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RESEARCH ARTICLE

Abundance, temporal variation, and microhabitat use of the house sparrow, *Passer domesticus* (Passeriformes: Passeridae), in urban and anthropogenic environments in Northeastern Brazil

Mayara Olinto Vicente[1], Frederico Gustavo Rodrigues França[2], Helder Farias Pereira de Araujo[3]

[1]*Programa de Pós-graduação em Ecologia e Monitoramento Ambiental, Universidade Federal da Paraíba. Campus IV Litoral Norte, 58297-000 Rio Tinto, PB, Brazil.*
[2]*Departamento de Engenharia e Meio Ambiente, Universidade Federal da Paraíba. Campus IV Litoral Norte, 58297-000 Rio Tinto, PB, Brazil.*
[3]*Departamento de Biociências, Universidade Federal da Paraíba. Campus II, 58397-000 Areia, PB, Brazil.*
*Corresponding author: Mayara Olinto Vicente (*mayaraolinto27@gmail.com*)*

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ABSTRACT. The increase in urbanization poses a significant threat to biodiversity, leading to the alteration of natural habitats and intensified competition between native and exotic species. The house sparrow, *Passer domesticus* (Linnaeus, 1758) is a globally widespread exotic and invasive species known for its environmental adaptability. However, recent studies have indicated that degrees of urbanization and microhabitat characteristics can influence house sparrow populations in diverse ways. In this study, we investigated the abundance, temporal variation, and microhabitat use of house sparrows across three areas with varying degrees of urbanization: urban areas (consisting of residential areas, paved streets, and squares), anthropic fields (including pastures and cultivated fields), and forests in Jacaraú, Northeastern Brazil. From October 2017 to September 2018, we employed the point count method to compare the abundance of house sparrows among the different areas. A total of 1880 records of house sparrows were obtained, with 56.3% observed in urban areas, 43.7% in anthropic fields, and none in the forest, indicating significant variations among the study areas. Throughout the year, active birds were observed in both urban areas and anthropic fields. Although no variations in bird abundance were found among the months in urban areas, a significant difference was observed in March (higher abundance) and October (lower abundance) in anthropic fields. The most frequently utilized microhabitats by house sparrows were ground surfaces, man-made structures, and artificial perches, whereas trees were the least used microhabitats. Our findings confirm that both habitat and microhabitat characteristics play crucial roles in determining the abundance and distribution patterns of the species in Brazil. Furthermore, our results suggest that house sparrows avoid using forests, and these environments can act as barriers to the species' distribution. These findings enhance our understanding of the ecological dynamics of house sparrows in Brazil and provide valuable insights for management.

KEY WORDS. Anthropogenic influence, exotic species, synanthropic species, urban adaptation, urban ecology.

INTRODUCTION

A consequence of the increasing urbanization of natural areas is the expansion of potentially invasive species (Everett 2000). These are considered the world's second biggest threat to biodiversity, as they are species whose introduction and dispersal threaten the lives of native species, the economy, and public health in the established area (Hulme 2007, Matos and Pivello 2009, Liebl et al. 2015). As the process of invasion by exotic species spreads, the alternatives to lessen their impact on natural ecosystems also reduce. However, some invasive species have adaptations

that allow them to live in anthropogenic ecosystems where human action does not interfere negatively and where they avoid competition with native species (Sol et al. 2002, Zalba and Ziller 2007, Guimarães 2012). Some of them have demographic parameters that exceed those of species that inhabit natural environments, such as larger populations, faster growth rates, and higher productivity, which reflect different modes, behaviors, and adaptations of these organisms to cities (McKinney 2006, Marzluff 2017).

The house sparrow, *Passer domesticus* (Linnaeus, 1758), is a small passerine native to parts of Asia, North Africa, and most of Europe, but has successfully established populations worldwide, including North America, Australia, South Africa, and South America (Hanson et al. 2020, BirdLife International 2023). It is a highly adaptable species, thriving in diverse habitats ranging from urban areas to rural landscapes. The house sparrows are not typically considered a characteristic or dominant species in natural forest ecosystems. Their presence in forests is usually scarce. The species is generally associated with human-mediated factors such as residential areas (houses, flats), allotments, gardens, and agricultural fields, where they find supplementary foraging sites, food sources, and nesting opportunities (Ramos-Elvira et al. 2023). In more remote and undisturbed forests, other bird species are usually more prevalent and adapted to specific ecological conditions (Menon et al. 2013). Due to their adaptability and close association with human habitats, house sparrows have become an important model species for urban ecology studies and avian behavior research (Shaw et al. 2008). Investigations into the species' response to urbanization have highlighted the influence of human-altered environments on their distribution and population dynamics. Genetic studies have provided insights into the evolutionary history of house sparrows and their ability to adapt to various ecological conditions (Liebl et al. 2015).

