



AMBIENT APPRAISAL

Nest Construction Mechanism of House Sparrow (*Passer domesticus*): A comparative study between Open and Inbox nests

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Study Area: Jangareddigudem, Andhra Pradesh, India

Coordinates: 17.1223° N, 81.2923° E

Key words: Breeding, Nesting sites, Nesting materials, Egg laying time

Abstract

Birds build nests for reproduction. House Sparrow uses available spaces in our houses for breeding. The lack of proper breeding spaces results in the reduction of their population. House Sparrow is a secondary cavity-nesting bird and hence can utilize the nest boxes for their breeding. Caliological studies were conducted to study the nest construction mechanism and to determine the nesting materials used in open nests and nest boxes in the study area, Jangareddigudem. We found the variations between open nests and inbox nests with regard to the nest construction time, collection of nesting materials at various stages, efforts and role of male and female sparrows in nest construction, stay of female birds in nests and egg-laying days. The time taken for the construction of inbox nests is nearly 8 to 10 days less compared to the open nests' construction. The number of nests in nest boxes was also determined. The rate of construction of Inbox nests was increased from 2.1 to 4.8 during the period 2016 to 2020. It indicates the increased population in the study area.

Introduction:

Most birds build nests for breeding. Bird nests are bio-engineered constructions. They build nests with various materials; all the components of the nests have their own structural importance in the nest construction as a whole (Biddle *et al.*, 2018). The nest construction mechanisms of birds involve direct benefits such as egg and nestling protection, sexual selection, kin selection, coercion and group augmentation (Leighton, 2016). The birds like Red-wattled Lapwing (*Vanellus indicus*), Yellow-wattled lapwing (*Vanellus malabaricus*), forest birds like Indian Nightjar (*Caprimulgus asiaticus*) lay eggs on open ground (Ali, 1996). Pheasants like Jungle fowl (*Gallus gallus*) lays eggs on the ground without litter (Yuan *et al.*, 2009), sometimes may dig a shallow pit, whereas Indian Peafowl (*Pavo cristatus*) lay on the ground with litter and leaf margin (Ali, 1996). Flamingos (*Phoenicopterus roseus*) make mound nests by gathering mud to maintain heat from cold conditions. The nests that are built on trees or any other open places are termed Outstanding nests. The birds like Woodpeckers make cavities by excavating on trunks and are called Primary Cavity Nesting Birds. The birds that built nests in the abandoned nests or cavities of primary nesters are called Secondary Cavity Nesting birds. House

Sparrow (*Passer domesticus*), Grey Tits (*Parus major*), Indian Robins (*Saxicoloides fulicata*) are opportunistic secondary cavity nesters.

House Sparrow built nests in the available spaces such as ventilators, between wall clefts, in sanitary pipes, hollows in the roofs, under roof tiles, cornices, behind photo frames, niches in the houses, streetlamps etc., with available materials (Indykiewicz, 1991). The category of House Sparrow nest is 'Open cup nest'. The nests constructed by House Sparrow in available places, other than nest boxes (henceforth will be referred to as 'Open Nests') may need more energy and also takes more time to complete. As the House Sparrow is a secondary cavity nester, it can also utilize nest boxes for breeding (Bhattacharya *et al.*, 2011, Gitanjali, 2014, Kumar *et al.*, 2019). House Sparrow exhibits flexibility in nesting sites when the regular nesting places are not available (buildings). They choose nest boxes if available (Shaw *et al.*, 2008). Several studies (Bhattacharya *et al.*, 2011, Chetan, 2012, Balaji, 2014, Gitanjali *et al.*, 2017, Kumar *et al.*, 2019) revealed the response and occupancy of nest boxes by House Sparrow. In the nest boxes, they built nests for each breeding attempt or sometimes old nests reused. Here onwards, the built nests in the nest boxes will be referred to

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as 'Inbox Nests'.

