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A Review on Behavioral Characteristics and Challenges Posed to the Survival of House Sparrows (*Passer domesticus*)

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Abstract: House sparrow (*Passer domesticus*) belongs to family Passeridae and order Passeriformes. They live in a diverse range of habitats, such as forests, grasslands, agricultural land, villages and towns, alongside they also have adapted to urban areas, including metropolitan cities. House sparrows play an important role in the ecosystem and carries substantial educational, recreational and aesthetic value. They have effectively lived together with humans because of their flexible dietary habits and rapid migration throughout urban areas, which is facilitated by their use of discarded food sources. Throughout its breeding cycle, the house sparrow, a sociable avian species, frequently forms pairs and produces loud voices. They mostly consume seeds and also ingest fruits, flower buds, kitchen scraps, weeds and insects. House sparrows adjust their foraging times and morning departures to meet their food requirements. The house sparrows normally establish large communal roosts; their preferred communal roosting sites are densely foliaged shrubs, plants and trees. The primary determinants of roosting places are tree height and foliage density rather than tree species. House sparrows exhibit seasonal variations in their roosting population, featuring an especially significant rise during the breeding season. House sparrows can form hetero-specific communal roosts with different bird species. House sparrows begin vocalizing around 30 min before dawn and usually leave the roost within 30 min of sunrise. Their nests are found in a variety of locations, including holes and crevices in human-made structures, the tops of telegraph poles, electric pipelines, ventilation holes, space available on electricity meters, nest boxes, or among creepers on walls, as well as dense shrubbery or trees. Generally, house sparrows construct cup-shaped nests and are sometimes inaccessible to predators. They utilize a wide variety of nesting materials, including fine twigs of plants, grasses, stems, roots, plant barks, cotton and plastic threads, human and other animal hairs. Male and female both are involved in the incubation of eggs and rearing of hatchlings, nestlings and fledglings of house sparrows. The overall survival of house sparrows is influenced by modern structure of buildings, use of pesticides and insecticides, expansion of urbanization, industrialization, shortage of foraging sites, food materials, suitable nesting sites, predation by natural predators, domestic cats and infection through various types of ecto and endoparasites.

Keywords: House sparrow, Habitat, Food, Roost, Nest, Predation, Survival

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Introduction

Passer domesticus, also known as the house sparrow, belongs to the order Passeriformes and the family Passeridae. Its global distribution spans almost all continents and encompasses a wide variety of ecosystems and habitats, including forests, grasslands, agricultural areas, desert zones and even urban contexts, including large cities (Chishty *et al.*, 2021; Choudhary and Chishty, 2022a, 2024a). House sparrow plays a crucial role in maintaining the equilibrium of ecosystems and possesses significant educational, recreational, economic and aesthetic worth. Many of our mythologies and folklore mention house sparrow, along with other birds like the common crow, eagles, cranes, vultures, peacocks and others. These birds were known to inhabit areas near human settlements (Ghosh *et al.*, 2010; Choudhary and Chishty, 2022a). House sparrows live in both rural and urban environments on a global scale. The ability of house sparrows to adapt to a variety of habitats and environments accounts for their widespread existence. According to Anderson (2006), Choudhary *et al.* (2021) and Choudhary and Chishty (2022a), house sparrows have become a prevalent bird species in various human settlement areas such as villages, towns, cities and metropolitan areas. House sparrows have successfully colonized urban settings, with flocks of sparrows frequently observed in gardens, commercial places, highways, parks and residential structures. According to Khera *et al.* (2009), house sparrows have been living with humans for a long time, providing valuable insights into habitat ecology. Urban contexts regard house sparrows as extremely adaptive, demonstrating versatility in response to varied forms and regular changes (Choudhary *et al.*, 2021; Choudhary and Chishty, 2022a). The present review study focused in detail on the various behavioral aspects and threats to the survival of house sparrow (*Passer domesticus*). A present review study attends following aspects: (1) Taxonomy, population distribution and adaptations of house sparrow; (2) Habitat, food and feeding habits and ecology; (3) Roosting, nesting and breeding; and (4) Threat to the survival of house sparrow.

