

An Analysis of the Effects of Urbanization on Birds and Animals in Habitats

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Abstract: *Changes in topography create new habitats with different environmental features. We must understand how people alter ecological processes affecting urban animal populations as habitat urbanization affects more wild regions. City ecologists use birds as models. It is well known that urban bird populations have fewer species and higher concentrations of a few successful species than wild surroundings. We know nothing about community-level transformation processes. We discuss the most important urban environmental elements impacting birds' physiology, behavior, and morphology and present new data to support them. We use bottom-up and top-down methods to study urban food webs, assuming that food availability and predation have affected urban bird populations. We might better understand urban bird assemblage patterns and processes using experimental, manipulative studies.*

Keywords: Urbanization, Habitat Fragmentation, Bird Adaptation, Biodiversity Loss

I. INTRODUCTION

Urbanization as a Worldwide Phenomenon

One million people relocate to cities weekly, boosting urbanization. The world's population moved to cities from 30% in 1950 to 50% in 2008 and continues to increase. This trend has been especially noticeable in growing African, Asian, and Latin American countries in recent decades. Human settlements increase environmental pressures. Urban areas have harmed energy flow, nutrient cycles, hydrology, thermal balance, and pollution. Due to high human concentrations, artificial and impermeable surfaces, changed and managed flora, and huge waste, they damage biodiversity and ecosystems. Urban environments differ from natural ones in many ways, which impact the animals and plants that live there.

Our examination begins with the biggest urban environmental changes. We then evaluate urban bird species diversity and composition following these changes. Second, we examine how top-down and bottom-up urban food chain elements impact city birds. Finally, we explore some limitations and recommend future objectives to better understand how these critical ecological parameters shift along an urbanization gradient and influence urban bird populations.

Urbanization: Effects on Environmental Components

Urbanization's changing local climate is likely its most notable feature. More particles as condensation nuclei enhance precipitation in cities. The urban heat island effect—urban areas having higher temperatures than their surroundings—is well-documented. When afternoon heat is reemitted at night, urban and non-urban temperatures may differ by several degrees. Cities have less springtime frost, therefore higher temperatures may encourage earlier flowering and longer vegetation growth. Early bud burst, flowering, and fruiting affect insect life cycles and bird species' arthropod food availability. If birds cannot adapt as fast to spring phenology as their invertebrate prey, the earlier emergence of arthropods may decouple predator-prey interactions by producing asynchrony between the peak abundance of phytophagous insects and insectivorous bird nesting. Warmer city conditions may assist birds overwinter and breed. It's hard to evaluate milder climate without additional habitat-urbanization elements like food availability.

Cities have several times more chemical contaminants than the global average. The specific method by which air, soil, and water pollution from industry, traffic, and heating or nutrient loads to water bodies influence biogeochemical and nutrient cycles and primary production is unclear. If they enter the food chain, they may affect birds and other animals

outside the city. Little, insectivorous songbirds are effective chemical pollution sensors due to their rapid metabolism and trophic level. Common urban birds like the House Sparrow *Passer domesticus*, House Wren *Troglodytes aedon*, and American Robin *Turdus migratorius* bioaccumulate heavy metals. Several studies have proven the negative, synergistic effects of such contaminants on birds' physiology, and young birds are more vulnerable, perish more, and have poorer body mass and condition. Heavy metal exposure may damage bird reproductive directly and indirectly. In 2014, Eeva et al. controlled dietary lead (Pb) levels in Great Tit *Parus major* nests and compared their physiological, biometrical, and plumage features to those of nestlings from a badly polluted environment near a copper smelter to assess their relative value. Despite similar lead exposure, severely polluted birds' chicks had worse survival, size, and health than the treatment group. Pollutants may affect avian nutrition by changing arthropod biodiversity.

Cities' many artificial light sources generate ecological light pollution, another urban disturbance. The majority of its complicated effects include animal movement, foraging, reproduction, and communication. It may also produce unforeseen rivalry or predator-prey interactions. Flying invertebrates and vertebrates, including birds, are affected by artificial nightlighting. Birds migrate at night and are sensitive to light pollution, thus they may use light sources instead of natural signals on the horizon, especially on nights with heavy clouds and fog. Drawn, they may become stuck, die from collision or weariness, or have reduced energy storage or delayed wintering or mating. Light stimulates singing, hence artificial evening lighting should change bird territorial and courtship behavior. Light pollution causes certain bird males to start their morning choruses earlier than in darker locations.

