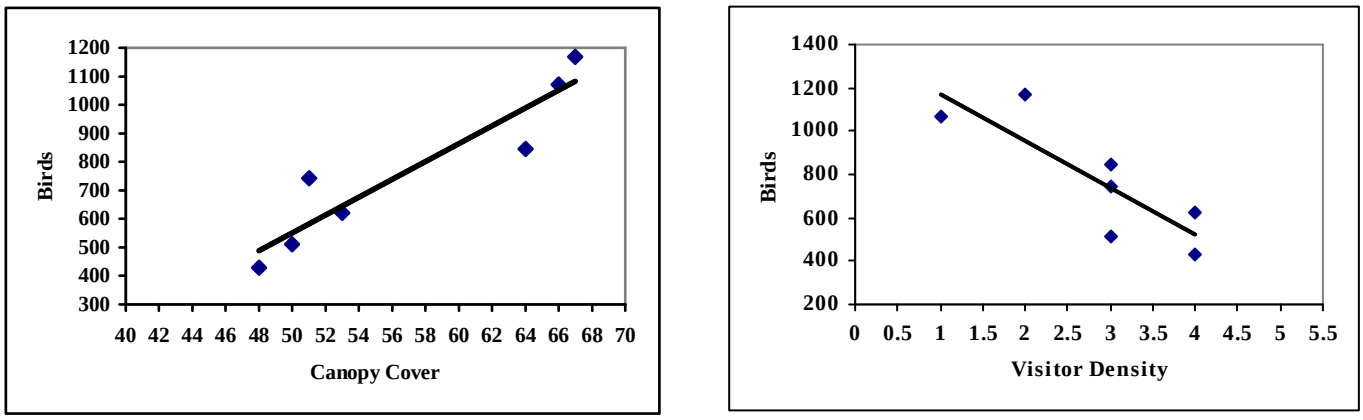

Fig 2: Relationship of birds with canopy cover and visitor density

4. Discussion

Urbanization results in a sequence of fundamental changes on the landscape which can vary from denudation of land, construction of infrastructure, increased human presence and other changes in disturbance regimes. Few synanthropic species of birds can exist and thrive well in such altered habitat and these contribute significantly towards urban bird community [23]. Replacement of native vegetation by exotic ones increase diversity of alien species [24, 25, 26, 27]. Elevated noise levels also interfere with vocal communication of birds [28].

In this context the magnitude of the role delegated to verdant areas like the study site in sustaining native as well as urban bird population becomes highly evident from its effective number of species (20.69). The diversity index was converted into the effective number of species (ENS), which allows effectual comparison of biodiversity between the communities. The effective number of species of this particular study site was found to be higher than the corresponding value (12.42) calculated from the diversity index of a nearby site situated in the same city [29]. While considering these numbers, it should also be borne in mind, that the study area is an *ex-situ* conservation site, which attracts large number of visitors throughout the year. The effect of human presence and activity is shown to be outsized by the functions provided by the vegetation and habitat of this study area situated within the urban boundary. Within this tourist enriched arbor, special niches are available, which cater to the needs of various bird species.

Passeriformes emerged as the most dominant order with representatives from 10 families and 14 different species. This is quite predictable as Passeriformes forms the largest order**.** Percentage occurrence of bird species showed highest value of 70.4 for Passeriformes. These birds have adapted so well to the prevailing conditions of this particular habitat, resulting in out-numbering others. The relative abundance of bird species might be associated to the availability of food and favourable habitat requirements of the species.

The high positive correlation between the birds and the canopy cover is an indication of the shelter, perching and roosting sites made available to them. Species like *Acridotheres tristis, Lonchura punctulata* and *Turdoides striata* showed very high positive correlation. *Bubulcus ibis* and *Columba livia* did not show this trend. *Columba* was mostly detected in close proximity to buildings and constructions. *Bubulcus ibis* and *Corvus splendens* who subsist on scavenging activity were not seriously affected by canopy coverage. The negative correlation with the visitor density noted in the case of most of the species clearly indicates that they avoid and abhor human interceptions into their territory. Exceptions like *Bubulcus ibis, Columba livia* and *Corvus splendens* were less sensitive to human activity. The luxuriant growth of vegetation and the secluded spots available in the study area provides perfect ambience for the residing and visiting birds.

Urbanization creates new habitats and offers higher amount of predictable resources required for the birds, owing to human activity routines [30]. This allows some species to flourish and to extend their breeding season, as seasonality does not restrict resource availability as in wild lands [31]. The zoo area is never deficient in resources. The feed given to the exhibit animals in many instances is being shared by many bird species, especially in open enclosures. The exhibit animals hosting parasites and ticks also provide a trophic niche for birds. All the basic requirements needed for the avian population is in surplus in this region.

5. Conclusion

The study suggests that the maintenance of a permeable and high quality matrix within the city boundaries can help to mitigate to a larger extent the adverse effects of habitat fragmentation and other effects of urbanization. Such milieu can act as a complementary habitat. The facilities available at the Thrissur Zoo are not at par with the other reputable zoos around the world. Still the dense growth of different species of trees and water bodies and the resources provided for various exhibited animals offer diverse habitat and favorable conditions which are being used by the native and urban population of birds.

The canopy cover and tree diversity could minister to providing natural habitat for birds and animals living around. Urban areas are being depleted of such habitats for developmental activities. The importance of the maintenance and upkeep of such habitats in order to sustain the species diversity of the area is a challenge to be taken up while planning for developmental activities in the urban sector.

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