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Impact of urbanization on Avain community structure in India: A review

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Abstract
Urbanization contributes to the loss of the world's biodiversity and the homogenization of its biota. Urban avian communities have reduced species richness, while the density of a few successful species is often higher in cities than in adjacent more natural habitats. They provide highly modified habitat for species that can adapt their feeding and other behaviours, or avoid the new conditions. Urban areas and human populations are rapidly growing. In addition, the urban sprawl has led to a highly fragmented landscape, with islets of suitable bird habitat surrounded by highways and buildings that frequently act as barriers, to birds. These altered conditions have changed the avifauna intensely, with many species disappearing once an area is urbanized, thus resulting in a significant loss of local biodiversity. In a slight majority of studies, bird density increased, but richness and evenness decreased in response to urbanization. But it is less understood which mechanisms generate and uphold these community-level changes. In this review we discuss the most important components of the urban environment influencing birds' community structure and compile several recent studies to illustrate their effects.

Keywords: Avian community, species richness, urbanization, homogenization

1. Introduction
The universal Birds are found globally. There are some 9700 species of birds living today; some 5000 species belong to the order Passeriformes, the perching birds or songbirds. The number of avian orders is still controversial and texts show different arrangements. The avifauna of India includes around 1314 species [1] of which 42 are endemic and 26 are rare or accidental. 82 species are globally threatened. The Indian Peacock (*Pavo cristatus*) is the national bird of India, with almost 150 species having become extinct after the arrival of humans. Environmental conditions are constantly changing due to human activities with urbanization being one of the most significant human-induced issues in the contemporary world [2-4]. As cities grow and expand, urbanization replaces native habitats with new man-made systems where natural and anthropogenic components interact [5]. Bird communities respond to this environmental variation in several ways. Habitat loss, destruction and degradation are the major threats to avian species richness and diversity. However, permanent presence of humans and higher densities of non-native predators have potential to affect avian nest placement [6]. With the rapid expansion of urban development, the importance of understanding the relationship between avian fauna and urban habitats is manifest. We live in a world dominated by heavily human-impacted ecosystems such as warming oceans polluted by plastic and petrochemicals, and from which marine life has been over-harvested, forests either completely lost or heavily fragmented, rural areas farmed ever more intensively, and rapidly expanding urban areas [7]. Of all of these human-transformed environments, arguably it is urban areas that have been transformed most extensively [8].
By 2008, more than half of the world's human population was living in urban areas [9], with urbanization continuing globally and rapidly [10]. Accompanying this burgeoning human population in our towns and cities has been the emergence of the concept of the 'urban bird' [11,12]. Although such urban birds may be adapted to urban environments, the urbanization process profoundly affects the majority of birds because it often involves the irreversible replacement of areas of natural and semi-natural rural habitats such as farmland and woodland with concreted areas of buildings and roads interspersed with gardens, parks and other green spaces [13, 14]. While urban birds face many challenges [12] that include exposure to novel predators [15], food sources [16, 17], habitat types, thermal ranges [18], and stressors such as noise [19, 20], light [21-23] and air pollution [24], their expansion and persistence in urban centers

offers us many opportunities to understand processes of adaptation to urban living and the development of urban spaces as conservation areas for wildlife more generally. The responses of birds to extrinsic factors in the urban environment play out through processes such as synurbisation [25], biotic homogenization [26-28], and ecological traps [29, 30].

By the year 2050, it is estimated that the majority of the global population will live in urban areas [31]. Threats to biodiversity are particularly inherent to such rapid urbanization, which raises concern over the future of the already reduced diversity in settings surrounding urban neighborhoods [32]. In many developing countries, a large number of wildlife survive outside protected areas on farmlands, pasturelands, and in urban areas [33]. Among all wildlife, birds are one of the most common wildlife in urban areas such as neighborhood's and cities, and many bird populations have been declining as a result of landscape changes due to urban expansion [34-37]. The impact of urban growth is both positive and negative depending on how the growth is managed.

2. Community Structure

A community structure may be defined as an association of interacting populations, usually defined by the nature of their interaction or the place in which they live. To understand the population structure of different bird species in any area, referred as community structure, measures of species richness, relative abundance and species diversity during different times are necessary for assuming and comprising the densities of bird species in different habitats or over different seasons in same habitat, the various methods are used to collect data [38].