Taxonomy, population, distribution and adaptation of house sparrow

Taxonomic classification: Kingdom: Animalia; Phylum: Chordata; Subphylum: Vertebrata; Class: Aves; Order: Passeriformes; Family: Passeridae; Genus: *Passer*; Species: *domesticus*; Common name: House sparrow (English), Chidiya (Hindi), Chaki or Chakli (Gujarati) (BirdLife International, 2024).

Population status and distribution: Rich *et al.* (2004) estimated the global population to be over 540,000,000 individuals of house sparrow. Nevertheless, the estimated European population ranges from 134,000,000 to 196,000,000 pairs, resulting in 269,000,000 to 392,000,000 adult individuals (BirdLife International, 2015). The European region accounts for around 30% of the world's population, resulting in a preliminary estimate of the global population size ranging from 896,000,000 to 1,310,000,000 mature individuals (BirdLife International, 2024). However, further confirmation of this estimate is necessary. Estimates indicate that the national population estimates in China and Russia range from approximately 100,000 breeding pairs (Brazil, 2009; BirdLife International, 2024). Population of house sparrow exhibits slight decrease in European region during 1980 to 2013 (EBCC, 2015). House sparrows possess a remarkable ability to adapt to human-occupied environments. Owing to their rapid introduction to many islands and continents, they have become one of the most widely distributed bird species (Smith, 2003, 2005). House sparrows have successfully coexisted with humans due to their adaptable feeding habits and ability to quickly migrate across cities by using discarded food sources (Lowther and Cink, 1992). Despite their adaptability and familiarity with urban settlements, house sparrow populations have been rapidly falling worldwide since 1980, including America (Erskine, 2005) and India (Gosh *et al.*,

2010).

Habitat, food and feeding ecology

House sparrows play a crucial role in maintaining the diversity of species and the bird population in urban environments. Owing to its strong affinity with humans and remarkable adaptability, this species has thrived in urban environments (Smith, 1963). House sparrows inhabit both rural and urban human habitats. The species, known as an urban specialist due to its presence in urban areas, has shown remarkable adaptability to a variety of environments. House sparrows are gregarious birds that are frequently observed in pairs during their breeding periods, emitting loud vocalizations. They have been present with humans in all types of human dwellings, including towns, villages, solitary homes, and other types of habitats. House sparrows are commonly known as seed eaters, although they also consume fruits, flower buds, kitchen scraps, weeds and insects (Wakely, 1986; Wilson *et al.,* 1996; Gavett and Choudhary *et al.*, 2021). Most of the time, nestlings feed on insects and caterpillars (Choudhary and Chishty, 2022a). The sparrows were able to rapidly proliferate in the areas surrounding agricultural fields due to their close association with the farmers. Compared to natural environments, urban regions show a reduction in the diversity of avian species. The urban habitat is a combination of built-up areas and green spaces, creating a challenging environment for avian species to establish permanent residence. Only certain species of birds can survive in areas with limited vegetation, such as commercial and industrial zones in urban centers. These conditions are only beneficial for specific bird species that can build nests in walls, such as feral pigeons, swallows, swifts and house sparrow (Sandstrom *et al.*, 2006; Choudhary and Chishty, 2022a, 2024a). House sparrow is diurnal, meaning it feeds during the day and stores a significant amount of energy to support thermoregulation and other metabolic activities at night. House sparrows appear to adapt their daily pattern and preferences based on numerous factors related to food predictability, such as the availability of food, the average daily supply and their energy requirements according to their current habitat and the risk of predation. House sparrows adjust their foraging times and morning departures to meet their feeding needs. According to Godfrey and Bryant (2000), birds expend more energy on thermoregulation and maintaining their body temperature during nights with low temperatures. Therefore, the timing of morning departures is influenced by the energy expended in thermoregulation overnight and the time at which a bird starts to search for food.

