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ORIGINAL ARTICLE

Which birds are Brazilians seeing on urban and non-urban feeders? An analysis based on a collective online birding

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Abstract

Many studies have shown the positive and negative impacts of feeding wild birds using feeders; however, none of them considered case studies in Brazil. In 2020, social isolation measures imposed by COVID-19 boosted Brazilians' interest in bird feeders, encouraging a group of birders to create an event (called JaneLives) to broadcast simultaneous live images of feeders across the country. Using the structure of JaneLives and relying on volunteers, we investigated which species visit Brazilian bird feeders, and discussed the effectiveness of our opportune citizen science initiative implemented during this event. Forty-eight feeders (19 urban and 29 non-urban) included in six biomes were sampled during nine JaneLives sessions (May–November 2020). The audience watched 133 species, 104 of which were visiting feeders. Non-urban feeders ($n = 94$) had higher richness than urban feeders ($n = 68$), but there were shared and unique species in both strata. Thraupidae, Turdidae, small, and medium birds (< 90 g) were the most common at the feeders. Owners of 23 feeders did data sampling at least once, while the other 25 feeders were sampled by 25 online birders (94.8% of their bird records were reliable). The narration that accompanied each JaneLives session enabled the audience to learn about Brazilian birds and increased environmental awareness. Audience numbers declined over the events, but the number of online birders was not affected. Ecolodges and parks that broadcasted their feeders received new clients afterwards. The events generated social interaction and pragmatic discussions about the usage of feeders, indicating that our citizen science initiative has potential for future research.

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Introduction

Birdwatching is a leisure activity in constant growth in Brazil since the beginning of the twenty-first century (Alexandrino et al. 2019; Carvalho and Hingst-Zaher 2019; Barbosa et al. 2021). The activity is encouraged by ecologists, ornithologists, and environmentalists, as observing nature is one of the most efficient ways of planting environmental awareness in society (Ballantyne et al. 2011; Dallimer et al. 2012; Keniger et al. 2013; Benites et al. 2020).

One of the best methods to promote the watching experience of free-living birds is through bird feeders in natural environments or even in human settlements (Orams 2002; Cox and Gaston 2016; Carvalho and Hingst-Zaher 2019). Food provisioning of bird feeders is practiced globally (Baverstock et al. 2019) and the market for bird food moves billions of dollars annually in the USA and millions in the UK and Europe (Jones and Reynolds 2008; Robb et al. 2008; Jones 2011; Cox and Gaston 2016). Bird feeders allow citizens to develop an emotional connection and respect for non-captive birds, which is beneficial to human well-being (Jones 2011; Galbraith et al. 2014; Cox and Gaston 2016).

Under the ecological perspective, bird feeders are considered a source of abundant food (Robb et al. 2008), being prone to disputes between several bird species and individuals (Francis et al. 2018) and an influence on local communities and populations (Jones 2011; Murray et al. 2016; Plummer et al. 2019; Shutt and Less 2021). Previous studies showed bird feeders causing changes in the breeding ecology of some species (O'Leary and Jones 2006), facilitating the spread of diseases (Hotchkiss et al. 2005; Murray et al. 2016; Lawson et al. 2018), and inducing the consumption of natural food resources nearby feeders (Orros and Fellowes 2012). Others also argued that individuals and species may become dependent on the food provided in certain periods of the year (Robb et al. 2008; Reynolds et al. 2017; Shutt and Less 2021). Thus, inevitably, the human behavior of keeping a bird feeder active (i.e., constant food provisioning over time) is equivalent to an environmental management activity (e.g., Ewen et al. 2015; Silva et al. 2020).

Several studies were systematically performed to measure the positive and negative impacts of feeders on birds and humans (e.g., Murray et al. 2016; Reynolds et al. 2017; Francis et al. 2018; Plummer et al. 2019; Shutt and Less 2021); however, none of the knowledge produced considers the Brazilian context (Murray et al. 2016). Brazil has different climate (Alvares et al. 2013) and biodiversity hotspots (Begossi et al. 2000), in which the dynamic of interactions between birds and their resources may be highly complex (e.g., Campagnoli and Christianini 2022) even in human-modified landscapes (Pizo 2007). Besides, Brazilians have different cultures, social characteristics, and perceptions of their fauna (Belaire et al. 2015; Melo et al. 2021). Consequently, the extrapolation of conclusions suggested by foreign studies is still mistrusted by Brazilian citizens and decision-makers, inciting controversial discussions on the encouragement or the banning of the use of bird feeders in the country (e.g., Olmos 2017; Baverstock et al. 2019).

In 2020, between March and September, Brazilians faced severe social isolation measures due to COVID-19 pandemic. Visits to public parks and nature reserves were prohibited, and accommodation and birding tours in ecolodges and private reserves diminished drastically (G1 2020a). In May, the 15th edition of the most popular Brazilian Bird Fair, AVISTAR (Alexandrino et al. 2018; Carvalho and Hingst-Zaher 2019), occurred free online (G1 2020b). Considering the huge public and predicting people's desire to watch free birds, on a Sunday morning, 17 May 2020, the event promoted the first JaneLives session, a simultaneous live broadcast of several bird feeders throughout Brazil (e.g., https://youtu.be/tgxwR_-XKJ4). Because of its tremendous success, this live event was repeated on nine subsequent dates, always on weekends. JaneLives and social isolation measures leveraged the interest of Brazilians in bird feeders. Following a worldwide trend (Galbraith et al. 2014; Cox and Gaston 2016; Baverstock et al. 2019), this popularization also raised questions among the public about which species occur at feeders and what impact these structures may cause on them. Thus, JaneLives was also planned to include a period of educational narration and a period in which the audience and owners of bird feeders could list the visiting species. The dynamics of the event and collective effort at bird sampling would supply the knowledge demand of all citizens involved, and would potentially create awareness of the pros and cons of using bird feeders. Scientific knowledge is better assimilated by citizens when data and discussions emanate from a collective effort (e.g., van Noordwijk et al. 2021), reaching the foundations of citizen science (Pettibone et al. 2016).

