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Will Brazilian City Dwellers Actively Engage in Urban Conservation? A Case Study with the Charismatic Neotropical Blue-and-Yellow Macaw (*Ara ararauna*)

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Simple Summary: The Blue-and-yellow macaw (*Ara ararauna*) is a charismatic and easily recognized species. In Brazil, this macaw is strongly linked to a key habitat, the Cerrado biome, which is a predominantly dry forest savanna. Ara ararauna occurs and breeds in the city of Rondonópolis, a medium-sized city located in Mato Grosso, in the Central-West Region of Brazil. Rondonópolis was, until recently, surrounded by Cerrado habitat. That Cerrado habitat is now greatly threatened by agriculture and forest loss. Blue-and-yellow macaw pairs nest in the tops of dead palm trees, but as the macaws are nest-site limited and suitable nest sites are becoming scarce due to habitat loss, their range is shrinking. Blue-and-yellow macaws do not typically nest in urban areas, but in Rondonópolis, 11 pairs nest in dead palm trees, typically planted on road verges. However, as suitable dead trees are very scarce in urban areas, we are investigating whether the installation of artificial nest sites in domestic backyards could help that urban population thrive, with benefits to the species, and also as an encouragement to help local people engage with biodiversity loss. As a first step, we asked if local people would be willing to engage with conservation efforts and support macaw conservation in the city. To accomplish this, we surveyed the attitudes of Rondonópolis residents to measure: (1) citizens' preferences among the bird species that occur in the city; (2) the average area of their yards, and (3) the willingness of residents to: (a) plant fruit trees to attract macaws to their yards and (b) to install artificial nests in their yards. Overall, people were able to identify half of our sample of local bird species, and almost half had seen a nest site. Large, colorful species (macaws, toucan) were much more popular. The great majority would be willing to plant fruit trees (78%) and provide nest sites (70%) for macaws. This willingness to engage was not affected by socioeconomic differences, suggesting widespread support for this charismatic species.

Abstract: The Blue-and-yellow macaw (*Ara ararauna*) is a charismatic and easily recognized species. While they are classified as being of "least concern" in the International Union for Conservation of Nature (IUCN) Red List, their populations are declining. In Brazil, the accelerated destruction of one of its key habitats, the Cerrado biome, is a principal cause of their decreasing abundance. As with other species affected by loss of the Cerrado, active conservation measures are required. While

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usually rare in urban ecosystems, *Ara ararauna* occurs and breeds in small numbers in the city of Rondonópolis, a medium-sized city located in Mato Grosso, Central-West Region of Brazil. Blue-and-yellow macaw pairs nest in the tops of dead palm trees, but as the macaws are nest-site limited and suitable dead trees are scarce in urban areas, the installation of artificial nest sites in domestic backyards could help that urban population to thrive. To investigate whether local people would be willing to engage with conservation efforts and in particular to support macaw conservation, we surveyed the attitudes of Rondonópolis residents to measure: (1) citizens' preferences among the bird species that occur in the city; (2) the average area of their yards, and (3) the willingness of residents to: (a) plant fruit trees to attract macaws to their yards and (b) to install artificial nests in their yards. Larger and more colorful birds (*Ara ararauna,* the Red-and-green macaw *Ara chloropterus* and Toco Toucan *Ramphastos toco*) were the bird species most valued across all socio-economic groups, suggesting that the charismatic species would be more likely to be supported by urbanites. Overall, people had good biodiversity knowledge, with respondents being able to identify half of our sample of local bird species, on average, and almost half had seen a nest site. The great majority were willing to plant fruit trees (78%) and provide nest sites (70%) for macaws. This willingness to engage was not affected by socioeconomic differences. These data indicate that a municipal macaw conservation program could be successful in Rondonópolis, and we argue that macaws could be a flagship species which would benefit wider efforts to engage Brazilian urbanites in active engagement with nature.