The aim of the paper is to discuss the mechanism of nest construction of Open nests in comparison to that of Inbox Nests with regard to nesting materials, role and involvement of male and female birds in the nest construction process, the influence of the weather conditions in the collection of nesting materials, number of the Inbox nests in the nest boxes, time taken for completing the construction process, mating attitude, beginning of night stays in the nests by female birds during construction process, first egg laying time etc., at the study area, Jangareddigudem.

Hypotheses of the study

- H₀₁: There is no significant difference between Open and Inbox nests with respect to the usage of various nesting materials for nest construction by House Sparrow.
- H_{a2}: There is significant difference in nest construction time by House Sparrow for the construction of Open nests and Inbox nests.
- H₀₃: There is no significant difference between Open and Inbox nests with respect to beginning of night stays by female birds during the construction of Open and Inbox nests.
- H_{a2}: There is significant difference in the role of male and female House Sparrows during nest construction.
- H_{a3}: There is significant difference between Open and Inbox nests with respect to beginning of night stays by female birds during the construction of Open and Inbox nests.

Our Survey

Survey area: Jangareddigudem is an upland area of West Godavari District of Andhra Pradesh state of India. Its altitude is 74 meters above median sea level, with a 15.8 Km² area. Jangareddigudem is a semi-urban town with a tropical climate. The town consists more of open areas. The conservation studies of House Sparrow have been conducted in the study area by providing nest boxes since 2014. The occupancy rate was reported about 97% (Mahesh & Suseela, 2021).

Observational studies were conducted while the sparrows were constructing the open nests from the day of beginning up to the completion of the nest. The same observational studies were also conducted at nest boxes. The observational studies made in the present study included- the time period taken for completing the nest construction, the role and involvement of male and female birds in the nest construction process, the influence of the weather conditions in the collection of nesting materials etc. Various nesting materials (outer structural, inner structural, fibrous lining and thermal insulators) used in the progress of the nest construction and composition of nesting materials were also determined. Statistical analysis was carried out using paired t-test to compare various parameters in the nest construction by House Sparrow between Open and Inbox nests viz., usage of different nesting materials, time taken for completion of nests, and beginning of night stays by female birds during the

construction of Open and Inbox nests.

Our observations:

Nest construction of Open nests: these were constructed in available places of houses such as in the crevices of the walls, ventilators, false roofs, behind photo frames, electric meters (Fig.-1a) and in rare cases they can be seen in too open places such as on hanging wires (Fig.-1b) and on plants (Fig.-1c). It was noticed to take about six to eight days for the collection of structural materials. The materials like Paddy grasses, Cynodon grass, and Goose Grass were collected for the construction of the outermost margin of the nest. It needs around one week time for the construction of the bottom or outer structural margin of the nest with large grasses. In the initial stages of nest construction, we have noticed the falling down of grasses, and recollection of the same grasses was observed at most of the nests. After that, thin grasses, coconut fibre, small green twigs of Parthenium, cucumber stems, in a few cases Palmyra fibres, broom fibres, and Nylon threads were as well collected and in rare cases thorns for inner structural construction. It needed six to seven days. After the collection of constructive materials, they turned to collect tiny grass leaves, Jute fibre, threads for the construction of the third set of layers (fibrous layer), and feathers for about

Table-1: Various nesting materials collected by House Sparrows for constructing Open and Inbox nests.

