

## RESEARCH ARTICLE



## Microhabitat of Endangered Species, *Lonchura oryzivora* in Malang City, Indonesia

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**Corresponding Author:**

Nirmala Ayu Aryanti

Study Program of Forestry  
University of Muhammadiyah  
Malang

E-mail:

nirmalaaryanti@gmail.com

Nirmala Ayu Aryanti<sup>a</sup>, Fahmi Maulana Abdillah<sup>b</sup>, Andini Maya Sari<sup>a,c</sup>, Naresvara Nircela Pradipta<sup>a</sup> and Pramana Yuda<sup>d</sup>

<sup>a</sup> Study Program of Forestry, Faculty of Agriculture-Animal Science, University of Muhammadiyah Malang, Malang 65144, Indonesia

<sup>b</sup> Forestry Service of East Java Provincial - UPT Raden Soerjo Forest Park, Malang 65126, Indonesia

<sup>c</sup> Wildlife Study Group, Study Program of Forestry, University of Muhammadiyah Malang, Malang 65144, Indonesia

<sup>d</sup> Study Program of Biology, Faculty of Biotechnology, University of Atma Jaya Yogyakarta, Yogyakarta 55281, Indonesia

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**Abstract**

Malang City, located in Java, Indonesia, faces significant anthropogenic pressures but remains an important habitat for the endangered Java sparrow (*Lonchura oryzivora*). Understanding how Java sparrows adapt to environments with high levels of human activity is essential for their conservation. This study focused on identifying the distribution of Java sparrows and investigating their habitat selection within Malang City. The bird positions were recorded within the tree canopy, and the frequency of canopy use by the birds was determined. Living in the middle of the city impacts the metabolism of birds, as indicated by taking samples and measuring the levels of lead found in their droppings and vegetation used. Encounters near the center of human activity show they can utilize buildings and vegetation they utilize. The Java sparrows predominantly utilize plant parts at the tree level, particularly focusing on the middle canopy part of the edge (TTt) and the middle part (TT). Laboratory tests revealed that the plants utilized by the Java sparrow contain high lead levels. Therefore, to conserve the Java sparrow, it is crucial to improve the quality of their habitat to make it more natural and conduct regular health monitoring to ensure their well-being.

Keywords: java sparrow, *Lagerstroemia speciosa*, lead pollution, *Lonchura oryzivora*, Malang, urban environment

**1. Introduction**

Malang City is one of the largest cities in East Java Province, with a residential area cover that is more dominant than other land uses. The high population level also impacts the presence of motorized vehicle users in Malang City [1,2]. Urban areas significantly affect health and quality of life, including poor air quality caused by various human activities (vehicle emissions, manufacturing, and waste combustion)[3]. However, there are still green open spaces with a diverse composition of vegetation [4] which support the diversity of biota in the city [5–7]. The presence of vegetation in Malang City, particularly urban forests with a high diversity of plant species, is associated with a high abundance of bird species [5].

The Java sparrow, *Lonchura oryzivora* (family Estrildidae), is an endemic species of Java and Bali. It has been introduced to other islands of Indonesia, reaching Sumatra, Kalimantan, Sulawesi, and Nusa Tenggara, as well as other countries, including Thailand, Philippines, China, Vietnam, Cambodia, Japan, and the Hawaiian Islands. According to the IUCN, it is categorized as an endangered species with a decreasing population trend due to hunting and pollution from agricultural activities, which make the nesting sites vulnerable to damage from development activities [8] and susceptible to avian malaria [9]. The distribution of Java sparrows in Java is scattered across various locations, ranging from forests to residential areas. In East Java, the highest population is in Malang City, where they occupy office areas and official residences of the Malang Regency Government [10] to this day.

