Intern. Stud. Sparrows 2024, 46: 4-19

DOI: 10.59443/ISSpar-2024-0001

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UNDERSTANDING URBAN SPARROW ECOLOGY: INSIGHTS INTO POPULATION DYNAMICS, FEEDING PATTERNS, AND NESTING PREFERENCES IN THE OOTY ATC MARKET ENVIRONMENT, WESTERN GHATS, NILGIRIS, TAMIL NADU, INDIA

ABSTRACT

This research delves into the ecology and behavior of the house sparrow (*Passer domesticus*) within the bustling urban environment of the ATC market in Ooty, India. Through a comprehensive study conducted between August 20 and October 3, 2023, various aspects of sparrow dynamics were explored, including population demographics, feeding patterns, nesting preferences, and human interactions. The study area, a 150-year-old market nestled in the Western Ghats, serves as a critical habitat for the sparrows, attracting thousands of visitors daily during peak seasons. Population analysis revealed intriguing trends, with male sparrows exhibiting wider population ranges and variability compared to females. Furthermore, female sparrows displayed consistent feeding patterns throughout the day, with slightly higher counts observed in the evening. Sparrows were observed consuming unconventional food items like beef, chicken, and pork alongside traditional sources such as grains and vegetables, highlighting their adaptability to urban environments and diets. Nesting behavior analysis underscored sparrows' preference for artificial structures, emphasizing the importance of providing suitable nesting habitats amidst urban development. However, a questionnaire survey revealed a concerning decline in sparrow awareness and conservation efforts among market visitors, necessitating urgent educational initiatives. The impending demolition of the ATC market poses a significant threat to the local sparrow population, emphasizing the need for immediate action to mitigate habitat loss and raise awareness for long-term conservation. Overall, this research provides valuable insights into the intricate relationship between sparrows and urban environments,

underscoring the importance of proactive conservation measures to ensure the survival of these resilient bird species.

Keywords: House sparrow, Urban ecology, Population dynamics, Feeding behaviour, Nesting preferences, Conservation awareness.

INTRODUCTION

The house sparrow, scientifically known as *Passer domesticus*, belongs to the Passeridae family within the Passer genus and is classified under the species domesticus (Fig. 1). It is recognized as one of the larger sparrow species, characterized by an average length ranging from 160 to 165 mm and a wingspan typically measuring between 210 and 255 mm (Lowther et al., 1992). The house sparrow holds the distinction of being the most widespread bird species across the globe (Anderson, 2006). The sexes exhibit dimorphism, with males displaying striking patterns while females appear relatively plain, characterized by a grey-brown crown, a pale buff eyebrow stripe, two wing bars, and a lack of markings on the throat and breast (Lowther et al., 1992). Birds are frequently employed as indicators in ecological monitoring due to their sensitivity to minor environmental shifts (Newton, 1995). The house sparrow, Passer domesticus, has coexisted with humans since ancient times, thereby making it an excellent indicator of ecological quality (Kheera et al., 2009). The house sparrow has been classified as a Red List species in the Netherlands and is considered endangered in the United Kingdom (Summer-Smith et al., 2003). In studies conducted in various locations in India, including Bangalore (Rajashekar et al., 2008), Kolkata (Modak et al., 2017), Haridwar (Saini et al., 2015), Tamil Nadu (Balaji et al., 2017), Delhi (Khera et al., 2010; Choudhary et al., 2019, 2020), and the State of India's Bird in Dehradun, Uttarakhand (Joshi et al., 2022), there has been evidence indicating a decline in the sparrow population. The house sparrow is experiencing a decline in numerous regions across the globe: Europe (De Laet Summer-Smith, 2007), Canada (Lepage et al., 2002), Australia (Olsen et al., 2003). According to data from the British Trust for Ornithology (BTO), the breeding population of house sparrows in Britain is currently estimated to be around 6 million pairs, marking a decline of approximately 50-60% since 1970. This two-thirds decline is particularly notable in built-up habitats, with half of them in suburban areas. In the Indian subcontinent, house sparrows are commonly found in India, including introduced populations in the Andaman Islands. They are also present in Pakistan, Bangladesh, Sri Lanka, and the Maldives (Ali et al., 1987). Any population experiencing stress and influenced by adverse environmental factors would suffer negative impacts, potentially leading to local extinctions and contributing to the widespread decline of the house sparrow (Baker et al., 2005). It has been noted that the population of house sparrows was significantly higher in the Ooty market (Jayaraman et al., 2017). The objectives of the study include examining:1. To look upon the abundance, distribution, and habitat preference of the sparrow in the market, 2. To analyze several factors including