	Species/material	Parts used
Materials used to weave nest	Durva grass (<i>Cynodon dactylon</i>)	Stem & Leaves
	Broom fibre (<i>Thysanolanena maxima</i>)	Inflorescence
	Coconut (<i>Cocos nucifera</i>)	Fibre of fruit
	Cucumbers (<i>Cucumis</i> sp.)	Stem
	Paddy (<i>Oryza sativa</i>)	Grass
	Goose grass (<i>Eleusine indica</i>)	Leaves
	Small twigs (unidentified)	Twigs
	Palmyra (<i>Borassus flabillifer</i>)	Fibre of petiole
	Neem (<i>Azadirachta indica</i>)	Leaves
	Nylon threads	Fibre
	Carrot grass (<i>Parthenium hysterophorus</i>)	Twigs
	Drumstick (<i>Moringa oleifera</i>)	Bark
	Leaves (Unidentified)	Leaves
	Tamarind (<i>Tamarindus indica</i>)	Leaves
	Lawn grass (<i>Zoysia japonica</i>)	Leaves
	Coconut (<i>Cocos nucifera</i>)	Leaf fibre
Lining and core of nest	Bamboo (<i>Bambusa vulgaris</i>)	Leaves
	Jujube (<i>Ziziphus jujube</i>)	Thorns
	Jute (<i>Corchorus olitorius</i>)	Fibre
	Synthetic fibre	Fibre
	Polythene	Pieces
	Cotton (<i>Gossypium herbaceum</i>)	Cotton fibres
	Cloth pieces	Pieces
	Domestic fowl (<i>Gallus gallus</i>)	Feathers
	Silk cotton (<i>Bombax cieba</i>)	Fibre
	Threads	Small pieces
	Paper	Small pieces
	House Sparrow (<i>Passer domesticus</i>)	Feathers
	Cigarette buds	Fibre



Figure-1: a) Open nest in Electrical meter box; b) Open Nest made in coil of hanging cable; c) Open nest in a shrub

Table-3: Average of inbox nests constructed in the observed nests for different years for the said study duration

Year	Observed Nests	Average of Inbox Nests	Duration
2016	12	2.12	4 years
2017	26	2.22	3 years
2018	30	3.12	2 years
2019	42	4.8	1 year
2020	50	4.8	1 year

Table-4: Female Staying in Nests during night time (n=40)

Mean	Variance	HM	df	t-Stat	t-Cri.	P	H ₀		
Open	Inbox	Open	Inbox						
16.25	11.7	1.1153	1.1897	0	39	17.4632	1.6848	2.460-E20	Rej

5 days. In the last three to four days, they collected synthetic fibres, cloth pieces, polythene pieces, and finally feathers for the Thermal lining (core) of the nest.

On the long-term observations from the years 2014 to 2020, the duration for completion of open nests was calculated. About 5 nests were discontinued, at the stage of structural construction. Only 2% of the nests were completed in 15 to 16 days duration. 50% of the nests were completed in 18 to 20 days. 23.75% of nests were completed in 20 days, 19.37 % nests in 22 days, 14.37% nests in 25 days,

and 13.75% nests in 24 days. Only 5 nests took 30 days for completion of nest construction. The average weight of Open nests was 94.07 gm. The maximum weight was 142 gm. The average time period taken by the House Sparrows for completing Open nests construction was around 23 days.

Construction materials used to fell down in the first few days. Sparrows used to wait for a certain time to approach the nesting site during the collection of nesting materials. Though both the sparrows, male and female, are involved in the collection of nesting materials, only males participated in the nest building. The role of a male sparrow in the collection of grasses was observed during the first 10 to 12 days, whereas females works for 10 more days.

For the open nests, they make a tunnel like entrance. The length of the entrance depends upon the cavity/space where they built the nests. The tunnel is around one inch in diameter. Stay of female birds in the nests during nighttime was observed after 16 days from the beginning of nest construction time.

We have noticed that most of the open nests were made in an east direction which comes to around 58.1%. The second priority is given to the north direction that comes to around 25.6% and then the south direction with 8.7%. The least priority is given to the west side of the houses, 7.5%, that too in the places where direct sunlight does not fall on them.