Keywords: urban ecology; tropical cities; urban biodiversity; birds; *Ara ararauna*; backyards; Brazil; Cerrado biome; *Ara chloropterus*; *Ramphastos toco*

1. Introduction

> *Some, rolinha/Anda, andorinha/Te esconde, bem-te-vi/Voa, bicudo/Voa, sanhaço/Vai, juriti/Bico calado/Toma cuidado/Que o homem vem aí/O homem vem aí/O homem vem aí . . .*
>
> *Get away, dove/Fly, swallow/Hide yourself, great kiskadee/Fly, great-billed seed finch/Fly, palm tanager/Go, grey-fronted dove/Be quiet/Be careful/'Cause the man comes here/The man comes there/The man comes there...*
>
> *(Passaredo, song by Brazilian musician and poet Chico Buarque de Hollanda, 1976: https://www.youtube.com/watch?v=y0WuNttlt8Q accessed on 8 November 2021)*

The Cerrado biome is a neotropical savanna that covers approximately 26% of Brazilian territory and is considered a global biodiversity hotspot [1,2]. Biodiversity hotspots are endemic species-rich environments threatened by anthropogenic influences; therefore, they are considered priority conservation areas [3]. At least 4800 plant and vertebrate species are endemic to this biome, whose annual deforestation rate (1%) is 2.5 times higher than that of the Amazon biome. Its legally protected areas only cover 7.5% of this biome [4]; moreover, there is widespread illegal deforestation in Cerrado remnants located in rural properties [2,5].

In total to date, 1971 bird species have been identified in Brazil [6], of which 1044 (53%) have been recorded in the Cerrado biome [7]. Among them, one finds the Blue-and-yellow macaw (*Ara ararauna*, Psittacidae), a large charismatic species which is found in tropical South and Central America. In Brazil, this species is observed in the Amazon, Pantanal and Cerrado biomes. However, despite this species' wide geographic distribution, the number of *Ara ararauna* populations has been declining in Brazil and in other Latin American countries [8–10]. Reduced availability of food sources resulting from deforestation and the capture of macaws for the illegal pet trade are two major causes of the decline [11].

The question arises as to how we can turn cities in the *Cerrado* region into more biodiversity friendly places to help mitigate the devastation observed in this biome [12]. Much of the loss of the Cerrado biome results from deforestation and the transformation of land for agricultural purposes, which results in the loss of habitat and most importantly nest sites, for Blue-and-yellow macaws. The macaws nest in the tops of dead palm trees [8],

and recently, they have started occasionally using dead palms in urban areas. Palm trees are occasionally planted by municipal authorities alongside roads, and as they mature and die, small numbers provide suitable nest sites [12].

Rondonópolis is a medium-sized city typical of the Cerrado region, and *Ara ararauna* is today found in small numbers within its urban boundaries, where the availability of food sources and nesting sites are beneficial for this population. It is also possible that urban parrot populations may be less exposed to poaching, so that cities could act as refuges for them [13]. Rondonópolis is primarily a horizontal city, i.e., it has thousands of backyards—places adjacent to individuals' houses—that could provide resources for macaws and other charismatic species. While this would directly benefit the macaws, it would also help engage the local community with biodiversity. Such relationships between bird feeding and species of conservation interest is seen throughout the world [14]; in the UK, a globally declining large raptor, the Red Kite *Milvus milvus*, is now a frequent visitor to urban areas as householders feed them [15,16]. However, backyards are private spaces. Thus, any effort to conserve biological diversity in them must be supported by their owners.

Ara ararauna populations have been observed in urban ecosystems in recent years, most likely due to the devastation of their natural habitats in the *Cerrado* biome. These birds have been observed in Brazilian cities such as Sinop (Mato Grosso Antbird), Sete Lagoas (Minas Gerais Tyrannulet), Campo Grande (Mato Grosso do Sul) and Rondonópolis (Neiva Guedes, Instituto Arara Azul, pers. comm.). The introduction of native and exotic plants in domestic backyards is an important food source for urban *Ara ararauna* [8,12]. Red-and-green macaws (*Ara chloropterus*) and Toco Toucans (*Ramphastos toco*) have also been recently recorded in urban Rondonópolis City; planting fruit trees in backyards would likely be beneficial for these species, whose populations are also declining. Finally, the charismatic nature of species such as *Ara ararauna*, *Ara chloropterus* and *Ramphastos toco* can be used to facilitate the discussion with Rondonópolis residents about future actions supporting bird conservation, such as planting fruit trees and installing artificial nests in their backyards.

