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Spatial variations of bird occupancy in Delhi: The significance of woodland habitat patches in urban centres

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ABSTRACT

Occupancy modeling, an important tool for conservation monitoring, was employed to assess the occupancy status of resident birds of Delhi and their association with persisting habitats, such as woodland, urban and open areas in an urbanized landscape. In the 240 sampling grids, each of 2.5 × 2.5 km, a total of 115 species were recorded during two alternative sampling years 2012 and 2014, out of which 31 terrestrial bird species were retained for the modeling exercise. Species occupancy related strongly to the extent of preferred habitat. Birds from woodland guild showed high occupancy (Ψ) in urban grids with green patches. Distribution maps developed for 31 terrestrial species provided strong evidence that the variations in occupancy values of a species across the study site was linked to the extent of persistent habitat and the type of urbanization taking place. For Delhi, estimates of occupancy for various species can form a baseline to study the future trends. The accelerating trend of urbanization, posing a serious challenge for biodiversity conservation can be most effectively dealt with by incorporating ecological knowledge of urban biodiversity in city planning. As a policy recommendation there is considerable merit in integrating islands of greenery in urban development because of their attractiveness for many types of arboreal birds, besides undertaking new plantation and habitat management programs.

1. Introduction

Common birds are effective and extremely popular indicators for evaluating biodiversity in all manner of natural and artificial habitats because they are diurnally active, easy to monitor and exhibit significant responses to different designs and effects brought about by habitat alterations (Bibby et al., 1992; Chace and Walsh, 2006; Yang et al., 2015). Maximizing bird diversity is considered to be a desired objective of most conservation programs, to be achieved by habitat protection and the creation of green corridors in urban environments (Niemela, 1999; Matsuba et al., 2016). The increasing urban sprawl, a common trend in most parts of the world today, while boosting the abundance of certain taxa, particularly omnivorous and granivorous birds, also simultaneously tends to reduce overall species diversity (Chace and Walsh, 2006). As remnant habitats are substituted by built up areas, urbanization processes inevitably lead to local extinction's (Marzluff, 2001) resulting in drastic fluctuations in community composition compounded by a host of analogous factors such as the introduction of exotics (Khera et al., 2009), human disturbance (MacGregor-Fors, 2008) and even supplementary feeding (Piper and Catterall, 2006; Fuller et al., 2008). Avian research trajectories of recent years testify to the increasing importance being given to urban ecology (Marzluff, 2001; Chace and Walsh, 2006; Evans et al., 2009). However, the majority of studies, reports research undertaken in developed countries such as USA, Canada and Western Europe, all from the temperate world. Studies employing robust analysis and sound experimental design from tropical and subtropical areas, where climate regimes, patterns of urban expansion, town planning and urban greening paradigms are notably different are few in numbers (e.g. Ortega-Álvarez and MacGregor-Fors, 2011; Yang et al., 2015; Matsuba et al., 2016).

Studies focusing on behavior, abundance, occupancy and community patterns (Fernandez-Juricic and Jokimäki, 2001; Marzluff 2001; Walker et al., 2008; Mckinney et al., 2011; Davis et al., 2012) of birds in urban premises have provided valuable insights about conservation of remnant habitats in built up areas (Niemela, 1999; Savard et al., 2000). However, from a methodological viewpoint, for many common birds, particularly small and insectivorous taxa, it is often difficult to have a proper assessment of their status because they tend to be imperfectly recorded in census programs, chiefly on account of their low detectability (Anderson et al., 2015). Most of the multi-species monitoring programs rely on raw counts and thus incorporate an inadvertent assumption of complete detection

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or constant detection across the survey sites, which is actually erroneous (Kellner and Swihart, 2014). Therefore, a robust estimation of detectability is the key for a proper assessment of the distribution and abundance patterns of birds across a wide range of habitats (Mackenzie et al., 2002). This problem has been rectified by the emergence of a powerful analytical tool called occupancy modeling (MacKenzie et al., 2006) which has novel applications for conservation monitoring studies and comprehending bird distributions at a landscape level.

Delhi, the capital city of India, has undergone rapid urbanization over the past several decades due to which human health, safety and biodiversity have been negatively impacted (Karn and Harada, 2001). With the rapid and often unplanned (Taubenböck et al., 2009) growth of urban centers across India (UNPFA, 2011), parks, gardens, tree lined avenues and residential yards are the only remnant habitats left for birds (Belaire et al., 2015). Much of the metropolis today is a mosaic of built up areas, lined with trees and interspersed with parks and gardens, planted with a variety of indigenous and ornamental flora in an uneven manner. Whereas in some areas (mostly commercial premises as well as some housing localities) buildings and other built up areas dominate, in others there is a mixture of vegetated patches, buildings and roads. Extensive and homogenous patches of native habitat are few in Delhi. The city itself can be said to be largely divided in terms of civic amenities and facilities and the economic profile of residents. All these factors can have some indirect influence on the distribution of remnant habitats. For instance, while its central parts afford green tree-lined avenues and residential yards planted with trees, extensive lawns, and flower beds, the rest of the city is more or less homogeneously urbanized and poorly planned with visibly fewer green spaces.