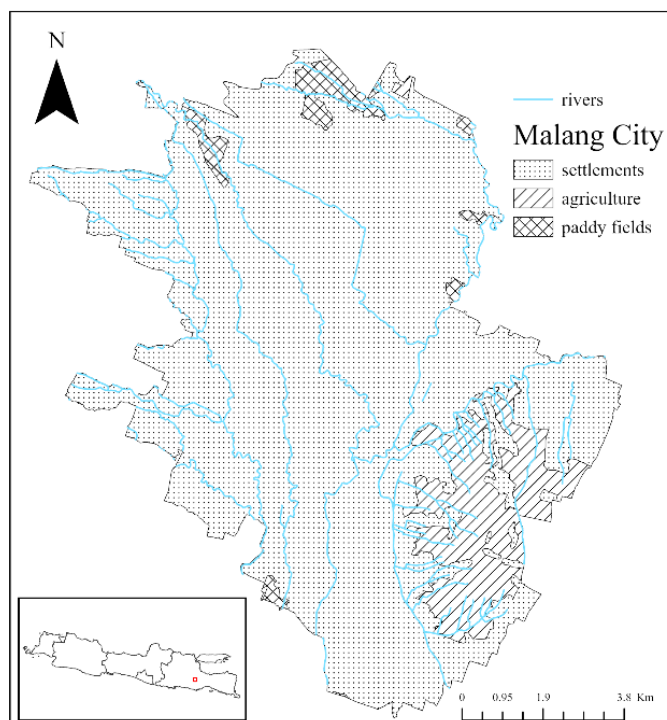
Pollution poses a threat to the health of wildlife living in polluted environments, primarily through oxidative stress induced by common anthropogenic pollutants such as heavy metals, polycyclic aromatic hydrocarbons (PAHs), and nitrogen oxides (NOx) [11]. The impacts of significant pollutants, particularly those affecting reproduction, accumulate and lead to population health issues, increased mortality, the loss of bird species, and the health of

ecosystem functions and services [12]. The variety of bird species in an ecosystem increases the role of each species in the ecosystem. Birds that eat seeds help distribute various plant species, scavenging species prevent infectious diseases by eating carrion, and predatory species biologically control vertebrate and invertebrate pests [13]. Plants or animals select specific resources and environmental conditions to survive and reproduce [14]. The habitat selection process drives wildlife in anthropogenic environments to act optimally, mainly when resources and food types are limited in the available space [15,16].

In this study, we investigate the distribution of Java sparrows to understand how they adapt to anthropogenic conditions with select resources in Malang City for survival. The distribution and habitat selections of Java sparrows in Malang City can show the ability of anthropogenic areas to support wildlife habitats. Our research outcomes could be a source of information for conservation strategies that enhance the city's ecological resilience to protect endangered species.