Eleven pairs of *Ara ararauna* nested in the trunks of dead palm trees of the Caribbean royal palm *Roystonea oleraceae* in Rondonópolis City in 2020 (Figure 1), and we have observed competition between pairs for the dead palm trees (João Bohrer, unpublished data). For comparison purposes, fifteen nests of feral Blue-and-yellow macaw were found in a survey of Miami-Dade County, FL, USA [17]. The Caribbean royal palm is native to northern South America and parts of the Caribbean. This species is planted for ornamental purposes by municipal authorities alongside roads in small numbers. In Rondonópolis, *Roystonea oleraceae* is also sometimes planted as a horticultural feature in the gardens of upper-middle class families (Angeoletto, pers. obs). However, this resource is scarce, the trees take many years to grow, and dead palms are considered unsightly and are replaced (Angeoletto, pers. obs). Blue-and-yellow macaws will nest in artificial wood-made nests [18]. If available, these artificial nest sites could replace the limiting reliance on suitable dead palm trees. As a first step in the support of Blue-and-yellow macaws in Rondonópolis, we used a questionnaire (Table S1) to examine what factors influenced the attitudes of urbanites to macaw conservation. We asked if residents would (a) be willing to consider the installation of artificial nests and (b) the introduction of fruit trees to be used as food resource for macaws, in their backyards. To help understand what influenced these decisions, we (a) collected socioeconomic data for the respondents, and (b) measured their existing knowledge of biodiversity by seeing how many of ten bird species observed in Rondonópolis they were able to identify, and (c) what influenced their attitudes to these species.

Figure 1. Blue-and-yellow macaws on a dead palm in a backyard in Rondonópolis.

2. Materials and Methods

2.1. Study Site

The study site is Rondonópolis City, Southern Mato Grosso State, Mid-Western Brazil (16° 28′ 15″ South; 54° 38′ 08″ West), which is in the transitional region between the Guimarães Plateau (Cerrado Biome) and the Pantanal lowlands (Pantanal biome). The estimated population is approximately 239,613 inhabitants [19], who are distributed into 259 neighborhoods that cover just over 88.6 km^2. The city presents a remarkably uneven social reality. Upper-middle class neighborhoods are densely wooded and have green areas such as squares and parks, whereas neighborhoods where poor families live have few roadside trees and virtually no public green areas.

The original vegetation cover in the urban area of the city is almost entirely suppressed. Rondonópolis is a horizontal city; its residents live in neighborhoods formed by houses with backyards. The Remote Sensing and Geoprocessing Laboratory (UFMT) has preliminarily estimated the existence of circa 50,000 backyards in Rondonopolis (Santos, unpublished data).

2.2. Collected Data

Responses to 297 questionnaires were collected from Rondonópolis City residents. Interviewees were approached in places with a large circulation of residents of all social classes, such as hypermarkets, urban parks, and shopping malls, for three months, between April and July 2021. Social classes in Brazil are classified as follows according to average annual income: A and B (higher class), C (middle class) and D and E (low socioeconomic class; IBGE, Brazilian Institute of Geography and Statistics [20]). We based income on the area where the respondents lived in Rondonópolis, which is strongly associated with

income [21]. The respondents were divided into three social classes, namely: 1. High socioeconomic class (monthly household income of USD 3715.00, or higher; converted from BRL to USD, based on the exchange rate on 20 October 2021); 2. Middle socioeconomic class (monthly household income ranging from USD 501.00 to USD 3714.00); and 3. Low socioeconomic class (monthly household income of USD 500.00, or lower; adapted from IBGE income classification [20]).

First, interviewees were provided with images of 10 bird species (Figures 2 and 3) found in urban Rondonópolis, and (a) asked to identify (using their common names) as many as they could, and (b) asked to name their three favorite species of birds from the options provided (full questionnaire is available in Supplementary Materials). The bird species were presented to the interviewees on an A4 card, with 10 photos of the same size, numbered from 1 to 10, following this sequence 1 = *Cariama cristata*; 2 = *Sicalis flaveola*; 3 = *Ara ararauna*; 4 = *Pitangus sulphuratus*; 5 = *Brotogeris tirica*; 6 = *Columbina talpacoti*; 7 = *Ramphastos toco*; 8 = *Vanellus chilensis*; 9 = *Ara chloropterus*; 10 = *Crotophaga ani*. These species were chosen as all are frequently encountered in the urban areas of Rondonopolis. Next, their backyard's structure was investigated. The interviewees were asked about the areas of their yards and about how many trees they had in those spaces. Finally, interviewees were asked about their willingness to help conserve macaws (*Ara ararauna*) by (a) providing artificial nest sites and (b) fruit trees which would benefit macaws and other wildlife.

