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# Sacred green spaces in semi-urban areas sustain more birds than its adjacent areas: A study from lower Gangetic plains, West Bengal, India

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**Abstract** With rapid urban expansion and flourishing real estate sector, remaining green patches in many sub-urban/peri-urban areas are facing immense threat and/or being destroyed. We therefore, explored the avian abundance and richness of green spaces around temples (sacred sites) and compared them with adjoining green spaces without religious places (control sites). The species richness and abundance in sacred sites (12.16 ± 0.65 species; 25.54 ± 1.176 individuals) was significantly higher than control sites (6.31 ± 0.77 species; 20.04 ± 1.4 individuals). The compositions of avian communities of sacred sites were significantly different and the presence of temple positively influenced the species richness. GLMM also revealed that the species richness was positively influenced by the distance to building and tree cover area and not influenced by distance to road, areas of water body, bare land. Our findings indicate that the green spaces around the sacred places have greater avian diversity in semi-urban areas, and could be prioritized for the conservation of avian diversity. Generating local support could be relatively easier due to traditional, religious and/or cultural belief against tree felling around the places of worship.

Keywords: Avifauna; Species richness, Sacred, green spaces, urbanization

**Összefoglalás** A gyors városi terjeszkedés és az ingatlanszektor virágzása miatt számos külvárosi és városkörnyéki zöldterületet óriási veszély vagy pusztulás fenyeget. Ezért megvizsgáltuk a templomok (szent helyek) körüli zöldterületek madárvilágát és fajgazdagságát a szomszédos, nem vallási jellegű zöldterületek (kontroll területek) összehasonlításában. A szent helyek fajgazdagsága és a fajok abundanciája (12,16 ± 0,65 faj; 25,54 ± 1,176 egyed) statisztikailag is kimutathatóan magasabb volt, mint a kontroll területeken (6,31 ± 0,77 faj; 20,04 ± 1,4 egyed). A szent helyek madárközösségeinek összetétele szignifikánsan különbözött, és a templom jelenléte pozitívan befolyásolta a fajgazdagságot. A GLMM azt is kimutatta, hogy a fajgazdagságot pozitívan befolyásolta az épületek távolsága és a fával borított terület nagysága, de nem befolyásolta az úttól való távolság, a vízfelület és a kopár terület nagysága. Eredményeink azt mutatják, hogy a szent helyeket körülölelő zöldterületek nagyobb diverzitással rendelkeznek a kevésbé városi területekhez képest, és elsődlegesek lehetnek a sokféleség megőrzése szempontjából. A helyi támogatások megszerzése viszonylag könnyebb lehet a hagyományos, vallási és/vagy kulturális hiedelmek miatt, amelyek ellenzik a fák kivágását a vallási helyek körül.

Kulcsszavak: madárvilág, fajgazdagság, szent, zöldterület, városiasodás

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## Introduction

Birds are widely distributed in various ecosystems (Mekonen 2017) and are often abundant in areas with suitable survival conditions (Veech *et al.* 2010). Urban areas across the globe are also inhabited by many species of flora and fauna (McKinney 2008, Shwartz *et al.* 2014), including birds (Echevema & Vassallo 2008, Hu & Cardoso 2009). However, there are marked differences between natural and human dominated ecosystems (Alberti 2005).

Cities and towns across the globe are ever-expanding with explosion in human population (Kumar 2017) leading to large scale destruction of many natural habitats, especially in the peri-urban areas. Such loss, degradation and fragmentation of habitats coupled with environmental changes (McKinney 2006, Bar-Massada *et al.* 2014), destruction of trees (Watson *et al.* 2004), reduction of wilderness areas (Dumont 2012, Di Marco *et al.* 2019) and increase in impervious surfaces (Souza *et al.* 2019), which often threatens the survival of many species thriving in these areas (Marzluff *et al.* 2001, Sol *et al.* 2017). In such a scenario, various native green spaces served as important remnant patches of habitats for wildlife thriving in human-dominated landscapes (McKinney 2002, Shwartz *et al.* 2014) and have received importance for wildlife conservation in many European countries (Clergeau *et al.* 2001). Apart from positively influencing the wellbeing and good health of human citizens (Cohencline *et al.* 2015, Shanahan *et al.* 2015, Botzat *et al.* 2016), green spaces in urban areas are often rich in biodiversity (Shwartz *et al.* 2014) and have long been identified to increase the functional connectivity for the local fauna (Ikin *et al.* 2015). For these reasons, urban green spaces have received importance for wildlife conservation in many western countries (Clergeau *et al.* 2001).