## 2. Materials and Methods

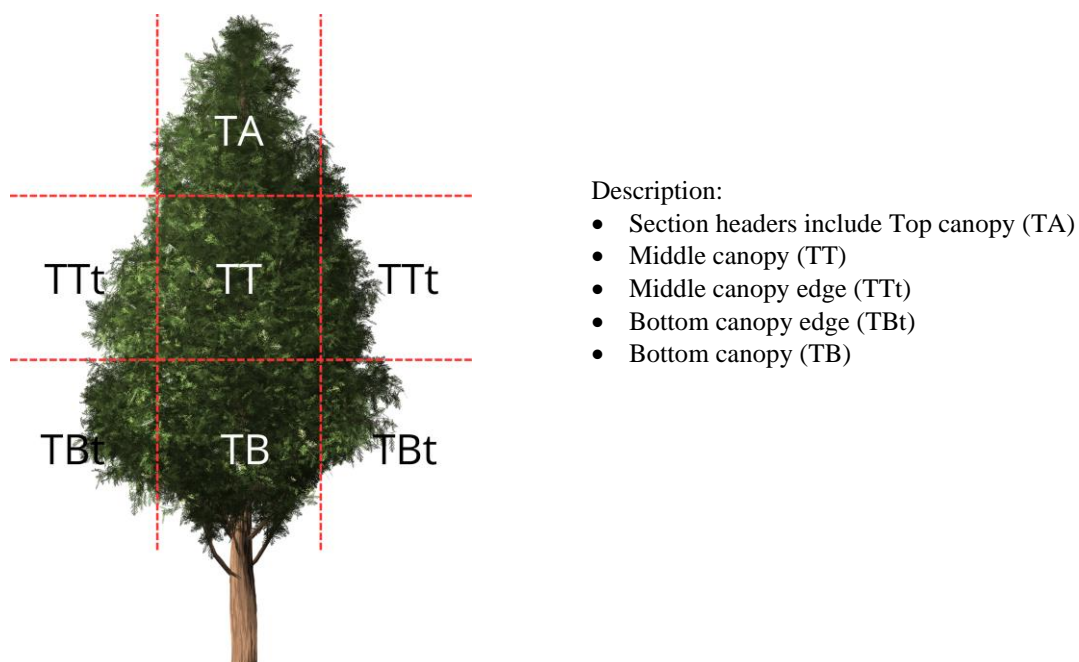
Research on the Java sparrow was conducted by performing a literature review to ascertain its presence in Malang City ( $7^{\circ}58'43.1''S - 112^{\circ}37'54.4''E$ ), which covers an area of 111,077 km<sup>2</sup> and ranges in elevation from 445 to 526 masl (mean above sea level). The land use in Malang City includes rice fields, settlements, and agriculture, with a population growth rate of 0.1% over the last three years. Situated amidst Mount Kawi, Mount Arjuno, and Mount Semeru, Malang City experiences temperatures ranging from 14.8 to 34°C [17]. This research aimed to identify the presence of Java sparrows through direct field observations, a literature review, and mapping using ArcGIS Pro.



**Figure 1.** Survey of the presence and resources utilized by Java sparrow in Malang City.

Observations were conducted in the office area to understand how the Java sparrow utilizes resources in its habitat by recording their locations. Based on these observations (primary) and literature studies (secondary), the highest number of encounters was recorded in the office area and the official residence of the Malang Regency Government ( $7^{\circ}58'57.6''S - 112^{\circ}37'55.3''E$ ). Observations included recording behaviors such as canopy space utilization (Figure 1), perch height and location, using the scan sampling method on observed individuals. This sampling method is commonly employed to observe grouped objects

engaged in activities together [17]. Observations were conducted during Java sparrows' active hours, namely from 06:00 to 09:00 WIB in the morning and from 15:00 to 18:00 WIB in the afternoon.



**Figure 2.** Design of sample positions within the tree canopy in Malang City.

The quality of resources utilized by Java sparrows in office areas and official residences was assessed by sampling plant parts where they are active and collecting their feces. The plants sampled included parts of the *Pinus merkusii* tree, and fresh droppings of Java sparrows were collected in the morning when they gathered to perch. The feces were found around the bottom of the *Pinus merkusii* canopy and on the roof of the building. These samples were analyzed to determine the level of lead (Pb) using Atomic Absorption Spectrophotometry (AAS) [18], conducted at the Analysis and Measurement Unit of the Chemistry Department, Faculty of Mathematics and Natural Sciences, Brawijaya University, Malang. Analysis was used to process data on the canopy space utilization by *Lonchura oryzivora* and was presented with diagrams. The observational data were then analyzed to determine the frequency of canopy use by the birds, using the following formula [17]:

$$\text{Frequency of canopy section use by birds: } \frac{x}{y} \times 100 \% \quad (1)$$