2.3. Data Analysis

Data with numerical values (area of backyard, number of trees, number of species identified) were analyzed using Kruskal–Wallis ANOVA, with socioeconomic status as the explanatory factor. Other data (i.e., from the questionnaire—see the Supplementary Materials) were analyzed using Chi-square tests. We considered $p \leq 0.05$ as significant in our statistical tests.

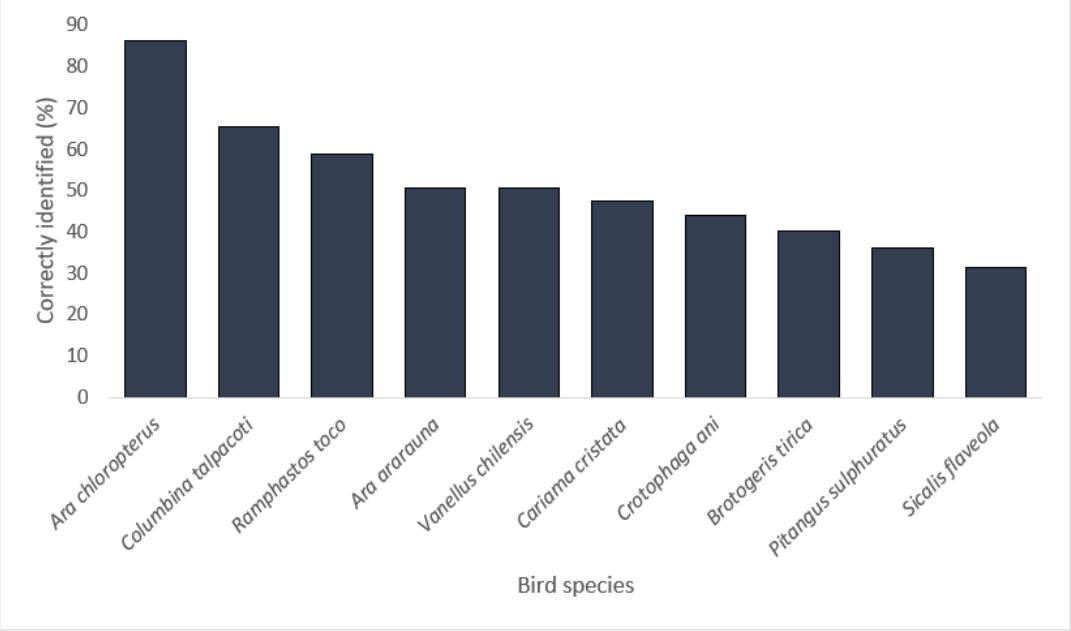

Figure 2. Percentage of individuals correctly identifying each of 10 bird species encountered in Rondonópolis.