Avian assemblages often serve as useful indicator of the habitat quality and biodiversity of any particular area (Alexandrino *et al.* 2016). Therefore, studies investigating bird species richness and diversity have been carried out in parks and forest remnants (Croci *et al.* 2008, Nielsen *et al.* 2014), cemeteries (Lussenhop 1977, Löki *et al.* 2019) and sacred groves (Kumar & Chhaya 2015) in urban areas. However, with flourishing real estate sector and rapid urbanization in many sub-urban/peri-urban areas, several green spaces have already been converted to built-up areas and many other remaining green patches are facing similar imminent threats, which make conservation of these habitats increasingly challenging for urban planners in the developing nations (Ikin *et al.* 2015, Gopal *et al.* 2018). The conservation biologists need to explore new areas within human dominated landscapes to conserve biodiversity. Religious places are often surrounded by green spaces and are the integral part of almost every sub-urban and urban landscapes. Yet, there is a clear paucity of studies on avian diversity from the green spaces around sacred/religious places from the developing nations with intense population explosion and rapid urbanization, and is practically absent from any semi-urban areas of a highly populated country like India. Therefore, we carried out this study in a semi-urban area (i) to make an assessment of the community composition, species richness and abundance of avifauna in the sacred green spaces compared to the adjoining matrix of non-sacred green spaces; and (ii) explored the relationship of habitat features with the species richness of birds. Our findings highlight the importance of the sacred sites in the semi-urban areas in sustaining avian diversity.

## Methods

### Data collection

Field surveys were carried out from January 2017 – May 2017 in Ashoknagar and adjoining areas (22.833°N, 88.633°E), which is a semi-urban area located in the lower Gangetic plains, India *(Figure 1)*. We selected three green spaces with temples (hereafter referred as a "sacred site") maintaining a minimum gap of 500 m between them. Temples are the building/architectures used as places of worship, which are usually surrounded by several large, old trees and other greeneries within their boundary. Adjacent to each sacred site, we selected one green space without temple (henceforth "control site") maintaining a minimum gap of 500 m between the sacred sites and their respective adjacent control sites. To assess the abundance and diversity of birds, we adopted belt transect method (Bibby *et al.* 2000). For this purpose, two fixed transects (length 100 m and width 10 m) were placed on each of the study sites keeping a gap of 200 m between adjacent transects to avoid overlapping of data. Thus, a total of 12 belt-transects (2 transects * 3 sacred sites + 2 transects * 3 control sites) were laid in the study area. Each of these transect was traversed on foot, twice in a month from January to May during days with calm weather conditions (without rain and strong wind) and during morning hours (between 07:00 and 09:30), when birds are usually most active. Equal efforts

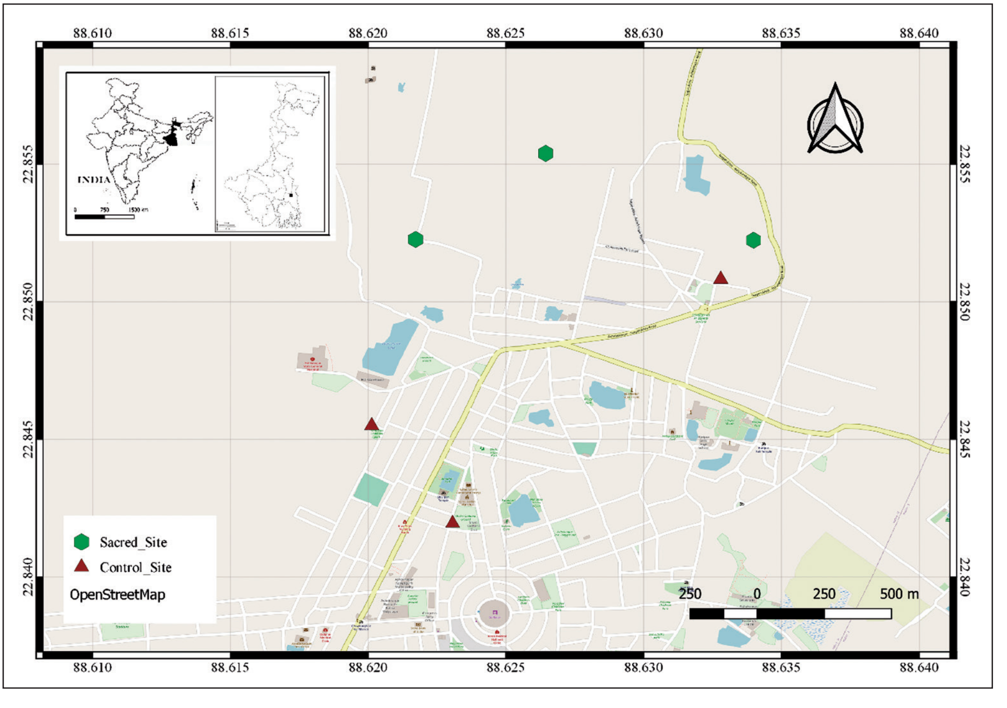


*Figure 1.* Location of the study area in West Bengal, India (a) and the locations of "sacred sites and control sites" within the study area (b)

*1. ábra* A vizsgálati terület elhelyezkedése India Nyugat-Bengál tartományában (a) és a felmért szent helyek és kontroll területek feltüntetésével (b) were made in each of the sampling sites and ten observations were made at each transect (i.e. twice in a month for five months). While traversing along the transects, we collected data on the abundance (total number of individual birds) and species richness (total number of avian species recorded) of avifauna that is present between 5 m on either side of transects. Bird were observed either with unaided eyes or with the help of a pair of binoculars (Nikon 8 × 40), identified using bird field guides (Grimmett *et al.* 2011) and photographs were taken with a digital camera (Fuji Finepix S6800) for documentation of the avifauna. Land covers are often considered as important habitat features for birds (Litteral & Shochat 2017). Google Earth satellite images are freely available with high resolution synoptic view of the study area and hence, used for the assessment of land cover features (Hu *et al.* 2013, Barik *et al.* 2021). We calculated the area of tree cover, bare land cover within the belt transect (i.e. 100 m × 10 m) by drawing separate polygons over the outer boundary of each land cover feature and measured the linear distance to nearest road, building and water body using a cloud free Google image in Google Earth Pro platform v7.3.3.7699.