urbanization, food availability, and nesting sites, 3. To identify the difference in the behavior and ecology between the study sites, 4. To provide recommendations for the conservation of the house sparrow in Ooty.

Fig. 1. Male (right) and Female (left) sparrow *Passer domesticus*

STUDY AREA

The present study was conducted in the Ooty Municipal Market (11.40685, 76.70296), situated in The Nilgiris, part of the Western Ghats (Fig. 2 and 3). Established during the British colonial era, this historic market spans approximately 6 acres in the heart of Ooty and is around 150 years old. It accommodates about 1,500 permanent and 500 temporary shops, attracting between 3,500 to 4,000 visitors on weekdays and 4,000 to 5,000 on weekends. During the peak summer tourist season, the daily footfall exceeds 5,000 visitors. The Market sits at an altitude of 2,240 meters, benefiting from a cooler climate compared to the surrounding plains, with summer temperatures ranging from 10°C to 25°C and winter temperatures from 0°C to 21°C. The annual rainfall is approximately 1,100 mm, contributing to the unique environmental and commercial dynamics of this high-altitude marketplace.

The study was conducted between August 20 to October 3 2023, with fieldwork carried out twice daily, from 7 AM to 8.30 AM and from 4 PM to 5.30 PM. Employing a population study random sampling method, nesting count, and feeding point count methodology, point count method was adopted to estimate the abundance of House Sparrows. The point count method involves an observer standing in a fixed location for a specified period, in this case for 1 minute and record all the sparrows seen within or without a fixed radius (Bibby et al. 2000). Every path of the market was analyzed and

Fig. 2. The study area Ooty municipal market (Map data ©2024 Google, Imagery ©2024 TerraMetrics)

was separated into 39 paths as given below (Fig. 2). Each Count was done with visible radius by following Dhanya (2011). The research focused on assessing population sizes and sex ratios among individuals. Observations included the sparrows' feeding behavior, both from food scraps on the ground and directly from shop offerings, while the total number of nests was meticulously recorded without causing any disturbance to the habitat. Utilizing binoculars for nest location and a 'Canon 200D Mark 2' camera for capturing images of nests and feeding materials, data collection was thorough. Furthermore, the precise locations of nesting sites within the market area were determined using a Garmin GPS device. Mapping was done with Google Earth. Questionnaire survey consists of 21 questions. These questions were asked in 10 days at ATC market stores.

DATA ANALYSIS

The research conducted a comprehensive analysis of the house sparrow population, focusing on their feeding patterns and habitat preferences. Mean and standard deviation calculations for these parameters were performed using Past software (Hammer, 2001), providing valuable insights into the central tendency and variability of the data. Additionally, a questionnaire survey was administered to shopkeepers in the ATC market to gauge their observations, which were reported as percentages. The analysis incorporated formulas such as the mean (μ) and standard deviation (σ) to quantify the central tendency and spread of the data, enhancing the understanding of the house sparrow dynamics in urban environments.

