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Factors influencing reproductive success of House Sparrow (*Passer domesticus*), A study with reference to open nests at Jangareddigudem urban, India

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Abstract

House Sparrow is a widely distributed man-follower bird. This passerine bird is a secondary cavity-nesting bird. This species is habituated to live in human settlements, and confined to make nests in human habitations in available cavities, especially on the roofs of thatched and tiled roofed houses. Replacement of such traditional houses with RCC buildings leads to the unavailability of nesting sites causing the decline of the House Sparrow population. Our current study is aimed to observe the nesting behavior and breeding success in Open nests in the study area, Jangareddigudem. We observed and studied the influence of various factors on the breeding success of House Sparrows *viz*., the direction of the Open nest, height at which the nest is placed from the ground, location of the nest from the roof edge, location from vegetation, and light illumination at the nest. We have applied Chi-square tests to study the effect of said factors on the clutch size, hatching success, fledging success, and as a whole overall breeding success. The most influencing factors on the overall breeding success of House Sparrows were found to be the light illumination followed by direction, then far/depth from the roof edge, then vegetation, and finally height at which the nest is made from the ground. With respect to individual reproductive parameters, clutch size was found to be influenced by light illumination, and both hatching and fledging success were found to be influenced by the height of the nests from the ground.

Keywords: House sparrow, Chi-square test, open nests, reproductive success

Introduction

House Sparrow (*Passer domesticus*) was a widely distributed tiny bird in and around human habitations (Ali, 1996). A gradual and massive decline of House Sparrow was noticed globally after the 1990s (Summers-Smith, 2003; Irfan and Chauhan, 2018). A marked decline in bird species in most places in India was also reported (Modak, 2015). The Survey by the Indian Council of Agricultural Research (2012) reported about an 80% decline rate of this small bird in Andhra Pradesh (Hussain *et al*., 2016). Recent studies by Berigan et al. (2020) reported that the House Sparrow population is still under decline trend. Changes in the house design and crop harvesting pattern are the main factors for its population decline (Chamberlein *et al.,* 2007; Robinson *et al.,* 2005).

House Sparrow is a secondary cavity-nesting bird. Nest site selections by birds involve several interdependent factors, which include the availability of food, free from predators for egg and nestling security, and light illumination (Atlanto *et al.,* 1985). They often choose secured nesting sites (Indykiewicz, 1991). The correlative factors that determine the nest site choice by House Sparrow are the situation of the niche, exposure of the nest site, nesting materials, and nesting height with relevant to spatial conditions (Indykiewicz, 1990). Light illumination stimulates the growth rate of the avian embryo and also has a positive effect on various physiological functions (Maurer *et al*., 2011). In general, the sparrows build nests in available places like crevices of tiled roofs, and thatched houses, and in rare cases, they also make nests in bushes (Mahesh and Suseela, 2022). The replacement of thatched houses and tile-roofed houses with RCC buildings resulted in a sudden change in the human habitat, ultimately affecting the available nesting sites in and around human settlements, both in urban and rural areas (Mahesh and Suseela, 2021).

Urbanization is one of the hurdles to getting nesting sites, which resulted in migration or adaptability of urban birds to cope-up with new conditions. The passerines exhibit a high degree of conservational attitude in their nesting behavior (Choudhary *et al.,* 2020). Non-availability of nesting sites in roofs and crevices made them choose open places in the RCC buildings for making nests. We have noticed the nests (hereafter referred to as ‘Open nests’) in the corners of L-bends of sanitary pipes (Fig.1a), ventilators, false roofing (if cavities are available), broken lamps, behind Air conditioner compressors (Fig. 1b), top cups of ceiling fans, behind photo-frames etc.

We have started the conservation activity of House Sparrow in Jangareddigudem urban by providing nest boxes. As a part of our conservation studies, we have examined the Open nests for

various factors *viz*., the direction of the Open nest, height at which the nest is placed from the ground, location of the nest from the roof edge i.e. far or depth from the roof edge, location from vegetation, and light illumination at the nest. In the present paper, we have studied the influence of above said parameters on the breeding success of House Sparrow at Open nests, and the significance of these factors on breeding success was tested by applying Chi-square tests. The following are the hypotheses framed to find out the statistical significance.

