Diversity of avifauna in Urban City, Vadodara, Gujarat

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ABSTRACT

Birds were surveyed in and around 9 different terrestrial habitats in Vadodara city in the semi-arid zone of Gujarat, India for two years (2005-2007). The habitats were mainly divided in to 3 categories disturbed, moderately disturbed and undisturbed. The density and diversity indices like species richness, Shannon-Weiner diversity index, evenness and abundance of birds were calculated for all the habitats to find out status of birds in the particular area compared to the other areas to find out the influence of urbanization on the same. Total 82 species of birds were observed. The areas with good vegetation, parks, and old type of buildings with moderate human disturbances support good diversity as well as density of birds. The study supports that highly disturbed areas have higher density of birds due to the presence of the urban exploiters such as pigeons. Moderately disturbed areas had higher density as well as diversity due to the presence of urban exploiter as well as native species whereas undisturbed areas had low bird density but high diversity because of native species of birds and vice -versa. Highly disturbed areas had the highest density of birds due to presence of urban exploiters but low species richness. One important point observed in the study was moderately disturbed areas have comparatively higher density as well as diversity of birds indicating that human settlements do favor terrestrial bird populations.

Key words: Birds, urban areas, Urban exploiters

INTRODUCTION

Marzluff (2001) defined urbanization as "the process of growth of cities that results into a strong gradient of human densities of suburbs which is increasingly complex and take urban characteristics". Urbanization is considered as one of the major threats to the bird

population as under the tremendous pressures of urbanization the native habitats are lost, fragmented or modified, the native vegetation is altered and the exotic species or ornamental plants get introduced (Strife, 2004). Here large areas of land are covered with concrete and coal tar; thereby percolation of water to underground water table gets reduced, resulting into changed habitats with few original species of native plants. This divides an urban area into several micro habitats leading to habitat fragmentation and producing strong effects on flora and fauna.

Birds, one of the most important indicators of the health of an ecosystem, react very rapidly to changes in their habitats (Morrison, 1986; Koskimies, 1989). Decline in the density and number of bird species have been correlated with habitat loss and fragmentation (Traut, 2003). Although, these changes in the habitat are the main cause of species decline, the mechanisms causing fragmentation and the spatial distribution of resources act at different scales (Flather and Sauer, 1996). Reports indicate that urbanization favours few species but selects against most such that the avian community composition of urban environment differs dramatically from local natural environments (Jokimaki and Suhonen, 1993; O'Connell *et al.*, 2000). The

