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From Natural to Anthropogenic: Comparative Analysis of House Crow Nesting Strategies in Urban and Rural Penang Environments

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ABSTRACT

The House Crow (*Corvus splendens*) exhibits exceptional generalist traits that enable its survival across diverse anthropogenic landscapes. Understanding how urbanization influences nesting behavior is crucial for managing this invasive species in Southeast Asia. This study investigates nest composition and identifies key factors influencing nest-site selection across an urbanization gradient in mainland Penang, Malaysia. Two contrasting sites were examined: Seberang Perai Tengah (SPT, urban site) and Seberang Perai Utara (SPU, rural/agricultural site). Forty-seven nests (30 from SPT, 17 from SPU) were systematically collected and analyzed for construction materials. Results revealed dramatic site-specific differences in material selection. Urban nests were dominated by metal wires (52.49% by count, 58.44% by weight), while rural nests primarily utilized natural materials—twigs (46.81% by count) and small branches (41.00% by weight). Both sites demonstrated heavy reliance on anthropogenic resources, with artificial nest materials (waste bins, construction sites, recycling centers, residential areas) more abundant than natural alternatives (95% urban, 73% rural). Nest-site preferences also differed between habitats. Urban crows selected trees with 70-100% canopy cover near food resources (mean distance = 300.35 ± 161.28 m), while rural crows preferred trees 4-9 m tall with canopies <15 m wide near water resources (mean distance = 402.13 ± 233.91 m). These findings highlight the House Crow's remarkable behavioral plasticity in response to urbanization, with nesting strategies shaped by local resource availability and tree architecture, providing insights for urban wildlife management.

Keywords: invasive species; nest materials; anthropogenic resources; natural resources

1. Introduction

The House crow (*Corvus splendens*), introduced to Malaysia in the late 1800s to control agricultural pests [1] has since become a dominant urban species due to its omnivorous diet and behavioral flexibility [2]. In Penang, particularly Seberang Perai, its growth has led to increased human-wildlife conflict, including competition with native birds, noise disturbances [3], and disease transmission [4]. Nesting ecology of *C. splendens* remains understudied in Malaysia. This study attempted to examine nest composition and nest-site selection of House crow in Seberang Perai Utara (SPU) and Seberang Perai Tengah (SPT).

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2. Methodology

2.1 Study Sites

The study was conducted from December 2024 to April 2025 in two regions of Seberang Perai, Penang, Malaysia; Seberang Perai Utara (SPU) and Seberang Perai Tengah (SPT). SPU is represented as suburban areas which included Pantai Robina and Lahar Yooi, while SPT represents urban areas which comprised of Taman Inderawasih, the area of Billion supermarket and Permatang Pauh. Nest samples were collected from Kampung Lahar Yooi and Permatang Pauh.

2.2 Nest collection and spatial mapping

The nests were carefully removed from their tree and were brought to the laboratory for inspection. The nest materials were categorized into plant-based (e.g., twigs, branches, leaves) and anthropogenic (e.g., metal wires, plastic strips, synthetic fibers). To understand nest material resource availability, a spatial mapping of nest material resources was conducted physically (site visit) and remotely (GPS). The location of nearby nest material resources was recorded within a 500-meter radius around each site. These resources were classified as either natural (e.g., vegetation patches) or artificial (e.g., waste dumps, construction sites).

2.3 Nest-site selection assessment

To evaluate nest-site preferences, two categories of variables were measured; macrohabitat parameters and tree features. Macrohabitat assessment included the measurement of the distance from each nesting tree to the food resources (e.g., disposal sites, wet markets) water bodies (e.g., rivers, drainage canals) and nest material resources (e.g., vegetation areas, construction sites). These distances were measured using QGIS v3.42 software.

2.4 Data analyses

To assess the clustering pattern of nest material resources, an Average Nearest Neighbor (ANN) analysis was used in ESRI ArcGIS V10.8.2 software. The ANN analysis calculated the R value (Moore and Carpenter, 1999) that determines how clustered or dispersed the nest material resources were within a particular area ($R < 1$; clustered, $R > 1$; dispersed uniformly, $R = 1$; random). The Z-score interpreted as $Z < -1.96$; highly clustered, $Z > 1.96$; highly dispersed, $-1.96 < Z < 1.96$; random. The P-value determined if the clustering or dispersal was statistically significant. While, Kruskal-Wallis test was used to identify significant differences among three tree types; Roosting Trees (RT), Nesting Tree (NT), and Control Trees (CT). The test was also conducted for the tree feature variables separately.