### Data analysis

Shapiro-Wilk's tests revealed that the abundance ($W = 0.938$, $df = 45$, $P = 0.02$) and species richness ($W = 0.94$, $df = 45$, $P = 0.02$) were non-normally distributed, over-dispersed and negatively skewed. Non-metric multidimensional scaling (henceforth, NMDS) is considered as a popular statistical method to compare bird communities between study sites (Legendre & Legendre 1998). Thus, we performed NMDS along with two-dimensional stress-plot ($K = 2$) to compare avian assemblages between sacred sites and control sites using Bray-Curtis similarity index. As the data was non-normally distributed, we carried out Kruskal-Wallis tests to evaluate the difference of abundance and species richness of avifauna between sacred sites and control sites (Kruskal & Wallis 1952). Thereafter, we performed Generalized Linear Mixed Model (GLMM) with negative binomial distribution and log link function to examine the effect of landscape variables on species richness of birds (Paun *et al.* 2019). We considered presence of temple, distance to road, building, water body, and areas of tree cover and grassland as fixed factors and study site as a random factor in the model to test their effects on species richness (response variable). All statistical analyses were performed in PAST, SPSS and RStudio software packages. Significance was tested at $P < 0.05$ and data were presented as mean ± standard error.

## Results

We recorded 45 species of birds belonging to 9 orders and 25 families during the study *(Table 1)*, of which the order Passeriformes has the highest number of species (n = 25). Most of the recorded species were resident (88.88%). NMDS of avian assemblages revealed that the species composition of bird communities in all three control areas overlapped, but were clearly and significantly different from the sacred areas *(Figure 2)*. We found a stress value of the NMDS ≤ 0.2, which indicates good representation of data (Tryjanowski *et al.*

*Table 1.* The bird species observed in the sacred sites and control sites together with their respective taxonomic positions (order, family), feeding guild (Car – carnivore, Omn – omnivore, Herb – herbivore, Nect – nectarivore, Gran – granivore, Ins – insectivore, Frug – frugivore), Habitat Specialization (G – generalist, S – Specialist) and global population trend (↓ – declining, ↑ – increasing, → – stable, and ? Unknown)

*1. táblázat* A szent helyeken és a kontroll területeken megfigyelt madárfajok, valamint azok taxonómiai helyzete (rend, család), táplálkozási guildje (Car – ragadozó, Omn – mindenevő, Herb – növényevő, Nect – nektárevő, Gran – nagyevő, Ins – rovarevő, Frug – gyümölcsevő), élőhelyi specializációja (G – generalista, S – specialista) és globális populációs trendja (↓ – csökkenő, ↑ – növekvő, → – stabil ? – ismeretlen)

| SL. No. | Order | Family | Common name | Scientific name | Feeding guild | Habitat Specialization | Global Population Trend | Sacred Site | Control site |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Columbiformes | Columbidae | Spotted Dove | *Streptopelia chinensis* | Gran | G | ↑ | ✓ | ✓ |
| 2 | Columbiformes | Columbidae | Yellow-footed Green Pigeon | *Treron phoenicopterus* | Gran | G | ↑ | ✓ | - |
| 3 | Columbiformes | Columbidae | Rock Dove | *Columba livia* | Gran | G | ↓ | ✓ | ✓ |
| 4 | Coraciiformes | Alcedinidae | Stork-billed Kingfisher | *Pelargopsis capensis* | Car | S | ↓ | ✓ | - |
| 5 | Coraciiformes | Alcedinidae | White-throated Kingfisher | *Halcyon smyrnensis* | Car | G | ↑ | ✓ | ✓ |
| 6 | Coraciiformes | Alcedinidae | Common Kingfisher | *Alcedo atthis* | Car | G | ? | ✓ | - |
| 7 | Coraciiformes | Meropidae | Green Bee-eater | *Merops orientalis* | Ins | G | ↑ | ✓ | |
| 8 | Cuculiformes | Cuculidae | Lesser Coucal | *Centropus bengalensis* | Omn | S | ↑ | ✓ | ✓ |
| 9 | Cuculiformes | Cuculidae | Asian Koel | *Eudynamys scolopaceus* | Omn | G | → | ✓ | ✓ |
| 10 | Gruiformes | Rallidae | White-breasted Waterhen | *Amaurornis phoenicurus* | Omn | G | ? | ✓ | - |
| 11 | Passeriformes | Dicruridae | Black Drongo | *Dicrurus macrocercus* | Ins | G | ? | ✓ | - |
| 12 | Passeriformes | Dicruridae | Bronzed Drongo | *Dicrurus aeneus* | Ins | S | ? | ✓ | - |
| 13 | Passeriformes | Aegithinidae | Common Iora | *Aegithina tiphia* | Ins | S | ? | ✓ | - |