A captive Eurasian Blackbird *Turdus merula* molts and de-velopes its reproductive system faster in low light than in dark woods nights. Urban and city-dweller Blackbirds were tested physiologically under controlled conditions. Forest birds' morning and evening timing was closer to natural twilight, whereas urban birds rose up before dawn and had a shorter circadian period. Russ et al. (2014) observed that urban Blackbirds with better night lighting hunt longer after sunset, especially in early spring when daylight is limited. The authors discovered no significant relationship between light intensity and body condition, indicating that birds may not benefit from longer foraging time but may have extra time for mating or other daytime activities. All of these studies suggest that artificial light pollution impacts urban birds' behavior and circadian rhythmicity.

Human-caused noise changes city and transportation acoustics. It hides territorial defense, mating attraction, warning calls, pair-bond maintenance sounds, and nestling begging cries, influencing animal communication and behavior. European robin *Erithacus rubecula* males avoid noise-emitting sources and sing differently depending on noise level. A few species believe noise harms bird breeding. Greater tits had smaller clutches and fewer chicks in loud highway areas. Other studies found that noisy territorial males are younger, lower-quality, and less successful in attracting mates, perhaps because females avoid these areas or hide their song. Males in louder area may suffer since females judge a possible mate by song repertoire and characteristics. Schroeder et al. (2012) found that House Sparrow parents breeding in chronic noise have lower reproductive success than parents in control areas because noise masks parent-offspring vocal communication, such as nestling begging calls. Noise pollution may also cause physiological stress or hinder predator-prey communication.

In elevated background noise, Chaffinches *Fringilla coelebs* become more vigilant and peck less when foraging, and Tree Swallow *Tachycineta bicolor* nestlings' ability to respond to parental alarm calls was reduced. Anthropogenic noise is usually low-frequency, hence bird species with high-frequency songs may be preadapted to urban contexts. Noise pollution may impair urban species' success, according to within-taxa comparisons in over 100 bird genera. Common Nightingale *Luscinia megarhynchos*, Great Tits, Song Sparrows *Melospiza melodia*, and Grey-shrikethrush *Colluricincla harmonica* can compensate for high noise levels by changing their singing amplitude or frequency. In cities, diurnal birds may sing at night to avoid daytime noise pollution.

Urban roads pollute, change hydrological systems, and increase crash fatality (Andrews et al. 2008). Animals avoid roads, particularly owing to motor noise, is widely known. Benítez-Lopez et al. (2010) observed that road proximity leads to a decline in bird population densities in their meta-analysis. However, Accipitriformes and Falconiformes were more abundant near infrastructure, perhaps due to roadkill carcasses providing more feeding possibilities. This research also found that road-effect zones may extend up to a kilometer in most bird species and are stronger in open areas than forests. Birds also adapt to road traffic, as Legagneux and Ducatez (2013) found that common European species adjusted their flight initiation distance to road speed limits, escaping earlier on roads with higher speed limits.

Urban structures are perhaps the most distinctive feature. Many birds cannot forage or reproduce in building-covered regions. Buildings also include more people, pets, pollution, noise, light, and vegetation, thus animals sensitive to disturbance may avoid them. More tolerant species may benefit from their presence. Buildings may provide thermal protection for overwintering arthropods, and certain bird species choose to roost or reproduce in them. Bird collision mortality is also greatly exacerbated by structures. Long-distance migratory on their yearly spring and autumn journeys are more sensitive to such threats, however a recent North-American bird research found no association between collision mortality and long-term population trends. Finally, rising construction density reduces plant cover and makes it more heterogeneous, impacting the distribution, abundance, and species richness of many local animal groups. Reduced plant cover reduces solar radiation and cools air temperature via evapotranspiration, contributing to urban heat islands.

Effects of Urbanization on Avian Biodiversity and Species Composition

Habitat urbanization has both good and negative consequences on bird populations, and their synergistic effects will determine whether species survive, colonize, or go extinct in cities. The many negatives of urban areas diminish species diversity. Bird diversity is lowest in urban cores. Bird biodiversity declines not monotonically with urbanization since bird species richness peaks in suburbs at moderate urbanization levels. Because regular, low-scale disturbances promote landscape heterogeneity, create novel communities, and prevent strong disturbance, the intermediate disturbance hypothesis predicts that areas with moderate disturbance will have higher species diversity. These rural-to-urban transition zones may include species that benefit and suffer from urbanization. But we don't know what suburban traits or methods boost local species diversity.