In Brazil, the house sparrow is considered an invasive exotic species, being registered in 2154 municipalities in 26 states (Lim and Sodhi 2004, Anderson 2016, Ferreira 2017, Wikiaves 2023). The species is among the most abundant birds in Brazilian urbanized areas (Carvalho 2012). The house sparrow arrived in Brazil in 1903, when it was introduced in Rio de Janeiro by the mayor at the time, whose objective was to carry out the biological control of invertebrates that threatened the health of the population and local plantations (Liebl et al. 2015, Wikiaves 2023). However, it became unwanted in several places because they are hosts and transmitters of parasites, for example, *Salmonella enterica*, *Toxoplasma gondii*, *Neospora caninum*, *Triatoma sordida*, and helminths (Brasil and Amato 1992, Pennycott et al. 2006, Gondim et al. 2010, GISD 2019, Santos et al. 2020).

Despite their wide distribution in Brazil, it's extremely limited the occurrence of the house sparrow in extensive forest areas, with several occurrence gaps in forest environments of Amazonia, Cerrado, and Atlantic Forest regions (Ferreira 2017). This absence may be due to negative interactions with native forest passerines, or ecological barriers arising from the structure of the natural ecosystem, which may not benefit the occurrence of the species (Anderson 2006), leading to a preference of the species for open, urbanized landscapes. Herein, we recorded the abundance of the house sparrow in Jacaraú, Northeastern Brazil, to evaluate how species occur in forests, anthropogenic grassland, and urban habitats. We also verified the variation of the occurrences during a year and the preference for the use of specific microhabitats.

MATERIAL AND METHODS

Study Area

The study was conducted in the municipality of Jacaraú (Fig. 1), state of Paraíba, 73 km from the capital João Pessoa, located in the Immediate Geographical Region of Mamanguape – Rio Tinto. It has an estimated population of 14,450 inhabitants and a land area equivalent to 253,033 km^2. It presents a tropical rainy climate with a dry summer and is represented by two regional ecosystems, Caatinga and Atlantic Forest (IBGE 2020) – AsKöppen climate classification, Tropical savanna with dry summer with Driest month precipitation in summer is less than 60 mm.

To allocate sample units in different habitat conditions, three habitat areas were established within the municipality boundary; these areas were classified as urban areas, anthropogenic grassland, and forest (Fig. 1).

The urban area (6°36'53.75"S, 35°17'28.60"W) covers 86 ha, which makes it possible to picture major changes in the natural landscape, continuous construction, a high number of artificial perches (poles, wires), a larger number of residents and random presence of trees and bushes. The Anthropic field (6°36'59.59"S, 35°16'42.65"W) cover 75 ha and is characterized by the presence of pastures, scattered trees and bushes, and agricultural crop, reduction in the number of buildings and inhabitants. This environment does not have paving, being found only dirty roads. The forest (6°37'7.00"S, 35°15'47.62"W) covers 111 ha, being a natural patch of the Atlantic Forest, with the presence of shrubs, low trees, and grasses on the edges. This environment does