Here, we bring a first compilation of which species occur at Brazilian bird feeders, based on data provided during JaneLives, a series of events that promoted online birding at dozens of feeders spread over different environments within a large geographical area. We also present comparisons of species richness in urban and non-urban bird feeders. Finally, we discuss the positive and negative aspects of this collective effort for bird data sampling and social benefits, and we suggest adjustments for future similar initiatives.

Methods

The dynamic of the JaneLives events

JaneLives was organized by a network of bird enthusiasts who knew each other from previous AVISTAR events. The number of people involved in the organization is not precise, but the organizers had different profiles and birding experiences (e.g., ranging from amateurs to formal researchers and from casual birders to specialists/bird guides/photographers). The primary goals were entertainment and online dissemination of information about Brazilian birds. The event's name is a juxtaposition of a part of a Portuguese word ("Jane" from "Janela," which means window) and the English "live," which together would mean "a live stream from the window," since many citizens would film their bird feeders from their windows. In total, 10 JaneLives occurred between 17 May and 29 November 2020. Days before each event, the organizers invited owners of bird feeders from different parts of Brazil (hereafter "owners," Fig. 1, Supplementary Material S1), and additional spontaneous candidates were also accepted. Once participation was set, minutes before the event, each owner positioned their camera (i.e., which varied from a simple smartphone to a webcam or even a professional camera attached to a computer) in front of their bird feeder and entered the Zoom chat (Fig. 1). The Zoom chat allowed 100 connections, which were composed of the team of moderators, the owners, and the general audience. The screen of one moderator was broadcast to AVISTAR's YouTube channel (e.g., https://www.youtube.com/c/AvistarBrasil) which would be watched by many other citizens. Thus, all JaneLives were broadcast via Zoom and YouTube, but on Zoom, the audience could follow all the feeders simultaneously while on YouTube, the audience would see only the images chosen by the moderator on Zoom. The events were publicized on social media and Zoom and YouTube links were available for everyone.

All JaneLives were composed of two parts: (1) flexible navigation period — occurred with variable duration at the beginning of the event. During this period, each citizen on Zoom was free to browse and watch feeders of their choice. Conversations by audio were not allowed and moderators controlled which microphone of bird feeders was activated to provide the audience with background sound composed of different species vocalizations; (2) narration period — this started immediately after period 1 and lasted until the end of the event. In this period, expert birdwatchers with a background in biology and ornithology narrated which species were showing on each feeder. They taught the audience identification techniques, explained about habits, behaviors, and the ecology of each species, as well as species conservation and social and environmental issues behind these subjects. During the narration, the Zoom audience no longer had control over navigation and just watched the feeder chosen by the narrators. The narration periods occurred during eight JaneLives (Tables 1 and 2).

Data sampling protocol and feeders

Because JaneLives involved citizens with different profiles and variable ornithological skills, we assumed that a complex data sampling protocol would not be followed

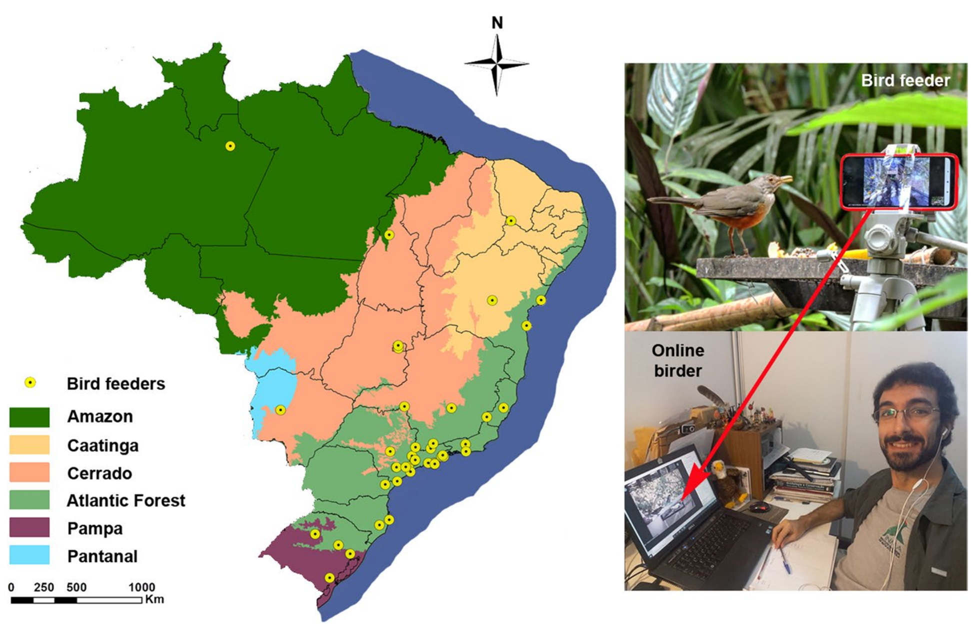

Fig. 1 The map of Brazil shows the geographic distribution of the 48 bird feeders that participated in the nine JaneLives sessions. The pictures illustrate the event dynamic, in which the image of each bird feeder was broadcasted to the audience and online birders