| SL. No. | Order | Family | Common name | Scientific name | Feeding guild | Habitat Specialization | Global Population Trend | Sacred Site | Control site |
|---|---|---|---|---|---|---|---|---|---|
| 14 | Passeriformes | Cisticolidae | Common Tailorbird | *Orthotomus sutorius* | Ins | G | → | ✓ | ✓ |
| 15 | Passeriformes | Corvidae | Rufous Treepie | *Dendrocitta vagabunda* | Ins | G | ↓ | ✓ | - |
| 16 | Passeriformes | Corvidae | House Crow | *Corvus splendens* | Omn | G | → | ✓ | ✓ |
| 17 | Passeriformes | Corvidae | Large-billed Crow | *Corvus macrorhynchos* | Omn | G | → | ✓ | ✓ |
| 18 | Passeriformes | Estrildidae | Tricoloured Munia | *Lonchura malacca* | Gran | S | → | ✓ | - |
| 19 | Passeriformes | Laniidae | Brown Shrike | *Lanius cristatus* | Ins | S | ↓ | ✓ | - |
| 20 | Passeriformes | Leiothrichidae | Jungle Babbler | *Turdoides striata* | Omn | G | → | ✓ | ✓ |
| 21 | Passeriformes | Monarchidae | Indian Paradise Flycatcher | *Terpsiphone paradise* | Inse | S | → | ✓ | - |
| 22 | Passeriformes | Monarchidae | Brown-breasted Flycatcher | *Muscicapa muttui* | Inse | S | ↓ | ✓ | - |
| 23 | Passeriformes | Muscicapidae | Oriental Magpie-Robin | *Copsychus saularis* | Inse | G | → | ✓ | ✓ |
| 24 | Passeriformes | Passeridae | House Sparrow | *Passer domesticus* | Omn | G | ↓ | ✓ | ✓ |
| 25 | Passeriformes | Muscicapidae | Red-throated Flycatcher | *Ficedula parva* | Ins | S | → | ✓ | - |
| 26 | Passeriformes | Nectariniidae | Purple Sunbird | *Nectarinia asiatica* | Nect | G | → | ✓ | - |
| 27 | Passeriformes | Nectariniidae | Purple-rumped Sunbird | *Leptocoma zeylonica* | Nect | G | → | ✓ | - |
| 28 | Passeriformes | Oriolidae | Black-hooded Oriole | *Oriolus xanthornus* | Omn | S | → | ✓ | ✓ |
| 29 | Passeriformes | Pycnonotidae | Red-whiskered Bulbul | *Pycnonotus jocosus* | Omn | G | ↓ | ✓ | - |

| SL. No. | Order | Family | Common name | Scientific name | Feeding guild | Habitat Specialization | Global Population Trend | Sacred Site | Control site |
|---|---|---|---|---|---|---|---|---|---|
| 30 | Passeriformes | Pycnonotidae | Red-vented Bulbul | *Pycnonotus cafer* | Omn | G | ↑ | ✓ | ✓ |
| 31 | Passeriformes | Sturnidae | Asian Pied Starling | *Gracupica contra* | Omn | G | ↑ | ✓ | ✓ |
| 32 | Passeriformes | Sturnidae | Chestnut-tailed Starling | *Sturnia malabarica* | Ins | S | ? | ✓ | - |
| 33 | Passeriformes | Sturnidae | Common Myna | *Acridotheres tristis* | Omn | G | ↑ | ✓ | ✓ |
| 34 | Passeriformes | Sturnidae | Jungle Myna | *Acridotheres fuscus* | Omn | G | ↓ | ✓ | ✓ |
| 35 | Passeriformes | Turdidae | Orange-headed Thrush | *Geokichla citrina* | Ins | S | ↓ | ✓ | - |
| 36 | Pelecaniformes | Ardeidae | Black-crowned Night Heron | *Nycticorax nycticorax* | Car | S | ↓ | ✓ | - |
| 37 | Pelecaniformes | Ardeidae | Indian Pond Heron | *Ardeola grayii* | Car | G | ? | ✓ | - |
| 38 | Pelecaniformes | Ardeidae | Cattle Egret | *Bubulcus ibis* | Car | S | ↑ | ✓ | ✓ |
| 39 | Piciformes | Picidae | Streak-throated Woodpecker | *Picus xanthopygaeus* | Ins | S | ? | ✓ | - |
| 40 | Piciformes | Picidae | Lesser Golden-backed Woodpecker | *Dinopium benghalense* | Ins | G | → | ✓ | - |
| 41 | Piciformes | Picidae | Fulvous-breasted Woodpecker | *Dendrocopos macei* | Ins | S | → | ✓ | - |
| 42 | Piciformes | Ramphastidae | Blue-throated Barbet | *Psilopogon asiaticus* | Frug | S | → | ✓ | - |
| 43 | Piciformes | Ramphastidae | Coppersmith Barbet | *Psilopogon haemacephalus* | Frug | S | ↑ | ✓ | - |
| 44 | Psittaciformes | Psittaculidae | Rose-ringed Parakeet | *Psittacula krameri* | Frug | G | ↑ | ✓ | - |
| 45 | Strigiformes | Strigidae | Brown Hawk Owl | *Ninox scutulata* | Car | S | ↓ | ✓ | - |