Fig. 3. Ooty ATC Municipal market- the red lines indicate the transect along which the studies were conducted (Map data ©2024 Google, Imagery ©2024 TerraMetrics)

RESULT

House Sparrow sex composition of population and feeding pattern in the ATC Municipal Market

The data provided offers a comprehensive insight into the population dynamics of male and female sparrows within the ATC market across morning and evening periods (Table 1). In the morning, the male sparrow population ranged from a minimum of 99 to a maximum of 140, with an average of 122.5 individuals, displaying a variation with a standard deviation of approximately 12.92. Similarly, the evening male population ranged from 70 to 154, with an average of 109.64 individuals and a slightly higher variation as indicated by a standard deviation of around 18.24. In contrast, female sparrows exhibited a narrower range of population counts, with morning numbers varying from 29 to 78 and evening counts ranging from 40 to 70. The morning female population had an average of 51.21 individuals and a standard deviation of approximately 10.52, while the evening female population had an average of 54.11 individuals and a slightly lower variation with a standard deviation of around 8.93. These statistics highlight fluctuations in sparrow populations throughout the day, with males generally displaying a wider range and higher variability compared to females. The statistics provided offer a comprehensive view of sparrow feeding patterns in the ATC market, divided by gender and feeding times (Table 2). Morning male feeding sessions exhibit a minimum count of 37 sparrows and a maximum of 73, with an average count of approximately 50.79 sparrows. The standard deviation of 10.03 indicates a moderate level of variability around this mean count. Evening male feeding sessions show similar trends, with a slightly higher mean count of around 51.21 sparrows and a maximum count of 78. Female sparrows, both in the morning and evening, demonstrate a consistent trend with higher mean counts compared to males. Morning female feeding sessions have an average count of 51.21 sparrows and evening sessions around 54.11. The variance and standard deviation for females' counts are slightly lower than those of males, indicating a somewhat tighter distribution of counts. Overall, the data suggests that female sparrows tend to feed

Table 1. Male and female sparrow population across morning and evening periods

Male population morning and evening			Female population morning and evening		
N	28	28	**N**	28	28
Minimum	99	70	**Minimum**	29	40
Maximum	140	154	**Maximum**	78	70
Total	3430	3070	**Total**	1434	1515
Mean	122.5	109.64	**Mean**	51.21	54.1
Std. error	2.44	3.45	**Std. error**	1.99	1.69
Variance	167	332.6	**Variance**	110.6	79.8
Stand. Dev	12.92	18.23	**Stand. Dev**	10.51	8.93
Median	125	111	**Median**	51.5	55

Table 2. Male and female Sparrows feeding patterns across morning and evening periods

	Morning male feeding	Evening male feeding		Morning female feeding	Evening female feeding
N	28	28	**N**	28	28
Minimum	37	29	**Minimum**	29	40
Maximum	73	78	**Maximum**	78	70
Total	1422	1434	**Total**	1434	1515
Mean	50.79	51.21	**Mean**	51.21	54.1
Std. error	1.89	1.99	**Std. error**	1.99	1.69
Variance	100.5	110.6	**Variance**	110.6	79.8
Stand. Dev	10.02	10.5	**Stand. Dev**	10.5	8.93
Median	49.5	51.5	**Median**	51.5	55

more consistently throughout the day compared to males, with slightly higher counts observed in the evening sessions. This information could be valuable for understanding sparrow behavior patterns and potentially informing conservation efforts or urban planning initiatives aimed at supporting local bird populations.

House Sparrows feeding habitat analysis in the ATC Municipal Market (Table 3) (Fig. 6)

Feeding in the Morning:

Pork: Both male and female sparrows showed similar average feeding amounts, with males consuming 1.64 pork meat and females consuming 1.64 pork meat on average. The standard deviation values suggest relatively consistent feeding behavior across genders (Fig. 4).

Fig. 4. Sparrows feeding on pork remnants at market food stands

Beef: Male sparrows consumed an average of 2.16 Beef Meat, slightly higher than females at 1.73 Beef Meat. The variance in feeding amounts was relatively low, indicating consistent consumption patterns.

Chicken: Similar to the evening session, both male and female sparrows showed similar average feeding amounts, with males consuming 1.8 Chicken meat and females consuming 1.7 Chicken meat on average. The standard deviation values suggest relatively consistent feeding behavior across genders.