Urbanization changes avifauna species and diversity. Based on their capacity to tolerate disturbance and utilize human-provided resources, Blair (1996) classified urban bird species as urban avoiders, adapters, and exploiters (McKinney 2002). Long-term travelers, habitat specialists, and sensitive species avoid ur-bans. The community-native birds reside in virgin areas with natural vegetation outside settlements. Cities lose urban avoiders most to urbanization. Edge species like urban adapters exploit human-provided resources like trash and bird feeders in suburbs and intermediate disturbance levels. Omnivores like Corvidae or Paridae or ground-feeding finches nest in cavities or shrubs. Rock (2005) and other gulls have roof-top colonies in coastal communities. In rural to urban transition zones, where land-use is most variable, native and non-native urban adapters predominate. Synurbic species are the most prevalent group in urban areas with scant natural habitats and human-altered conditions. Since urban populations are denser than wild ones, some animals tolerate and prefer them. Unless a species is synurbic everywhere, it is best to speak about synurbic populations rather than species. Many urban exploiters have a few dominating, alien species and few native ones, and their diversity and abundance are not dependent on natural vegetation. Worldwide synurbic species like the Feral Pigeon *Columba livia*, House Sparrow, and European Starling *Sturnus vulgaris* depend on humans. The House Crow *Corvus splendens*, Common Myna *Acridotheres tristis* in Australia or India, Blackbird in Europe, and House Finch *Haemorhous mexicanus* in North America are additional species. Like the House Sparrow, exploiters have a long history with humans and thrive in human-dominated environments. Many urban adaptations are early successional species from nearby natural environments.

Urban bird groups are simpler and have more exotic species. Human actions including importing non-native species, changing plant composition, and establishing comparable habitats are responsible for this trend. Evans et al. (2009) observed no latitudinal gradient in bird species richness in British cities but comparable slopes in non-urban Europe. These successful urban-dweller species are (pre)adapted to human-created conditions and can live in urban areas globally, excluding non-synurbic species, according to Shochat et al. (2010). Biologic homogeneity encompasses taxonomic homogenization.

Luck & Smallbone (2010) say natural vegetation maintains native animals and promotes urban species richness. Unlike synurbic bird species, native forest species prefer enlarged and aggregated vegetation and dislike foreign urban vegetation. Exotic vegetation and urbanization are usually positively related, making it hard to disentangle vegetation from other habitat urbanization effects. If feeders favor overabundant, bigger, and aggressive species over smaller, subordinate species, even innocent activities like bird-feeding in suburban gardens might indirectly limit local avian

biodiversity. In a UK correlative study, bird feeder densities were positively correlated with urban-dweller species like Eurasian Blackbirds and House Sparrows, but not with garden species like Great Tit and Blue Tit *Cyanistes caeruleus*.

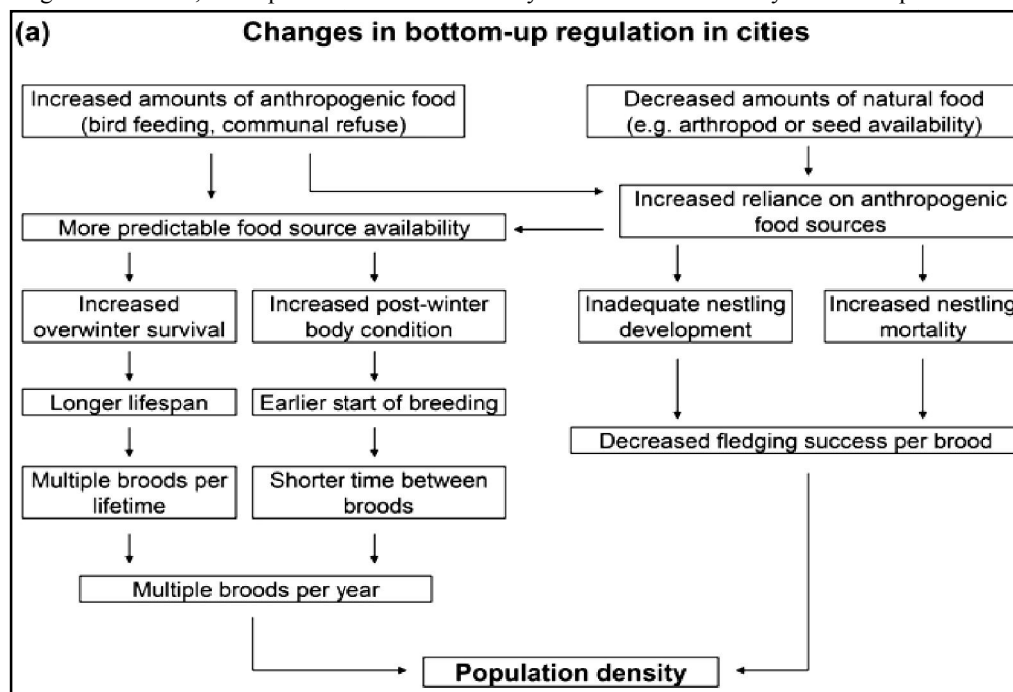
Mechanisms Generating Changes in Urban Avian Communities

Several unfavorable direct and indirect consequences of human-related environmental variables on urban avifauna have been addressed. As said, not all human activities harm birds, as shown by the substantial rise in certain urban species' numbers. Human-influenced food webs also shape these amazing population density differences. Cities are thought to have more resources and decreased predation danger. The remainder of the review will outline these assumptions.