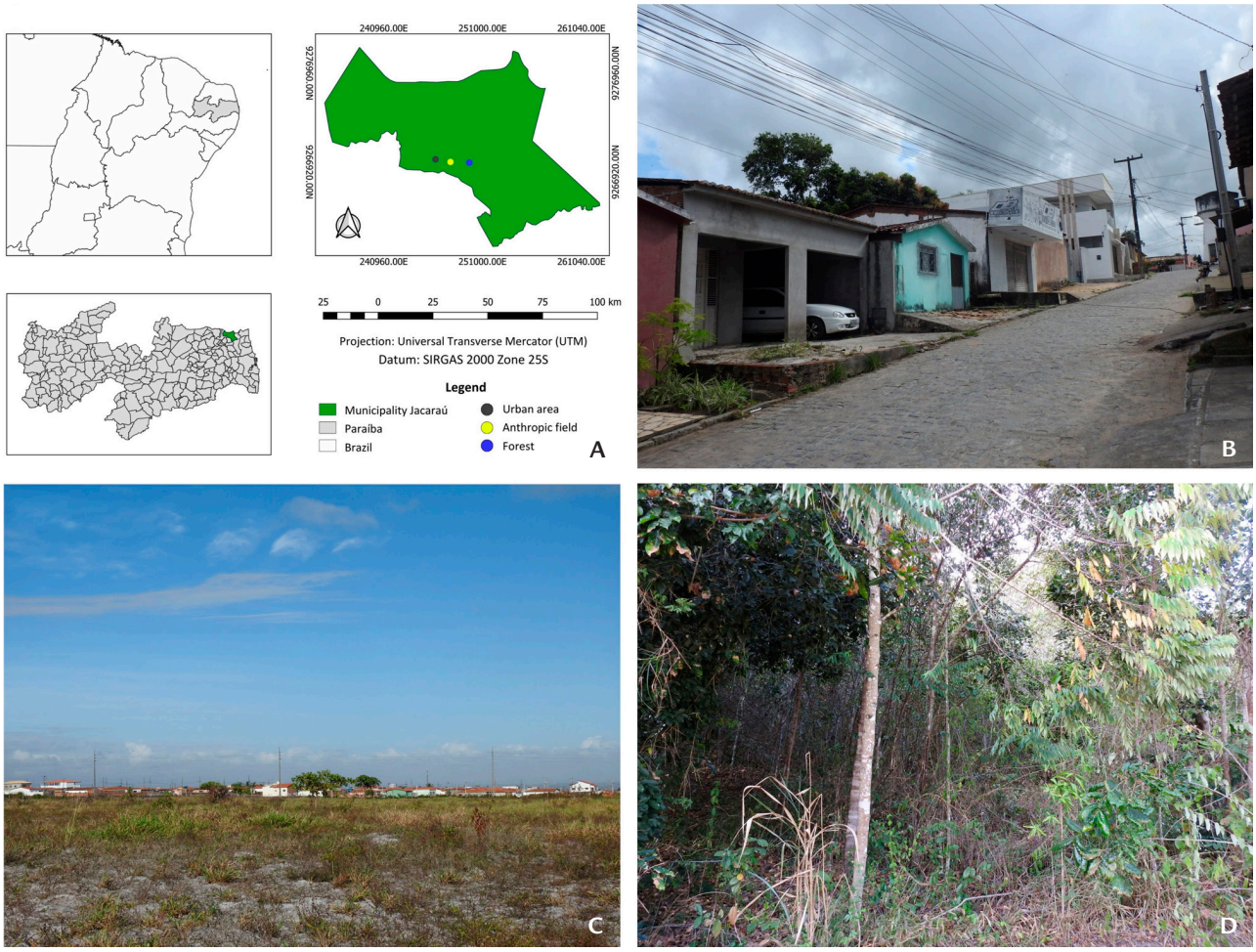

Figure 1. (A) Schematic map showing the study area: Jacaraú, Paraíba, northeast Brazil; (B–D) surveyed environments: (B) urban area of the city of Jacaraú; (C) anthropic field; (D) forest. Photos: Mayara O. Vicente.

not have the presence of constructions or buildings, but there is anthropic interference, such as sugar cane crops, in its boundaries.

Field sampling

We used the point count method (Bibby et al. 2000) to determine the house sparrow relative abundance in each area. All surveys were conducted between October 2017 and September 2018, being three consecutive days of counting per month.