Figure-1. Location of 9 terrestrial habitats in Vadodara city.
(a) India (b) Gujarat State with location of Vadodara city (C) Vadodara City
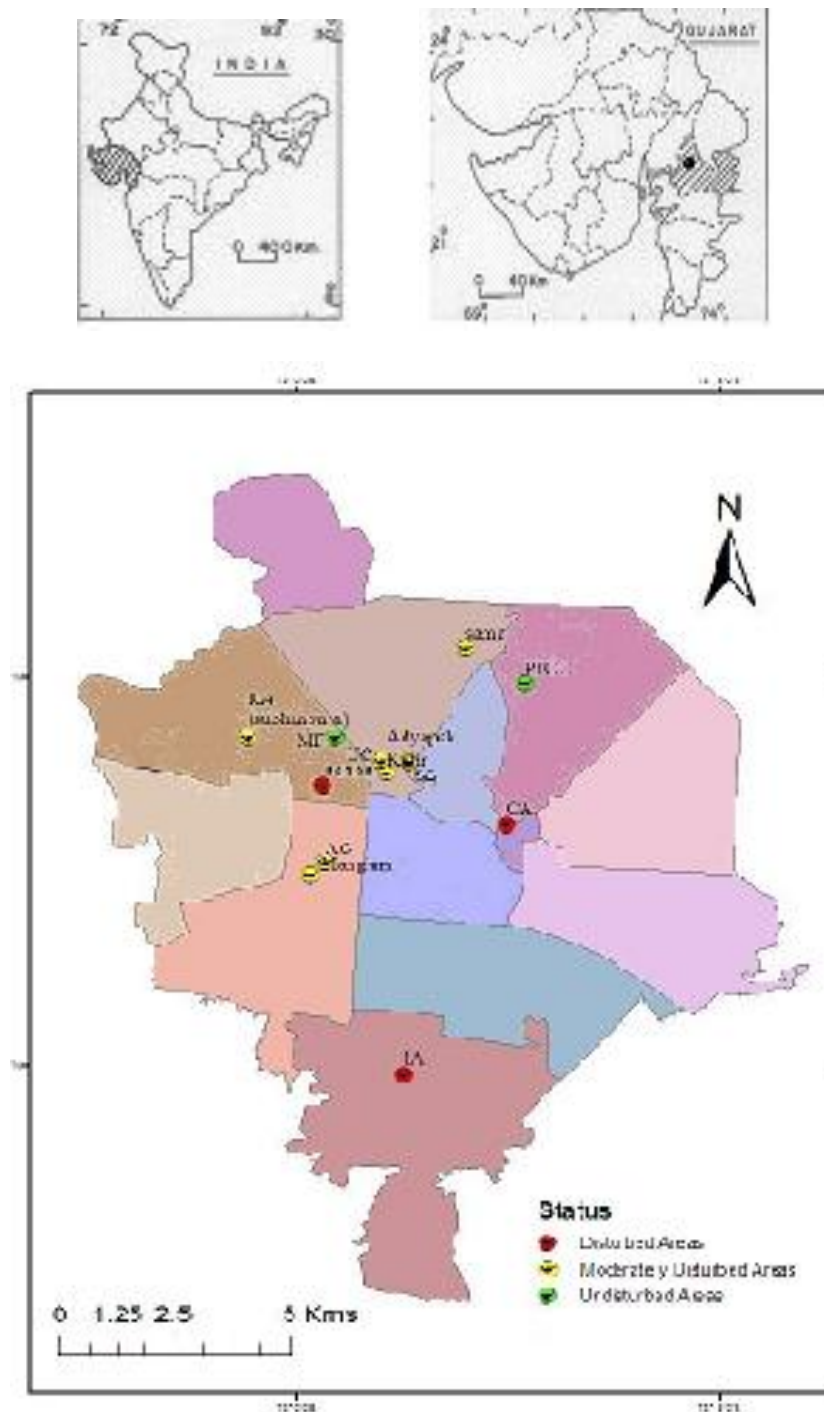
increase in urban development decreases the species richness and diversity but increases the density of birds (Traut, 2003). That is, some species of birds prefer human settlements and increase in number while others are reduced in number by the urban development (Marzluff, 2001). In other words, increased urbanization with the increase elements such as housing density typically leads to an increase in avian biomass but a reduction in species richness (Chace and Walsh, 2004). This relationship has been further emphasized by

Clergeau *et al.* (1998) stating that the urban communities are dominated by few omnivore species which are able to adapt to the additional resources available to them in urban environment. However, graminivore species like pigeon (*Columba livia*) adapt well to man made environments and are considered the most troublesome bird pest of cities and suburbs (Marsh and Howard, 1982). Thus, the anthropogenically manipulated landscapes can create heterogeneous

Figure-2. Location of 9 terrestrial habitats in Vadodara city.
I Disturbed areas (DA) (a) R. C. Dutt Road (RCDR) (b) City area (CA) and (c) Industrial area (IA). II Moderately Disturbed areas (MD) (d) Sayaji Garden (Kamatibaug) (SG), (e) University Campus (UC), (f) Akota Garden (AG) and Residential area (RA). III Undistributed areas (UD) (h) Model farm (MF) and (i) PTC campus (PTCC).