Hypothesis

$H_{o1:}$ There is no significant relation between the clutch size of the House Sparrow and the Open Nest site location parameters such as the direction of the Open nest, Height at which the nest was made from the ground, far or depth of the nest from the roof edge, nest location from vegetation, and light illumination at the nest.

$H_{a1:}$ There is a significant relation between the clutch size of the House Sparrow and the Open Nest site location parameters such as the direction of the Open nest, the Height at which the nest was made from the ground, far or depth of the nest from the roof edge, nest location from vegetation, and light illumination at the nest.

$H_{o2:}$ There is no significant relation between the hatching success of the House Sparrow and the Open Nest site location parameters such as the direction of the Open nest, Height at which the nest was made from the ground, far or depth of the nest from the roof edge, nest location from vegetation, and light illumination at the nest.

$H_{a2:}$ There is a significant relation between the hatching success of the House Sparrow and the Open Nest site location parameters such as the direction of the Open nest, the Height at which the nest was made from the ground, far or depth of the nest from the roof edge, nest location from vegetation, and light illumination at the nest.

$H_{o3:}$ There is no significant relation between the fledging success of the House Sparrow and the Open Nest site location parameters such as the direction of the Open nest, Height at which the nest was made from the ground, far or depth of the nest from the roof edge, nest location from vegetation, and light illumination at the nest.

$H_{a3:}$ There is a significant relation between the fledging success of the House Sparrow and the Open Nest site location parameters such as the direction of the Open nest, the Height at which the

nest was made from the ground, far or depth of the nest from the roof edge, nest location from vegetation, and light illumination at the nest.

$H_{o4:}$ There is no significant relation between the overall breeding success of House Sparrows and the Open Nest site location parameters such as the direction of the Open nest, Height at which the nest was made from the ground, far or depth of the nest from the roof edge, nest location from vegetation, and light illumination at the nest.

$H_{a4:}$ There is a significant relation between the overall breeding success of House Sparrows and the Open Nest site location parameters such as the direction of the Open nest, the Height at which the nest was made from the ground, far or depth of the nest from the roof edge, nest location from vegetation, and light illumination at the nest.

Material and methods

Study area

Jangareddigudem is an upland area of the Eluru district of Andhra Pradesh state of India. It is at 74 ms altitude from the median sea level. This semi-urban town is constituted of a 15.8 Km^2 area. The town is located in a tropical climate, and once it was a shrub jungle. Now the town is with several pockets of open areas, plantations, and cultivating lands. The town Jangareddigudem has been selected for House Sparrow conservation studies because of its geographical location and lack of bulk food resources like paddy and cereal cultivation around the town. As per our survey conducted in 2014, the population of House Sparrows was very less in the study area (Mahesh & Suseela, 2021), and now with our conservation efforts using artificial nest boxes, we could able to increase the bird population.

Data collection

Regular monitoring was done for Open nests construction by the birds in the study area. A periodical checkup of nest boxes was conducted to study the breeding aspects. We followed the guidelines described by the Principle Chief Conservator of Forests (PCCF), Wildlife, Andhra Pradesh, India, for monitoring the nests and other parameters. For each Open nest, we have recorded (i) Clutch size (*i.e*. number of eggs laid per attempt) (ii) Number of hatched, and (iii) the Number of Fledged Chicks. By these three parameters, we calculated the hatching success (young

ones hatched/eggs laid), Fledging success (number of young ones fledged out/total eggs laid), and annual breeding success (young ones fledged/eggs laid) at each Open nest.

Statistical Analysis

The influence of various Open Nest factors such as the direction of the Open nest, Height at which the nest was made from the ground, far/depth of the nest from the roof edge, far from vegetation, and light illumination on reproductive parameters (clutch size, hatching success, fledging success and overall breeding success) was studied applying Chi-square tests.

Results

Number of Open Nests

In the year 2014, when the conservation activity was started, we found 9 Open nests in the study area. By the next year (2015), House Sparrows made 14 new Open nests. In the third year, i.e. 2016, 33 more Open nests were added. A maximum number of Open nests i.e. 40 numbers were built in the year 2017. Because of the increase in installation of the nest boxes in the study area, a gradual decrease in the Open nests was observed from the year 2018. 23 nests were observed in the year 2018, 18 nests in 2019, 15 nests in 2020, and 8 nests in the year 2021.