Table 1 Data sampling protocol followed by each volunteer at the event. Data collection was voluntary

Volunteer	Data type	Data sampling protocol*	Sampling effort
Owner of bird feeder	Bird that was using the feeder	During the event, these citizens should list the species observed at their feeders consuming the provisioned food. Species that were nearby but were not observed at the feeder were not considered, even if it was a species observed visiting the feeder on another day/occasion.	These citizens should indicate the period in which species were listed (from 1 or 2 or from both). The starting time and ending time of sampling should also be informed, but this information was commonly forgotten by these volunteers.
Online birder	Bird that was using the feeder but observed online through Zoom	During the event, these citizens should list the species observed on each feeder they watched. They were free to watch as many feeders as they liked during period 1, as well as to watch each one for as long as they liked.	Information of starting time and ending time of sampling at each feeder were not mandatory. Instead, these citizens should only indicate the period in which species were listed (from 1 or 2 or from both).

*In our protocol, citizens had the choice not only to list the species but also to count the maximum number of individuals of each species viewed at the same time at the feeder, similar to the protocol of project FeederWatch (www.projectfeederwatch.org). However, for the present manuscript, we are using only species data

Table 2 The dynamic of nine Janelives in which bird data were collected. The event started with period 1 "Flexible navigation period," followed by period 2 "Narration period." The maximum sampling effort possible performed on each day is based on the period in which data were collected, following starting and ending time as informed by volunteers (BRT). *The narration period did not happen on 17 May

Event day (2020)	Event starting time and period 1	Ending time of period 1 and starting time of period 2	The later time of ending of sampling informed by online birders in that event	n. non-urban feeders	n. urban feeders	Maximum sampling effort possible at that event
17 May*	07:00	09:00	09:00	15	10	2 h
30 May	06:30	08:00	10:40	15	12	4 h 10 min
27 June	06:30	08:00	09:00	8	7	3 h 30 min
25 July	14:30	15:30	16:30	7	6	2 h
29 August	07:00	08:30	10:30	11	4	3 h 30 min
26 September	07:00	08:15	09:30	9	6	2 h 30 min
18 October	07:00	07:45	09:50	10	2	2 h 50 min
24 October	08:00	09:30	09:30	3	3	1 h 30 min
29 November	06:50	07:40	09:30	3	5	2 h 40 min

(Sauermann and Franzoni 2015; Balázs et al. 2021). Thus, we only set a data sampling focusing on birds using the feeders (i.e., spatial standardization) within the event period (i.e., temporal standardization, indicating in which period the data were collected). The owners followed one sampling protocol (they stayed next to the feeders during the event) while the audience on Zoom (hereafter "online birders") followed another (Table 1). The participation in data sampling was voluntary, but days before each event, the organizers recruited volunteers (owners and online birders) using social media and informal invitations. Invitations at the beginning of the event were also used. Nine of 10 JaneLives had pre-event organizations for data collection (Table 2), from which bird data were collected from 48 bird feeders (19 urban and 29 non-urban) spread over the six Brazilian biomes (36 municipalities from 12 states and the Federal District, Fig. 1, Supplementary Material S1 and S2). However, there was a bias towards the Atlantic Forest biome (37 bird feeders, 13 urban and 24 non-urban). After the bird sampling, each volunteer sent the collected data to the team responsible for the database organization.

Each owner designed what they called a "bird feeder" according to their own creativity and desire. Although some also used hummingbird feeders or provisioned food right on the floor (for terrestrial birds), our analysis of urban and non-urban feeders does not consider species data from these food-spots. Instead, we intend to provide knowledge of which species use human-made structures suspended or supported by other arrangements, or even natural platforms in which human intervention was done to attract a variety of bird species and families (Fig. 1, Supplementary Material S1). Because there are Brazilian studies evaluating hummingbird feeders (e.g., Lanna et al. 2017), we decided not to go into this topic. The ages of each bird feeder, as declared by each owner, were variable (age counted from the time when the owners started food provisioning and maintained it periodically ever since). There were feeders created a few months before the first JaneLives as well as those maintained for approximately 20 years. Four owners started using feeders after the first editions of JaneLives (Supplementary Material S1). During the events, commercial fruits, such as banana and papaya, were the most offered on feeders, present in all 100% of them. However, avocado, slices of orange, apple, broken corn, sunflower seeds, and birdseed were also used eventually by some owners (see pictures in Supplementary Material S1). We classified each bird feeder as "urban" or "non-urban" considering land use cover and landscape characteristics within a 1000 m radius surrounding each feeder (Effective Mesh Size analysis followed by non-metric multidimensional scaling, see details in Supplementary Material S2).

Data analysis

We excluded from our analysis species of the Trochilidae family and species observed only feeding on the floor. We used rarefaction curves in EstimateS 9.1 (Colwell 2013) to evaluate if a reliable number of species likely to use feeders has been reached.

Using body mass provided in Wilman et al. (2014), we classified each species in categories of body mass, considering those under 30 g as small-sized species (Alexandrino et al. 2017), medium-sized species between 31 and 90 g, and large species above 90 g. We choose these classes after an initial inspection of the species pool and split them into three sets using visual differences in size. We followed Pacheco et al. (2021) for bird nomenclature and taxonomy.