We conducted 10 points in each habitat area per month totaling 120 points per habitat. The points were randomly selected, and the birds were surveyed inside a 50 m circumference radius for each point. The points were separated by at least 200 m or more from each other. The searches took five minutes per point, and they were conducted at sunrise, between 5:30 a.m. and 7:30 a.m. All surveys were conducted by the same researcher, and the records were made visual and auditory, being some specimens photographed and recorded (Fig. 2)

The microhabitat structures used by house sparrows during sampling were based on personal observations and followed the groups: (A) Trees – includes sparrow individuals observed in herbs, tree branches, and bushes; (B) Ground – gathers individuals observed on exposed soil, soil with vegetation and on paving; (C) Buildings – includes individuals observed in residential modifications or man-made structures that may serve as nesting sites for the sparrow, such as roofs, walls of houses, satellite dishes and air conditioners; (D) Artificial perches – attaches individuals

Figure 2. The house sparrow *Passer domesticus* in Jacaraú, northeast Brazil: (A) a male using a building microhabitat; (B) a female on the ground. Photos: Mayara O. Vicente.

observed during landing to structures such as poles, wires and fences. Each observed sparrow was categorized into one of the groupings presented.

Data Analyzes

To analyze variations in sparrow abundance between sampled habitat areas, microhabitats, and seasonality throughout the year, we performed Kruskal-Wallis tests, with the post-hoc Nemenyi (Elliott and Hynan 2011). The analysis was conducted in the RStudio statistical software (version 1.1.456) using the "PMCMR" package (Pohlert 2014). For all analyses, a 95% confidence interval was considered. Through seasonality, we intend to verify if there is temporal variation in the abundance of the species or if it is a resident.

RESULTS

We recorded 1,880 house sparrows at the counting points for one one-year survey, being 56.3% registered in the urban area, 43.7% in the anthropic field, and none in the forest. There was a significant difference among the sampled habitat areas (KW-x^2 = 26.141; df = 3; p < 0,01), with forest records significantly different in urban and anthropic field (p > 0.05). However, no difference between the urban area and the anthropic field (p > 0.05) (Fig. 3).

There was no temporal variation in the abundance of house sparrows recorded in the urban area (KW-x^2 = 9.8063; df = 11; p > 0.05). However, there was a significant temporal variation (KW-x^2 = 27.012; df = 11; p < 0.05) in the anthropic field, and March was the month of greatest contact with the species and October and January were the least (Fig. 4).

There was a significant difference in the use of micro-habitat structures in the urban area (KW-x^2 = 25.456; df = 3; p < 0.01) and in the anthropic field (KW-x^2 = 23.822; df = 3; p < 0.01). Most records were done on ground and artificial perches in the urban area, significantly differing from the record on trees (p < 0.01). In the anthropic field, the highest numbers of contacts were on the ground, constructions, and perches, which differed significantly from trees (p < 0.01) (Fig. 5).

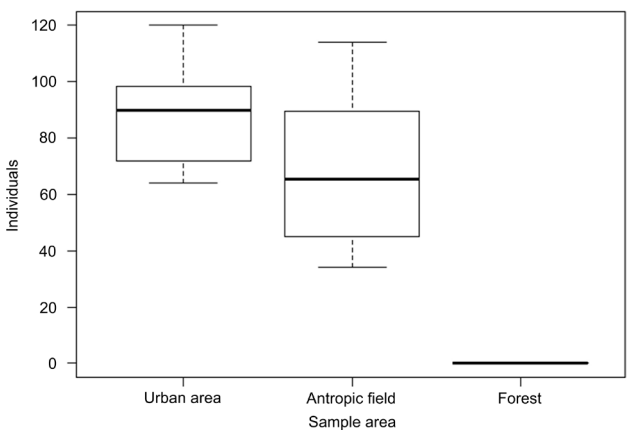

Figure 3. Variation in house sparrow, *Passer domesticus,* abundance between environments with different levels of urbanization. In Boxplot, the box is delimited by the 1st and 3rd quartiles, the median is represented by the horizontal line inside the box, and the extreme vertical lines represent the minimum and maximum values.

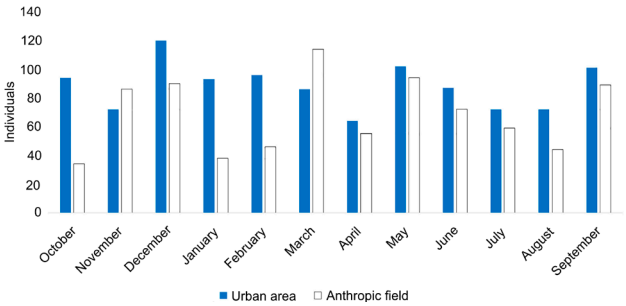

Figure 4. Temporal distribution of house sparrow, *Passer domesticus*, abundance in the urban area and the anthropic field, from October 2017 to September 2018.