Changes in resource-based forces

Food or nutrient-constrained lower trophic levels are controlled bottom-up. Bottom-up impacts arise when primary output increases or human-provided food affects city resource-based pressures. Major urban food supply adjustments may reduce avian hunger and increase reproduction. Increased food supplies may appear to affect wild bird populations, however our knowledge is limited.

This bottom-up effect is paradoxical since high consumer density may restrict per capita food consumption due to fierce competition despite ample population resources. Urbanites may be less fit than nonurbanites due to resource overmatching. To solve this, a competitive model stresses city food intake consistency. The concept states that on



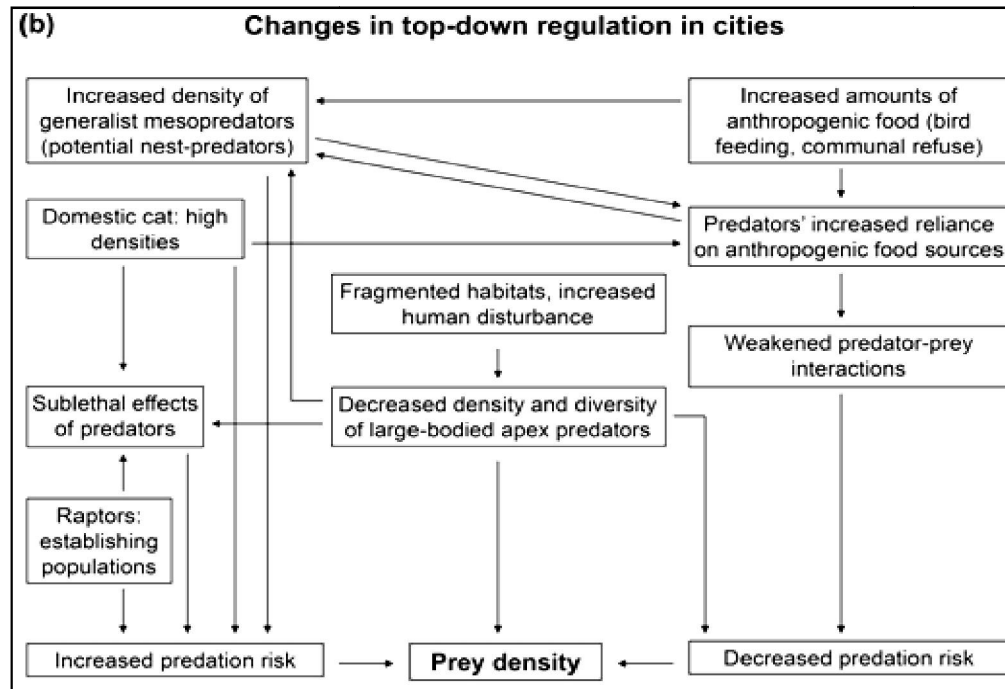


Fig. Conceptualization of the effects of habitat urbanization on food-web dynamics

Urban bird biomass is largely low-quality individuals with limited competing skills and low body stores that can only exist day-to-day but would be removed by natural selection in uncertain resource renewal conditions. They become uncompetitive, 'living on the credit of tomorrow'. Despite poor reproductive success, such folks make up a major portion of urban populations. Competition winners are a minority in urban areas and must maintain huge body reserves to reproduce. This hypothesis predicts city overexploitation, resulting in bigger populations with poorer physical condition, competitive performance, average fitness, and variation.

Successful synanthropic bird species may not fit this idea, but certain urban bird populations may. A study on the Northern Cardinal *Cardinalis cardinalis* found that its density in urban forests was four times higher than in rural areas, but it did not find any habitat-related differences in annual breeding success, apparent survival rates, or body condition. Urbanization negatively correlated with certain metrics of birds' physiology in a recent house finch study, but these differences were seasonal, suggesting only short-term damage to birds' quality. Urbanization did not impact stress reactions, physiology, coloring, or body condition in house sparrows, although they were smaller and not slimmer than their rural counterparts. Another study found no difference in competitive performance or ability variance between urban and rural sparrows, nor did body mass impact success. A song sparrow study found that habitat urbanization did not damage birds' stress physiology or physical health. These results invalidate the credit card idea and imply that adult urban sparrows' smaller bodies may not signal physical weakness or competitiveness.