We used permutational multivariate analysis of variance (PERMANOVA, Anderson 2001) to investigate the interaction effect of strata (urban and non-urban feeders) with the sampling effort on bird richness. We created a stratified permutation procedure to maintain the nested structure of the data (sampling effort nested in strata) in the PERMANOVA to control possible spatial autocorrelation of the data. We also built simpler models when the interaction terms were non-significant. The PERMANOVA probability values were based on 999 permutations. We performed the analyses considering all bird feeders in all biomes. The Atlantic Forest biome had a higher number of feeders; therefore, we also carried out analyses considering only feeders in this biome. All analyses were run in the R environment for statistical computing (R Core Team 2021, version 4.0.5), using the packages vegan 2.5-7 (Oksanen et al. 2020), ggplot2 (Wickham 2016), and gridExtra (Auguie et al. 2017).

To depict the public interest in JaneLives throughout its editions, we took the number of total and simultaneous views for each YouTube transmission (we used only data from independent events, thus, 17 May and 26 October were excluded from this analysis as they took place during online Bird Fairs). As a measure of citizen engagement for bird sampling, we used the number of online birders and owners who made bird lists at each event.

Because our sampling protocol did not request information from online birders of their period of sampling at each bird feeder, and most of the owners forgot to note the time of their sampling, our only indication of sampling effort at each event was based on the earlier and later times reported by some volunteers who spontaneously noted this data. Thus, we consider this period as the maximum sampling effort possible for each event (Table 2). To assess the potential of JaneLives to broadcast live bird images and information, we listed the accumulated species at each event and throughout the nine events, using the data provided within the maximum sampling effort possible. In this analysis, we used all species that appeared in the lives, regardless whether they were at the feeders or not.

Results

Birds on feeders

In total, 133 species were observed during the JaneLives transmissions, from nine orders and 26 families (Supplementary Material S4), but only 104 were observed at the bird feeders. In the last four events, there was no addition of new species at the bird feeders, indicating we obtained a representative species list with our sampling effort (Fig. 2a).

Species richness at non-urban bird feeders ($n = 94$) was higher than at urban feeders ($n = 68$). The landscape was indicated as responsible for the species richness differences between both strata (PERMANOVA, $R^2 = 0.070$; $P = 0.006$, see Fig. 2b), but the variation in sampling effort between strata at each event also influenced the result (Fig. 2c; $R^2 = 0.689$; $P \leq 0.001$). We observed similar results within the Atlantic Forest biome, but species richness differences between non-urban ($n = 76$) and urban feeders ($n = 52$) were explained only by the landscape ($R^2 = 0.343$; $P = 0.003$) without influence of the sampling effort ($R^2 = 0.425$; $P = 0.12$).

Fifty-eight species occurred in both strata, but non-urban bird feeders had higher exclusive species ($n = 36$) than urban feeders ($n = 10$). *Thraupis sayaca* and *Turdus rufiventris* were the most common species observed, with occurrence at more than 50% of all feeders (respectively 30 and 26 feeders), and another six species were observed at least 20 feeders (Fig. 2d). In contrast, 86 species occurred at less than 10 feeders (Supplementary Material S4). While 11 species occurred equally at non-urban and urban feeders and 15 species had a higher occurrence at urban feeders, 78