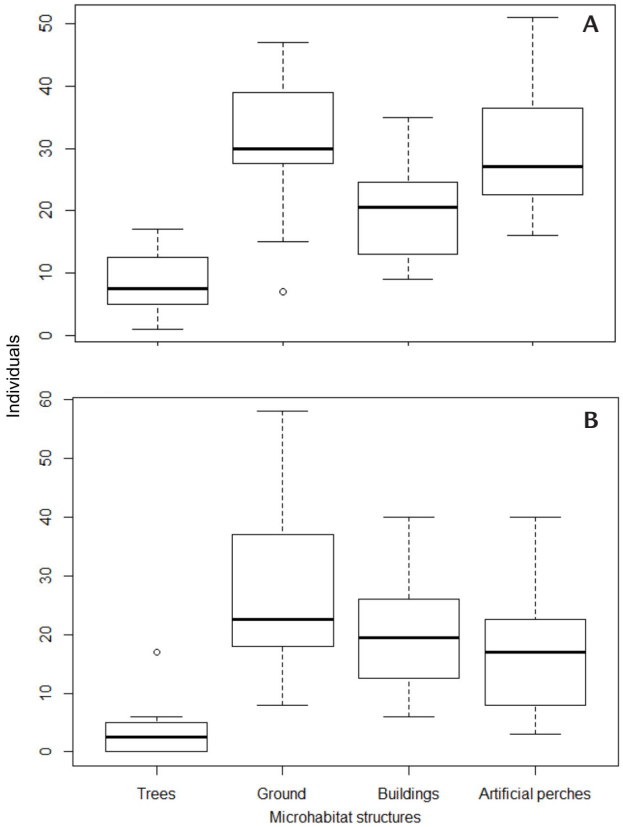

Figure 5. Variation in the use of microhabitat structures from October 2017 to September 2018: (A) urban area; (B) anthropic field.

DISCUSSION

Our findings support the evidence that the house sparrow occurs in anthropic habitats and avoids natural habitats, but there is a temporal variation in their abundance in different anthropic habitats. While house sparrows are abundant in the cities for the whole year, there is a temporal variation in abundance in the anthropic fields. Human buildings are the main microhabitats used by house sparrows during activity, such as ground surfaces, man-made structures, and artificial perches, and trees are often avoided for this period. These data about habitat use and population abundance provides evidence about the biological association of the house sparrow with anthropic habitats and their potential dispersion ease when natural landscapes are modified.

The absence of individuals in the forests, coupled with their presence in anthropogenic environments utilizing diverse structures, provides evidence that urban areas in northeast Brazil can positively impact the population of the house sparrow. This preference for urbanized environments has also been explored in population studies of the species in other Brazilian regions (Lima 2012, Ferreira 2017, Hanson et al. 2020). These areas offer more suitable locations for feeding and nesting, provide escape from predators, and are less influenced by competitors such as the Saffron Finch, *Sicalis flaveola* (Linnaeus, 1766) (Alexandre et al. 2022). Consequently, the house sparrow has become one of the most successful birds in large Brazilian cities such as São Paulo, Rio de Janeiro, and Brasília. However, it is not prevalent in cities in northern Brazil (Sick 1997, Ferreira 2017), which are surrounded by the Amazon Forest, which may act as a barrier to the species' dispersal.

Areas inhabited by house sparrows can influence the composition and structure of native passerine bird communities through synergistic interactions with human activities (Bokony et al. 2010). Certain behavioral traits and habits have contributed to the global success of house sparrow populations. These include their aggressive behavior, such as attacking birds of smaller or similar size in foraging areas and actively destroying the nests of other species (Gowaty 1984, Kimball 1997, Macgregor-Fors et al. 2010). In Northeast Brazil, this aggressive behavior is exemplified in interactions with two native species: the Tropical Wren, *Troglodytes musculus* Naumann, 1823, known locally as "corruíras", and the Brazilian Canary, *Sicalis flaveola brasiliensis* (Gmelin, 1789). House sparrows commonly displace wrens from nesting sites, leading to direct competition for these locations. This competition arises because both species exhibit similar nesting behaviors, such as occupying cavities in human-made structures. Exotic sparrows also deter other birds from feeders by their habit of flocking and vocalizing loudly, displaying threatening behaviors, and harassing other birds. This behavior can permanently drive away other birds,

as observed with canaries during foraging in the presence of house sparrows (Sick 1997).