Food availability and predictability may boost urban bird biomass (Fuller et al. 2008). Gulls and ibises *Threskiornis* sp. live in urban landfills in Australia (Martin et al. 2011) and Europe. Not only do humans unknowingly feed animals. In the UK, 50–75% of families feed birds bread, lard, and peanuts, totaling hundreds of thousands of tons per year. Artificial food may influence urban bird reproduction by altering parents or nestlings in many ways. Separate the effects of increased food on adult birds and nestlings to determine how it affects breeding success.

Mature birds first. According to the constraint hypothesis, energy and/or nourishment restrict female egg production before breeding. Food and a higher temperature curb energy demands before breeding in urban areas, enhancing overwinter survival and adult body condition. Urban passerines' earlier egg-laying dates may indicate this improved condition, although urban settings should expect larger clutch sizes at least initially. Not all urban birds have improved pre-breeding conditions. Various metropolitan environments have comparable body conditions for Northern Cardinals, House Sparrows, and Song Sparrows, females may breed sooner because human-supplied food precedes the mating

season, suggesting adequate chick rearing circumstances. Environmental data is important to birds. Winter food supplementation may mislead birds into an ecological trap by forecasting higher food availability later in the mating season in temperate areas, while bird feeding frequently stops in spring. Early breeding may delay nestlings' nutritional demands and natural food availability, limiting chick survival. This idea suggests that additional meal studies may extend laying dates but seldom increase clutch size, however some birds have bigger clutches.

The short- and long-term effects of food supplementation on birds' health and breeding must be separated. Food supplementation before or during breeding may affect results. In a landscape-scale experiment on Blue Tits in forests, Robb et al. subsidized peanuts ad libitum for months but stopped six weeks before egg-laying to determine short- and long-term impacts. In supplemented sites, birds lay eggs earlier and fledged more chicks per nest, but clutch size, hatching ratio, and fledgling mass were equal in treated and control groups. The investigators thought enhanced parental care at subsidized areas boosted nestling survival.

In a similar study on the same species, fat provision decreased egg quality in the next mating season, however vitamin E mitigated this. Birds may have developed reliant on such conveniently available, energy-rich food sources, which may have increased their overwinter survival but restricted their nutritional variety, preventing them from storing up egg-formation ingredients. Fat supplement did not affect clutch size in a follow-up study with the same design, but it did damage fledged young number, weight, and size. Many weeks of food supplementation before hatching decreased clutch size and number of hatched young in a three-year forest great and blue tit research. These results are hard to explain, although the provided food may be fat-rich but protein-poor, producing nutritional issues. Bird feeding may increase adult survival, and life-history theory suggests longer-lived birds spawn less each brood. Florida scrub-jays given protein- and fat-rich diet had greater laying dates, egg masses, and clutch sizes than those fed solely fat, according to Reynolds et al. (2003). However, clutch size rose year, presumably owing to natural food availability.

These studies suggest that food supplementation may alter adult bird reproduction. The impacts of bird feeding vary by species, year, natural resource availability, and food quality, and the long-term implications of copious additional food sources on individuals and communities remain unclear. Most of the above supplementary-feeding studies were not conducted in urban habitats, but many of the differences between fed and unfed tits are also found in urban and non-urban populations, suggesting abundant anthropogenic food sources may play. We simply remark that bird feeding may affect wild bird populations via behavioral changes, territorial conflict, illness transmission, or migratory patterns.

The abundance of manufactured food may lead nestlings to eat more "junk food," especially when natural food is scarce. No matter the setting, wilderness and suburban Florida Scrub-jay parents preferred wax-worm over peanut during nestling raising. When arthropod food handling time was extended experimentally, peanut ratios increased, but suburban parents preferred natural food. As in a recent report on the species' suburban and wildland habitats, our findings suggest reduced arthropod availability in suburbs. Urban European starling nestlings ingest more human excrement than rural ones. Common suburban Australian magpies *Gymnorhina tibicen* fed their offspring less natural food. Nestlings require protein, although adult birds may eat urban food. Compared to non-urban chicks, urban chicks have lower body mass and higher mortality rates and breeding adult recruitment in numerous bird species. Nestling feeding quantity and quality are crucial for chick survival and growth. House Sparrow, Song Sparrow, and Western Gull experiments show developmental fallbacks remain throughout adulthood. Experimental investigations show that high-quality nestling feeding boosts nestling output. Urban Carrion Crow *Corvus corone corone* pairs given protein-rich diets raised bigger and more chicks. This study demonstrated that feeding Parkland great tits mealworms from hatching to fledging increased nestling size but not offspring quantity. The extra food may have been eaten by parents or given to nestlings. Peach et al. (2014) discovered that mealworm-supplemented House Sparrow nests increased nestling production in suburban and rural areas. An urban and rural dwelling research confirmed nestling food's effects.

