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Cover: Common Silverline *Spindasis vulcanus vulcanus* in poster colours adapted from photograph by Kalpesh Tayade. © Pooja R. Patil.

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COMMUNICATION

Avifaunal diversity in Indian Institute of Technology Guwahati Campus, Assam, India

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Abstract: Indian Institute of Technology - Guwahati (IITG), Assam, is an ecologically rich campus hosting different species of birds, butterflies and mammals. It accommodates several migratory and resident species of birds across different seasons. However, information is scanty on avian diversity with respect to the different habitats of the campus. Therefore, the present study attempts to gain insight into avian diversity with respect to habitat heterogeneity by considering the species presence-absence dataset collected for three years (2017–2020). A multivariate Beta (*β*) diversity analysis is carried out for the IITG campus constituted of five primary habitats, viz., secondary growth, eco–forest, water bodies, swampy-marshy area, and constructions. Of 152 bird species observed in the IITG campus, the highest number is reported from secondary growth, followed by eco-forest. The multivariate analysis shows that the average *β*–diversity for the IITG campus is approximately equal to 79%, which is in accordance with another published study. These observations are examined in light of hypotheses and phenomena documented in the literature, such as habitat heterogeneity hypothesis, niche-based hypothesis and anthropogenic impact on habitats. The study also establishes that the IITG is among the educational institutes and campuses that host many migratory bird species. Lastly, based on the outcomes of *β*–diversity analysis, it is suggested that the conservation effort for avian species in the campus should be directed towards individual habitats uniformly.

Keywords: Campus avian diversity, habitat heterogeneity, presence-absence dataset, multivariate *β* – diversity.

Abbreviations: 2D—Two dimensional | *a*—Number of species shared between two habitats | A_R—Richness agreement | *b,c*—Number of species present in one habitat but absent in another | CBC—Campus Bird Count | D_R—Richness difference | IBA—Important bird and biodiversity area | IITG—Indian Institute of Technology Guwahati | N_s—Species nestedness | PAST—Paleontological Statistics software package for education and data analysis | R_S—Species replacement | S_J—Jaccard's similarity index | $\bar{x}$—Mean index | *α*—Alpha diversity, diversity of individual habitat | *β*—Beta diversity | β_+—Additive beta diversity | $\beta_\times$—Multiplicative beta diversity | β_J—Jaccard's dissimilarity index or Beta diversity | $\bar{\beta}_J$—Mean of all multivariate beta diversity values | $\beta_{J,\ avg}$—Average of multivariate beta diversity of one habitat | β_s—Sorenson's index | *γ*—Gamma diversity, the total number of species in an area encircling all the habitats.

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Author contributions: Documentation, data analysis, structure and overall preparation of the manuscript, and communication are done by UHR. RB has contributed in terms of documentation, data analysis, and manuscript structure.

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ASSAM BIRD MONITORING NETWORK

Indian Institute of Technology Guwahati

INTRODUCTION

The state of Assam, situated in the northeastern part of India, is home to over 700 avian species (BirdLife-International 2022). The bird and biodiversity hotspots of Assam include 55 IBAs (Important bird and biodiversity areas), which also cover the state's National Parks and Wildlife Sanctuaries (Rahmani et al. 2016). However, the presence of avian species is not limited to the aforementioned designated sites. It extends to lesser-known birding areas such as a city, a remote wetland, a college campus or even an individual's backyard. Among them, the university campuses are distinctive because they can possess heterogeneous habitats along with continuous anthropogenic influences. Moreover, Liu et al. (2021) reviewed the campus biodiversity surveys of at least 300 universities and colleges worldwide since 1940. They found that each campus contains an average of 66 bird species, including threatened species, offering a major refuge for birds in nearby urban areas. It was then proposed that the campuses with high diversity should be protected for research, conservation, and biodiversity education. Further, to implement more bio-diversity-friendly designs, the suggested primary step is to monitor and investigate the biodiversity of university campuses. Similarly, from the perspective of the Indian academic campuses, Guthula et al. (2022) found an average of 88 bird species per campus based on the survey conducted on total of 335 Indian academic campuses. These observations and suggestions motivated the present authors to study the avian diversity of the Indian Institute of Technology, Guwahati (IITG) campus.

The campus of IITG is beautifully manicured in the proximity of many IBAs located nearby Guwahati city viz, 'Dadara-Pasara-Singimari', 'Deepor Beel' (Assamese: lake) bird sanctuary, 'Amchang' hills, 'Chandubi' lake, and adjoining areas, 'Jengdia Beel-Satgaon' and 'Pabitora' wildlife sanctuary (Rahmani et al. 2016). The campus is composed of diverse habitats such as forest patches, hillocks, wetlands, bushes, and a few lakes, making it perfectly suitable for accommodating a wide range of bird species. The diverse vegetation found in such habitat heterogeneous sites decides the overall rich avifaunal composition of the area (MacArthur & MacArthur 1961) . The campus with diverse habitats hosts not only resident birds but also many migratory species. However, no scientific documentation of the avifauna inside the IITG campus was conducted in the past. Thus, a study addressing the avian diversity within the IITG campus was deemed necessary. This investigation is an attempt to document the avian species of the IITG campus for three years (2017–2020) and to perform a diversity analysis of the bird species among different habitats of the campus using multivariate Beta (β) diversity analysis. This has been one of the most prevalent techniques to compare the diversities of different species assemblages (Anderson et al. 2011; Schmera et al. 2020), especially where the field data are collected only as the presence or absence of species. This study is particularly important to highlight the richness of avian species on the campus besides quantitative comparison of diversity among the different campus habitats. In the literature, there are many documented campus-based avian studies, but only as species checklists (Gupta et al. 2009; Surasinghe & Alwis 2010; Ali et al. 2013; Kabir et al. 2017; Manohar et al. 2017; Sailo et al. 2019), without thorough and quantitative habitat-wise diversity analysis. On the other hand, Chakdar et al. (2016) & Trivedi & Vaghela (2020) conducted a diversity & abundance analysis based on the dataset of species-wise number of individual birds. The overall trend suggests that most campus-based diversity analyses are checklists or abundance-based and are not based on a presence-absence dataset. To address this skewness, the present study is aimed to carry out a diversity analysis based on the presence-absence dataset. Moreover, this technique can emphasize the individual identity of the species rather than its abundance (Anderson et al. 2011). This technique is elaborated in the Methodology section, followed by results, discussion, and a brief conclusion emphasizing the threats and conservation measures.

METHODS

Study Area

The present study has been carried out in the IITG campus located at 26.185^0N and 91.688^0E, nearby Guwahati, Assam. The campus spanning over 2.8 km^2 of area is situated on the northern banks of the river Brahmaputra. The campus was established in 1995, and since then, the habitat has been significantly changed due to infrastructural development. The climate of the campus area is warm and humid, with an average annual rainfall of 1,752 mm. The temperature of the site ranges between maximum and minimum temperatures of 32.6^0 (August) and 11.0^0 (January) (Govt. of India 2021). The campus is surrounded by marshy areas to the east and north, human settlements to the west, and the 'Brahmaputra' river and sandy riverbanks in the south. Moreover, in the proximity of the campus, the hilly areas