In rural areas, house sparrows forage and feed on seeds of cultivated grain crops such as grains, wheat, barley, corn and maize. Annual herb seeds from grasses (Graminae), rushes (Juncidae), goosefoot (Chenopodium), docks (Polygonacaea) and chickweed (*Stellaria* spp.) are also a significant food source. Birds living in densely populated regions supplement their natural vegetable diet with a range of domestic trash that humans purposefully discard. House sparrows, known for their use of garden feeders, consistently emerged as the most common species in London throughout the year. Nestlings, on the other hand, eat virtually solely insects and other invertebrates (both larval and adult), with the prey species changing depending on the season. Aphids (Aphidoidea), spiders (Arachnida), beetles (Coleoptera), weevils (Curculionidae), grasshoppers (Orthoptera) and caterpillars (Lepidoptera) are the most significant taxa (Wilson *et al.*, 1999). House sparrows, like many other bird species, undergo dietary changes as they grow. Adult house sparrows are largely granivorous, but nestlings feed on insects for the first three days before transitioning to plant food (Anderson, 2006). Alena *et al.* (2011) conducted a study in the Czech Republic on the condition of nestling house sparrows in terms of meal composition and total food consumption. Beetles (mainly Scarabeidae) and Diptera (particularly muscids and tipulids) were the nestlings' primary food sources. The amount of food found in feces samples increased with nestling age. An increase

in total plant mass caused this increase, while the total animal mass remained constant with nestling age. The body condition of older nestlings was positively correlated with the total amount of food and the mass of animal components in their diet.

According to Vincent (2005), the population of invertebrate prey within house sparrow breeding ranges in suburban and rural garden settings minimizes the number and quality of fledgling chicks. In suburban areas, the combined impacts of relatively high rates of chick hunger and low body weights at fledgling (and thus low post-fledlging survival) are sufficient to produce rapid population decreases. The availability of adequate habitat, such as native deciduous vegetation, trees, and grassland, is likely to influence invertebrate populations in suburban settings. Although there is little indication that essential invertebrate prey populations have reduced in urban-suburban settings, such losses could explain the observed declines in urban-suburban house sparrow populations. Anderson (1984) examined the overlap in nestling diets of village populations of house sparrows and found that Coleoptera, Dipteran and Lepidoptera were the most often detected in these nestling diets. Wieloch (1975) examined the diets of house sparrow nestlings (*Passer domesticus*) and tree sparrows (*Passer montanus*) in Ukraine's, starting with the day the chick hatches from the egg. He observed that the chicks primarily consumed insects, but as they matured, they started incorporating vegetable matter into their diet.

Roosting, Nesting and breeding behavior

Selection of roost sites was found to be influenced by a variety of factors, including predation, microclimate, ectoparasitism and interspecies and intra-species competition. In a study of crepuscular birds, it was found that camouflage at roost sites was a critical factor in the selection of roost sites. This is due to the fact that these birds rely on cryptic plumage to defend themselves from predators by avoiding detection (Holyoak, 2001). Several avian species from various orders and families, with a wide range of behaviors and habitats, gather together to roost for at least a portion of the year (Ali and Ripley, 1983 a, b). Roosting refers to the act of birds settling down to rest or sleep, typically throughout the night. Nocturnal birds may also engage in roosting during the daytime. Various types of roosting behavior can be observed in different bird species. Some birds are naturally solitary, preferring to engage in activities such as feeding and roosting alone. House sparrows form enormous communal roosts. They like densely foliaged bushes, plants, and trees for communal roosting. Tree height and foliage density, not tree species, primarily determine the roosting sites (North, 1968). When deciduous trees' foliage density decreases, they change their roosting spots. There are seasonal changes in the roosting population of house sparrows, with a significant increase during the breeding season. House sparrows can form hetero-specific communal roosts with different bird species (Anderson, 2006). Community roosts can provide people with important information, House sparrow arrives at its roosting site two hours before nightfall. From the time the first birds arrive at their roosting sites until well after sunset, they engage in communal vocalization. Only an alarm signal interrupts this continuous tweeting; in the absence of an urgent threat, it resumes shortly. House sparrows begin vocalizing around 30 min before dawn and usually leave the roost within 30 min of sunrise (North, 1968). The importance of communal roosting in house sparrows is not widely understood. However, communal roosts may serve as a key hub for the exchange of information regarding optimal feeding areas and avian mating status throughout the breeding season (Anderson, 1990, 2006).