2017). Although, the avian communities in three control sites highly overlapped, yet the birds of three sacred sites did not overlap with each other *(Figure 2)*. Out of all species of birds recorded during this study, 28 species (62.23%) were noticed exclusively on sacred sites, 17 species (37.78%) were found only in the control sites and 17 species (37.78%)

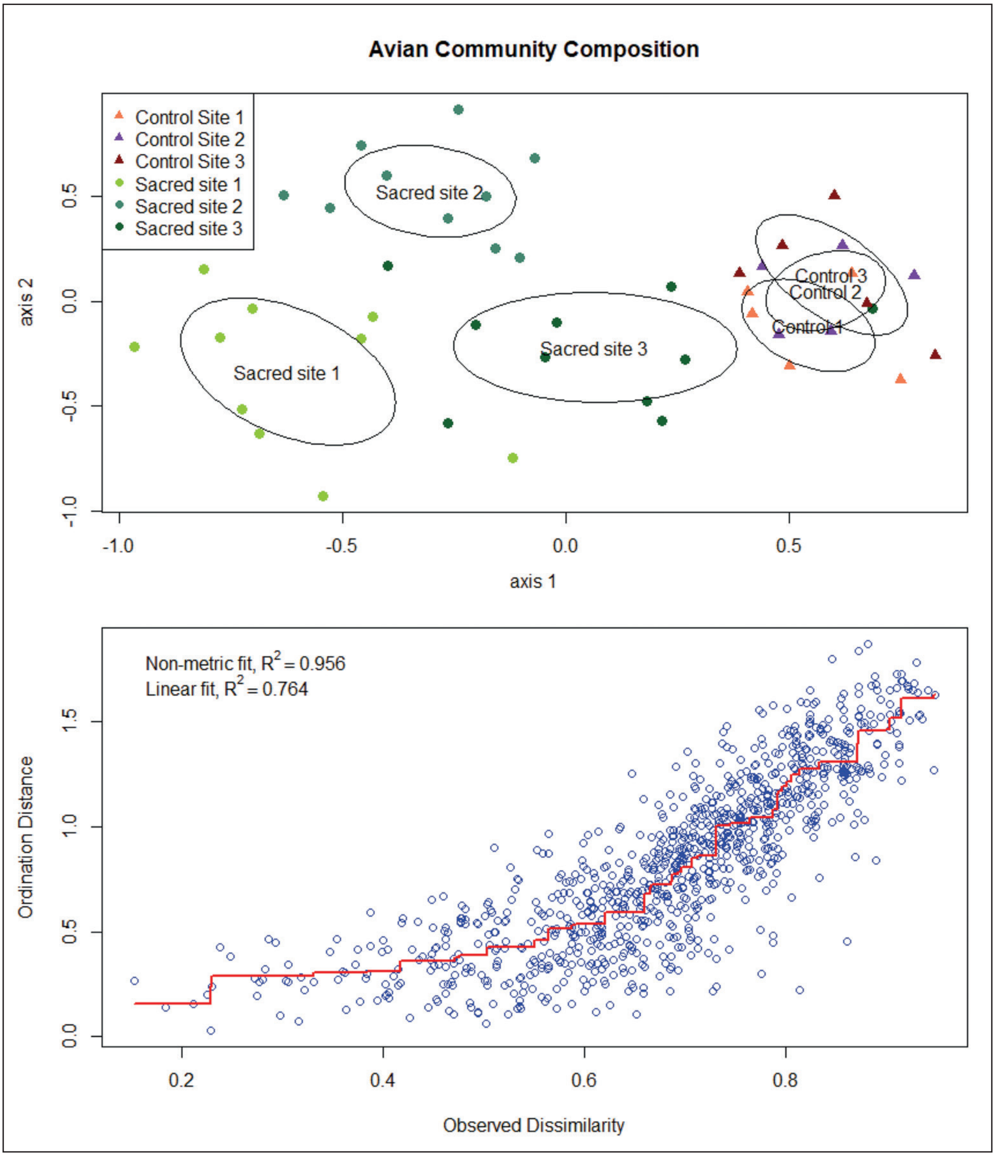


*Figure 2.* Non-metric multidimensional scaling (NMDS) of avian assemblages sampled in sacred sites and control sites using Bray-Curtis similarity index in the study area along with the stress-plot (2D stress = 0.23)

*2. ábra* A szent helyeken és a kontroll területeken felmért madárközösségek nem-metrikus többdimenziós skálázása (NMDS) a Bray-Curtis hasonlósági index segítségével, a stressz-diagrammal kiegészítve (2D stressz = 0,23)