Vegetable: Male sparrows consumed an average of 12.1 Vegetables, while females consumed 15.07 Vegetables on average. The standard deviation values indicate relatively consistent feeding behavior across genders.

Grain: Male sparrows consumed an average of 17.36 grains, slightly higher than females at 16.96 grains. The standard deviation values suggest relatively consistent feeding behavior across genders.

Table 3. Sparrows feeding habitat analysis in the Morning session

Sparrow feeding morning														
Pork			Beef line			Chicken			Vegetable			Grain		
N	25	25	N	25	26	N	25	24	N	28	28	N	28	28
Minimum	0	0	Minimum	0	0	Minimum	0	1	Minimum	1	4	Minimum	8	8
Maximum	5	6	Maximum	5	4	Maximum	5	3	Maximum	24	25	Maximum	28	35
Total	41	41	Total	54	45	Total	45	41	Total	339	422	Total	486	475
Mean	1.64	1.64	Mean	2.16	1.73	Mean	1.8	1.7	Mean	12.1	15.07	Mean	17.36	16.96
Std. error	0.26	0.28	Std. error	0.26	0.2	Std. error	0.24	0.18	Std. error	1.1	1.09	Std. error	1.04	1.23
Variance	1.66	1.9	Variance	1.72	1	Variance	1.5	0.73	Variance	33.9	33.03	Variance	30	47.1
Stand. Dev	1.3	1.4	Stand. Dev	1.31	1	Stand. Dev	1.22	0.86	Stand. Dev	5.82	5.75	Stand. Dev	5.5	6.9
Median	1	1	Median	2	2	Median	2	1	Median	11.5	15.5	Median	16.5	16

Feeding in the Evening (Table 4):

Pork: The average number of male sparrows fed was approximately 1.32, while for females, it was 1.14. The variability in feeding amounts was relatively low, with a standard deviation of around 0.86 for males and 0.65 for females.

Beef: Male sparrows consumed an average of 2.64 Beef Meat, slightly higher than females at 2.38 Beef Meat. The variance in feeding amounts was higher compared to other feeding materials, indicating greater variability in consumption patterns.

Chicken: Both male and female sparrows showed similar average feeding amounts, with males consuming 1.69 Chicken meat and females consuming 1.58 Chicken meat on average. The standard deviation values suggest relatively consistent feeding behavior across genders.

Vegetable: Male sparrows consumed an average of 12.11 Vegetables, while females consumed 13.04 Vegetables on average. However, the variance and standard deviation values were higher compared to other feeding materials, suggesting greater variability in consumption patterns.

Grain: Male sparrows consumed an average of 19.89 grains, slightly lower than females at 19.43 grains. The standard deviation values indicate relatively consistent feeding behavior across genders, despite the higher average consumption (Fig. 5).

Fig. 5. Sparrow feeding on grains kept in front of the market shop

In both the evening and morning feeding sessions, the highest count feeding for male sparrows were observed in the Grain category. In the evening session, males consumed an average of 19.89 grains, and in the morning session, they consumed an average of 17.36 grains. For female sparrows, the highest count feeding was also observed in the Grain category during the evening session, with an average consumption of 19.43 grains.

Table 4. Sparrows feeding habitat analysis in the Evening session

Sparrow feeding evening														
Pork			Beef line			Chicken			Vegetable			Grain		
N	28	28	N	25	24	N	26	26	N	28	28	N	28	28
Minimum	0	0	Minimum	0	0	Minimum	0	1	Minimum	4	5	Minimum	2	4
Maximum	4	2	Maximum	5	5	Maximum	4	4	Maximum	19	21	Maximum	26	32
Total	37	32	Total	66	57	Total	44	41	Total	339	365	Total	557	544
Mean	1.32	1.14	Mean	2.6	2.4	Mean	1.7	1.6	Mean	12.1	13	Mean	19.9	19.4
Std. error	0.16	0.122	Std. error	0.32	0.24	Std. error	0.16	0.15	Std. error	0.78	0.89	Std. error	1.03	0.89
Variance	0.74	0.42	Variance	2.57	1.46	Variance	0.7	0.65	Variance	17.1	22.4	Variance	29.9	22.4
Stand. Dev	0.86	0.65	Stand. Dev	1.6	1.2	Stand. Dev	0.83	0.8	Stand. Dev	4.13	4.7	Stand. Dev	5.47	4.73
Median	1	1	Median	2	2	Median	2	1	Median	12.5	14	Median	20.5	19