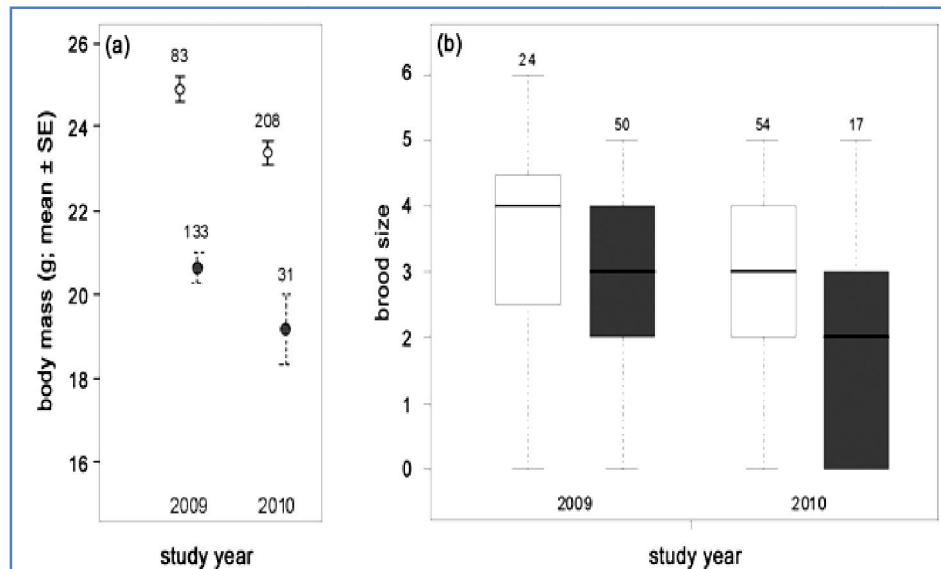


Fig. 2. Differences in (a) nestling growth (as measured by body mass before fledging) and (b) breeding success (as measured by brood size before fledging) in House Sparrows living in rural (white) and suburban (grey) habitats in Hungary in 2009 and 2010. The number of (a) nestlings and (b) nests are shown in each graph

Despite the large differences between free-living suburban and rural populations of the same site, sparrows given ad libitum food of varying composition performed identically in all breeding parameters.

Thus, urbanization may reduce the amount and variety of high-quality nestling food like arthropods, which may explain certain urban passerine birds' reduced reproductive success and smaller nestlings. While quantitative data on arthropod taxa densities and diversities is scarce, elevated pollutant levels, higher pavement cover, increased pesticide use in residential gardens and park areas, strong shrub layer thinning, mown turf, and leaf litter removal in green spaces, and high exotic plant populations may reduce their presence in urban areas. A recent research on two parid species' feeding preferences in a diverse urban green patch highlighted tree patches and native plant taxa. Blue tits foraged more on native plants than exotics and deciduous over evergreens, however this selectivity decreased during nestling rearing, perhaps owing to time constraints. Great tit parents favored native deciduous plants to evergreens before hatching but non-natives thereafter. Both species prefer larger deciduous trees, which may boost arthropod diversity.

Many insectivorous birds cannot obtain aphids or other tiny arthropod groups due to urbanization (Raupp et al. 2010). Smaller arthropods within a species in urban and polluted regions may alter nestling food value. A research on chick-feeding behavior of the same species suggests that suburban nestlings eat less caterpillars and orthopterans because their parents offer less big food items. Big prey items are the best nestling food since their delivery rate predicts fledging mass and recruitment. Schwagmeyer and Mock (2008) found that a large invertebrate prey item (>2 cm) had 30-40 times the dry weight of a small one (< 0.6 cm), suggesting its greater value. It is uncertain if a huge prey item is preferable because it supplies a disproportionately higher quantity of nutrients or because it represents nutritionally valuable species

Predation pressure restricts populations, causing top-down control. Complex human-influenced systems manage urban food web consumer-based pressures. Top-down factors may affect urban bird community dynamics, although their effects are less known than bottom-up ones. Because urban birds fear people less and their natural predators are few, the predation-relaxation or safe-zone theory claims that urban environments have less predation pressure. The greater biomass of urban bird prey species may be attributed to relaxed predation.