Due to the urban development there is a segregation of species into the ones that spread along urban corridors and others which live in natural habitats [39]. Bird's communities lack ground and scrub- nesting species in the urban centers of town due to loss of habitat. Degradation of world habitat is operational on a massive scale and is rising. This increase is mainly due to the human activities which may have a major impact on avian diversity. These are examples of extreme landscape transformations caused by man which have significant impact on the biodiversity [40]. Urban landscapes are much more different from the natural ones in various environmental features which in turn determine the properties of the avian communities trying to persist in these habitats.

Urban development also has an impact on the species composition of the avifauna apart from the diversity. According to the terminology of [41], bird species of urban areas can be characterized as urban avoiders, urban adapters and urban exploiters, differing in the degree to which they can tolerate disturbance and utilize and rely on human provided resources [42]. It is really important to address the various mechanisms that lead to the loss of avian diversity in the urban settings with the ultimate goal of transforming urban environments into species rich ecosystems that has potential to harbour large number of bird communities.

The species which have high density in urban areas are called synurbic species [43]. They become dependent on human sources. For example, House Sparrow, is world widely synurbic. Functional diversity of birds decreased due to increase in urbanization. The introduction of exotic species in urban areas leads to the reduction in native species and poses a great threat to local ecosystem [44]. Alteration in energy flux, nutrient cycles and highly increased pollution levels have been observed due to urbanization. The replacement of many specialist species by a few generalist species is called functional homogenization [45].

Urban birds are expected to produce lower-quality offspring than rural birds. One reason for this is that selection may favor parents producing large broods at the expense of fledglings' body condition, because even low-quality offspring may have high chances of survival in urban habitats [46]. The adverse ecological effects may constrain the body size or condition of offspring. For example, several studies found that nestlings in urban habitats are fed by a reduced amount of, or lower quality food and reach lower body mass than nestlings in natural habitats [47-49]

The contamination of food, water or soil by toxic materials (e.g. heavy metals) may have similar detrimental effects on nestling development. Many species have become extinct through human activities like excessive hunting, logging, large-scale use of insecticides and pesticides in agriculture and industrial pollution. Two birds that have become extinct in India are Mountain Quail and the Pink-Headed Duck [50,51]

Numerous species have come to depend on human activities for food and are widespread to the point of being pests. They have adapted well to the rapid urbanization and growth in human population. For example, the House Crow and Rock Pigeon thrive near human habitation in large parts of the world. While in addition to these two species, the Common Myna, Bank Myna and Black Kite are thriving in India; Vultures (*Aegypinae*) and the House Crow are facing an inexplicable decline in their population.

3. Negative Impacts of Urbanization

3.1 Bird Species Richness and Community Composition

The presence of a species in a particular habitat patch is influenced not only by the size and structure of the patch, but also by the landscape surrounding the patch [52,53]. The urbanization processes lead to a reduction in biodiversity [54, 55]. Due to the transformation of natural habitats into agricultural, industrial and urbanized areas. Thus, urban development reduces available habitat and has resulted in declines in animal populations [56-58]. For example, urban riparian patches are embedded in a matrix of human-modified habitat, and bird diversity declines as this matrix becomes increasingly fragmented [59]. Highly toxic pesticides have been used extensively to control pests since the 1970s [60], which has often been thought to explain the decline in abundance and diversity of birds in agricultural habitats

Although urban development reduced bird species richness and several endangered species (e.g., *Ciconia nigra, Platalea minor and Grus grus*) vanished in River habitats, species richness and diversity were higher in the River habitat than in the other habitats. Similarly, the proportion of exclusive species in the River habitat could be considered high, which may be accounted for by the number of species dependent on flooded environments. Conditions in the river zone (e.g., moisture regimes, nutrient availability) often contrast strongly with those predominating in the surrounding non-river matrix [61, 62]. This leads to distinct patterning of vegetation associations in the landscape [63] and birds respond positively to such diversity of habitats [64, 65].

3.2 Biotic homogenization

[66-69] reported that Urbanization not only extirpates native species from an area but also promotes the establishment of non-native species. The massive disturbances created by city

growth not only destroy the habitat of native species but they create habitat for a relatively few species that are adapting to urban and suburban conditions. This process of replacing localized native species with increasingly widespread non-native species promotes biotic homogenization on several spatial scales. A major consequence for conservation is that non-native species may often enrich local biodiversity [70] but global diversity is decreased by the subsequent extinction of unique local species that are lost to the global species pool.