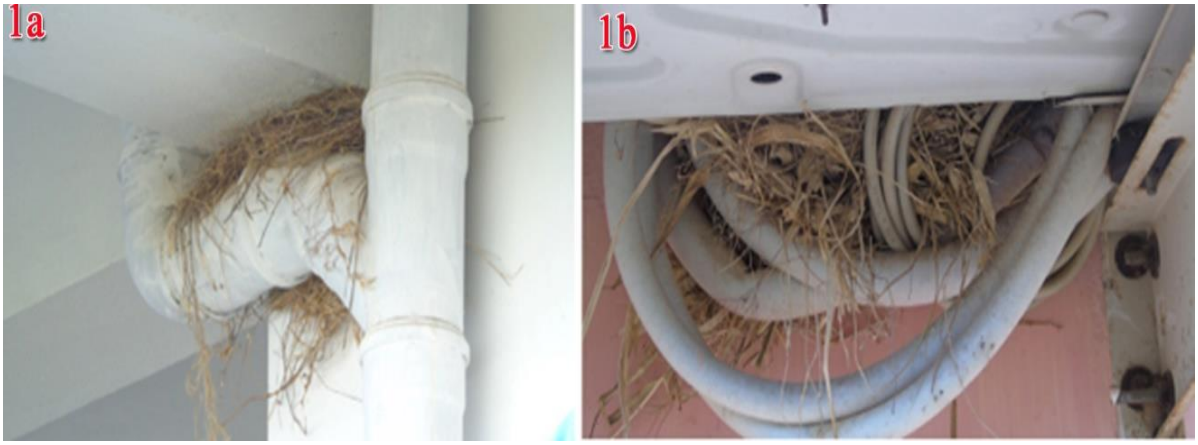

Figure1a. Open nest of House Sparrow on Sanitary pipe. Figure b shows an open nest at the back of the air-conditioner compressor

Open nest site location factors

With respect to the direction of Open nests (either with regard to the corner or wall-facing direction or the direction of the entrance of the cavity), the majority of the nests were north-directed. Among

the 160 observed Open nests, 93 (58% of observed nests) were north-directed, 44 east directed, 12 west directed, and 11 south directed. Among these, 11 nests were built at less than 10 feet in height. Most of the nests (139) were observed between 10 to 20 feet in height which constitutes about 86.8% of observed nests. Only 10 nests were found above 20 feet in height. Coming to the depth/far from the roof edge, the majority of the nests, 110 nests (68.75%) were found between 3 to 6 feet in depth. About 24 nests were found below 3 feet depth, and 26 nests were found beyond 6 feet depth (from these 10 nests were observed beyond 10 feet depth, found in parking cellars).

With regard to the distance of the nest from vegetation, 3 Open nests were found in bushes, 48 nests were found within 20 ms distance, 97 nests were observed at around 100 m distance (60.6% of observed nests), and only 12 nests were found beyond 100 m but less than 200 m from vegetation. Considering light illumination at the Open nests, 118 nests were built at 40% and at below 40% illumination of light (that constitute 73.74% of observed nests), 34 nests were found between 40-60% light illumination, and only 8 nests were observed at more than 60% of light illumination, which also includes three nests built in bushes.

Open nest site location factors Vs Reproductive success

The studied Open nests were built in the available cavities by the selection of House Sparrows. All the observed factors such as the direction of the Open nest, the Height at which the nest was made, far/depth from the roof edge, far from vegetation, and light illumination, have shown significant impact on the reproductive parameters (Clutch size, hatching success, fledging success, and overall breeding success).

Clutch Size

The average clutch size from all observed Open nests in the study area is 2.83 (sd 0.86). Clutch size of the House Sparrow was found to be greatly influenced by the direction of the nest (*P* value $=1.18E^{-07}$), the Height at which the nest is made from the ground (*P* value $=2.91E^{-08}$), depth/far of the nest from roof edge (*P* value $=9.84E^{-07}$), Nest location away from vegetation (*P* value $=2.54E^{-05}$), and light illumination at the nest (*P* value $=3.94E^{-10}$). All the studied factors were found to influence the clutch size of the House Sparrow, as is evident from their *P* values of less than 0.05 ($P<0.05$), thereby rejecting the null hypothesis

In comparison, maximum clutch size was observed in the north direction. The height of the nest from the ground is also an influential factor, which showed a significant effect on clutch size, and

an optimum clutch size was observed when the nests are made between 10 to 18 feet height. 3 to 6 feet distance from the roof edge is the most feasible, where optimum clutch size was noticed. Nests placed at a distance of below 100 m from vegetation have shown optimum egg output, and a light illumination of 40% or less than that in the Open nests stimulated optimal clutch size (Fig.2).