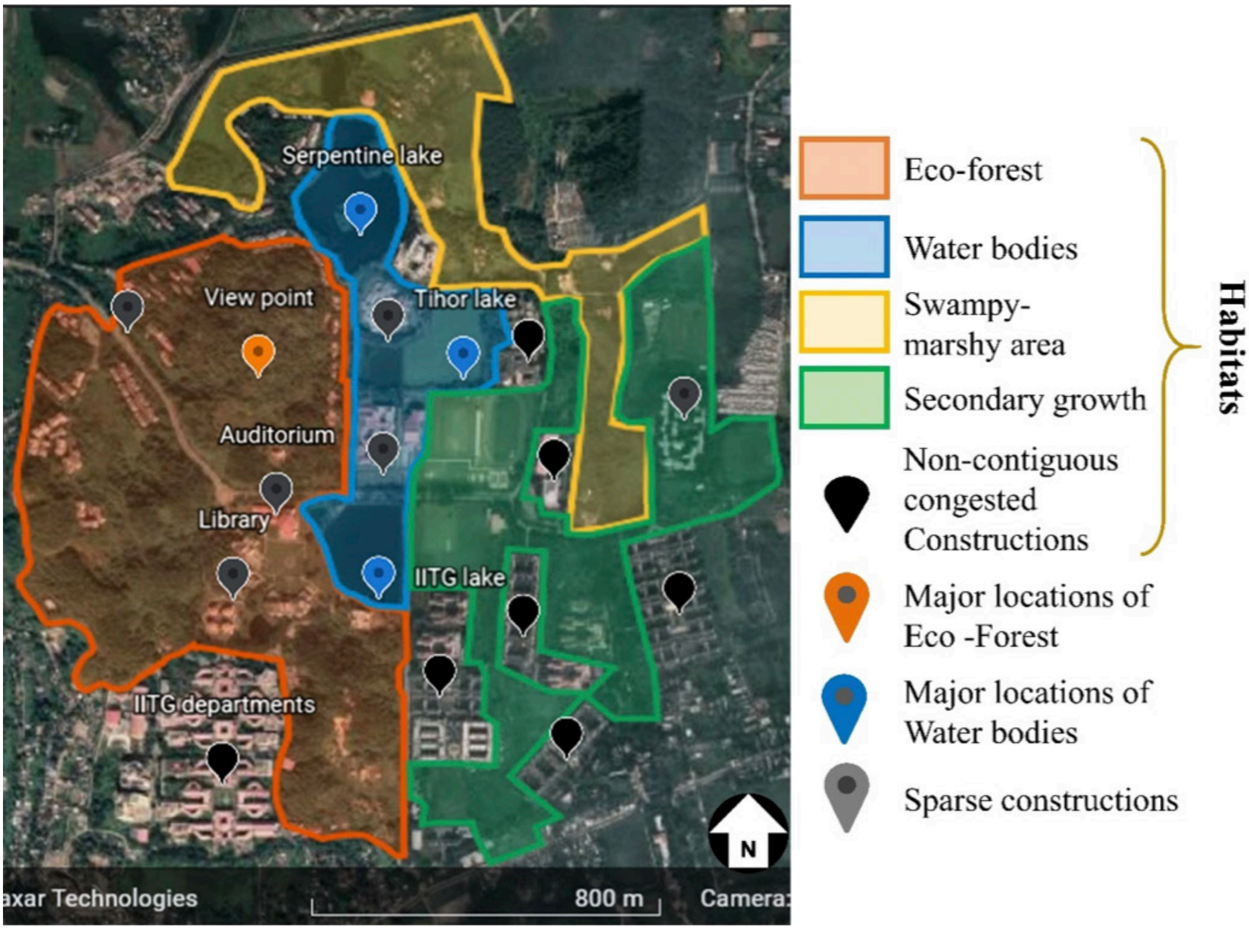

Image 1. Habitats of the Indian Institute of Technology, Guwahati campus.

'Kali Pahar' (Assamese: hill) in the north and 'Nilanchal' hills in the south are located.

The campus area is divided into multiple habitat types, as depicted in Image 1 in the form of a map based on their topology and vegetation type. The approximate area of each habitat type is estimated by Google Earth and listed in Table 1 in ascending order. The eco-forest habitat, spread mainly over a hilly and uneven campus area, is the remains of the wooded forest that was present before the establishment of the campus. The highest peak in the eco-forest habitat is the 'view-point', with the lowest human disturbance compared to other habitats. The dominant tree species and other plants in this habitat are *Tectona grandis, Dipterocarpus* sp., *Eucalyptus maculata, Acacia auriculiformis, Bombax ceiba, Erythrina stricta, Butea monosperma, Ficus hispida, Ficus racemosa, Artocarpus heterophyllus, Ailanthus excelsa, Neolamarckia cadamba, Aegle marmelos, Aglaia spectabilis, Toona ciliata, Holmskioldia sanguinea, Aporosa octandra, Nyctanthes arbor-tristis, Costus speciosus,* and *Areca catechu* among others (Kar et al. 2012). The aquatic habitat of the campus is of two major categories: water bodies & swampy-marshy habitats. The water bodies are a combination of large lakes & ponds, viz., 'Tihor', Serpentine, and IITG lakes, as delineated in the form of blue location icons in Image 1. These lakes were present before the establishment of the campus and are not yet landfilled. Among the lakes, Serpentine contains island-type small patches, providing safe shelter to the aquatic birds. The water bodies are surrounded by trees such as *Roystonea* sp., *Cassia*

Table 1. Area of different habitats.

Habitat type	Area (km²)
Water bodies	0.235
Swampy-marshy	0.307
Secondary growth	0.456
Eco-forest	0.783
Constructions	1.019
Total	**2.8**

javanica, Delonix regia, Lagerstroemia speciosa, and *Michelia champaca* for campus beautification. Most of the patches of the swampy-marshy habitat are a result of rainwater accumulation over the sites from which the vegetation was removed and then abandoned with no construction. Some of them have been present before the establishment of the campus. The aquatic species include *Canna indica, Colocasia esculenta, Nymphaea rubra*, *Eichhornia crassipes, Hymenachne* sp., and some species of ferns are abundant in this habitat. The scattered distribution of tree species such as *Cocos nucifera, Ziziphus jujuba, Syzygium cumini, Ailanthus integrifolia, Dillenia indica, Mimusops elengi, Ficus religiosa, Lantana* sp., and *Bambusa* sp. can be observed on the fringes of the Swampy-marshy habitat. The secondary growth habitat consists of shrubs, bushes, grassy meadows, and sparsely distributed trees. This area usually remains disturbed by construction activities, transportation, and human activities. Additionally, the playgrounds having grass/lawns are also included in this habitat. This habitat is dominated by tree species such as *Alstonia scholaris, D. regia, Dalbergia sissoo, Acacia farnesiana, Eucalyptus hybrida, Albizia lebbeck, Gmelina arborea, Psidium guajava, Terminalia bellirica, Samanea saman, Monoon longifolium, Terminalia arjuna, Phyllanthus emblica, Mangifera indica, Polyalthia longifolia, Cassia fistula, Azadirachta indica, M. elengi, Ficus benghalensis,* and others. Lastly, the habitat type named 'Constructions' (their locations marked by black icons in Image 1) is the only habitat which is non-contiguous and dispersed within the range of other aforementioned habitats. This area is scarcely populated with tree species such as *D. sissoo, A. lebbeck, M. longifolium, M. elengi, N. cadamba, A. scholaris* and *P. longifolia,* along with other floral species planted for campus beautification. It is important to note that sparse construction sites (their locations marked by gray icons in Image 1) are still present in all other habitats; however, they are not as congested as the construction habitat.

Data Collection

To collect species presence-absence datasets for the diversity analysis, methodologies described in Hill et al. (2005) are implemented, as discussed in this section. As this task involves mobile species, the line/strip transect survey method is preferred, in which the surveyor walks along the line and records the presence/absence of individual species. The line transect method has been widely implemented in many avian surveys (Surasinghe & Alwis 2010; Devi et al. 2012; Kottawa-Arachchi & Gamage 2015; Chakdar et al. 2016; Pragasan & Madesh 2018; Singh et al. 2020; Trivedi & Vaghela 2020). Other attributes of this survey method, such as the number of individuals and their perpendicular distances from the line, are omitted here since the aim of the present survey does not include density and detectability parameters. Additionally, some of the merits of the line transect method are the ability to cover a large distance, address the common, and elusive species, low bias, versatility, and efficiency (Hill et al. 2005). Considering this, the line transect method is applied especially over the well-defined fixed routes, trails, bridle paths, and roads in the IITG habitats and boundaries around the habitats, water bodies, and swampy-marshy areas. Other documented studies have also adopted a similar methodology (Gupta et al. 2009; Ali et al. 2013; Kabir et al. 2017).

To standardize this technique, timed search type method is intertwined with the same, especially while surveying for the presence-absence of the species. Therefore, the line transect surveys were usually made in the early morning (06:00–09:00) and sometimes at night for nocturnal species such as owls (Ali et al. 2013). Such surveys were conducted weekly for three years (2017–2020) in all the seasons of a year (viz, winter, summer, and monsoon), and the data were tabulated habitat-wise (Appendix 1). Sometimes, the point counts method and opportunistic sightings of the birds were also used along with line transects for the habitats (Pragasan & Madesh 2018). It is important to clarify that birds in flight are included in the dataset only when the particular species is found using the particular habitat; for example, any raptor hovering or soaring in search of prey, the swifts or swallows hawking in proximity to the habitat or transects.