RCDR

CA

IA

UC, SG

AG

MF

PTTC
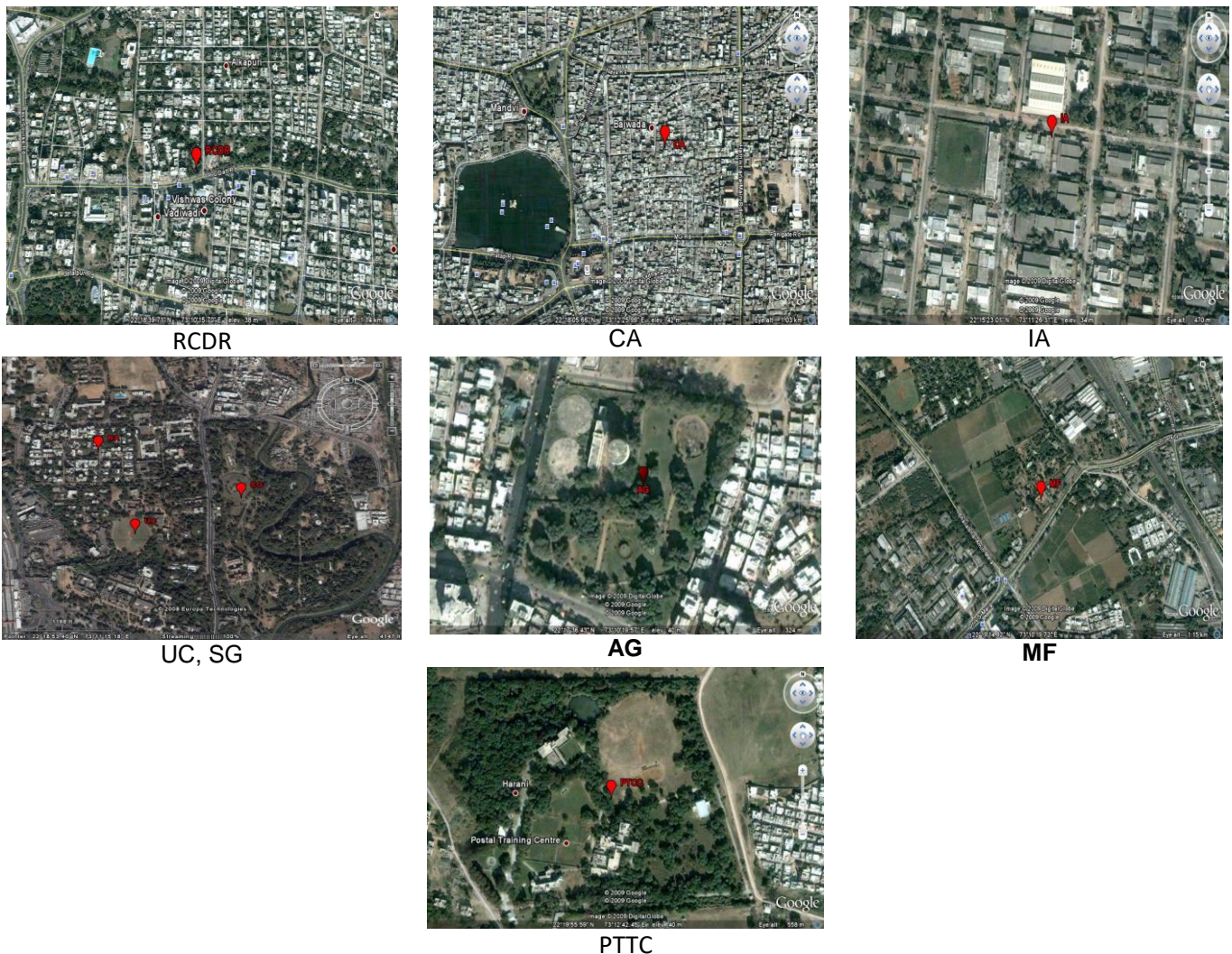
environment attracting specialized species (Strife, 2004).