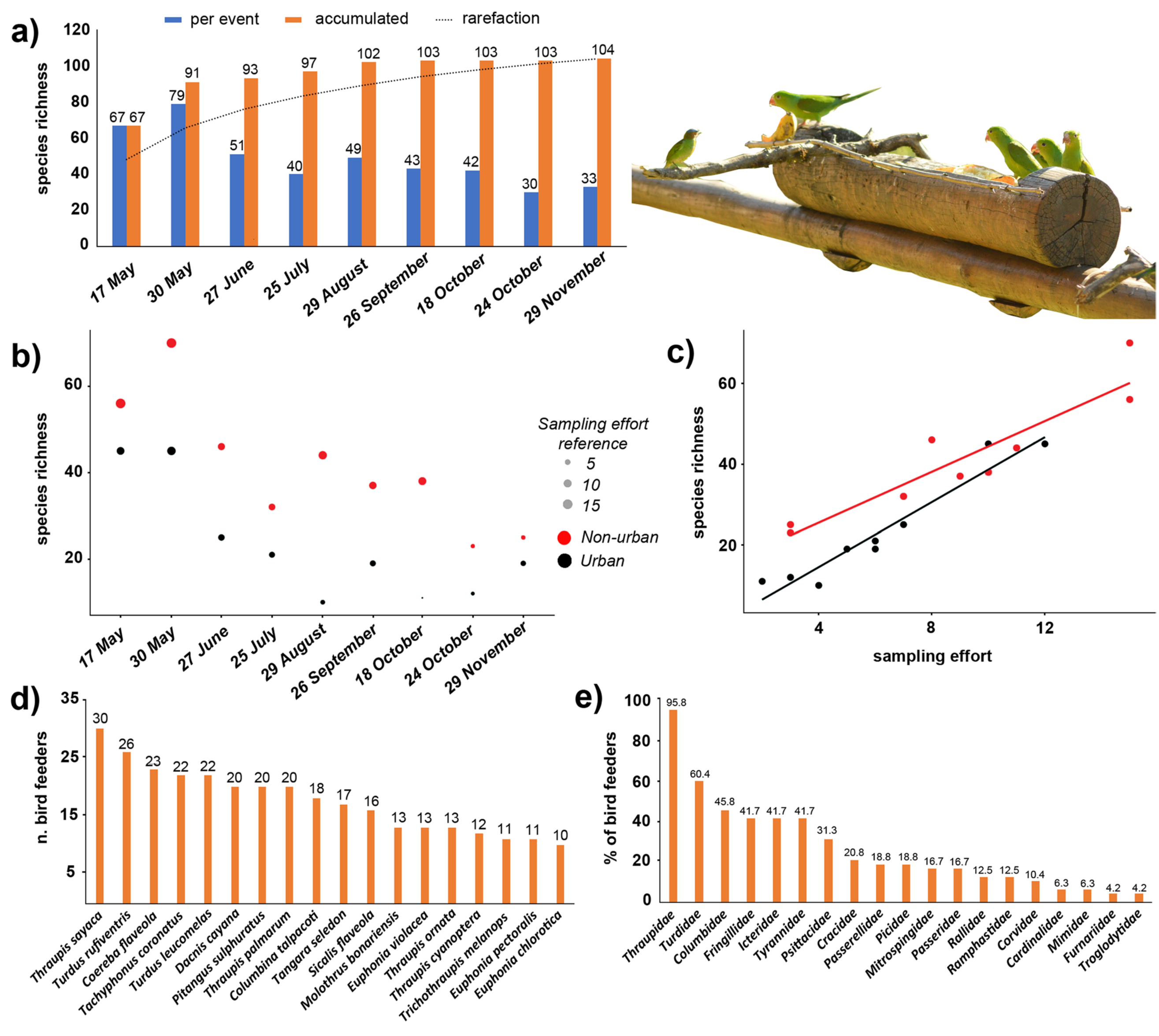

Fig. 2 **a** Species richness of each JaneLives and accumulated after nine events. **b** Species richness observed at non-urban and urban bird feeders during each event. The size of each point represents the number of bird feeders in each strata at each event. **c** PERMANOVA analysis indicated that the difference in species richness between non-urban and urban bird feeders was also influenced by the difference in sampling effort. **d** Eighteen species occurred at more than 10 bird feeders during JaneLives. **e** Families with the highest presence at bird feeders, with emphasis on Thraupidae that occurred at almost all feeders

others had a higher occurrence at non-urban feeders. These results suggest that urban feeders tend to be used by a homogeneous bird community in comparison to non-urban feeders (Fig. 2b).

Thraupidae and Turdidae were the families most present (Fig. 2e), with the emphasis of 42 Thraupidae species observed. Small- and medium-sized birds were present at all bird feeders, while large species were limited to few localities (e.g., *Zenaida auriculata* — 110.5 g was at seven feeders; *Penelope obscura* — 1770 g at six; *Celeus flavescens* — 139 g at five; *Colaptes melanochloros* — 127.27 g at four; and *Ortalis araucuan* — 547.72 g, *Ramphastos dicolorus* — 331 g, and *Ramphastos vitellinus* — 360.36 g were at three; Supplementary Material S4). House sparrow (*Passer domesticus*) was the only exotic species observed, with occurrence limited to eight feeders (three non-urban and five urban).

Audience and sampling effort carried out

The number of bird feeders at each event varied from 6 to 28 (mean = 15). In general, the participation of each bird feeder owner decreased over the JaneLives editions. There were events where 20 owners did bird sampling on their feeder, but there were also days when no owner did this (Fig. 3a).

Twenty-five online birders did samplings over JaneLives, but the number of times they participated and each one's method of collecting data were quite varied. While eight of them participated in four events or more, the majority (n = 17) took part and carried out bird sampling in less than three events (Supplementary Material S3). Some events counted with 12 online birders, but others had only one that did bird sampling (Fig. 3b). There were not only days in which online birders did sampling at all feeders equally but also days in which some birders decided to sample only one feeder while the others were sampling all feeders. Most of the online birders (n = 18) performed sampling by taking notes of species and individuals, while others (n = 7) preferred just to make a species list. After nine events, the accumulated number of species for each online birder ranged from 6 up to 75, with more species being added by them as they participated (Supplementary Material S3). During each event, an average of 48 species was observed at feeders by online birders (maximum 79 species, minimum 30).

In total, online birders provided 2170 bird records (each species observed at each feeder), of which only 1.4% of them (n = 31) did not have enough information to check the species identification (e.g., simple records such as "a blue bird" or "a tanager"). Only 5.1% of the records (n = 111) had a high probability of misidentification (e.g., identification up to the genus level, identification of a species far away from the geographic distribution, or indication of a "non-identified species").

From the 48 bird feeders, four were located in parks or natural reserves, 13 were in small tourist or housing enterprises (e.g., ecolodges and hotels near nature, where feeders are used as part of the tourist attraction), and 31 were in citizens' residences (e.g., in the garden, on the balcony of an apartment, and at a country house, Supplementary Material S1).