Hatching Success

The baby sparrows that come out from incubated eggs are called hatchlings. The mean of the hatched eggs is 2.23 (sd 0.72). Hatching success too was found to be influenced by all the studied nest site location parameters, with their *P*-values of less than 0.05($P<0.05$), rejecting the Null hypothesis. The direction of the Open nest was found to be an influential factor in hatching success (*P* value =$1.18E^{-07}$). 100% hatching success occurred at 48.75% of the observed Open nests, but the successive rate was higher in the north-directed nests (37 of north-directed nests out of a total 78 exhibited 100% hatching success). The results showed that the height at which the nest is made from the floor has also influenced hatching success (*P* value =$2.91E^{-08}$), and from the studies, it was found that 10-18 feet height is feasible for obtaining maximum hatchlings (Fig.3m). Location of the nest from slab edge (far from roof edge) also played a significant role in the hatching success (*P* value =$9.84E^{-07}$). Maximum hatching rate was observed at the Open nests that were constructed at 3 to 6 feet depth from the slab edge. The location of the nest far from vegetation is another significant factor that influenced hatching success (*P* value = 0.005) and nests that were made within a 100 m radius of vegetation have given the maximum hatchling rate. Light illumination also significantly influenced hatching success in House Sparrow (*P* value =$1.61E^{-05}$). In the case of light illumination, 40% or less than that illumination favored hatching success.

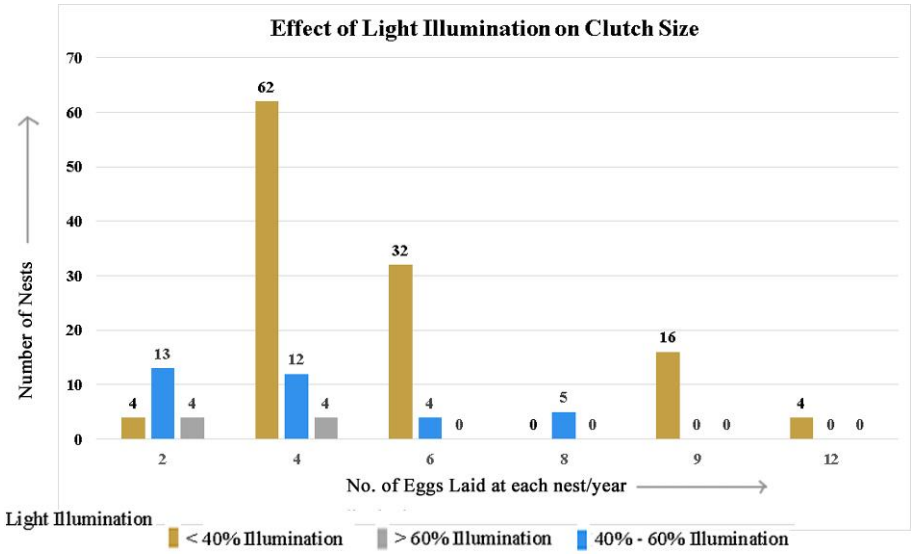

Figure 2. Influence of Light illumination on Clutch size.

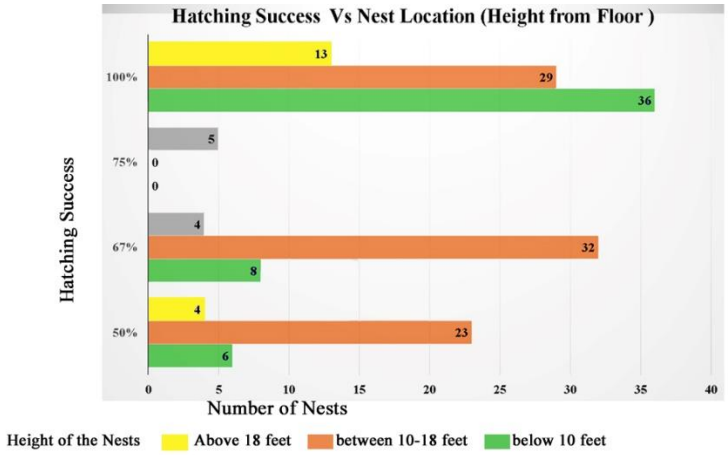

Figure 3. Effect of Nest Location (height from ground) on hatching success.