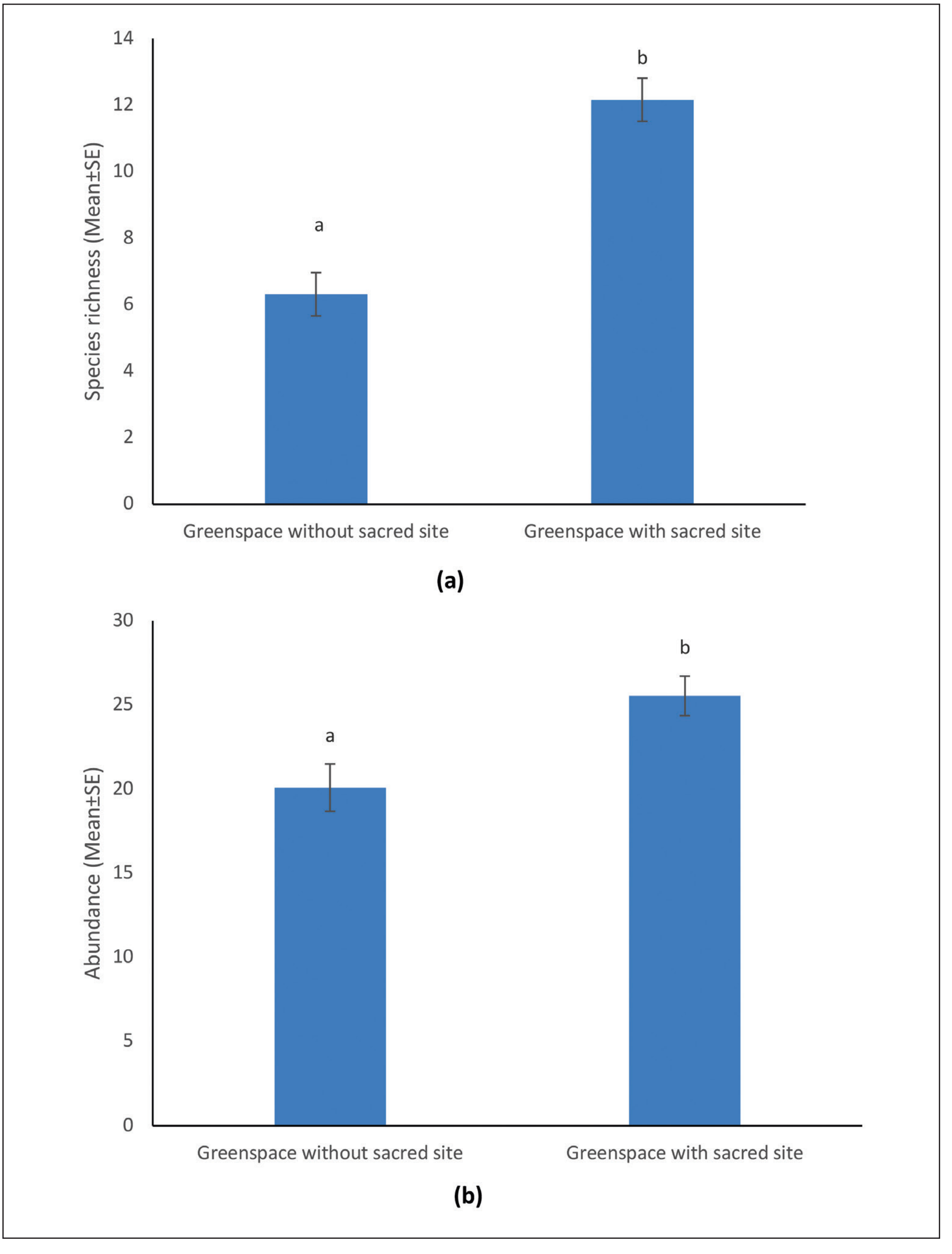


*Figure 3.* (a) Species richness and (b) Abundance of birds in sacred sites and control sites [Columns with different letters indicate significant difference (Bonferroni post hoc tests $P < 0.05$). Error bars indicate standard errors (SE) of means]

*3. ábra* A szent helyeken és a kontroll területeken mért fajgazdagság (a) és madárbőség (b), ahol az oszlopok betűjelei a szignifikáns eltéréseket jelölik (Bonferroni korrekció, $P < 0,05$), feltüntetve az átlagok standard hibáját is