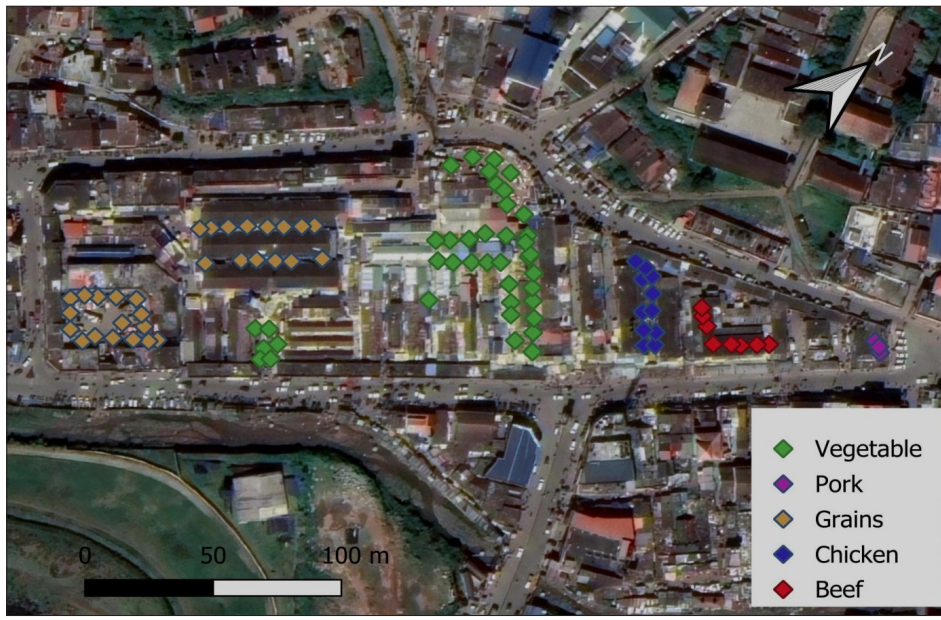

Fig. 6. House sparrows feeding materials in Ooty ATC Municipal market (Map data ©2024 Google, Imagery ©2024 TerraMetrics)

House Sparrows Nesting inside the ATC Municipal Market (Table 5) (Fig. 7 and 9)

Fig. 7. Female sparrow observed occupying an artificial nest box installed by market workers within the market area

In the bustling environment of the ATC market, sparrows have shown remarkable adaptability in nesting preferences. Out of a total of 164 live nests observed, the majority were found in artificial nest boxes (98). Out of the 50 artificial nesting boxes provided

in the market, 38 were occupied by sparrow nests (Jayaraman et al. 2017), showcasing a positive response to provided infrastructure. Mud walls emerged as another favored nesting site, with 25 nests, reflecting the birds' affinity for natural materials. Roof holes and roller shutter gates provided shelter for 20 and 4 nests respectively, suggesting the sparrows' inclination towards elevated spaces. Interestingly, sparrow populations exhibited a propensity for nesting in man-made structures, as evidenced by nests in EB boxes (3), steel pipe holes (12), wooden boxes (1), and plastic pipe holes (1) (Fig. 7). These findings underscore the adaptability of sparrows in urban environments, highlighting the importance of providing suitable nesting habitats amidst anthropogenic landscapes.