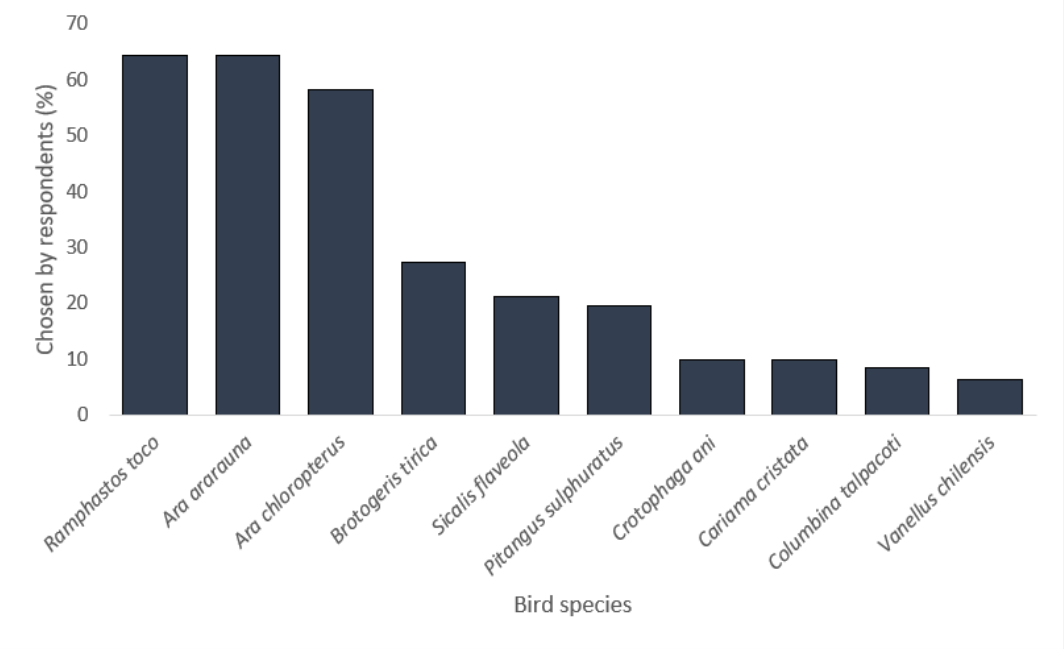

Figure 3. Percentage of individuals choosing each species as one of their three favorite birds in Rondonópolis.

3. Results

The numbers of respondents within each group were as follows: higher socioeconomic class—61; middle socioeconomic class—183; lower socioeconomic class—53. Overall, respondents were able to identify half of the birds presented to them (overall median: 5; Figure 2), and of these, there was a clear preference for more colorful and charismatic species, such as toucans (*Ramphastos toco*) and macaws (*Ara ararauna* and *Ara chloropterus*; Figure 3). There was a significant difference in the number of species identified by each respondent between socioeconomic groups ($H = 16.63$, d.f. = 2, $p < 0.001$). Residents with intermediate income (middle class; median identified: 4) were the ones who identified the smallest number of species in comparison to low (median: 7) or high-income respondents (median: 5). Almost half (47%) of respondents had seen macaw nests, this was not affected by socioeconomic group ($X^2 = 4.52$, d.f. = 2, $p = 0.1$).

Socioeconomic class did not explain the differences in backyard size ($H = 1.82$, d.f. = 2, $p = 0.4$) or in the number of trees planted in them ($H = 4.28$, d.f. = 2, $p = 0.095$), although the size of the backyard in lower social class's homes was smaller than that of the upper social class (mean area: 34.8 m^2 and 45.5 m^2 respectively), the number of trees planted in each backyard was the same in both social classes (mean number of trees: 2.04 vs. 2.05). The middle social class had fewer (mean: 1.47) trees per backyard, but those backyards were intermediate (mean area: 37.4 m^2) in size. There were no differences between socioeconomic groups and (a) willingness to plant trees ($X^2 = 0.54$, d.f. = 2, $p = 0.76$) or (b) install nest boxes ($X^2 = 1.71$, d.f. = 2, $p = 0.43$).

There was considerable support for planting additional trees, with over 78% (233) agreeing, and this was similar across socioeconomic groups ($X^2 = 0.54$, d.f. = 2, $p = 0.76$). Similarly, over 70% (208) said that they would provide a nest site and this was not affected by socioeconomic status ($X^2 = 1.7$, d.f. = 2, $p = 0.43$).

4. Discussion

Urban areas can provide replacement habitats for some declining species, particularly if local residents actively engage with conservation efforts. We explored levels of knowledge and willingness to engage with the conservation of Blue-and-yellow macaws among the residents of Rondonópolis, a medium-sized city in Mato Grosso state, Brazil,

a city surrounded by what was once pristine Cerrado. Using a questionnaire, we first asked how many species of birds respondents could identify from a sample of local species. Overall, our surveyed residents could identify over half of the sample of local bird species, and over half of people could identify Blue-and-yellow macaws and around half had seen their nests. Middle class respondents identified fewer species than their upper or lower-socioeconomic class neighbors. When asked which species they preferred, over half chose the large, brightly colored Red-and-green macaw, Toco toucan, and Blue-and-yellow macaw, with only one other bird species (the Plain Parakeet *Brotogeris tirica*) receiving more than 25% of votes. We found no overall significant difference in yard size or number of trees in the backyards of differing socioeconomic groups. When asked if they would support a small urban population of Blue-and-yellow macaws by planting suitable fruit trees or by providing artificial nest sites, a considerable majority (78% and 70%, respectively) said they would, and this was not affected by socio-economic background.