Instruments such as cameras (Nikon Coolpix P510 and Canon Powershot S×50 hs) and field binoculars (Solognac 500 dpi, 8 × 40) were used to record the observations. Audio records were also used to identify the bird species by listening to the call on the spot or recording it in an audio recorder (Zoom H4n) and later analyzing it. Every identified species was cross-checked with the help of bird guides and handbooks (Grimmett et al. 2016), besides referring to the eBird database (ebird 2021). The abundance code is qualitative; for example, if an individual of a species is found slightly less than 10 times out of 10 different visits for birding, it is assigned as C—common, and, similarly, species were assigned as U—uncommon and R—rare, if recorded roughly for five times & 1–2 times out of 10 visits, respectively. These abundance codes, along with residency status & migratory status for each species, are provided in Appendix 1.

Mathematical Formulation for Data Analysis

As mentioned in the data collection section, the data of avian species in the aforementioned habitats are collected in the form of a presence-absence matrix. In this method, the presence & absence of a given species for each habitat are recorded in binary values 1 & 0 (Appendix 1), respectively. Usually, this approach is preferred when the difference/variations of species numbers/identities among assemblages, communities, habitats, and along spatial or temporal gradients are emphasized (Magurran 1988). Moreover, a focus on the identities of species (especially the role of rare species) rather than their abundance (individual numbers) is necessary for conservation and biodiversity studies (Anderson et al. 2011). Since the present investigation opted for a comparison of diversity between habitats of the IITG campus, the presence-absence dataset is sufficient.

As per the literature, the β – diversity is one of the most prevalent techniques used to compare the diversities of different assemblages whenever the species presence-absence data is available (Koleff et al. 2003; Anderson et al. 2011). Historically, the concept of β – diversity and its mathematical formulation in the form of β – diversity indices were proposed by R.H. Whittaker in 1960, and thereafter, ecologists have derived many indices for different applications. Some of these indices can even facilitate the use of abundance and presence-absence data. Basically, the β – diversity quantifies the dissimilarity or variation between habitats and assemblages in terms of varieties of species. Ecologists have classified the broad range of β – diversity indices into two major classical categories, viz., multiplicative & additive indices, as expressed in Equations 1 & 2, respectively.

$$\text{Multiplicative } \beta-\text{diversity, } \beta_{\times} = \frac{\gamma}{\bar{\alpha}} \quad (1)$$

$$\text{Additive } \beta-\text{diversity, } \beta_{+} = \gamma - \bar{\alpha} \quad (2)$$

Where, γ = total numbars of species in area circling all the habitats
$\bar{\alpha}$ = average of number of species found in each habitats, or average divesity

The latter is more popular since it has the same dimension and unit as its independent variables (γ, α); hence, they can be directly compared. Therefore, the additive approach of β – diversity is chosen for the present investigation. It is important to note that the present study uses the measure of multivariate additive β – diversity instead of classical additive β – diversity. This approach facilitates the comparison of β – diversity of a given assemblage/habitat with all of the other habitats available in the given area in the form of their pairs which is not possible in the classical approach (Anderson et al. 2011). Moreover, the value of β – diversity depends on the value of γ; therefore, it should be normalized by the value of γ as per equation 3 (Ricotta & Pavoine 2015).

$$\text{Normalized } \beta-\text{diversity, } \beta_{+} = \frac{\gamma - \alpha}{\gamma} \quad (3)$$

One common usage of β – diversity is to study the change of species diversity along an environmental gradient (i.e., elevation, latitude, longitude, temperature, upstream to downstream of a river, and others) (Legendre & Legendre 2012). On the other hand, the same index can also be used to compare species diversity & highlight dissimilarity in species compositions of different assemblages or habitats (Magurran 1988). As the multivariate β – diversity analysis deals with the dissimilarity between two assemblages (mentioned in the last paragraph), it is necessary to define an index which can quantify the same. In the literature on numerical ecology, more than 24 types of different types of β – diversity indices are available for the purpose (Koleff et al. 2003). Among them, Jaccard's dissimilarity index is mathematically less vigorous yet intuitive. To understand the index, the notions of shared and unshared species between two assemblages/habitats have to be clarified, as shown in Figure 1. The species shared between both the assemblages/habitats are marked as '*a*'. The species present in Habitat—1 but not in Habitat—2 are marked as '*b*'. Similarly, the species present in Habitat—2 but not in Habitat—1 are defined as '*c*'. The summation of these quantities gives γ – diversity. The species absent from both the habitats, but present in other habitats, are excluded while calculating multivariate indices, i.e., exclusion of joint absences is implemented in multivariate analysis (Anderson et al. 2011). Using the definitions of *a*, *b* and *c*, the Jaccard's similarity & dissimilarity (β – diversity) in the normalized form can be calculated using Equations 4 & 5. β_J emphasizes species *b* & *c*, which are not shared by both habitats, clearly quantifying the dissimilarity between the two habitats. The summation of β_J & S_J results in unity.

$$\text{Jaccard's similarity index, } S_J = \frac{a}{a+b+c} = \frac{a}{\gamma} \quad (4)$$

$$\text{Jaccard's dissimilarity index, } \beta_J = \text{Beta diversity} = \text{Species variation} = \frac{b+c}{a+b+c} = 1 - S_J \quad (5)$$

The dissimilarity (β_J) between two habitats can be divided into two parts, namely the species replacement (R_S) & richness difference (D_R), as depicted in Figure 1. When a particular number of species in focal Habitat – 1 is replaced by different but the same number of species in Habitat – 2, then the phenomenon is known as species replacement (R_S) and the number of species participated is known as replaced species (Podani & Schmera 2011; Legendre 2014). It is important to clarify that the term 'replacement' or 'variation' is used for heterogeneous habitats-based studies, while the alternative term 'turnover' is more prevalent for gradient-based studies (Anderson et al. 2011). The number of dissimilar species not part of the replacement phenomenon is marked as the difference in richness (D_R). Both these quantities are defined in Equations 6 & 9, respectively. The (1 – component) of both the quantities are known as species nestedness (N_S) and richness agreement (A_R) as expressed by Equations 7 & 8, respectively. Whenever the species of Habitat – 1 is a subset of Habitat – 2, it can be stated that both habitats have pure nestedness between them. It is also observed that the higher the value of β_J, the higher the anti-nested characteristics for the artificial presence-absence dataset (Podani & Schmera 2011). The species nestedness (N_S) & species agreement (A_R) can clearly be visualized in Figure 2.

$$\text{Species nestedness index, } N_S = \frac{a+|b-c|}{a+b+c} = 1 - R_S \quad (7)$$

$$\text{Richness agreement index, } A_R = \frac{a+(2\times \min(b,c))}{a+b+c} = \left(\frac{a}{a+b+c}\right)+\left(2\times\frac{\min(b,c)}{a+b+c}\right) \quad (8)$$

$$= S_J + (2\times \text{William's index})$$

$$\text{Richness difference index, } D_R = \frac{|b-c|}{a+b+c} = 1 - A_R \quad (9)$$

$$S_J + R_S + D_R = 1 \quad (10)$$

The above indices can be calculated using PAST (Paleontological Statistics software package for education and data analysis) software (Hammer et al. 2001). It is important to note that all the indices cannot be calculated directly by PAST software; however, William's index (Koleff et al. 2003) & Jaccard's similarity index can be estimated directly by the software. Using the estimated values of both indices, the remaining indices are calculated by equations 4 through 10. It is important to note that the normalization using the denominator (*2a+b+c*) can also be implemented in the form of Sorenson's index (β_S). Nevertheless, the Jaccard's index (β_J) is chosen since it gives an amplified value because of the lower value of (*a+b+c*), i.e., $\beta_J > \beta_S$.

To visualize the numerical values of indices intuitively, the simplex approach of visualization is implemented since the summation of S_J, R_S and D_R result in a value equal to 1 as per equation 10 (Podani & Schmera 2011). A graphical depiction of the 2D (two-dimensional) simplex approach in the form of a Ternary plot is shown in Figure 3. The apices of the equilateral triangle in the ternary plot represent 100% values of R_S, S_J & D_R. Their values decrease along their respective simplices and result into 100% values of their (1 – component), creating apices of the inner equilateral triangle. The apices of this inner triangle represent 100% values of N_S, β_J and A_R. The dotted sides of the inner triangle denote 50% values of R_S, S_J and D_R. Any point inside a ternary plot possesses values of R_S, S_J and D_R corresponding to a pair of dissimilar habitats/assemblages. Thus, the 2D simplex approach in the form of a ternary graph is used to represent indices for present investigations.