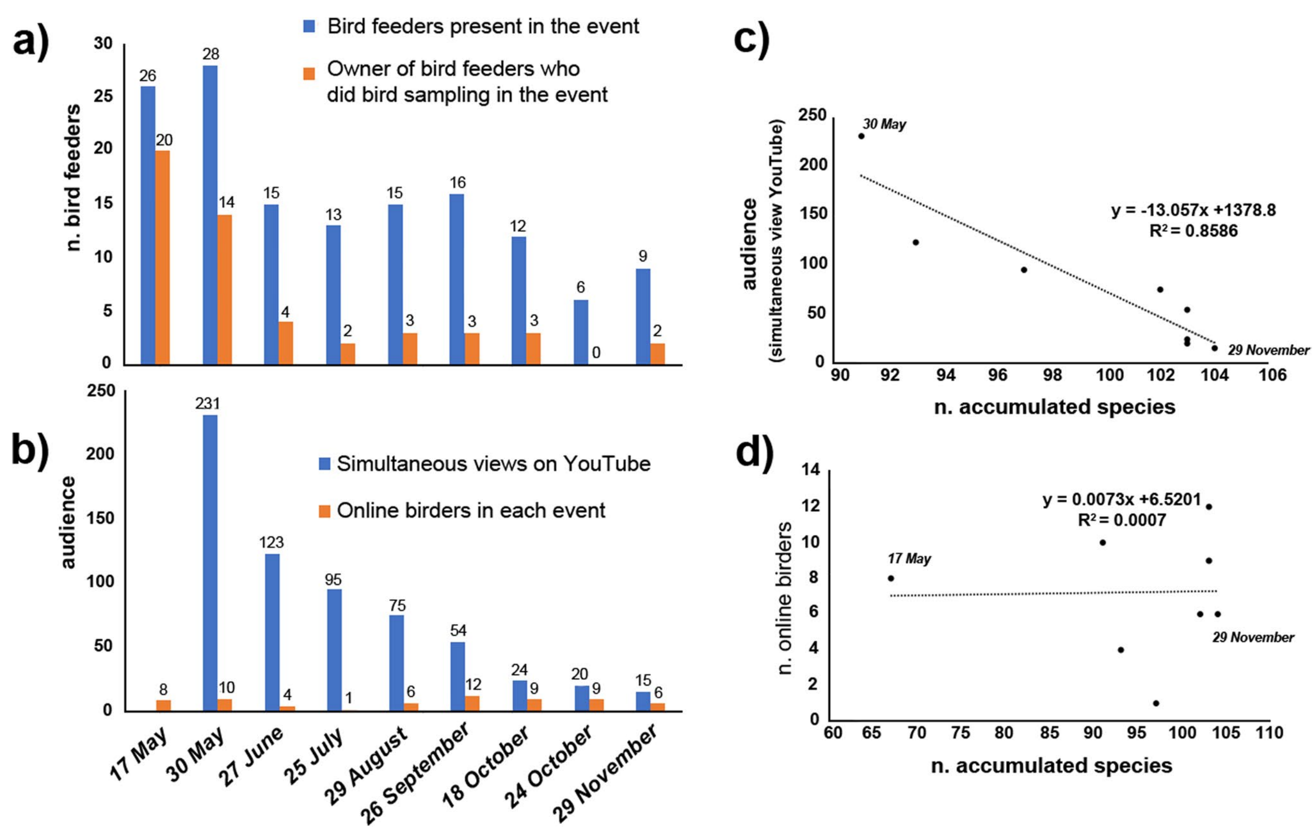

Fig. 3 **a** Number of bird feeders present at each event and number of owners who did bird sampling on their feeder on that day. **b** Audience at each event (number of YouTube viewers) and number of online birders who did bird sampling on that day. **c** Negative relation (P < 0.001) between total audience numbers and the number of accumulated species throughout the nine events, suggesting that audience interest decreased due to the low increment of new species at each event. **d** The number of online birders at each event did not follow the low increment of new species at each event

Discussion

Birds using feeders in Brazil

Although the dynamic of JaneLives compromised the application of a sampling design able to detect richness differences without compromising the robustness of statistical analysis, our results suggest that, in general, urban bird feeders in Brazil are used by fewer species than feeders located in non-urban landscapes. This result meets expectations for urban areas, where bird richness is less than in non-urban areas (Abilhoa and Amorin 2017; Leveau et al. 2017; MacGregor-Fors and Garcia Arroyo 2017). However, we believe that many other factors not monitored in our study may influence the occurrence of species at Brazilian feeders (e.g., other landscape features, the quality of provisioned food, urbanization level, distance from natural ecosystems, and latitude), which would better explain the variations of species' occurrences at feeders around the country. For example, considering only feeders within the Atlantic Forest biome, with similar a sampling effort and structural characteristics, we observed that feeders in a less urbanized landscape also had richness and species composition comparable to feeders in forested landscapes (e.g., see urban bird feeders "Vil_Oli," "INMA" versus non-urban "Caio_Tati" and "PECB," 48% Jaccard similarity, Supplementary Material S1 and S2). On the other hand, keeping the same rigor but comparing feeders from the opposite sides in the urbanization gradient, we also observed disparate species composition (< 30% Jaccard), although similar richness (e.g., see urban bird feeders "Gil_Mull," "Ped_Fer" versus non-urban "Sít_Flor," all within Pampa biome, Supplementary Material S1 and S2).

Even with a limited sampling method, our study highlighted there are urban bird feeders in Brazil with an occurrence of up to 24 species and non-urban feeders being visited by up to 36 species (Supplementary Material S1). These are elevated numbers when compared with other bird feeders monitored in the Neotropical region (Seijas and Seijas-Falkenhagen 2020, reported 16 species at an urban feeder), and are above the mean richness reported from urban (mean = 22.1 species) and non-urban bird feeders (mean = 22.9 species) monitored in North America (data from 684 feeders monitored between 2016 and 2020 by Project FeederWatch, see https://feederwatch.org/explore/raw-dataset-requests).