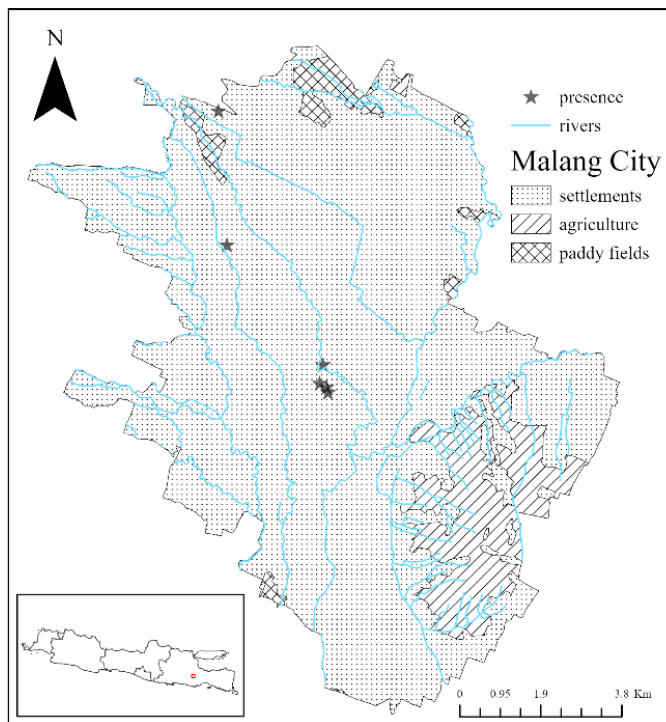
Where x is number of birds during the observation time and y is the total number of birds during the observation time.

### 3. Results and Discussion

#### 3.1. Results

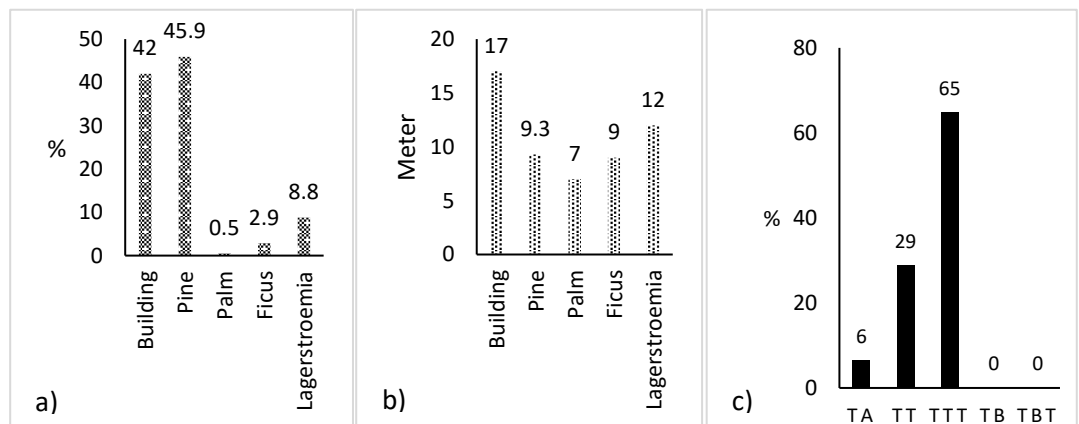
Based on direct surveys, we found a new record of three Java sparrow individuals in the settlements of North Malang City. Many individuals can be found in Malang City based on direct encounters at the animal market (Splendid) and office areas. In 2014, animal markets were also observed selling Java sparrows in small cages [19] with more than four individuals. According to Kurnianto [20], 3–4 individuals of Java sparrows were found at Brawijaya University and we rediscovered two individuals in 2023. All recorded encounters of the Java sparrow in Malang City are in settlement land cover. The Java sparrow was found perching in the office area and official residences of the Malang Regency Government in the center of

Malang City. They were active on buildings and trees, specifically *Pinus merkusii*, *Araucaria cunninghamii*, *Ficus benjamina*, and *Lagerstroemia speciosa*.



**Figure 3.** Map of Java sparrow distribution in Malang City obtained through direct surveys.

The utilization of canopy space by Java sparrows in the urban area of Malang City was found in almost all parts. However, they were more often found in the middle edge canopy (TTt), the middle canopy (TT), and then the upper canopy (TA). Buildings were the most frequent perched site, indicating that they nest on the roof of the building and have lots of bird droppings (Figure 4a). *Lagerstroemia speciosa* was identified as a preferred perching spot for Java sparrows, particularly during seasons when it flowers and produces fruit, offering additional food sources (Figure 5c).