In multivariate analysis, the aforementioned indices are calculated for different pairs of habitats; therefore, if there are *m* number of habitats in a given area, the total number of such pairs would be ${}_mC_2$ as per equation 11. Hence, the average value of these indices from these pair values can be calculated using Equation 12.

$$\text{Number of total habitat-wise pairs} = {}_mC_2 = \frac{m!}{2!(m-2)!} = \frac{m^2-m}{2} \quad (11)$$

Where, m = Number of total habitats or assemblages

$$\text{Average index, } \bar{x} = \frac{2\times\sum_{i,j=1,\ i<j}^{m} x_{ij}}{(m^2-m)} \quad (12)$$

RESULTS AND DISCUSSION

Species Richness

In total, 152 species of birds belonging to 108 genera, 50 families and 14 orders were recorded on the IITG campus (Appendix 1). Among them, 35 species are winter migrants (including altitudinal migrants), four summer migrants, and others are resident and local migrants (Choudhury 2000; Grimmett et al. 2016). The highest number of species is found in secondary growth (83 species), followed by eco-forest (68 species), swampy-marshy area (57 species), constructions (38 species), and water bodies (33 species), as shown in Figure 3. In the case of species that are specific to a habitat type, the highest numbers are recorded in eco-forest followed by swampy-marshy areas, secondary growth, water bodies and, constructions. The highest difference between the aforementioned numbers (total

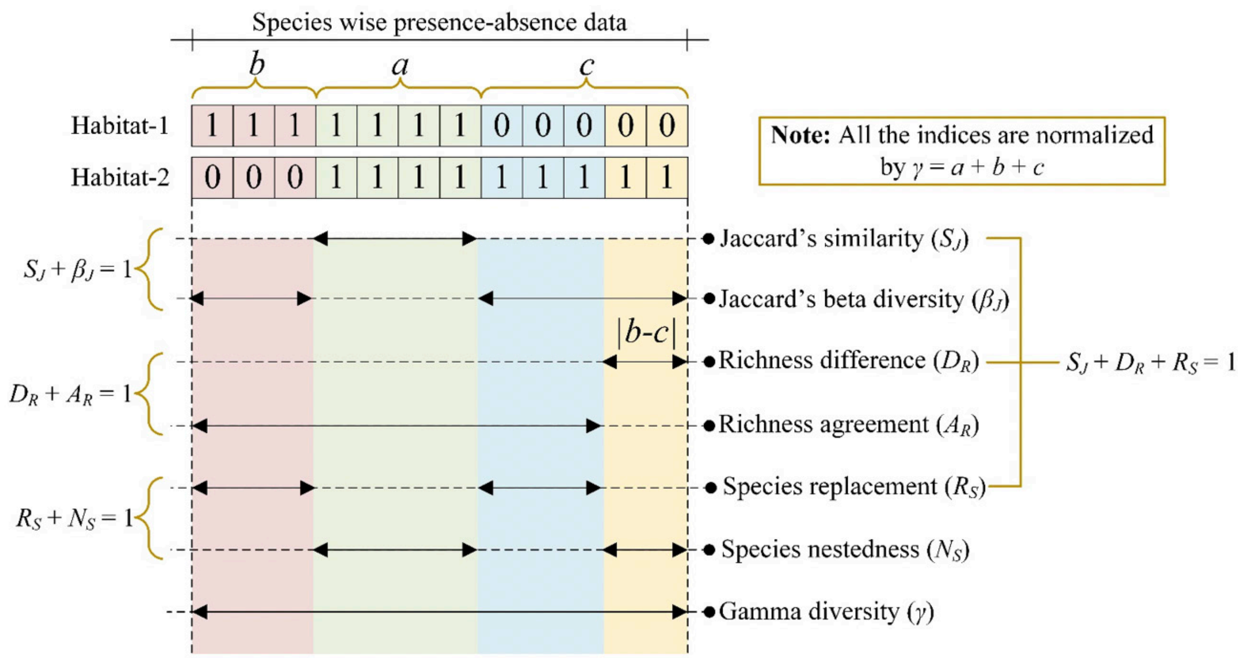

Figure 1. Derivation of different additive diversity indices.

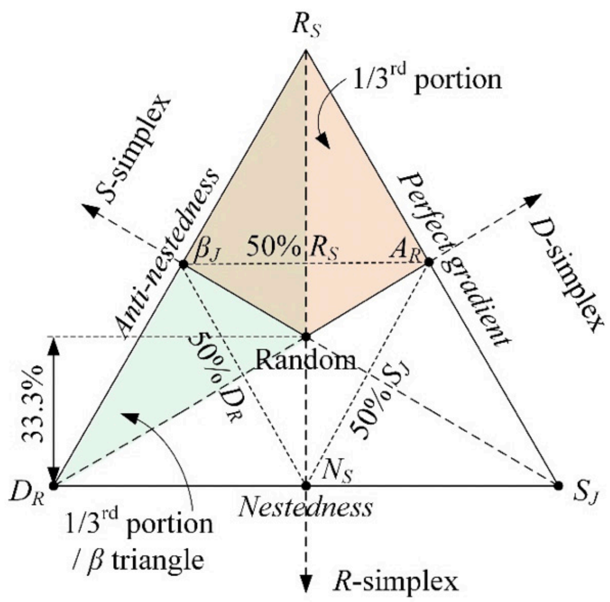

Figure 2. 2D simplex approach by ternary plot.

number of species found in a habitat and the number of species that can only be found in the same habitat) is found in secondary growth, which clearly indicates that most of the species are generalists. The lowest difference is found for water bodies indicating a major share of specialist species. Approximately 36%, 35%, and 33% of the total species are specialists in species composition of water bodies, swampy-marshy areas, and eco-forest habitats, respectively. On the other hand, the values are 17% & 13% (approximately 1/3rd of previous values) for habitats like secondary growth & construction habitats, which clearly indicate that the percentage of specialist species decreases due to construction work & associated disturbances. These results are also supported by similar findings for the Assam University Campus (Chakdar et al. 2016).

Approximately 49% of species belong to only one habitat type, i.e., nearly half of the total species are specialists (Table 2). Five species are found in all of the five habitats; Black Kite *Milvus migrans*, Asian Barred Owlet *Glaucidium cuculoides*, Spotted Owlet *Athene brama*, Black Drongo *Dicrurus macrocercus*, and Red-vented Bulbul *Pycnonotus cafer*. Similarly, species namely the Spotted Dove *Streptopelia chinensis*, Cattle Egret *Bubulcus ibis*, Shikra *Accipiter badius*, Taiga Flycatcher *Ficedula albicilla*, and White Wagtail *Motacilla alba* are recorded in four habitats (different habitats for each species) out of the total five habitats. The qualitative abundance of each species is tabulated in Appendix 1.

Variation in Species Compositions Among Different Habitats of IITG Campus

Following the methodology discussed in the section on mathematical formulation for data analysis, multivariate values of Jaccard's similarity index (S_J) & William's index are estimated (Table 3). After that, other indices such as β_J, R_S, D_R, N_S and A_R are calculated. As per

Table 4, all of the multivariate β_J values are more than 50%, clearly showing high β – diversity of all the habitats in the IITG campus. The high β – diversity values can be explained by the habitat heterogeneity hypothesis, which states that an increase in the number of distinct habitats leads to an increase in β – diversity and hence the overall diversity in a landscape (MacArthur & MacArthur 1961). Because of habitat heterogeneity, a successful adaptation of a particular species to one habitat leads to its inferior competitiveness for another habitat. As a tradeoff between both, distinct habitats in an area may be distinct in terms of species composition, resulting in higher β – diversity among them (Cramer & Willig 2005; Soininen et al. 2007). Additionally, the number of partitionable niche dimensions is expanded due to habitat heterogeneity. The maximum value of β_J = 94.8% is obtained between eco-forest & water bodies habitats. Although both the habitats are contiguous, these habitat types have very contrasting characteristics, i.e., the former is a hilly wooded forest and the latter is aquatic. A similar trend is reported for contrasting habitats even in a gradient-based study (Goettsch & Hernández 2006). The lowest value of β_J = 57.1% is found between eco-forest & swampy-marshy areas. Average β – diversities ($\beta_{J,\, avg}$) (e.g., for habitat – 1 of the present case, β_J for pairs 12, 13, 14, and 15 are averaged) of each habitat is more than 70%. The overall $\bar{\beta}_J$ calculated using Equation 12 is approximately 79%, showing very high β – diversity for the overall IITG campus area.