Table 5. Sparrow nesting type

Nesting type	Total no of nests
EB box	3
Mud wall	25
Roof holes	20
Steel pipe hole	12
Wooden box	1
Plastic pipe hole	1
Roller shutter gate	4
Artificial nest box	98
Totel	**164**

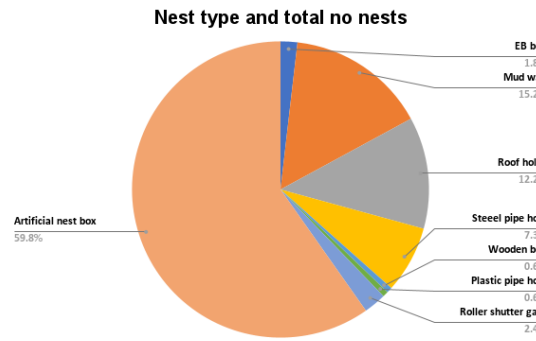

Fig. 8. Nest type and Total no. of nests

Fig. 9. House Sparrows nesting sites inside the ATC Municipal Market (Map data ©2024 Google, Imagery ©2024 TerraMetrics)

House Sparrow Questionnaire Survey inside the ATC market people (Table 6)
A total of 21 questions were asked to ATC market people. These questions are important. The survey reveals a concerning decline in sparrow awareness and conservation efforts, with only 40% of respondents feeding sparrows. Despite acknowledging sparrows as human-friendly (85.71%), there's a lack of action, as indicated by low awareness about biodiversity protection (0%) and prevalent nest removal (91.42%). This highlights an urgent need for education and concerted efforts to reverse sparrow decline.

Table 6. Questionnaire survey

A	B	C	D
S.NO	**QUESTIONS**	**YES**	**NO**
1	Able to identify sparrow?	94.28%	5.71%
2	Differentiate sparrow sex?	48.57%	51.42%
3	Are sparrow[7] seen in you sector?	77.14%	22.85%
4	Is sparrow[7] abundance high in market?	68.57%	31.42%
5	Are the declined comparing previous year?	88.57%	11.42%
6	Do you feed the sparrows and place water?	60%	40%
7	If the bird is about to be predated or any threat to it, do mind helping it in any way?	62.85%	37.15%
8	How do you see this bird (threat /blessing)?	88.57%	11.42%
9	Is the bird seen preadeted ?	54.28%	45.71%
10	Any artificial box kept for sparrow?	45.71%	54.28%
11	Have you cleared away any nest in your shop built by sparrow? (If yes-reason)	91.42%	5.71%
12	Do you believe when you touch a sparrow, their family would deny the bird touched by humans ?	62.85%	37.14%
13	Are nesting seen throughout the year	80%	20%
14	Do they consume meat throughout the year?	22.85%	77.14%
15	Is the uncleaned area in market affect any living?	62.85%	37.14%
16	Which part of the day they are active? Morning/Evening/ Both	62.85%	37.14%
17	SPARROW IS CONSIDERED AS HUMAN FRIENDLY – Do you believe?	85.71%	14.25%
18	Do you believe sparrow declined by Tower | Terrace Building | Pesticides | humans are not friendly with birds?	57.14%	42.85%
19	Have you been given awareness about protecting our biodiversity?	0%	100%
20	Are you worried about the decline?	80%	20%
21	How often do you feed sparrow? Feed dependence/Feed independence	40%	60%

DISCUSSION

The comprehensive analysis sheds light on various aspects of sparrow behavior and ecology within the ATC market environment, focusing particularly on population dynamics, feeding patterns, nesting preferences, and human interactions through a questionnaire survey. This multi-faceted approach offers valuable insights into the