Due to lower predation, urban prey species survive better than rural ones. This is indirect since better food, a friendlier environment, and decreased migration may boost survival. Thus, using survival rates to estimate predation pressure does not disclose background processes. You might also track prey species' antipredator behavior over urbanization. Flight initiation distance is used to estimate prey's perceived predation hazard. High-risk birds flush sooner and escape

more from predation in diverse situations. Urban areas sometimes have shorter FIDs for the same species, particularly for sensitive raptor species. FID is usually measured as a reaction to approaching humans, but it is also used to measure birds' predation perception. Most urban people do not kill or persecute birds, therefore this may be untrue if birds consider humans more hazardous than sparrowhawks, cats, or other predators. Although fearlessness towards artificial disruptions may benefit urban habitats, it may not be an evolved response to predators. FID may not accurately assess predation risk. More study is required. Despite this, FID studies provide a way to reduce urban bird predation. Humans in cities may provide predator-free areas for smaller prey species, since larger predators have higher FIDs.

Contrary to the predation-relaxation assumption, urban environments often have higher abundances of potential predators such as corvids and mammalian, omnivorous mesopredators. A rising number of monitoring studies show that many predatory animals can adapt to and benefit from human-modified settings and have boosted their urban populations. Non-native mesopredators like the Domestic Cat *Felis catus* may also achieve large concentrations in cities, much exceeding their ecological carrying capability. These predators are most abundant in urban habitats, where their avian prey species also thrive, contradicting top-down control predictions. This predation paradox appears to be widespread in urban habitats. This contradiction calls into doubt top-down regulation of urban bird populations.

Many considerations make assessing this conundrum difficult. First, various predators prey on nests and fledged youngsters and adults. Raptors feed on adult birds, whereas feral mammalian mesopredators and corvids prey on eggs and nestlings. Predators' responses to urban areas are complicated. Like prey species, urbanization favors generalists over specialists, hence their numbers are expected to alter differentially along the urbanization gradient. In urban settings without susceptible apex-predator species, mesopredators may be released, thereby boosting nest and fledged bird predation. Large-bodied carnivores and snakes seem to suffer from urbanization, while generalist bird and omnivorous mammal predators thrive in urban areas, especially introduced predators. Despite their high densities, it is unclear if these prospective predators operate as predators or depend on conveniently available food sources like waste or pet food. If omnivorous predators eat other foods instead of hunting, predation rates are lower than expected given predator abundance. Some corvid findings support this idea. Despite their abundance in cities, correlative studies based on common bird census data in Britain found no negative relationships between nest predator densities and their preys and avian densities or species richness. The common nest-predator Black-billed Magpies *Pica pica* were removed from suburban parks in Paris, however the ten observed songbird species did not increase. To test nest predator effect, fake nests are most often used.

Although several articles have been published, the conclusions are inconsistent, leaving the link between habitat urbanization and nest predation rates unclear. In a decade-long monitoring study of over 1,000 natural nests in forest sections along the urban gradient, the authors discovered no consistent association between urbanization and daily nest survival rates. Although urbanization and the presence of several mesopredator species were positively connected, nest predation rates were related to predator concentrations in rural environments, not urban forest patches. In conclusion, certain predators' reliance on anthropogenic food sources may weaken trophic linkages between predators and prey, which may reduce predation pressure due to drastically increased prey numbers. Urban bird groups may also include more species with good nest defense mechanisms against urban-adapted predatory species, making them less prone to nest predation.

Abundant alternative food supplies may decouple prey-predator relationships, yet urbanizing raptors seldom eat human garbage or subsidized food. Raptor species' responses to urbanization may shift swiftly, notwithstanding their prior neglect as city predators: The Eurasian Sparrowhawk *Accipiter nisus*, the Northern Goshawk *Accipiter gentilis*, the Eurasian Kestrel *Falco tinnunculus*, and the Merlin *Falco columbarius* have recently established breeding populations in cities. The Eurasian Sparrowhawk, a major predator of smaller songbirds, is increasing in urbanized habitats, reaching high densities in Hamburg and Prague. Since the early 1980s, sparrowhawks have bred in Budapest, Hungary, and in 2007, 200 pairs were estimated, which surpasses the breeding population in many natural environments. Winter sparrowhawk hunting in Budapest is estimated at 500–600. A recent research put the Eurasian Kestrel's breeding density in Vienna at 89–122 breeding pairs/100 km², greatest in the city center. If raptors adapt to city prey species, such a high predator-prey ratio may increase predation risk. Urban kestrels consume more avian prey due to the lower availability of diurnal rodents in heavily urbanized areas, but nocturnal raptors like the Tawny Owl *Strix aluco* also take more bird prey in urban areas. The fact that several studies reveal growing breeding populations of different raptor