**Figure 4.** The Java sparrow uses habitat components in Malang City (a), percentage of tree canopy utilization (b), and frequency of canopy section use (c) by Java sparrow in Malang City.

Based on the observation results, the Java sparrow extensively uses Pine trees with three dominant canopy sections and buildings. The lead content was tested, and bird droppings were discovered, one of which was found under the trees and building section. Table 1 shows the dissolved lead levels in the Pine tree canopy and feces of Java sparrow. High lead content in the upper canopy (TA) is  $75.69 \text{ mg kg}^{-1}$ , and in the middle canopy (TT) is  $69.59 \text{ mg kg}^{-1}$ .

Both positions are parts of the tree with the highest intensity of Java sparrow activity. The exposure of Java sparrow to lead was confirmed by the results of fecal lead analysis, which reached 205.61 mg kg<sup>-1</sup>.

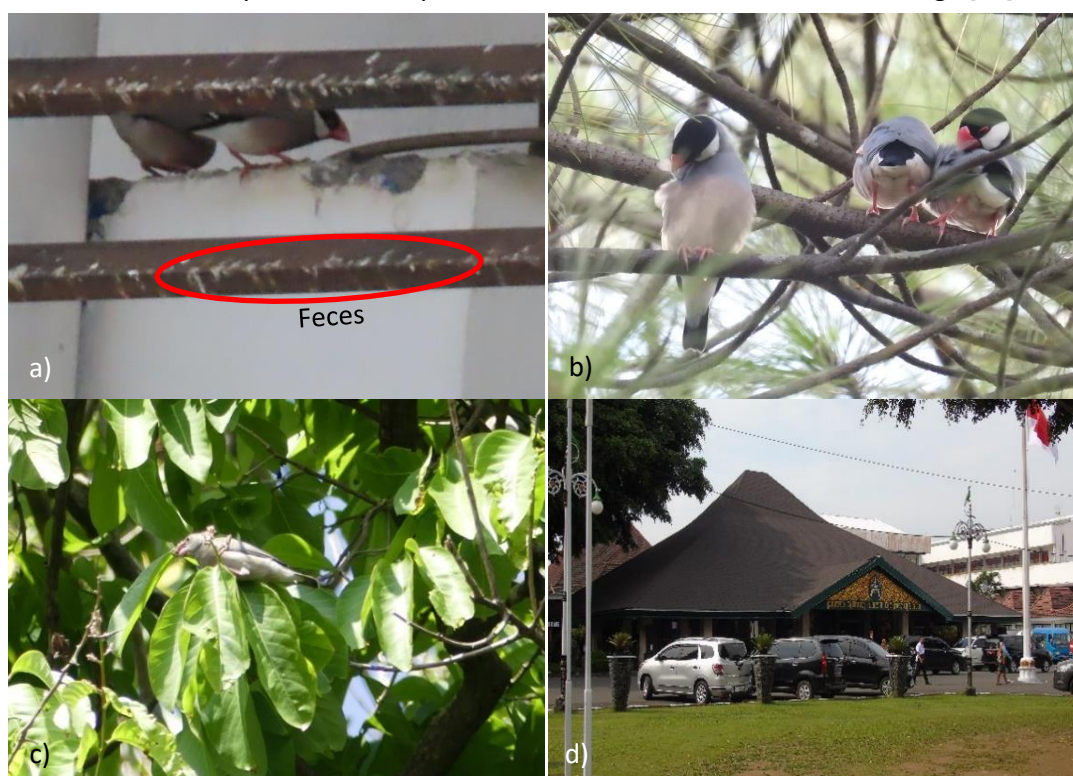
**Table 1.** Dissolved Pb levels in Pine tree canopy and Java sparrow faeces in Malang City