Breeding period varies with latitude. The bird breeds mostly between March and June in north India, till September or October in central India and all year in southern India (Jansen, 1983; Choudhary and Chishty, 2022a, 2024a). A young male with a nest site may find a mate soon. However, the couples formed are only permanent after successfully rearing a brood in the nest

(Smith, 1958). During the mating season, a male may approach a new mate if his current mate refuses to lay another clutch while the male is still in reproductive condition (Smith, 1958). During pair formation, display is shaped like an expanded and overblown version of the advertisement call, indicating possession of a nest site (Smith, 1958). Nest building occurs intensively between February and May (Vincent, 2005). House sparrow nests are found in a variety of locations, including holes and crevices in human-made structures, the tops of telegraph poles, electric pipelines, ventilation holes, space available on electricity meters, nest boxes, or among creepers on walls, as well as dense shrubbery or trees (Smith, 1958; Lowther and Cink, 1992; Choudhary and Chishty, 2022a, 2024a). Unmated females prefer enclosed nest locations over open nest sites, with few exceptions where appropriate cavities are limited (Cink, 1976; Smith, 2003, 2005). House sparrows breed earlier and produce more successful broods at enclosed protective nest locations than when nesting in open areas such as tree branches (McGillivray, 1980, 1981).

Male and female parents nourish their nestlings equally (Smith, 2003, 2005). Parents continue to feed their offspring for another 10 to 14 days until they achieve nutritional independence (Smith, 2003, 2005). House sparrows can often raise two or three broods every year (Vincent, 2005). The complete cycle of nest occupation, from egg-laying to young fledging, takes 28-31 days, with a 36-40 day break between succeeding clutches (Seel, 1968; Smith, 2003, 2005). At approximately 24 h intervals, house sparrows deposit their eggs. Incubation encompasses both reproductive male and females (Seel, 1968). The incubation period is the duration from the placement of the last eggs in the clutch to the hatching of the first offspring (Seel, 1968). The incubation period's duration is determined by the ambient temperature (Singer and Yom-Tov, 1988). The incubation period ranges from 10 to 17 days, with an average duration of 11 to 12 days (Singer and Yom-Tov, 1988; Lowther and Cink, 1992). The nests of house sparrows are constructed using a diverse range of materials such as feathers, grass inflorescences, plant bark and roots, threads, wool and paper (Indykiewicz, 1991; Choudhary *et al.*, 2021; Choudhary and Chishty, 2022a, 2024a). Nests can range from a basic cup of vegetation at the bottom of nest boxes to a substantial nest that extends across the whole chamber with just a little opening at the entrance (Lowther and Cink, 1992; Choudhary and Chishty, 2022a, 2024a). Mature birds typically engage in reproduction at an earlier stage of the season. The normal clutch size in India varies from one to seven eggs, with four being the most prevalent number (Naik and Mistry, 1972; Naik, 1974; Choudhary and Chishty, 2022a, 2024a). The eggs exhibit a color range from white to greenish or bluish-white with brown spots. The final egg that is laid usually has less pronounced markings (Novotny, 1970; Lowther and Cink, 1992; Choudhary *et al.,* 2021). Male house sparrows produce vocalizations, known as chirps, throughout the breeding season in order to attract females. These chirps increase in volume as the female approaches the nests. In their study, Mathew and Naik (1998) examined the reproductive behavior of house sparrows. They found that breeding patterns in rural settings were highly structured and consistent, in contrast to the more irregular and disrupted breeding observed in urban areas. Additionally, it was noted that the breeding concluded earlier in rural areas. The study also evaluated clutch size, finding no significant impact of habitat on clutch size. However, it was observed that the number of clutches laid in the nest box was greater in rural locations compared to urban areas. Magnussen and Jensen (2010) investigated the reproductive biology of the wild house sparrows. Their findings are based on the ringing of nestlings just prior to their fledgling. The study aimed to estimate the reproduction output by analyzing the means of dates and numbers. The study's findings revealed that the first, second, and third clutches of eggs typically deposit at the beginning of May, the middle of June, and the beginning of July, respectively. House sparrows often build their