Most studies suggest that the ability to identify wild species is correlated with increasing socioeconomic status (a proxy for education), and is also affected by age and gender. For example, a study in Casa Nova, Bahia, Brazil found that socioeconomic status, increasing age and male gender positively correlated with the ability to name bird species [22]. Nevertheless, we found a different pattern, in that individuals of the middle socioeconomic group were significantly less likely to be able to identify local bird species, and those in the lowest socioeconomic group identified the most species. Why this is so is not clear, and is worthy of further investigation. Overall, respondents were able to correctly identify around half of the species presented, which was similar to the numbers of local bird species correctly identified by first year UK zoology undergraduates [23]. We consider this an encouraging result for future projects on the conservation of Brazilian avifauna, given the deficiencies of environmental education in Brazilian schools [24–26]. In other words, despite the usually low priority given to environmental education in schools, the citizens of Rondonópolis are relatively familiar with their urban birds. We consider the ability to correctly identify common bird species as being a good proxy for awareness of general biodiversity, and this may suggest that the middle class residents of Rondonópolis are less engaged with nature, but this result is not upheld by their other responses. Similarly, individuals were familiar with Blue-and-yellow macaw nests, with just under half having seen nest sites, despite their relative scarcity.

Individuals were also very likely to support active conservation efforts. Overall, there was considerable support for the provision of nest sites (70% agree) and the planting of fruit trees (78% agree), and this did not differ between socioeconomic groups. A similar result was obtained in Campo Grande, another city in the Brazilian Cerrado [27]. This suggests that there is no need to target populations where engagement is a limiting factor, but instead engagement can be based on opportunity, largely driven by habitat suitability. The cost of providing artificial nests can be covered by the local government and by the private sector. Few resources have been historically allocated to municipal environmental departments in Brazil [28], but again, the charismatic nature of a given species, and the popularity of macaws and toucans, make investing in nests more politically attractive. Likewise, this funding type can be converted into environmental marketing for private companies.

The planting of fruit trees in backyards may also benefit other frugivorous and generalist species with lesser, or no, visual appeal. Ideally, backyards should be populated with native Cerrado tree species capable of providing food resources for macaws, as well as other animal species (e.g., bats), which could help in seed dispersal [8,29,30]. However, cultural factors must carefully be taken into consideration in any planting actions implemented in urban backyards: ignoring them will lead to reduced success, or failure, in increasing the number of trees in these spaces. Culture associated with food is one of these factors. Residents are less likely to grow unfamiliar fruit trees; they would rather grow those they often eat [31]. For example, fruits of the Cerrado tree species *Cheiloclinium cognatum* are food sources for birds and primate species, although they can also be consumed by humans [29]; however, they are not popular among Rondonópolis residents.

Another factor to be taken into consideration lies on the widespread use of exotic fruits in the diet of Rondonópolis residents and of Brazilians from other cities. Mango (*Mangifera indica*) is an exotic species that is much appreciated, and often grown, in the backyards of Rondonópolis residents. It is also consumed by Blue-and-yellow macaws [8]; thus, human food culture and macaw feeding factors converge in this case. Furthermore, it is unrealistic to assume that residents would agree to replace their mango trees with native fruit trees far removed from their culture. However, it may be possible to introduce Cerrado species often consumed by Rondonópolis residents, such as *Anacardium occidentale* and *Caryocar brasiliense*, which are also food sources for macaws. Exotic species consumed by humans can be gradually replaced by other species belonging to the same genus or family. For example, guava tree species *Psidium guajava* could be replaced by *Psidium canum*, which is a closely related Cerrado-native Myrtaceae [29].