Urbanization is one of the most homogenizing activities of all. Many studies show that the construction and expansion of towns and cities promote the loss of native species and their replacement by non-native species. Urbanization is closely associated with two basic factors that increase non-native species richness: (1) increasing importation of non-native individuals and (2) Favorable habitat for the establishment of non-native species. Human settlements import non-native species for several reasons, ranging from the accidental importation by traffic (trucks, planes and ships) associated with centers of commerce to the intentional importation of species for cultivation, pets, and other human uses [71].

3.3 Cellular towers and HT wires

The advent of cell phones has resulted in the proliferation of cell phone towers in the urban landscapes; cell phone towers are now as ubiquitous as the house sparrows were. Research in Spain proved that the microwaves released from these towers are harmful to house sparrows and the increase in the concentration of microwaves results leads to decrease in house sparrow and other bird populations. The recent surveys on avifauna have shown that rapid high voltage electric wires and mobile towers are major contributors for the decline of some of the bird species.

3.4 Ecological factors

Birds adapt to the urban ecosystem both physiologically (changes in stress hormones) and in behavior (e.g., changes in foraging behavior, extending the breeding season). In general, urban bird communities include less species and higher abundances than those from natural habitats [72]. Several ecological factors like roosting sites, nesting sites, food and water points have definite relationship with population of feral pigeon in urban areas [73]. Food such as refuse is likely to provide important resources for some species [74]. Studies of bird communities in urban parks have shown that parks are considerably richer in bird species diversity and richness than other urban habitats [75]

According to [76] the garden areas are likely to contain a high proportion of native shrubs which can provide cover and insects for foraging birds. Urban habitats are often of superior quality to raptors because there they are often free from persecution and have an adequate food supply allowing use of otherwise unsuitable or unproductive nesting sites [77, 78]. Avian fecundity in urban areas is a reflection of species-specific adaptability to urban resources, and to levels of nest predation and nest parasitism.

Predation pressures may ease or increase depending on the characteristics of the city and the region. On the one hand, there are presumably fewer natural predators (e.g., large mammals and raptors) in the urban areas compared to natural nonurban areas. On the other hand, corvids, feral cats. Likewise, many smaller raptors such as Peregrine Falcons and Lesser Kestrels (*Falco naumanni)* perform very well nowadays in the urban setting [77, 79]. However, in a comparative study of multiple urban species, it was shown that feathers of urban birds were more difficult to pluck (i.e., an anti-predation response), which was interpreted as reduced pressures from natural selection caused by predation in urban habitats [80]. These factors are more variable across cities, when present, they are likely to be strong drivers of population-level shifts in phenotypic traits.

3.5 Urban drivers

The last general urban driver is human presence. Birds perceive humans as a threat, and this threat is something that urban birds need to handle, since they interact and are exposed to humans constantly [81]. Encounters with humans are likely to stress birds, in particular during the breeding season. Human behaviors toward birds are also likely to differ depending on species, for example, small birds are generally accepted to stay close, whereas larger species are vigorously scared away and even hunted in the city. Also, human behavior toward birds are context-specific; we want them close when we choose to for example actively feed them, but we do not want them too close while eating outside ourselves. Apart from the abovementioned drivers, there are a few other factors namely, food abundance, pathogens, and predation

3.6 Stress Physiology and Its Consequences

The main physiological responses investigated in relation to urbanization or to single urban stressors is stress physiology (oxidative stress and corticosterone, commonly referred to as a stress hormone). Oxidative stress is the key target for toxicological research but also in relation to cost of life, since oxidative stress is part of the unavoidable aging process [82]. Environmental influences on oxidative stress can be multiple, e.g., pollution, radiation, disease, and food intake. However, the main factor in the urban environment is probably chemical pollution (such as NOx and soot). Many of the urban air pollutants act as prooxidants, which will react with and cause damage to life-sustaining molecules such as proteins, lipids, and DNA, unless they are detoxified by the protective antioxidants. Oxidative damages are commonly used as biomarkers of poor health, leading to premature death. Another aging biomarker that may be linked to oxidative stress is the shortening of telomeres [83]