The authors of the present paper implemented the current approach of β – diversity analysis in another documented research article (Surasinghe & Alwis 2010) to gain more insight into the species variation in different habitats of college campuses besides the present study. The study recorded 145 species distributed into seven different habitats of the 'Sabargamuwa' university campus (area ≈ 0.5 km^2, established in 1990); however, β – diversity analysis and species variation along habitats were not analyzed. Authors of the present paper calculated $\bar{\beta}_J$ ≈ 82% for 'Sabargamuwa' university campus, which is close to the $\bar{\beta}_J$ ≈ 79% of the IITG campus area (area ≈ 2.8 km^2, established in 1995).

The results of the multivariate analysis are presented in a graphical ternary plot (Figures 5,6) using the values of R_S, D_R, and S_J listed in Tables 3 & 5. As discussed, the ternary plot provides a better understanding of the relative composition of richness difference (D_R) & species replacement (R_S) constituting β_J. Figure 4 shows that most of the multivariate data points are enclosed by β – triangle (depicted in Figure 2) and are leaning towards the left side of the equilateral triangle, indicating high β_J values. A similar type of trend is also observed in Figure 5. Further, the majority of the points (circular & solid red markers) are congregated in the top 1/3rd portion of a quadrilateral (depicted in Figure 2) with a propensity towards replacement (R_S apex) rather than the richness difference (D_R apex). Therefore, species replacement is dominating factor behind the high β – diversity of IITG habitats. The reason might be that the specialist species of one habitat are replaced by those of another habitat without much relative difference between them in terms of species numbers. This can also be explained by the niche-based hypothesis, which states that the difference in habitat compositions drives species turnover between different locations along a gradient or species variation through replacement among different habitats in a given area (Anderson et al. 2011; Lorenzón et al. 2016).

On the other hand, the points are equally dispersed towards R_S apex (circular markers) & D_R apex (solid circular markers) for Figure 5. Hence, the species replacement and richness difference are equally responsible for the high β – diversity of 'Sabargamuwa' university campus. Graphically, the points of Figure 4 are distributed along R – simplex, while they are along S – simplex for Fig. 6 while maintaining inclination towards high β_J values. The habitat pair of secondary growth and constructions yields the highest value of nestedness (N_S ≈ 88.5%) among IITG habitats, indicating a subset relationship between them. The dispersed and non-contiguous nature of the constructions habitat inside the

Table 2. Number of species found in the given number of habitats.

Number of total habitats	Number of species
1	74
2	46
3	22
4	5
5	5

Table 3. Values for Jaccard's similarity index-S_J (upper triangle) and William's index (lower triangle).

Habitats*	1	2	3	4	5
1	—	0.052	0.096	0.428	0.235
2	0.291	—	0.304	0.105	0.111
3	0.403	0.173	—	0.241	0.160
4	0.219	0.211	0.267	—	0.367
5	0.200	0.412	0.296	0.057	—

*Habitats are tagged as: 1—Eco-forest | 2—Water bodies | 3—Swampy-marshy area | 4—Secondary growth | 5—Constructions.

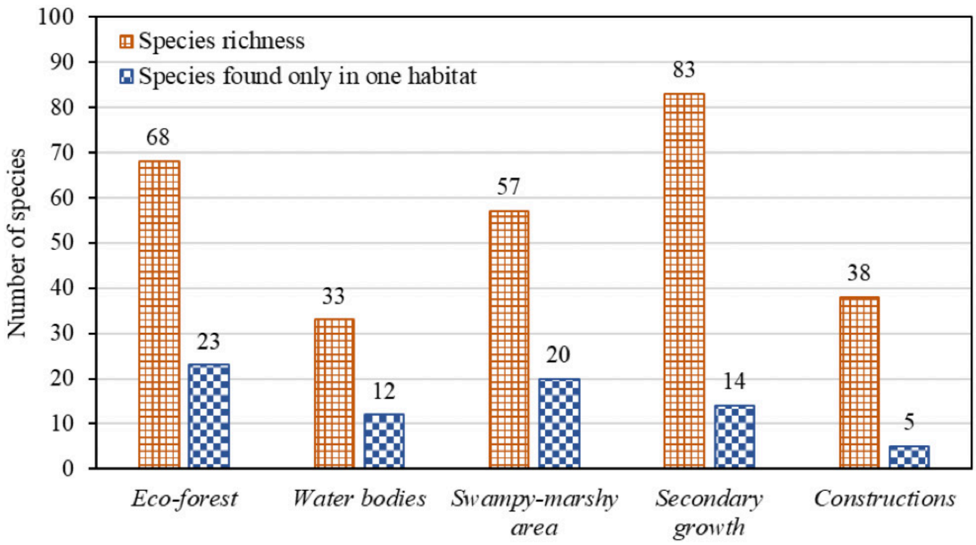

Figure 3. Habitat-wise species richness.

Table 4. Values for Jaccard's dissimilarity index (β_J) (upper triangle) and Nestedness index (N_S) (lower triangle).

Habitats*	1	2	3	4	5	$\beta_{J,\,avg}$	$\bar{\beta}_J$
1	—	0.947	0.903	0.571	0.764	0.796	
2	0.416	—	0.695	0.894	0.888	0.856	
3	0.192	0.652	—	0.758	0.835	0.799	0.789
4	0.561	0.576	0.464	—	0.632	0.714	
5	0.600	0.174	0.407	0.885	—	0.781	

* Habitats are tagged as: 1—Eco-forest | 2—Water bodies | 3—Swampy-marshy area | 4—Secondary growth | 5—Constructions.

secondary growth habitat might be the reason for such species composition. A corresponding multivariate point (red square marker) is also located towards the triangle's lower side, clearly showing a prominent nestedness behavior. Likewise, the nestedness is observed between dry-mixed semi-evergreen forest and residential habitat in Figure 5 (red solid square marker at point 45). A similar trend of high β – diversity is observed for the Colorado fish dataset (Smith 1978), involving six different sites and 26 fish species in the ternary plot (Podani & Schmera 2011). The high β – diversity was constituted by D_R as a major factor and R_S as a minor factor. The reason behind this trend was believed to be many extinctions and a few successful colonization.

Therefore, it can be concluded that the habitats in IITG habitats proclaim high β – diversity due to habitat heterogeneity. The main factor behind high β – diversity is species replacement rather than species richness differences. Most importantly, habitat heterogeneity is also a result of anthropogenic impacts. The β – diversity is observed to increase during the initial stage of the anthropogenic impacts due to the extinction of rarer specialist species and the establishment of invasive generalist species (considering the campus a biogeographic island) (Socolar et al. 2016). Gradually, the invasive generalist species become more dominant while eradicating native specialist species. Hence, the entire process gives a momentary increment in β-diversity followed by a simultaneous drop in β-diversity and overall species richness. Therefore, the high β-diversity of the IITG campus indirectly indicates the initial phase of anthropogenic impact.

It is noteworthy to clarify that the present analysis only emphasizes presence-absence data, not the abundance data, providing equal weightage to both rare and abundant species. Nevertheless, the species list with qualitative abundance code is provided in Appendix 1 for further insights.

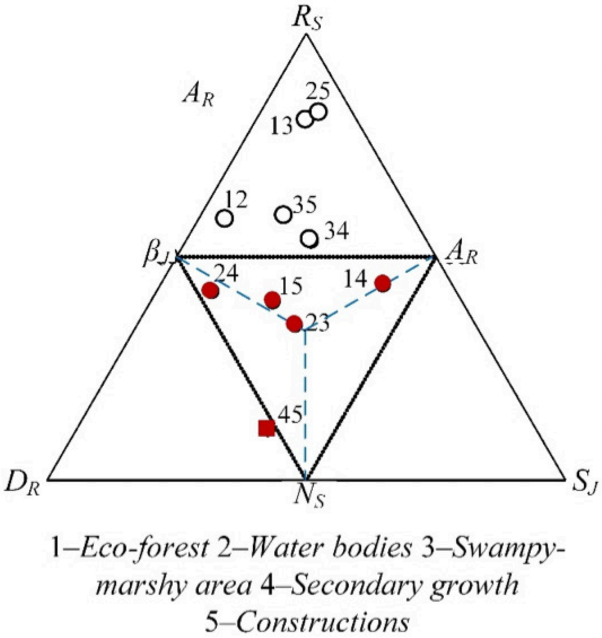

Figure 4. Ternary plot for IITG habitats.