Among the observed open nests, 52.5% of the nests were constructed at 11 to 15 feet height, around 31.25% nests below 10 feet, and 16.25% of nests were found above 15 feet but below 20 feet. Open nests were not found above the 20 feet height. More than half of the nests were constructed at 5-6 feet depth from the slab. About 60% of the nests were made at 5 feet depth. 22% of nests were made below 5 feet in depth. 11.87 % nests were found at



Figure-2: a) Structural nest construction by Paddy grass ; b) Collecting synthetic fibre for the core of the nest

Table-3: Time required for the Collection of Nesting materials and nest completion

#	Time	Mean Open N	Inbox N	Variance Open N	Inbox N	Obs.	H.M.	df	t-Stat	t-Critical	H0
1	Outer Structural Materials	6.95	3.675	1.333	0.583	40	0	39	14.6485	1.684875	Rejected
2	Inner Structural materials	6.525	4.025	1.332	0.332	40	0	39	11.8019	1.684875	Rejected
3	Fibrous Lining materials	5.075	3.725	0.789	0.225	40	0	39	7.459	1.684875	Rejected
4	Thermal Insulators	3.55	3.45	0.253	0.407	40	0	39	0.780	1.684875	Accepted
5	Total time	22.1	14.825	4.86	1.394	40	0	39	17.530	1.684875	Rejected

*tested at 5% level of significance

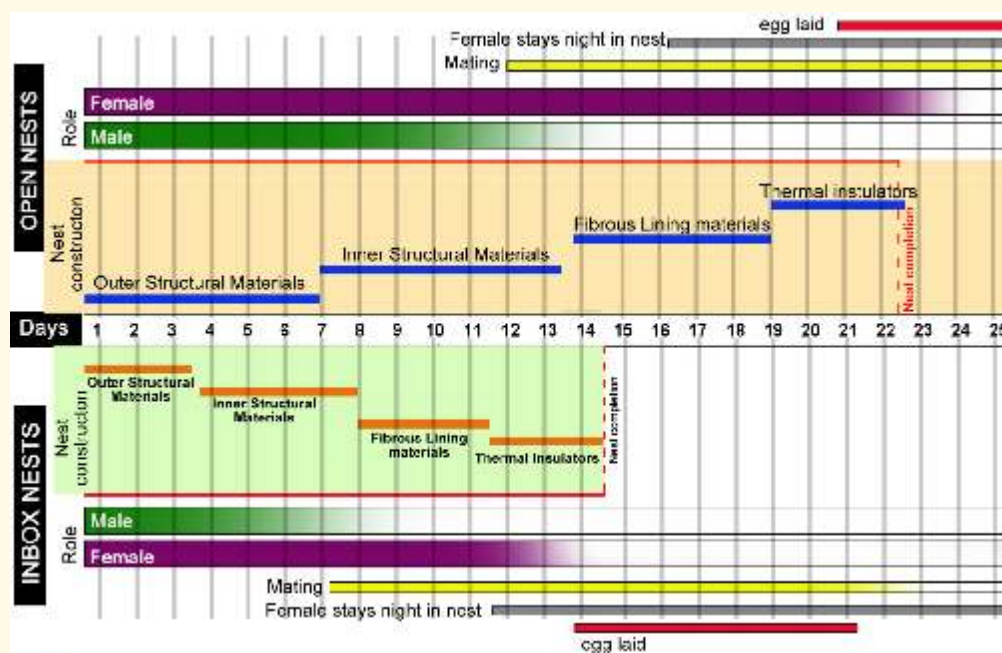


Figure-3: Graphical representation of nest construction duration, role of male and female in nest construction, mating behaviour, female bird stay time in nest during night, eggs laying time between Open nests and Inbox nests.

8 to 12 feet depth. In rare cases, only 2.5% of nests were constructed at 20 feet depth. Two nests were found in bushes.