3. Results & discussion

3.1 Nest Composition Analysis

A total of 46 House crow (*Corvus splendens*) nests were analyzed; 30 from Permatang Pauh (SPT) and 17 from Lahar Yooi (SPU). This analysis revealed distinct patterns in material usage influenced by urbanization. In SPT, metal wires dominated more than half of the nest materials both by count and by weight (Figure 1). Conversely, SPU's nests were composed primarily of twigs and branches by count (Figure 2a), with branches and metal wires dominating by weight (Figure 2b). The incorporation of metal-based materials was notably higher (52.49%) than in other urban areas in India [5; 8.0%]

and Pakistan [6; 5.8%]. Metal wires in nest construction probably serves as structural reinforcement and provides stability for the nest as well as potential deterrence against predators or rival crows due to their shine and sharpness [7]. Plant-based materials usage in suburban nests highlighted the plasticity behavior of House crows where they can utilize any type of nesting materials depending on nest material resources availability. Moreover, the utilization of different types of nesting material might also be related to social learning behaviour among the House crows or other birds [8].

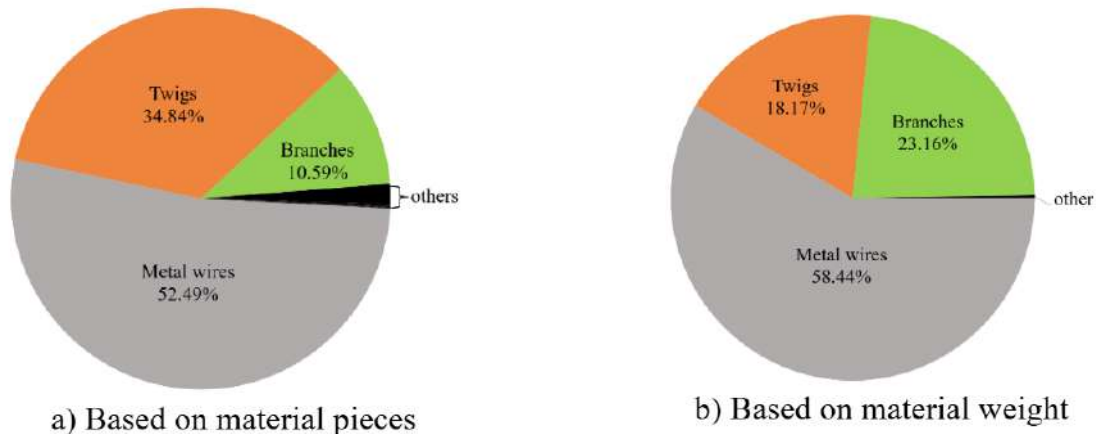


Fig. 1. Nest composition at Seberang Perai Tengah (SPT) based on two different measures

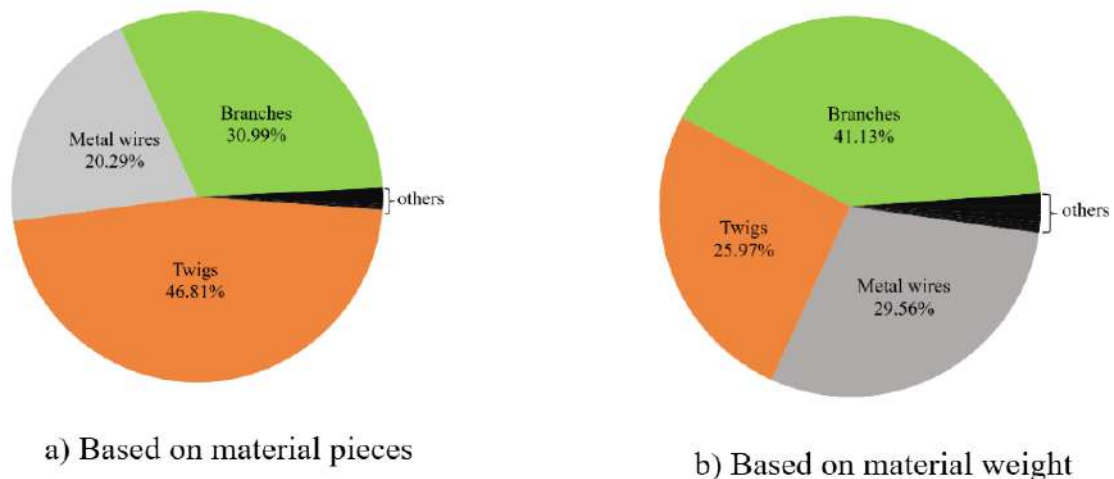


Fig. 2: Nest composition at Seberang Perai Utara (SPU) based on two different measures