No	Sample	Analysis Results Pb (Lead) content mg kg <sup>-1</sup>
1	Top canopy (TA)	75.69 ± 0.03
2	Lower canopy (TB)	69.59 ± 0.04
3	Middle canopy (TT)	69.59 ± 0.04
4	Middle canopy edge (TTt)	27.59 ± 0.02
5	Faeces	205.61

### 3.2. Discussion

Malang City has a fast population growth rate, resulting in a higher area of residential land. Based on literature studies and direct encounter surveys, it was found that all observations were in residential areas. The existence of the Java sparrow is free but also found to be traded in animal markets in Malang City. Areas heavily modified by humans can support biodiversity, even in endangered species [21,22]. The Java sparrows found in dense settlement showed Malang City can still be a habitat for highly sensitive species in polluted environments [6].

The Java sparrow is found in habitats modified by humans but can survive by utilizing parts of the land that are still vegetated [23]. Java sparrows found in Thailand that prefers more fragmented habitats because they are more heterogeneous for foraging. Many birds occupy buildings and search for seeds in grassy areas [24] compared to consuming grain, especially rice, which can be found in rice fields. In West Bali National Park, Java sparrows live in their natural habitat, which consists of savannah that provides seeds [25]. The presence of wild birds is influenced by the availability of food and the location of their home range [26].



**Figure 5.** The Java sparrow utilizes part of the building (a); *Pinus merkusii* plants in the office area (b); the Java sparrow consumes *Lagerstroemia speciosa* fruit (c); offices and official houses of the Malang Regency Government (d).

The ability of bird species to nest and breed near main roads as office area in Figure 5, indicates their adaptability to the environment. In Malang City, Java sparrows have chosen

locations that allow them to avoid predators. While predators threaten local bird species, they have not adapted to crowded environments like those near highways [27]. Instead, they are more attracted to areas with household waste and more active at night due to quieter conditions [28,29]. The office areas and official residences of the Malang District Government in the city center are surrounded by high-rise buildings and main roads. This bird species is rarely found in forests [30], making the Java sparrow a generalist species capable of utilizing resources in its urban habitat [31].

They typically nest in holes or under the roofs of buildings for shelter and breeding [10,32]. *Pinus merkusii* was frequently observed in this study, often in large numbers, serving various purposes. Like Bachman's Sparrows in Texas inhabiting pine ecosystems, Java sparrows were more commonly found in areas with medium canopy cover, as dense canopy can inhibit the growth of lower plants like grass seeds, which serve as a food source [33]. *Lagerstroemia speciosa* was identified as a preferred perching spot for Java sparrows, particularly during seasons when it flowers and produces fruit, offering additional food sources.

Generally, the sparrow's diet consists of grains [34,35] and seeds [25]. The Java sparrow used canopy space of the TT section is a comfortable and safe place from weather and predators [36]. Canopy space of TTt and TA sections because of the location of *Pinus merkusii* fruits at the end of the trunk, branches, or twigs [37], and makes it easier for birds to move from one tree to another. Many trees in settlements benefit Java sparrows as perches to rest or find shelter from predators or bad weather.

Java sparrows' use of tree canopy space in urban areas potentially negatively impacts these animals. One of the impacts of air pollutants (heavy metals) from fossil fuels in urban areas is the accumulation of lead that sticks to the leaves and bark of twigs in the canopy space with high toxicity [38]. *Pinus nigra* growing in urban Bulgaria has a high lead content in leaves of 2.2–2.7 mg kg<sup>-1</sup> and twigs of 9.6–16.0 mg kg<sup>-1</sup>. The leaves, twigs, and other plant organs can accumulate and translocate the air pollutant lead [39]. The Java sparrow's high dependence on trees for activities will likely expose it to Lead. Lead is an environmental contaminant that negatively affects health, reproduction, and behavior and potentially causes death [40].