Urban environment with its concrete jungles, recreational parks and gardens of private premises do provide nesting and roosting habitats with additional food supplies provided by man. Though the numbers of the studies that describe avian responses to urbanization are immense and growing (Marzluff *et al.*, 2001). Such studies in Asia and particularly in Indian climatic conditions are meagre. There are an estimated 961 resident land and fresh water bird species in the oriental region belonging to 66 families (Welty and Baptista, 1988). With migratory species, 1,225 species of birds are recorded within Indian subcontinent (Ali and Ripley 1969). Almost half of these species *i.e.*, 526 species are recorded in Gujarat (Parasharya *et al.,* 2004), of which 244 are reported in Vadodara district of

Central Gujarat (Padate *et al.*, 2001). Further, lower in the terrestrial as well as aquatic habitats of the city (Rathod, 2009) and about 80 species in various terrestrial habitats of the Vadodara city (Padate *et al.*, 1998). However, their density, diversity and distribution in the city have not been reported.

The present paper discusses the influence of ongoing urbanization on species richness, density, the species diversity index (Shanon-Wiener Index, H') and evenness (E) of the avifauna and similarity index of birds between selected areas of Vadodara city.

MATERIALS AND METHODS

Study Areas:
Vadodara is one of the cultural and educational centers of Gujarat state. This city has palaces, parks,

ponds, residential and commercial areas as well as industries that attract people from other areas. Vadodara (22° 22' 37.4" N, 22° 22' 59.4" N and 73° 7' 20.8" E, 73° 15' 42.07" E) is expanding very fast with the development of residential as well as industrial areas and business centers producing a strong gradient of suburbs.

Nine different terrestrial habitats were selected from Vadodara district (Figure-1 & 2). These areas were divided into three categories according to the varying anthropogenic disturbances.

I Disturbed areas (DA) (a) R. C. Dutt Road (RCDR) (b) City area (CA) and (c) Industrial area (IA). II Moderately Disturbed areas (MD) (d) Sayaji Garden (Kamatibaug) (SG), (e) University Campus (UC), (f) Akota Garden (AG) and Residential area (RA). III Undistributed areas (UD) (h) Model farm (MF) and (i) PTC campus (PTCC).

Methodology:

The study areas were visited once in a month from October 2005 to September 2007, for 2 hours starting from sunrise, amounting to a total of 216 visits. Birds were observed using 8×50 or 7×35 binoculars and identified on the basis of standard books by Ali (1996) and Grimmett et al., (1999). The birds were counted using transect method and / or point count method (Rodgers, 1991). Species richness (number of species), diversity indices like Shannon- Wiener and equitability (Krebs, 1985) were calculated for each visit to evaluate the distribution of birds (Rodgers, 1991). Further, Jaccard's similarity indices was calculated for all the study areas (Table-1). The transect area, approximate building cover and vegetation cover of different study areas surveyed in the Vadodara city (Table-2).

Statistical Analysis

Table-1 Jaccard's index of birds between different study areas in Vadodara city.

Site	PTCC	MF	RA	AG	SG	UC	IA	CA
RCDR	0.3	0.33	0.36	0.42	0.33	0.36	0.51	0.63
CA	0.23	0.32	0.28	0.35	0.26	0.25	0.43	
IA	0.4	0.52	0.65	0.62	0.56	0.58		
UC	0.6	0.59	0.65	0.6	0.62			
SG	0.65	0.52	0.59	0.55				
AG	0.5	0.57	0.63					
RA	0.53	0.49						
MF	0.62							

Table-2. Study areas, Site locations, Site characteristics, transect area, building and vegetation cover (%).

| Study areas	Site locations	Site characteristics	Transect area (Km^2)	% cover (Approximate)	
Disturbed areas				Buildings	Vegetation
RCDR (R.C. Dutt Road)	22° 18' 35 N 73° 10' 17 E	Highly populated	0.03	75%	25%
CA (City area)	22° 18' 06 N 73° 12' 27 E	highly populated	0.05	95%	5%
IA (Industrial area)	22° 14' 53 N 73° 11' 14 E	Industrial buildings	0.05	50%	50%
Moderately Disturbed areas					
SG (Sayaji Garden)	22° 18. 53' N 73° 11 20' E	least human disturbances	0.087	5%	95%
UC (University Campus)	22° 18. 46' N 73° 11 07' E		0.087	40%	60%
AG (Akota Garden)	22° 17' 36" N 73° 10' 19" E	least human disturbances	0.03	5%	95%
RA (Residential areas)	22° 20' 22" N 73° 11' 58" E	moderately populated	0.2	40%	60%
Undisturbed areas					
MF (Model Farm)	22⁰ 17' 13" N 73⁰ 10'25" E	very less human disturbances	0.35	5%	95%
PTCC (PTC campus)	22⁰ 19' 55" N 73⁰ 12' 40" E	very less human disturbances	0.2	5%	95%