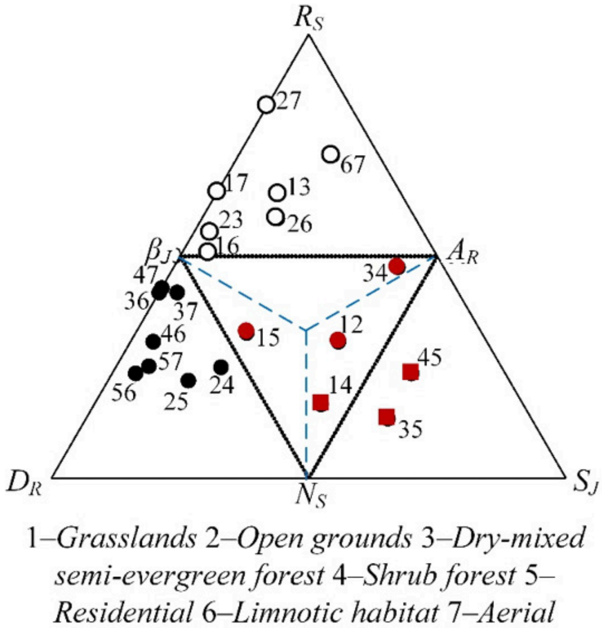

Figure 5. Ternary plot for reported data of Surasinghe & Alwis (2010).

Table 5. Values for Species replacement index (R_S) (upper triangle) and Richness difference index (D_R) (lower triangle).

Habitats*	1	2	3	4	5
1	—	0.583	0.807	0.438	0.400
2	0.364	—	0.347	0.423	0.825
3	0.096	0.347	—	0.535	0.592
4	0.133	0.471	0.223	—	0.114
5	0.364	0.063	0.246	0.517	—

* Habitats are tagged as: 1—Eco-forest | 2—Water bodies | 3—Swampy-marshy area | 4—Secondary growth | 5—Constructions.

Table 6. List of recorded species under the IUCN Red List.

IUCN Red List status	Species name	*Taxonomic name*
Critically Endangered	Slender-Billed Vulture	*Gyps tenuirostris*
Endangered	Greater Adjutant	*Leptoptilos dubius*
Vulnerable	Common Pochard	*Aythya ferina*
	Lesser Adjutant	*Leptoptilos javanicus*
Near Threatened	Ferruginous Duck	*Aythya nyroca*
	Himalayan Griffon	*Gyps himalayensis*
	Red-Breasted Parakeet	*Psittacula alexandri*
	Oriental Darter	*Anhinga Melanogaster*

THREATS AND CONSERVATION MEASURES

Not much past documented data are available in the literature about the avian diversity of the IITG campus; nevertheless, a checklist from a web source is available from July 2000–February 2002 (Praveen 2002). The documentation was done during that time of the year when most of the area within the campus was a part of the wetland on which the autonomous institute was built. As eBird was launched only in 2014 in India, the earlier historical records of species within campus could not be found in the portal. Hence, the authors had to rely on the website on which the aforementioned documentation had been uploaded. The checklist listed 120 species, most of which had been observed during the period of the present study (2017–2020). The exceptions are Eurasian Wryneck *Jynx torquilla*, Little-ringed Plover *Charadrius dubius*, Osprey *Pandion haliaetus*, Eurasian Marsh Harrier *Circus aeruginosus*, and Common Kestrel *Falco tinnunculus* that were not observed during the period. These species are common in nearby wetlands and water bodies. The reason behind their disappearance from the campus could be the deterioration of water bodies and marshy areas besides the peripheral vegetation that came up due to construction activities.

During the 2017–2020 timeframe, one critically endangered, one endangered, two vulnerable and three near threatened species were recorded as per IUCN Red List norms as enlisted in Table 6. Both the migratory aquatic species, viz., Common Pochard *Aythya ferina* and Ferruginous Duck *Aythya nyroca* can be observed in the water bodies of the campus during winter in small numbers (10–20); however, their presence have become less frequent with each winter as per the observations of the authors. Another important observation by the authors is that both the species, besides other duck & pochard species, are mostly found in Serpentine and 'Tihor' lakes, and not in the IITG lake. The reason can be the small island type patches and bushes on the fringes of the lakes, except that of the IITG lake, which provides safe roosting places for the aforementioned species (as the majority of them are nocturnal feeders) (Ali & Ripley 1978) away from the reach of feral cats, dogs, and Indian Jackal *Canis aureus indicus*. Over time, vegetation on the fringes of the IITG lake has been removed due to constant construction work, fencing, and campus beautification by planting Bottle palm tree species. This would be one of the probable reasons behind their less frequent presence. Preservation of the small island patches and vegetation on peripheral fringes can be an important step to maintain the Water bodies undegraded for the critically endangered and near threatened aquatic species besides other species.

The Red-breasted Parakeet usually prefers forest and wooded habitats. Therefore, it is recorded in eco-forest and wooded areas of secondary growth. It nests in the cavities of trees and is mainly frugivorous. Therefore, it is advisable to conserve already present teak wood patches and other trees along with fruit-bearing ones like Gular Tree *Ficus racemosa*.

As mentioned in the 'Results and Discussion' section, the IITG campus has a high value of β – diversity, with species replacement as a dominating factor. It is reported in the literature that the replacement across multiple habitats in a given area (or turnover for gradient-based study) implies the focus to be on conservation efforts over multiple habitats rather than any single habitat (Socolar et al. 2016). Hence, the conservation effort for the avian community of the IITG campus should be directed towards each habitat uniformly. Moreover, the species richness of the campus is 152 species, which is way over the average species richness (by considering the dataset of 300 plus campuses), equal to 66, as per the review conducted by (Liu et al. 2021). For such avian (or overall) diversity-rich campuses, different key steps were suggested (Kobori & Primack 2003; Colding & Barthel 2017; Liu et al. 2021). It is recommended that a—certain parts of the campus should be protected with minimal scraping and disturbance | b—diversity of university campuses should be monitored thoroughly to plan more diversity-friendly designs, | c—provide nature-based education and awareness to campus residents, especially the students as they are the next generation of potential birders/naturalists | d—restoration of biodiversity in the surrounding area with biodiversity protected in campus | e—implement primary biodiversity educational courses. In this direction, different activities are being carried out in the IITG campus, as narrated in the following paragraph.

Awareness of the avifauna within the IITG campus was restricted only to the birders with experience. Therefore, the authors, with support from the IITG population (refer to acknowledgement), tried to spread the message of the presence of birds within the campus by organizing 'Bird Walk' events frequently. During these events, participants were provided with the necessary support to identify and understand the importance of birds. These events have been organized as a part of the 'Campus Bird Count (CBC)' and 'Bihu Bird Count' projects every year since 2017 & 2020, respectively. The CBC, conducted under the banner of 'Great Backyard Bird Count' by Bird Count India (https://birdcount.in/about/), has further accelerated the process of counting the species and the number of birds in a given time frame within various campuses across the country. Other Campuses within Assam have also participated in CBC since its inception in 2014, with IITG recording one of the highest numbers of species yearly. 'Bihu Bird Count' is a regional citizen science project hosted by Assam Bird Monitoring network and Bird Count India, integrating with the celebration of 'Bihu' festivals (celebrated three times a year) with documentation of avifauna since its initiation in the year 2020. Especially for water bodies and swampy-marshy habitats, the 'Asian Waterbird Census' (by Bird Count India and International Waterbird census – IWC) has also been organized in the IITG campus to record migratory waterbirds. Plantation drives are also being organized from time to time in the eco-forest, secondary growth and periphery of the water bodies, which will be beneficial, especially for IITG lake, to address the concerns mentioned earlier. Further, a pictorial guide on birds in the form of a coffee table book (Bhaduri et al. 2020) is also launched by the IITG to inform visitors and students about avian diversity.