3.2 Nest material resources distribution

Although the focal area in SPU (2.3562 km²) was larger than in SPT (1.5708 km²) (Table 1), a higher density of resources was identified in SPT (222 resources/km²) compared to SPU (107 resources/km²). Both study sites dominated by artificial nest material resources (94% in SPT and 74% in SPU). The artificial nest material resources in both SPT (n=330; R= 0.79; z-score= -7.13; p < 0.05) and SPU (n= 186; R= 0.47, z-score= - 13.77; p < 0.05) were significantly clustered, while natural nest material resources displayed contrasting patterns, it dispersed uniformly in SPT (n= 20; R=1.31; z-score= 2.61; p < 0.05) and clustered in SPU (n= 67; R= 0.81; z-score= -2.96; p < 0.05) (Table 2). This suggests that House Crows in SPU benefit from a resource-rich environment where both natural and artificial materials are accessible within short distances, supporting the idea that birds prefer nearby materials to reduce transport effort [9-10] The nests were mostly found in SPT (19 nests/km²)

compared to SPU (6 nests/km²), suggesting that SPT provides more favorable nesting conditions or high resource availability for the species.

Table 1

Summary of nest material resource points in Seberang Perai Tengah (SPT) & Seberang Perai Utara (SPU)

Focal Area	Seberang Perai Tengah			Seberang Perai Utara		
	Artificial Resources	Natural Resources	Number of Nests	Artificial Resources	Natural Resources	Number of Nests
A	131	11	4	34	14	8
B	199	9	26	116	42	1
C	-	-	-	36	11	7
Total	330	20	30	186	67	16

Note: Size for each focal area with 500 m radius = 0.7854 km²

Table 2

Summary of Average Nearest Neighbour (ANN) analysis in Seberang Perai Tengah (SPT) & Seberang Perai Utara (SPU)

Average Nearest Neighbour (ANN)	Seberang Perai Tengah		Seberang Perai Utara	
	Artificial Resources	Natural Resources	Artificial Resources	Natural Resources
R value	0.79	1.31	0.47	0.81
z-score	-7.13	2.60	-13.77	-2.96
p-value	0.000	0.009	0.000	0.003
Distribution pattern	Clustered	Dispersed	Clustered	Clustered

3.2 Influence of macrohabitat and tree features

Nesting trees were located closer to food resources (300.35 ± 161.28 m) in Seberang Perai Tengah (SPT), while they were situated closer to water resources (402.13 ± 233.91 m) in Seberang Perai Utara (SPU). These findings suggest that crows in SPT may prioritize immediate access to anthropogenic food waste, consistent with urban foraging behavior, while those in SPU may benefit from water proximity, potentially linked to roosting or thermoregulation needs. This pattern supports earlier observations by Soh et al. (2002), who noted that House crows often nest near food centers to reduce foraging effort during breeding.

In term of tree features, the canopy cover was the only parameters influencing roosting trees selection in SPT (H (2) =7.147, p=0.028; 70-100% cover) among other parameters, while the roosting trees in SPU had relatively similar canopy cover percentage among the other tree types. The roosting trees in SPT were having sparsely foliated interiors and provided sturdy branches for nocturnal perching. Several studies [11-13] suggest that large crowns help reduce wind velocity and heat loss, and trees near buildings may offer additional shelter from wind and rain [14]. As for the nesting trees in SPT, they had less canopy coverage, medium tree height, narrower canopy width and smaller tree trunk compared to the roosting trees. However, in SPU, the tree height (H (2) =10.64, p=0.005; 4-9 m height), canopy width (H (2) =10.36, p=0.006; <15m wide), and first branch height (H (2) =7.651, p=0.022) significantly influenced the nesting trees. The coastal landscape of SPU is causing the House crows to situated their nests at short trees to reduce the risk of nests being blown away [15]. The nesting tree mostly had narrower canopies, which can prevent wind shear, provide nest stability and access to central branches for nest structural support.

4. Conclusions

This study demonstrates the House crow's adaptive success across urban gradients in Seberang Perai Tengah and Seberang Perai Utara, driven by clustered access to nest materials, strategic

macrohabitat proximity, and selective use of tree features. Urban sites (SPT in this study) showed high reliance on artificial nest material resources and proximity to food, while suburban zones (referring to SPU in this study) offered mixed usage of nesting material and access to water both supporting efficient nesting through localized resource clusters. Tree structural traits influenced nest-site selection, reflecting functional nesting priorities. These findings underscore the species' behavioral plasticity and give insight for management strategies for its ecological impact in urbanising landscapes.

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