The results are expressed as mean $\pm$ SEM where n = 24 (×9). The data for each visit was used for statistical analysis with the help of one-way analysis of variance (ANOVA) or t-test by using statistical software. The p value for ANOVA and t-test is non-significant if P > 0.05 (ns), significant if P < 0.05 (*), significantly significant (**) if P is < 0.001 and highly significant (***) if P < 0.0001. The positive and negative impacts of urban pressures on avifauna are discussed.

RESULTS AND DISCUSSION

82 species were observed during study period. Further, disturbed areas (DA) among the three disturbed areas; RCDR, CA and IA; highest total species richness, (n=33) was noted at IA with highly significant (P < 0.0001, $F_{2, 69}$ 136.2) differences. This could be due to good vegetation present near the industrial area and comparatively low human disturbances. Distribution of the bird species in urban areas have been related with the urban- rural gradients as well as different anthropogenic activities (Reynaud and Thioulouse, 2000). However, the density of birds was highest at RCDR followed by CA and lowest at IA again with highly significant differences (P < 0.0001, $F_{2, 69}$ 25.59). Urbanization leads to changes in habitat structure and resource availability and that results into segregation of the avian community (Beissinger and Osborne, 1982; Fraterrigo and Wiens 2005). Common species like pigeons, crows were less common in undisturbed areas while native or indigenous species of birds were almost totally absent from disturbed urban areas where the density of buildings is high as compared to tree abundance. Pigeons are well adapted to man made environments and are considered the most troublesome bird pests in cities and suburbs (Marsh and Howard, 1982). Commercial buildings constructed with exposed I-beam are preferred nesting sites for pigeons (Geis, 1976). The urban areas with minimum vegetation support low species of birds as compared to areas with dense vegetation (Clergeau et al., 1998). Further, density of house?? is also support the population of pigeon, crows and mynas. Similar