nests in enclosed natural cavities that are inaccessible to nest predators such as domestic cats and corvids (Smith, 2003; Vincent, 2005; Weir, 2015; Choudhary *et al.*, 2021; Choudhary and Chishty, 2022, 2024a). However, they may prey on fledglings. Inter-specific competition between house sparrows and other bird species arises as a result of overlapping use of resources such as food and nesting sites.

Threat for house sparrow survival

Avian species are sensitive to changes in landscape shape, structure and use, making them strong indicators of urbanization's impact. Urbanization has both direct and indirect effects on birds (Marzluff, 1997). As metropolitan areas and transportation networks grow, they fragment and diminish bird habitats, while changes in farming methods, agricultural practices and pesticide and insecticide use have an impact on food supplies. It alters ecosystem processes, both directly and indirectly and impacts both avian habitat and food supply chains. Changes in bird population dynamics have an impact on the avian community in a particular area (Choudhary and Chishty, 2023). Mitschke *et al.* (2000), Hole *et al.* (2002) and Smith (2003) attribute the decline of house and tree sparrows to intensified agricultural practices, building designs that prevent nesting and changes in food supply. However, the decrease in house sparrows can be more complex (Shaw *et al.,* 2008). They suggest that factors such as urban design, housing density, urban greenery, nesting availability and human socioeconomic level are all relevant. MacLeod *et al.* (2006) describe the possibility of increased predation, as well as behavioral changes, as a key factor contributing to the reduction of house sparrows in urban regions of Britain. A scarcity of weed seeds, increased agricultural practices such as the rapid use of insecticides and competition with other living organisms are all possible causes of house sparrow decline (Rajashekar and Venkatesha, 2008; Daniels, 2008; Khera *et al.*, 2009; Ghosh *et al.*, 2010; Bhattacharya *et al.*, 2011). Manoj *et al.* (2012) proposed a number of potential causes for this detrimental pattern, including insufficient food availability, a scarcity of suitable nesting sites, increased predation and increased competition, all of which are contributing to the dramatic decline in house sparrow populations. This was due to a lack of food and shelter in stables, as well as the indirect consequence of losing dung-dwelling invertebrates. However, the continued urbanization process and emphasis on agricultural output created major opportunities for more colonization and an increase in the overall population across the country (Holloway, 1996).

Birds, including house sparrows, frequently die due to collisions with artificial structures and automobiles, poisoning and predation by household pets, including domestic cats and feral dogs (Choudhary *et al.*, 2021; Choudhary and Chishty, 2022b, 2024b, c). House sparrows face less predation pressure than other open-nesting species. Therefore, other factors, like the availability of food for the parents, are more likely to influence mortality during the nesting stage (Dyer *et al.,* 1977). Lack (1954) posited that mortality variables impacted by population density, such as food scarcity, predation, parasitism and disease, must limit the size of the species' early populations. However, Lack (1954) proposed that food shortage was the fundamental constraint on the populations of many bird species, particularly in terms of reproductive rate. Food scarcity can have a direct influence on individuals, resulting in reproductive failure (Newton, 1998). House sparrows are susceptible to a variety of endoparasites, including protozoans that cause avian malaria, toxoplasmosis and coccidiosis. They can also be infected by Platyhelminthes and nematodes, which are primarily intestinal parasites. But the impact of these disease-causing parasites on house sparrow populations is little understood (Anderson, 2006). House sparrows commonly carry ectoparasites such as mites and ticks (Acari), feather lice (Mallophaga) and fleas (Siphonantera) (Cyprich *et*