intricate relationship between sparrows and their urban habitat. The population dynamics analysis reveals interesting trends, with male sparrows displaying wider population ranges and higher variability compared to females. This suggests potential differences in behavior or habitat preferences between genders, warranting further investigation. Additionally, the observation of consistent feeding patterns among females throughout the day, with slightly higher counts in the evening, implies a degree of stability in their feeding behavior, which contrasts with the more variable feeding patterns observed in males. The feeding habitat analysis provides detailed information on sparrow dietary preferences, with an unexpected finding that sparrows consume beef, chicken, and pork alongside traditional food sources like grains and vegetables. Rural birds primarily consumed cereal grains and insects, mainly coleopterans. In contrast, urban sparrows had a varied diet, including grains, birdseed, other seeds (primarily mast), and insects (primarily coleopterans). Unlike their rural counterparts, urban sparrows may lack a single abundant and consistently available food source like grains (Gavett et al. 1986). The preference of House Sparrows for introduced cereal grains could elucidate their historical prosperity and potentially contribute to their recent population declines as the supply of agricultural seeds diminishes (Christopher 2015). The abundance of food, including grains, vegetables, and insects particularly caterpillars in vegetables as well as appropriate nesting locations may have a significant role in the sparrow population's high density in rural open spaces and residential buildings (Girish et al. 2012). This observation challenges conventional assumptions about sparrow diets and underscores the adaptability of these birds to urban environments where non-traditional food sources may be abundant. The study's quantification of feeding amounts for different food types further enriches our understanding of sparrow dietary habits, highlighting potential implications for conservation and management strategies. The breeding success of house sparrows in urbanized settings may be limited by a decline in insect prey (which is essential for raising the nestlings), alternative food sources such as grains, and a shortage of suitable nesting locations (Joshi et al. 2022). The nesting behavior analysis emphases sparrows' adaptability to urban landscapes, with a preference for artificial nest boxes Fig. 4 and other man-made structures. This underscores the importance of providing suitable nesting habitats amidst urban development to support sparrow populations, particularly in environments where natural nesting sites may be scarce. The holes in mud walls and compound walls serve as great places for House Sparrows to nest. This suggests that the species is able to adapt to its altered surroundings in GAC Udhagamandalam (Jayaraman et al. 2018). The medium-density urban region has a comparatively greater population of House Sparrows, which may be explained by the abundance of nesting opportunities in the vicinity, such as masonry holes, overhanging roof edges, crevices, etc. (Khera et al. 2010). The questionnaire survey reveals a concerning decline in sparrow awareness and conservation efforts among ATC market visitors. Despite acknowledging sparrows as human-friendly, there

appears to be a disconnect between perception and action, with low awareness about biodiversity protection and prevalent nest removal practices. This highlights the urgent need for educational initiatives and community engagement to raise awareness about sparrow conservation and foster stewardship among the local population. This paper presents a deep and comprehensive research discussion on various aspects of sparrow ecology and behavior within the ATC market environment. The finding of sparrows consuming fresh beef, chicken, and pork (Fig. 2) underscores the complexity of urban wildlife interactions and emphases the importance of further research and conservation efforts to ensure the survival of these adaptable and resilient bird species. By witnessing a house sparrow in a green space in New York City, USA, eat the meat from a discarded chicken "drumstick," we can further our understanding that this species may eat meat as part of its diet (MacGregor-Fors et al 2020). The house sparrow *Passer domesticus* has an atypical feeding habit in the meat market, where it feeds pieces of mutton to its nestlings at Udhagamandalam in the Nilgiris (Karthick et al. 2018).

CONCLUSION

In conclusion, the impending demolition of the ATC market in Ooty poses a significant threat to the local sparrow population, which has thrived in the area due to the availability of food and the presence of artificial nests provided by shopkeepers. With the destruction of their nesting spots, the sparrows face the daunting challenge of finding alternative locations to build their nests, putting their population at risk. Urgent action is needed to mitigate the impact of this disruption on the sparrow community. Efforts should focus on identifying and establishing new nesting sites in close proximity to the former market area to ensure the continued survival and well-being of these beloved birds. Additionally, raising awareness among the local community about the importance of conserving and protecting sparrow habitats is essential for fostering long-term sustainability and coexistence within urban environments.

ACKNOWLEDGEMENT

The authors are heartily thankful to, Mr. Rohan Premkumar from The Hindu and Mr. N. Sadiq Ali founder of Wildlife Nature conservation Trust for the moral support of our work.

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