Nest construction in Inbox Nests: during the nest construction for Inbox Nests, the Outer structural materials were collected in the first three to four days. We have noticed that both male and female sparrows shared role in collecting the structural materials (Fig.-2a). We have noticed that both male and female sparrows shared role in collecting the structural materials. We have noticed that male sparrows stay for about two to three minutes in the nest box before the setup of grasses. Females were noticed to carry the materials necessary for construction and they as well observe the construction work done by the male birds. Materials such as paddy grass, dürvā grass (*Cynodon*), coconut fibre, broom fibre etc., were carried by both the birds for constructing outer structural layer. Collection of grasses, cucumber stems, tendrils, green leaves, small twigs of Carrot grass (*Parthinium*) etc. Construction of this part of the nest almost took 3-4 days. It required about four days to complete the inner structural lining. From the eighth day onwards, for the construction of fibrous lining, they collected only thin fibres, fine grass leaves, broom fibre etc., for about four days. In the last three to four days, they collected feathers, cotton, polythene pieces, paper pieces, cloth pieces and synthetic fibres (extracted from Plaster of Paris sheets used for false roofing) for Thermal lining (Fig.-2b). The average weight of first Inbox nest was 42.2 gm.

Construction activity is mostly done during morning hours, between 7:30 am to 10:00 am. On cloudy days, the collection work

continued up to 11:30 am. Collection of nesting materials was rarely observed during evening hours. The average weight of the first nest of the Inbox nests was 42.203 gm. From the second nest (that was constructed on the first nest, in the next successive breeding by the same couple or by another couple of Sparrows) onwards, the number of structural materials was reduced to half.

The collection of the finest fibres by the female was observed even Coming to the duration of completion of observed Inbox nests, 10% of the nests were completed in 12 to 13 days, 25% in two-week days, 30% were completed in 15 days, 27.5 % nests in 16 days and about 5% nests in 17 to 18 days. The average time period taken by the House Sparrows for completing first Inbox nest construction was around 14.8 days.

With regard to the direction of installation of nest boxes and their occupancy, 23.75% nest-boxes were installed in east direction, and around 60% in north direction. Of the installed boxes, 58.75% were occupied in both the directions. Only 2.5% nests were installed in South direction, and Of these only half of the nest boxes were occupied. All the nest boxes that were installed in sunset direction (west direction) were occupied.

With respect to the height at which nest boxes are installed, 50% of the nest boxes were installed at around 10 feet height, and among them, 96.25% were occupied. All of the nest boxes placed between 10 to 20 feet were occupied, which constitute to 25%. Remaining 25% of the nest boxes were installed at 21 feet and above, and among them, 97.5% of the nests were occupied. 45% of the nest boxes were installed below the 3 feet depth, 37.5 % nest boxes were between 3-6 feet, 17.5% nest boxes at 6 feet and beyond. Their occupancy rate was 97.2%, 96.6% and 100% respectively.

On the random selection, we examined about 160 nest boxes. Among them, 12 nest boxes were selected from the installed nests of the year 2016, 26 of 2017, 30 of 2018, 42 of 2019 and 50 of 2020. In the period of four years, on average, 8.5 nests were built in the

selected nest boxes that were installed in the year 2016. In the year 2017, of 26 selected installed nest boxes, on an average, about 6.68 nests were found in a period of 3 years. The installed nests (30 nests chosen for the study) in the year 2018 accommodated about 6.25 nests in a period of 2 years. From the 42 of 2019 year installed nest boxes, about 4.8 nests were built in a period of 1 year and from selected 50 of 2020 year installed nest boxes, about 4.8 nests were built. The average nests built per year are calculated as 2.12, 2.22, 3.12, 4.8 and 4.8 in the years 2016, 2017, 2018, 2019 and 2020 respectively. The highest average of 4.8 nests that found in the nest boxes installed in the years 2019 and 2020 indicates the increased population in the study area and also the demand for the breeding spaces. Table-2 shows the average of inbox nests constructed in observed nests during different years for the said study duration.