In the context of Delhi while some studies on waterbirds (Urfi, 2010) have focused on the general impacts of urban growth and reduction in feeding spaces, others have tended to highlight the importance of large green spaces with high structural variability and habitat heterogeneity for the maintenance of avian diversity (Khera et al., 2009). However, robust scientific information on birds from multiple habitat guilds is missing from Delhi as well as other Indian cities (Magle et al., 2012). We employed occupancy modeling for studying the common terrestrial birds of Delhi during two alternative sampling years 2012 and 2014, using single-season occupancy models for species belonging to various habitats such as human habitation, woodland and open area in urban premises. An unprecedented urban growth, which has led to an irreversible change in land-use, has created discrete patches of woodlands within the city (Taubenböck et al., 2009). We predicted that the occupancy of the woodland species would be higher not only within such isolated forest patches (Barth et al., 2015; Khera et al., 2009) but also in areas having urban parks, tree lined avenues and interspersed forest patches (Ikin et al., 2013). Therefore, the key objective of this study was to assess the occupancy status of different species in an urban area and their associations with persisting habitats. To ascertain the importance of habitat islands within the urban matrix and the extent to which different bird species are related to landscape biogeographic variables, we provide a methodical evaluation of occupancy and related covariates. The occupancy estimates of different species, as they emerge from the present study, can serve as baseline information for future conservation monitoring projects. By plotting their occupancy values on a city map one can easily ascertain the geographical spread of each species, as is attempted here. While our study covers all common resident terrestrial birds in urban premises, we closely examine the guild of arboreal birds, since many of these taxa are often highly specialized in terms of their feeding and nesting habits and therefore strongly dependent upon their remnant habitat.

2. Methods

2.1. Study area

The Delhi region broadly falls in an area lying at the confluence of the semi-arid Punjab plains and upper Gangetic plains in north India. The two dominating natural features of this region are the river Yamuna and the spur of the Arravali range, locally known as the ridge (Fig. 1). The natural forest cover of Delhi is estimated to be over 20% of its total area (Forest Survey of India, 2011).

2.1.1. Field study design

We designed our field study protocol using Arc GIS Explorer (ESRI, 2011) which allows for exploration and visualization of GIS information and creating custom maps. The present study undertakes a complete coverage of Delhi state. A 50×50 km square grid was overlaid on the map of Delhi, which was further sub-divided into 240 smaller grids of dimensions 2.5×2.5 km. This grid size was sufficient in meeting our study objectives, as it was small enough to relate occupancy with local habitat features (Bibby et al., 1992), especially levels of urbanization and extent of remnant habitat patches, yet large enough to facilitate a complete coverage of the study area within a reasonable amount of field effort.

2.2. Bird surveys

We conducted field studies during February to April, in two alternate years, 2012 and 2014. The chosen season is a favorable time for field work, because with the approach of spring, bird activity is considerably heightened, thereby facilitating easy detection. Although variations exist between different species in terms of their activity because of variation in their breeding times, roosting and nesting behavior, our study aimed for a general compromise between various factors impacting bird sampling. We recorded all birds sighted within 30 m on either side of the line transect (Bibby et al., 1992) ignoring those flying above the canopy level. Since the registration of different birds always relates strongly to the quantum of the study effort, we plotted species accumulation curves in two representative habitats, i.e., forested area and built-up area at few randomly selected sites. For this purpose we laid out five transects, each of variable length (1800 m–2400 m) in select forest and urban habitats and traversed at constant speed. The curves flattened after a distance of about 1 km, with the asymptote reaching up to 17 and 15 species, for the two areas, respectively. Hence, we chose a transect length of 1 km laid in the center of each grid for the present study. We recorded presence/absence data for species sighted (without any visual aids) and heard on both sides of a transect. Cases in which slight deviations from a predefined path had to be taken due to the presence of buildings and other structures were very few (CA 7.5%). Mostly we covered four transects during each day of sampling and these were traversed by a single observer walking at slow and steady pace during 06.00–9.30 h, only on clear days.

2.3. Estimation of habitat variables

We estimated the broad landscape categories (woodland, urban area and open area) in each grid using satellite imagery obtained from the Global Land Cover Facility (Landsat ETM; 30×30 m resolution), closest to the period when the bird surveys were conducted. We conducted an unsupervised classification of the image using ILWIS ver 3.8. (ILWIS, 2016) and classified the image data by aggregating the natural spectral groupings. We determined the land cover identity of these spectral groups by comparing the classified image data to ground reference data and assigned each group to one of three land use classes of interest: woodland, urban and open