Table 1 shows the dissolved lead levels in the pine tree canopy and feces of Java sparrow. High lead content in the upper canopy (TA) is 75.69 mg kg<sup>-1</sup>, and in the middle (TT) is 69.59 mg kg<sup>-1</sup>. Both positions are parts of the tree with the high Java sparrow activity intensity. The exposure of Java sparrow to lead was confirmed by the results of fecal lead analysis, which reached 205.61 mg kg<sup>-1</sup>. In addition to their activities in Pine trees, sparrows perhaps feed on small insects, nectar, and seeds.

In the case of Nevada pine forests in the United States, omnivorous and granivorous birds like the sparrow also eat Ponderosa Pine seeds to survive the winter. Small insects such as spiders, grasshoppers, and caterpillars around Pine trees are also preyed upon [41,42]. Not only from activities but also food sources derived from Pine trees, such as nectar, seeds, and insects, have the potential to be exposed to lead and accumulate in the body of Java sparrow. This research only examined the lead content in frequently used trees and bird droppings.

Lead particles enter the digestive tract and then dissolve in the form of lead salts into the bloodstream and throughout the body. Lead will concentrate in the internal organs of birds, especially the kidneys and bones, for a long time. A portion of the metals in feces is also transported internally through the liver and into the bile [43,44]. Each species and variations between individual species with different diets and physiology cause significant differences in the composition of levels and mass of metals in feces [43].

Lead impact analysis of Striated Heron (*Butorides striatus*) in heavy metal contaminated habitats in the Parana River, South America, showed lead concentrations in the internal organ layers of the bird, namely kidneys at 4.11 mg kg<sup>-1</sup>, feathers at 11.76 mg kg<sup>-1</sup>, and vertebrae between 7.21 and 20.81 mg kg<sup>-1</sup>. However, some cases of chronic lead exposure in Aves showed little sign of toxicity [39]. The lack of signs of toxicity is also shown in the Java sparrow because this species is adaptive and has high nesting and breeding ability.

Despite the advantages of residential areas, there are also threats, such as the decline of Java sparrow populations in urban and natural areas. The potential food available causes their

reproduction to increase, but the poor quality of food available in residential areas can impact the quality of fitness of bird generations [31,45]. The ability to survive in settlements threatens the existence of species with environmental contamination of food sources that have been polluted from chemicals or heavy metals that can affect metabolism in the body [46] in the form of poisoning or fading of feather color [47]. Feather color is the most honest individual quality and influences the process of reproductive success. Pairs of *Paroaria coronata*, with males with brighter plumage, produce more offspring than duller males [48].

However, dense urban areas are unsuitable for Java sparrow habitat, even though they can adapt to human-modified environments. The Java sparrow can survive by maintaining the presence of plants as food sources and nests in urban areas so that it can be considered in urban planning. Urban planning involves developing wildlife-inclusive urban design [49] with various urban parks as terrestrial or aquatic micro-habitats at the landscape scale. Including regulations prohibiting hunting, capture, or nest destruction by locals [50]. Java sparrow populations are most likely to be in local government offices, where they are highly likely to be protected due to their increasingly alarming status. Further research is needed on how declining environmental quality affects Java sparrow reproduction and populations, especially in urban areas.

#### 4. Conclusions

Losing their natural habitats, the Java sparrows can adapt to live in urban areas in Malang City and even support their life, as they come into close contact with pollutants contaminating their habitat components. Heavy metals, such as lead, are highly dissolved in individual birds' feces and plants, serving as potential food sources. The largest population of Java sparrows in Malang City is found in office areas with high human activity, where development activities can threaten their nesting place. This study provides information for decision makers, such as designing legislation for conservation of urban bird diversity. It also provides baseline research for ecological conservation on local governments lands.

#### Author Contributions

**AMS:** Investigation, Writing; **FMA:** Investigation, Writing; **NAA:** Conceptualization, Methodology, Software, Writing, Review & Editing; **NNP:** Conceptualization, Methodology, Writing, Review & Editing; **PY:** Review & Editing.

#### Conflicts of Interest

There are no conflicts to declare.

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