Hormones have also been of great interest in relation to how birds respond to urbanization [84] especially stress and reproductive hormones. This is because hormones trigger behavioral and other physiological responses, thus representing key targets for selection. Changes in hormones have been associated with resource availability, conspecific interactions, predation, night light and human disturbance. Regarding hormones that affect reproduction, gonadotropin-releasing hormone is stimulated by day length. Due to the artificial night lighting in urban habitats the day becomes longer than in areas lacking street lights. Indeed, in urban environments gonadotropin releasing hormone and other reproductive hormones are more stimulated which is the likely mechanistic explanation for the advancement of the timing of mating behaviors and reproduction [85].

3.7 Pollution

The process of habitat urbanization bears impact on more and more natural habitats, it is essential for us to understand the changes we bring forth in the ecological forces shaping urban animal communities. Songbirds are good indicators of chemical pollution, since they occupy high trophic levels and

have high metabolic rate. In urban areas enhanced levels of bioaccumulation of heavy metals has already been demonstrated in many common bird species, e.g. in the House Sparrow (*Passer domesticus*) [86, 87, 88], the House Wren (*Troglodytes aedon*) or the American Robin (T*urdusmigratorius*) [89]. The detrimental, synergistic effects of such pollutants on birds' physiology is also documented by several studies [90, 91] and it also known that young individuals are more sensitive in general [92], suffering from higher mortality, reduced body mass and condition [93].

Heavy metal pollution may pose both direct and indirect detrimental effects on birds' reproductive success. To assess their relative importance, a recent study [94] manipulated the dietary lead (Pb) levels at Great Tit Parus major nests, and compared these nestlings' physiological, biometrical and plumage traits to those of the nestlings living in a heavily polluted area (near a copper smelter). Despite of the similar exposure of lead in the treatment group and in the birds of the highly polluted area, chicks of the latter exhibited lower survival, decreased size and also the signs of inferior health state, compared to the treatment groups. This result underlines the potential indirect effects pollutants e.g. by affecting the arthropod fauna serving as food for the birds. India is the world's largest user of chemical pesticides and fertilizers. This intensification in agriculture has led to serious decline in several farmland birds and the house sparrow is no exclusion. The change in cropping patterns and introduction of exotic crops has also led to a decrease in food and large-scale habitat destruction [95].

Urban areas are also source of chemical pollution due to the emissions from industries, nutrient loads to water bodies Urbanization can have favorable as well as harmful effects on the birds, it all depends on the ability of birds whether they are able to colonize in the urban areas with the conditions existing there or not. However, it is not necessary that the urbanization causes the avian diversity to decline, as the bird species often tend to top at the intermediate urbanization levels [96]. Urban areas are also sources of many types of chemical pollution, with concentrations several times higher than the global average. Air, soil and water pollution (due to emissions from industry, traffic and heating, or nutrient loads to water bodies) cause changes in biogeochemical and nutrient cycles and primary production [97].

3.8 Urban heat island effect

Altered local weather conditions are the most important feature of urban environment. Urban heat island effect is one of the best documented climatic features of cities, referring to the higher temperatures of urban areas compared to their surroundings [98, 99].

3.9 Ecological Light Pollution

Ecological light pollution is another characteristic disturbance related to urban settlements which is caused by the high number of artificial light sources used in the cities. This results in new interactions between the predators and competitor's species of birds. It has complex and subtle effects mainly on animal behaviour via affecting animals' orientation, migration, foraging, reproduction and communication [100]. In birds, especially migrant species are susceptible to light pollution as many migrate during night, and hypothesized to use light sources as visual references instead of natural cues on the horizon, especially on nights with heavy clouds and fog [101]. Once being attracted, they can either become trapped and/or die from collision or exhaustion, and may additionally suffer from other consequences, e.g. reduced energy stores or delayed arrival at wintering or breeding areas.

As light is supposed to initiate singing behaviour in birds, artificial night time illumination should also affect territorial and courtship behaviour [102]. In line with this, males of several bird species have been demonstrated to start their dawn choruses earlier in sites with more pronounced light pollution compared to their conspecifics of darker territories [103, 104]. Artificial light pollution has a substantial effect on behaviour and modifies the endogenous circadian rhythmicity of urban birds.