al., 2002; Anderson, 2006). Enterobacteriaceae, Micrococcaceae, Streptococcaceae, Bacillaceae and Cryptococcaceae were some of the pathogens and fungi that were found in 67% of house sparrow eggs in Poland (Kozlowski *et al.,* 1991a, b). Destruction of embryos at the age of one day revealed a high incidence of illnesses, predominantly attributed to *Escherichia coli*. Hence, the existence of microbial infection in avian species can be a substantial determinant of mortality among hatchlings and nestlings (Pinowski *et al.*, 1994). Pennycott *et al.* (2002) found that *Salmonella typhimurium*, a well-known bacterial strain, could be responsible for increased mortality rates in garden birds that forage and feed communally. Free-living wild house sparrows frequently contract salmonellosis, a viral infection, during the winter and spring (Wilson and MacDonald, 1967; Macdonald, 1978). According to Singh *et al.* (2013) other major causes of house sparrow decline include a lack of animal feed during the early stages of nestling development and intense competition for nesting sites from birds such as common myna, red-rumped swallow and others. In urban areas, the house sparrow competes with other birds for nesting sites. Due to their small size and lack of aggression, house sparrows often have to relinquish their breeding spots to other birds. One possible explanation for the fall in house sparrow populations is a lack of suitable nesting sites in modern or rebuilt structures. Modern homes increasingly use plastic boards, curved tiles, or roofing sheets to deter birds. House sparrows primarily live in cavities with a crack in soffit boards and beneath tiles, which may affect the availability of nesting sites (Vincent, 2005; Choudhary *et al.,* 2021; Choudhary and Chishty, 2022a, 2024b). Singh *et al.* (2013) found that the shortage of nesting sites in modern houses and building structures, as well as the decrease in the number of mud dwellings, contribute to the decline of house sparrows in a particular area. Metropolitan areas are essentially removing prickly shrubs and trees under 7 feet, which house sparrows prefer as roosting sites. A notable determinant that may have an adverse effect on house sparrows is a decrease in the accessibility of invertebrate prey, which is essential for feeding nestlings during their initial developmental phases. The decrease in plant diversity in fields supported by weed-free crops, the expansion of cultivated land through the plowing of headlands, and the increased use of pesticides and herbicides have led to a reduction in the population of arthropods in rural regions. This phenomenon is attributable to both the direct damaging effects of pesticides on invertebrates and the depletion of food plants. Enhanced hygienic standards in gardens and the inclination for more organized landscaping of garden areas may lead to a possible decrease in arthropod populations in urban environments (Donald, 1998). Two major factors contribute to the fall in invertebrate prey: the direct impact of increased pesticide use and effectiveness and the indirect influence of the loss of native plant species in agricultural settings. House sparrows typically breed two or three times per year. Multi-brooded species nestlings need a steady supply of invertebrate food to nurture their progeny over the course of a long breeding season. They are likely to rely on a variety of invertebrates, each with its own restricted and distinct availability times. The simplification of farming systems, as well as the loss of habitat diversity, may have reduced farmed landscapes' ability to continuously provide invertebrate food resources throughout the breeding season (Anderson, 1984). House sparrow breeding success impacts the decline of arthropods and other invertebrates in a particular location. Arthropods and other invertebrates become debilitated due to a lack of availability, which has a negative impact on their reproductive performance (Alena *et al.,* 2011). There is a scarcity of food, specifically aphids that adults feed to their young, pollution from vehicles using unleaded fuel, increased predation by domestic cats or sparrow hawks (*Accipiter nisus*), cleaner streets resulting in fewer opportunities for foraging, competition for food from other avian species and loss of nesting sites, particularly beneath house roofs. Finally, if a

colony's size falls below a critical threshold, it may have a detrimental impact on breeding behavior, resulting in decreased breeding and colony death (Smith, 2003).

Ethical Statement

This is a review article hence no Ethical Approval needed.

Author Contributions

Each author has contributed equally to the study's planning, writing, and editing. All authors have read and agreed to the published version of the manuscript.

Conflict of Interest

The authors declare no conflicts of interest.

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