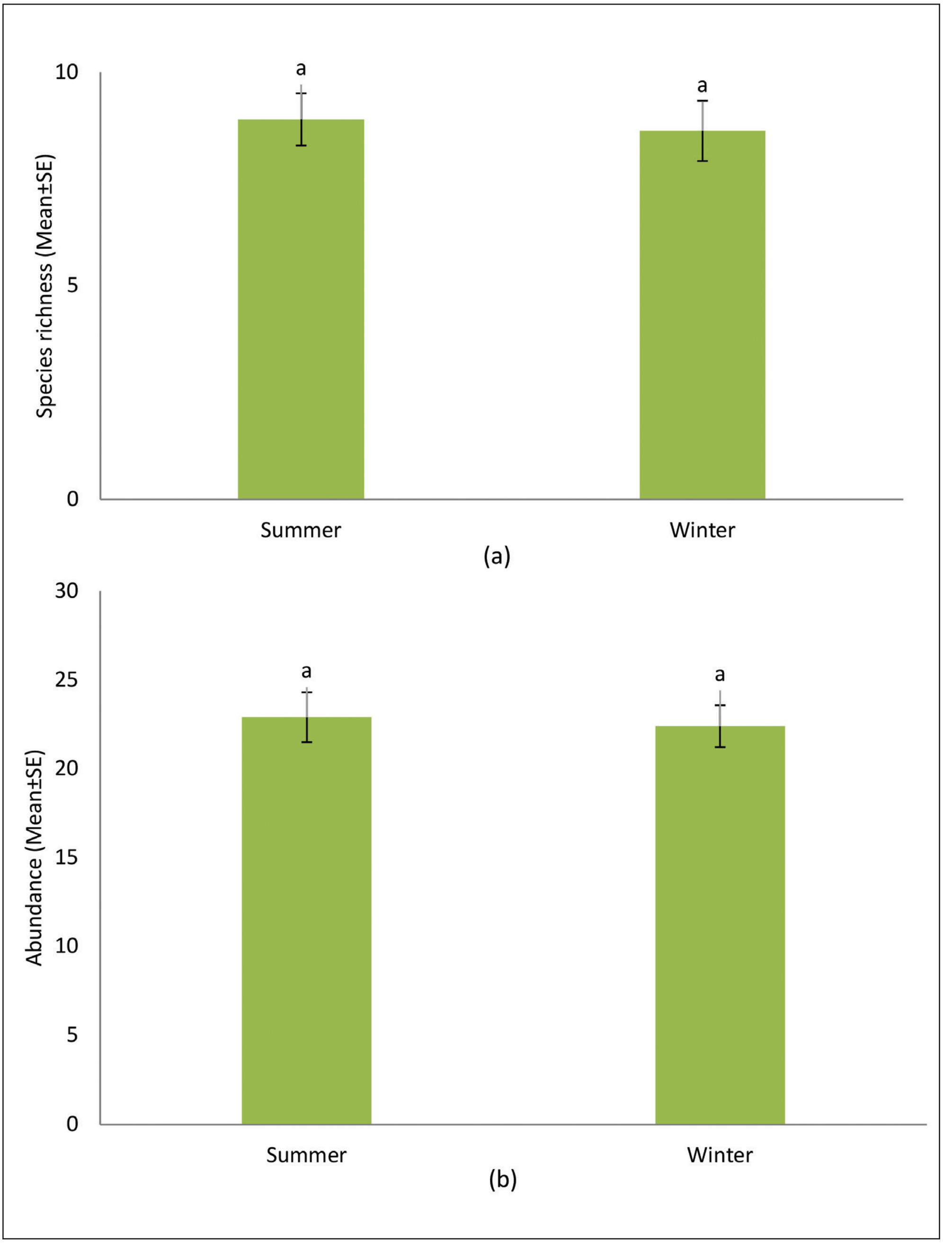


*Figure 4.* (a) Species richness and (b) abundance of birds during summer and winter [Columns with the same letters are not significantly different from each other (Bonferroni post hoc tests P > 0.05). Error bars indicate standard errors (SE) of means]

*4. ábra* A nyári és a téli időszakban mért fajgazdagság (a) és madárbőség (b), ahol az oszlopok betűjelei a szignifikáns eltéréseket jelölik (Bonferroni korrekció, P < 0,05), feltüntetve az átlagok standard hibáját is were common in both sacred and control sites. Among the unique species recorded from sites during the present study, 14 were insectivores, 5 were carnivores, 3 were frugivores and others were granivores, omnivores and nectarivores. Out of 45 species encountered in the study sites, 19 (42.3%) species were habitat specialists, of which 17 species were forest dwellers and mainly found only in sacred sites, while 26 (57.7%) were generalist species and were found in both sacred and control sites (SoIB 2020) *(Table 1)*.

*Table 2.* Generalized linear mixed model (GLMM) accounting for variation in urban bird species richness in relation to the habitat features Road, Building, Water body, Bare land and Tree cover. Significant variables (at P < 0.05) are in bold

*2. táblázat* Az általánosított lineáris kevert modell (GLMM) eredményei a madarak városi fajgazdagságának varianciáját magyarázandó változókkal, út, épület, vízfelület, kopár terület és faborítottság. A szignifikáns változók (P < 0,05) félkövérrel kiemelve

| Fixed effects | β | SE | z | p |
|---|---|---|---|---|
| Presence of Temple | **0.65** | 0.11 | 5.87 | **4.27e-09** |
| Tree cover | **0.73** | 0.13 | 5.64 | **1.75e-08** |
| Bare land | 0.14 | 0.1 | 1.42 | 0.16 |
| Road | 0.32 | 0.17 | 1.93 | 0.06 |
| Building | **0.33** | 0.1 | 3.26 | **0.002** |
| Water body | 0.08 | 0.12 | 0.71 | 0.48 |

The species richness in sacred sites (12.16 ± 0.65 species) was significantly higher (Kruskal-Wallis test: $H = 37.28$, $P < 0.05$) than in control sites (6.3 ± 0.77 species) as shown in *Figure 3a*. Likewise, *Figure 3b* shows that the abundance of birds were also significantly higher (Kruskal-Wallis test: $H = 10.97$, $P < 0.05$) in sacred sites (25.54 ± 1.176 individuals) as compared to their neighboring control sites (20.04 ± 1.403 individuals). But no significant seasonal difference was noticed in the abundance (Kruskal-Wallis test: $H = 0.1$, $P > 0.05$) and species richness (Kruskal-Wallis test: $H = 0.09$, $P > 0.05$) as shown in *Figure 4*.