As a synanthropic species, it can be found in cities as well as suburbs and farmlands. We observed a significant abundance of species in anthropogenic grasslands. This adaptation to living in urban environments and open agricultural ecosystems aids in the species' dispersal, facilitating the expansion of the sparrow across all continents except Antarctica, always in proximity to human habitations (Hanson et al. 2020). Although plantations are adjacent to forest areas, we only recorded house sparrows in plantations and not in forests. The occurrence of the species in north Brazil is scarce, with current records spatially related to open roads cutting through the Amazon rainforest (Ferreira 2017, Wikiaves 2023). The house sparrow is a synanthropic species that can experience population reduction where human actions are a contributing factor to population exclusion (Ravinet et al. 2018), such as reforestation practices, for instance. Climatic and vegetation variables significantly influence house sparrows dispersion, underscoring the importance of environmental conditions on population persistence since several sparrow populations are declining (Geue et al. 2016). These studies conducted with populations in Romania and Bulgaria highlight road construction in forest areas as creating favorable environments for its dispersal and population expansions and suggest that reforestation actions can reduce its distribution (Anderson 2006, Geue et al. 2016).

We observed seasonal variation in house sparrow abundance in pastures or anthropic fields but not in urban areas, indicating that while the species remains active throughout the year in cities, its activity may be influenced by climate conditions in environments with fewer refuges. March and April, when there was the greatest contact with the species, are months with high rainfall rates in the municipality, while October and November have less rainfall and the contacts were the least. However, other studied Brazilian regions with different climatic regimes also reported that the species was active and abundant throughout the year (Sacco et al. 2013, Cardoso et al. 2013, Franchin 2003). Therefore, to manage this exotic species in Brazil, it's important to understand the influence of climate and habitat associated with their reproductive period throughout the year, with built-up environments favoring nesting areas (Furtado 1979, Ferreira 2017).

We frequently observe individuals of the species utilizing man-made structures, such as buildings and artificial perches. These structures provide nesting sites and protect roosting locations. A study conducted in central Brazil demonstrated that while perches did not influence the richness and abundance of local avifauna, their implementation in degraded areas attracted sparrow populations (Guimarães 2014). Sparrows benefit from architectural structures less than 5 m in height. Despite their adaptation to urban environments, the presence of grasses enhances their use of urban landscapes (Alexandre et al. 2022). However, the use of cavities in buildings can also aid in the dispersion of zoonoses, posing potential harm to people cohabiting with these urban birds, such as house sparrows or domestic pigeons (Forattini et al. 1971). To mitigate this risk, it is crucial to raise public awareness to prevent direct contact with the birds (Araújo et al. 2016). Finally, we recorded the highest number of individuals on the ground, as the sampling time coincided with these birds' foraging time (Scherer et al. 2010). The house sparrow exhibits a generalist habit, incorporating a range of items into its diet, from grains to remnants of human food. This feeding habit is one of the characteristics that benefit synanthropic birds since humans produce a lot of resources for them (Silveira 2012, Ribeiro and Cristo 2017).

Final remarks

Our findings highlight the adaptability of house sparrows to urban and anthropogenic environments, where they exploit specific microhabitats to meet their ecological requirements. Its aversion to forests can create conditions to prevent or control the expansion of the species since the house sparrow is an exotic species. Future studies should continue to monitor the impact of environmental changes on sparrow populations, given their sensitivity to climatic and habitat variables. This could provide valuable insights into urban ecology and the effects of anthropogenic influence on wildlife.

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MOV: Conceptualization, Formal Analysis, Resources, Project administration, Writing – original draft, Writing – review & editing. HFPA: Conceptualization, Formal Analysis, Resources, Project administration, Writing – original draft, Writing – review & editing. FGRF: Writing – review & editing.

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