Open nests Vs Inbox nests: The differences in the nest building work between Open nests and Inbox nests is summarized in Fig. 3. The Figure shows a comparative note of nest construction duration, role of male and female in nest construction, mating behaviour, female bird stay time in nest during night, eggs laying time between Open nests and Inbox nests.

The total average time to complete Open nests was 23 days, and this was around 14.8 days in case of Inbox nests. For Open nests, male involvement for collection of nesting materials is up to 10-12 days and where as in Inbox nests, it is about 6 days. Females involve up to the completion of nest construction that is starting from the collection of nesting materials to the total completion of construction process. Stay of female bird in the nests during night time was observed after 16 days from the beginning of nest construction in Open nests and it was after 11-12 days from the beginning of nest construction in Inbox nests. Mating occurs at around 12th day after the beginning of nest construction in Open nests and in case of Inbox nests it was on 7th or 8th day. With regard to egg laying, laying of first egg in Open nests was observed on 21st day, and in Inbox nests it was on 13th to 14th day.

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Statistical analysis was carried out using paired t-test to compare the usage of various nesting materials (outer structural, inner structural, fibrous lining, and thermal insulators) by House Sparrows for Open and Inbox nests construction. Table 3 shows the comparative analysis of nesting materials between Open and

Inbox nests using paired t-test. From the table 3, it is clearly evident that nesting materials viz., outer structural, inner structural and fibrous lining materials were different between Open and Inbox nests (H_0 rejected). In case of thermal insulators, the null hypothesis is accepted, indicating the differences in these materials between the two types of nests. With regard to the time taken for construction of Open and Inbox nests, H_0 is rejected, indicating a significant difference in this particular parameter between the two types of nests. The time taken for completion of nest construction was more with Open nests compared to Inbox nests. Table 4 shows the beginning of the night stay by the female birds in Open and Inbox nests during nest construction process. From table 4, it is clear that there is a significant difference in the beginning times of night stays by the female birds in the nests with respect to both the type of nests (H_0 rejected). It was early in Inbox nests compared to Open nests.

Discussion

The observed nest in the coil of cable wire indicates the need for the nesting sites, in the study area (Fig-1b). The average number of constructed Inbox nests per year from 2016 to 2020 was increased from 2.2 to 4.8 indicating the increased population and need for nest boxes for the growing population. Usually sparrows make new Inbox nests for each breeding attempt, but in some cases they too utilize the existing ones. Probably, the number of breeding attempts is more than the number of Inbox Nests. In our observational studies, couple of times, it was observed that, for the next successive breedings, they collected at least few thin fibres. The multi-brooded species, widely distributed in urban areas, may reuse the open-cup nests for their next successive breeding attempt (Cavit *et al.*, 1999).

Among all the nest boxes, on average, 50% were used to build seven nests. Several studies by Møller (1992), Lehmann (1993) Marzel *et al.* (2005) revealed that the parasitic load is more with the presence of old Inbox Nests. Hence, towards annual maintenance, we used to clean the nest boxes. But to conduct the present study, we left some of the nests to observe their long-term usage and occupancy status and to understand the maximum number of nests that can be accommodated in the specially designed nest box. Special care was given to avoid the entry of pests and ants into those nests.

It is the first observational study conducted by us to find the nest construction mechanism and the role of males and females during the nest construction. On comparison, the female spends a long time in the collection of nesting materials. The collection of the finest fibres by the female was observed even after laying of the eggs. Stay of female bird in the nests during night time was observed after 11.7 days from the beginning of nest construction. Table 1 shows the various nesting materials collected by House Sparrows for constructing Open and Inbox nests. Males take part role mostly in the collection of structural materials in the collection of structural materials and rarely in lining materials during the nest construction process. Sometimes

it was noticed the participation of male birds in the collection of thin fibrous grasses, while they are using the existed nests in the nest boxes. The time needed for collecting the thermal insulators for the core of the nest takes almost 3 to 5 days both in Open nests and Inbox nests. The quantum of the lining materials is almost the same in both types of nests.