Fledging success

The number of nestlings fledged out from the total number of hatchlings at each Open nest per year was calculated. On average, 1.808 nestlings were fledged out (sd 0.82). All the factors that were studied *viz.*, the direction of the nest, height at which the nest is made from the ground, depth/far of the nest from the roof edge, nest location away from vegetation and light illumination at the nest, showed a significant influence of fledging success with *P* values 0.004, $1.94E^{-07}$, $5.56E^{-05}$, 0.002, and $1.61E^{-05}$ respectively. The P values of less than 0.05($P<0.05$) with respect to the

influence of all the studied nest site location parameters on fledging success indicate a significant relationship between the two, rejecting the null hypothesis. 100% of hatchlings fledged out at 62.5% of the observed nests irrespective of the direction of the nest. But, north-directed nests have given maximum fledging success. Fledging success was greatly influenced by the height of the nest. Cent percent fledging success was observed at 76% of the nests, where the nests were built between 10-18 feet height from the floor (Fig.4), whereas less than 50% success was observed above or more than the 10-18 feet range. With respect to depth/far from the roof edge, mixed results were observed. Cent percent fledging success was observed only at 11.88% of the nests, and 67% of fledging success was observed at 74 (46.25%) of the Open nests. Regarding the location of the nest that was built far from vegetation, maximum fledging success was recorded with nests made in a 100 m radius. A light illumination of less than 40% has greatly stimulated fledging success.

Overall breeding success

The number of young ones successfully fledged out from each nest from the total number of eggs laid gives overall breeding success. The average breeding success at Open nests was 0.63 (sd 0.27). the chi-square tests to study the influence of various nest site location parameters on overall breeding success rejected the null hypothesis as is evident from the significant *P* values (*P*=<0.05) for all the studied factors, indicating a significant relationship. The direction of the nests significantly influenced overall breeding success with a *P-VALUE* of $6.37E^{-05}$. North direction credited maximum output. The height at which nests were made from the ground also significantly influenced overall breeding success with a *P-VALUE* of 0.031. Height from the floor recorded a moderate effect on overall breeding success, but 10 to 18 feet height from the ground was found to be a feasible height (Fig.5). The other factors such as nests made far/depth from the roof edge (*P* value=0.017), far from vegetation (*P* value= 0.018), and light illumination (p value=$2.06E^{-09}$) too showed a significant effect on overall breeding success. 68% of the nests have given maximum breeding success, where the nests were built at around 3 to 6 feet depth from the slab edge. Nests within a 100 m radius of vegetation have given better yields compared to the nests beyond 100 m and above from vegetation. Nests that get less than 40% of the illumination of light gave maximum output. Figure 5 shows the effect of light illumination on overall breeding success

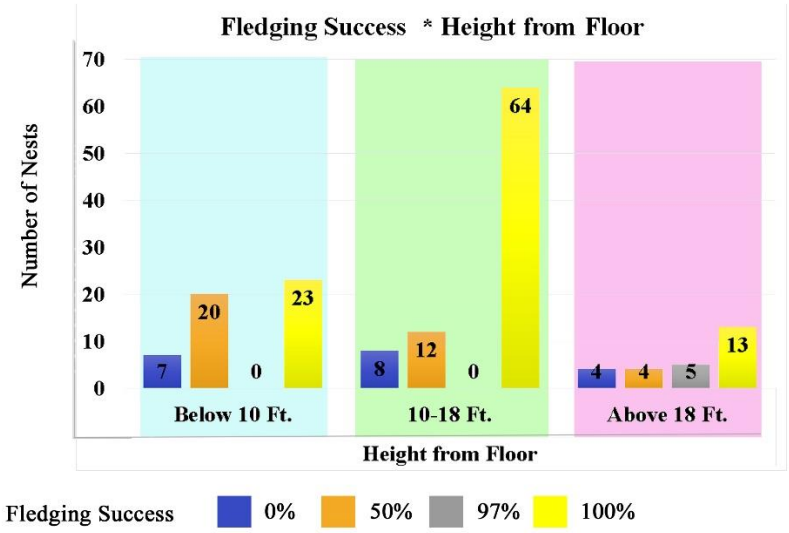

Figure 4. The fledging success of House Sparrow at various heights of Open nests.