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Appendix 1. Checklist of avian species recorded in IITG during 2017–2020.

	Name	Scientific name	Presence-Absence data for different habitats					Abundance code	Residency code	IUCN Status
			Eco-forest	Water bodies	Swampy -marshy area	Secondary growth	Constructions			
1	Common Pochard	*Aythya ferina*	0	1	0	0	0	U	WM	VU
2	Cotton Pygmy-Goose	*Nettapus coromandelianus*	0	1	0	0	0	R	R	LC
3	Eurasian Wigeon	*Anas penelope*	0	1	0	0	0	R	WM	LC
4	Ferruginous Duck	*Aythya nyroca*	0	1	0	0	0	U	WM	NT
5	Fulvous Whistling-Duck	*Dendrocygna bicolor*	0	1	1	0	0	U	WM	LC
6	Gadwall	*Mareca strepera*	0	1	0	0	0	U	WM	LC
7	Green-Winged Teal	*Anas crecca*	0	1	0	0	0	U	WM	LC
8	Lesser Whistling-Duck	*Dendrocygna javanica*	0	1	1	0	0	C	R	LC
9	Tufted Duck	*Aythya fuligula*	0	1	0	0	0	U	WM	LC
10	Yellow-Footed Green-Pigeon	*Treron phoenicopterus*	1	0	0	1	0	C	R	LC
11	Spotted Dove	*Streptopelia chinensis*	1	0	1	1	1	C	R	LC
12	Red Collared-Dove	*Streptopelia tranquebarica*	0	0	0	1	0	U	R	LC
13	Eurasian Collared-Dove	*Streptopelia decaocto*	1	0	0	1	0	C	R	LC
14	Rock Pigeon	*Columba livia*	0	0	0	1	0	C	R	LC
15	Asian Koel	*Eudynamys scolopaceus*	1	0	0	1	1	C	R	LC
16	Common Hawk-Cuckoo	*Hierococcyx varius*	1	0	0	1	0	C	R	LC
17	Banded Bay-Cuckoo	*Cacomantis sonneratii*	1	0	0	0	0	R	R	LC
18	Greater Coucal	*Centropus sinensis*	1	0	1	1	0	C	R	LC
19	Lesser Coucal	*Centropus bengalensis*	0	0	1	1	0	C	R	LC
20	Green-Billed Malkoha	*Phaenicophaeus tristis*	1	0	0	0	0	U	R	LC
21	Plaintive Cuckoo	*Cacomantis merulinus*	1	0	0	0	0	R	R	LC
22	Pied Cuckoo	*Clamator jacobinus*	1	0	0	0	0	U	SM	LC
23	Indian Cuckoo	*Cuculus micropterus*	1	0	0	1	0	C	SM	LC
24	Asian Palm-Swift	*Cypsiurus balasiensis*	1	0	0	1	0	C	R	LC
25	House Swift	*Apus nipalensis*	0	0	0	0	1	C	R	LC
26	Brown-Cheeked Rail	*Rallus indicus*	0	0	1	0	0	R	WM	LC
27	Slaty-Breasted Rail	*Lewinia striata*	0	0	1	0	0	R	R	LC
28	Eurasian Moorhen	*Gallinula chloropus*	0	1	1	0	0	C	R	LC
29	White-Breasted Waterhen	*Amaurornis phoenicurus*	0	1	1	1	0	C	R	LC
30	Eurasian Coot	*Fulica atra*	0	1	0	0	0	C	R	LC
31	Grey-Headed Swamphen	*Porphyrio poliocephalus*	0	0	1	0	0	R	R	LC
32	Red-Wattled Lapwing	*Vanellus indicus*	0	0	1	1	1	C	R	LC
33	Bronze-Winged Jacana	*Metopidius indicus*	0	1	1	0	0	C	R	LC
34	Pheasant-Tailed Jacana	*Hydrophasianus chirurgus*	0	1	0	0	0	R	R	LC
35	Asian Openbill	*Anastomus oscitans*	0	1	1	0	0	C	R	LC
36	Greater Adjutant	*Leptoptilos dubius*	0	0	1	0	0	U	R	EN
37	Lesser Adjutant	*Leptoptilos javanicus*	0	0	1	0	0	U	R	VU
38	Oriental Darter	*Anhinga melanogaster*	0	0	1	0	0	R	R	NT

	Name	Scientific name	Presence-Absence data for different habitats					Abundance code	Residency code	IUCN Status
			Eco-forest	Water bodies	Swampy -marshy area	Secondary growth	Constructions			
39	Little Cormorant	*Microcarbo niger*	0	1	1	0	0	C	R	LC
40	Great Cormorant	*Phalacrocorax carbo*	0	1	0	0	0	R	R	LC
41	Cinnamon Bittern	*Ixobrychus cinnamomeus*	0	0	1	1	0	C	R	LC
42	Indian Pond-Heron	*Ardeola grayii*	0	1	1	0	0	C	R	LC
43	Black-Crowned Night-Heron	*Nycticorax nycticorax*	0	0	1	0	0	U	R	LC
44	Purple Heron	*Ardea purpurea*	0	1	1	0	0	U	R	LC
45	Striated Heron	*Butorides striata*	0	0	1	0	0	U	R	LC
46	Cattle Egret	*Bubulcus ibis*	0	1	1	1	1	C	R	LC
47	Little Egret	*Egretta garzetta*	0	1	1	1	0	C	R	LC
48	Intermediate Egret	*Ardea intermedia*	0	0	1	0	0	U	R	LC
49	Yellow Bittern	*Ixobrychus sinensis*	0	0	1	0	0	R	R	LC
50	Booted Eagle	*Hieraaetus pennatus*	1	0	0	0	0	U	WM	LC
51	Crested Serpent-Eagle	*Spilornis cheela*	1	0	0	0	0	R	R	LC
52	Short-Toed Snake-Eagle	*Circaetus gallicus*	0	0	0	1	0	R	R	LC
53	Oriental Honey-Buzzard	*Pernis ptilorhynchus*	1	0	0	0	0	R	R	LC
54	Black Kite	*Milvus migrans*	1	1	1	1	1	C	R	LC
55	Black-Winged Kite	*Elanus caeruleus*	0	0	0	1	0	R	R	LC
56	Shikra	*Accipiter badius*	1	0	1	1	1	C	R	LC
57	Himalayan Griffon	*Gyps himalayensis*	1	0	0	0	0	R	WM	NT
58	Slender-Billed Vulture	*Gyps tenuirostris*	0	0	0	1	0	R	R	CR
59	Asian Barred Owlet	*Glaucidium cuculoides*	1	1	1	1	1	C	R	LC
60	Spotted Owlet	*Athene brama*	1	1	1	1	1	C	R	LC
61	Barn Owl	*Tyto alba*	0	0	0	1	1	U	R	LC
62	Brown Hawk-Owl	*Ninox scutulata*	0	0	1	1	1	C	R	LC
63	Oriental Scops Owl	*Otus sunia*	1	0	0	0	0	R	R	LC
64	Eurasian Hoopoe	*Upupa epops*	0	0	0	1	0	C	R	LC
65	Oriental Pied Hornbill	*Anthracoceros albirostris*	1	0	0	0	0	R	R	LC
66	Stork-Billed Kingfisher	*Pelargopsis capensis*	0	0	1	0	0	U	R	LC
67	White-Throated Kingfisher	*Halcyon smyrnensis*	0	1	1	1	0	C	R	LC
68	Common Kingfisher	*Alcedo atthis*	0	1	1	0	0	R	R	LC
69	Pied Kingfisher	*Ceryle rudis*	0	1	0	0	0	R	R	LC
70	Green Bee-Eater	*Merops orientalis*	1	0	0	1	0	C	R	LC
71	Chestnut-Headed Bee-Eater	*Merops leschenaulti*	1	0	0	0	0	U	SM	LC
72	Blue-Tailed Bee-Eater	*Merops philippinus*	0	0	0	1	0	U	SM	LC
73	Indo-Chinese Roller	*Coracias affinis*	0	0	0	1	1	C	R	LC
74	Coppersmith Barbet	*Psilopogon haemacephalus*	1	0	0	1	0	U	R	LC
75	Blue-Throated Barbet	*Psilopogon asiaticus*	1	0	0	1	0	C	R	LC
76	Lineated Barbet	*Psilopogon lineatus*	1	0	0	1	0	C	R	LC
77	Fulvous-Breasted Woodpecker	*Dendrocopos macei*	1	0	0	1	0	C	R	LC