For the collection of outer structural materials, it took almost double the time for Open nests than the Inbox nests. Collection of inner structural materials for Open and Inbox nests needed 6.5 days and 4.0 days respectively. And for fibrous lining materials it was 5.07 and 3.72 days for Open and Inbox nests respectively. There is a gradual reduction in time of construction from outer structural to core of the nest. For the thermal lining (inner core), they took almost equal time period i.e., 3.55 and 3.45 days respectively for Open and Inbox nests.

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During the initial days of the nest construction, we observed that male bird offers females for mating. But female offers mating only around 12 days of the nest construction in case of open nests and after one week time in case of Inbox nests. It was found that females stay in the nest for nights one or two days prior to laying the eggs until the last nestling fledges out. It was also observed that the female used to sit in the entrance hole of the nest boxes during afternoons for about 2 hours without any major movements.

In these observational studies, we found that eight nest boxes were abandoned (nest boxes nos. 75, 88, 98, 159, 177, 301, 354 & 407) due to the entry of the House Gecko (*Hemidactylus frenatus*). Their eggs were found in the uppermost Inbox Nests. In some cases, eggs of House Gecko were found in between the old Inbox Nests.

Sparrows build nests for direct benefit only. Sexual selection, kin selection, and two other mechanisms described by Leighton (2016) such as coercion and group augmentation were not found to influence nest construction by sparrows in our observational study. Direction is an important parameter for the construction of Open nests. Most of the nests were found in east and north directions, and few nests were also found in south and west directions. This could be due to the house design, and to avoid direct exposure to hot sun. Houses are as well constructed with extended slab on east, north sides and at

north-east corners. Such extended slab does not allow direct sunlight on the nests. Most of the Open nests were observed between 10 to 20 feet height. Depth of the nest from roof edge was an optional factor, and depends on the availability of crevices to build the nest. Sparrows usually prefer 6 feet and more depth to build nests. Coming to Inbox nests, direction plays key role in the occupancy, and most of the nest boxes placed towards east and north direction showed quick occupancy compared to the other two directions. Nest boxes installed at a height between 10-20 feet were found to be feasible for occupation. Depth from roof edge also found to be one of the important factors for occupation, and in our observation nest boxes installed beyond 6 feet showed quick occupancy. This could be due to sufficient light illumination and as well the locations are secured, and away from predators.

The Sparrows collected large grasses and other supportive plant materials like tendrils, cucumber stems, and Neem (*Azadirachta indica*) leaves as structural materials. In rare cases, for construction, they also used materials such as peels of the stem of the Drumstick plant (*Moringa oleifera*) and thorns of Jujube (*Ziziphus jujuba*). We have found two dead fledglings in one nest, where their legs were tied in the synthetic fibres (used to stitch rice bags). As per the observations of Heiz (1984), the materials used for lining were wool, feathers and a bit of paper. Whereas in our findings in addition to those materials, the synthetic fibres, cloth pieces and polythene pieces were also found.

Conclusively, House Sparrows construct nests with the available nesting materials from their nearest resources. The amount of structural material used to construct nests was several times more in the open nests than in inbox nests. It requires more effort and also is a time taking process. In other words, the use of nest boxes conserves the efforts and as well time to build nests. On average, the nest construction takes around 14 days (for the first nest) in nest boxes, whereas it was almost double in the open nests. There is an associated advantage with the use of nest boxes, as these reduces the effort and there by promote quick breeding. This can in turn increase the House Sparrow population. Suitable nest box model with minimum required space can reduce construction energy among the House Sparrows and can help in perpetuation of these man followers in existing concrete jungles. The increase in the nest construction rate from 2016 to 2020 denotes the increased population and need for nest boxes in the study area. Future research can be done to find out any distinguishable impact on reproductive capacity and successive reproductive seasons in House Sparrow with reference to open nests and inbox nests.

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