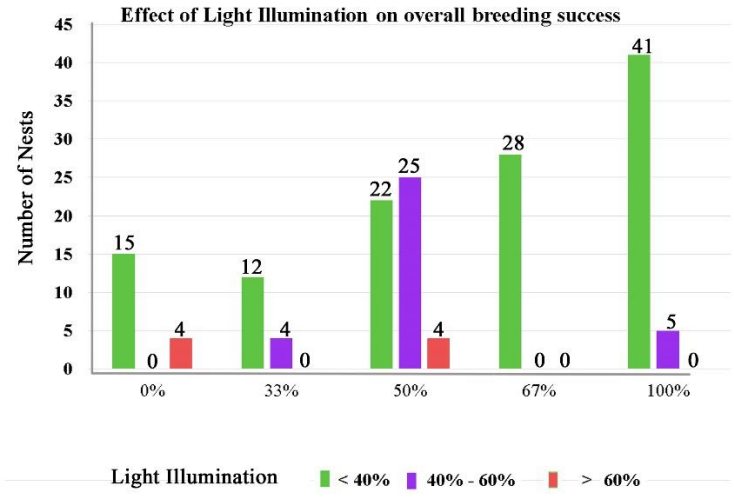

Figure 5. Effect of Light illumination Overall Breeding Success.

Discussion

The current study is the first observational study on Open nests with respect to the influence of various nest site parameters on the reproductive success of House Sparrows. Our observations have clearly shown the adaptability of Sparrows to urban conditions. These tiny birds utilized all the available crevices in RCC structures like- the back side of the air-conditioner compressors, sanitary pipes, behind photo frames, electric pipes, etc. Considering individual reproductive parameters, light illumination was found to be the most influential on clutch size, and the Height at which the nest is placed from the ground influenced both hatching & fledging success. Coming to overall breeding success, among various factors studied, light illumination was found to be the most significant followed by direction, then far/depth from the roof edge, then vegetation, and finally height at which the nest is made from the ground.

Sparrows do not prefer light illumination. In our studies, only 8 of the observed nests were found at a light illumination of above 60%. Among these eight nests, only one-time breeding activity was recorded. A 100% success rate was observed in 78 of the nests, irrespective to the height of the nest. Most of the observed nests (118 of 160 observed Open nests) were observed at a light illumination of less than 40% and 34 nests were observed at 40-60% illumination. About 45% of the 118 nests i.e. 53 nests recorded 100% hatching.

Sufficient light illumination is necessary for the physiology of the embryo. It can be correlated with the percentage of light illumination at the nest location. In our studies, we have found that a daylight illumination of less than 40% is more effective for breeding activity. All the studied reproductive parameters are significantly more at 40% and less than 40% light illumination. According to Maurer et al. (2011), light illumination induces embryo development and causes bone growth in avian embryos. Observational studies by Buschmann et al. (2006) also revealed that light stimulates embryonic growth in the pigeon (*Columbo livia*) eggs, during the incubation period. The pigeon pairs maintain regular intervals of light illumination in incubating eggs with a gap of 55 seconds for every 43 minutes to expose proper light to embryos. Hence, the developing visual pathways are stimulated repeatedly by light until 3 hours before the end of the breeding season.

Our studies revealed that clutch size, hatching success, and fledgling success was greatly influenced at 40% and less than to that light illumination, when compared to more illuminations, in the case of House Sparrow. The studies on dark tree cavities for nesting challenges by

Wesolowski and Maziarz (2012) also reported the same attitude. In their studies, secondary cavity nesters like Great Tits (*Parus major*) also choose dark places for nesting. The Great Tits built deeper nests when nest boxes were provided with more illumination and shallower nests when boxes were placed in dark areas, reflecting the condition-dependent behavior. About 2 to 3 times more breeding success was observed at nests made in the north direction, compared to east-directed nests. Only one-time breeding activity was recorded in South and West-directed nests. The houses are usually made with less roof-edge on the south and west sides compared to the north and east sides, which may result in the receipt of more sunlight in those directions. Moreover, the north direction will receive daylight only for a short span and this is because of the sun's path (East to South to South West to West). The more light illumination might be a cause for less breeding activity in the south and west-directed nests. Among the 93 north-directed nests, at 51 nests (54%), 100% fledging success was observed, at 5 (5.4%) nests 67% hatching success, and at 24 nests (25%), 50% hatching success was observed. But at 13 nests (14%), the death of hatchlings has taken place. The observed reasons for the mortality of nestlings were improper feeding (raw rice), the presence of ants, and some arthropod parasites in the nest.