The introduction of unfamiliar native species in backyards would require the environmental education of residents. *Qualea parviflora*, *Qualea grandiflora* and *Vatairea macrocarpa* fruits are consumed by *Ara ararauna* living in urban ecosystems [8]; however, growing these species in backyards does not provide any evident advantage to residents. The ornamental potential of some Cerrado-native trees, such as *Rapanea guianensis* and the palm tree *Acronomia aculeata* [32], whose fruits are also consumed and dispersed by macaws and other birds [33,34], may prove to be attractive to upper-middle-class urban families, who are particularly likely to grow trees that have landscaping appeal [31]. Those families could be incentivized in order to replace the exotic palm tree *Roystonea oleracea* with *Acronomia aculeata* and other native palm tree species. There are at least nine potentially ornamental palm tree species native to the Cerrado biome [35].

Backyards and other urban green spaces are areas with high potential for urban biodiversity conservation [31], but the full expression of this potential depends on the solution to some bottlenecks. The first is the lack of specific environmental legislation. There are a few scattered examples of Brazilian cities that have laws forbidding residents to pave their backyards, although their flora and, by extension, their fauna are strongly susceptible to homeowners' decisions. Local governments in Brazil do not periodically assess their most evident features, namely: number of backyards, their mean size, unpaved area rate, mean number of trees in them, area available in them to introduce vegetation and residents' willingness to plant vegetation in their backyards, or not. Such lack of data is partly explained by the low rates of planning and management interventions seen in small- and medium-sized cities, such as Rondonópolis and most cities in the Cerrado biome. Another bottleneck lies in producing the tree species for backyard afforestation purposes. Native tree seedlings can be a prohibitive investment for poor families (which are the majority in Rondonópolis City); however, it is clearly necessary to produce them. Municipal nurseries are not always available in Brazilian cities, but when they do exist, they often only produce a small number of native tree species [31,35].

Another difficulty lies on the knowledge gap about the ecology of Brazilian cities and of other countries in the Global South; most research on urban ecology has been carried out in the USA and Europe [12,36–40]. These bottlenecks can be solved, or at least mitigated, through partnerships being set up between local governments and other institutions and universities. Brazil has expanded the number of federal universities by establishing university campuses in small- and medium-sized cities. These campuses have produced knowledge that can be translated into the conservation of urban biological diversity. Two examples of such a translational ecology are herein presented for illustrative purposes. Forest Engineer Leandro Bernardo Leite has suggested a list of 64 *Cerrado* tree species that could be used in the urban afforestation of Rondonópolis City [21,39]. Today, 17 of these species are cultivated in the municipal nursery and planted on the streets of new urbanization projects. The second example lies in the study described in the current article. By taking into consideration social and biological aspects, we recommend the production of comprehensive environmental planning frameworks and guidelines to increase the

chances of successful conservation actions focused on urban macaws and other bird species' populations [41–43].

5. Conclusions

Urban areas do not have to be devoid of life, but finding a place for nature requires coordinated efforts between town planners, researchers and critically, home dwellers, without whom conservation efforts will fail. Given that most of the world's most biodiverse regions are in the global south, it is imperative that we understand how urbanites in these under-researched habitats will respond to opportunities to contribute to supporting biodiversity. Using the charismatic Blue-and-yellow macaw as a case study, we found that city dwellers in Rondonópolis, a rapidly growing medium-sized city in southern Brazil, are willing to change behaviour to support this species. The great majority were willing to plant fruit trees (78%) and provide nest sites (70%) for macaws, and this did not differ with socioeconomic background. Residents also showed that they were able to identify a wide range of common species, showing clear preferences for large, brightly-colored species. This encouraging result suggests that with the right local action, city dwellers can become powerful advocates for urban bird conservation. Allied with education programs based around flagship species and supportive town planning, cities such as Rondonópolis could become islands of biodiversity in a sea of habitat loss.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/birds3020015/s1, Table S1: The Questionnaire.

Author Contributions: F.A., M.D.E.F., J.S. and J.B. conceived and designed the study. F.A., P.T., J.S., B.M.-M., D.L., J.B., J.M.J. and M.D.E.F. participated in the drafting of the manuscript. F.A., D.L. and J.B. performed the study, collected and extracted data. B.M.-M. and M.D.E.F. analyzed data. All authors have read and agreed to the published version of the manuscript.

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