GLMM revealed that the species richness was positively influenced by presence of temple, tree cover area and distance to building and was not influenced by distance to road, areas of water body, bare land *(Table 2)*. The areas of tree cover within the sacred sites were significantly larger ($H = 13.66$, df = 1, $P < 0.05$) and bare lands were significantly less ($H = 4.918$, df = 1, $P < 0.05$) than the control sites.

## Discussion

Sacred groves in inaccessible and remote terrains are rich in biodiversity as they are less disturbed. The sacred sites can also serve as important areas for conservation of biodiversity in semi-urban and rural areas (Devkota 2013, Gopal *et al.* 2018). Urban cemeteries are known to serve as important habitat for many sensitive and threatened species (Čanády & Mošanský 2017). These areas often act as 'habitat islands' for many rare and native species (Morrehouse & Hassen 2004) and have been found to sustain rich biodiversity in many urban areas across the globe (Bhagwat & Rutte 2006, Kowarik *et al*. 2016). Green spaces around the religious places (i.e. sacred green spaces) are often integral component of many urban ecosystems around the globe. We found that the sacred green spaces (sacred sites) in human dominated areas sustained higher species richness of birds than its neighboring green spaces without sacred areas (control sites). During the present study, the species richness of birds did not show any significant seasonal difference between summer and winter, possibly because most of the birds were resident birds and were present throughout the year in our study area in different weather conditions.

Land cover features also give important cues for birds to decide upon whether to use that particular habitat or not (Cody 1981). Greater habitat heterogeneity and complexity of vegetation increase the species richness of avifaunal communities (Lorenzón *et al.* 2016, Mukhopadhyay & Mazumdar 2017, 2019). Importance of any green space to birds is influenced by the density and diversity of trees, number of native flora, as well as the amount of anthropogenic disturbances existing there (Mills *et al.* 1989, Chamberlain *et al.* 2007). We found that the species richness of birds during the present study were positively influenced by the areas of tree cover *(Table 2)*, which is in agreement with earlier studies (Chamberlain *et al.* 2007). Areas with rich vegetation in the green spaces usually sustain greater bird abundance as compared to areas with impoverished vegetation (Chace & Walsh 2006). Increasing tree cover provides crucial resources for the arboreal and forest birds (Ciach & Fröhlich 2017). Not only inside the green spaces, increased amount of vegetation cover in the adjoining urban areas also increased the richness and abundance of the native fauna (Ikin *et al.* 2013, 2015), while the surrounding dense urban matrix leads to the decline in the abundance and diversity of native birds (Canedoli *et al.* 2018). Moreover, buildings in urban areas are often impoverished of suitable resources (Rodewald *et al.* 2011). They also manifest greater associated anthropogenic pressures (Rodewald *et al.* 2011). Few urban exploiters may be found in greater numbers in areas closer to buildings, but most of the urban avoiders tend to avoid buildings (Blair 1996). During the present study, we also found habitat specialists (19 species), including 17 forest dwelling species, in the sacred sites and they clearly avoided the control sites. For these reasons, we found the species richness of birds being higher in areas away from buildings *(Table 2)*, and are therefore, attractive for birds. Human attitude plays very important role in shaping the composition of avifauna in any particular habitat (Reynaud 1995, Borghesio 2008). Sacred green spaces are often associated with various cultural and religious importance to the local people (Rutte 2011) and are considered as 'cultural heritage sites with conservation importance' (Verschuuren *et al.* 2010). The devotees and other people visiting the religious places are in a peaceful and contemplating state of mind, when they usually appreciate the presence of natural surroundings. People out of religious belief also refrain from destroying the flora and fauna in these sacred spaces even in the urban areas. Possibly for this attitude of people many religious places (at least in our study area) are surrounded by large amount of green spaces, with fair number of old trees, which in turn sustain rich avian diversity. We clearly found that the areas of tree cover within the sacred sites were significantly larger than their adjoining sites without temples. Such human attitude and religious belief against tree felling around the places of worship are often very effective in saving trees and other floral components in these areas (Nagendra 2016), which in turn make such sacred green spaces important from the perspective of conservation of avian diversity (McKinney 2002, Shwartz *et al.* 2014).

Our findings emphasize the importance of green spaces around religious places in conserving avian diversity in human dominated landscapes. Particularly in urban/

semi-urban areas in developing countries, which are rapidly losing the green spaces due to infrastructure development, the sacred green spaces often serve as stable, favorable and "keystone habitats" for several forest-dwelling birds and urban avoiders to thrive in the human dominated habitats (Brandt *et al.* 2013, Gopal *et al.* 2018). Hence, we suggest that the green spaces around the religious places in urban and semi-urban areas should be prioritized for the conservation of avian diversity, which might not only be beneficial for the conservation of avian communities, but also other species thriving in those areas. In spite of rapid urbanization, generating people support for conserving such sacred green spaces could also be relatively easier using the traditional religious / spiritual / cultural belief systems of people (Rutte 2011), as compared to many other natural habitats in human dominated areas. Managers and wildlife planners have to realize the importance of such sites from biodiversity conservation perspective. More studies need to be carried out in human dominated areas across the globe to understand the role of these sacred green spaces in conserving avian diversity in particular, and biodiversity parse.

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