Figure-3. Species richness, Density, Shannon- Wiener index and evenness of birds at different areas of Vadodara city.
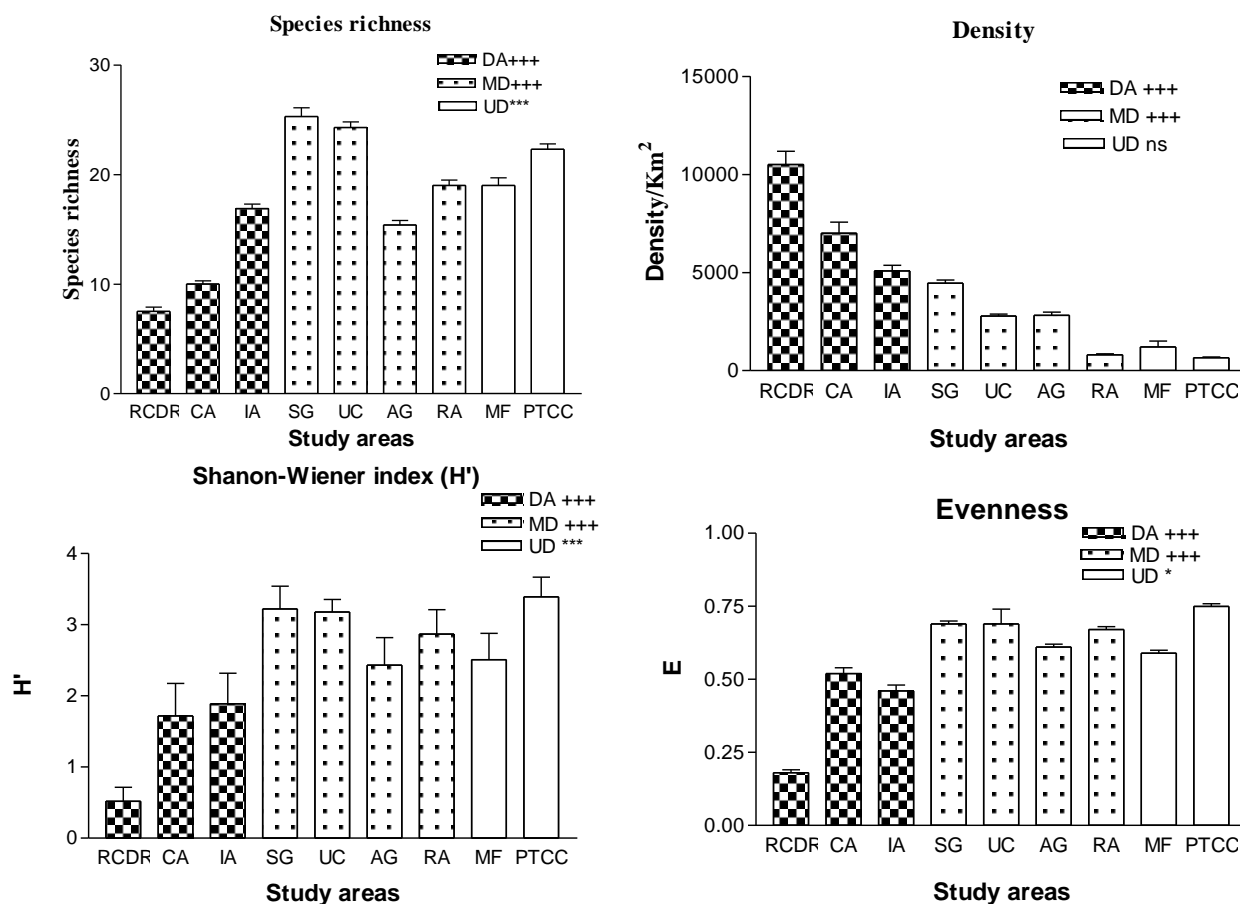
DA (Disturbed Areas) MD (Moderately disturbed Areas) and UD (Undisturbed Areas)
*/ + P< 0.05, ** /++ P< 0.001, *** / +++ P < 0.0001, ns = non-significant
*For T-test, + For ANNOVA

results were obtained by *Kark et al.* (2007) wherein they observed that a few hardy species termed as "urban exploiter" which are totally habituated with the urban conditions.

Differences in diversity indices and evenness amongst disturbed areas is also highly significant (H′ P < 0.0001, $F_{2, 69}$ 92.92, evenness P < 0.0001, $F_{2, 69}$ 75.78).

Among the four moderately disturbed areas (MD), SG, UC, AG and RA, the highest total species richness 56 (mean 25.3 ± 0.8) was observed at SG (Figure-3). This is supports the fact that moderate levels of development increases bird species richness (Tilghman, 1987; Shwartz *et al.*, 2007) and significant differences were observed (P < 0.0001, $F_{3, 92}$ 57.87). Further, SG is one such big garden in Vadodara city with zoo, a toy train, a planetarium and a museum. Ninety-five percent of vegetation cover at SG includes 97 species of trees, 42 species of herbs, 22 species of shrubs and 5 species of climbers (Thaker and Jasrai, 2005). SG being a public park, composition of its plant species changes every season/year making the habitat more complex. A small river Vishwamitri cuts the park into two parts adding to variations in the habitat. Trees at SG provide roosting sites for variety of the urban exploiters. In the urban ecosystem parks are usually the most heterogeneous green spaces that are important habitats for bird communities (Shwartz *et al.*, 2007). The amount of shrub cover in urban parks is principal microhabitat characteristic that is expected to have a greater availability of escape covers and higher tolerance levels of birds to visitors (Knight and Temple, 1995; Fernandez- J, *et al.*, 2001).