3.10 Anthropogenic noise pollution

Birds also have to adjust to the noise levels; Increased noise levels interfere with the vocal communicating abilities of the birds. This interference may negatively impact avifauna. It has impacts on animal communication systems and behaviour by masking acoustic signals related to territorial defense, mate attraction, alarm calls, pair-bond maintaining calls, and begging calls of nestlings [105]. For example, in European robin Erithacusrubecula it has been experimentally demonstrated that noise level influences both spatial distribution of males (they avoid noise-emitting sources) and their singing behaviour [106]. Noise intensity can be considered as a proxy for other negative effects within streets, the higher the exposure to noise, the greater the impacts associated with urbanization, and therefore, the smaller the number and abundance of bird species able to occupy streets of an urban landscape [107]. Tree Swallows Tachycinetabicolor the experimentally elevated static noise reduced nestlings' ability to respond parental alarm calls properly.

4. Positive impact of Urbanization on Avian community

The effects of streets on biodiversity is an important aspect of urban ecology, but it has been neglected worldwide. Several vegetation attributes (e.g. street tree density and diversity) have important effects on biodiversity and ecological processes. Exposure to noise was the most limiting factor for bird community. However, the average size of arboreal patches and, especially the characteristics of street trees, were able to reduce the negative effects of noise on the bird community. Characteristics of the urban vegetation, such as street trees, gardens and natural habitat patches, are important for the maintenance of bird populations in cities [108]. Actions such as planting native tree species [109], planning an ecological network connecting habitat patches [108] and ensuring the availability of resources for native fauna [110] increase bird species richness, abundance and diversity as well as reducing the negative effects of the urbanization process, such as biotic homogenization [111]. These results show the importance of adequately planning and the management of the urban afforestation process: such as increase the number of large and native tree species in the streets is able to mitigate the negative effects of the urbanization on birds that occupy the urban matrix. Urban bird species richness, abundance and community is positively influenced by the amount of native street tree species [112,113,114,115]. This is related to birds' preferences for native tree species as nesting sites [116] and the availability of resources and consequently improve human wellbeing and quality of life. Furthermore, trees also can act as sound barriers causing sound to disperse and dissipate [117]. "We

need nature as much in the city as in the countryside" was written in book Designed with nature [118].

Fifty years later, we still need to learn how to enhance, preserve and live with biodiversity within urban landscapes. With the current planning and management practices, Belo Horizonte is only able to retain 20% of its rich and diverse bird community within the urban matrix. Therefore, we need to change the current focus on a purely aesthetic and utilitarian view of the urban afforestation process [119] decisions must consider the functionality of the urban landscape and the green elements as interconnected units [120] Considering that bird species can be used as indicators of urban ecological integrity [121], planning and management practices, especially those related to street trees studies [122, 110, 109] are able to reduce the negative effects of urbanization on biodiversity.

Moreover, very little is known about how birds are influenced by disturbances and vegetation characteristics of streets. Traffic volume and the size of the vegetation gap affects the movement of songbirds [123] and traffic noise has an influence on antipredator behavior [124], causing changes in song patterns [125]. However, when the urban vegetation is properly managed, streets need not be completely negative to urban birds. Species can use street trees to move between urban parks and habitat patches [126]. Streetscapes that contain predominantly native tree species, increase native bird species richness and abundance, and the bird community is more similar to that in natural habitat patches than in streetscapes, which are composed mainly of exotic tree species [127]. Urbanization has a positive impact on the bird abundance of few species, which are adapted to urbanization and particularly those, which are omnivorous or need nesting sites resembling to those of the cliffs or ledges.

5. Conclusion

The present study contributes to the knowledge about the impact of urbanization on the bird population. Urbanization has led to an immense change of the avifauna. Species have fled and vanished in response to urbanization but also flourished and changed. It is clear that urbanization is a huge threat to biodiversity and the existence of many bird species and urbanization is not expected to slow down in any close future, rather the opposite [9]. Thus, conservationists and city planners have an important task for the future. Their actions can in fact have great positive effects on the bird community. Urbanization results into higher populations of fewer bird species. But at the same time, number of species is greatly reduced in urban environments, thus creating problems of survival for other species. Urbanization has an adverse impact on the bird biodiversity. Future studies will entail, whether urbanization will be an opportunity for species radiation or if it will continue to be a habitat of species eradication and homogenization.

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