species in urban contexts suggests that their population-regulatory function should not be discounted. A British research indicated that sparrowhawk numbers recovered and colonized urban habitats following the DDT prohibition, which coincided with the collapse of house sparrow populations. Accordingly, an experimental investigation found that urbanization affects a common prey species' predation pressure. By altering predation risk, the authors showed that urban house sparrows reacted more strongly to simulated Sparrowhawk assaults than rural birds and that urban sparrows' fearfulness increased with age. These findings challenge the idea that cities reduce predation risk for Sparrowhawks and reflect distinct lifetime experiences with raptors in their native habitat.

Finally, we must include the do-mestic cat, a particular predator found in most metropolitan settings. Cats mostly threaten fledged birds, particularly youngsters, although they also prey on urban nests. Cat predation is one of the main human-related causes of bird mortality because this species lives in urban areas at high densities compared to any native predator and hunts wild species even when subsidized. Experimental manipulation of cat density in the urban matrix is complex, making it impossible to prove or disprove their influence on prey species population size. A common way to measure cats' predation rates is to ask cat owners how many prey their pets return. Converting this statistics to real and typical predation rates is further difficult since prey returning rates vary by cat, season, and owner. A new US article shows another key limitation of this strategy. This research used cat-borne video cameras to observe domestic cats' activities and found that just 23% of their prey items were brought home, implying that earlier studies based on cat owners' surveys greatly overestimated free-ranging cats' predation rates. Whether this proportion is only the doomed surplus of prey populations and cats are causing only compensatory mortality or cat-posed mortality significantly contributes to species population loss is unknown.

Cats' visible parental nest protection behavior lowered pa- rental provisioning and increased nest predation, according to Bonnington et al. (2013). Once again, Domestic Cats harm urban avifauna species. A large-scale British correlative study found no negative correlation between urban bird and cat densities. Different bird species reacted differently. We found negative relationships between avian species richness and cat density, especially in vulnerable bird groups like small-bodied, ground-foraging birds. Cats' long-term and pervasive presence and the lack of negative correlations between predator and prey densities may suggest that urban avifauna contains a subset of species that can withstand cat predation.

II. CONCLUSION

This review shows that habitat urbanization impacts bird populations in several ways. As said, food supplies and predation danger might complicate urban bird life. In the recent decade, several case studies have been done, but their conclusions are occasionally conflicting, showing that urban avian community ecological dynamics are still poorly understood. We finish by discussing our biggest knowledge gaps and future research directions. A major problem is literature biases in model species and locations. Many studies have focused on sparrows, tits, and the Eurasian Blackbird. How applicable are these findings to other bird species? Urban Silver Gull *Larus novaehollandiae* males had 10% more bulk and bodily condition than non-urbanized island males. This implies that same urban environmental elements may impact animals differently. Research was mostly done in Europe or North America due to regional bias, reducing generalizability. The most heavily affected core areas of cities have minimal data, therefore we know little about this urbanization gradient section. Further limiting our knowledge of urban ecological dynamics because although bottom-up control seems to depict a more or less universal urban landscape pattern, top-down control may be location-specific. Many factors can affect predators' response to habitat-urbanization and their top-down regulatory role, including species composition of the native predator fauna, predators' timing of establishing urban populations, urban landscape development, availability of resources, and human attitudes toward certain predator species. These factors vary by location, affecting urban predators and prey. This variance may make it difficult to discern a large-scale urban gradient predation pressure trend. Rethinking existing, apparently simple notions requires further study on various species from varied temperate zones and urban gradients.

The Domestic Cat, the most prevalent urban predator, has a contradictory role that requires more investigation. Cats' diet components, predation rates, and prey species' availability, density, and population size should be monitored to identify susceptible wild species and their characteristics and determine if this predator's mortality limits city populations. Along with direct mortality, predators' sub-lethal effects on prey populations must be addressed. In high-

predator regions, predators' non-lethal impacts may exceed killing. More research on these small consequences may help explain predators' urban regulation. Descriptive studies on urban passerines' dietary components during chick-rearing may help us estimate their anthropogenic food dependence for bottom-up regulation. Prioritize experimental research too. Control food availability at sites with different levels of habitat urbanization and observe birds' responses to assess this force.

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