A heronary of native water bird species like Cattle egret (*Bubulcus ibis*), Little egret (*Egretta garzetta*), Intermediate egret (*Mesophoyx intermedia*), Indian Pond Heron (*Ardeola grayii*), Night heron (*Butorides striatus*) and Little cormorant (*Phalacrocorax niger*) adds to the species richness of the park. However, bird density showed a different trend with highest at SG followed by AG, UC and RA (P < 0.0001, $F_{3, 92}$ 127.2). Further, AG support good bird diversity which could be due to presence of 95% native vegetation and surrounding areas has residential buildings and gardens were occupied by joggers during morning time. These visitors to urban parks are a relatively benign source of disturbance as the birds are not killed or pursued by them (Cooke, 1980). The birds in such gardens learn to tolerate human intrusions (Rodgers and Smith, 1995; Riffel *et al.*, 1996) and hence 62% of the species were shared by the two regions UC and SG (Rathod, 2009). (Shannon-Wiener indices P < 0.0001, $F_{3, 92}$ 31.52, evenness P < 0.0001, $F_{3, 92}$ 7.4)

Between the two undisturbed areas (UD), the areas with good vegetation, MF and PTCC. The significant differences between the species richness of two undisturbed areas total species MF (n=51) (P < 0.0001). Total species richness was 51 MF (Model farm), located in the center of the city but having agricultural land surrounded by large trees (95%). In

modern world, men tend to build urban centers in highly productive ecosystems that also support high levels of biodiversity (Huston, 1993; Balmford *et al.*, 2001). They also develop farms away from urban centers. Such mosaic habitat with urban and agriculture patches present both direct problems of habitat modification and indirect effects of chemical pollution that may disturb water and nutrient cycles (Pimentel *et al.*, 1992). However, the agriculture provides a concentrated and highly predictable source of food to birds (Dhindsa and Saini, 1994).

Species richness was highest (n=58) at PTCC with dense vegetation (95%) and low building cover (5%) which provided serene habitat. When the diversity of native species increases the density and the diversity of common birds decreases (REF??). This indicates that undisturbed areas support good diversity of birds with less density. With high Shannon-Wiener index (H') and evenness probably because of high vegetation cover Several species of birds that were common in Vadodara few decades ago are reduced in number today (Padate, communicated)

At Undisturbed areas, MF and PTCC, differences in diversity were highly significant (P < 0.0001) and evenness was significant (P < 0.05).

Jaccard's index (Similarity index):

At least 30% of birds were common in different urban areas of Vadodara city, Gujarat, in semiarid zone of India. The Jaccard's indices between all 9 study areas are given in table 3. RCDR shares 30 to 40 species with moderately disturbed and undisturbed areas. Among the three disturbed areas they share 40 to 60%. Moderately disturbed areas share 50 to 60 % species among them. The undisturbed areas share 30 to 60 % of species with disturbed and moderately disturbed areas.

CONCLUSION

The urban areas with good vegetation, parks, and old type of buildings support good diversity of birds. Some species of birds are totally adapted to the urban conditions, where as several others are not. Even some migratory species of birds can visit the undisturbed areas amidst disturbed habitats. In present study a gradation in the urban exploiter is noted. From the present study it can be said that the moderately disturbed areas with human presence as well as good vegetation cover are the preferred habitats by both urban exploiters as well as native species. In other words moderately disturbed areas are preferred by majority of the species, the urban exploiters, the urban adaptors and the native ones. Urbanization can provide diverse unpredictable food supplies in the form of human leftovers, hence in heterogenous habitats all "urban exploiters", "urban adaptors" as well as "native species" are found. A marked decline in species diversity occurs over the time if the degree of urbanization increases (Batten, 1972).

Further studies on a larger scale may show statistically and clinically significant differences and support previous published clinical data and animal studies about their role.

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Conflict of Interests

Authors declare that there is no conflict of interests regarding the publication of this paper.

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