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78	Black-Rumped Flameback	*Dinopium benghalense*	1	0	0	1	0	C	R	LC
79	Greater Flameback	*Chrysocolaptes guttacristatus*	1	0	0	1	0	C	R	LC
80	Rufous Woodpecker	*Micropternus brachyurus*	1	0	0	0	0	R	R	LC
81	Peregrine Falcon	*Falco peregrinus*	0	0	0	1	0	R	WM	LC
82	Rose-Ringed Parakeet	*Psittacula krameri*	0	0	0	1	0	U	R	LC
83	Red-Breasted Parakeet	*Psittacula alexandri*	1	0	0	1	0	U	R	NT
84	Large Cuckooshrike	*Coracina macei*	1	0	0	1	1	C	R	LC
85	Black-Hooded Oriole	*Oriolus xanthornus*	1	0	0	1	1	C	R	LC
86	Ashy Woodswallow	*Artamus fuscus*	0	0	0	1	0	C	R	LC
87	Common Iora	*Aegithina tiphia*	1	0	1	1	0	C	R	LC
88	White-Throated Fantail	*Rhipidura albicollis*	0	0	0	1	0	U	R	LC
89	Black Drongo	*Dicrurus macrocercus*	1	1	1	1	1	C	R	LC
90	Ashy Drongo	*Dicrurus leucophaeus*	1	0	0	0	0	U	WM	LC
91	Hair-Crested Drongo	*Dicrurus hottentottus*	1	0	0	1	0	C	R	LC
92	Greater Racket-Tailed Drongo	*Dicrurus paradiseus*	1	0	0	0	0	R	R	LC
93	Black-Naped Monarch	*Hypothymis azurea*	1	0	0	0	0	U	R	LC
94	Long-Tailed Shrike	*Lanius schach*	0	0	0	1	1	C	WM	LC
95	Brown Shrike	*Lanius cristatus*	1	0	0	1	1	C	WM	LC
96	Grey-Backed Shrike	*Lanius tephronotus*	1	0	0	1	1	C	WM	LC
97	House Crow	*Corvus splendens*	0	0	0	1	1	C	R	LC
98	Large-Billed Crow	*Corvus macrorhynchos*	0	0	0	1	1	U	R	LC
99	Rufous Treepie	*Dendrocitta vagabunda*	1	0	0	1	0	C	R	LC
100	Grey-Headed Canary-Flycatcher	*Culicicapa ceylonensis*	1	0	0	0	0	U	WM	LC
101	Cinereous Tit	*Parus cinereus*	1	0	0	1	1	C	R	LC
102	Gray breasted Prinia	*Prinia hodgsonii*	1	0	1	1	0	C	R	LC
103	Plain Prinia	*Prinia inornata*	0	0	1	1	0	U	R	LC
104	Common Tailorbird	*Orthotomus sutorius*	1	0	0	1	1	C	R	LC
105	Thick-Billed Warbler	*Arundinax aedon*	0	0	1	1	0	U	WM	LC
106	Clamorous Reed Warbler	*Acrocephalus stentoreus*	0	0	1	1	0	U	WM	LC
107	Zitting Cisticola	*Cisticola juncidis*	0	0	0	1	0	U	R	LC
108	Paddyfield Warbler	*Acrocephalus agricola*	0	0	1	0	0	U	WM	LC
109	Blyth's Reed Warbler	*Acrocephalus dumetorum*	0	0	1	0	0	U	WM	LC
110	Rusty Rumped Warbler	*Locustella certhiola*	0	0	1	0	0	R	WM	LC
111	Striated Grassbird	*Megalurus palustris*	0	0	0	1	0	U	R	LC
112	Barn Swallow	*Hirundo rustica*	0	0	1	0	0	C	R	LC
113	Red-Rumped Swallow	*Cecropis daurica*	0	0	1	0	0	U	WM	LC
114	Striated Swallow	*Cecropis striolata*	0	0	1	0	0	U	R	LC
115	Bengal bush lark	*Mirafra assamica*	0	0	1	0	0	R	R	LC
116	Red-Vented Bulbul	*Pycnonotus cafer*	1	1	1	1	1	C	R	LC

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117	Black-Crested Bulbul	*Rubigula flaviventris*	1	0	0	0	0	R	R	LC
118	Red-Whiskered Bulbul	*Pycnonotus jocosus*	1	0	0	1	0	C	R	LC
119	Tickell's Leaf Warbler	*Phylloscopus affinis*	1	0	0	0	0	U	WM	LC
120	Dusky Warbler	*Phylloscopus fuscatus*	0	1	1	1	0	C	WM	LC
121	Greenish Warbler	*Phylloscopus trochiloides*	1	0	0	0	0	C	WM	LC
122	Blyth's Leaf Warbler	*Phylloscopus reguloides*	1	0	0	0	0	R	WM	LC
123	Oriental White-Eye	*Zosterops palpebrosus*	1	0	0	1	0	C	R	LC
124	Pin-Striped Tit-Babbler	*Mixornis gularis*	1	0	0	0	0	R	R	LC
125	Puff Throated Babbler	*Pellorneum ruficeps*	1	0	0	0	0	R	R	LC
126	Jungle Babbler	*Turdoides striata*	1	0	0	1	1	C	R	LC
127	Asian Pied Starling	*Gracupica contra*	0	0	0	1	1	C	R	LC
128	Chestnut-Tailed Starling	*Sturnia malabarica*	1	0	0	1	0	C	R	LC
129	Common Myna	*Acridotheres tristis*	0	0	0	1	1	C	R	LC
130	Jungle Myna	*Acridotheres fuscus*	1	0	0	1	0	U	R	LC
131	Great Myna	*Acridotheres grandis*	0	0	1	0	0	U	R	LC
132	Common Hill Myna	*Gracula religiosa*	0	0	0	1	0	R	R	LC
133	Taiga Flycatcher	*Ficedula albicilla*	1	0	1	1	1	C	WM	LC
134	Oriental Magpie-Robin	*Copsychus saularis*	1	0	0	1	1	C	R	LC
135	White-Rumped Shama	*Copsychus malabaricus*	1	0	0	0	0	U	R	LC
136	Blue Whistling-Thrush	*Myophonus caeruleus*	0	0	0	0	1	U	R	LC
137	Blue Rock-Thrush	*Myophonus caeruleus*	0	0	0	0	1	R	WM	LC
138	Siberian Rubythroat	*Calliope calliope*	0	0	1	0	0	R	WM	LC
139	Black Redstart	*Phoenicurus ochruros*	1	0	0	1	0	U	WM	LC
140	Siberian Stonechat	*Saxicola maurus*	0	0	1	1	0	C	WM	LC
141	Crimson Sunbird	*Aethopyga siparaja*	1	0	0	1	1	C	R	LC
142	Purple Sunbird	*Cinnyris asiaticus*	1	0	0	1	1	C	R	LC
143	Baya Weaver	*Ploceus philippinus*	0	0	1	1	0	C	R	LC
144	Chestnut Munia	*Lonchura atricapilla*	1	0	0	1	0	U	R	LC
145	Scaly-Breasted Munia	*Lonchura punctulata*	1	0	0	1	1	C	R	LC
146	House Sparrow	*Passer domesticus*	0	0	0	0	1	C	R	LC
147	Eurasian Tree Sparrow	*Passer montanus*	0	0	0	0	1	C	R	LC
148	White-Browed Wagtail	*Motacilla maderaspatensis*	0	1	1	0	0	U	WM	LC
149	White Wagtail	*Motacilla alba*	0	1	1	1	1	C	WM	LC
150	Paddyfield Pipit	*Anthus rufulus*	0	0	1	1	1	C	R	LC
151	Citrine Wagtail	*Motacilla citreola*	0	1	0	0	0	U	WM	LC
152	Olive-Backed Pipit	*Anthus hodgsoni*	1	0	0	1	0	U	WM	LC

Abundance code: C—common | U—uncommon | R—rare
Residency status: R—resident | SM—summer migrant | WM—winter migrant
IUCN Red List status: LC—Least Concern | NT—Near Threatened | VU—Vulnerable | EN—Endangered | CR—Critically Endangered

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