Our results corroborate other studies carried out in other countries where typically small- and medium-sized birds (up to 90 g) are the most common at feeders (Reynolds et al. 2017). However, we observed some feeders in Brazil attracting large birds (> 90 g) that consume fruits, such as species from Ramphastidade (toucans), Cracidae (guan), Psittacidae (parrots and macaws), Corvidae (jays), Columbidae (pigeons), and Rallidae (rails). Although these birds were mostly observed at non-urban bird feeders ($n = 16$), we also observed species from these families at nine urban feeders.

The most common species observed at feeders were typically considered fruit and seed eaters; however, we also observed species commonly considered insectivorous (e.g., ruby-crowned tanager, black-goggled tanager, Wilman et al. 2014, Supplementary Material S4). This result indicates that diet categories (e.g., Wilman et al. 2014) or foraging guilds (e.g., Alexandrino et al. 2017) previously proposed in literature for birds may not be readily useful for studies evaluating species on feeders.

Studies abroad have shown that house sparrow populations can benefit from using bird feeders (Galbraith et al. 2015). However, the species was present at only eight monitored feeders, suggesting that these structures do not necessarily benefit the species in Brazil. While in the Northern hemisphere and Oceania the main food provisioned is seed and grains (Reynolds et al. 2017; Tryjanowski et al. 2018), which may benefit sparrows, the popular food on Brazilian feeders are bananas and papaya. Both are cheap fruits in Brazil and were on all 48 bird feeders monitored in our study, as well as on other feeders in the Neotropical region (Seijas and Seijas-Falkenhagen 2020).

Because of the interactions between all volunteers during the JaneLives events, we observed the first empirical evidence of the drop in birds visiting some feeders during the hot and wet season in Brazil (i.e., usually comprising September–March in latitudes near the Tropic of Capricorn). Twelve owners of old non-urban bird feeders in the Atlantic Forest declared that this scenario would happen after August, and low visiting rates would continue until the end of the hot season (i.e., March). Although we did not collect bird data to test this assumption, the diminishing engagement of these owners in events in the hot season is an indication of the reliability of their knowledge. Thus, this result suggests that some feeders in Brazil could support some species during the cold season, as happens in the Northern hemisphere (Reynolds et al. 2017) and as the diversity of natural food availability increases in the environment (i.e., plant species fruiting or flowering and arthropods, Develey and Peres 2000; Morellato et al. 2000), species may decrease feeding activities at feeders.

JaneLives — citizen science and social benefits

Although JaneLives was created for entertainment, the efforts of some participants made the event support a semi-structured collaborative citizen science initiative, where citizens participated in the study design, data collection, analysis, and dissemination of the knowledge generated (Shirk et al. 2012). More than providing the first bird data from dozens of bird feeders all over Brazil, our study showed that the event generated expressive social and environmental benefits, as highlighted below.

The event broadcasted live images of up to 133 Brazilian bird species in a period when social isolation due to COVID-19 was severe. Human mental health and well-being are improved when they interact with nature (Dallimer et al. 2012; Keniger et al. 2013; Galbraith et al. 2014; Cox and Gaston 2016), and we believe JaneLives contributed to reducing the negative effects of social isolation, as occurred in other parts of the world (Benites et al. 2020; Randler et al. 2020).

The narration period was similar to what a citizen may have during a field trip with a trained bird guide (Sekercioglu 2002; Steven et al. 2021). Images are worth a thousand words, and catching a bird image at unexpected moments may stamp the citizen's memory forever (Folmer et al. 2013; Hanisch et al. 2019). Thus, narration contributed to embedding knowledge about species characteristics and habits in the audience. We also observed at each event the audience raising questions about the number of species that appeared during transmissions. Species richness is an environmental factor easily comprehended by ordinary citizens (Dallimer et al. 2012; Belaire et al. 2015), admired by owners of bird feeders (Cox and Gaston 2015), and perceived by birders (Alexandrino et al. 2012, 2019; Steven et al. 2021). Therefore, near the end of each event, the team responsible for bird data organization always appeared in the transmission to inform the total number of species observed. Receiving this feedback, the online birders could finally recognize that their effort was useful, which helped to engage them to participate in the next events (i.e., the number of online birders did not follow the drop in audience numbers in the course of the events, Figs. 3c and d). Finally, for the general audience, we believe the event format raised their environmental awareness. The event promoted simultaneous online birding in different environments and biomes, and the narrators opportunely included subjects about species diversity in Brazil and the reasons for the species composition differences between the feeders. During some events, the audience also questioned why there were so few house sparrows at the feeders, which provided a chance for the narrators to explain the impacts of exotic species and management possibilities (e.g., our results suggested that prioritizing fruits on feeders instead of seeds may diminish the interest of sparrows in visiting the feeder).

In some countries, the period of severest social restrictions due to the pandemic has influenced the behaviors of birders in choosing places to go birding (e.g., birding became more local, Randler et al. 2020; Basile et al. 2021), and we believe JaneLives has contributed to this scenario in Brazil. Bird feeders in parks or ecolodges specialized in receiving birders have inadvertently publicized their establishment and region. Thus, the owners of 11 bird feeders (eight from ecolodges, two from natural reserves, one from an urban park) stated that they received visitors who became interested in the location after watching JaneLives.