Depth from the slab is another essential and influenced factor. The depth of the nest from 3 to 6 feet is more comfortable for the sparrows than the deeper nests. The Open nests that are found at less than 3 feet (24 nests), are observed behind the air conditioner compressors, on sanitary pipes located towards the west side. These locations are not comfortable and as well not secured. A maximum success rate with respect to clutch size and a number of breeding attempts was observed at the nests located between 3 to 6 feet in depth. The observed reasons are- the zone is much more secure from all unfavorable weather conditions and predators, and light illumination for good growth of nestlings. Only one-time breeding activity was recorded at the nests that are made below 3 feet depth and it could be due to more light illumination. The presence of vegetation near the nesting sites had a significant value on the clutch size, hatching success, and fledging success. The nests that were made Presence of vegetation near to the nesting sites provide a concealed environment to the birds, from exposure to predators and vegetation as well as lowers light illumination and provide shadier habitats (Götmark *et al*.,1995). Moreover, the presence of vegetation near to the nesting sites lowers the energy expenditure of parent sparrows for fetching food to feed their nestlings. The nests within a 100 m radius of vegetation showed significant

success with all the reproductive parameters studied. The nests that were away from vegetation (more than 150 to 200 m) have shown comparatively less success.

Among the various factors studied, the height of the nest (the height at which the nest is made from the ground) was found to influence both hatching and fledging success. But when it comes to overall breeding success, its influence is comparatively less. Nests made at a height between 10 – 18 feet from the ground favored breeding success. A height of this range could be the comfortable zone for sparrows for their overall activities *viz.*, collection of nesting materials, fetching food for nestlings, etc. As per our observation, most of the Open nests were found in to two storied buildings. Our observations are almost similar to observations made by Indykiewicz (1991). In his studies, he found that most of the nests are made between heights from 3-5 m (i.e. 9 to 15 feet). According to him, the sparrows might have preferred this height for three reasons- to evade predators, to reduce energy expenditure during feeding the nestlings, and the nonavailability of nesting places below 3 m height. A similar observation was also made by Rajasekhara (2006) during his studies at Bengaluru, India. He observed that most of the nests were built between heights of 1.5 to 6 m (10.5 to 18 feet).

The overall breeding success was about 63.97% of the total laid eggs. Mortality of nestlings was caused by various factors such as entry of ants into the nest, insufficient and improper diet to the nestlings (malnutrition), etc. Studies by Van Balen et al. (2002) described that certain species like *Parus montanus, Parus palustris, Parus major,* and *Ficedula hypoleuca* are opportunistic and lay more eggs when finding larger cavities. In our study also, we observed the same sort of phenomenon depending on the nesting site. The secondary cavity-nesting passerine birds most likely select concealed cavities to avoid predation pressure (Chotpresertkoon *et al*., 2017). The concealed cavity nesting behavior was also reflected by House Sparrow by choosing the nesting site's depth from the slab. Though the concealed cavities are not readily available, with the existing crevices, they made concealed nests by forming a twisted tunnel-like entrance.

The current study was conducted to observe the effect of various nest site location factors that influence the breeding success of House Sparrow at Open nests in Indian geographical conditions. The most influencing factors considering overall breeding success were found to be the light illumination (40% or less than 40%) then direction (north) then far from the roof edge (3 -6 feet), then far from vegetation (around 100 m) and finally height of the nest from the ground (10 to 18 feet). In our study, a height between 10 to 18 feet from the ground and a depth of 3-6 feet from

the slab edge favored the breeding success of House Sparrows. The location of the nest within 100 m distance from vegetation and the light illumination of 40% (or <40%) has a significant influence on breeding success. The studies of these kinds will be useful to the conservation activists, who involve in the conservation activities of House Sparrows to follow certain guidelines while installing nest boxes in urban areas for achieving optimum breeding success, which helps in the perpetuation of this tiny bird population.

Acknowledgments

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