Throughout data analysis and formulation of this manuscript, led by two formal researchers in the team (E.R.A. and T.A.C.), two meetings with all online birders and owners of bird feeders took place to expose and discuss the data obtained during JaneLives. These meetings introduced some principles of scientific methodology to many of these citizens. Many of them understood the limitation of comparisons between urban and non-urban feeders due to the lack of a standard sampling effort at all feeders, the differences of birding skills between online birders, and the significant geographical variation between feeders. Once these limitations were recognized, many participants presented solutions to contour methodological issues for future events, and to carry out new investigations about Brazilian bird feeders (see the lessons in the next topic).

Flaws and lessons for future citizen science initiatives

Just as any citizen science project is prone to inconsistencies (e.g., Alexandrino et al. 2019; Balázs et al. 2021), we recognize flaws in our initiative. Although our results indicate that some citizen science principles were achieved (e.g., citizens participating in more than one investigation stage by their own choice), there were benefits for all citizens involved (Pettibone et al. 2016).

We realized that establishing an easy data sampling protocol and staffing (mainly for those with few or no skills in data sampling) were not enough to create a spontaneous desire in the audience (including some owners of bird feeders) to do bird sampling. Twenty-five owners of bird feeders out of the 48 did not carry out any sampling (Supplementary Material S1). There were five other owners of bird feeders that participated briefly at some events (not considered in our analysis), but no information of the birds at their feeders was provided, even after our attempts to engage them.

During the recruitment stage, many citizens admitted not being confident enough to follow the sampling protocol, corroborating that not all bird enthusiasts feel able to identify the species they observe (Cox and Gaston 2015; Alexandrino et al. 2019). We believe the live events may have also contributed to uneasiness among some citizens to join the data collection.

Among volunteers who did carry out bird sampling, there was high variation in their participation during each JaneLives, following a tendency in citizen science projects (Boakes et al. 2016). Each volunteer has different reasons for not participating in all the events, but we recognized some main factors:

(a) After August 2020, due to the first relaxation measures of social isolation, there was a gradual return of clients to ecolodges and hotels that had bird feeders, which hindered their owners from participating in JaneLives. Also, many online birders and owners of bird feeders in their homes returned to birding in the field over the weekends (Alexandrino et al. 2018), the days of JaneLives sessions.
(b) We believe the audience perceived the low increment of new species during the course of the events, compromising that feeling of seeing a novelty, highly valued by birders (Alexandrino et al. 2019, Fig. 3c). Consequently, the decrease in audience numbers may have contributed to the low motivation of owners of bird feeders to keep participating in the events. In addition, many owners of bird feeders declared a drop of birds visiting their feeders as spring and the fruitification season in many plant species in the surrounding environment started.

We also recognized our failure to provide better effective feedback to volunteers. At each event, only two members of the organization were responsible for receiving the data from all volunteers, standardizing species nomenclature (i.e., some birders followed eBird names while others followed WikiAves), and making manual data entries into the JaneLives bird database. This work was done mostly minutes before the end of each event, limiting the team to compute only a provisional estimative of species richness, although other information could be extracted from the volunteers' lists (e.g., species composition of each feeder and species occurrence at each feeder) if there was more time.

Another flaw, also related to the time and personal constraints, was the absence of an open-automated platform for data entry in the bird database. Through an automated platform with fixed filters based on the data sampling protocol, errors would be diminished in the database, also reducing the manual labor of the organizers (Bonter and Greig 2021). Because we did not have this tool, our database needed constant revision. To avoid any misinterpretation about each feeder based on our non-reviewed data, we decided not to open the database up to all volunteers. However, we recognized that through open access to the database, volunteers would observe how their efforts were adding information to the investigation about bird feeders during each event, encouraging them to invite new citizens to participate. As a way of avoiding these problems in the future, or similar initiatives, we suggest the use of free platforms to build an automated tool for data entry (e.g.,www.anecdata.org).

Finally, as online birders were not obligated to note the time that they spent watching each feeder, more in-depth comparisons between the feeders were compromised. This reinforces the importance of future similar collective initiatives making sampling effort information mandatory in the protocol.

Conclusions

So far, the only citizen science initiative in the world to monitor bird feeders through a large spatial and temporal extension is the Project FeederWatch (Bonter and Greig 2021). Although JaneLives was far from reaching the same efficiency, we emphasize that it was the first time in the world in which citizens tried to carry out online birding and sampling at feeders simultaneously.

Studies about feeders and supplementary feeding for wildlife have commonly been published in international literature (Reynolds et al. 2017), and in countries where birding and leisure in nature are common activities (Steven et al. 2021), citizens have contributed to the discussions about the use of feeders. In Brazil, up until the beginning of JaneLives, discussion of the subject was taboo for many. While some citizens always criticized bird feeders highlighting the negative impacts indicated by foreign studies, on the other hand, many others defended feeders as useful for tourism and environmental education (Olmos 2017). JaneLives was the first suitable ambiance in Brazil where citizens from both profiles were talking unconcernedly with each other about this topic.

Although there is no official number for Brazil, the huge audience of JaneLives suggests that bird feeders may be in use in many more tourist spots and homes than we thought. Thus, to help Brazilians use bird feeders rationally, and identify positive and negative impacts considering different local contexts, further investigations must be carried out in the country. We hope our study encourages new research from now on.

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Declarations

Conflict of interest The authors declare no competing interests.

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